Equation 3: Investment

Equation 3 explains the change in gross investment. It is based on the following three equations:

$$\text{(31)} \qquad I_{it}^{n*} = \alpha_1 \Delta Y_{it} + \alpha_2 \Delta Y_{it-1} + \alpha_3 \Delta Y_{it-2} + \alpha_4 \Delta Y_{it-3} ,$$

$$\text{(32)} \qquad I_{it}^{*} = I_{it}^{n*} + DEP_{it} ,$$

$$\text{(33)} \qquad \Delta I_{it} = \lambda (I_{it}^{*} - I_{it-1}) , \quad 0 < \lambda \leq 1 .$$

Combining the three equations yields:

$$\text{(34)} \qquad \Delta I_{it} = \lambda\alpha_1 \Delta Y_{it} + \lambda\alpha_2 \Delta Y_{it-1} + \lambda\alpha_3 \Delta Y_{it-2} + \lambda\alpha_4 \Delta Y_{it-3} - \lambda I_{it-1} + \lambda DEP_{it} .$$

Equation (31) states that desired net investment (I_{it}^{n*}) is a function of past changes in output. The past output variables are taken to be proxies for expected future output. Desired gross investment (I_{it}^{*}) in equation (32) is equal to desired net investment plus depreciation (DEP_{it}). Equation (33) states that actual gross investment partially adjusts to desired gross investment each period. Data on DEP_{it} are not available, and for the empirical work DEP_{it} was approximated by a constant and linear time trend: $DEP_{it} = \beta_0 + \beta_1 t$. The investment equation thus consists of a regression of the change in gross investment on current and past changes in output, lagged gross investment, a constant, and time. One would expect the output coefficients to be positive, the coefficient for lagged gross investment to be negative, and the coefficient for time to be positive. This is generally the case in Table 4. In many cases not all of the output coefficient estimates are significant, which is not surprising given the likely collinearity among the output variables.

The investment equation estimated here is similar to the investment equation estimated in the U.S. model, with two important exceptions. For the U.S. model a capital stock series and an "excess" capital series were constructed. Desired net investment was assumed to be a function of the amount of excess capital on hand as well as of the output changes. Also, depreciation was assumed to be proportional to the capital stock. This introduces two new explanatory variables into the estimated equation --the amount of excess capital on hand and the measure of depreciation --and subtracts one variable--time. (See Chapter 5 in Fair (1976) for further discussion.)

Equation 4: Production

Equation 4 explains the level of production. It is based on the following three equations:

$$V_t^* = \beta S_t \ , \tag{35}$$

$$Y_t^* \equiv S_t + \alpha(V_t^* - V_{t-1}) \ , \tag{36}$$

$$Y_t - Y_{t-1} = \lambda(Y_t^* - Y_{t-1}) \ . \tag{37}$$

Combining the three equations yields:

$$Y_t = \lambda(1+\alpha\beta)S_t - \lambda\alpha V_{t-1} + (1-\lambda)Y_{t-1} \ . \tag{38}$$

Equation (35) states that the desired level of inventories is proportional to current sales. Equation (36) states that the desired level of production is equal to sales plus some fraction of the difference between the desired level of inventories and the level on hand at the end of the previous period. Equation (37) states that actual production partially adjusts to desired production each period. The implied values of λ , α , and β are presented in Table 4 along with the actual coefficient estimates. The values of λ are less than one, and it is generally the case that λ is greater than α for a given country. In a few cases the original estimates implied a negative value of α , and in these cases V_{it-1} was dropped as an explanatory variable. First order serial correlation of the error term is quite pronounced in most of the equations.

Equation 5: The GNP deflator

Equation 5 explains the GNP deflator. It is the key price equation in the model for each country. The explanatory variables include the price of imports, interest rates, and a demand pressure variable, $\tilde{Y}_{it}/POP_{it}$. It is clear from the results that import prices have an important effect on domestic prices for most countries. The estimated coefficient of the demand pressure variable is also significant for a number of countries, and at least some slight effect of interest rates on prices has been estimated for some countries.

The demand pressure variable was constructed as follows. $\log(Y_{it}/POP_{it})$ was first regressed on a constant, time, and three seasonal dummy variables, and the estimated standard error, $\widehat{SE}$, and the fitted values, $\widehat{\log(Y_{it}/POP_{it})}$, from this regression were recorded. (The results from these regressions are presented last in Table 4.) A new series, Y'_{it}/POP_{it} , was then constructed, where

$$(39) \qquad Y'_{it}/POP_{it} = \exp[\widehat{\log(Y_{it}/POP_{it})} + 4\cdot\widehat{SE}] \ .$$

$\tilde{Y}_{it}/POP_{it}$ was taken to be:

$$(40) \qquad \tilde{Y}_{it}/POP_{it} = \frac{Y_{it}/POP_{it}}{Y'_{it}/POP_{it}} - 1 .$$

The demand pressure variable in equation (40) is equal to zero when the actual value of $\log(Y_{it}/POP_{it})$ is 4 standard errors greater than the value predicted by the above mentioned regression and is less than zero otherwise.[8] Given that the log of the demand pressure variable is used in the price equation, and assuming that this variable has the expected positive coefficient estimate, this treatment means that as the actual value of real per capita output approaches Y'_{it}/POP_{it}, the predicted price level approaches plus infinity. Given the other equations in the model, this would never be a solution of the overall model, and so this treatment bounds the output of the country from above. This is a way with limited data of putting supply constraints into the model.

There are a number of theoretical arguments that can be made for the inclusion of import prices in the domestic price equation, and given the seeming empirical significance of import prices on domestic prices, some of these should perhaps be mentioned here. In this discussion of the U.S. model in Fair (1976), it is argued that import prices may affect a firm's expectations of other firms' pricing behavior, which may in turn affect its own price decision. This "expectational" justification is consistent with the profit maximizing model of firm behavior in Fair (1974). On a more practical level, if some wages and prices in a country are indexed and if the index in part includes import prices, them import prices

[8]This is assuming that the actual value of $\log(Y_{it}/POP_{it})$ is never more than 4 standard errors greater than the value predicted by the regression. For no country was the actual value greater than 4 standard errors from the predicted value in any quarter.

may directly or indirectly (through a wage effect on prices) affect domestic prices.

Another implication of the profit maximizing model in Fair (1974) is that interest rates should have a positive effect on prices. This, as noted above, was found to be true for some countries. This was also found to be true for the U.S.

Equation 6: The demand for money

Equation 6 explains the per capita demand for money. Both the interest rate and the income variables are generally significant in this equation. For all countries except Austria and the Philippines the estimated coefficient of the interest rate was of the expected negative sign.

Equations 7a and 7b: The interest rate reaction functions

The candidates for inclusion as explanatory variables in the interest rate reaction functions are variables that one believes may affect the monetary authority's decision regarding short term interest rates. In addition, the U.S. interest rate may be an important explanatory variable in the equations estimated over the fixed exchange rate period if bonds are close substitutes. The variables that were tried include the lagged rate of inflation, the lagged rate of growth of the money supply, the demand pressure variable, the change in assets, the lagged rate of change of import prices, the exchange rate (equation 7b only), and the German interest rate. The form of the asset variable that was tried is $A^*_{it}/(PY_{it}POP_{it})$. Except for division by $PY_{it}POP_{it}$, the change in this variable is the balance of payments on current account. For some countries, depending on the initial results, the current and one period lagged values were entered separately. It may be that the monetary authorities respond in part to the level of assets and in part to the change, and entering the current and lagged values separately will pick this up.

Although equations 7a and 7b are estimated over fairly small numbers of observations because of the breaking up of the sample periods, a number of significant coefficient estimates were obtained. The estimates vary considerably across countries, but in general it does seem that monetary authorities in other countries "lean against the wind." This conclusion is consistent with the results for the U.S., where the Fed is also estimated to lean against the wind. (See Fair (1978).) The U.S. rate, as expected, is a more important explanatory variable in the fixed exchange rate period than it is in the flexible rate period.

Equation 8: The long term interest rate

Equation 8 is a standard term structure equation. The current and lagged short term interest rates and the rate of inflation term are meant to be proxies for expected future short term interest rates. Many of the current and lagged short term rates are significant. The rate of inflation term is in general not very important.

Equation 9b: The exchange rate reaction function

Equation 9b explains the spot exchange rate. Candidates for inclusion as explanatory variables in this equation are variables that one believes affect the monetary authority's decision regarding the exchange rate. If, as mentioned in Section II, a monetary authority takes into account market forces in choosing its exchange rate target, then variables measuring these forces should be included in this equation. The variables that were tried include the price level of country i relative to the

U.S. price level, the short term interest rate of country i relative to the U.S. rate, the demand pressure variable of country i relative to the demand pressure variable in the U.S. model $(ZJ_{1t}^{\prime u})$, the one-quarter lagged value of the change in real per capita net foreign assets of country i relative to the change in the same variable for the U.S., and the German exchange rate.

As was the case for the interest rate reaction functions, the results vary considerably across countries, but in general significant effects of these variables appear to be found. (Remember that these estimates, like the estimates for the interest rate reaction functions, are based on a relative small number of observations.) The German exchange rate has an important positive effect on the exchange rates of the other European countries. The signs of the effects of the other variables, when they are operating, are (all changes are relative to the U.S.): an increase in a country's price level or demand pressure variable has a positive effect on its exchange rate (a depreciation), and an increase in a country's short term interest rate or change in assets has a negative effect (an appreciation). The change in asset variable, $\Delta(A_{it-1}^{*}/(PY_{it-1}POP_{it-1}))$, is the per capita balance of payments of the country in 1975 local currency. When subtracting from this variable the similar variable for the U.S., the U.S. variable must be multiplied by the 1975 exchange rate (e_{i75}) to make the units comparable.

Equation 10b: The forward rate

Equation 10b is the estimated arbitrage condition. Although this equation plays no role in the model, it is of interest to see how close the quarterly data match the arbitrage condition. If the condition were met exactly, the coefficient estimates of log ee_{it} and $\frac{1}{4}\log\frac{(1+r_{it}/100)}{(1+r_{1t}/100)}$ would be 1.0 and the fit would be perfect. As can be seen, the results do indicate that the data are consistent with the arbitrage condition, especially considering the poor quality of some of the interest rate data.

