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FORECASTING U.S. EXPORT AND IMPORT PRICES AND VOLUMES IN A CHANGING WORLD ECONOMY

by

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I. Introduction and Summary

During the 1970's, the prediction error of U.S. trade forecasting models has increased substantially.1/ This increase in forecasting error can be attributed in large part to upheavals in the international economic environment that have altered the historical relationships (of the 1950's and 1960's) between U.S. trade flows and their income, relative price and cyclical determinants. Over the past five years, world price inflation has accelerated, and divergences in inflation rates across countries have widened, accompanied by a transition from relatively stable to sharply fluctuating exchange rates. There have also been significant changes in the cyclical behavior of economic activity in industrial countries and in the purchasing power of developing countries. This paper describes the construction and performance of a forecasting model that follows in the tradition of partial equilibrium econometric models of U.S. trade, but with several important modifications in light of these and other recent changes in the world economy.2/

The salient features of the model presented here can be summarized as follows. First, price or supply equations are included in addition to demand equations, which have traditionally been used by themselves to predict trade flows. The price equations are based on an oligopolistic markup model of pricing behavior, with the effects of different contract currency denominations and order delivery lags taken into account. These equations are found to perform well in predicting the dynamic impacts of changes in exchange rates, supply conditions and competitive factors on the prices of traded goods.[3/] The specification of separate price equations also serves to reduce the problem of simultaneous equation bias in single equation estimation.[4/]

Second, the equations are aggregative, though agricultural exports and fuel imports are excluded.[5/] Those two categories were influenced during much of the historical sample period by subsidies and quotas, and more recently by large discontinuous Soviet grain purchases and OPEC price hikes, all of which have caused them to deviate substantially from the rest of the U.S. merchandise trade. In addition, fuel and agricultural goods, which are basic commodities and fairly homogenous across national boundaries, should be treated in a world market framework, with import demand specified as the excess of domestic demand over domestic supply at the world price.[6/] Most other goods in U.S. trade, being largely manufactured or semi-manufactured goods that are heterogenous across sources of supply, conform more readily to the separable-market model employed in this paper.

Third, the model allows for changes in inventories of imported goods, using domestic inventory change as a proxy. The large swings in U.S. business inventory adjustment during the recent cyclical recession-recovery period help to explain the exceptionally large fluctuations in imports during that period, following a period of fifteen years during which both imports and domestic inventories were much less volatile.

Fourth, an effort is made to explain and correct for some of the upward shift in the income elasticity of U.S. import demand during the 1960's and early 1970's.[7/] It is assumed that the observed shift during that period was caused partly by increases in U.S. consumer awareness and tastes for new foreign products, especially durable goods from Germany and Japan. It is further assumed that these changes were stimulated by increases in foreign product availability, and foreign selling and servicing effort in the United States. Lagged foreign domestic investment expenditure, as a proxy for the growth in foreign output capacity, is included in the import demand equation to capture these phenomena. The inclusion of that variable significantly reduces the estimated income elasticity and improves the post-sample prediction performance of the import equation.

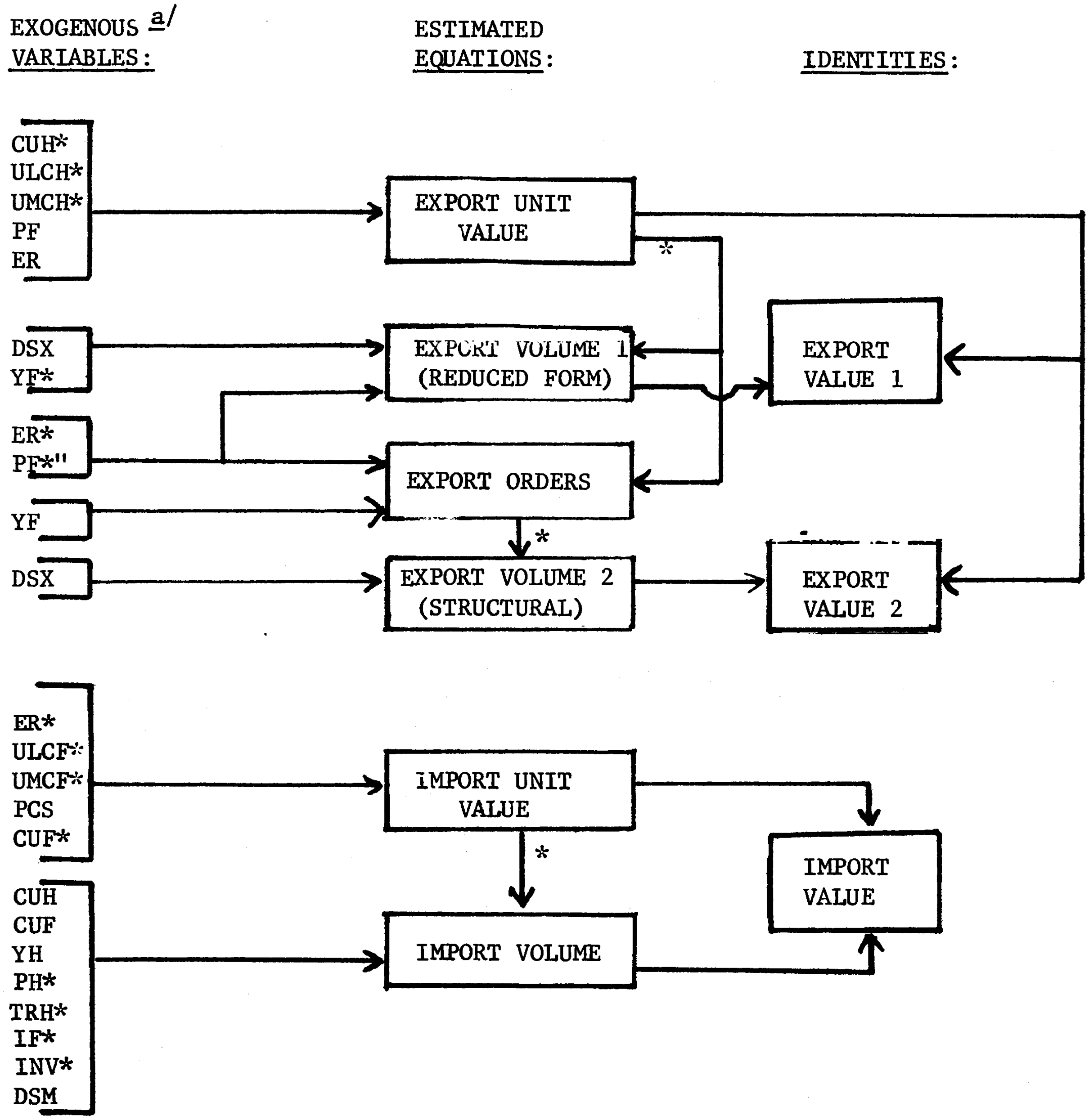
Fifth, in order to capture the impact of recent changes in the purchasing power of developing (especially oil-exporting) countries, an attempt is made to combine proxy variables for those countries with available activity variables for foreign industrial countries in the export demand equation. None of the variables tested yield statistically significant results, however. Instead, use is made of information contained in data on U.S. export orders, which reflect demand for U.S. exports in all foreign countries. Both in-sample and post-sample predictions of exports based on a distributed lag of export orders are found to be significantly more accurate than those based on foreign demand determinants for which data are available.

For *ex ante* forecasting, however, the advantage to the orders specification disappears when the distributed order-delivery lag runs out after several quarters, since beyond that point, orders themselves must be predicted by foreign demand determinants.

The overall structure of the forecasting model is summarized in the flow chart on the next page. In a first stage, unit values are predicted by their exogenous determinants. The predicted unit values along with additional exogenous variables are then fed into the volume equations. Nonagricultural export volume is predicted in one of two alternative procedures: (1) a quasi-reduced-form demand equation, and (2) a structural, two-stage procedure in which export orders are predicted in a demand equation and export volume is then determined by a distributed lag of orders. Nonfuel import volume is predicted in a demand equation.[8/] Import and export values are then derived from the predicted volumes and unit values.

In what follows, Section II describes the price equations and Section III the volume equations. In each of these sections, the theoretical structure is outlined first, followed by the estimation results and a summary of the post-sample prediction performance of the equations. Section IV presents the paper's conclusions. A description of the data and a complete list of the mnemonics used in the paper are given in Appendix A, and the performance of the model in eight quarters of post-sample prediction during 1974-75 is analyzed in Appendix B.

CHART 1 FLOW DIAGRAM OF THE FORECASTING MODEL



*Variables with lagged impacts.

a/ See Table A1, Appendix A for definition of variables.

II. Price Equations

The price equations are specified in two parts. First, contract prices (prices at which goods are ordered) are determined in supply equations. Second, unit values (average dollar prices at the time of delivery) are determined by distributed lags of contract prices and exchange rates. Since contract prices are not observed, the price equations must be estimated as reduced-form unit value equations.

Before the model is presented we should note several potential problems with the use of unit value data. While these problems have been well documented elsewhere,[9/] a summary is given here so that we may be aware of their potential impact on the equation estimates. First, a unit value is not a price but an estimated average value per physical unit of a commodity category that may encompass a range of different goods. A change in the unit value of a specific category of goods could be associated with a change in the commodity mix of that category as well as a change in the prices of the goods included. Second, until the last year or so, the U.S. Customs Bureau followed several practices in establishing the value of imports that distorted their true value and unit value. To begin with, Customs adjusted imports invoiced in dollars for exchange rate changes, effectively treating them as foreign-currency contracts. Also, the value of imports, whether invoiced in foreign currency or dollars, was adjusted for exchange rate changes only if the rate changed by more than 5 per cent within a given quarter.[10/] Magee (1974) estimated that these and other Customs practices yielded errors ranging from -2.6 per cent to 5.9 per cent in the valuation of imports from Japan and Germany during the period of exchange rate realignment between 1971 and 1973.

Unfortunately no better price data are available. Domestic wholesale price indexes and GNP deflators have been used as substitutes for export prices in previous research,[11/] but these also have several statistical and analytical deficiencies. Domestic price indexes include prices of imports and nontradables as well as exportables, and the weighting or commodity composition of such indexes may be very different from the composition of exports. Thus, domesitc price indexes cannot be used to assess the dynamic impacts of changes in exchange rates and domestic cost conditions on export prices. The unit value data do at least avoid these problems, and must be accepted as the best of a bad lot for the time being.[12/]

Contract Price Equation

The following discussion is simplified by treating the contract price as an export contract price. The U.S. import unit value will be derived from the foreign export contract price.

