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5 The Mark III International Transmission Model: Specification

Michael R. Darby and Alan C. Stockman

The Mark III International Transmission Model provides a convenient framework for testing a variety of hypotheses about the workings of and linkages among individual macroeconomics. It is a quarterly macroeconometric model of the United States, the United Kingdom, Canada, France, Germany, Italy, Japan, and the Netherlands estimated for 1957 through 1976.[1] A number of hypotheses are incorporated in the structure of the model so that the data can determine their empirical relevance; test results for those hypotheses will be reported in the next chapter. More complex alternative hypotheses involving the impact of anticipated changes in aggregate demand variables and the channels of influence of the real oil price are examined in chapters 8 and 9. Simulation experiments with a simplified version of the model are reported in chapter 7. Both the full model as specified here and the simulation (Mark IV) model are available to other researchers via the TROLL system upon arrangement with the authors.

The Mark III Model has been constructed to test the existence of various channels by which inflation can be transmitted from country to country and to quantify the relative importance of those channels. We have attempted to include all the major channels emphasized in the international literature to determine their empirical relevance. We have been very parsimonious in our choice of exogenous variables lest a possible transmission channel be assumed away.[2]

Briefly, the model consists of two sorts of submodels: the reserve country (U.S.) submodel and the nonreserve country submodels. In turn,

1. This is the period covered by the basic project data bank (see chapter 4) after loss of initial observations due to lagged values appearing in the model proper and in the definitions of expected values.
2. The model is identified by a large number of lagged endogenous variables.

the latter submodels exist in two forms, pegged and floating, according to whether the exchange rate is taken as exogenous or an exchange intervention reaction function is specified. Each submodel contains eight to ten behavioral equations and about the same number of identities. Each submodel can be conveniently divided into two main groups of behavioral equations, domestic and international. The specification of the domestic equations is presented in section 5.1, and the international equations and identities follow. Section 5.3 discusses the formation of expectations in the model. The chapter concludes with a review of the international transmission channels contained in the model.

5.1 The Domestic Subsectors

These subsectors consist of four or five stochastic equations which can be identified by the variable upon which we have normalized for simultaneous estimation. They are the real-income, price-level, unemployment-rate, nominal money, and interest-rate equations. Since these equations are nearly identical for all the different submodels, it is simplest to go through them equation by equation. Note that for easy reference, notation and the model equations are collected in tables 5.1 through 5.7 at the end of this chapter.

5.1.1 Real Income—Equations (R1) and (N1)

The real-income equation is similar to that of Barro (1978), except that it is specified in growth-rate form and it includes real-government-spending and scaled-export shocks (innovations) in addition to nominal money shocks. The most easily accessible form of the equation is

$$(5.1)\qquad \begin{aligned} \Delta \log y_j = {} & \alpha_{j1} - \alpha_{j2}(\log y_{j,t-1} - \log y^P_{j,t-1}) \\ & + \sum_{i=0}^{3} \alpha_{j,3+i}\hat{M}_{j,t-i} + \sum_{i=0}^{3} \alpha_{j,7+i}\hat{g}_{j,t-i} \\ & + \sum_{i=0}^{3} \alpha_{j,11+i}\hat{x}_{j,t-i} + \epsilon_{j1}. \end{aligned}$$

This form allows the money, government-spending, and export shocks ($\hat{M}_j$, $\hat{g}_j$, and $\hat{x}_j$) to have an impact in the first four quarters, but thereafter the same exponential decay at the rate α_{j2} is imposed however the logarithmic transitory income ($\log y_j - \log y_j^P$) is achieved. This allows considerable freedom without estimating a great many coefficients.[3] Note that if real income initially equals permanent income and no shocks (including the disturbance ϵ_{j1}) occur, real income grows at the trend rate of α_{j1} per quarter. The estimating equations (R1) for the reserve sub-

3. Inclusion of actual values of money, government spending, and scaled exports is explored in chapter 9 below. A detailed derivation of the equation is presented there in section 9.1.

model and (N1) for the nonreserve submodels are the same as (5.1) except for shifting log $y_{j,t-1}$ from the left to the right side. (See tables 5.2, 5.3, and 5.4.)

5.1.2 Price Level—Equations (R2) and (N2)

The price-level equation is obtained by equating nominal money supply and demand and solving for the price level. The demand for money function used is generalized from that of Carr and Darby (1981). The Carr-Darby function allows for different adjustment processes depending on whether a change in nominal money is anticipated or unanticipated. The logarithm of real money demand is assumed to be a function of logarithmic permanent and transitory income, the domestic interest rate R_j, the foreign interest rate adjusted for expected depreciation, the lagged logarithm of real money, and a four-quarter distributed lag on the money shocks.[4] Thus a typical nonreserve money demand function would be

$$
\begin{aligned}
(5.2) \qquad \log M_j^D - \log P_j = {} & \chi_1 + \chi_2 \log y_j^P + \chi_3(\log y_j - \log y_j^P) \\
& + \chi_4 R_j + \chi_5[R_1 + (4\Delta \log E_{j,t+1})^*] \\
& + \chi_6(\log M_{j,t-1} - \log P_{j,t-1}) \\
& + \sum_{i=0}^{3} \chi_{7+i} \hat{M}_{j,t-i} - \epsilon_{j2}.
\end{aligned}
$$

The coefficients χ_2 and χ_3 are expected to have positive signs, χ_4 and χ_5 are supposed to be negative, and the partial adjustment parameter χ_6 should lie between 0 and 1. The impact effect χ_7 of a money demand shock should also lie between 0 and 1 and indicates the shock-absorber increase in money demand. The values χ_8 through χ_{10} allow for lagged shock-absorber demand effects.

The price-level equation is obtained by substituting the money market equilibrium condition that nominal money supply log M equals nominal money demand log M^D and normalizing on log P_j:

$$
\begin{aligned}
(\mathrm{N2}) \qquad \log P_j = {} & \log M_j + \beta_{j1} + \beta_{j2} \log y_j^P + \beta_{j3}(\log y_j - \log y_j^P) \\
& + \beta_{j4} R_j + \beta_{j5}[R_1 + (4\Delta \log E_{j,t+1})^*] \\
& + \beta_{j6}(\log M_{j,t-1} - \log P_{j,t-1}) \\
& + \sum_{i=0}^{3} \beta_{j,7+i} \hat{M}_{j,t-i} + \epsilon_{j2}.
\end{aligned}
$$

Obviously the β_{ji} are simply the negative of the corresponding χ_i. Thus the expected parameter values are

4. The foreign interest rate is included at the suggestion of Don Mathieson and Michael Hamburger to test for the substitutability of foreign bonds for domestic money. The U.S. interest rate R_1 is used for the nonreserve countries, and the U.K. interest rate is used for the United States. Carr and Darby (1981) entered only the current money shock, but our distributed lag permits the data to determine a more complicated adjustment process.

$$\beta_{j2}, \beta_{j3} < 0 \qquad 0 \geq \beta_{j6}, \beta_{j7} \geq -1$$
$$\beta_{j4}, \beta_{j5} > 0.$$

The reserve-country equation is practically the same except that the U.K. interest rate and expected depreciation are used instead of the U.S. variables for the foreign interest rate. Thus

$$\text{(R2)} \qquad \begin{aligned} \log P_1 = {} & \log M_1 + \beta_{11} + \beta_{12} \log y_1^P \\ & + \beta_{13}(\log y_1 - \log y_1^P) + \beta_{14} R_1 \\ & + \beta_{15}[R_2 - (4\Delta \log E_{2,t+1})^*] \\ & + \beta_{16}(\log M_{1,t-1} - \log P_{1,t-1}) \\ & + \sum_{i=0}^{3} \beta_{1,7+i} \hat{M}_{1,t-i} + \epsilon_{12}. \end{aligned}$$

Note that we subtract the expected depreciation of the foreign currency $(\Delta \log E_{2,t+1})^*$ here while we add the expected depreciation of the domestic currency in equations (N2). The expected parameter values for β_{12} through β_{17} are as indicated above.