Equation 11: The export price index

Equation 11 provides a link from the GNP deflator to the export price index. Export prices are needed when the countries are linked together (see Table 3). If a country produced only one good, then the export price would be the domestic price and only one price equation would be needed. In practice, of course, a country produces many goods, only some of which are exported. If a country is a price taker with respect to its exports, then its export prices would just be the world prices of the export goods. To try to capture the in between case where a country has some affect on its export prices, but not complete control over every price, the export price index was regressed on the GNP deflator and a world price index.

The world price index ($PW\$_{it}$) is defined in Table 1. It is a weighted average of the export prices (in dollars) of the individual countries. Type B countries and oil exporting countries (countries 26 through 35) are excluded from the calculations. The weight for each country is the ratio of its total exports to the total exports of all the countries. The world price index differs for different countries because the individual country is excluded from the calculations for itself.

Since the world price index is in dollars, it needs to be multiplied by the exchange rate to convert it into local currency before being used as an explanatory variable in the export price equation for a given country. (The export price index explained by equation 11 is in local currency.)

For some countries, depending on the initial results, this was done, but for others the world price index in dollars and the exchange rate were entered separately. The results in Table 4 show, as expected, that export prices are in part linked to domestic prices and in part to world prices.

It should be stressed that equation 11 is meant only as a rough approximation. If more disaggregated data were available, one would want to estimate separate price equations for each good, where some goods' prices would be strongly influenced by world prices and some would not. This type of disaggregation is beyond the scope of this study.

As noted above, equation 11 is used to link the export price index to the GNP deflator. The world price index is added to the equation to try to lessen the bias of the coefficient estimate of the GNP deflator. The world price index is not meant to be an endogenous variable. Although it is measured as a weighted average of the export price indices of the individual countries, which are endogenous, its use in equation 11 is merely as a control variable. The export price index of one country is indirectly affected by the export prices of other countries through the effect of import prices on the GNP deflator in equation 5 and the effect of the GNP deflator on the export price index in equation 11. It would be (in a loose sense) double counting to have the export price index of a country also be affected by the export prices of other countries through their effect on the world price index. Again, this treatment, which at best provides only a rough approximation to the truth, is dictated by the use of the aggregated data.

Summary

This completes the discussion of the estimated equations. Given the poor quality of much of the data, especially for the non industrial countries, the results do not seem too bad. The least precise estimates in terms of t-statistics are those for the interest rate and exchange rate reaction functions, which are based on relatively few observations. Even for these equations, however, the results do not seem unreasonable. In particular, it is encouraging that a number of explanatory variables were found to be significant (by conventional standards) in the exchange rate equations aside from the lagged dependent variable and the German exchange rate.

IV. The Predictive Accuracy of the Model

The evaluation of macroeconometric models is a difficult problem. Any model is likely to be only an approximation to the true structure of the economy, and one would like to choose that model that provides the best approximation. The problem is deciding what one means by best approximation. It is difficult to compare the fit of one model to the fit of another because models differ in the number and types of variables that are taken to be exogenous. Also, there is a serious danger of data mining with macro time series data, and it is not easy to control for this. A model may be poorly specified (i.e., a bad approximation to the true structure) but fit the data well because of data mining.

I have recently proposed a method (Fair (1980a)) that I think can be used in the long run to compare alternative models. The method provides estimates of forecast error variances that take into account the four main sources of uncertainty: uncertainty due to the error terms, the coefficient estimates, the exogenous-variable forecasts, and the possible misspecification of the model. It puts each model on an equal footing and so allows comparisons to be made across models. The method is unfortunately expensive to use, since it is based on successive reestimation and stochastic simulation of the model, and it is beyond the computer budget for this project to apply it to the model.

Because this method has not been used, this paper provides no rigorous comparison of the present model to other models. What was done instead is the following. Three eight-quarter prediction periods were chosen: a fixed exchange rate period, 1970I-1971IV, and two flexible rate periods, 1974I-1975IV and 1976I-1977IV. For each of these periods both static and dynamic predictions were generated using the actual values of the exogenous variables.[9] Root mean squared errors (RMSEs) were computed for each endogenous variable for each run. The same procedure was followed for what will be called the "autoregressive" model. For the autoregressive model each of the variables on the left hand side of a stochastic equation in the regular model is regressed on a constant, time, three seasonal dummy variables, and the first four lagged values of the left hand side variable. The autoregressive model consists of a set of completely unrelated equations. The predictions and errors in one equation have no effect on any of the other equations. The same estimation periods were used for this model as were used for the regular model. The variables

[9]The model was solved using the Fair-Parke (1981) program, which uses the Gauss-Seidel technique. Iteration occurs for a given quarter both within the countries (the Table 2 part of the model) and among countries (the Table 3 calculations). Convergence was generally quite rapid, requiring between about 3 and 7 Table 3 calculations per quarter. The approximate time on the IBM 370-158 at Yale for one eight-quarter simulation of the complete model (including the U.S. model) was 3.5 minutes.

explained by definitions in the regular model are not part of the autoregressive model.

The results are presented in Tables 5, 6, and 7. For the results in Table 5 a weighted average of the RMSEs across all countries except the U.S. was taken for each variable. The RMSEs were weighted by the ratio of the country's real GNP (in 75$) in the last (i.e., eighth) quarter of the prediction period to the total real GNP of all the countries. This provides a summary measure of the overall fit of the model with respect to each variable. The RMSEs of the individual countries are presented in Table 6 for one run, the dynamic simulation for the period 1974I-1975IV. This is the period of the large increase in the price of oil by OPEC and is not a particularly easy period to explain. The RMSEs for the U.S. are presented in Table 7.

Each number in parentheses in Tables 5 and 6 is the ratio of the RMSE to the corresponding RMSE for the autoregressive model. Two of the variables in the tables, PM and X75$, are explained by definitions in the regular model, and so no RMSEs from the autoregressive model are available for these. Each number in parentheses in Table 7 is the ratio of the RMSE to the corresponding RMSE when the rest of the world is taken to be exogenous from the point of view of the U.S.

The following general conclusions can be drawn from Table 5. (1) The model is the same as or less accurate than the autoregressive model for GNP and its two major components, consumption and investment. It is the same as or more accurate than the autoregressive model for the GNP deflator, the two interest rates, the exchange rate, imports, and the price of exports. The two models are about the same for the money supply. (2) The best period for the accuracy of the model relative to that for

TABLE 5. Weighted RMSEs for All Countries Except the U.S.

STA = Static simulation.
DYN = Dynamic simulation.

Eq. No. in Tables 4 or 5		Variable	701-714 STA	701-714 DYN	741-754 STA	741-754 DYN	761-774 STA	761-774 DYN
4	Real GNP	Y	1.95(1.38)	4.32(2.17)	2.10(1.17)	3.29(1.03)	1.90(1.46)	3.71(1.92)
5	GNP Deflator	PY	0.81(0.98)	2.53(1.13)	1.19(0.84)	2.28(0.49)	0.98(1.00)	2.60(1.03)
7a, 7b	Interest Rate	r	0.56(0.87)	0.91(1.04)	0.75(0.87)	1.14(0.91)	0.88(0.95)	1.80(0.93)
9b	Exchange Rate	e	a	a	3.80(0.99)	5.26(0.98)	2.56(0.96)	4.32(0.71)
V	Import Price	PM	0.66	1.66	2.97	4.42	2.17	3.85
6	Money Supply	M1*	2.99(1.05)	6.60(1.18)	2.85(0.96)	3.87(0.86)	2.55(1.08)	3.83(1.19)
1	Imports	M	4.70(0.97)	9.43(1.33)	4.79(0.79)	6.44(0.58)	4.30(0.88)	6.56(0.97)
2	Consumption	C	1.85(1.14)	3.77(1.45)	2.32(1.07)	3.28(0.81)	1.92(1.28)	3.95(1.70)
3	Investment	I	4.07(1.45)	10.28(1.98)	4.21(1.16)	7.67(1.07)	3.41(1.23)	7.79(1.52)
8	Interest Rate	R	0.27(0.92)	0.49(1.04)	0.43(0.84)	0.74(0.66)	0.41(0.98)	0.90(0.90)
11	Export Price	PX	1.81(0.83)	3.87(0.63)	3.71(1.03)	5.14(0.51)	2.66(1.09)	4.34(0.70)
II	Exports	X75$	1.97	5.21	2.18	3.00	1.50	2.65

Notes: 1. Each number in parentheses is the ratio of the RMSE to the corresponding RMSE for the autoregressive model.

2. All errors are in percentage points.

3. Weights are GNP in 75$ in the last quarter of the period.

a = fixed exchange rate period for almost all countries.