U.S. trade is assumed to take place in a world of imperfect competition, where products are differentiated across sources of supply. Suppliers are imperfect competitors who have some, though not complete control over their prices, and they are assumed to discriminate between their home and foreign markets.[13/] Price setting behavior is described by a markup model, where price, PX, is set at some markup above the variable cost of production:[14/]

(1) $PXH = \lambda H * (ULCH + UMCH)$

(1a) $PXF = \lambda F * (ULCF + UMCF)$

where suffix "H" denotes home (U.S.) and "F" foreign

λ = the markup factor, $\lambda > 1$

ULC = Unit labor cost

UMC = Unit material cost

The markup factor for the average firm producing an exportable product is assumed to vary with fixed costs of production (which are assumed constant for simplicity) and with domestic and foreign demand for the firm's product. Demand pressure is represented by capacity utilization. The firm is also assumed to respond to changes in its foreign competitors' prices and the exchange rate. The markup factor is adjusted to keep the firm's price from getting out of line with its competitors' prices (in a common currency) by enough to threaten its foreign market share. The markup functions are written in implicit form:

(2) $\lambda H = f_1 (CUH, CUF, PF * ER)$

(2a) $\lambda H = f_2 (CUF, CUH, PH/ER)$

where

CUH = domestic capacity utilization

CUF = foreign capacity utilization

PF = foreign competitor's price, in foreign currency

PH = domestic competitor's price in domestic currency

ER = exchange rate in domestic currency per unit of foreign currency

There is no clear theoretical basis for selecting a functional form for the markup equations. As a practical matter, by assuming they are multiplicative, we can take logarithmic transformations of (1) and (1a) and substitute them into (2) and (2a), which allows us to write the price equations in log-linear form:

$$(3)\quad \ln PXH = ao + a1 \ln CUH + a2 \ln CUF + a3 \ln PF + a4 \ln ER + a5 \ln (ULCH + UMCH)$$

$$(3a)\quad \ln PXF = ao' + a1' \ln CUF + a2' \ln CUH + a3' \ln PH + a4' \ln ER + a5' \ln (ULCF + UMCF)$$

where we expect: $a1,\ldots,a4$ and $a1',\ldots,a3' > 0$

$a4' < 0$
$a5 = a5' = 1.$

The foreign export contract price equation (3a) is modified further to include an index of coffee and sugar prices (PCS):

$$(3b)\quad \ln PXF = ao' + a1' \ln CUF + a2' \ln CUH + a3' \ln PH + a4' \ln ER + a5' \ln (ULCF + UMCF) + a6' \ln PCS$$

These prices are treated separately in the foreign export price equation because: (1) they are world commodity market prices that do not conform to a markup model, (2) they have been particularly volatile in recent years, and

(3) coffee and sugar account for a significant share of U.S. nonfuel import value (6 per cent in 1970-75), but are not adequately represented in available foreign cost data.

Export Unit Value Equation

Because of order-delivery delays, and because some contracts are invoiced in foreign currencies, the export unit value, which is measured on the date of delivery, represents a combination of present and past export contract prices and exchange rates. If we assume that changes in exchange rates are unanticipated and that they do not affect prices of outstanding contracts, this relationship can be expressed:[15/]

$$(4) \quad UVX = \sum_{i=0}^{n} C_i \ (b(PX_{t-i}/ER_{t-i})\ ER_t + (1-b)\ PX_{t-i})$$

where C_i = the share of exports in period t contracted for in period t-i, where $\sum_i C_i = 1$.

b = the share of contracts invoiced in foreign currency assumed constant over time. [16/]

1-b = the share of contracts invoiced in dollars.

The first term within the summation in (4) accounts for changes in the dollar value of exports contracted at prices fixed in foreign currency when the exchange rate changes between the contract data and the delivery date. The second term, representing export prices contracted in dollars, is unaffected by exchange rate changes.

Since the contract price, PX, is not observed, the unit value equation must be estimated in reduced form by substituting equation (3) into (4). Because of the structure of (4) this yields a complex nonlinear combination of current and lagged price determinants and exchange rates. Two different approaches could be used to simplify matters. First, we could assume that all U.S. exports are invoiced in dollars, so that b is zero and (4) is reduced to:

$$(5) \quad UVX_t = \sum_{i=0}^{n} C_i \, PX_{t-i}$$

This assumption may not be too far afield, given Grassman's (1973) results which suggest that b is small in the case of U.S. exports.[17/] Second, we could pursue a more heuristic approach by, 1) assuming no explicit functional form for the unit value equation a priori, 2) including each of the variables in the equation separately, and 3) allowing the data to determine the empirical structure. Practically speaking, both approaches yield the same estimation equation, but the former allows us to interpret the estimated coefficients more specifically. Substituting (3) into (5) we have:

$$(6) \quad UVX = \sum_{i=0}^{n} C_i \left(a_o CUH^{a_1} CUF^{a_2} PF^{a_3} (ULCH + UMCH)^{a_5}\right)_{t-i}$$

This equation is approximated by the estimation equation:

$$(7) \quad \ln UVX_t = d_o + \sum_{i=0}^{n} d_{1i} \ln CUH_{t-i} + d_{2i} \ln CUF_{t-i} + d_{3i} \ln PF_{t-i} + d_{4i} \ln ER_{t-i} + d_{5i} \ln (ULCH + UMCH)_{t-i}$$

In the case of a discrete lag, where i is limited to one value, the expected values of the coefficients in (7), d_{ji}, are equal to those in (6), a_j (for $j=1,\ldots,5$).

Import Unit Value Equation

Import unit values, like export unit values, represent combinations of present and past export contract prices and exchange rates. Under the same assumptions used to write equation (4), we can write a similar equation for import unit value:[18/]

$$(8) \quad UVM_t = \sum_{i=0}^{n'} e_i \left(g\ PXF_{t-i} * ER_{t-i} + (1-g)\ PXF_{t-i} * ER_t\right)$$

where PXF_t = the foreign export contract price in foreign currency in period t

e_i = share of imports in period t that were contracted for in period t-i, where $\sum_i e_i = 1$

g = share of import contracts invoiced in dollars

1-g = share of import contracts invoiced in foreign currency.

This equation differs from (4) because PX and PXF are in different currencies (in each case the exporting country's currency), while UVX and UVM are in the same currency (dollars).

Equation (8) is subject to the same specification difficulties as equation (4), and the simplifying alternatives are similar to those outlined above. As with the export unit value equation, we could assume that all imports are invoiced in the exporter's currency. While there is empirical evidence to suggest that this is not the case,[19/] U.S. Customs procedures for valuing imports have tended to give figures that behave as if this assumption held.[20/]

Setting g equal to zero, (8) is reduced to:

$$(9)\quad UVM_t = ER_t \sum_{i=0}^{n'} e_i \, PXF_{t-i}$$

Substituting (3b) into (9) yields:

$$(10)\quad UVM_t = ER_t \sum_{i=0}^{n'} e_i \left(CUF^{a1'} \, CUH^{a2'} \, PH^{a3'} \, ER^{a4'} \, (ULCF + UMCF)^{a5'} \, PCS^{a6'}\right)_{t-1}$$

This is approximated by the estimation equation:

$$(11)\quad \ln UVM_t = k_o + \sum_{i=0}^{n'} k_{1i} \ln CUF_{t-i} \; k_{2i} \ln CUH_{t-i} + k_{3i} \ln PH_{t-i} + k_{4i} \ln ER_{t-i} + k_{5i} \ln (ULCF + UMCF)_{t-i} + k_{6i} \ln PCS_{t-i}$$

where $k_i = a_i'$ (i= 1, 2, 3, 5, 6), and $k_4 = 1 + a_4'$, in the limiting case where $n' = 0$.

Unit Value Equation Estimates

Equations (7) and (11) were estimated using quarterly data for the period 1956 III - 1975 IV. Descriptions of the data employed and a summary listing of the mnemonics are provided in Appendix A. In the estimation process, distributed lags ranging from one to eight quarters were tested on all variables using the Almon technique, and serial correlation was adjusted for using the Cochrane-Orcutt technique. The results are shown in Table 1.

Perhaps the most striking result is that the estimated lags are very short--no more than one quarter. All attempts to find longer lags yielded coefficients that were either statistically insignificant or had the wrong sign or both. This result is in general agreement with Magee's (1974)

Table 1. Unit Value Equation Estimates (1956III-1975IV)[a/]

1. Export Unit Value Equation

$$\ln UVX_t = \underset{(-.80)}{-.34} + \underset{(2.20)}{.10} \ln CUH_{t-1} + \underset{(4.08)}{.28} \ln (PF * ER)_t$$
$$+ \underset{(15.62)}{.98} \ln (.33\ ULCH + .67\ UMCH)_{t-1}$$

R^2 (corrected) = .9959 Durban Watson = 1.98 Rho = .62 (6.96)

Prediction Error[b/]

	In Sample	Post Sample (1974 I - 1975 IV)			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	1.39	2.59	-1.82	3.86	3.57
% (of in-sample mean)	1.3%	2.4%	-1.7%	3.5%	3.3%

2. Import Unit Value Equation

$$\ln UVM_t = \underset{(-8.07)}{-4.44} + \underset{(2.03)}{.17} \ln CUF_{t-1} + \underset{(3.71)}{.34} \ln ER_t + \underset{(4.03)}{.37} \ln ER_{t-1}$$
$$\underset{(19.00)}{1.05} \ln (.33\ ULCF + .67\ UMCF)_{t-1} + \underset{(2.83)}{.06} \ln PCS_t$$

R^2 (corrected) = .9978 Durban Watson = 2.25 Rho =.82 (12.69)

Prediction Error[b/]

	In Sample	Post Sample (1974 I - 1975 IV)			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	1.52	4.04	-2.38	10.83	-9.62
% (of in-sample mean)	1.4%	3.7%	-2.2%	9.8%	-8.7%

a/ See (Table A1 in Appendix A) for definition of variables; numbers in parentheses are t-ratios.

b/ Post-sample predictions were obtained by reestimating the equations presented here through 1973IV instead of 1975IV, and simulating over the period 1974I-1975IV. Static post-sample simulations use actual values of the lagged dependent variable in the autocorrelation adjustment, while dynamic simulations predicted values. The in-sample SER's (which are comparable to the static post-sample RMSE's) pertain to the equations estimated through 1975IV, as do all the other in-sample statistics listed. For convenience in assessing the degree of prediction error, the SER and post sample statistics are also expressed as percentages of the means of the dependent variables over the whole sample period, 1956I-1975IV. See Appendix B for a more detailed description of the post-sample prediction procedures and definitions of the error statistics.

findings that combined order-delivery, transportation, and port entry lags averaged about 90-100 days for U.S. imports from Germany and Japan in 1971 and 1973. It also suggests that for items with longer order-delivery lags, either: a) changes in exchange rates and other price determinants are foreseen when contracts are entered into, b) contracts are flexible enough to be adjusted for exchange rate and cost changes prior to delivery, or c) such goods account for a relatively small portion of U.S. trade.

