April, 1977

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DIFFERENTIAL RESPONSES TO PRICE AND EXCHANGE RATE INFLUENCES IN THE FOREIGN TRADE OF SELECTED INDUSTRIAL COUNTRIES

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I. Overview

Determining how trade flows respond to price and exchange rate changes has posed a difficult problem in international economics. The lag with which currency depreciation or price inflation may affect imports and exports has important policy implications, but most work in this area has been somewhat conjectural. Some writers have argued that under a system of fixed exchange rates, trade flows responded differently to changes in goods' prices than to exchange rate changes, but in the literature to date there is little empirical evidence on this proposition.

In this paper we provide statistical evidence on the differential reactions of trade flows to changes in domestic prices, foreign prices and exchange rates over the 1957-71 period, that is, prior to the general breakdown of the Bretton Woods system. Using a quarterly import and export model for six major countries: Canada, France, Germany, Japan, the United Kingdom and the United States, we investigate the comparative length of full price and exchange rate response times. In addition, we explore the short-run behavior of trade under the assumption that the long-run response to equivalent changes in traded goods' prices and exchange rates should be the same. Our results support two general conclusions: a) the length of full response lags on exchange rate changes tended to be shorter than for changes in prices and, b) in the early part of the response interval, the impact of parity changes on trade flows tended to be greater than that of price changes.

II. Price and Exchange Rate Effects: Some Background

Elements of the question we investigate in this paper can be traced back to Orcutt's seminal article /13/ on the shortcomings of empirical work on trade flows.

Of the five reasons Orcutt gave why estimates of price elasticities might be biased downward, most have been addressed by subsequent literature. The focal point of the current study is Orcutt's last argument, which has to date received little attention:

> E. The Price Elasticity of Demand for Imports or Exports is Probably Much Larger for Large Price Changes Than for Small Price Changes.
>
> ...There are several reasons to expect the demand schedule for imports to be more inelastic for small than for large....price variations....Thus small price changes and particularly those which appear to be of a temporary nature will be ignored. Little shifting will take place until the differential is at least sufficient to cover the costs of switching, whereas a _large and fairly permanent change produced by depreciation_ would result in substantial substitution (/13/, pp. 541-542, emphasis ours).

Under the fixed rate regime exchange rate changes were more abrupt and tended to be larger than period-to-period changes in relative prices among the major trading countries. However, Orcutt does not indicate whether _cumulative_ price shifts which, over time, create a discrepancy of similar magnitude to a single exchange rate change, would lead to different long-run adjustments by traders. Orcutt's argument was thus subsequently interpreted to mean that adjustment to an exchange rate change of a certain magnitude will be quicker than adjustment to a price change of similar magnitude. Leamer and Stern [9] interpreted Orcutt's point as follows:

> Since in our judgment the assumption of an underlying long run demand relationship seems absolutely basic, we assume Orcutt's point is really that adjustment to large price changes is <u>more</u> <u>rapid</u> than adjustment to small changes. This will be especially true in the case of devaluation when the price changes are clearly going to be permanent and there will be no adjustment delay <u>in</u> <u>anticipation</u> of a reversal of the price change. ([9], p. 34, emphasis ours).

On the other hand, Junz and Rhomberg [8] point out that the short-run response to a devaluation may appear either slower <u>or</u> faster than the response to a price change.

> As to the response to exchange rate changes compared with that to other relative cost changes, the generally larger size of par value changes and the publicity that attaches to them argues for a more immediate response than that to price changes in general. On the other hand, if par value changes are undertaken - as they have tended to be - to correct large disequilibria which have cumulated over some period of time, relatively large resource shifts with a correspondingly long response time may be required. These two factors could well offset each other, so that reactions to exchange rate changes might appear neither faster and stronger nor slower and feebler than reactions to price changes measured in national currencies. Although this need not be true in the short run, the homogeneity assumptions made in economic theory argue that the long-run response to par value changes, other things being equal, should not differ from that to relative price changes in general. ([8], p. 413.)

There are really two questions intertwined in the above observations. The first is whether the response of trade flows to changes in <u>prices</u> (or relative prices) differs for large than for small changes.

The second is whether the response of trade flows to exchange rate changes differs, at least in the short-run, from responses to changes in the goods' prices. This paper concentrates on the second of these questions, but to the extent that large changes in relative prices might in the past have been caused by exchange rate changes, any evidence on the first question would be informative. Such evidence is found in two studies done many years apart.

In one of the early rejoinders to Orcutt, T.C. Liu [10] estimated functions in which the change in U.S. imports depended on both the change in relative prices and on the same term squared. The squared term appeared more significant than the simple relative in Liu's empirical results. More recently, Goldstein and Khan [6] searched for a similar "quantum effect" in import demand equations for 12 industrial countries.[1/] They found that neither the size of the price elasticity nor the speed of adjustment seemed related to the size of the change in prices, and concluded that their tests were "unanimous" in rejecting the existence of a quantum effect. Both of these studies used relative price variables and neither attempted to disentangle exchange rate from price effects, so the evidence they develop on Orcutt's original point is incomplete at best.

Only a few efforts have been made to estimate trade flow functions which include separate price and exchange rate terms. Hooper [7] and Wilson [17], for instance, constructed disaggregated U.S. trade models which incorporated separate price and exchange rate regressors. But the only direct test for different responses of trade flows to changes in (relative) prices and exchange rates in a multi-country framework is found in the 1973 study by Junz and Rhomberg [8]. For a pooled sample of 13 industrial countries they regressed three-year percentage changes in export market shares on current and successively lagged changes in relative prices (unit values) and relative exchange rates.

They found that

> for the three-and four year lags, the response to price changes seems to have been about the same however these changes came about. The national currency price elasticity is statistically significant throughout. The relative exchange rate variable becomes significant only when lagged by two years or more ([8], pp. 416-417).[2]

These results, however, provide no conclusive answer to the specific questions we consider here. Junz and Rhomberg measured market-share changes, not trade flows directly; pooling the sample imposes the same parameters on each country in the pool; and measuring partial-correlations with price and exchange rate variables lagged one period at a time yields no picture of the length or shape of a full response pattern through time. In the next section we outline a method for estimating, separately, these price and exchange rate response patterns.

III. Model and Methodology

The model of trade flows developed in this section is conventional in the sense that it includes variables found in many other studies of imports and exports, and is estimated in a familiar functional form. It is less conventional in the way certain common restrictions are relaxed and in the way others are imposed.

The long run demand for imports ($\bar{M}$) is assumed to depend upon income or activity in the importing country (Y), the foreign currency price of imported goods (P_f), the price of import substitutes (P_d), the exchange rate (R), and one or more additional cyclic or trend variables (Z). Our starting point is thus:

$$\bar{M} = \bar{M}(Y, P_d, R, P_f, Z) \tag{1}$$

If the functional form of this general long-run relationship is assumed to be multiplicative (except, perhaps, for the variable Z), taking logarithms yields:

$$\ln\bar{M} = k + \alpha \ln Y + \beta \ln P_d + \gamma \ln R + \delta \ln P_f + \eta Z \tag{2}$$

It is generally agreed, however, that imports will not adjust instantaneously to their long-run equilibrium level following a change in any of their determining variables. Thus, the level of imports observed in any period (M_t) is commonly expressed as a distributed lag function of the independent variables. In the present paper we concentrate only on the lagged response of trade flows to price and exchange rate changes and do not consider lags on the activity or other variables. [3/]

The prototype estimating equation was thus:

$$\ln M_t = k + \alpha \ln Y_t + \sum_{i=0}^{n_1} \beta_i \ln P_{d,t-i} + \sum_{i=0}^{n_2} \gamma_i \ln R_{t-i} + \sum_{i=0}^{n_3} \delta_i \ln P_{f,t-i} + \eta Z_t + \epsilon_t \quad (3)$$

The long-run or steady state effects shown in relation (2) are derived from the estimates yielded by (3) as the sums of the lag coefficients (e.g., $\beta = \Sigma \beta_i$). Because of the collinearity which usually exists between the many price and income terms in (3), previous work has usually employed two kinds of additional parameter constraints. The first involves imposing homogeneity on the foreign and domestic price responses by consolidating the price and exchange rate variables and estimating in terms of price relatives ($P_f \cdot R/P_d$). The homogeneity postulate (sometimes described as assuming there is no "money illusion") has some theoretical appeal, and does facilitate estimation of equation (3). Secondly, constraints are normally applied to the lag structures, often by assuming a partial-adjustment mechanism or, following Almon, by assuming that distributed lag coefficients lie on a polynomial curve. Both these parametrizations impose rigid conditions on coefficient estimates.