TABLE 6. RMSEs for the Individual Countries: Dynamic Simulation, 741-754

Country	Real GNP Y	GNP Deflator PY	Interest Rate r	Exchange Rate e	Import Price PM	Money Supply M1*	Imports M	Consumption C	Investment I	Interest Rate R	Export Price PX	Exports X75$
Canada	0.8(0.56)	2.0(0.67)	0.7(0.72)	2.0(1.07)	3.4	3.1(0.98)	3.7(0.80)	0.9(0.59)	3.0(1.08)	0.5(0.69)	6.2(0.87)	7.9
Japan	3.6(0.78)	0.7(0.27)	0.5(0.96)	3.2(1.04)	2.6	2.4(1.05)	4.0(0.21)	2.8(0.32)	7.5(0.74)	--	4.1(0.34)	2.7
Austria	3.3(1.16)	2.5(0.58)	1.6(1.91)	5.7(0.96)	2.5	3.9(1.42)	4.3(0.52)	3.1(1.84)	8.2(1.55)	--	2.9(0.33)	1.7
Belgium	1.5(0.54)	2.3(0.34)	1.2(0.62)	5.1(0.94)	2.8	2.5(0.93)	2.6(0.23)	1.6(0.66)	6.0(1.29)	0.3(0.56)	4.2(0.43)	2.1
Denmark	1.8(0.32)	1.3(0.33)	1.4(0.30)	4.5(0.85)	3.8	5.3(0.77)	5.5(0.42)	4.3(0.71)	7.4(0.56)	1.4(0.81)	3.5(0.44)	3.3
France	1.3(0.72)	1.0(0.26)	1.4(0.98)	8.0(1.07)	7.0	3.7(0.94)	4.3(0.46)	1.4(1.00)	3.1(1.03)	0.7(0.59)	2.9(0.29)	1.8
Germany	1.6(0.57)	0.7(0.26)	1.7(1.34)	4.6(0.91)	3.5	1.8(0.52)	3.3(0.51)	1.5(3.57)	6.3(0.59)	0.5(0.47)	4.9(0.55)	2.7
Italy	2.5(1.16)	2.0(0.18)	1.9(0.47)	6.4(0.82)	4.1	2.1(0.19)	5.6(0.36)	1.2(0.34)	9.4(2.77)	0.5(0.28)	4.8(0.41)	1.9
Netherlands	0.9(0.39)	1.0(0.31)	1.4(0.68)	5.2(0.92)	3.1	3.2(0.70)	4.0(0.48)	2.5(1.09)	5.3(0.61)	0.7(0.64)	4.1(0.39)	1.8
Norway	1.9(0.95)	1.3(0.45)	2.0(0.99)	6.0(1.14)	1.6	6.4(1.23)	5.6(1.21)	2.1(0.96)	--	0.3(0.73)	2.1(0.21)	3.1
Sweden	3.9(1.60)	1.8(0.52)	2.0(2.45)	5.5(0.91)	3.4	7.7(2.15)	6.2(1.19)	2.8(0.92)	4.5(1.38)	0.5(1.71)	6.0(0.68)	3.1
Switzerland	5.5(0.83)	3.4(1.82)	1.4(1.36)	12.9(2.11)	8.1	4.0(0.53)	7.7(0.46)	3.9(0.64)	14.3(0.80)	0.8(1.27)	3.7(0.56)	2.4
U.K.	2.7(1.16)	5.4(0.63)	0.5(0.74)	5.5(1.09)	7.8	6.1(1.62)	6.5(1.34)	2.9(0.89)	5.4(1.34)	2.0(0.83)	5.6(0.60)	3.0
Finland	8.4(3.96)	6.9(0.82)	0.1(0.34)	3.3(0.72)	5.9	16.5(1.60)	18.1(1.88)	7.9(3.28)	17.0(2.13)	--	13.1(0.71)	3.0
Greece	4.5(0.58)	4.2(0.88)	3.3(1.56)	--	3.9	9.9(2.32)	8.1(0.58)	--	27.7(0.93)	--	4.7(0.43)	2.0
Ireland	5.4(2.27)	4.7(0.92)	1.0(1.11)	4.3(0.79)	5.1	3.5(0.51)	11.0(0.69)	5.3(0.97)	10.3(0.66)	1.9(0.79)	2.2(0.43)	5.1
Portugal	8.9(1.25)	2.5(0.44)	0.7(0.59)	7.6(1.36)	5.3	4.5(1.46)	17.1(0.64)	4.6(0.92)	9.1(0.93)	0.1(0.07)	2.5(0.44)	3.4
Spain	5.8(1.84)	1.6(1.37)	0.2(0.65)	6.7(0.87)	4.3	5.9(2.22)	10.5(2.59)	3.7(1.19)	12.6(2.34)	--	5.4(0.60)	2.9
Yugoslavia	3.7(2.25)	9.3(1.90)	--	--	4.5	--	4.3(0.57)	3.4(0.99)	8.5(1.10)	--	5.9(0.77)	1.3
Australia	3.0(1.76)	6.6(1.02)	1.4(2.21)	8.2(3.63)	10.0	4.8(0.53)	12.1(1.28)	2.0(1.22)	5.7(3.37)	1.0(2.42)	3.7(0.69)	3.0
New Zealand	0.7(1.04)	4.1(0.82)	0.6(0.96)	9.6(3.05)	9.9	4.3(0.81)	11.2(0.69)	4.2(3.47)	11.8(0.77)	0.4(0.96)	20.7(1.76)	4.4
South Africa	5.8(1.81)	3.4(2.36)	1.6(2.14)	--	3.8	3.3(0.89)	7.5(0.51)	3.9(2.23)	14.5(1.38)	1.0(1.76)	2.4(0.32)	2.2
Iran	3.5(0.99)	--	0.6(1.25)	--	3.9	14.0(1.29)	10.5(0.56)	3.4(0.75)	--	--	--	2.5
Libya	5.5(0.60)	--	--	--	3.8	--	14.6(1.13)	11.2(1.17)	10.0(0.70)	--	--	3.9
Nigeria	7.8(0.81)	--	--	--	3.4	--	5.1(0.42)	10.2(0.68)	16.4(1.29)	--	--	4.6
Saudi Arabia	3.4(1.18)	--	--	--	3.7	--	7.6(1.89)	9.9(1.62)	--	--	--	3.2
Venezuela	3.5(2.83)	--	--	--	4.5	--	8.5(1.40)	13.0(0.99)	--	--	--	5.2
Argentina	8.8(2.03)	--	--	--	2.7	--	14.9(0.70)	8.2(2.39)	8.9(2.61)	--	--	2.5
Brazil	5.4(1.16)	2.4(1.26)	--	5.1(0.41)	2.2	--	14.6(1.08)	5.5(0.97)	10.6(2.04)	--	9.8(0.76)	2.8
Chile	8.1(0.54)	17.3(0.21)	--	--	3.1	--	24.8(0.27)	10.7(1.04)	11.8(0.67)	--	17.7(0.21)	4.4
Colombia	5.7(1.86)	2.2(1.09)	--	5.4(1.41)	8.8	5.5(0.50)	19.8(1.42)	3.1(0.95)	12.6(2.32)	--	9.2(0.72)	4.5
Mexico	2.3(1.08)	--	--	--	5.1	--	6.0(0.53)	5.5(1.03)	4.3(2.01)	--	--	7.4
Peru	10.8(3.38)	--	--	--	4.0	11.5(1.58)	25.4(1.04)	11.5(2.45)	37.0(1.97)	--	--	0.8
Egypt	2.7(0.46)	--	--	--	3.0	--	23.1(2.11)	7.1(1.98)	--	--	--	1.2
Israel	5.7(0.95)	6.5(0.65)	--	--	4.5	--	7.7(0.86)	5.0(1.16)	17.8(1.23)	--	6.1(0.88)	3.2
Jordan	9.0(0.79)	16.4(1.13)	--	--	3.6	--	7.4(0.33)	8.9(1.10)	--	--	36.7(1.17)	3.8
Syria	17.7(1.63)	6.9(0.46)	--	--	4.0	--	15.7(1.25)	29.5(1.91)	--	--	22.5(0.79)	0.8
India	6.9(2.84)	4.8(0.91)	--	3.4(0.97)	4.4	--	6.6(0.99)	6.9(0.89)	5.9(1.04)	0.0(0.18)	4.0(0.49)	2.4
Korea	15.3(3.37)	4.4(0.51)	1.1(1.02)	--	3.7	4.6(0.58)	15.6(0.90)	13.1(2.83)	28.2(1.97)	--	9.0(1.20)	4.5
Malaysia	2.1(1.48)	4.2(0.88)	--	--	2.0	--	6.0(0.51)	4.8(0.73)	13.7(1.18)	--	11.9(1.35)	2.8
Pakistan	2.4(1.21)	2.0(0.69)	1.0(1.27)	--	2.6	--	5.7(1.13)	--	11.1(1.23)	--	13.8(2.24)	1.9
Philippines	7.4(1.54)	4.0(0.72)	2.7(1.20)	--	3.1	2.1(0.45)	8.3(1.38)	6.0(1.04)	24.6(1.45)	--	19.8(0.93)	4.8
Thailand	3.4(0.74)	3.6(1.22)	0.7(1.10)	--	3.0	2.3(0.45)	6.0(0.34)	3.1(0.88)	--	--	9.6(1.13)	2.3
Weighted	3.3(1.03)	2.3(0.49)	1.1(0.91)	5.3(0.98)	4.4	3.9(0.86)	6.4(0.58)	3.3(0.81)	7.7(1.07)	0.7(0.66)	5.1(0.51)	3.0

Notes: 1. Each number in parentheses is the ratio of the RMSE to the corresponding RMSE for the autogregressive model.
2. All errors are in percentage points.

TABLE 7. RMSEs for the U.S.

STA = Static simulation.
DYN = Dynamic simulation.

	Variable	701-714 STA	701-714 DYN	741-754 STA	741-754 DYN	761-774 STA	761-774 DYN
Real GNP	Y	0.50(1.05)	0.25(0.76)	0.81(1.04)	2.31(1.07)	0.74(1.05)	1.32(1.02)
GNP Deflator	PY	0.27(0.98)	0.32(0.53)	0.33(1.06)	1.23(2.31)	0.37(1.08)	0.80(1.20)
Interest Rate	r	0.54(1.01)	0.84(0.98)	0.57(1.02)	0.83(1.10)	0.25(1.00)	0.31(1.00)
Import Price	PM	0.65	2.06	1.28	3.53	0.61	0.95
Money Supply	M1*	1.15(1.00)	3.37(0.99)	1.02(1.00)	0.83(0.96)	0.66(1.00)	1.07(1.02)
Imports	IM	2.48(1.02)	4.44(1.13)	4.40(0.99)	8.06(1.08)	2.32(1.01)	4.48(1.05)
Interest Rate	R	0.28(1.01)	0.37(1.01)	0.28(1.02)	0.33(1.12)	0.12(1.01)	0.31(1.01)
Export Price	PX	1.03(1.00)	1.87(1.18)	1.97(1.03)	6.01(1.14)	1.15(1.03)	2.32(1.07)
Exports	X75$	1.14	1.87	1.68	2.64	1.33	2.20

Notes: 1. Each number in parentheses is the ratio of the RMSE to the corresponding RMSE when the rest of the world is taken to be exogenous.