Unit costs have exactly a one-quarter lag, and the coefficients in both the export and import unit value equations are very close to unity, as expected. The slight deviations from unity in the cost coefficients can be explained by errors in the proxies used for unit material costs. Capacity utilization in the exporting country exerts a significant influence on pricing behavior, with a one-quarter lag in both the import and export equations.[21/] Capacity utilization in the importing country was found to have no significant impact--possibly due to collinearity with capacity utilization in the exporting country--and was dropped from both equations. Coffee and sugar prices have a significant impact with no lag; and the estimated elasticity is relatively small, reflecting the small share of those goods in total imports.

Competing prices in the importing country exerted a significant impact on the export unit value, but not on the import unit value. The latter result suggests that U.S. competition is relatively unimportant to foreign export price setting behavior. The exchange rate coefficients indicate that both U.S. and foreign exporters eventually pass through nearly three-fourths of an exchange rate change into import prices in the importing country's currency. The result that U.S. dollar export prices rise by 28 per cent of a percentage increase in the exchange rate (in dollars per unit of foreign currency), for example, means that the foreign currency prices of U.S. exports fall by 72 per cent of that change. Similarly, U.S. import prices in dollars eventually rise by an estimated 71 per cent of an exchange rate depreciation.[22/] While the exchange rate affects import prices with a two-quarter distributed lag, there is no lag in its impact on export prices. This result is consistent with Grassman's (1973) conclusion that U.S. exports are denominated predominantly in dollars. That is, if exports were denominated in foreign currency, the current export unit value would reflect the behavior of exchange rates in the past when orders were placed, as indicated in equation (4).

Finally, to test the assumption that the spot exchange rate is dominant in the transactions of traders, both unit value equations were reestimated with 90-day forward exchange rates substituted for spot exchange rates. The equations using the forward rates yielded lower t-ratios and R^2's, though the differences were not statistically significant. This result suggests that the estimated equations are not very sensitive to this assumption.

The post-sample prediction performance of unit value equations is summarized in the mean error (ME) and root-mean-squared error (RMSE) statistics in Table 1, where the RMSE is comparable to the in-sample standard error of the regression (SER). These statistics are expressed both in levels and as percentages of the in-sample means. In view of the data problems associated with the unit value series, the unit value equations performed remarkably well in both in-sample and post-sample prediction. The export unit value equation showed a RMSE of 2.4 per cent in static post-sample prediction over eight quarters, compared with a 1.3 per cent in-sample SER. The corresponding figures for the import unit value equation were 3.7 per cent and 1.4 per cent. Dynamic post-sample prediction errors were somewhat higher, especially for the import unit value equation, suggesting that the equation would be less stable than the export unit value equation in ex-ante forecasting. These post-sample results are discussed in detail in Appendix B.

III. Volume Equations

This section presents the theoretical specification and empirical estimation of the export and import volume equations. The volume equation specifications are treated in two parts. First, orders for traded goods are determined in demand equations. Then, the volumes of shipments are determined by distributed lags of current and past orders, adjusted for dock strike disruptions. Reduced-form equations for this structure are also specified, and in the case of imports, where data on orders are not available, only the reduced-form equation is estimated.

Export and Import orders are treated as consumer and producer demands. Home and foreign consumers and producers are assumed to allocate their expenditures among domestic and foreign consumer and producer goods, subject to the prices and nonprice rationing of those goods, in such a way that their utility and profit functions are maximized.[23/] The demand specifications written below are based on the assumption that traded goods produced domestically are imperfect substitutes for those produced in other countries. The demand equations are written in implicit form:

(12) DX = DX (YF, TRF * PXH/ER, PF, CUH, CUF)

(13) DM = DM (YH, TRH * PXF * ER, PH, CUF, CUH)

where DX = Export demand (volume of orders)

DM = Import demand (volume of orders)

Y = Nominal income

TR = Index of tariff rates and transport costs (assumed constant except for the U.S. tariff rate).

All other variables in (12) and (13) are the same as defined in Section I.

The first explanatory variable in each equation is aggregate income or activity, where producer demands are treated as derived domestic consumer demands. The second term is the price of the traded goods in the importing country, and the third term is the price of domestic substitutes. The last two terms in each equation are proxies for cyclical demand pressure and nonprice rationing. These two variables behave like price variables: as demand pressure and capacity utilization increase during cyclical upswings, available supply is rationed by such measures as longer order-delivery lags, tighter customer credit conditions, and reduction of other contract "extras".[24/]

We expect DX to vary positively with YF, ER, PF and CUF and negatively with TRF, PXH and CUH, while DM is expected to vary positively with YF, PH, and CUH, and negatively with TRH, PXF, ER and CUF. Because of possible delays in recognition of changes in determinants and in response to such changes once they have been recognized, DX and DM will in practice be functions of past as well as present values of these explanatory variables. Moreover, because importers are aware of order-delivery lags, and will to some extent anticipate their needs at the time of delivery, DX and DM may also be functions of expected future values of the explanatory variables. For simplicity, it is assumed that expectations do not extend beyond the delivery date, and that all expectations are fulfilled. This assumption allows us to treat expectations in the distributed lag framework of the reduced-form volume equations outlined below.

Export and Import Volumes

Since there are lags between the placement of orders and their eventual delivery, export and import volumes (which are measured at the time of delivery) represent flows of goods ordered in the past.

Taking account of disruptions to the normal flow of goods caused by dock strikes, these relationships can be expressed:

$$(14)\quad (X/UVX)_t = \left(\sum_{i=0}^{n} a_i \, DX_{t-i}\right) + DSX_t$$

$$(15)\quad (M/UVM)_t = \left(\sum_{i=0}^{n'} b_i \, DM_{t-i}\right) + DSM_t$$

where

$(X/UVX)_t$ = Volume of exports in period t (value divided by unit value)

$(M/UVM)_t$ = Volume of imports in period t (valued divided by unit value)

a_i = Share of exports in period t ordered in period t-i

b_i = Share of imports in period t ordered in period t-i

DSX_i = Deviation of exports from their normal flow due to dock strikes

DXM_i = Deviation of imports from their normal flow due to dock strikes

Data are available on export orders, so that (12) and (14) can be estimated directly. However, they are not available for import orders, so that import volume must be estimated in a quasi-reduced-form equation.[25/] Writing the import order equation (13) in linear form and substituting it into the volume equation (15), we have:

$$(16)\quad (M/UVM)_t = c_o + \sum_{i=0}^{n} (c_{1i}\, YH_{t-i} + c_{2i}\, (TRH * PXF * ER)_{t-i} + c_{3i}\, PH_{t-i} + c_{4i}\, CUF_{t-i} + c_{5i}\, CUH_{t-i}) + DSX_t$$

where the coefficients include combinations of the order-delivery lags in (15) and the recognition-response lags and expectation leads included implicity in (13). A similar reduced-form equation can be derived for export volume in order to test the reduced-form approach against the structural approach:

$$(17)\quad (X/UVX)_t = d_o + \sum_{i=0}^{n'} (d_{1i}\, YF_{t-i} + d_{2i}\, (TRF * PXH/ER)_{t-i} + d_{3i}\, PF_{t-i} + d_{4i}\, CUH_{t-i} + d_{5i}\, CUF_{t-i}) + DSX_t$$

Before these equations can be estimated, several additional adjustments are required. First, contract prices (PXH and PXF) are not observed, and unit values, which reflect past as well as present contract prices, must be used as an approximation. The error involved in this approximation may be relatively small, because of the short contract price lags indicated in the estimated unit value equations. Moreover, the reduced-form volume equations implicity include order-delivery lags that may be very similar to those reflected in the unit values. Fitted unit values obtained from the equations presented in Table 1 are used in the volume equations in a two-stage estimation procedure.

Second, the model as specified, ignores the impact of changes in the stocks of traded goods on the flows of those goods. The volatile fluctuations of U.S. imports in 1973-75, for example, has been explained in part by the large swings in business inventory investment.[26/] Because of the difficulty involved in obtaining reliable historical data and projections of foreign inventory data, only the import equation is adjusted for inventory change.

If we assume that observed imports, M/UVM are equal to imports currently desired for intermediate and final consumption, (M/UVM)*, plus the change in inventories of imported goods on hand, INVM, we have:

(18) $M/UVM = (M/UVM)^* + INVM$

where (M/UVM)* is determined in equation (16) above.

Unfortunately, data are not available for INVM, and domestic inventory investment data must be used as a substitute. Assuming that the change in inventories of imported goods move linearly with the domestic inventory change, INV, we have:

(19) $INVM = e_o + e_i\ INV$

Export and Import Volume Estimation Results

The structural equations (12), (14), and the reduced-form equations (17) and (20) were estimated in both linear and log-linear functional forms. The data employed are described in Appendix A. Numerous lag and lead structures were tested using the Almon technique, with a second-degree polynominal and a zero-end constraint. Serial correlation was corrected for using the Cochrane-Orcutt technique.

The final equation estimates, selected on the basis of in-sample fit, are ahown in Table 2. All variables with coefficient estimates that were either the wrong sign or statistically insignificant were dropped from the final equations. The results can be summarized as follows:

1. Functional Form

   a.) The log-linear functional form performed better than the linear form for both the reduced-form import and export equations and the structural export orders equation. The linear form proved better for the structural equation relating export volume to a distributed lag of orders.

   b.) In all of the demand equations the relative price and real income specification was superior to the specification treating prices and income as separate nominal variables, possibly because of multicollinearity among the separate price variables.