5.1.3 Unemployment Rate—Equations (R3) and (N3)

This is a dynamic form of Okun's law which allows for an eight-quarter distributed lag effect of real income growth on changes in the unemployment rate. It is included only in the U.S., U.K., and French submodels. The other countries in the model have unemployment rates which are uncorrelated with present and past changes in real income. For those countries, logarithmic transitory real income replaces the unemployment rate in the nominal money reaction functions.

5.1.4 Nominal Money—Equations (R4) and (N4)

A standard nominal money reaction function (N4) has been adopted for the nonreserve countries. We have specified a form with sufficient generality to allow for varying lags in acquisition and utilization of information by the various monetary authorities.[5] The reaction functions explain the nominal money growth rate by the current and appropriately lagged scaled balance of payments, the lagged unemployment rate or transitory real income, lagged inflation rates, and current and lagged innovations in real government spending. Semiannual observations were used for lagged values to reduce the number of fitted coefficients except for the unemployment-rate or transitory-income variable, for which preliminary experimentation suggested a complicated lag pattern. Since

5. Preliminary investigation uncovered substantial variation in how quickly different countries responded to the various determinants. In the exploratory Mark II version of the model, money reaction functions were tailored to the individual countries (see Darby 1979). Experience with that approach indicated both difficulties in cross-country comparisons and difficulties with understated standard errors.

under floating exchange rates more attention can be paid to inflation goals and less to balance-of-payments equilibrium, we used a floating dummy variable to estimate shifts in the inflation and balance-of-payments coefficients during the floating period. This equation is

$$
\begin{aligned}
\text{(N4)} \qquad \Delta \log M_j = {} & \eta_{j1} + \eta_{j2} t + \eta_{j3} \hat{g}_j + \eta_{j4}(\hat{g}_{j,t-1} + \hat{g}_{j,t-2}) \\
& + \eta_{j5}(\hat{g}_{j,t-3} + \hat{g}_{j,t-4}) \\
& + \eta_{j6}(\log P_{j,t-1} \log P_{j,t-3}) \\
& + \eta_{j7}[DF_j(\log P_{j,t-1} - \log P_{j,t-3})] \\
& + \eta_{j8}(\log P_{j,t-3} - \log P_{j,t-5}) \\
& + \eta_{j9}[DF_j(\log P_{j,t-3} - \log P_{j,t-5})] \\
& + \eta_{j,10} u_{j,t-1} + \eta_{j,11} u_{j,t-2} + \eta_{j,12} u_{j,t-3} \\
& + \eta_{j,13} u_{j,t-4} + \eta_{j,14} (B/Y)_j \\
& + \eta_{j,15}[DF_j(B/Y)_j] \\
& + \eta_{j,16}[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}] \\
& + \eta_{j,17}\{DF_j[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}]\} \\
& + \eta_{j,18}[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}] \\
& + \eta_{j,19}\{DF_j[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}]\} \\
& + \epsilon_{j4},
\end{aligned}
$$

where minus logarithmic transitory income ($\log y_j^P - \log y_j$) is substituted for u in the equations for Canada, Germany, Italy, Japan, and the Netherlands.

The real-government-spending shocks are included to allow for monetization of unusual deficits.[6] If this occurs, then the coefficients should be positive at least initially with negative lagged coefficients possible if the central bank reverses its even-keeling operations. Inflation coefficients η_{j6} and η_{j8} should be negative. The additional coefficients η_{j7} and η_{j9} during the floating period should also be negative if the central bank shifts weight from the balance of payments to fighting inflation.[7] Some of the coefficients $\eta_{j,10}$ through $\eta_{j,13}$ should be positive so that higher levels of unemployment or lower levels of transitory income are associated with higher nominal-money growth rates. In preliminary experiments, it was noted that the data seemed to indicate it was the change rather than the level that entered.[8] Given the problems with unemployment-rate data, in five of our countries negative logarithmic transitory income ($\log y_j^P - \log y_j$) was substituted for u_j. While the expected signs are thus preserved, the coefficients should be lower by a factor of 3 to 4 than in the unemployment-rate countries.

6. We experimented with changes in interest rates to model even keeling directly, but simultaneity was too severe to obtain usable estimates.

7. At least some countries may have ceased worry about either the balance of payments or inflation once the commitment to a pegged exchange rate was dropped.

8. That is, the sum of the coefficients was often zero with a positive coefficient followed by an offsetting negative coefficient.

The balance of payments is scaled here (to avoid nonlinearities in the model) by nominal income rather than nominal high-powered money as is common in the monetary approach literature. Since the ratio of nominal high-powered money to nominal income H/Y is reasonably stable in our sample period, conversions are straightforward from one scaling to the other. If the coefficient on the contemporaneous scaled balance of payments[9] equals Y/H, this indicates the absence of sterilization since the proportional increase in the money supply equals the ratio of the balance-of-payments surplus to high-powered money. The remainder of the nominal-money reaction function could be thought of as determining money growth due to domestic credit as in the monetary approach literature. If the coefficient of $(B/Y)_j$ is less than Y/H, then some sterilization is being practiced, regardless of whether monetary control is being exercised.[10] The lagged response of money growth to the balance of payments is important to the stability of a pegged exchange-rate system if monetary control is exercised through short-run sterilization. Both impact and cumulative effects of the balance of payments will be discussed in some detail in chapter 6.

The nominal-money reaction function (R4) for the reserve-currency country differs from the nonreserve equations in (*a*) omitting all terms involving the balance of payments and the floating dummy and (*b*) including two lagged dependent variables in response to a seemingly complicated adjustment process and indicated by earlier work. The first of these differences is consistent with the unique role of the reserve country stressed in Darby (1980). For the most part, the balance of payments consists of purchases and sales of U.S.–dollar denominated interest-bearing securities and deposits which have no effect on U.S. high-powered money. Any intervention undertaken by the U.S. monetary authorities can be sterilized so that the U.S. controls its nominal money supply and implicitly determines the world price level under pegged exchange rates. Empirical work reported in Darby (1981) supports the absence of balance-of-payments effects on U.S. nominal money growth. In fact, as reported there, whenever the current and two lagged semiannual scaled balance-of-payments terms were added to equation (R4) or variants thereof, their estimated coefficients were trivial in magnitude, insignificantly different from zero, and generally perverse in sign. Thus the balance-of-payments link is severed, and international influences affect the U.S. money supply only indirectly via the lagged inflation and unemployment rates.