2. All errors are in percentage points.

the autoregressive model is 1974I-1975IV. (3) In going from a static simulation to a dynamic simulation, the accuracy of the model improves relative to that for the autoregressive model for the 1974I-1975IV period. The relative accuracy worsens for the 1970I-1971IV period. It is about the same for the 1976I-1977IV period.

The RMSEs in Table 6 give a general idea of how well the model explains the individual countries. The RMSEs are generally larger for the smaller countries, which is as expected given, among other things, the poor quality of much of the data for the smaller countries.

The main conclusion to be drawn from the results for the U.S. in Table 7 is that the fit of the U.S. model is not very sensitive to whether or not the U.S. model is included in the overall model, i.e., to whether or not the rest of the world is taken to be exogenous in the U.S. model. Note also that the U.S. RMSEs for a given variable are generally much smaller than the corresponding RMSEs for the other countries in Table 5.[10]

Although the results in this section give one a general idea of the accuracy of the model, they do not, as mentioned above, provide a test of the model. It is unclear how the model would compare to the autoregressive model if the method in Fair (1980a) were used.
This method takes into account exogenous variable uncertainty, whereas the procedure followed in this section does not, which biases the current results against the autoregressive model. The autoregressive model has no non trivial exogenous variables. The important exogenous variables in the regular model are the government spending variable (G_{it}) and the price of exports of the oil exporting countries. On the other hand, the

[10]The U.S. model is compared to an autoregressive model in Fair (1980a), and so no comparisons of this kind are presented here.

autoregressive model may be more misspecified than the regular model, which would bias the current results, which are all within sample, against the regular model. The method has been used to compare the U.S. model and an autoregressive model (Fair (1980a)), and the results in general indicate that the autoregressive model is more misspecified. In future work it will be of interest to use the method to compare the present model not only to the autoregressive model but also to other structural models.

V. The Properties of the Model

A useful way of examining the properties of the model is to consider the effects of changing government policy variables. The results of one experiment are reported in this section: an increase in the purchase of U.S. goods by the U.S. government. This experiment was performed in both a fixed exchange rate period (1970I-1971IV) and a flexible rate period (1976I-1977IV). The results of other experiments are reported in a sequel to this paper, Fair (1981). This paper provides much more discussion of the properties of the model than space limitations allow in this section.

Before discussing the results of the experiment, it will be useful to explain some of the *ceteris paribus* effects in the model. In what follows a variable is said to have a "direct" effect on another variable if it appears on the right hand side of the equation (either a stochastic equation or a definition) explaining the other variable. Most endogenous variables have at least an indirect effect on the other endogenous variables--either contemporaneously or with a lag of one quarter. Because of this, it is difficult to explain the properties of the model in a systematic way. The following discussion is designed to try to give a general idea of the properties of the model without going into every possible indirect effect. The experiment, of course, takes all effects into account, and so the experimental results provide a check on the less rigorous discussion of the properties.

It should also be kept in mind in the following discussion that not all of the effects operate for all countries. To conserve space, no distinction is made across countries. Each effect is discussed as if it applied to all countries. All interest rates referred to in the discussion are short term interest rates unless otherwise noted.

Trade Effects Among Countries

There is a standard trade multiplier effect in the model. An autonomous increase in GNP in country i increases its demand for imports, which increases the exports of other countries and thus their GNP and demand for imports, which then increases the exports of country i and thus its GNP. In short, exports affect imports and vice versa.

Price Effects Among Countries

There is also a price multiplier effect in the model. An autonomous increase in country i's domestic price level increases its export prices, which increases the import prices of other countries, which increases their domestic prices, including their export prices, which then increases country i's import prices and thus its domestic and export prices. In short, export prices affect import prices and vice versa.

Direct Interest Rate Effects Among Countries

The U.S. short term interest rate appears as an explanatory variable in the interest rate reaction functions of a number of countries. The U.S. rate is more important in the fixed exchange rate period than it is in the flexible rate period, but even in the flexible rate period it has an effect on some countries. This means that an increase in the U.S. interest rate directly increases other countries' rates. The German interest rate appears as an explanatory variable in the interest rate reaction functions of a few other European countries, and so an increase in the German interest rate also directly increases other countries' rates.

Direct Exchange Rate Effects Among Countries

The German exchange rate appears as an explanatory variable in the exchange rate equations of the other European countries. The German exchange rate thus directly affects other exchange rates. All exchange rates are relative to the U.S. dollar, and so each explanatory variable in the exchange rate equations (other than the lagged dependent variable and the German exchange rate) is the particular variable of the country relative to the same variable for the U.S. This means that the following U.S. variables appear as explanatory variables in the exchange rate equations: the GNP deflator, the short term interest rate, the demand pressure variable, and the change in net foreign assets.

Direct Effects Within a Country

The short term interest rate directly affects the long term rate (equation 8). The short term rate or the long term rate has a direct negative effect on imports and consumption (equations 1 and 2) and a direct positive effect on the GNP deflator (equation 5). The short term rate has a direct negative effect on the demand for money and the exchange rate (equations 6 and 9b). (Remember that an increase in the exchange rate is a depreciation of the country's currency.)

The asset variable, which is a measure of the net asset position of the country vis-a-vis the rest of the world, has a direct positive effect on imports and consumption (equations 1 and 2) and a direct negative effect on the short term interest rate and the exchange rate (equations 7a, 7b, and 9b).

The exchange rate has a direct positive effect on the price of imports and the price of exports, both of which are in units of the local currency (equations V and 11). It also has a direct negative effect on the price of exports in dollars (because the coefficient estimate of the log of the exchange rate in equation 11 is less than 1). It has a direct positive effect on the short term interest rate for three countries (equation 7b).

The price of imports has a direct negative effect on imports (equation 1), a direct positive effect on the GNP deflator (equation 5), a direct negative effect on the asset variable (equations 17 and 18), and a direct positive effect on the short term interest rate for four countries (equation 7b). The price of exports has a direct positive effect on the asset variable (equations 17 and 18). The GNP deflator has direct positive effects on imports, the demand for money, the short term and long term interest rates, the exchange rate, and the price of exports (equations 1, 6, 7a, 7b, 8, 9b, and 11).

The level of imports has a direct negative effect on final sales and the asset variable, and the level of exports has a direct positive effect on these two variables (equations 16, 17, and 18). The level of final sales has a direct positive effect on GNP (equation 4). Any deviation of GNP from final sales in a period is absorbed by a change in inventories (equation 12). The stock of inventories has a direct negative effect on production (equation 4).

GNP or the demand pressure variable (which is a nonlinear function of GNP) has a direct positive effect on imports, consumption, investment, the GNP deflator, the demand for money, the short term interest rate, and the exchange rate.

Some Indirect Effects Within a Country

It should be clear that there are very few unambiguous indirect effects in the model with respect to sign. The signs depend on the relative sizes of the coefficient estimates. It will nevertheless be useful to consider the likely signs of some indirect effects, even though these signs are not necessarily logical consequences of the model.

Consider first the indirect effect of the exchange rate on GNP. The main direct effect of the exchange rate is on the price of imports, at least in the short run. The price of imports has a direct negative effect on imports, and the level of imports has a direct positive effect on GNP. In other words, an increase in the price of imports causes substitution from imports to domestically produced goods, which raises GNP. The exchange rate thus has an indirect positive effect on GNP through this channel (i.e., depreciation increases GNP).

Depreciation also lowers the dollar price of exports, which lowers the import price indices of countries that import from the given country, which in turn increases the demand for the given country's exports. Therefore, depreciation also increases GNP through this channel.

Depreciation is likely to have a negative indirect effect on GNP through a third channel. The likely initial effect of a depreciation on the balance of payments is negative. Depreciation raises the local currency price of imports more than it does the local currency price of exports, which, other things being equal, has a negative effect on the balance of payments. Depreciation also lowers imports and raises exports, which has a positive effect on the balance of payments. This latter effect is, however, likely to be smaller initially than the price effect, and so the initial net effect is likely to be negative. (This is, of course, the " J curve" effect.) A decrease in the balance of payments decreases net foreign assets, which directly decreases imports and consumption and directly increases the short term interest rate. Although the decrease in imports raises GNP, the decrease in consumption and the increase in the interest rate lower GNP, and the net effect is likely to be negative. Depreciation is thus likely to have an initial indirect negative effect on GNP through this "asset" effect channel.

Depreciation has two main indirect effects on the GNP deflator, one positive and one ambiguous. The positive effect is through the price of imports, which has a direct positive effect on the GNP deflator. The second effect is through GNP. If the net effect of depreciation on GNP is positive, this will have a positive effect on the GNP deflator through the direct positive effect of the demand pressure variable on the GNP deflator. If the net effect of depreciation on GNP is negative, the indirect effect on the GNP deflator is negative.

There are three main effects of the short term interest rate on GNP, one negative, one ambiguous, and one positive. The negative effect is through consumption. An increase in the short term rate increases the long term rate. An increase in the short term rate or the long term rate decreases consumption, which lowers GNP. The ambiguous effect is through the exchange rate. An increase in the short term rate has a negative effect on the exchange rate (an appreciation), which has an ambiguous effect on GNP. The positive effect is through imports. An increase in the short term or long term rate lowers imports, which, other things being equal, raises GNP. The consumption effect is likely to be the dominant one, and so the net effect of the short term rate on GNP is likely to be negative.

An increase in interest rates has three main effects on the GNP deflator, one positive and two negative. The positive effect is a direct one: interest rates appear as explanatory variables in the price equation (equation 5). The first negative effect is the negative indirect effect of interest rates on GNP and thus on the demand pressure variable. The other negative effect is the effect on the exchange rate: the exchange rate appreciates, which lowers the price of imports, which lowers the GNP deflator.