The current study relaxes these conventions in several respects. Rather than consolidating several price terms, which in effect <u>defines</u> the coefficient on each price element to be the same in each lag period, we assume only that the <u>long-run</u> import response to changes in P_f and R is about the same, but that the short-period effects may differ. We therefore estimated lag coefficients on these variables separately, subject to a side constraint expressing the equality of coefficient sums. Also, there is no compelling evidence that trade flows respond symmetrically to domestic and foreign prices, so we treated P_d separately as well. In addition, we estimated all lag structures by the Shiller procedure, which is more flexible than the older approaches mentioned above. Since both the lag estimator and the side-constraint on coefficient sums are implemented by mixed estimation methods, the technique for both is briefly set forth below.

Shiller [14] derived his estimator in a Bayesian framework. He assumes that lag coefficients evolve smoothly. This is given expression by saying that lag coefficient differences (of some degree) are distributed normally with zero mean and a certain covariance. The resulting estimator is similar to the Almon in the sense that, in an exact polynomial of degree "p", the "p+1"th differences of the coefficients are equal to zero. The advantage of the Shiller procedure is that the researcher can tighten or relax the constraint which urges that each lag structure approximate polynomial form. This method has also been depicted in the mixed estimation framework by Shiller [15]. The prior information appended to a general regression of the form $Y = X\beta + \epsilon$ by this method can be summarized by the linear relation:

$$r = R\beta + v$$

where

$$r = 0 \qquad E(v) = 0 \qquad (4)$$

$$E(vv') = V = \sigma_v^2 I$$

A similar prior restriction can be written to express our expectation that the long-run effects on import demand of foreign price and exchange-rate changes are the same. That is, we expect the differences between the sums of the coefficients on these two terms to be equal to zero:

$E(\Sigma Y_i - \Sigma\delta_i) = 0$. This constraint, too, takes the form of equation (4):

$$q = Q\beta + u$$

where
$$q = 0 \qquad E(u) = 0 \tag{5}$$
$$E(uu') = U = \sigma_u^2 I$$

When the additional information contained in (4) and (5) is appended to the original regression relation, we have:

$$Y^* = \begin{bmatrix} Y \\ r \\ q \end{bmatrix} = \begin{bmatrix} X \\ R \\ Q \end{bmatrix} \beta + \begin{bmatrix} \epsilon \\ v \\ u \end{bmatrix} = X^* \beta + \epsilon^* \tag{6}$$
$$E(\epsilon^* \epsilon^{*\prime}) = \Sigma$$

The augmented relation can be estimated by generalized least squares as

$$\hat{\beta}^* = [X^{*\prime}\Sigma^{-1}X^*]^{-1} X^{*\prime}\Sigma^{-1}Y^* \tag{7}$$

Assuming, as in the above, that covariances between error components are zero, Σ^{-1} can be written as follows:

$$\Sigma^{-1} = \begin{bmatrix} 1/\sigma_\epsilon^2 & & 0 \\ & 1/\sigma_v^2 & \\ 0 & & 1/\sigma_u^2 \end{bmatrix} \tag{8a}$$

Recalling that

$$r = q = 0 \tag{8b}$$

equation (7) reduces to

$$\hat{\beta}^* = [X'X + \frac{\sigma_\epsilon^2}{\sigma_v^2} R'R + \frac{\sigma_\epsilon^2}{\sigma_u^2} Q'Q\,]^{-1} X'Y$$

$$= [X'X + k^2 R'R + l^2 Q'Q]^{-1} X'Y \tag{9}$$

Equation (9) can be estimated easily by ordinary least squares if the two matrixes representing the prior constraints are computed, scaled and added to the moment matrix of the regressors in the initial relation prior to inversion.[4/]

Several further comments are in order about the prior information we employed. First, because we suppose that lagged trade responses to price and exchange-rate changes might build up, peak, and decline through time, we employed third-difference coefficient priors. These priors imply, but do not require, lag estimates following a second degree curve. Also, since lagged influences should ultimately diminish, we constrained the far-endpoints to zero. Second, it may be noted that both the sum-priors and lag-priors are uninformative with respect to individual lag coefficients. We expect the area under two estimated curves to be about equal in magnitude and the coefficients in each separate distribution to follow liberal guidelines, but that is all. We remained free to explore lag structures of any length while searching for the best combination of response patterns. Third, in this study we were interested mainly in comparing the responses of trade flows to prices of the traded goods themselves and to exchange rates. We were less interested in the response to prices of the importer's domestic goods, and therefore assumed the lag lengths on the domestic and foreign price distributions to be the same. That is, $n_3 = n_1$ in the notation of equation (3). This is just a provisional assumption that the time it takes imports to adjust fully to foreign and domestic price influences is about the same. Such a restriction simplifies estimation but does not require the two price distributions to share further resemblance. We explored numerous permutations of n_1, $n_3 \gtrless n_2$.

An equation such as (3) could apply to a country's total imports or any subcategory of imports. In this study, the subcategory is the trade of six industrial nations among themselves. Thus "imports" of country "i" means its imports from the other five in the sample. Exports are treated analagously. Foreign variables in each equation are therefore defined as weighted averages across the five trading partners, using current period trade shares as the weights. 5/

Equations (10) and (11) on the following page summarize the final estimating equations, together with the foregoing prior restrictions and weighting procedure. The equations are symmetric with respect to imports and exports. A fuller description of the data and certain problems in data-choice appear in the Appendix.

Final Estimating Equations and Restrictions

Imports

$$\ln M_{it} = \kappa + \alpha \ln Y_{it} + \sum_{k=0}^{n} \beta_k \ln P_{i,t-k} + \sum_{k=0}^{n} \delta_k \ln P^m_{f,t-k} \tag{10}$$

$$+ \sum_{k=0}^{m} \gamma_k \ln R^m_{t-k} + \eta Z_{it} + \varepsilon_t \qquad (m \gtreqless n)$$

where $\forall_t$

$$P^m_f = \sum_{j \neq i} w^m_{ij} P_j \qquad R^m = \sum_{j \neq i} w^m_{ij} R_j / R_i$$

and $w^m_{ij} = \frac{M_{ij}}{M_i} = \frac{M_{ij}}{\sum_{j \neq i} M_{ij}}$; (i,j=1,6)

Exports

$$\ln X_{it} = \kappa + \alpha \ln Y^x_{ft} + \sum_{k=0}^{n} \beta_k \ln P^x_{f,t-k} + \sum_{k=0}^{n} \delta_k \ln P_{i,t-k} \tag{11}$$

$$+ \sum_{k=0}^{m} \gamma_k \ln R^x_{t-k} + \eta Z^x_{ft} + \varepsilon_t \qquad (m \gtreqless n)$$

where $\forall_t$

$$Y^x_f = \sum_{j \neq i} w^x_{ij} Y_j; \quad P^x_f = \sum_{j \neq i} w^x_{ij} P_j; \quad R^x_f = \sum_{j \neq i} w^x_{ij} R_i / R_j$$

$$Z^x_f = \sum_{j \neq i} w^x_{ij} Z_j$$

and $w^x_{ij} = \frac{X_{ij}}{X_i} = \frac{X_{ij}}{\sum_{j \neq i} X_{ij}}$; (i,j=1,6)

Restrictions in both Import and Export Equations

1) $E(\Delta^3 \beta_k) = E(\Delta^3 \delta_k) = E(\Delta^3 \gamma_k) = 0$

2) $E(\Sigma \delta_k - \Sigma \gamma_k) = 0$

$\Sigma \beta_k$ is unconstrained

Sign Expectations: $\hat{\alpha} > 0$; $\hat{\beta} > 0$; $\hat{\delta} < 0$; $\hat{\gamma} < 0$; $\hat{\eta} \gtrless 0$.