9. This is $\eta_{j,14}$ during the pegged period and $\eta_{j,14} + \eta_{j,15}$ during the floating period.
10. This question is discussed at length in part III (especially chapters 10 and 11).

5.1.5 Interest Rate—Equations (R5) and (N5)

The real interest-rate equation is based on a goods market equilibrium condition, but problems were encountered in specifying a dynamic investment function. As a result, we explain the real interest rate by the lagged expected inflation rate, time, the lagged interest rate, and four-quarter distributed lags on innovations in nominal money, real government spending, and real net exports. The nominal interest rate is therefore explained by these terms and by the expected inflation rate. Thus the interest-rate and real-income equations can be interpreted as reflecting the outcome of a short-period IS-LM model which shifts around long-run equilibrium in response to current and lagged innovations in the demand variables. Persistent effects on the real interest rate are possible via the lagged expected-inflation and interest rates.

To be precise, the equations estimated are of the form

(R5) & (N5)

$$\begin{aligned} R_j = {} & \delta_{j1} + \delta_{j2}t + \delta_{j3}(4\Delta \log P_{j,t+1})^* + \delta_{j4}R_{j,t-1} \\ & + \delta_{j5}(4\Delta \log P_j)^* + \sum_{i=0}^{3} \delta_{j,6+i}\hat{M}_{j,t-i} \\ & + \sum_{i=0} \delta_{j,10+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3} \delta_{j,14+i}\hat{x}_{j,t-i} + \epsilon_{j5}. \end{aligned}$$

As with the real-income equations, the last twelve RHS terms capture the effects of innovations in aggregate demand variables on the interest rate. The first five terms specify a normal level[11] of the interest rate and a rather free partial adjustment process. If there is partial adjustment of the real interest rate but instantaneous adjustment to changes in inflation expectations, then it can be shown that $\delta_{j5} = -\delta_{j3}\delta_{j4}$, where δ_{j3} is the full impact of expected inflation on the nominal interest rate.[12] If a partial adjustment process applies to the nominal rate, then δ_{j5} goes to zero and δ_{j3} goes to the long-run impact times $(1 - \delta_{j4})$.

5.2 The International Subsectors

The international subsectors consist of an import demand equation, an import supply equation, an export equilibrium equation, a net-capital-outflows equation, and, for floating nonreserve submodels only, an exchange-rate intervention reaction function. As explained below, different normalizations are used for the import demand and supply equations under floating exchange rates to correspond to the exchange intervention reaction function.

11. The normal level of the interest rate may be growing via the time trend term $\delta_{j2}t$.

12. Because of income taxation, this need not be unity as in the classic Fisher equation; see Darby (1975).

5.2.1 Import Demand—Equations (R7), (N7P), and (N7F)

The basic form of the import demand equation is used for the reserve and pegged nonreserve submodels. The dependent variable is imports as a fraction of income.[13] The standard explanatory variables are the lagged dependent variable, permanent income, and distributed lags on the relative price of imports and domestic logarithmic transitory income:

(R7) & (N7P)

$$(I/Y)_j = \lambda_{j1} + \lambda_{j2}(I/Y)_{j,t-1} + \lambda_{j3}\log y_j^P + \sum_{i=0}^{1} \lambda_{j,4+i}(\log y_{j,t-i} - \log y_{j,t-i}^P) + \sum_{i=0}^{3} \lambda_{j,6+i} Z_{j,t-i} + \epsilon_{j7}.$$

If a partial adjustment process is operative here, λ_{j2} should fall between 0 and 1. The sign λ_{j3} depends on whether the long-run income elasticity of imports is greater or less than unity. The coefficients λ_{j4} and λ_{j5} are similarly ambiguous in sign since they indicate whether transitory income increases imports more of less than in proportion to income. The relative price of imports variable Z_j is the logarithm of import prices less the logarithm of the domestic price level. Whether the coefficients λ_{j6} through λ_{j9} are positive or negative depends on the relative price elasticity of imports since the dependent variable is the scaled *value* of imports. The traditional literature has suggested a so-called *J*-curve phenomenon in which the short-run price elasticity is much smaller than in the long run. This would be reflected in a positive λ_{j6} offset by negative values of λ_{j7} through λ_{j9}.

For the floating nonreserve submodel, the import demand equation is renormalized by solving for the current relative price of imports:

(N7F)

$$Z_j = \frac{-\lambda_{j1}}{\lambda_{j6}} + \frac{1}{\lambda_{j6}}(I/Y)_j - \frac{\lambda_{j2}}{\lambda_{j6}}(I/Y)_{j,t-1} - \frac{\lambda_{j3}}{\lambda_{j6}}\log y_j^P - \sum_{i=0}^{1} \frac{\lambda_{j,4+i}}{\lambda_{j6}}(\log y_{j,t-i} - \log y_{j,t-i}^P) - \sum_{i=1}^{3} \frac{\lambda_{j,6+i}}{\lambda_{j6}} Z_{j,t-i} - \frac{\epsilon_{j7}}{\lambda_{j6}}.$$

Under floating rates, scaled imports are given by the balance-of-payments identity.

5.2.2 Import Supply—Equations (R8), (N8P), and (N8F)

The import supply equation is used to determine the logarithm of import prices in the reserve and pegged nonreserve submodels. It was

13. We similarly measure exports and capital flows as a fraction of income so that a balance of payments scaled as a fraction of income results from imposition of the identity to assure asset market equilibrium.

necessary to first-difference the equation to obtain stationary residuals. The equation explains the change in the logarithm of import prices by a constant and the first differences of the logarithm of the real oil price, the scaled import variable, the logarithm of foreign real income, the logarithm of the foreign price level, the logarithm of the exchange rate, and also the lagged dependent variable.

(R8) & (N8P)

$$\begin{aligned}\log P_j^I = {} & \log P_{j,t-1}^I + \mu_{j1} + \mu_{j2}\Delta \log P_{j,t-1}^I \\ & + \mu_{j3}\Delta \log P^{RO} + \mu_{j4}\Delta \log y_j^R + \mu_{j5}\Delta (I/Y)_j \\ & + \mu_{j6}\Delta \log P_j^R + \mu_{j7}\Delta \log E_j + \epsilon_{j8}.\end{aligned}$$

The coefficient μ_{j2} should lie between 0 and 1 if there is a partial adjustment process for import prices, perhaps due to shipping and contracting lags. The real price of oil is included as an exogenous variable shifting the import supply curve since no OPEC country is included directly in the model; so μ_{j3} should be positive. Rest-of-world real income proxies foreign capacity, and so μ_{j4} is expected to be positive. The supply curve may be either flat or upward sloping depending on the country and its importance in the world demand for its imports; so $\mu_{j5} \geq 0$. Both μ_{j6} and μ_{j7} should be positive since $\log P_j^R + \log E_j$ is the logarithm of rest-of-world prices converted into domestic currency units. The equality constraint is not imposed a priori on μ_{j6} and μ_{j7} since at least under pegged rates changes in $\log E_j$ may be associated with offsetting movements in tariffs and other barriers.