The Results of the Experiment

The effects of increasing U.S. government expenditures on some of the key variables in the model are presented in Tables 8 and 9 for the main countries. Each number in the tables is the percentage difference between the two- or six-quarter-ahead predicted value of the variable before and after the change divided by the percentage change in autonomous income. For these results the estimated residuals were added to the stochastic equations and treated as exogenous. This means that when the model is simulated using the actual values of the exogenous variables, a perfect tracking solution is obtained. The base path before the change is thus the perfect tracking solution, and so the predicted values after the change are merely compared to the actual values.[11]

Consider first the results in Table 8, which are for the fixed exchange rate period. The increase in U.S. government spending increased U.S. income, which in turn increased U.S. imports. This increased other countries' exports, which in turn increased their income and imports. This is the trade multiplier effect. The increase in U.S. income also led to an increase in the U.S. price level, which increased other countries' import prices. This led to an increase in other countries' export prices, which resulted in further increases in other countries' import prices. This is the price multiplier effect.

The other important effect in this case is the interest rate effect. The increase in U.S. income and prices led to an increase in the U.S. interest rate through the reaction function of the Federal Reserve. This offset some of the increase in U.S. income that would otherwise have occurred and also led to an increase in other countries' interest rates. The interest rates for all countries except Japan were higher after two quarters. This worldwide increase in interest rates offset some of the increase in world income that would otherwise have occurred. In the case of the Netherlands this effect was large enough to lead to a net negative effect on GNP in the second quarter.[12]

---

[11]Each number in Tables 8 and 9 is thus $[(\hat{y}_{jt} - y_{jt})/y_{jt}]/[\Delta G_{1t}/Y_{1t}]$, where $\hat{y}_{jt}$ is the two- or six-quarter-ahead predicted value of y_{jt} after the change. ΔG_{1t} is the change in U.S. government spending in quarter t, and Y_{1t} is the actual value of U.S. GNP in quarter t.

[12]Some multiplier results for other multicountry econometric models are presented in Tables 1 and 2 in Fair (1979b), and these provide a rough basis of comparison for the results from the present experiment (U.S. increase in a fixed exchange rate period). In general, the present income multipliers are smaller and the price multipliers are larger than those of the other models. This is, of course, as expected, since the other models are primarily trade multiplier models and so have weak or non-existent price multiplier and interest rate effects.

TABLE 8. Percentage Change in the Variable after Two and Six Quarters Induced by a Sustained One Percent Autonomous Increase in U.S. Real GNP

Initial Change in 1970I (fixed exchange rate period).

Country	Real GNP Y		GNP Deflator PY		Short Term Interest Rate r		Import Price PM		Money Supply M1*		Imports M		Consumption C		Investment I		Long Term Interest Rate R		Export Price PX		Exports X75$		Balance of Payments[a] BOP*	
	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6
U.S.	1.25	1.32	0.20	0.11	0.49	0.76	0.03	0.15	0.01	-0.29	1.65	3.91	0.10	0.05	1.89	4.75	0.11	0.33	0.20	0.08	0.04	0.40	-134.751	-435.691
Canada	0.19	0.71	0.10	0.44	0.52	-0.39	0.15	0.04	-0.82	-0.55	0.20	1.28	-0.04	0.20	0.19	0.59	0.17	-0.04	0.09	0.40	1.32	3.34	49.767	127.197
Japan	0.06	0.30	-0.00	0.01	-0.01	0.03	0.08	0.07	0.03	0.18	0.00	0.10	0.02	0.14	0.01	0.24	--	--	-0.00	0.01	0.65	1.78	9.155	34.402
Austria	0.03	0.16	0.00	0.05	0.17	0.04	0.01	0.06	0.01	0.07	-0.16	-0.78	-0.05	-0.23	0.03	0.18	--	--	0.00	0.02	0.09	0.33	0.047	0.245
Belgium	0.03	0.22	0.01	0.04	0.56	0.08	0.03	0.04	-0.23	-1.16	0.01	-0.06	-0.01	-0.04	0.02	0.18	0.07	0.13	0.00	0.01	0.09	0.39	0.047	0.629
Denmark	0.06	0.21	0.01	0.04	0.18	-0.11	0.02	0.05	-0.21	0.21	0.03	0.19	0.04	0.15	0.06	0.25	0.04	-0.01	0.00	0.00	0.17	0.51	0.005	0.014
France	0.02	0.08	0.00	0.01	0.33	-0.25	0.03	0.05	-0.11	-0.26	-0.01	-0.02	0.00	-0.00	0.03	0.12	0.08	0.02	0.00	0.00	0.09	0.33	0.014	0.079
Germany	0.05	0.21	0.01	0.18	0.38	-0.27	0.03	0.03	-0.54	0.24	-0.05	0.09	-0.02	0.04	0.08	0.34	0.11	0.01	0.00	0.07	0.17	0.47	0.054	0.144
Italy	0.04	0.15	0.02	0.25	0.17	0.25	0.03	0.04	-0.07	-0.86	0.02	-0.05	0.01	-0.01	0.07	0.36	0.04	0.14	0.01	0.07	0.19	0.54	2.690	14.192
Netherlands	-0.02	0.04	0.00	-0.02	0.50	-0.36	0.03	0.05	-1.02	0.59	-0.02	-0.02	-0.06	-0.10	-0.01	0.03	0.09	0.02	0.00	-0.00	0.07	0.25	0.003	0.021
Norway	0.02	0.11	0.00	0.02	--	--	0.02	0.07	0.02	0.09	0.03	0.13	0.01	0.07	--	--	0.00	0.00	0.00	-0.00	0.14	0.57	0.001	0.008
Sweden	0.05	0.17	0.03	0.17	0.23	-0.21	0.02	0.04	-0.07	0.11	-0.02	0.17	0.02	0.10	0.03	0.13	0.04	-0.01	0.01	0.08	0.13	0.48	0.010	0.036
Switzerland	0.04	0.40	0.01	0.18	0.10	0.13	0.03	0.05	-0.10	-0.39	-0.04	0.18	-0.03	0.21	0.06	0.75	0.04	0.14	0.00	0.09	0.17	0.45	0.010	0.017
U.K.	0.05	0.16	0.01	0.09	0.17	-0.13	0.04	0.07	-0.23	0.02	0.08	0.27	0.03	0.12	0.04	0.11	0.04	0.01	0.00	0.05	0.23	0.68	1.621	9.557
Finland	0.03	0.12	0.00	0.02	0.00	0.00	0.01	0.05	0.01	0.09	0.04	0.18	0.01	0.07	0.02	0.11	--	--	0.00	0.01	0.11	0.39	0.722	2.363

[a]Change is absolute change, not percentage change, in units of local currency.

TABLE 9. Percentage Change in the Variable after Two and Six Quarters Induced by a Sustained One Percent Autonomous Increase in U.S. Real GNP

Initial Change in 1976I (flexible exchange rate period)

	Real GNP Y		GNP Deflator PY		Short Term Interest Rate r		Exchange Rate e		Import Price PM		Money Supply M1*	
	2	6	2	6	2	6	2	6	2	6	2	6
U.S.	1.43	1.39	0.17	0.54	0.36	0.89	--	--	0.05	0.55	-0.07	-0.33
Canada	0.18	0.55	0.05	0.56	0.22	0.60	-0.00	0.01	0.07	0.50	-0.16	-0.89
Japan	0.06	0.18	-0.02	-0.12	-0.04	-0.14	-0.80	-3.42	-0.74	-3.08	0.02	0.08
Austria	0.04	0.10	0.01	0.22	0.00	0.03	0.44	-0.52	0.35	0.15	0.01	0.15
Belgium	0.06	0.09	0.00	0.01	0.01	0.14	0.07	-0.87	0.06	-0.25	-0.00	-0.01
Denmark	0.04	-0.01	-0.01	-0.09	-0.04	-0.11	-0.04	-0.95	-0.13	-0.41	0.04	0.04
France	0.03	0.01	-0.01	-0.12	0.15	0.30	-0.11	-1.71	-0.15	-1.21	-0.02	-0.20
Germany	0.05	0.19	0.01	0.10	0.12	0.43	0.17	-0.94	0.18	-0.46	-0.06	-0.25
Italy	0.04	0.19	-0.01	-0.27	-0.05	-0.40	-0.10	-1.68	-0.12	-1.18	0.01	0.17
Netherlands	0.03	-0.03	-0.00	0.03	0.44	0.82	0.15	-0.79	0.14	-0.21	-0.43	-0.80
Norway	0.03	0.11	0.03	0.26	0.04	0.28	0.22	0.07	0.16	0.67	0.04	0.28
Sweden	0.04	0.21	0.02	0.36	0.11	0.44	0.52	0.05	0.51	0.64	0.00	0.13
Switzerland	0.07	0.26	0.02	0.11	0.09	0.13	0.43	-0.97	0.42	-0.27	-0.06	-0.21
U.K.	0.07	0.21	0.00	-0.09	0.00	0.04	-0.13	-2.04	-0.12	-1.54	0.03	0.07
Finland	0.05	0.24	0.03	0.37	-0.00	0.00	0.55	1.21	0.44	1.77	0.02	0.45

	Imports M		Consumption C		Investment I		Long Term Interest Rate R		Export Price PX		Exports X75$		Balance of Payments[a] BOP*	
	2	6	2	6	2	6	2	6	2	6	2	6	2	6
U.S.	1.68	2.95	0.31	-0.01	2.36	5.26	0.16	0.41	0.08	0.41	0.09	0.60	-452.807	-985.274
Canada	0.20	1.14	-0.00	0.04	0.15	0.44	0.07	0.27	0.04	0.51	1.32	2.67	114.732	182.173
Japan	0.12	1.12	0.03	0.17	0.02	0.22	--	--	-0.53	-2.31	0.51	1.09	30.555	41.713
Austria	-0.00	0.11	0.02	0.06	0.07	0.14	--	--	0.29	-0.27	0.09	0.27	-0.016	-0.308
Belgium	0.06	0.24	0.04	0.04	0.04	0.10	0.00	0.03	0.04	-0.47	0.11	0.31	0.117	-1.245
Denmark	0.09	0.32	0.03	-0.00	0.04	-0.01	-0.01	-0.03	-0.02	-0.46	0.17	0.39	0.036	-0.013
France	0.05	0.30	0.01	-0.01	0.04	0.04	0.04	0.12	-0.05	-0.84	0.12	0.32	0.138	0.358
Germany	0.04	0.00	-0.00	-0.02	0.11	0.41	0.03	0.16	0.04	-0.15	0.15	0.46	-0.007	0.546
Italy	0.05	0.42	0.02	0.18	0.08	0.46	-0.01	-0.11	-0.07	-1.16	0.17	0.40	16.022	-11.398
Netherlands	0.02	0.01	-0.03	-0.23	0.03	-0.02	0.08	0.25	0.12	-0.64	0.10	0.30	0.019	-0.107
Norway	0.03	0.05	0.02	0.03	--	--	0.00	0.06	0.19	0.08	0.14	0.44	0.012	-0.111
Sweden	0.04	0.01	0.02	0.11	0.04	0.17	0.02	0.10	0.14	0.18	0.15	0.41	-0.069	-0.042
Switzerland	-0.02	0.17	-0.02	0.04	0.16	0.84	0.03	0.10	0.13	-0.21	0.17	0.45	-0.008	0.024
U.K.	0.10	0.40	0.04	0.23	0.04	0.16	0.00	0.00	-0.04	-0.69	0.23	0.53	16.041	110.061
Finland	0.00	0.09	0.02	0.18	0.04	0.28	--	--	0.46	1.11	0.09	0.29	5.837	-64.815

[a]Change is absolute change, not percentage change, in units of local currency.