2. Nonprice Rationing

   Nonprice rationing proxies performed poorly in the export equation and were dropped. In the import equation problems of collinearity

Table 2. Nonfuel Import Volume and Nonagricultural Export Orders Equations, 1956 III - 1975 IV. [a]

1. Import Volume

$$\ln(M/UVM)_t = 1.45 + 1.06 \ln(YH/PH)_t \underset{(-5.32)}{-.54} \ln(TH \cdot UVM/PH)^* + \underset{(8.93)}{.82} DSM_t$$

$$\underset{(4.64)}{.67} \ln(CUH/CUF)_t + \underset{(10.84)}{.54} \ln IF_{t-1} + \underset{(2.82)}{.002} INV_t + \underset{(2.39)}{.002} INV_{t-1}$$

*price lags:	t	t-1	t-2	t-3	t-4	t-5	t-6	t-7
	-.18	-.14	-.10	-.06	-.04	-.02	-.01	.00
	(-4.44)	(-5.07)	(-5.46)	(-4.42)	(-2.55)	(-1.22)	(-0.42)	(.08)

R^2 (corrected) = .9945 Durban Watson = 1.78 Rho = .43 (4.05)

Prediction Error, 1956 III - 1975 IV [b]

	In Sample	Post Sample (1974 I - 1975 IV).			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	.95	2.42	-.34	3.47	.06
% (of in-sample mean)	3.0%	7.7%	-1.1%	11.1%	0.2%

2. Export Orders[c]

$$\ln XO_t = \underset{(-7.89)}{-9.13} + \underset{(8.75)}{1.73} \ln(YF/PF)_t \underset{(-2.41)}{-.83} \ln(UVX/ER \cdot PF)^*$$

*price lags:	t	t-1	t-2	t-3	t-4
	.20	-.13	-.31	-.35	-.25
	(.74)	(-1.25)	(-2.80)	(-2.43)	(-2.24)

R^2 (corrected) = .9711 Durban Watson = 2.00 Rho = .61 (4.75)

Prediction Error, 1965 IV - 1975 IV [b]

	In Sample	Post Sample (1974 I - 1975 IV).			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	.83	1.55	-1.26	2.54	-2.34
% (of in-sample mean)	5.6%	10.6%	-8.6%	17.3%	-16.0%

Table 2 (Continued)

3. Export Volume (Reduced-Form Demand Equation)[c/]

$$\ln (X/UVX) = \underset{(-1.55)}{1.05} + \underset{(11.84)}{1.39} \ln (YF/PF)_{t-1} \underset{(-3.72)}{-.79} \ln (UVX/ER \cdot PF)^{*} + \underset{(5.10)}{.97} DSX_t$$

*price lags:

t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8
.08	-.01	-.08	-.13	-.15	-.16	-.15	-.12	-.07
(.80)	(-0.13)	(-2.03)	(-4.32)	(-4.57)	(-4.18)	(-3.86)	(-3.6)	(-3.48)

R^2 (corrected) = .9741 Durban Watson = 1.88 Rho = .42 (3.00)

Prediction Error, 1965 IV - 1975 IV[b/]

	In Sample	Post Sample (1974 I - 1975 IV).			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	1.56	2.65	-2.30	3.50	-3.38
% (of in-sample mean)	4.7%	8.0%	-6.9%	10.6%	-10.2%

4. Export Volume (Structural Equation Using Export Orders)[c/]

$$(X/UVX)_t = \underset{(5.27)}{1563.7} + \underset{(23.95)}{469.4} XO^{*} + \underset{(5.19)}{.83} DSX_t$$

*Order lag:

t	t-1	t-2	t-3
125.7	140.8	124.9	78.0
(2.72)	(23.98)	(5.07)	(3.24)

R^2 (corrected) = .9827 Durban Watson = 1.96 Rho = .49 (3.55)

Prediction Error, 1965 IV - 1975 IV[b/]

	In-Sample	Post Sample (1974 I - 1975 IV).			
		Static		Dynamic	
	SER	RMSE	ME	RMSE	ME
Level (bil. 1967 $, SAAR)	1.11	1.46	1.06	1.88	1.43
% (of in-sample mean)	3.3%	4.4%	3.2%	5.6%	4.3%

a/ See Appendix A for definition of variables, numbers of parentheses are t-ratios

b/ See footnote b to Table 1 on p. 14.

c/ The export equations were estimated from 1965III-1975IV because several foreign data series were not readily available earlier.

between the U.S. and foreign capacity utilization variables were overcome by expressing those variables in ratio form (analogous to the relative price variable). Thus, an increase in home demand pressure or nonprice rationing stimulates import demand only if it exceeds the increase in foreign demand pressure. A threshold specification, 1/(1-CU), was tried in both the import and export equations, but did not yield statistically significant results.

3. Inventory Change

Inclusion of the inventory change variable in any form improved the fit of the import equation (equation 1 in Table 2) in terms of its R^2 corrected for degrees of freedom. The threshold specification for domestic inventory change was dropped in favor of the unadjusted inventory variable, and a current and one-quarter-lagged specification for that variable yielded superior results. The latter result suggests that part of the adjustment of inventories of imported goods may have lagged the change in total domestic nonfarm business inventories. Also, the fact that the coefficients are positive and statistically significant suggests that intended inventory change dominated unintended change over the sample period.

4. Income Elasticity Shift Factor

Lagged foreign domestic investment expenditures, IF_{t-1}, the proxy for developments underlying the shift in U.S. import demand during the mid-1960's, has a significant coefficient and substantially improved the overall equation fit. With the inclusion of that variable, the estimated income elasticity fell from 1.7 to 1.1, suggesting that the increase in U.S. consumer and producer tastes for and awareness of new foreign goods during the 1960's and early 1970's was correlated with the rise in income during that period. The foreign domestic investment proxy variable probably also captured some of the variance in imports attributable to the U.S.-Canadian Automotive Agreement that began in the mid-1960's.

5. Developing Country Activity Variable

The attempts made in the export orders and reduced-form export volume equations to include activity data for developing countries failed. Both export earnings and exchange reserves of those countries had statistically insignificant coefficients, and when combined with GNP of industrial countries, they worsened the fit on the coefficient of that variable.

6. Price Lags

a.) In all of the demand equations, only the relative price variables were found to have significant distributed lags of more than one quarter length. Lag lengths of from zero to sixteen quarters were tried, and the results shown in Table 2 yielded the best in-sample fits for both the "individual" lag coefficients and the overall equations. For the import equation a seven-quarter lag was chosen, though only the first four lagged coefficients were statistically significant. The estimated lag pattern suggests that three-fourths of the full impact of a given import price change is felt within three quarters. This lag structure is similar to those estimated by Ahluwalia and Hernández-Catá (1975) and Stern (1976), despite important differences in equation specifications.[31/] Clark (1974) found a twenty-quarter price lag using a slightly different estimation technique and equation specification for an equation explaining imports of finished manufactured goods, (which account for a little less than half of total U.S. nonfuel imports).[32/]

b.) The price lags in the export demand equations (including both the reduced-form export volume equation (3) and the orders equation (2) are longer and the long-run elasticities greater than those in the import equation. Most of the impact of a price or exchange rate change on exports is observed between three and five quarters later. The fact that the export price lag is longer than the import price lag is consistent with the commodity compositions of those trade flows. Capital goods, for example, with typically long production lgas, account for a much greater share of U.S. exports than imports.[33/] Also, the fact that the estimated long-run price elasticity is higher for exports than for imports may be consistent with the absence of nonprice rationing proxies in the export equation. Collinearity between export price and nonprice rationing could help to explain both the difficulty in obtaining significant coefficeints on the latter variable, and the size of the coefficient on the former relative to those in the import equation.

7. Export Orders and Export Volume Results

a.) Export orders (equation 2) proved more difficult to predict than export volume in reduced form (equation 3), but the structural relationship between export volume and orders (equation 4) was significantly more stable than that between export volume and its reduced-form determinants, on the basis of both in-sample and post-sample prediction accuracy.

b.) A comparison of estimated lag structures in the reduced-form and structural versions of the export volume model suggests internal consistency between the two approaches. The distributed lag between exports and orders is three quarters long--about the same as the difference between the price lags in the reduced-form export volume equation (eight quarters) and the structural export orders equation (four quarters). The three-quarter lag between orders and exports is also consistent with Isard's (1975a) results, which showed a nine-month lag between export orders and shipments using monthly data. While this result does not agree with the one-quarter lag obtained in the export unit value equation, the relatively short price-equation lag could be explained by price flexibility during the contract period or by anticipation of changes in price determinants.

Prediction Performance

All four volume equations perform well in-sample. Their corrected R^2's are all greater than .97, and their standard errors (SER's) are generally less than 5% of the in-sample mean of the dependent variable. The prediction error is somewhat higher in post-sample simulation, with root-mean-squared-errors (RMSE's) ranging from 4 to 10 per cent for static simulations and from 6 to 17 per cent for dynamic simulations.[34/] These errors would be half to two-thirds as large if expressed as percentages of post-sample instead of in-sample means.[35/]

At the low end of these error ranges is the equation predicting export volume on the basis of orders (equation 4). That equation shows errors about half as large as the error statistics of the reduced-form volume equation, both in sample and post sample. Thus, the relative stability of the structural export volume-orders relationship affords a more accurate forecasting technique than the conventional export volume demand equation. The advantage to the former exists no more than one or two quarters ahead in *ex-ante* forecasting, however, because the distributed lag between exports and orders is only three quarters long. Beyond three quarters ahead the structural equation depends totally on predicted orders, which are determined in a demand equation (2) that is much less accurate than the export demand equation (3). The orders demand equation shows post-sample prediction errors that are, proportionally, 25 per cent greater in static simulation and 60 to 70 per cent greater in dynamic simulation than those of the export demand equation. The post-sample prediction performance of these equations is considered in more detail in Appendix B.

III. Conclusions

This paper set out to construct a partial equilibrium forecasting model of U.S. trade flows that would perform reasonably well in explaining the impacts on those trade flows of exchange rate fluctuations, cyclical swings in activity, changes in the purchasing power of developing countries and other recent international economic developments. In fulfilling this task, a number of modifications were made in the conventional single equation approach to trade forecasting. The important modifications include: specification of separate price equations, accounting for the impact of inventory adjustment on trade flows, incorporation of available information on export orders, and adjustment for changes in tastes. In the process of estimating the model, various alternative functional forms and lag structures were tested extensively in-sample, and several final specifications were tested further in post-sample simulations.

A number of interesting results were obtained in the process of estimating and testing these equations. First, despite the relatively poor quantity of the price (unit value) data employed, the estimated price equations performed remarkably well in predicting the lagged impacts of exchange rates, production costs and demand pressure on those price variables. This prediction performance held up during a particularly volatile post-sample period (1974-75) as well as during the in-sample period.

Second, the results of testing alternative exchange rate specifications do not show strong evidence that either spot or forward exchange rates dominate export contract pricing decisions. Both rates were tested, and the spot rate yielded slightly better results.

Third, the price equation estimates suggest that both U.S. exporters and foreign exporters to the U.S. market eventually pass through about 70 per cent of an exchange rate change into their export prices in terns of the importing currency. This pass-through estimate is consistent with the estimates of other recent studies, but the estimated time period during which it takes place (two quarters) is somewhat shorter than previously estimated.