The import supply equation is renormalized to solve for the exchange rate in the floating nonreserve submodels:

(N8F)

$$\begin{aligned}\log E_j = {} & \log E_{j,t-1} - \frac{\mu_{j1}}{\mu_{j7}} + \frac{1}{\mu_7}\Delta \log P_j^I \\ & - \frac{\mu_{j2}}{\mu_{j7}}\Delta \log P_{j,t-1}^I - \frac{\mu_{j3}}{\mu_{j7}}\Delta \log P^{RO} \\ & - \frac{\mu_{j4}}{\mu_{j7}}\Delta \log y_j^R - \frac{\mu_{j5}}{\mu_{j7}}\Delta (I/Y)_j \\ & - \frac{\theta_{j6}}{\mu_{j7}}\Delta \log P_j^R - \frac{\epsilon_{j8}}{\mu_{j7}}.\end{aligned}$$

Of course in a simultaneous model, no single equation can be said to determine the exchange rate or any other endogenous variable.

5.2.3 Exports—Equations (R6) and (N6)

No acceptable price series were generally available for exports, so we specified an equilibrium equation in the form

(R6) & (N6)

$$
\begin{aligned}
(X/Y)_j = {} & \theta_{j1} + \theta_{j2}t + \theta_{j3}\log P^{RO} + \theta_{j4}(\log y_j - \log y_j^P) \\
& + \sum_{i=0}^{1} \theta_{j,5+i}(X/Y)_{j,t-1-i} + \sum_{i=0}^{1} \theta_{j,7+i}\log y_{j,t-i}^R \\
& + \sum_{i=0}^{1} \theta_{j,9+i}\log P_{j,t-i} + \sum_{i=0}^{1} \theta_{j,11+i}\log P_{j,t-i}^R \\
& + \sum_{i=0}^{1} \theta_{j,13+i}\log E_{j,t-i} \\
& + \sum_{i=0}^{1} \theta_{j,15+i}DF_{j,t-i}\log E_{j,t-i} + \epsilon_{j6}.
\end{aligned}
$$

Time (in lieu of an index of permanent incomes) and the two foreign real-income variables shift foreign demand, so θ_{j7} and θ_{j8} should be positive. The real price of oil indicates increased wealth of OPEC export demanders, so θ_{j3} should be positive. Domestic transitory income has a negative effect since X is scaled by Y but a positive effect as a capacity measure, so θ_{j4} has an ambiguous sign. Two lagged dependent variables were included to allow for partial adjustment processes in both export supply and demand similar to those allowed for imports; θ_{j5} and θ_{j6} should lie between 0 and 1. The price variables enter because a decrease in the logarithm of the domestic price level relative to the exchange-rate-converted foreign price level (i.e. $\log P_j - \log P_j^R - \log E_j$) should encourage domestic tradables production generally and the sale of exports in particular. Thus θ_{j9} and $\theta_{j,10}$ should be negative while $\theta_{j,11}$ through $\theta_{j,14}$ should be positive. The coefficients $\theta_{j,15}$ and $\theta_{j,16}$ allow for differential effects of exchange-rate changes under floating exchange rates. For the reserve country, the exchange rate is identically 1 and all foreign prices are converted into dollars in computing $\log P^R$; thus the terms involving $\theta_{j,13}$ through $\theta_{j,16}$ are omitted in (R6).

5.2.4 Net Capital Outflows—Equations (R9) and (N9)

These equations are specified along traditional portfolio adjustment lines. An alternative approach is explored by Melvin in chapter 13 below. It should be noted that both the levels and changes of the components of the interest-rate differential appear: As is well known, changes in the interest differential will cause flows necessary to adjust the portfolio to a new equilibrium. The levels also appear because the interest-rate differential affects the optimal portfolio and hence capital flows in the context of real growth. Our dependent variable is measured to avoid counting most spurious nominal capital flows due to high levels of nominal interest rates, but if a country increases its accumulation of *nominal* dollar reserves when U.S. inflation and interest rates are high, then its scaled private capital outflows are decreased and U.S. capital outflows correspondingly increased.

The equation used is

(R9) & (N9)

$$\begin{aligned}(C/Y)_j = {} & \xi_{j1} + \xi_{j2}t + \xi_{j3}\log P^{RO} + \xi_{j4}R_j \\ & + \xi_{j5}(4\Delta \log E_{j,t+1})^* + \xi_{j6}R_1 \\ & + \xi_{j7}[(X/Y)_j - (I/Y)_j] \\ & + \xi_{j8}(\log y_j - \log y_j^P) + \xi_{j9}\Delta \log y_j \\ & + \xi_{j,10}\Delta \log y_j^R \\ & + \sum_{i=0}^{2} \xi_{j,11+i}\Delta R_{j,t-i} + \sum_{i=0}^{2} \xi_{j,14+i}\Delta R_{1,t-i} \\ & + \sum_{i=0}^{2} \xi_{j,17+i}\Delta(4\Delta \log E_{j,t+1-i})^* + \epsilon_{j9}.\end{aligned}$$

Domestic transitory income is included because of the use of Y as a scaling variable; so ξ_{j8} would be negative. Time and the change in domestic and foreign real income capture trend and cyclical movements in wealth. The sign of ξ_{j2} is indeterminant, but ξ_{j9} should be positive and $\xi_{j,10}$ negative on the view that they measure increases in the scale of the domestic and foreign portfolios. However, if booms attract foreign investment while recessions deter it, just the opposite signs would be anticipated.[14] Similarly the creation of OPEC as captured by log P^{RO} increases the potential wealth of foreign investors but may also deter foreign investment via increased uncertainty. Finally, increases in the scaled trade balance $(X/Y)_j - (I/Y)_j$ is widely supposed to induce an increase in trade credit so that ξ_{j7} is positive.

As to the interest variables, we have the domestic interest rate R_j, the foreign interest rate R_1, and the corresponding expected depreciation of the exchange rate $(4\Delta\ \lambda o\gamma\ E_{j,t+1})^*$.[15] Generally the increase in the differential $R_j - (4\Delta \log E_{j,t+1})^* - R_1$ will decrease net capital outflows in long-run equilibrium and particularly during a transitional portfolio adjustment period. Therefore the coefficients should be generally negative on the level and changes in R_j but positive for the levels and changes in $(4\Delta \log E_{j,t+1})^*$ and R_1. The implicit constraints were not imposed because of varying quality of data on each component of the differential, and because of the problems inherent in measuring the balances of payments in nominal terms.

5.2.5 Balance of Payments—Equations (N10F)

In the nonreserve floating submodel, a tenth behavioral equation is added to complete the model since the logarithm of the exchange rate becomes an endogenous variable. This is our exchange intervention equation which explains the scaled balance of payments by the lagged

14. Branson (1968) and Prachowny (1969) have other explanations for ambiguity of the income signs.

15. For the U.S. equation (R9), the British interest rate R_2 is used as the foreign interest rate and the corresponding expected depreciation is $-(4\Delta \log E_{2,t+1})^*$.

dependent variable and the log change in the exchange rate as compared to the same log change lagged one-quarter and to the lagged differential between the domestic and U.S. inflation rates:

(N10F)
$$(B/Y)_j = \psi_{j1} + \psi_{j2}(B/Y)_{j,t-1} + \psi_{j3}\Delta \log E_j + \psi_{j4}\Delta \log E_{j,t-1} + \psi_{j5}(\Delta \log P_{j,t-1} - \Delta \log P_{1,t-1}) + \epsilon_{j,10}.$$

The coefficient ψ_{j2} could be positive or negative depending on whether intervention is persistent or self-reversing. If the authorities resist depreciations of the exchange rate at a faster rate than recently or than indicated by the fundamentals (differential inflation), then ψ_{j3} should be negative and ψ_{j4} and ψ_{j5} positive.