The U.S. increase had a negative effect on the U.S. balance of payments and a positive effect on the other countries' balance of payments. This has, other things being equal, a negative effect on other countries' interest rates. For some of the countries the net effect on the interest rate after six quarters was negative. This reverses at least part of the initial negative effect of the world wide increase in interest rates on world income.

Although GNP increased for all countries except the Netherlands, imports declined for some countries. This is due in part to the effects of higher initial interest rates and in part to the fact that import prices increased more initially than domestic prices. An increase in import prices relative to domestic prices leads to a substitution away from imported goods.

Note finally with respect to Table 8 that the money supply decreased for many countries. Although income was higher, interest rates were also higher, and in many cases the negative interest rate effect dominated.

The results in Table 9 are for the flexible exchange rate period. One key difference between the fixed and flexible rate periods is that the U.S. interest rate has smaller direct effects on other countries' interest rates. The changes in the other countries' interest rates after two quarters are smaller in Table 9 than in Table 8. This means that there is less initial offset to the trade multiplier effect from higher interest rates in the flexible rate period.

There are four main effects of the U.S. spending increase on exchange rates, three negative and one positive. The spending increase raised U.S. output and prices relative to those of the other countries, both of which have a negative effect on other countries' exchange rates (an appreciation). The U.S. balance of payments fell relative to those of the other countries (the balance of payments of other countries generally rose), and this also has a negative effect on exchange rates. The positive effect is the interest rate effect. The U.S. short term interest rate rose relative to other countries' rates, and this has a positive effect on exchange rates (a depreciation). As can be seen in Table 9, the net effect can go either way. For some countries, such as Germany, there is a depreciation after two quarters (the interest rate effect dominating) and an appreciation after six quarters.

The changes in the price of imports are much higher in the flexible rate period. This is, of course, due to the fact that exchange rate changes are no longer zero. The changes in the price of exports are also higher for the same reason. The changes in import prices are negative for countries whose exchange rate appreciates. For most of these countries the fall in import prices led to a fall in the GNP deflator. In other words, the U.S. expansion generally led to a fall in inflation rates in those countries whose exchange rates appreciated. This is contrary to the case in Table 8, where the U.S. expansion led to an increase in almost all countries' inflation rates.

The balance of payments fell for some countries in Table 9, contrary to the case in Table 8. If a country's exchange rate depreciates in response to the U.S. expansion (the interest rate effect dominating), then, as noted above, the initial effect on the balance of payments is likely to be negative (the J curve effect).

The rest of the results in Table 9 should be self explanatory given the above discussion. As a final comment, it would be possible, as some people have suggested to me, to compare the properties of the present model to the properties of Model A in Fair (1979a). Model A is a "quasi-empirical" two-country model obtained by linking the U.S. model to a model exactly like it. Model A has the advantage of allowing more versions of the theoretical model to be analyzed. This may be of interest in future work, but in general I look on Model A as merely an intermediate step between the theoretical model and the present econometric model.

VI. Conclusion

The econometric model presented in this paper provides quantitative estimates of the trade, price, and interest rate linkages among countries. Some information on these linkages is presented in Section V. Much more information is presented in a sequel to this paper, Fair (1981). It is clear from the results in Tables 8 and 9 that there are important quantitative differences between the fixed and flexible rate periods, which shows the importance of trying to model exchange rates accurately.

The models of the individual countries can be easily replaced by alternative models within the context of the overall model, and it is hoped that this study will induce work of this kind.[13] It will be interesting to see how sensitive the properties of the overall model are to the replacement of individual models. As more observations become available under flexible exchange rates, it should be possible to get more precise estimates of the interest rate and exchange rate reaction functions, and it will also be interesting to see how sensitive the properties of the model are to the new estimates. Another important area for future work

---

[13] It is quite easy in the Fair-Parke program, which estimates and solves the model, to replace one individual country model with another.

is estimating the responsiveness of the trade shares (the α_{jit}) to changes in relative prices.

In the more distant future the overall model will need to be tested using a method like the one in Fair (1980a). A method like this should help decide which version of the model is the best and how this version compares to alternative models. In the meantime, the results from the model must be interpreted with considerable caution.

DATA APPENDIX

The collection of the data for the U.S. model is described in Fair (1976, 1980b), and this discussion will not be repeated here. The data for all the other countries were obtained from the International Financial Statistics (IFS) tape (October 1980) and the Direction of Trade (DOT) tape (October 1980). The following steps were involved in the construction of the data base:

1. A program was written to read the IFS tape and create for each country all the variables in Table 1 except the variables for which DOT data are needed: $M75\$A_{it}$, $M75\$B_{it}$, PM'_{it} , $XX\$_{ijt}$, $XX75\$_{ijt}$, α_{jit} , and ψ_{2it} . Most of the work in constructing the data base was writing this program. No two countries were exactly alike with respect to the availability of the data, and so separate subroutines were written for each country.[1] The individual treatment of the countries is discussed below. The output from this program was stored by country on a tape called IFS1.
2. A program was written to read the DOT tape and create the $XX\$_{jit}$ data (the bilateral trade data). The output from this program was stored by country on a tape called DOT1.
3. The IFS1 and DOT1 tapes were sorted to store the data by quarter.

[1]Before these subroutines were written, a program was written to print the IFS data in a convenient format. The information needed to write the individual subroutines was taken from this printout. I am indebted to William Parke for help in writing the initial program that read the tape.

The sorted tapes were then used together to create the variables mentioned in step 1. This completed the construction of the data base.

The individual treatment of the data for each country is outlined in Table A-1. The comments in the table discuss any special treatment of the country. If no comments appear for a particular country, then all the data were available and nothing special needed to be done. Two standard procedures were followed for all the countries, and it is necessary to discuss these before considering the comments in Table A-1. First, if no quarterly National Income Accounts (NIA) data were available, then quarterly data were interpolated from annual data using quarterly data on the industrial production index (IP). If quarterly data on IP were not available, then the procedure in Table A-2 was used to create the quarterly data. One can thus tell from Table A-1 how the quarterly NIA data were constructed (if they were constructed) by noting whether or not IP data were available.

The second standard procedure concerns the construction of the Balance of Payments (BOP) data, and this procedure is presented in Table A-3. The key variable that is created in this process is BOP^*_{it} , the balance of payments on current account. It is used in the construction of the asset variable, A^*_{it} , for each country. Quarterly BOP data do not generally begin as early as the other data, and the procedure in Table A-3 allows data on BOP^*_{it} to be constructed as far back as the beginning of the data for merchandise imports and exports ($M\$_{it}$ and $X\$_{it}$). When all data are available, the procedure is a way of linking the BOP and non-BOP data.