IV. Empirical Results

We estimated equations (10) and (11) for imports and exports of the six included countries. In each case we explored all permutations of 4, 6, 8, 10 and 12 quarter lag lengths on the exchange-rate and price variables, with the lag lengths on the two price terms always the same. Various combinations of the cyclical and trend variables were tried. To assimilate the numerous results (more than 100 equations for each case), we first ascertained the combination of cyclic and/or trend terms which performed best. Coefficient and significance patterns in equations with the best features served as guides in the rest of the search. The most satisfactory results are presented in Tables 1 through 6 on the following pages.[6/]

In general, the long-run coefficient estimates we obtained had the expected signs. The only exceptions were in the equations for German and U.K. imports, which showed small positive long-run foreign price and exchange-rate elasticities. Estimated coefficients on activity variables were positive in all cases, although some of the rejected Japanese equations produced negative coefficients. Signs and significance of the cyclical and trend-activity terms varied across the final equations in which they appeared. Cyclical influences on Canadian and Japanese exports and French, Japanese, U.K. and U.S. imports appeared particularly strong.

In equations such as those shown in Tables 1-6, the detailed response of imports and exports to price and exchange rate changes depends on two factors: the length of the estimated lag distributions and the relative sizes of the coefficients in each period. While the estimated lag length indicates the amount of time necessary for an effect to work

Table 1: FINAL EQUATIONS AND LAG ESTIMATES FOR CANADA

IMPORTS

		Long-run Estimates							
constant	lnY	$\ln P_f$	lnR	lnP	$t \cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y$	$\bar{R}^2$/SE	DW/DF
17.155 (3.76)	1.868 (4.91)	-2.751	-2.750	1.203		-.087 (-.15)		.984 .038	1.43 40

Lag Quarter	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	.051 (.07)	-.370 (-1.24)	-.628 (-4.51)	-.724 (-2.61)	-.655 (-2.03)	-.417 (-1.78)	-.009 (-.11)						
lnR	-.553 (-1.92)	-.499 (-4.13)	-.443 (-3.92)	-.386 (-2.97)	-.326 (-2.52)	-.261 (-1.98)	-.186 (-1.38)	-.098 (-.91)	.003 (.04)				
lnP	1.334 (2.60)	.631 (3.02)	.113 (.62)	-.217 (-.82)	-.353 (-1.26)	-.288 (-1.44)	-.017 (-.23)						

EXPORTS

		Long-run Estimates							
constant	$\ln Y_f$	lnP	lnR	$\ln P_f$	$t \cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
-16.897 (-7.96)	.584 (1.85)	-.204	-.204	4.821		1.396 (2.30)		.994 .028	1.75 40

Lag Quarter	0	1	2	3	4	5	6	7	8	9	10	11	12
lnP	-.512 (-1.27)	-.254 (-1.10)	-.058 (-.36)	.078 (.53)	.156 (1.10)	.182 (1.37)	.162 (1.36)	.115 (1.02)	.050 (.43)	-.011 (-.09)	-.050 (-.38)	-.052 (-.53)	-.013 (-.22)
lnR	-.155 (-.43)	-.067 (-.60)	-.009 (-.04)	.017 (.09)	.011 (.19)								
$\ln P_f$	-.160 (-.38)	.055 (.23)	.240 (1.27)	.393 (2.00)	.515 (2.58)	.604 (3.22)	.658 (3.82)	.671 (3.99)	.638 (3.57)	.554 (2.93)	.420 (2.35)	.235 (1.86)	.001 (.02)

Notes to Tables 1-6: Variables and sources are described in the Data Appendix. $\bar{R}^2$ is adjusted for degrees of freedom; SE = standard error of estimate; DW = Durbin-Watson statistic; DF = degrees of freedom adjusted for prior restrictions. T-statistics are in parentheses beneath coefficients. With DF = 40, critical values of t are 2.02 (95%) and 1.68 (90%).

Table 2: FINAL EQUATIONS AND LAG ESTIMATES FOR **FRANCE**

IMPORTS

	constant	$\ln Y$	Long-run Estimates $\ln P_f$	$\ln R$	$\ln P$	$t \cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y$	$\bar{R}^2$/SE	DW/DF
	3.505	1.070	-1.218	-1.216	1.761	.002			.991	2.01
	(1.99)	(3.15)				(2.18)			.035	40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	-.551	-.363	-.210	-.090	-.004								
	(-.65)	(-4.71)	(-.49)	(-.21)	(-.05)								
$\ln R$	-.705	-.363	-.130	-.010	-.008								
	(- 3.27)	(-4.86)	(-1.11)	(-.10)	(-.11)								
$\ln P$	1.074	.525	.164	-.008	.006								
	(2.42)	(3.36)	(.79)	(-.04)	(.09)								

EXPORTS

	constant	$\ln Y_f$	Long-run Estimates $\ln P$	$\ln R$	$\ln P_f$	$t \cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
	-13.694	2.138	-.399	-.393	2.976	-.022			.984	1.84
	(-1.37)	(3.03)				(-.82)			.047	40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P$	-.101	-.106	-.094	-.069	-.039	-.010	.021						
	(-.25)	(-.57)	(-.70)	(-.44)	(-.24)	(-.07)	(.23)						
$\ln R$	-.223	-.112	-.039	-.006	-.013								
	(-.67)	(-.77)	(-.20)	(-.04)	(-.14)								
$\ln P_f$	-.272	.309	.676	.828	.767	.490	-.001						
	(-.30)	(1.32)	(1.79)	(1.35)	(1.20)	(1.12)	(-.10)						

Notes: See Table 1.

Table 3: FINAL EQUATIONS AND LAG ESTIMATES FOR GERMANY

IMPORTS

constant	lnY	Long-run Estimates $\ln P_f$	$\ln R$	$\ln P$	$t \cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y$	$\bar{R}^2$/SE	DW/DF
-7.628 (-1.62)	1.460 (11.55)	.118	.116	1.91		-3.86 (-.95)		.987 .039	1.56 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	.378 (.36)	.038 (.28)	-.139 (-.23)	-.154 (-.27)	-.007 (-.09)								
lnR	-.082 (-.33)	.023 (.18)	.077 (.43)	.077 (.53)	.020 (.27)								
lnP	1.292 (1.35)	.363 (2.63)	-.164 (-.28)	-.289 (-.52)	-.011 (-.14)								

EXPORTS

constant	$\ln Y_f$	Long-run Estimates $\ln P$	$\ln R$	$\ln P_f$	$t \cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
-7.392 (-4.83)	1.108 (4.36)	-1.874	-1.869	5.483		.494 (.69)		.992 .036	2.18 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
lnP	-1.628 (-3.17)	-.827 (-5.14)	-.229 (-1.48)	.163 (.60)	.340 (1.17)	.293 (1.43)	.015 (.21)						
lnR	-.747 (-2.72)	-.569 (-4.38)	-.380 (-2.06)	-.185 (-1.19)	.012 (.17)								
$\ln P_f$	1.062 (1.32)	1.130 (4.48)	1.104 (3.50)	.982 (1.97)	.761 (1.46)	.437 (1.21)	.007 (.10)						

Notes: See Table 1.