Fourth, movements in U.S. imports during the recession-recovery cycle of the past three years have been closely associated with domestic inventory adjustment. When a domestic inventory change variable was added to the import volume equation, prediction error was significantly reduced. The import equation's forecasting performance was also improved when an adjustment was made for changes in U.S. consumer and producer tastes for and awareness of new foreign goods during the 1960's and early 1970's. When lagged foreign domestic investment (a proxy for the increase in availability of new foreign goods) was added to the import equation, the estimated income elasticity of import demand dropped substantially. This is because income was correlated with the investment variable and the underlying factors it represents (which previously had been excluded from the import equation).

Fifth, the estimated lag structures of the volume equations indicate that income and cyclical variables have an immediate impact on trade volume, with their full effects being felt within two quarters. The full effects of changes in prices and exchange rates, however, take place over a longer period of time -- up to a year for imports and two years for exports. The relatively longer lags on the export side reflect the comparative commodity compositions of U.S. imports and exports. Capital goods, with typically long production lags, account for a much larger share of exports than imports.

Finally, the accuracy of near-term forecasts of U.S. exports can be improved substantially by making use of data available for U.S. export orders. In tests with alternative export specifications, an equation based on a distributed lag of orders proved clearly superior to an equation based on foreign demand determinants. The superiority of the orders relationship may be due to the fact that orders represent total foreign demand more accurately than the relatively few foreign demand determinants for which data series are available. The advantage of the distributed-lag orders-export relationship exists only for near term forecasting, however, since orders themselves must be predicted by foreign demand determinants.

Appendix A - Data

This appendix describes the data used in estimation and lists of the sources of those data. A summary listing of variable names used in the paper is given in Table A1. The choice of data was limited in large part to variables that are projected on a regular basis in-house at the Federal Reserve Board. All of the data were used on a seasonally-adjusted basis.

1. Trade Data

a.) Prices - Unit values of U.S. nonagricultural exports and nonfuel imports. These data were obtained from the Department of Commerce back to 1967; before that they were constructed from unit value indexes available by economic class.

b.) Volumes - Constructed from nonagricultural export and nonfuel import value data (Balance of Payments basis), deflated by unit value data.

c.) Export Orders - M4-A series on Manufactures' Export Orders of Durable Goods, compiled by the Bureau of Census. These data cover about half of U.S. nonagricultural exports, including almost all capital goods and about half of industrial supplies and materials. They were deflated using a procedure developed by Isard (1975a).

2. U.S. Data.

   a.) Income - U.S. GNP (deflated by GNP deflator)

   b.) Price - GNP deflator for private nonfarm business product

   c.) Unit Costs - BLS data for unit labor costs in all manufacturing; wholesale price index for industrial materials (as a proxy for unit materials cost). These two indexes were weighted together using the relative shares of material inputs and value added attributed to labor in the production of tradable goods (.67 and .33, respectively), estimated from the 1967 U.S. input-output table.

   d.) Capacity Utilization - (nonprice rationing proxy) FRB index of capacity utilization for total manufacturers.

   e.) Inventory Change - constant dollar change in nonfarm business inventories.

   f.) Tariffs - index relfecting the Kennedy-Round tariff reductions and the 10 per cent surchange in 1971.

3. Foreign Data

Foreign data are represented by the five major industrial country trading partners of the United States: Canada, Japan, Germany, the United Kingdom and France. Data from the individual countries were indexed and weighted together by country share in U.S. nonagricultural exports or nonfuel imports in 1970-73. The weights, expressed as percentages of the five-country total, are:

U.S. Trade Shares by Country in 1970-73

	Nonagricultural Exports	Nonfuel Imports
Canada	46%	39%
Japan	16%	26%
Germany	18%	20%
U.K.	11%	8%
France	9%	7%
Total	100%	100%
Share of U.S. trade with All countries	55%	74%

a.) Income - Real GNP for each country except France, for which industrial production was used.

b.) Price - Wholesale price index, manufacturing.

c.) Unit Costs - unit labor costs, approximated by hourly earnings times manhours worked in manufacturing, divided by the index of industrial production; unit material cost, approximated by the wholesale price index for manufacturing. The foreign cost data were combined using the same weights as for the U.S. cost variables.

d.) Capacity Utilization - Wharton index for manufacturing capacity utilization.

e.) Investment (foreign supply shift proxy) - Real gross domestic fixed investment, held constant after 1973I (the pre-recession cyclical peak in foreign activity).

f.) Coffee and Sugar Prices - spot prices in U.S. ports, combined with weights of .61 and .39 respectively (their relative shares in U.S. imports in 1970-73).

4. Exchange Rates

a.) Spot Rates - quarterly averages of daily spot rates.

b.) Forward Rates - quarterly averages of end-of-month observations of 90-day forward rates.

5. Dock Strike Adjustment Factor

Dock strike adjustment factors were taken from Isard (1975b). Isard's variables, which are disaggregated by end-use group, were averaged together using commodity import and export shares as weights. The variables are constructed as estimates of the ratio of actual trade to "normal" trade that would have occurred in the absence of strikes. In a logarithmic specification, the expected value of the dock strike variable coefficient is unity. See Isard (1975b, p. 25).

Table A1 — Definition of Variables Used in Estimated Equations

CUF	=	Foreign manufacturing capacity utilization
CUH	=	U.S. manufacturing capacity utilization
DSM	=	Dock strike adjustment variable for imports
DSX	=	Dock strike adjustment variable for exports
ER	=	Exchange rate in dollars per unit of foreign currency
IF	=	Real foreign domestic investment expenditures
INV	=	Change in U.S. nonfarm business inventories (constant dollar)
M	=	Nonfuel import value.
PCS	=	World price of coffee and sugar (trade-weighted average)
PF	=	foreign manufacturing WPI.
PH	=	U.S. private nonfarm deflator (the GNP deflator is used to deflate U.S. GNP).
TRH	=	U.S. tariff index
ULCF	=	Foreign wage earnings per unit of output
ULCH	=	U.S. unit labor cost, manufacturing
UMCF	=	Weighted average of foreign manufacturing WPI used as a proxy for unit material cost in import unit value equation.
UMCH	=	U.S. WPI industrial materials, proxy for unit material costs.
UVM	=	Unit Value, nonfuel imports
UVX	=	Unit Value, nonagricultural exports
X	=	Nonagricultural export value, BOP basis.
X	=	Manufactures' export orders, (volume estimate)
YF/PF	=	Foreign real GNP
YH/PH	=	U.S. real GNP

Table A1. Data Sources By Variable and Country

Variable:	Canada	France	Germany	Japan	UK	US
	Country and Source Number:[a/]					
Import and Export Unit Values	--	--	--	--	--	2, 3
Import and Export Values	--	--	--	--	--	1
GNP Deflator	--	--	--	--	--	1
Wholesale Price Index, manufactures	5	8	9	10	12	--
Wholesale Price Index, industrial materials	--	--	--	--	--	1
Unit labor cost[b/]...............	14	14	9, 14	14	12, 14	16
GNP	6	--	9	11	12	1
Industrial production	--	15	--	--	--	--
Manufacturing Capacity Utilization	17	17	17	17	17	4
Spot Exchange Rate	4	4	4	4	4	4
Forward Exchange Rate	13	13	13	13	13	13

a/ Sources listed on next two pages, numbers correspond to numbers of sources listed.
b/ Where not available, these data were constructed from compensation or wages and salaries per manhour divided by output per manhour.

Statistical Sources

Source No.	
1	U.S. Department of Commerce, Survey of Current Business.
2	U.S. Department of Commerce, Indexes of U.S. Exports and Imports by Economic Class: 1919 to 1971
3	U.S. Department of Commerce, Bureau of International Commerce, trade tapes.
4	Federal Reserve Board, Federal Reserve Bulletin. Canada.
5	Dominion Bureau of Statistics, Canadian Statistical Review and Annual Supplement to Section 1.
6	Statistics Canada, National Income, Expenditure Statistics
7	Bank of Canada, Bank of Canada Review
8	Institute National de Statistiques et Etudes Economiques, Bulletin Mensuel de Statistique
9	Bundesbank, Statistiche Beihefte zu den Monatscherichten der Deutschen Bundesbank, Reihe 4
10	Bank of Japan, Monthly Economic Statistics
11	Bank of Japan, Basic Data for Economic Analysis, April 1975
12	Central Statistical Office, Economic Trends International
13	IMF International Financial Statistics, and IMF tapes.

Statistical Sources (Continued)

Source No.	
14	OECD Main Economic Indicators
15	OECD Industrial Production
16	Federal Reserve Board Macrodata library
17	Wharton School

Appendix B - Post Sample Prediction Tests

This appendix presents an analysis of the forecasting performance of the unit value and volume equations and derived value predictions. To approximate *ex-ante* forecasting conditions as closely as possible, the equations were reestimated with an abbreviated sample period through the end of 1973. The reestimated equations were then used to predict imports and exports over the subsequent eight quarters. The post-sample simulation period, 1974I - 1975IV provided a rigorous proving ground for the model, as the behavior of actual trade prices and volumes and their determinants was particularly volatile during that period.

Two types of simulations were run: static simulations, in which actual values of the lagged dependent variables were used, and dynamic simulations in which predicted values of those variables were used.[1/] The dynamic simulation results are the more appropriate basis for assessing the potential *ex-ante* forecasting performance of the model, since predicted values of the lagged dependent variable must be used in *ex-ante* forecasting.

1/ The lagged dependent variable enters through the autocorrelation adjustment. For example, a stochastic equation of the form:

$$Y_t = a X_t + u_t$$

with a first-order-autocorrelated error term u_t:

$$u_t = e_t + \rho u_{t-1}$$

when adjusted for autocorrelation, is estimated in the form:

$$Y_t = a(X_t - \rho X_{t-1}) + \rho Y_{t-1} + e_t$$

where the error term e_t is not autocorrelated, and the lagged dependent variable Y_{t-1} appears as a determinant of Y_t. A description of this adjustment technique is provided in Johnston (1972 pp. 259-265).

The post-sample predictions, for both static and dynamic simulations are listed in Tables B1-B3 at the end of this appendix. Also listed are the actual values and the in-sample predictions of the same equations run through 1975 IV. The mean error (ME) and root-mean-squared error (RMSE) of prediction, expressed as percentages of the mean of the actual values during the post-sample simulation period, are listed below each set of predictions.[2/] The trade values listed were calculated from the predicted volumes and unit values. The actual values and the in-sample and dynamic post sample prediction results for unit values, volumes and values are also shown graphically in Charts B1-B3.