Most of the comments in Table A-1 are self explanatory. Data for

TABLE A-1. Individual Treatment of the Data per Country

Country	1c	Quar. NIA Data?	Comments
1. United States	U.S. Dollars (mil.)	yes	See Fair (1976, 1980a) for discussion of the U.S. data.
2. Canada	Can. Dollars (mil.)	yes	Splice in M1* series at 673.
3. Japan	Yen (bil.)	yes	R from 681.
4. Austria	Schillings (bil.)	yes	Discount rate data for r . R from 701. Made up data for PX and PM for 611-633.
5. Belgium	Bel. Francs (bil.)	no	Made up data for R for 631-633.
6. Denmark	Den. Kroner (bil.)	no	Discount rate data for r prior to 721.
7. France	Fr. Francs (bil.)	no	Interpolated data for IFS71V for 571-614, using IFS73 . EMPL used for quarterly interpolations for NIA data.
8. Germany	D. Mark (bil.)	yes	---
9. Italy	Lire (bil.)	most	Discount rate data for r prior to 711. Quarterly C , ΔV , and G data interpolated using quarterly Y data.
10. Netherlands	Guilders (bil.)	no	---
11. Norway	Nor. Kroner (bil.)		Discount rate data for r prior to 714.
12. Sweden	Swe. Kroner (bil.)	no	Discount rate data for r prior to 743.
13. Switzerland	Swiss Francs (bil.)	no	Discount rate data for r . EMPL used for quarterly interpolations for NIA data. Made up data for PX and PM for 601-604.
14. United Kingdom	U.K. Pounds (mil.)	yes	---
15. Finland	Markkaa (mil.)	no	Discount rate data for r . No R .
16. Greece	Drachmas (bil.)	no	Discount rate data for r . No F . No R . Table A-2 procedure for PM for 571-594.
17. Ireland	Irish Pounds (mil.)	no	Discount rate data for r prior to 702. No F .
18. Portugal	Escudos (bil.)	no	Discount rate data for r . No F . No PX . Made up data for R for 742-754. Made up data for IP for 743 and 744. PY data for PX .
†19. Romania	Lei	---	Only e data available from IFS.
20. Spain	Pesetas (bil.)	no	Discount rate data for r . No R .
†21. Turkey	Liras (bil.)	---	Discount rate data for r . No F . No R . No IP . PX and PM from 681 on.
22. Yugoslavia	Dinars (bil.)	no	No r . No F . No R . Quarterly PX and PM data interpolated using quarterly CPI data.
23. Australia	Aust. Dollars (mil.)	yes	---
24. New Zealand	N.Z. Dollars (mil.)	no	Discount rate data for r . No F . No IP . NIA year begins April 1.
25. South Africa	Rand (mil.)	most	No F . Quarterly Y data for 611-694 interpolated using quarterly IP data.
†26. Algeria	Alg. Dinars (mil.)	---	No r . No F . No R . No IP . No PM . Made up data for IFS70 for 711-713 and for IFS71V for 711-733. PX data from 721.
†27. Indonesia	Rupiahs (bil.)	no	No r . No F . No R . No IP . No PM . No ΔV . CPI to deflate IM .
28. Iran	Rials (bil.)	no	Discount rate data for r . No F . No R . No IP . No PM . NIA year begins March 21. No V1 . CPI to deflate IM .
†29. Iraq	Iraq Dinars (mil.)	no	No r . No F . No R . No IP . No PM . CPI to deflate IM .
†30. Kuwait	Ku. Dinars (mil.)	no	No r . No F . No R . No IP . No PM . No Y data. Used CPI data for PY . Table A-2 procedure for other NIA data. NIA year begins April 1.
31. Libya	Lib. Dinars (mil.)	no	No r . No F . No R . No IP . No PM . CPI to deflate IM .
32. Nigeria	Naira (mil.)	no	Discount rate data for r . No F . No R . No PM . CPI to deflate IM . No ΔV . NIA year begins April 1.
33. Saudi Arabia	Riyals (bil.)	no	No r . No F . No R . No IP . No PM . CPI to deflate IM . Table A-2 procedure for IFS71V for 571-674 and 721-734. NIA year begins July 1.
†34. United Arab Emirates	Dirham (mil.)	---	No r . No F . No R . No IP . No PM . No BOP data.
35. Venezuela	Bolivares (mil.)	---	Discount rate data for r . No F . No R . No PM . No IP . CPI to deflate IM .
36. Argentina	Arg. Pesos (bil.)	no	No r . No F . No R . No PM . No PX . CPI to deflate IM . PY data for PX .
37. Brazil	Cruzerios (bil.)	no	Discount rate data for r . No F . No R . PM from 721 on. CPI to deflate IM . Set $\Delta V = 0$ for 751 on. IFS71V for 771-784 interpolated using IFS71.V0.
38. Chile	Chile Pesos (mil.)	no	No r . No F . No R . PX from 754 on. Made up data for M$ for 671-674. Set $\Delta V = 0$ for 771-774. PY to deflate EX . PY data for PX prior to 754.
39. Colombia	Col. Pesos (mil.)	no	Discount rate data for r . No F . No R . No IP . IFS70..D for X$ for 781-784.
40. Mexico	Mex. Pesos (bil.)	no	No r . No F . No R . No PM . No PX . CPI to deflate IM . PY data for PX .
41. Peru	Soles (bil.)	no	Discount rate data for r . No F . No R . No IP . No PM . CPI to deflate IM .
42. Egypt	Egy. Pounds (mil.)	no	Discount rate data for r . No F . No R . No IP . No PM . No PX . CPI to deflate IM . PY data for PX .
43. Israel	Isr. Pounds (mil.)	yes	No r . No F . No R . No ΔV .
44. Jordan	Jor. Dinars (mil.)	no	Discount rate data for r . No F . No R . No Y data. Used CPI data for PY . Table A-2 procedure for PX and PM .
†45. Lebanon	Leb. Pounds (mil.)	---	Only data on e , MP* , X$, and POP .
46. Syria	Syr. Pounds (mil.)	no	No r . No F . No R . No IP . Table A-2 procedure for PX and PM . No ΔV .
†47. Bangladesh	Taka (mil.)	---	No r . No F . No R . No IP . No PX . No PM .
†48. Republic of China (Taiwan)	N.T. Dollars (bil.)	---	Eliminated from the IFS and DOT tapes.
†49. Hong Kong	H.K. Dollars (bil.)	---	Only e data available from IFS.
50. India	Ind. Rupees (bil.)	no	No F . NIA year begins April 1.
51. Korea	Won (bil.)	yes	Discount rate data for r . No F . No R . PY to deflate C .
52. Malaysia	Ringgit (mil.)	no	No r . No F . No R . PY to deflate IM for 701-704. No ΔV .
53. Pakistan	Pak. Rupees (mil.)	no	No F . NIA year begins July 1.
54. Philippines	Phil. Pesos (mil.)	no	Discount rate data for r . No F . No R .
†55. Singapore	Sing. Dollars (mil.)	no	No r . No F . No R . No EX . No IM .
56. Thailand	Baht (bil.)	no	Discount rate data for r . No F . No R . No IP .
†57. Bulgaria			No IFS data.
†58. China (Mainland)			No IFS data.
†59. Cuba			No IFS data.
†60. Czechoslovakia			No IFS data.
†61. E. Germany			No IFS data.
†62. Hungary			No IFS data.
†63. Poland			No IFS data.
†64. USSR			No IFS data.
65. Rest of World			

TABLE A-2. Procedure Used to Create Quarterly Data from Annual Data When No Quarterly Interpolation Variables Were Available

Let:

y_t = (observed) average value of the variable for year t ,

y_{it} = (unobserved) average value of the variable for quarter i of year t $(i = 1, 2, 3, 4)$.

Then:

$$\text{(i)} \quad y_{1t} + y_{2t} + y_{3t} + y_{4t} = \lambda y_t \ ,$$

where $\lambda = \begin{cases} 1 \text{ for flow variables (at quarterly rates)} \\ 4 \text{ for stock variables and price variables.} \end{cases}$

Assume that the annual data begin in year 1, and let $\lambda y_1 = a_1$, $\lambda y_2 = a_2$, $\lambda y_3 = a_3$, ... The key assumption is that the four quarterly changes within the year are the same:

$$\text{(ii)} \quad y_{1t} - y_{4t-1} = y_{2t} - y_{1t} = y_{3t} - y_{2t} = y_{4t} - y_{3t} = \begin{cases} \delta_2 & \text{for} \quad t = 1,2 \\ \delta_t & \text{for} \quad t \geqq 3 \end{cases}$$

Given (i) and (ii) for $t = 1,2$, one can solve for y_{40} and δ_2 in terms of a_1 and a_2 :

$$y_{40} = \frac{13}{32}a_1 - \frac{5}{32}a_2 \ ,$$

$$\delta_2 = \frac{a_2 - a_1}{16} \ .$$

Using y_{40} and δ_2 , one can then construct quarterly data for years 1 and 2 using (ii). Given y_{42} from these calculations and given (i) and (ii) for $t = 3$, one can solve for δ_3 in terms of a_3 and y_{42} :

$$\delta_3 = \frac{a_3 - 4y_{42}}{10} \ .$$

Using y_{42} and δ_3 , one can then construct quarterly data for year 3. One can then solve for δ_4 in terms of y_{43} and a_4 , and so on.

Note: The annual population data that were collected for the model are mid-year estimates. In order to apply the above procedure to these data, the assumption was first made that each mid-year value is the same as the average value for the year.

TABLE A-3. Construction of the Balance of Payments Data: Data for BOP^*_{it} and TT^*_{it}

Let:

$M\$'_{it}$ = merchandise imports (fob) in \$, BOP data. [= IFS77ABD .]

$M\$_{it}$ = merchandise imports (fob) in \$. [In Table 1.]

$X\$'_{it}$ = merchandise exports (fob) in \$, BOP data. [= IFS77AAD .]

$X\$_{it}$ = merchandise exports (fob) in \$. [In Table 1.]

$MS\$_{it}$ = other goods, services, and income (debit) in \$. BOP data. [= IFS77ADD .]

$XS\$_{it}$ = other goods, services, and income (credit) in \$. BOP data. [= IFS77ACD .]

$PT\$_{it}$ = private unrequited transfer in \$. BOP data. [= IFS77AED .]

$OT\$_{it}$ = official unrequited transfers in \$. BOP data. [= IFS77AGD .]

A. When quarterly data on all the above variables were available, then:

(i) $BOP\$_{it} = X\$'_{it} + XS\$_{it} - M\$'_{it} - MS\$_{it} + PT\$_{it} + OT\$_{it}$,

(ii) $TT\$_{it} = BOP\$_{it} - X\$_{it} - XS\$_{it} + M\$_{it} + MS\$_{it}$,

where $BOP\$_{it}$ is total net goods, services, and transfers in \$ (balance of payments on current account) and $TT\$_{it}$ is total net transfers in \$.

B. When only annual data on $M\$'_{it}$ were available, interpolated quarterly data were constructed using $M\$_{it}$. Similarly for $MS\$_{it}$.

When only annual data on $X\$'_{it}$ were available, interpolated quarterly data were constructed using $M\$_{it}$. Similarly for $XS\$_{it}$, $PT\$_{it}$, and $OT\$_{it}$.

When no data on $M\$'_{it}$ were available, then $M\$'_{it}$ was taken to be $\lambda \cdot M\$_{it}$, where λ is the last observed annual value of $M\$'/M\$$. Similarly for $MS\$_{it}$ (where λ is the last observed annual value of $MS\$/M\$$).

When no data on $X\$'_{it}$ were available, then $X\$'_{it}$ was taken to be $\lambda \cdot X\$_{it}$, where λ is the last observed annual value of $X\$'/X\$$. Similarly for $XS\$_{it}$ (where λ is the last observed annual value of $XS\$/X\$$), for $PT\$_{it}$ where λ is the last observed annual value of $PT\$/X\$$), and for $OT\$_{it}$ (where λ is the last observed annual value of $OT\$/X\$$).

Equations (i) and (ii) were then used to construct quarterly data for $BOP\$_{it}$ and $TT\$_{it}$.