5.2.6 Identities—Equations (R11)–(R19) and (N11)–(N19)

Logarithmic permanent income is defined in identities (R11) and (N11).[16] Identities (R12) and (N12P) determine the scaled balance of payments; this is solved instead for scaled imports in the floating (N12F). Money and export shocks are defined in identities (R13), (R14), (N13), and (N14). Identities (R15) and (N15P) define the relative price of imports; in the floating case, this is solved for import prices as in (N15F). The expectational identities (R16), (R17), (N16), and (N17) are for expectations of next period's prices and exchange rate based on current information. Their specification is discussed in section 5.3. Nominal-income-weighted geometric averages of the other seven countries' real income and prices are defined by identities (R18), (R19), (N18), and (N19). The weights W_j are the ratios of country j's total nominal income (converted by E_j into dollars) for 1955I–76IV to the total for all eight countries. The parameters base y_j and base P_j set the indices y_j^R and P_j^R to 1 for 1970 and are listed with the W_j in table 5.7. Although these variables are endogenous for the whole model, they are treated somewhat differently in the simultaneous equation estimation method discussed in chapter 6.

5.3 Expected Values

There are four explicit plus one implicit expectational variables in the model: The explicit variables are $(4\Delta \log E_j)^*$, $(4\Delta \log P_j)^*$, $(\log M_j)^*$, and $(X/Y)_j^*$; $(\log g_j)^*$ also must be estimated in creating the exogenous variable $\hat{g}_j$. The first two of these variables appear in the model with leads

16. The weight ϕ_{j2} of current income in permanent income is taken as 0.025 following Darby (1977–78); this is equivalent to a real yield on all (human and nonhuman) wealth of about 10% per annum. The trend quarterly growth rate ϕ_{j3} was estimated, together with the initial value of $\log y_j^P$, by fitting the regression $\log y_j = \log y_j^P + \phi_{j3}t$; therefore $\phi_{j1} \equiv \phi_{j3}(1 - \phi_{j2})$.

so that they are based on current information. Therefore we treat them as endogenous for purposes of estimation.[17] The other three expected values are based only on lagged information and are therefore treated as predetermined for purposes of estimation.

The three predetermined expectational variables are all based on optimal univariate ARIMA processes. We also tried defining $(\log M_j)^*$ in terms of a transfer function based on the money-supply reaction functions (R4) and (N4), but the univariate process worked somewhat better both in terms of explanatory power and in terms of meeting our prior notions regarding the values of coefficients.[18] Since we are treating real government spending as exogenous, it was appropriate to model $(\log g_j)^*$ by a univariate ARIMA process. Because of the short lags in the export equations and the relatively minor role of export shocks in the model as estimated, we did not attempt a full-scale transfer function approach for $(X/Y)_j^*$.

For the expected inflation rate $(4\Delta \log P_j)^*$ we adopted a transfer function based on the price-level equations (R2) and (N2) with information lags imposed. As detailed in table 5.5, the expected inflation rate $(4\Delta \log P_{j,t+1})^*$ is the systematic part of a transfer function which has as input series $(\log M_j)^*$, two lags of $\log M_j$, $\Delta \log y_{j,t-1}$, R_j, $R_{j,t-1}$, current and lagged exchange-rate-adjusted foreign interest rate, two lags of $\log P_j$, and three lagged money shocks. Note that since this expected inflation rate appears in the interest-rate equation, it is appropriate to assume that the information set includes current interest rates.

Finally, expected growth in the exchange rate $(4\Delta \log E_{j,t+1})^*$ differs by period and country. In general we do not wish to use the forward rate for this expectation because (1) this would require an additional equation for each nonreserve country to explain endogenously the forward rate's movements relative to movements in the expected growth in the exchange rate, and especially (2) the forward rate data are incomplete. For the floating period, we fitted regressions explaining $E_{j,t+1}$ by the current values of the variables appearing in the exchange-rate equation (N8F) and the lagged dependent variable. No significant autocorrelation appeared in the residuals. The predicted value of these regressions is used as $(4\Delta \log E_{j,t+1})^*$. Details are in part (*a*) of table 5.6. For the pegged period, we use a transfer function which has input series useful to predict both a revaluation and movements occurring in the absence of a revaluation. The expected change due to a revaluation is assumed to vary with the level of the scaled balance of payments and with this level times its

17. See identities (R16), (R17), (N16), and (N17).

18. This is understandable if the acquisition and processing of information is costly. See Darby (1976) and Feige and Pearce (1976). Some results on the sensitivity of estimates to alternative definitions of $(\log M_j)^*$ are reported in chapter 9.

absolute value.[19] Movements occurring in the absence of a revaluation are captured by the current growth rate and the logarithmic difference between the actual and pegged values of E_j. The latter variable may serve as well in predicting revaluations. Finally, lagged revaluation dummies are included because of the different meaning of the variables in the quarter immediately following a revaluation. Details are given in table 5.6, part (*b*).

5.4 International Linkages

Before turning to estimates in chapter 6 and simulations in chapter 7, let us summarize the manner in which alternative channels for the international transmission of inflation are specified in the model. The goal of estimation is to assess the relative empirical magnitudes of these channels.

First, changes in foreign prices affect domestic prices through a Humean price-specie-flow mechanism, which can occur either within a quarter or more slowly over time. Imports and exports are affected, in the model, by current and lagged changes in domestic prices. Unless this change in the balance of trade is exactly offset by a change in net capital outflows, it affects the balance of payments. But current and lagged levels of the balance of payments can affect nominal money growth (and the model permits this effect to differ under pegged and flexible exchange rates)—and hence inflation. (For a direct entry of the foreign price level into the domestic price equation, see Darby 1979.)

Second, changes in the expected foreign inflation rate (and hence interest rate) may affect the demand for domestic money through a currency substitution channel. Thus a permanent change in foreign inflation may have a temporary effect on domestic inflation through this channel.

Third, variables affecting international capital flows affect domestic inflation through their effect on the balance of payments and hence the nominal money supply. These effects may operate in the model either within the quarter or with lags. Since changes in the domestic money supply may induce changes in interest rates, real income, and the domestic price level, it may induce capital flows that have subsequent effects on the nominal money supply through the balance of payments. Thus the model permits the possibility that massive capital flows would frustrate any attempts at an independent monetary policy by a non-reserve-currency country. Another possibility permitted in the model is that such monetary policy may have short-run effects, but lead to offsetting capital flows after a lag.

19. This formulation closely approximates an expectation based on a Tobit analysis in which both the probability of a change and the size of the change varies with the balance of payments.