The results of these simulations can be summarized as follows. The unit value predictions were very accurate. The export unit value prediction error averaged about 1 per cent in static predictions and 2 per cent in dynamic predictions over the eight-quarter post sample period. The import unit value error was somewhat higher. Both equations tended to underpredict, especially in 1975, but even then they followed the turning points in actual unit values fairly closely.

2/ The mean error is defined: $ME = 1/n \sum_{i=1}^{n} (Ai-Pi)$, where A is actual and P is predicted. A positive mean error indicates overprediction, and a negative mean error underprediction. The root mean squared error is defined:

$$RMSE = \sqrt{1/n \sum_{i=1}^{n} (Ai-Pi)^2}$$

These statistics are presented as percentages of the post-sample means in Tables B1-B3, hence they are lower than the corresponding statistics in Tables 1 and 2, which are presented as percentages of the in-sample means.

In particular, both the actual and predicted import unit values turned down abruptly in the second half of 1975, reflecting in large part the effects of the appreciation of the dollar against most foreign currencies during that period.

The import volume post-sample predictions showed a very low mean error, but a fairly high root-mean-squared error. In 1974, the import equation underpredicted and in 1975 it overpredicted. These errors reflected, in part, the unprecedented swing in domestic inventory adjustment during that period, which was not adequately captured in the estimated equation. Inventories were built up strongly in early 1974 and liquidated rapidly in the first half of 1975. The in-sample predictions, using an equation that incorporated the volatile inventory behavior in estimation, followed the pattern of actual imports more accurately during that period. The overprediction of import volume in 1975 also reflected the underprediction of import unit value, which has a negative impact on import demand.

The export order and export volume demand equations tended to underpredict during the post-sample period. This tendancy can be explained in large part by the absence of activity variables for developing countries in those equations. While foreign industrial countries were experiencing a recession in 1974-75, demand in nonindustrial countries rose strongly, reflecting the jump in OPEC oil revenues and in revenues of other primary producing countries in 1974 and the increase in international borrowing by non oil developing countries in 1975.

The structural export equation (based on orders) performed better in post-sample prediction. Moreover, unlike the reduced-form equation, it tended to overpredict exports during the simulation period. In fact, if predicted orders had been used instead of actual orders in post-sample simulation of the structural equation, that equation would have yielded even more accurate predictions, since its tendency to overpredict would have been offset by the tendency of the orders demand equation to underpredict. The relative accuracy of the structural export volume equation can probably be explained in large part by the fact that orders reflect demand in a broader range of foreign countries (notably developing countries) than the five major industrial countries represented by the foreign activity variable included in the reduced-form equation.

The superiority of the structural equation is even more pronounced in the value prediction results illustrated in Chart B3. This is because underprediction in the export unit value equation was offset by overprediction in the structural volume equation, whereas it was augmented by underprediction in the reduced-form volume equation.

Table B1. In Sample and Dynamic Post Sample Unit Value Predictions, 1974I - 1975IV. (1967=100, seasonally adjusted)

1. Nonagricultural Export Unit Value

		Actual	In-Sample	Post-Sample Static	Post-Sample Dynamic
1974	I	146.7	145.3	144.0	144.0
	II	154.2	153.9	152.8	151.2
	III	167.9	165.6	164.2	162.4
	IV	176.0	179.5	178.5	175.2
1975	I	184.8	183.6	182.7	182.2
	II	186.8	185.5	183.2	181.7
	III	186.9	188.2	185.6	182.7
	IV	189.8	189.4	187.5	185.1
ME%			-0.17%	-1.05%	-2.05%
RMSE%			1.01%	1.49%	2.22%

2. Nonfuel Import Unit Value

		Actual	In-Sample	Post-Sample Static	Post-Sample Dynamic
1974	I	166.6	167.5	166.6	166.6
	II	182.2	179.4	176.5	176.5
	III	196.4	192.7	191.6	186.7
	IV	206.5	204.9	201.8	193.5
1975	I	211.0	210.2	207.3	196.5
	II	214.5	212.0	209.7	197.8
	III	204.9	210.6	208.9	195.4
	IV	203.7	205.9	203.4	195.7
ME%			-0.16%	-1.26%	-4.86%
RMSE%			1.48%	2.04%	5.47%

Table B2. In-Sample and Post-Sample Volume Predictions
(Billions of 1967 dollars, seasonally adjusted annual rates).

1. Nonagricultural Export Volume

		Actual	In-Sample		Post-Sample			
			Reduced Form	Structural	Reduced Form		Structural	
					Static	Dynamic	Static	Dynamic
1974	I	45.4	45.0	45.4	43.5	43.5	46.1	46.1
	II	47.9	45.4	47.0	43.7	43.1	47.8	48.0
	III	47.3	47.5	47.2	44.7	43.0	47.7	47.7
	IV	45.4	47.7	46.5	44.7	42.9	47.1	47.3
1975	I	45.4	47.3	46.6	44.0	42.3	47.2	47.0
	II	44.9	45.9	45.8	43.0	41.9	46.7	47.3
	III	45.0	45.5	46.5	42.8	41.8	47.6	48.4
	IV	46.1	45.5	46.7	43.1	42.0	47.9	49.1
ME%			0.65%	1.44%	-4.98%	-7.22%	2.29%	3.09%
RMSE%			3.17%	2.16%	5.37%	7.58%	3.16%	4.07%
2. Nonagricultural Export Orders Volume								
1974	I	22.2	21.5		20.2	20.2		
	II	22.5	22.2		21.4	20.3		
	III	20.2	22.6		21.2	19.9		
	IV	20.9	20.7		19.2	19.2		
1975	I	21.5	20.6		19.8	18.8		
	II	21.8	20.9		20.3	18.8		
	III	22.5	21.2		20.6	18.9		
	IV	22.3	21.8		21.1	19.0		
ME%			-1.38%		-5.81%	-10.8%		
RMSE%			5.13%		7.14%	11.72%		
3. Nonfuel Import Volume								
1974	I	42.9	40.7		39.1	39.1		
	II	39.8	39.8		39.1	37.3		
	III	39.9	38.8		37.5	36.9		
	IV	39.9	38.6		37.4	37.1		
1975	I	35.4	35.4		35.0	34.8		
	II	29.8	31.5		32.9	33.7		
	III	33.2	32.6		34.1	37.5		
	IV	35.7	35.8		38.8	40.7		
ME %			-1.15%		-0.91%	0.17%		
RMSE %			3.16%		6.54%	9.37%		

Table B3. In-Sample and Post-Sample Value Predictions
(Billions of dollars, seasonally adjusted annual rates).

1. Nonagricultural Export Value

		Actual	In-Sample		Post-Sample			
			Reduced Form	Structural	Reduced-Form		Structural	
					Static	Dynamic	Static	Dynamic
1974	I	66.6	65.4	66.1	62.6	62.6	66.4	66.4
	II	73.8	69.8	72.2	66.8	65.2	73.0	72.6
	III	79.1	78.6	78.2	73.4	69.8	78.3	77.5
	IV	84.0	85.7	83.5	79.1	75.2	84.1	82.9
1975	I	83.8	86.8	85.6	80.4	77.1	86.2	85.6
	II	83.8	85.1	85.0	78.8	76.1	87.2	85.9
	III	84.2	85.7	87.5	79.4	76.4	88.3	88.4
	IV	87.7	86.2	88.4	80.8	77.7	89.8	90.9
ME%			0.05%	0.08%	-6.49%	-9.78%	1.6%	0.90%
RMSE%			2.63%	1.96%	6.65%	10.02%	2.8%	2.8%

2. Nonfuel Import Value

		Actual	In-Sample Reduced Form	In-Sample Structural	Post-Sample Reduced-Form Static	Post-Sample Reduced-Form Dynamic	Post-Sample Structural Static	Post-Sample Structural Dynamic
1974	I	71.4	68.2		65.1	65.1		
	II	72.6	71.4		69.0	65.8		
	III	78.4	74.7		71.9	68.9		
	IV	82.4	79.2		75.5	71.8		
1975	I	74.7	74.4		72.6	68.4		
	II	63.8	66.8		69.0	66.7		
	III	68.0	68.7		71.2	73.3		
	IV	72.7	73.6		78.9	79.6		
ME%			-1.20%		-1.85%	-4.18%		
RMSE%			3.28%		7.23%	9.83%		

CHART B1: IN-SAMPLE AND DYNAMIC POST-SAMPLE UNIT VALUE PREDICTIONS
(1967=100)