Table 4: FINAL EQUATIONS AND LAG ESTIMATES FOR JAPAN

IMPORTS

constant	lnY	Long-run Estimates $\ln P_f$	lnR	lnP	$t \cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y$	$\bar{R}^2$/SE	DW/DF
-25.721 (-2.16)	1.686 (7.15)	-1.251	-1.254	7.693	-.009 (-3.76)			.979 .051	1.45 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	1.301 (1.74)	.830 (2.17)	.391 (1.45)	-.012 (-.04)	-.361 (-1.10)	-.630 (-1.94)	-.793 (-2.46)	-.825 (-2.53)	-.710 (-2.33)	-.438 (-2.01)	-.005 (-.04)		
lnR	-.494 (-.56)	-.380 (-1.36)	-.259 (-.53)	-.130 (-.28)	.009 (.09)								
lnP	2.203 (3.19)	1.649 (3.39)	1.209 (2.85)	.879 (2.09)	.635 (1.49)	.460 (1.05)	.321 (.72)	.204 (.47)	.106 (.28)	.035 (.14)	-.005 (-.05)		

EXPORTS

constant	$\ln Y_f$	Long-run Estimates lnP	lnR	$\ln P_f$	$t \cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
85.171 (1.90)	.864 (1.48)	-11.676	-11.677	4.905	.011 (2.80)		1.467 (1.77)	.991 .058	.848 39

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
lnP	-.869 (-1.13)	-1.186 (-1.70)	-1.415 (-1.83)	-1.551 (-1.87)	-1.585 (-1.91)	-1.514 (-1.94)	-1.340 (-1.93)	-1.081 (-1.84)	-.757 (-1.66)	-.389 (-1.38)	.012 (.10)		
lnR	-.324 (-.37)	-1.790 (-1.85)	-2.640 (-2.10)	-2.879 (-2.11)	-2.511 (-2.09)	-1.546 (-2.04)	.012 (.11)						
$\ln P_f$	1.733 (1.87)	1.098 (2.10)	.637 (1.64)	.341 (.82)	.191 (.41)	.150 (.31)	.171 (.34)	.206 (.41)	.208 (.47)	.151 (.50)	.020 (.17)		

Notes: See Table 1.

Table 5: FINAL EQUATIONS AND LAG ESTIMATES FOR the **UNITED KINGDOM**

IMPORTS

constant	lnY	Long-run Estimates $\ln P_f$	Long-run Estimates lnR	Long-run Estimates lnP	$t\cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y$	$\bar{R}^2$/SE	DW/DF
-20.555 (-3.30)	2.575 (5.21)	.033	.030	3.118	-.005 (-2.71)			.942 .054	1.55 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	1.151 (1.28)	.916 (1.92)	.643 (2.27)	.332 (1.18)	-.007 (-.002)	-.328 (-.95)	-.603 (-1.66)	-.764 (-2.06)	-.751 (-2.20)	-.518 (-2.19)	-.043 (-.41)		
lnR	.542 (1.98)	.286 (2.35)	.077 (.64)	-.085 (-.66)	-.198 (-1.51)	-.248 (-1.69)	-.228 (-1.43)	-.137 (-1.03)	.020 (.20)				
lnP	-.831 (-1.48)	-.347 (-1.48)	.054 (.23)	.369 (1.21)	.598 (1.81)	.740 (2.25)	.792 (2.39)	.751 (2.20)	.612 (1.89)	.367 (1.59)	.014 (.13)		

EXPORTS

constant	$\ln Y_f$	Long-run Estimates lnP	Long-run Estimates lnR	Long-run Estimates $\ln P_f$	$t\cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
-7.127 (-.77)	1.751 (2.56)	-.372	-.375	1.778	-.003 (-1.15)			.962 .048	1.76 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
lnP	-.063 (-.12)	.031 (.12)	.061 (.37)	.033 (.19)	-.031 (-.16)	-.101 (-.48)	-.142 (-.67)	-.125 (-.77)	-.034 (-.36)				
lnR	-.725 (-2.39)	-.125 (-1.61)	.202 (1.17)	.252 (1.51)	.022 (.24)								
$\ln P_f$	.822 (1.12)	.506 (1.47)	.272 (1.11)	.118 (.34)	.034 .08	.0003 (.00)	-.002 (-.01)	.007 (.03)	.020 (.21)				

Notes: See Table 1.

Table 6: FINAL EQUATIONS AND LAG ESTIMATES FOR UNITED STATES

IMPORTS[1/]

constant	$\ln Y^*$	Long-run Estimates $\ln P_f$	$\ln R$	$\ln P$	$t \cdot \ln Y$	$\ln(Y/Y^T)$	$\Delta \ln Y^*$	$\bar{R}^2$/SE	DW/DF
-7.971 (-1.08)	4.028 (8.66)	-4.781	-4.781	8.769	-.006 (-4.61)		1.098 (1.44)	.994 .034	1.75 39

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P_f$	-1.766 (-2.48)	-1.319 (-3.27)	-.914 (-3.50)	-.566 (-2.08)	-.281 (-.88)	-.071 (-.21)	.053 (.18)	.082 (.42)	.011 (.17)				
$\ln R$	-.090 (-.24)	-.031 (-.20)	-.044 (-.30)	-.125 (-.61)	-.258 (-1.13)	-.420 (-1.86)	-.580 (-2.57)	-.707 (-2.88)	-.771 (-2.78)	-.747 (-2.53)	-.619 (-2.26)	-.376 (-2.01)	-.014 (-.20)
$\ln P$	1.516 (2.36)	1.430 (4.45)	1.340 (5.80)	1.243 (3.99)	1.123 (2.95)	.956 (2.42)	.729 (2.10)	.416 (1.86)	.013 (.18)				

EXPORTS

constant	$\ln Y_f$	Long-run Estimates $\ln P$	$\ln R$	$\ln P_f$	$t \cdot \ln Y_f$	$\ln(Y_f/Y_f^T)$	$\Delta \ln Y_f$	$\bar{R}^2$/SE	DW/DF
8.194 (1.16)	2.151 (4.15)	-3.309	-3.310	4.185	-.004 (-1.76)		.	.981 .040	1.66 40

Lag Quarter:	0	1	2	3	4	5	6	7	8	9	10	11	12
$\ln P$	1.232 (1.57)	.602 (1.26)	.075 (.25)	-.348 (-1.48)	-.670 (-3.21)	-.889 (-4.50)	-.997 (-4.94)	-.979 (-4.55)	-.818 (-3.88)	-.500 (-3.23)	-.018 (-.22)		
$\ln R$	.648 (.95)	-.014 (-.05)	-.482 (-3.00)	-.760 (-2.42)	-.864 (-2.03)	-.820 (-1.77)	-.651 (-1.56)	-.373 (-1.37)	.006 (.08)				
$\ln P_f$	.480 (.47)	.501 (.73)	.508 (1.11)	.504 (1.49)	.490 (1.64)	4.66 (1.49)	.426 (1.23)	.366 (1.01)	.279 (.85)	.160 (.72)	.006 (.07)		

Notes: See Table 1.
1/ Y* = real GNP; Y = industrial production.

out completely, the relative size of the coefficients determines what percentage of the total response will take effect within a certain period of time. In most cases, the best equations were those in which the length of the full response lags to price and exchange-rate movements were not the same. The length of the price lags was as long or longer than the length of the exchange-rate lags in all but two cases: the Canadian and U.S. import functions. The most satisfactory French and German import equations displayed price and exchange-rate lags which were approximately equal in length. In the remaining eight equations price lags stretch out longer than exchange-rate lags; the differences are pronounced in both Japanese equations and in the Canadian export function.

The fact that exchange-rate lags are generally shorter than price lags in these results seems consistent with the hypothesis that exchange rate shifts had a quicker impact on trade flows than price changes. However, a shorter lag-length on a given variables does not necessarily imply that it will have greater <u>initial</u> impact in the expected direction. There could be cases, for instance, in which total exchange rate effects work out over a shorter period than total price effects, but with the latter initially working more quickly. We therefore devised a measure to illustrate the degree to which one of these two effects dominates the full response through time.