C. After data on $BOP\$_{it}$ and $TT\$_{it}$ were constructed, data on BOP^*_{it} and TT^*_{it} were constructed as:

(iii) $BOP^*_{it} = e_{it} BOP\$_{it}$,

(iv) $TT^*_{it} = e_{it} TT\$_{it}$.

D. Notice from MS_{it} and XS_{it} in Table 1 and from $MS\$_{it}$ and $XS\$_{it}$ above that

$$MS\$_{it} = (PM_{it} MS_{it})/e_{it} ,$$

$$XS\$_{it} = (PX_{it} XS_{it})/e_{it} .$$

Notice also from Table 1 that

$$M\$_{it} = (PM_{it} M_{it})/e_{it} ,$$

$$X\$_{it} = (e_{i75} PX_{it}\ X75\$_{it})/e_{it} .$$

Therefore, from (i)-(iv) the equation for BOP^*_{it} can be written

$$BOP^*_{it} = PX_{it}(e_{i75} X75\$_{it} + XS_{it}) - PM_{it}(M_{it} + MS_{it}) + TT^*_{it} ,$$

which is equation 17 in Table 2.

E. For countries with no PM data it is not the case that $M\$_{it} = (PM_{it} M_{it})/e_{it}$. (See note 1 to Table 1.) For these countries TT^*_{it} was taken to be

$$TT^*_{it} = BOP^*_{it} - PX_{it}(e_{i75} X75\$_{it} + XS_{it}) - PM_{it}(M_{it} + MS_{it}) ,$$

where PM_{it} and M_{it} are defined in note 1 to Table 1.

a variable were "made up" if there were a relatively small gap in an otherwise good series. In these cases the data were usually made up by linearly interpolating between the closest two available observations. In a few cases quarterly data on the consumer price index (CPI) were used for quarterly interpolations of annual data, and for France and Switzerland quarterly data on employment (EMPL) rather than on industrial production were used for the quarterly interpolation of the NIA data. For many countries only discount rate data were available for the short term interest rate (r), and these cases are mentioned in the table. For a few countries the NIA year began other than January 1, and this had to be taken into account in the quarterly interpolations. These cases are also mentioned in the table. For a few countries data on real GNP (Y) were not available, but data on the nominal NIA variables were. In these cases, as indicated in the table, CPI data were used for the GNP deflator. Real GNP was then taken to be nominal GNP divided by the GNP deflator.

Quarterly population data were not available for any country, and the procedure in Table A-2 was used to construct quarterly from annual data. See in particular the note at the bottom of the table.

Quarterly DOT data began only in 1970I, and no attempt was made to construct DOT data before this quarter. Instead, the variables in the model were constructed in such a way (with one exception noted below) that no DOT data were needed in the estimation of the model. In other words, no DOT data were used for the estimates in Table 4. This allowed the estimation periods for most countries to be much longer than would otherwise be the case. The DOT data are needed, of course, for the solution of the model, and so the earliest quarter for which the model can be solved in 1970I. In a few cases annual but not quarterly DOT data were available, and in these cases the procedure in Table A-2 was used to construct the quarterly data. In a few cases no DOT data existed, and in these cases the observations were assumed to be zero.

For a few countries no data on import prices were available, and for these countries the data were constructed as indicated in note 1 to Table 1 in the text. This construction required the existence of DOT data, and this is the exception mentioned above where DOT data were needed for the estimation work. For countries for which DOT data were used in the construction of the import price index, the estimation period had to begin no earlier than 1970I for the equations that relied on these data.

The links to and from the U.S. model are listed in Table A-4. The two key exogenous foreign sector variables in the U.S. model are the real value of exports (EX^u) and the import price deflator (PIM^u). When the U.S. model is embedded in the overall model, these two variables become endogenous. The endogenous variables in the U.S. model that affect the rest of the model are the real value of imports (IM^u), the export price deflator (PEX^u), the bill rate $(RBILL^u)$, the GNP deflator $(GNPD^u)$, real GNP $(GNPR^u)$, and a demand pressure variable (ZJ'^u). The data base for the U.S. model is different from the data base for the U.S. on the IFS tape (among other things, the real variables in the U.S. model are in 72\$, whereas the real variables for the U.S. on the IFS tape are in 75\$), and the δ_{it} variables in Table A-4 are used to link the two data sets.

The sample periods that were used for the estimation work are listed in Table 4 in the text. The beginning of the sample period was usually taken to be four quarters after the beginning of the data, and the end

TABLE A-4. Links To and From the U.S. Model

A. Relevant endogenous variables in the U.S. model (Fair, 1980b):

IM^u_t = real value of imports (NIA) in 72\$.

PEX^u_t = implicit price deflator for exports (NIA), 1972 = 1.0.

$RBILL^u_t$ = three-month treasury bill rate, percentage points.

$GNPD^u_t$ = GNP deflator, 1972 = 1.0.

$GNPR^u_t$ = real GNP in 72\$.

ZJ'^u_t = demand pressure variable.

Links from the endogenous variables in the U.S. model to the variables that affect the rest of the world:

$M75\$A_{1t} = IM^u_t/\delta_{2t} - M75\$B_{1t} - MS_{1t} - IMDIS_{1t}$. [merchandise imports in 75\$ from Type A countries.]

$PX_{1t} = PEX^u_t/\delta_{3t}$. [export price index, 1975 = 1.0.]

$PY_{1t} = GNPD^u_t/\delta_{6t}$. [GNP deflator, 1975 = 1.0.]

$r_{1t} = RBILL^u_t$. [three-month interest rate.]

$Y_{1t} = GNPR^u_t/\delta_{5t}$. [real GNP in 75\$.]

B. Relevant exogenous variables in the U.S. model:

EX^u_t = real value of exports (NIA) in 72\$.

PIM^u_t = implicit price deflator for imports (NIA), 1972 = 1.0.

Links from the rest of the world to the exogenous variables in the U.S. model:

$$EX^u_t = \delta_{1t}EX_{1t} = \delta_{1t}(X75\$_{1t} + XS_{1t} + EXDIS_{1t}) \ .$$

$$PIM^u_t = \delta_{4t}PM_{1t} \ .$$

C. New exogenous variables:

$$\delta_{1t} = EX^u_t/EX_{1t} = EX^u_t/(X75\$_{1t} + XS_{1t} + EXDIS_{1t}) \ .$$

$$\delta_{2t} = IM^u_t/(M75\$A_{1t} + M75\$B_{1t} + MS_{1t} + IMDIS_{1t}) = IM^u_t/IM_{1t} \ .$$

$$\delta_{3t} = PEX^u_t/PX_{1t} \ .$$

$$\delta_{4t} = PIM^u_t/PM_{1t} \ .$$

$$\delta_{5t} = GNPR^u_t/Y_{1t} \ .$$

$$\delta_{6t} = GNPD^u_t/PY_{1t} \ .$$

D. Other relevant equations:

$$M_{1t} = M75\$A_{1t} + M75\$B_{1t} \ .$$

$$BOP^*_{1t} = PX_{1t}(X75\$_{1t} + XS_{1t}) - PM_{1t}(M_{1t} + MS_{1t}) + TT^*_{1t} \ .$$

$$A^*_{1t} = A^*_{1t-1} + BOP^*_{1t} \ .$$

of the sample period was usually taken to be the last quarter of the data. One can thus tell from Table 4 approximately how much data are available for each country.

REFERENCES

Ball, R. J., ed. The International Linkage of National Economic Models. Amsterdam: North-Holland, 1973.

Berner, Richard, Peter Clark, Howard Howe, Sung Kwack, and Guy Stevens. "Modeling the International Influences on the U.S. Economy: A Multi-Country Approach," International Finance Discussion Paper No. 93, Board of Governors of the Federal Reserve System, 1976.

Dornbusch, Rudiger. "Capital Mobility, Flexible Exchange Rates and Macroeconomic Equilibrium." In Recent Developments in International Monetary Economics, edited by E. Claassen and P. Salin. Amsterdam: North-Holland, 1976.

Fair, Ray C. A Model of Macroeconomic Activity. Vol. 1. The Theoretical Model. Cambridge, Mass.: Ballinger, 1974.

__________. A Model of Macroeconomic Activity. Vol. 2. The Empirical Model. Cambridge, Mass.: Ballinger, 1976.

__________. "The Sensitivity of Fiscal Policy Effects to Assumptions about the Behavior of the Federal Reserve." Econometrica. 46 (September 1978): 1165-80.

__________. "A Model of the Balance of Payments." Journal of International Economics. 9 (February 1979): 25-46. (a)

__________. "On Modeling the Economic Linkages among Countries." In International Economic Policy: Theory and Evidence, edited by Rudiger Dornbusch and Jacob A. Frenkel. Baltimore: The Johns Hopkins University Press, 1979. (b)

__________. "Estimating the Expected Predictive Accuracy of Econometric Models." International Economic Review. 21 (June 1980): 355-378. (a)

__________. "The Fair Model as of August 1, 1980." Mimeographed. New Haven, Conn.: Yale University, 1980. (b)

__________. "Estimated Output, Price, Interest Rate, and Exchange Rate Linkages Among Countries." Cowles Foundation Discussion Paper No. 592, April 30, 1981.

__________ and William R. Parke. "The Fair-Parke Program for the Estimation and Analysis of Nonlinear Econometric Models." Mimeographed, New Haven, Conn.: Yale University, March 1981.

Frenkel, Jacob A. and Harry G. Johnson, eds. The Monetary Approach to the Balance of Payments. Toronto: University of Toronto Press, 1976.

Frenkel, Jacob A. and Carlos A. Rodrigues. "Portfolio Equilibrium and the Balance of Payments: A Monetary Approach." The American Economic Review. 65 (September 1975): 674-88.

Hickman, Bert G. "International Transmission of Economic Fluctuations and Inflation." In International Aspects of Stabilization Policies, edited by Albert Ando, Richard Herring, and Richard Martson. Boston: Federal Reserve Bank of Boston, 1974.

Kouri, Penti J. K. "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run." Scandinavian Journal of Economics. 2 (May 1976): 280-304.