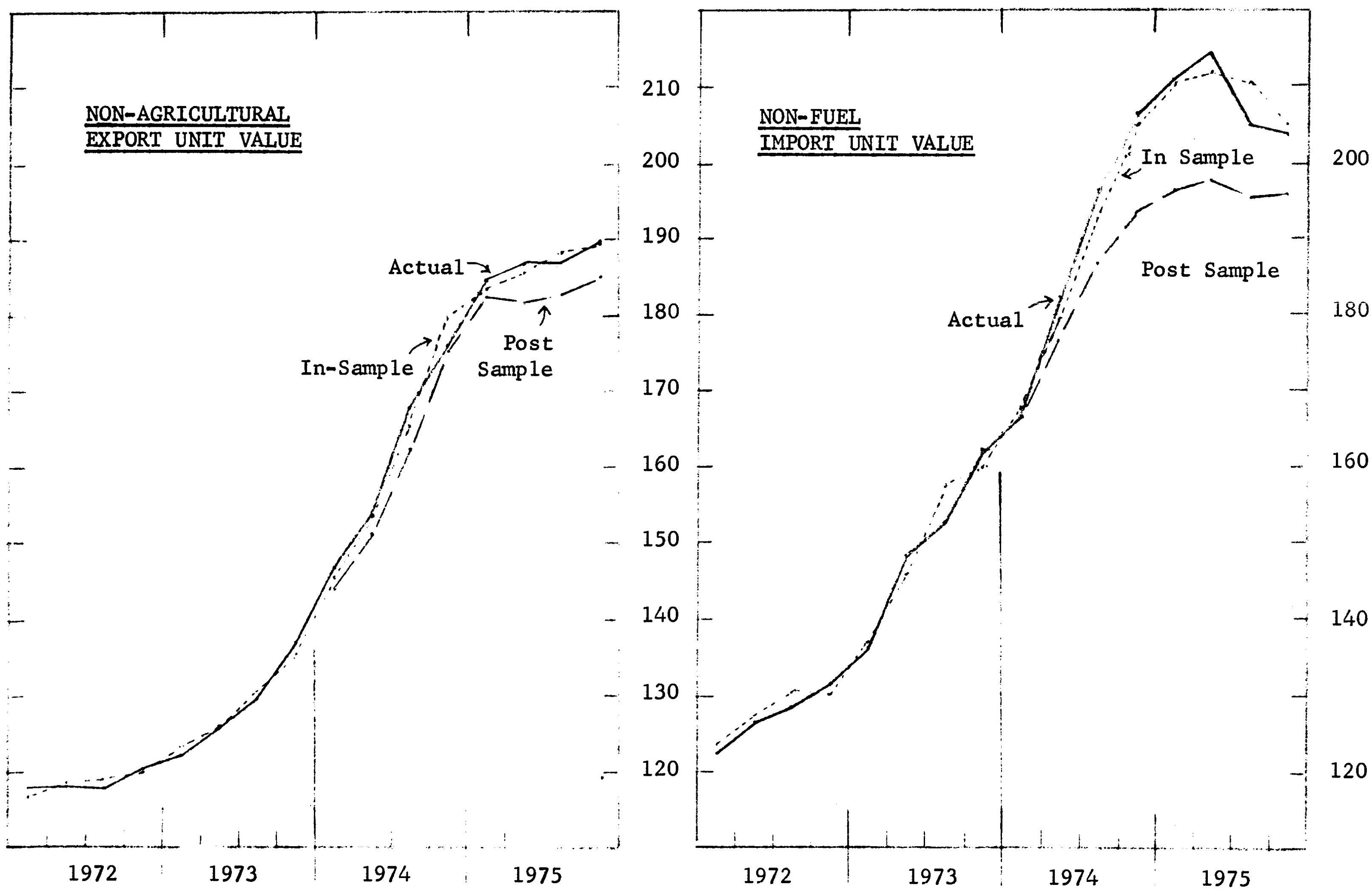
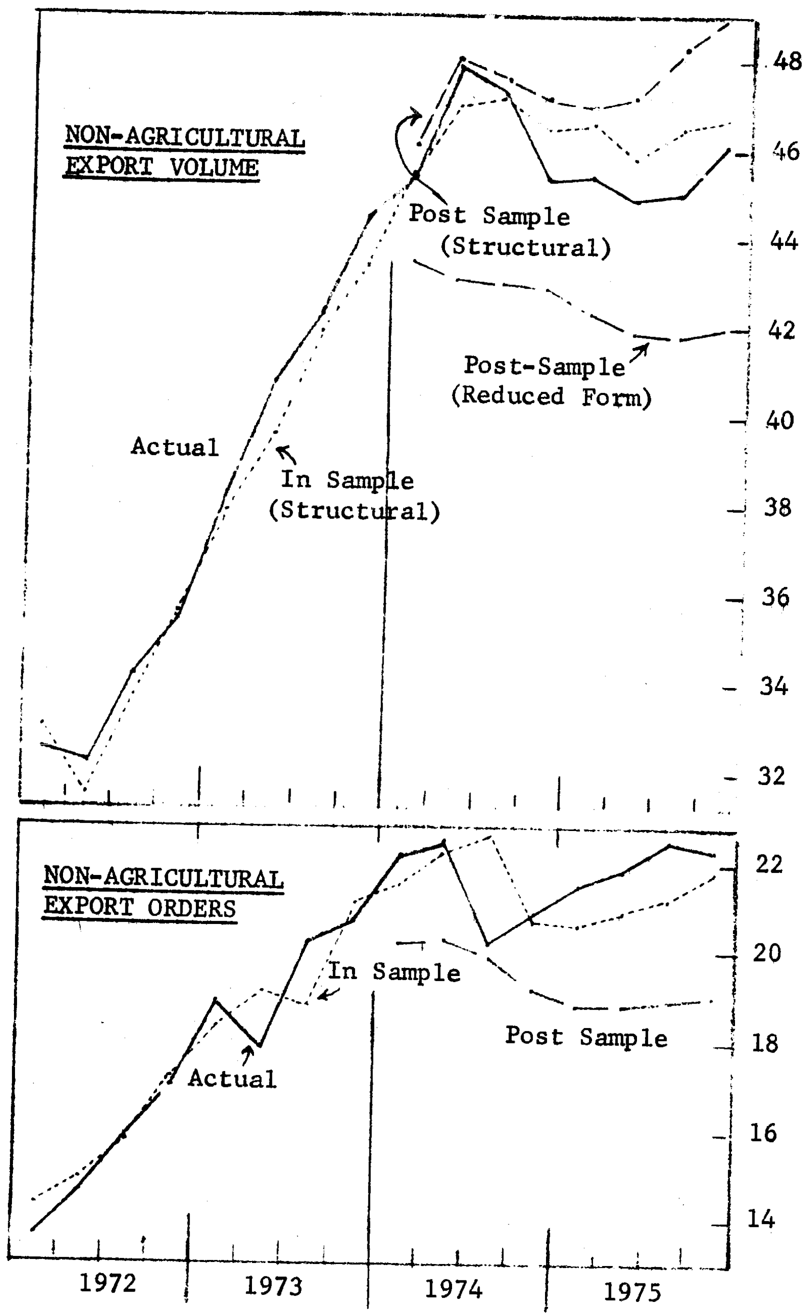


CHART 32:

IN-SAMPLE AND DYNAMIC POST SAMPLE VOLUME PREDICTIONS
(Billions of 1967 dollars, SAAR)



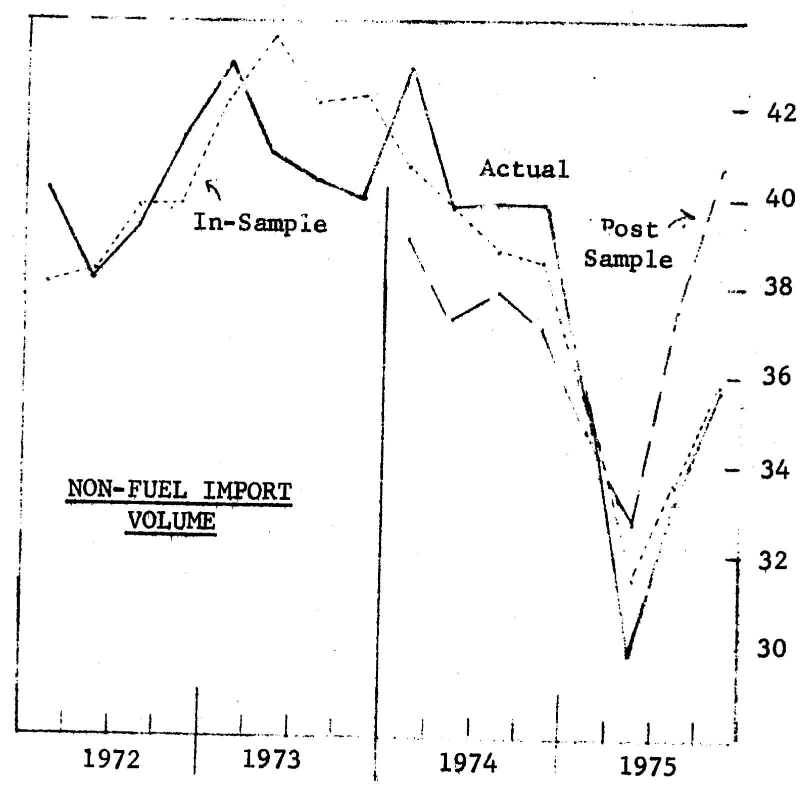
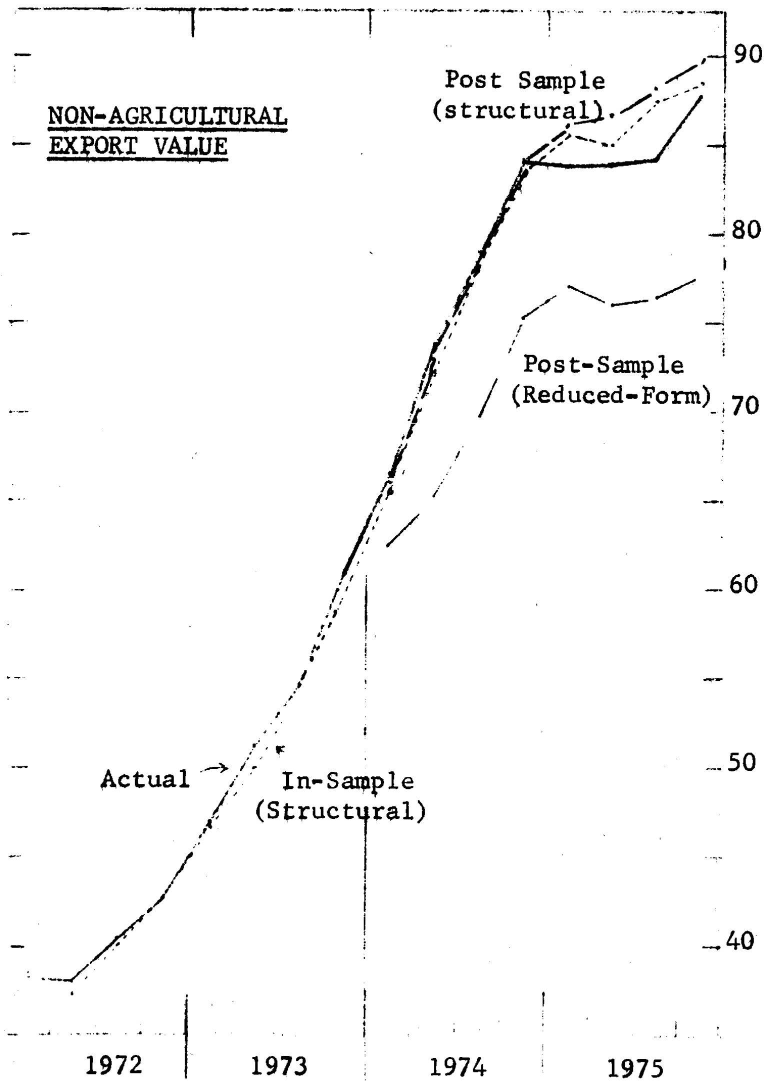
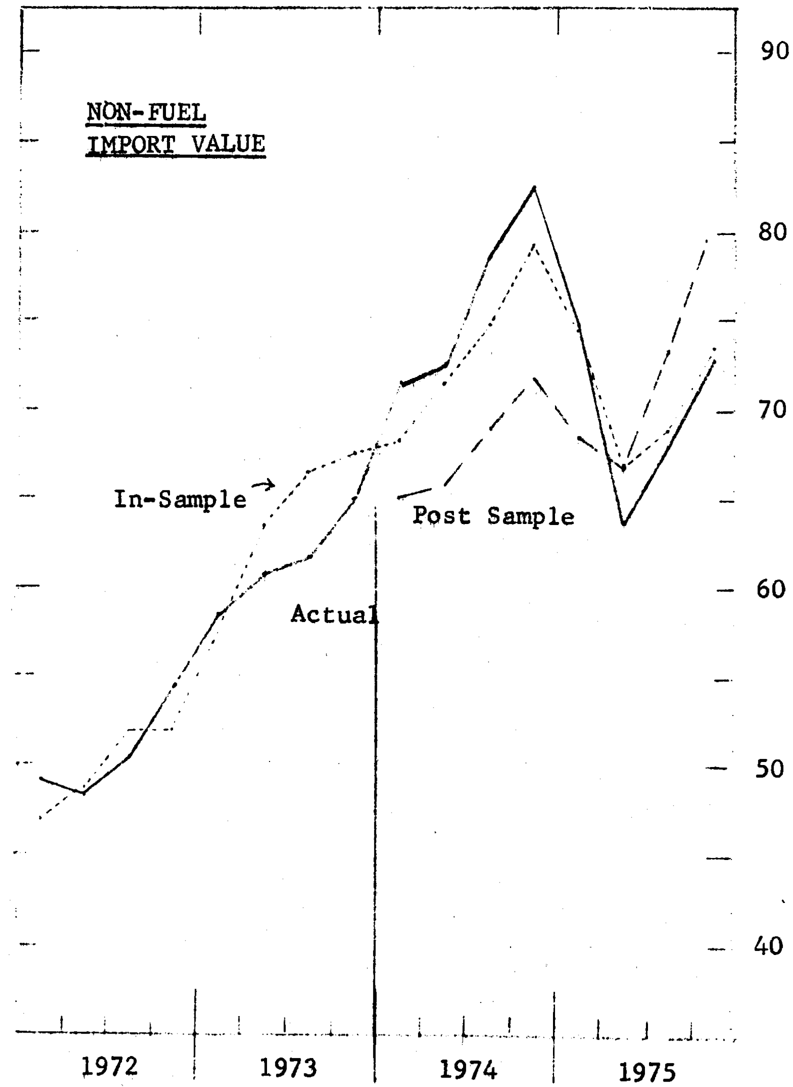