Consider the statistic

$$C_t = \frac{\sum_{j=0}^{t} (\hat{\gamma}_j - \hat{\delta}_j)}{\left| \sum_{t=0}^{T} \sum_{j=0}^{t} (\hat{\gamma}_j - \hat{\delta}_j) \right|}$$

where: $\hat{\gamma}_j$, $\hat{\delta}_j$ = estimated lag coefficients on the exchange rate and price variables over lag lengths n and m, respectively.

$T = \max(n,m)$

C_t can be interpreted as the normalized, cumulative dominance of the price or exchange rate influence up to quarter t in the total combined response period. The normalization by the sum of the successive cumulative differences over the entire lag distribution makes the statistic comparable across countries for which different elasticity estimates were obtained.

As constructed, C_t will be negative whenever the cumulative influence of exchange rate changes is relatively more negative up to quarter t in the estimated lags; C_t will be positive if the cumulative price influence is relatively more negative up to the same quarter. Also by construction, C_t is scale free; it provides no information on the signs, sums, or significance levels of individual coefficients in any distribution. Nonetheless, it provides a useful summary statistic on the relative dominance of price or exchange rate changes in affecting trade flows in the expected direction. 7/

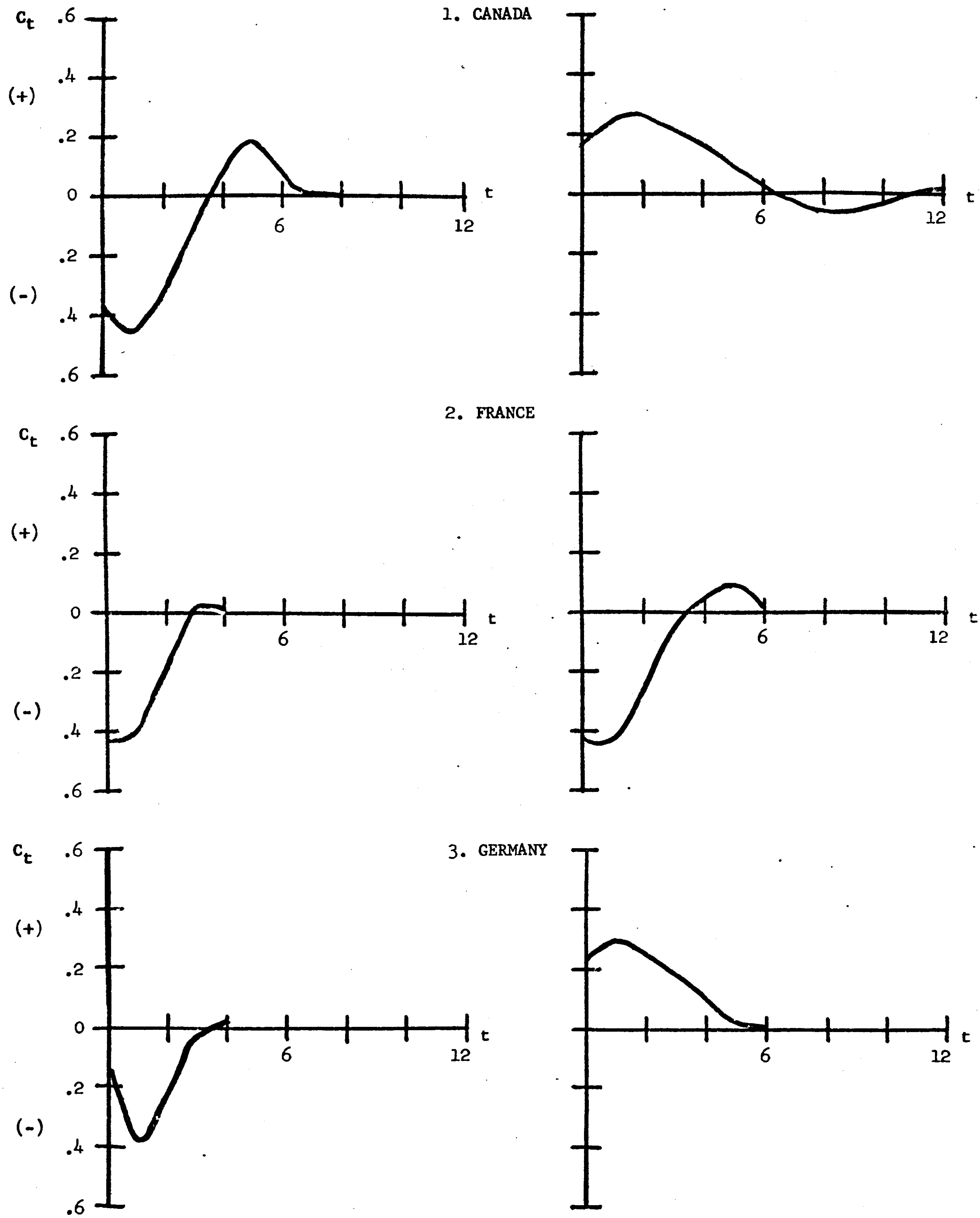
Figures 1 through 6 on the following pages display the C_t derived from the import and export demand equations for each of the six countries. With countable exceptions, it appears that in the early quarters of the response period, the relative impact of exchange rate changes was in fact greater than that of price changes. The degree of dominance ranges from mild (e.g., for Japanese and U.K. imports) to very pronounced (e.g., Canadian imports and in both French equations). Among the three exceptions -- i.e., initial price dominance -- the U.S.

FIGURES 1-3

RELATIVE CUMULATIVE PREDOMINANCE OF PRICE (+) OR EXCHANGE RATE (-)