Fourth, changes in foreign real income may affect the domestic price level through an "absorption" channel: changes in income may affect the balance of payments and hence the money supply and price level by affecting either the balance of trade or capital flows. Furthermore, export shocks may affect domestic real income and, through the demand for money, the domestic price level.

Finally, changes in the real price of oil may affect domestic variables through effects on the trade balance, import prices, and international capital flows. Chapter 8 reports tests of whether there is an additional direct effect of this (or some other) kind of international supply shock on real income and the price level, or whether the effect can operate mainly through the effects on the trade balance and capital flows. It should be noted that both the balance of trade and the capital account may operate either separately or simultaneously in the model to transmit inflation internationally through the channels discussed here.

Estimates of the model are presented in chapter 6.

Acknowledgments

The other contributors to this volume have made innumerable contributions to the specification and estimation of the model reported in this chapter and the next. The authors acknowledge the able research assistance of Daniel M. Laskar, Michael T. Melvin, M. Holly Crawford, and Andrew A. Vogel and helpful suggestions from members of the project Advisory Board and the UCLA Monetary Economics Workshop. An exploratory version of the model was reported in Darby (1979).

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Table 5.1 Symbols Used in Mark III Model

baseP_j	Base to set mean value of log p_j^R to 0 for 1970 (i.e. P_j^R has geometric mean 1 for 1970). See table 5.7.
basey_j	Base to set mean value of log y_j^R to 0 for 1970 (i.e. y_j^R has geometric mean 1 for 1970). See table 5.7.
$(B/Y)_j$	Balance of payments as a fraction of GNP. (GDP is substituted if GNP is unavailable. The balance of payments is on the official reserve settlement basis at quarterly rates where possible and otherwise is the quarterly change in official reserves.)
$(C/Y)_j$	Net capital outflows as a fraction of GNP (measured as $(X/Y)_j - (I/Y)_j - 4(B/Y)_j$).
DF_j	Dummy variable equal to 1 for floating exchange-rate period; 0 otherwise.
E_j	Exchange rate in domestic currency units (DCUs) per U.S. dollar ($E_1 \equiv 1$).
g_j	Real government spending.
$\hat{g}_j$	Innovation in real government spending, log g_j – (log g_j)*.
$(I/Y)_j$	Imports as a fraction of GNP.

Table 5.1 (continued)

M_j	Money stock in billions of DCUs.
$\hat{M}_j$	Innovation in money, $\log M_j - (\log M_j)^*$.
P_j	Price deflator for GNP (or GDP) in DCUs per base-year DCU (1970 = 1.000).
P_j^I	Import price index (1970 = 1.000).
P_j^R	Index of foreign prices converted by exchange rates into U.S. dollars per base-year U.S. dollar.
P^{RO}	Real price of oil (dollar price of barrel of Venezuelan oil divided by P_1).
R_j	Short-term nominal interest rate in decimal per annum form (three-month treasury bill yield where available).
t	Time index (1955I = 1, 1955II = 2, etc.).
u_j	Unemployment rate in decimal form.
W_j	Nominal income weight; share of country j in total sample nominal income. See table 5.7.
$(X/Y)_j$	Exports as a fraction of GNP.
$\hat{x}_j$	Innovation in exports, $(X/Y)_j - (X/Y)_j^*$.
y_j	Real GNP (or GDP if GNP unavailable) in billions of base-year DCUs.
y_j^P	Permanent income in billions of base-year DCUs.
y_j^R	Index of foreign real income (1970 = 1.000).
Z_j	Relative price of imports, $\log P_j^I - \log P_j$.
*	Indicates expected value based on information up through previous quarter, with exception noted in section 5.3.

Country indices:

1 United States	5 Germany
2 United Kingdom	6 Italy
3 Canada	7 Japan
4 France	8 Netherlands

Table 5.2 **Reserve Country (U.S.) Submodel**

EQUATIONS

(R1) $$\log y_1 = \alpha_{11} + \alpha_{12}\log y^P_{1,t-1} + (1-\alpha_{12})\log y_{1,t-1} + \sum_{i=0}^{3}\alpha_{1,3+i}\hat{M}_{1,t-i} + \sum_{i=0}^{3}\alpha_{1,7+i}\hat{g}_{1,t-i} + \sum_{i=0}^{3}\alpha_{1,11+i}\hat{x}_{1,t-i} + \epsilon_{11}$$

(R2) $$\log P_1 = \log M_1 + \beta_{11} + \beta_{12}\log y^P_1 + \beta_{13}(\log y_1 - \log y^P_1) + \beta_{14}R_1 + \beta_{15}[R_2 - (4\Delta\log E_{2,t+1})^*] + \beta_{16}(\log M_{1,t-1} - \log P_{1,t-1}) + \sum_{i=0}^{3}\beta_{1,7+i}\hat{M}_{1,t-i} + \epsilon_{12}$$

(R3) $$u_1 = u_{1,t-1} + \gamma_{11} + \sum_{i=0}^{7}\gamma_{1,2+i}\Delta\log y_{1,t-i} + \epsilon_{13}$$

(R4) $$\Delta\log M_1 = \eta_{11} + \eta_{12}t + \eta_{13}\hat{g}_1 + \eta_{14}(\hat{g}_{1,t-1} + \hat{g}_{1,t-2}) + \eta_{15}(\hat{g}_{1,t-3} + \hat{g}_{1,t-4}) + \eta_{16}(\log P_{1,t-1} - \log P_{1,t-3}) + \eta_{18}(\log P_{1,t-3} - \log P_{1,t-5}) + \eta_{1,10}u_{1,t-1} + \eta_{1,11}u_{1,t-2} + \eta_{1,12}u_{1,t-3} + \eta_{1,13}u_{1,t-4} + \eta_{1,20}\Delta\log M_{1,t-1} + \eta_{1,21}\Delta\log M_{1,t-2} + \epsilon_{14}$$

(R5) $$R_1 = \delta_{11} + \delta_{12}t + \delta_{13}(4\Delta\log P_{1,t+1})^* + \delta_{14}R_{1,t-1} + \delta_{15}(4\Delta\log P_1)^* + \sum_{i=0}^{3}\delta_{1,6+i}\hat{M}_{1,t-i} + \sum_{i=0}^{3}\delta_{1,10+i}\hat{g}_{1,t-i} + \sum_{i=0}^{3}\delta_{1,14+i}\hat{x}_{1,t-i} + \epsilon_{15}$$

(R6) $$(X/Y)_1 = \theta_{11} + \theta_{12}t + \theta_{13}\log P^{RO} + \theta_{14}(\log y_1 - \log y^P_1) + \sum_{i=0}^{1}\theta_{1,5+i}(X/Y)_{1,t-1-i} + \sum_{i=0}^{1}\theta_{1,7+i}\log y^R_{1,t-i} + \sum_{i=0}^{1}\theta_{1,9+i}\log P_{1,t-i} + \sum_{i=0}^{1}\theta_{11+i}\log P^R_{1,t-i} + \epsilon_{16}$$