CHART 4: IN-SAMPLE AND DYNAMIC POST-SAMPLE VALUE PREDICTIONS
(Billions of dollars, S.A.A.R.)





Footnotes

*/ Economist, International Finance Division, Board of Governors of the Federal Reserve System. The views expressed herein are solely those of the author and do not necessarily represent the views of the Federal Reserve System. I am indebted to Bob Stern, John Wilson, Ted Truman, Peter Isard and Peter Clark for their helpful suggestions as the research in this paper progressed, and especially to Jeff Shafer, Guy Stevens and Woody Fleisig for their valuable comments on an earlier draft. Chiriyan Dominick assisted greatly with the estimation and post-sample testing of the model. Any remaining shortcommings are my own responsibility.

1/ See, for example, Parish and Dilullo (1972) and Hooper and Wilson (1973) for discussions of forecasting error in U.S. trade equations in the early 1970's. In an analysis of U.S. trade forecasts made at the Federal Reserve Board over the past five years, Hooper (1975) found that the root-mean-squared error of ex-ante forecasts made six months ahead increased steadily from an average of 4 per cent of the actual value in 1970 to 9 per cent in 1975. For forecasts made one year ahead the error increased from 6 per cent to 13 per cent.

2/ The model developed in this paper represents in part an extension of earlier work by Hooper and Wilson (1974) and Hooper (1975). The structure of this model is also similar in some respect to U.S. trade models recently constructed by Clark (1973), Ahluwalia and Hernández-Catá (1975), Stern (1976), and Hooper and Kohlhagen (1976).

3/ The "prices" employed are unit values, which are at best rough approximations of what they are supposed to measure. This issue is considered at greater length in Section II below.

4/ See Orcutt (1950).

5/ Equations disaggregated by End-Use commodity group and by geographical region were also experimented with, but they performed no better in post-sample prediction than the aggregate multilateral equations presented here. Since substantially greater resources are needed to manage the data base and project the exogenous determinants of the disaggregated equations, they are not used for forecasting and are not reported in this paper. See Hooper and Wilson (1973) and Hooper and Morisse (1974) for analyses of disaggregated equations and their predictive performance.

6/ See Leamer and Stern (1970, pp. 11-12). Separate forecasting models for the two excluded categories have been and are being developed in the U.S. International Transactions Section of the Federal Reserve Board by Fleisig (1975) and Hooper and Underwood (1976).

Footnotes (Continued)

7/ See Wilson (1973) and Stern (1976).

8/ Data on U.S. import orders are not available.

9/ See Magee (1974) and U.S. Congress (1961).

10/ The former practice has apparently been phased out in recent years, but the latter is still in effect.

11/ See, for example, Hooper and Wilson (1974).

12/ The Bureau of Labor Statistics has started to publish price data for a partial coverage of U.S. trade, but these data go back only a few years on an annual basis and even less on a quarterly basis.

13/ See Gray (1965) and Johnson (1967) for discussions of imperfect competition in international trade.

14/ The model described here is very similar to one used by Clark (1974), and described in detail by Eckstein and Fromm (1968).

15/ This expression is similar to one used by Artus (1974), except that Artus assumed (4) is a log-linear relationship, which is not the way the unit value index is constructed. Note that this formulation implicity assumes that traders' pricing decisions are based on the spot exchange rate and not the forward rate. To the extent that this assumption does not hold and spot rates diverge significantly from forward rates our estimates may be biased. This assumption is tested in the empirical analysis by substituting the forward rate for the spot rate in (4).

16/ This is a fairly strict assumption since b is likely to vary over time to some degree. However, as we note below, Grassman's (1973) survey results suggest that b is very small in the case of U.S. exports, so that variance in b is not likely to bias our empirical estimates significantly.

17/ In analyzing the currency-composition of Sweden's trade in 1968, Grassman (p. 11) found that 95 per cent of Sweden's imports from the United States and Canada were invoiced in the exporting country's currency.

Footnotes (Continued)

18/ This equation is similar to one used by Ahluwalia and Hernández-Catá (1975), though following Artus (1974), they used a logarithmic functional form. This specification also assumes that traders deal in the spot and not the forward market, an assumption that is tested below.

19/ Grassman (1973) found that Sweden's exports to the United States were an exception to his general conclusion that exports are invoiced in the exporting country's currency. Roughly two-thirds of Sweden's exports to the United States and Canada in 1968 were invoiced in dollars, while most of Sweden's exports elsewhere were in Swedish kronor. See Grassman (1973, p. 111). Also, Magee (1974) estimated that about two-thirds of U.S. imports from Japan in 1971 and 1973 were invoiced in dollars.

20/ See p. 6 above. As was also noted earlier, the Customs practice of assuming that U.S. imports are invoiced in foreign currency has been revised recently to a procedure that more accurately reflects the currency composition of U.S. import contracts. From equation (8) it can be seen that this revision will lengthen the observed lag between changes in exchange rates and changes in import unit values.

21/ Clark (1974) found similar lags on capacity utilization and cost variables in his unit value equations, which were more disaggregated and covered an earlier sample period.

22/ The pass-through results are in general agreement with Ahluwalia and Hernandez-Cata (1975) and Stern (1976). Using fairly similar models, both found about the same rates of pass-through for imports and the latter for exports. Both also found somewhat longer--though in some cases statistically insignificant--lags in pass-through than were obtained here. Clark (1973) obtained slightly lower rates of pass-through on imports and slightly higher on exports, though in both cases the lags were somewhat longer.

23/ The volume equations presented here are similar in structure to those derived theoretically by Hooper and Kohlhagen (1976). The major differences are that exchange rate uncertainty is assumed away and traders are assumed to deal in the spot and not the forward exchange market. Hooper and Kohlhagen found in their empirical analysis that while exchange risk has had some effect on trade prices, it has had no noticeable effect on volume. Moreover, the results discussed at the end of Section I above suggest that the model is not sensitive to the particular specification of spot or forward exchange rates.

Footnotes

24/ See Gregory (1971) for a more detailed discussion of nonprice rationing and its impact on trade flows. Gregory considers only the impact of domestic nonprice rationing on import demand, but the same arguments can be used for inclusion of foreign cyclical variables in the import demand equation, and U.S. cyclical variables in the export demand equation.

25/ This equation is not strictly in reduced form because the endogenous price variable is included as a determinant.

26/ See, for example, Survey of Current Business (December 1975, p. 14), and Federal Reserve Bulletin (April 1976 p. 286). The latter source states that, "The relatively greater percentage swings in import volumes... reflect the sensitivity of imports to the major inventory adjustment that occurred during the U.S. recession. Nonfarm business inventories in the United States, including inventories of imported goods, were built up considerably during 1973 and 1974 and then liquidated rapidly during 1975, accentuating the decline in import volumes."

27/ Gregory (1971) used inventory change in this fashion as a non-price rationing proxy.

28/ This is an overly simplistic treatment of the problem. In the presence of unintended inventory change, the equation estimates are subject to simultaneous equation bias, since undesired inventory change is partly determined by the flow of imports. A more appropriate treatment would be to specify the determinants of desired inventory investment and substitute those for INV in the import volume equation. This specification was not adopted in the interest of keeping the model as simple as possible. The specification employed has been tested extensively in both in-sample and post-sample simulations with a U.S. import volume equation and with the addition of the inventory variable, the equation's prediction performance was found to improve significantly.

29/ See Hooper (1976) for a detailed description of the alternative proxy variables tested.

30/ See Leamer and Stern (1970, p. 10).

31/ These other two studies used similar estimation techniques, but their equations differed from the one reported here in several respects. Both of these studies included import and domestic prices as separate variables rather than in ratio form. They also used different nonprice rationing or cyclical variables, and did not take the impact of inventory change on import demand into account explicitly. Finally, Stern included fuels, while the other study excluded both fuels and autos from Canada.

Footnotes (Continued)

32/ He used a second-degree Almon polynominal constrained to zero at both ends; equation (1) in Table 2 employs a far-zero constraint only.

33/ In 1975, capital goods accounted for 42 per cent of nonagricultural exports and 14 per cent of nonfuel imports. Magee (1974) found production lags of up to 10 months on certain machinery items, much longer than for most other commodities in his survey.

34/ The dynamic stimulation results are the appropriate basis for assessing ex-ante forecasting potential, since those simulations use predicted values of the lagged dependent variable in equations adjusted for autocorrelation, whereas the static simulations use the actual value. In ex-ante forecasting predicted values must be used.

35/ See Appendix B.

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