EFFECT IN LAGGED RESPONSE OF TRADE FLOWS

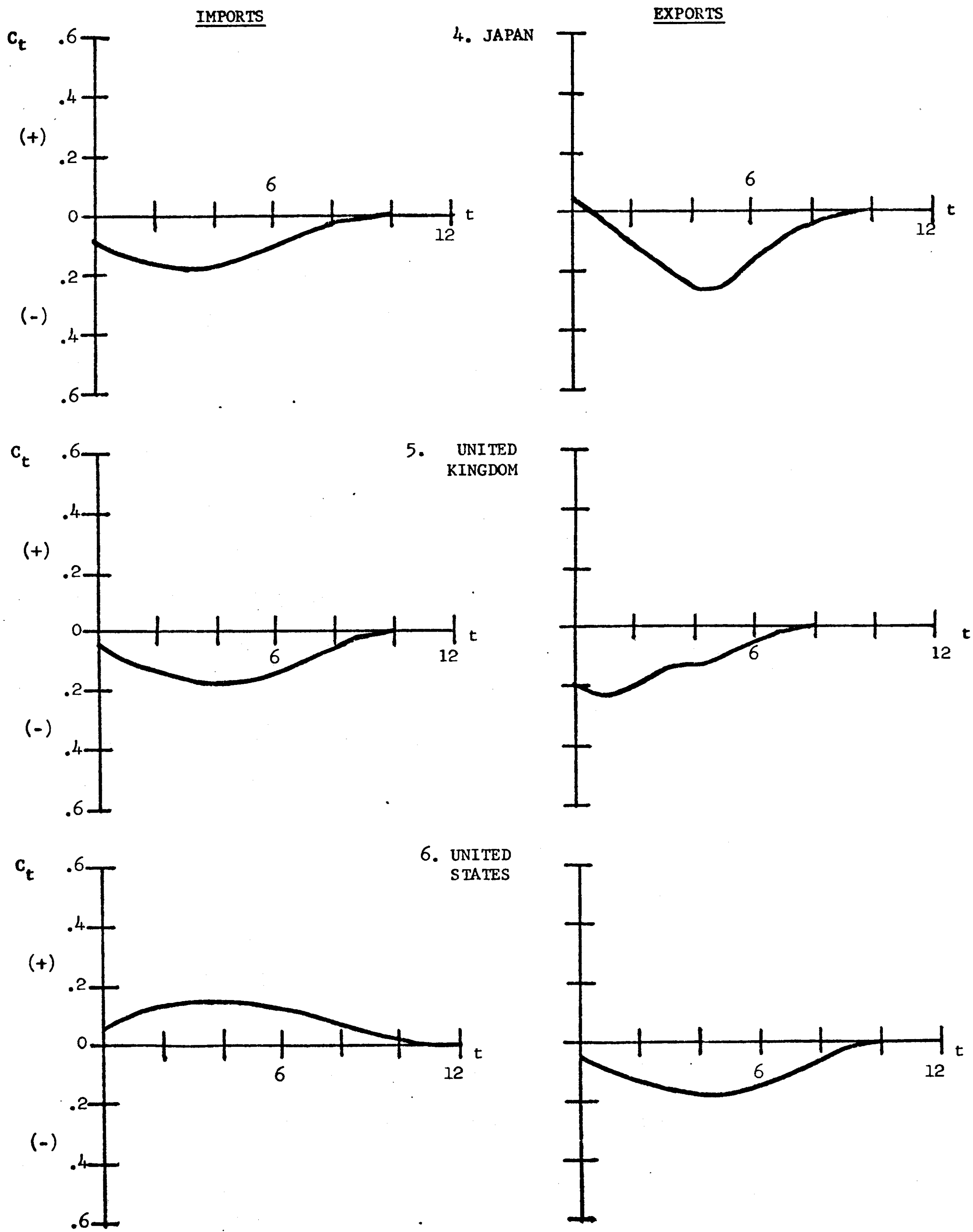
IMPORTS EXPORTS



FIGURES 4-6

RELATIVE CUMULATIVE PREDOMINANCE OF PRICE (+) OR EXCHANGE RATE (-)

EFFECT IN LAGGED RESPONSE OF TRADE FLOWS



import and Canadian export responses complement each other, probably because of the heavy share each has in the other's trade. German export response also shows relative price dominance over the whole lag, but for this there is no evident counterpart elsewhere. Judging from overall patterns, it seems reasonable to conclude that in most instances exchange rate effects both took hold earlier and tended to dominate price effects over the period during which trade flows adjusted fully.

Several of the general and individual import and export results show features to which we might call attention. A rather striking pattern in the results was the tendency of the estimated long-run response of trade volumes to changes in the <u>importer's</u> price index to be larger than the response to changes in the exporter's price level. That is, in the import equations, the long-run response of imports to changes in the prices of import-substitutes was usually higher (in absolute value) than the response to the weighted average of prices in the exporting countries. Similar results characterize the export equations, suggesting that trade flows do not respond symmetrically to changes in domestic and foreign prices. Such a result reinforces our view that imposing homogeneity (through estimation in price-relatives) may not be appropriate in empirical trade studies.

With regard to individual country findings, the Canadian export equation showed little long-run response to the Canadian price or to the exchange rate. None of the coefficients in these distributions is significantly different from zero at conventional levels. Price changes in the home markets of Canada's trading partners, however, appear to influence Canadian exports strongly. Strong cyclical influences are also indicated. These findings may reflect Canada's position as a residual supplier of primary and manufactured goods to the other industrial countries, notably the United States.

In the French import equations lag-coefficients for both the foreign price and exchange-rate terms tended to go to zero for all lags greater than about four quarters. The coefficients also tended to trace a monotonic curve, which was not required by our estimating procedure. This possibly indicates some form of underlying adaptive mechanism. Most of the domestic price reaction came through exceedingly fast -- within two quarters. French export results showed very little responsiveness to changes in French prices or to exchange-rates, but, as with Canada, a larger reaction to price changes in foreign markets. Again, coefficient estimates failed to detect lagged influences beyond a few quarters.

The German import equations showed positive but trivially small long-run exchange-rate and foreign price elasticities, but imports clearly seemed to respond to domestic price developments, albeit with a very short lag. The equation in Table 3 illustrates a result we sometimes encountered: price and/or exchange-rate coefficients in the early part of the response interval had the opposite sign from what was expected for the lag sum. (More vivid examples are found in the Japanese and U.K. import and in the U.S. export equations.) We did not regard this result as paradoxical. One explanation is that in some cases importers correctly anticipate impending price increases and lodge orders in advance. Deliveries, i.e., measured trade flows, might therefore occur about the same time published prices rise, so that the apparent correlation would be positive for a period or two, although the long-run effect should still be negative. Analagous reasoning holds for exchange-rate changes.

There is great contrast in the size and statistical significance of the estimated German import and export parameters shown in Table 3. These results suggest that German import demand over the sample responded moderately to domestic price changes, but was almost impervious to foreign price and exchange-rate influences. On the export side, however, all three influences played an important role.

Estimates of the Japanese equations were much less stable than those for any other country. The domestic price and exchange-rate results in the export equation are especially suspicious; a wide variety of estimates was obtained when lag permutations were searched, and the residuals were strongly serially correlated. Negative activity elasticities also turned up occasionally. We explored alternative functions and variables to identify possible misspecifications, but without success.

The equations for U.K. imports also performed poorly, but the results were best when the length of the price lags was set longer than the length of the exchange-rate lag. Our estimates suggest that U.K. import volumes responded negligibly to exchange-rate and foreign price changes: the coefficients have positive signs for several quarters before going negative, implying that import volume response will be "perverse" for a long while following price or rate changes. Although these results are disappointing, we are not the first to search in vain for price responsiveness in U.K. imports. Both Marston [12] and Deppler [5] had similar difficulties.[8/] Results from the U.K. export function showed a negative but small long-run response to changes in U.K. prices and exchange rates. Except for the exchange rate coefficients, the estimates eluded statistical significance. Though the evidence is shaky, the equation nonetheless suggests a quick and measurable reaction of exports to parity adjustments, but with offsetting influences after the first two quarters. This finding is consistent with Deppler's conclusion, referring to U.K. trade after the 1967 devaluation, that "so far as exchange rate effects are observable, they occur fairly promptly"([5], p. 620).

The U.S. import function differs from the others in that the activity variable was real GNP rather than industrial production. We tried both GNP and IP for those few countries where series on both were available over the sample, but GNP performed slightly better only in the U.S. case. The final equation shown in Table 6 shows fairly high income and domestic price elasticities; as in many other cases we found a higher long-run response to domestic price than to foreign price or exchange-rate changes. The U.S. results also give persuasive evidence of a faster foreign price than exchange rate effect on imports, one of the few cases where this occurred. Coefficients in the foreign price distribution are large and significant for the first several quarters and then diminish rapidly, whereas exchange-rate coefficients did not become significantly different from zero until lags of five or more quarters had been reached. In the export function, by contrast, there is clear evidence of a faster exchange-rate than price effect, in that coefficients on the lagged rate turn negative before those in the domestic price distribution. This suggests that about a year had to pass following an exchange rate change over this sample before the net change in U.S. exports was in the expected direction. The net adjustment period was even longer in the case of domestic price changes. These findings seem consistent with the long, and at the time unexpectedly long, delay before the 1971 Smithsonian currency realignments had their anticipated impact on U.S. export volumes.

V. Conclusions

If the empirical evidence given above sustains any conclusion, it would be that trade flows did adjust differently to different price stimuli in the fixed rate era. Many of the effects we measured appeared weak, but they indicate that import and export reactions were quicker and the total response time was shorter when an exchange rate, rather than exporter's national currency price, caused a change in international prices. There is of course no assurance that the same kind of response would still prevail under floating rates; in fact we suspect it would not. Exchange rate changes have now largely lost the attributes (size, speed, and "permanence") by which they could be distinguished clearly from price shifts under the old regime.