(R7) $$(I/Y)_1 = \lambda_{11} + \lambda_{12}(I/Y)_{1,t-1} + \lambda_{13}\log y^P_1 + \sum_{i=0}^{1}\lambda_{1,4+i}\log y_{1,t-i} - \log y^P_{1,t-i}) + \sum_{i=0}^{3}\lambda_{1,6+i}Z_{1,t-i} + \epsilon_{17}$$

(R8) $$\log P^I_1 = \log P^I_{1,t-1} + \mu_{11} + \mu_{12}\Delta\log P^I_{1,t-1} + \mu_{13}\Delta\log P^{RO} + \mu_{14}\Delta\log y^R_1 + \mu_{15}\Delta(I/Y)_1 + \mu_{16}\Delta\log P^R_1 + \epsilon_{18}$$

(R9)[†] $$(C/Y)_1 = \xi_{11} + \xi_{12}t + \xi_{13}\log P^{RO} + \xi_{14}R_1 - \xi_{15}(4\Delta\log E_{2,t+1})^* + \xi_{16}R_2 + \xi_{17}[(X/Y)_1 - (I/Y)_1] + \xi_{18}(\log y_1 - \log y^P_1) + \xi_{19}\Delta\log y_1 + \xi_{1,10}\Delta\log y^R_1 + \sum_{i=0}^{2}\xi_{1,11+i}\Delta R_{1,t-i} + \sum_{i=0}^{2}\xi_{1,14+i}\Delta R_{2,t-i} - \sum_{i=0}^{2}\xi_{1,17+i}\Delta(4\Delta\log E_{2,t+1-i})^* + \epsilon_{19}$$

(R10) No equation ($E_1 \equiv 1$).

Table 5.2 (continued)

IDENTITIES

(R11) $\log y_1^P \equiv \phi_{11} + \phi_{12}\log y_1 + (1 - \phi_{12})\log y_{1,t-1}^P$

(R12) $(B/Y)_1 \equiv [(X/Y)_1 - (I/Y)_1 - (C/Y)_1]/4$

(R13) $\hat{M}_1 \equiv \log M_1 - (\log M_1)^*$

(R14) $\hat{x}_1 \equiv (X/Y)_1 - (X/Y)_1^*$

(R15) $Z_1 \equiv \log P_1^I - \log P_1$

(R16) $(4\Delta \log P_{1,t+1})^*$: See table 5.5 for a complete listing.

(R17) $(4\Delta \log E_{2,t+1})^*$: See table 5.6 for a complete listing.

(R18) $\log y_1^R \equiv \dfrac{1}{1 - W_1} \sum_{i=2}^{8} W_i \log y_i - \text{base}\, y_1$

(R19) $\log P_1^R \equiv \dfrac{1}{1 - W_1} \sum_{i=2}^{8} W_i (\log P_i - \log E_i) - \text{base}\, P_1$

ENDOGENOUS VARIABLES

$\log y_1$, $\log P_1$, u_1, $\log M_1$, R_1, $(X/Y)_1$, $(I/Y)_1$, $\log P_1^I$, $(C/Y)_1$;
$\log y_1^P$, $(B/Y)_1$, $\hat{M}_1$, $\hat{x}_1$, Z_1, $(4\Delta \log P_{1,t+1})^*$, $(4\Delta \log E_{2,t+1})^*$

PREDETERMINED VARIABLES

Exogenous Variables
$\hat{g}_1$, $\hat{g}_{1,t-1}$, $\hat{g}_{1,t-2}$, $\hat{g}_{1,t-3}$, $\hat{g}_{1,t-4}$, $\log P^{RO}$, $\log P_{t-1}^{RO}$, t

Expected Values Based on Prior Information
$(\log M_1)^*$, $(X/Y)_1^*$

Lagged Endogenous Variables
$(4\Delta \log E_2)^*$, $(4\Delta \log E_{2,t-1})^*$, $(4\Delta \log E_{2,t-2})^*$, $(I/Y)_{1,t-1}$, $\log M_{1,t-1}$, $\log M_{1,t-2}$, $\log M_{1,t-3}$, $\hat{M}_{1,t-1}$, $\hat{M}_{1,t-2}$, $\hat{M}_{1,t-3}$, $\log P_{1,t-1}$, $\log P_{1,t-2}$, $\log P_{1,t-3}$, $\log P_{1,t-4}$, $\log P_{1,t-5}$, $\log P_{t-1}^I$, $\log P_{t-2}^I$, $R_{1,t-1}$, $R_{1,t-2}$, $R_{1,t-3}$, $u_{1,t-1}$, $u_{1,t-2}$, $u_{1,t-3}$, $u_{1,t-4}$, $(X/Y)_{1,t-1}$, $(X/Y)_{1,t-2}$, $\hat{x}_{1,t-1}$, $\hat{x}_{1,t-2}$, $\hat{x}_{1,t-3}$, $\log y_{1,t-1}$, $\log y_{1,t-2}$, $\log y_{1,t-3}$, $\log y_{1,t-4}$, $\log y_{1,t-5}$, $\log y_{1,t-6}$, $\log y_{1,t-7}$, $\log y_{1,t-8}$, $\log y_{1,t-1}^P$, $Z_{1,t-1}$, $Z_{1,t-2}$, $Z_{1,t-3}$

Foreign Variables (endogenous in full model)[§]
$\log E_2$, $\log P_1^R$, R_2, $\log y_1^R$

Lagged Foreign Variables
$\log E_{2,t-1}$, $\log E_{2,t-2}$, $\log E_{2,t-3}$, $\log P_{1,t-1}^R$, $R_{2,t-1}$, $R_{2,t-2}$, $R_{2,t-3}$, $\log y_{1,t-1}^R$

[†]The United Kingdom (index 2) is used as the best alternative capital market in estimating the U.S. capital flows equation. Note that this equation is irrelevant to the previous equations since the balance of payments does not affect the U.S. money supply.

[§]In estimating the submodels by principal-components 2SLS, we include in our instrument list fitted values for these foreign variables based on the foreign countries' domestic predetermined variables. See chapter 6 for details.

Table 5.3 **Nonreserve Country Submodel: Pegged Exchange Rate Periods**

EQUATIONS

(N1) $$\log y_j = \alpha_{j1} + \alpha_{j2}\log y^P_{j,t-1} + (1-\alpha_{j2})\log y_{j,t-1} + \sum_{i=0}^{3}\alpha_{j,3+i}\hat{M}_{j,t-i} + \sum_{i=0}^{3}\alpha_{j,7+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3}\alpha_{j,11+i}\hat{x}_{j,t-i} + \epsilon_{j1}$$

(N2) $$\log P_j = \log M_j + \beta_{j1} + \beta_{j2}\log y^P_j + \beta_{j3}(\log y_j - \log y^P_j) + \beta_{j4}R_j + \beta_{j5}[R_1 + (4\Delta \log E_{j,t+1})^*] + \beta_{j6}(\log M_{j,t-1} - \log P_{j,t-1}) + \sum_{i=0}^{3}\beta_{j,7+i}\hat{M}_{j,t-i} + \epsilon_{j2}$$

(N3)† $$u_j = u_{j,t-1} + \gamma_{j1} + \sum_{i=0}^{7}\gamma_{j,2+i}\Delta \log y_{j,t-i} + \epsilon_{j3}$$