Secondly, we note with interest that the equations for several countries (e.g. Germany) showed greatly contrasting patterns of import and export response to price and exchange rate changes. We have not pursued this observation, but clearly it has implications for the way some countries' trade balances would adjust to these stimuli.

Thirdly, we found that it is possible to estimate separate and statistically significant lag structures for the domestic prices of importing countries, something which has seldom been tried. Our findings tend to support the arguments against the homogeneity postulate, and suggest that in the long run trade flows are somehow affected <u>more</u> by changes in domestic prices in importing countries than by those in exporting countries.

Finally, our primary focus has been on the <u>relative</u> properties of various lag structures. From this point of view we emphasize that the results given in the preceding tables and figures are typical of many others on which we have not reported. That is, when we experimented with longer and shorter price and exchange rate responses, their relative properties stayed basically unchanged. In terms of the absolute duration of full adjustment of trade flows to changes in these variables, however, we must report that in most cases it did not seem very long. With one exception we could not find lagged effects which lingered as long as three years; in most cases the estimates deteriorated severely long before reaching this horizon.

Data Appendix

This appendix provides a description of the data series used and a discussion of certain issues in data-choice. Most data were collected on a monthly basis and later averaged to obtain the quarterly series used in estimating the equations presented in this paper.

Imports and Exports (M_i and X_i): For each country (Canada, France, Germany, Japan, the United Kingdom and the United States), the volume of imports from and exports to the five other countries in the sample were calculated from export data as:

$$X_i^{SA} = \sum_{i \neq j} \left(\frac{X\$_{ij}}{PX_i \cdot R_i} \right)^{SA} \qquad M_i^{SA} = \sum_{j \neq i} \left(\frac{X\$_{ji}}{PX_j \cdot R_j} \right)^{SA}$$

where: $X\$_{ij}$ = value of exports from country i to country j, f.o.b., in millions of U.S. dollars;

PX_i = export unit value index (1963=100) for country i;

R_i = index of country i's spot exchange rate (dollar price of foreign currency, 1963=100).

Each deflated bilateral trade flow was seasonally adjusted (SA) on a monthly basis using the Census Bureau's X-11 program before the sums defining "total" trade flows were taken. The monthly results were averaged to obtain the quarterly figures.

Data on monthly exports in U.S. dollars were obtained from O.E.C.D., Statistics of Foreign Trade, Series A, except for those on Japanese exports before April, 1963, which were obtained in yen from Bank of Japan, Economic Statistics Monthly, and converted into dollars. Export unit value indexes were obtained from O.E.C.D., Main Economic

Indicators, Historical Statistics 1955-1971 (hereafter referred to as MEI), except for United States and Japanese export unit values, which are from national sources. Exchange rates are spot rates, end of month, in U.S. cents per foreign currency unit (indexed to the 1963 base) from MEI.

Income/Activity (Y_i): Industrial production was taken as the activity variable, except for the United States where GNP was used. The IP indexes were seasonally adjusted "Industrial Production - Total" from MEI (1963 = 100).

Prices (P_i): For each country we chose a wholesale or producer's price index (1963 = 100) as close as possible to an index of the wholesale price of manufactured goods. For Canada, the United Kingdom, and the United States, we used "Wholesale Prices: Manufactured Goods" from MEI. For France, which lacks a WPI for manufactures, we used "Wholesale Prices: Intermediate Goods," also from MEI. For Germany we used "Producer Prices for Industrial Products - Manufacturing Industry" from Federal Statistics Office, Wirtschaft und Statistik, adjusted prior to 1968 to remove the turnover tax.

We chose wholesale (or producer) prices rather than export prices or export unit-values for two reasons. First, export price series are not available for all the countries over the sample. Where they are available, export indexes have the advantage that they show prices to foreign purchasers, but the disadvantage that their coverage of potentially tradeable goods, as well as those already traded, will be less than provided by the wholesale index. In contrast to export prices, unit values are available, but they do not seem appropriate as a determinant of trade flows, although they can be used as a deflator. This is because unit values are an ex post measure of the prices of goods shipped during the current period, not the prices at which goods are offered for future delivery. They are also influenced by an uncertain mix of commodity and price changes. Unit values can, in fact, be "explained" as some lagged function of wholesale and/or export prices in earlier periods.[9/]

A second, and for our purposes serious objection to export price or unit-value indexes stems from their possible interaction with exchange-rate changes. The degree to which parity changes are absorbed by traders is highly uncertain,[10/] but to the extent that export prices and exchange rates interact, it would not seem desirable to use both in equations (10) and (11), when our intention is to distinguish between their effects. We therefore concentrated on local wholesale prices because of their relatively greater "distance" from exchange-rate effects and their greater coverage of potentially tradeable goods. As a practical matter, we also estimated equations using export unit values and found very little difference from results obtained using the wholesale price series.

Exchange Rates (R): Exchange rates are an index (1963 = 100) of the spot value of the home currency in relation to those of the trade partners. Monthly rates were gathered in terms of U.S. cents per foreign currency unit from MEI and averaged to a quarterly basis. Cross rates for the import functions were import-weighted ratios of the dollar price of each partner currency to that of the importer (R_j/R_i). In the export function the rate was the export-weighted reciprocal of the same indexes (R_i/R_j). This procedure generates cross-rate indexes in such a way that sign expectations on the exchange-rate and exporter's price term are both negative in equations (10) and (11).

The 1957-1971 sample includes the following exchange rate developments:

France:	Dec. 29, 1958	Par-value established with IMF.
	Jan. 1, 1960	New franc replaces old franc at 1:100 ratio.
	Aug. 10, 1969	Franc devalued by 11.1 per cent.
Germany:	March 6, 1961	DM revalued by 5.0 per cent.
	Oct. 26, 1969	DM revalued by 9.3 per cent.
	May 9, 1971	DM floated.
Japan:		No change until suspension of dollar convertibility in August, 1971.
U.K.	Nov. 18, 1967	Pound sterling devalued by 14.3 per cent.
Canada:	Prior to May, 1962	Canadian dollar floated.
	May 2, 1962	Par-value with U.S. dollar reestablished at 1.75 per cent above the level set in 1949.
	June 1, 1970	Canadian dollar floated.

Although Canada's exchange rate floated prior to May, 1962, and after May, 1970, its variation against the U.S. dollar during long periods was small enough, and the several changes sharp enough, that Canada was treated as a fixed-rate country in this study. From January, 1957, to June, 1961, the US$/C$ rate showed little change. In June it fell sharply (by about 4.5 per cent) and from then until the May 1962 repegging drifted down slowly. After the June 1970 float, the Canadian dollar rose abruptly (by about 4 per cent), and from then until the end of 1971 changed only slightly. The size and speed of these rate changes, therefore, strongly resemble what might occur under a fixed-rate regime.

Several, but not all, spot exchange rates against the dollar changed noticeably when dollar convertibility was suspended in August, 1971, although formal realignments did not take place until the end of the year. We assume that the last two quarters of 1971 belong to the fixed-rate era so far as estimated behavioral relations are concerned.

Cyclic Influences (Z_i): After experiements with several cyclic proxies, two basic forms were adopted: the log of the ratio of the current level of activity to the trend activity level ($\ln Y_t/Y_t^T$), where the trend value was estimated as a semilog function of time over 1957-1971; and the growth rate of activity, expressed as a first difference in logs ($\Delta \ln Y_t$).11/ The possibility of gradually shifting parameters was explored by experiments with a time-trend interaction with the activity term ($t \cdot \ln Y_t$). This proved useful in some functions.

FOOTNOTES

*Division of International Finance, Board of Governors of the Federal Reserve System, and the University of Maryland, Baltimore County, respectively. The views expressed herein are solely those of the authors and do not necessarily represent those of their institutions. The authors are grateful to their colleagues, especially to Peter Clark and Dick Berner, for useful discussions. Irene Cavanagh patiently assembled the required data and provided excellent research assistance. We are indebted to Phyllis Lockhart for the graphs in Section IV, and to Nancy Sullivan and Sandy Clayton for their capable typing of several drafts of this paper.

1/ Goldstein and Khan considered two forms which the quantum effect might take. In one they entered the absolute value of the change in logs of their (relative) price term as a regressor; in another they hypothesized that the speed of adjustment might be a function of the size of the price change.

2/ Based on their regressions Junz and Rhomberg conclude that "the response of trade flows to relative price changes quite clearly seems to stretch out over a rather longer period than has generally been assumed, perhaps around four to five years." ([18], p. 418). Goldstein and Khan [6] reach the opposite conclusion, that average response time is fairly short. In the present paper we are interested mainly in relative rather than absolute response times.

3/ Most previous work has found that activity lags are, in any case, much shorter than price lags. See, for instance, Wilson ([17], Chapter IV) and Ahluwahlia and Hernandez-Cata [1]. In the latter study activity lags are also suppressed completely.

4/ The scaling factors, k^2 and l^2, represent estimates of the ratio of the error variance in the basic relation to the error variance in the respective constraints. The higher they are set, the more rigorously the priors are enforced. If these scalars were set equal to zero, estimation of (9) would yield OLS results. The empirical results in Section IV were obtained using $k^2=0.25$ and $l^2=1.0$ for all equations. The authors settled on these values because we wanted to enforce the coefficient-sum prior more strongly than the (unrelated) lag curve prior, which we wanted to be as loose as practicable. Setting l^2 at 1.0 yielded results that in all cases nearly satisfied the sum expectations. Given l^2, we experimented with various lower values of k^2. For k^2 much below the 0.25 level we began to encounter inversion problems on the longer equations, some of which contained over 40 regressors.

5/ Moving weights were deemed preferable to fixed weights, though slowly changing trade shares will cause variation in the weighted regressors (e.g., price and rate terms), even if their components do not change. Since both the exchange-rate and price variables are affected in like manner, this should not bias the results on our central question. Because in some cases import and export shares changed markedly over the sample, a fixed weight scheme would sometimes seriously misrepresent the importance to any country of some of its five trade partners.

6/ The entire set of results is, of course, available from the authors on request.

7/ C_t has the property that its sum over all t equals $\pm$ 1 because of the normalization by absolute values. Also, $C_T = 0$, because the cross constraints in the equations called for the long-run effect of price and exchange-rate changes to be equal.

8/ Deppler writes: "The striking feature about the effects of the [1967] devaluation on U.K. import volume is that they are perverse." He cites the earlier "unenlightening suggestion [by the NIESR] that there was an autonomous upward shift in the propensity to import which coincided with the devaluation" ([5], p. 626).

9/ For example, see Ahluwalia and Hernández-Catá ([1], pp. 797-99 and Tables, passim). Ahluwalia and Hernández-Catá follow Artus ([2], pp. 590-91) in writing an equation for unit values as a lagged function of export prices and exchange rates. This function has the characteristic that the two lag lengths are the same. We are not persuaded that this must be the case.

10/ Clark ([4], pp. 21-22) has estimated equations which suggest that the weighted average export unit values of major industrial countries "absorbed" some of the exchange-rate changes which took place between 1964 and mid-1973. He found that over 6 quarters a 1 per cent change in the weighted exchange rate was associated with a subsequent .32 per cent offsetting change in weighted export prices. There are several reasons why this estimate may be an upper bound. One is that Clark's dependent variable is a mixture of export prices and unit values. Unit values may react to exchange rate changes if there is a subsequent shift in the composition of trade, even if quoted prices do not change. This would lend an upward bias to estimates of the amount of absorption which took place in the weighted average. Second, for the United States Clark ([4], p. 17 and p. 48, fn. 17) finds no evidence that U.S. exporters adjusted their prices in response to the 1971 dollar depreciation. This implies that they made no adjustments in response to earlier parity changes by other countries. The weighted price terms in our equations include a U.S. component, which would therefore mitigate any absorption effects occurring elsewhere. See also Branson ([3], pp. 52ff) on the absorption and passthrough problems.

11/ These two variables are proxies for somewhat different things. The first will be positive if the level of current industrial production is above the estimated trend, and negative otherwise, irrespective of the direction of movement. The second will be positive in any period in which industrial production is rising, negative otherwise, irrespective of level.

REFERENCES

[1] Ahluwalia, Isher J. and Hernández-Catá, Ernesto, "An Econometric Model of U. S. Merchandise Imports under Fixed and Fluctuating Exchange Rates, 1959-1973", International Monetary Fund Staff Papers, Vol. XXII, No. 3 (November, 1975), 791-824.

[2] Artus, Jacques R., "The Behavior of Export Prices for Manufactures", International Monetary Fund Staff Papers, Vol. XXI, No. 3 (November, 1974), 583-604.

[3] Branson, William H., "The Trade Effects of the 1971 Currency Realignments", Brookings Papers on Economic Activity (1972, No.1), 15-58.

[4] Clark, Peter B., "The Effects of Recent Exchange Rate Changes on the U. S. Trade Balance", International Finance Discussion Paper No. 52, Board of Governors of the Federal Reserve System, Sept. 9, 1974.

[5] Deppler, Michael C., "Some Evidence on the Effects of Exchange Rate Changes on Trade", International Monetary Fund Staff Papers, Vol. XXI, No. 3 (November, 1974), 605-636.

[6] Goldstein, Morris, and Khan, Mohsin S., "Large Versus Small Price Changes and the Demand for Imports", International Monetary Fund Staff Papers, Vol. XXIII, No. 1 (March, 1976), 200-225.

[7] Hooper, Peter III, "The Construction of a Trade Sector for the Michigan Quarterly Forecasting Model of the U. S. Economy, DHL-III", (processed), December, 1972.

[8] Junz, Helen, and Rhomberg, Rudolf R., "Price Competitiveness in Export Trade Among Industrial Countries", American Economic Review, Papers and Proceedings, Vol. 63, No. 2 (May, 1973), 412-418.

[9] Leamer, Edward E., and Stern, Robert M., Quantitative International Economics, Boston: Allyn and Bacon, 1970.

[10] Liu, Ta-Chung, "The Elasticity of U. S. Import Demand: A Theoretical and Empirical Reappraisal", International Monetary Fund Staff Papers, Vol. III, No. 4 (February, 1954), 416-441.

[11] Magee, Stephen P., "Prices, Incomes, and Foreign Trade", in Peter B. Kenen, ed., International Trade and Finance: Frontiers for Research, London: Cambridge University Press, 1975.

[12] Marston, Richard, "Income Effects and Delivery Lags in British Import Demand, 1955-1967", Journal of International Economics, Vol. 1, No. 4, 1971, 375-399.

[13] Orcutt, Guy H., "Measurement of Price Elasticities in International Trade", Review of Economics and Statistics, Vol. XXXII, No. 2 (May, 1950), 117-132 (reprinted in R. Caves and H. G. Johnson, eds., Readings in International Economics , London: George Allen and Unwin, 1968, 528-552.)

[14] Shiller, Robert J., "A Distributed Lag Estimator Derived from Smoothness Priors", Econometrica, Vol. 41, No. 4 (July, 1973), 775-787.

[15] _______________, "Estimation of the Investment and Price Equations of a Macroeconomic Model", Federal Reserve Board Staff Economic Papers No. 61, April, 1971.

[16] Stern, Robert M., Francis, J. H., and Schumaker, B., "Price Elasticities in International Trade: A Compilation and Annotated Bibliography of Recent Research", (processed), 1975.

[17] Wilson, John F., "Yet Another Econometric Model of U. S. Imports, 1958-1971, Disaggregated by End-Use Commodity Groups and Region of Origin", Ph.D. Dissertation in Economics, University of Pennsylvania, 1973.