(N4)§ $$\Delta \log M_j = \eta_{j1} + \eta_{j2}t + \eta_{j3}\hat{g}_j + \eta_{j4}(\hat{g}_{j,t-1} + \hat{g}_{j,t-2}) + \eta_{j5}(\hat{g}_{j,t-3} + \hat{g}_{j,t-4}) + \eta_{j6}(\log P_{j,t-1} - \log P_{j,t-3}) + \eta_{j7}[DF_j(\log P_{j,t-1} - \log P_{j,t-3})] + \eta_{j8}(\log P_{j,t-3} - \log P_{j,t-5}) + \eta_{j9}[DF_j(\log P_{j,t-3} - \log P_{j,t-5})] + \eta_{j,10}u_{j,t-1} + \eta_{j,11}u_{j,t-2} + \eta_{j,12}u_{j,t-3} + \eta_{j,13}u_{j,t-4} + \eta_{j,14}(B/Y)_j + \eta_{j,15}[DF_j(B/Y)_j] + \eta_{j,16}[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}] + \eta_{j,17}\{DF_j[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}]\} + \eta_{j,18}[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}] + \eta_{j,19}\{DF_j[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}]\} + \epsilon_{j4}$$

(N5) $$R_j = \delta_{j1} + \delta_{j2}t + \delta_{j3}(4\Delta \log P_{j,t+1})^* + \delta_{j4}R_{j,t-1} + \delta_{j5}(4\Delta \log P_j)^* + \sum_{i=0}^{3}\delta_{j,6+i}\hat{M}_{j,t-i} + \sum_{i=0}^{3}\delta_{j,10+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3}\delta_{j,14+i}\hat{x}_{j,t-i} + \epsilon_{j5}$$

(N6) $$(X/Y)_j = \theta_{j1} + \theta_{j2}t + \theta_{j3}\log P^{RO} + \theta_{j4}(\log y_j - \log y^P_j) + \sum_{i=0}^{1}\theta_{j,5+i}(X/Y)_{j,t-1-i} + \sum_{i=0}^{1}\theta_{j,7+i}\log y^R_{j,t-i} + \sum_{i=0}^{1}\theta_{j,9+i}\log P_{j,t-i} + \sum_{i=0}^{1}\theta_{j,11+i}\log P^R_{j,t-i} + \sum_{i=0}^{1}\theta_{j,13+i}\log E_{j,t-i} + \sum_{i=0}^{1}\theta_{j,15+i}DF_{j,t-i}\log E_{j,t-i} + \epsilon_{j6}$$

(N7P) $$(I/Y)_j = \lambda_{j1} + \lambda_{j2}(I/Y)_{j,t-1} + \lambda_{j3}\log y^P_j + \sum_{i=0}^{1}\lambda_{j,4+i}(\log y_{j,t-i} - \log y^P_{j,t-i}) + \sum_{i=0}^{3}\lambda_{j,6+i}Z_{j,t-i} + \epsilon_{j7}$$

(N8P) $$\log P^I_j = \log P^I_{j,t-1} + \mu_{j1} + \mu_{j2}\Delta \log P^I_{j,t-1} + \mu_{j3}\Delta \log P^{RO} + \mu_{j4}\Delta \log y^R_j + \mu_{j5}\Delta(I/Y)_j + \mu_{j6}\Delta \log P^R_j + \mu_{j7}\Delta \log E_j + \epsilon_{j8}$$

(N9) $$(C/Y)_j = \xi_{j1} + \xi_{j2}t + \xi_{j3}\log P^{RO} + \xi_{j4}R_j + \xi_{j5}(4\Delta \log E_{j,t+1})^* + \xi_{j6}R_1 + \xi_{j7}[(X/Y)_j - (I/Y)_j] + \xi_{j8}(\log y_j - \log y^P_j) + \xi_{j9}\Delta \log y_j + \xi_{j10}\Delta \log y^R_j + \sum_{i=0}^{2}\xi_{j,11+i}\Delta R_{j,t-i} + \sum_{i=0}^{2}\xi_{j,14+i}\Delta R_{1,t-i} + \sum_{i=0}^{2}\xi_{j,17+i}\Delta(4\Delta \log E_{j,t+1-i})^* + \epsilon_{j9}$$

(N10) No equation for pegged rate periods.

Table 5.3 (continued)

IDENTITIES

(N11) $\log y_j^P \equiv \theta_{j1} + \theta_{j2}\log y_j + (1-\theta_{j2})\log y_{j,t-1}^P$

(N12P) $(B/Y)_j \equiv [(X/Y)_j - (I/Y)_j - (C/Y)_j]/4$

(N13) $\hat{M}_j \equiv \log M_j - (\log M_j)^*$

(N14) $\hat{x}_j \equiv (X/Y)_j - (X/Y)_j^*$

(N15P) $Z_j \equiv \log P_j^I - \log P_j$

(N16) $(4\Delta \log P_{j,t+1})^*$: Varies according to country. See table 5.5 for a complete listing.

(N17) $(4\Delta \log E_{j,t+1})^*$: Varies according to country. See table 5.6 for a complete listing.

(N18) $\log y_j^R \equiv \frac{1}{1-W_j} \sum_{\substack{i=1 \\ i\neq j}}^{8} W_i \log y_i - \text{base}y_j$

(N19) $\log P_j^R \equiv \frac{1}{1-W_j} \sum_{\substack{i=1 \\ i\neq j}}^{8} W_i(\log P_i - \log E_i) - \text{base}P_j$

ENDOGENOUS VARIABLES

$\log y_j$, $\log P_j$, u_j, $\log M_j$, R_j, $(X/Y)_j$, $(I/Y)_j$, $\log P_j^I$, $(C/Y)_j$;
$\log y_j^P$, $(B/Y)_j$, $\hat{M}_j$, $\hat{x}_j$, Z_j, $(4\Delta \log P_{j,t+1})^*$, $(4\Delta \log E_{j,t+1})^*$

PREDETERMINED VARIABLES

Exogenous Variables
DF_j, $DF_{j,t-1}$, $\log E_j$, $\log E_{j,t-1}$, $\log E_{j,t-2}$, $\log E_{j,t-3}$, $\hat{g}_j$, $\hat{g}_{j,t-1}$, $\hat{g}_{j,t-2}$, $\hat{g}_{j,t-3}$, $\hat{g}_{j,t-4}$, $\log P^{RO}$, $\log P_{t-1}^{RO}$, t

Expected Values Based on Prior Information
$(\log M_j)^*$, $(X/Y)_j^*$

Lagged Endogenous Variables
$(4\Delta \log E_j)^*$, $(4\Delta \log E_{j,t-1})^*$, $(4\Delta \log E_{j,t-2})^*$, $(I/Y)_{j,t-1}$, $\log M_{j,t-1}$, $\hat{M}_{j,t-1}$, $\hat{M}_{j,t-2}$, $\hat{M}_{j,t-3}$, $\log P_{j,t-1}$, $\log P_{j,t-3}$, $\log P_{j,t-5}$, $\log P_{j,t-1}^I$, $\log P_{j,t-2}^I$, $R_{j,t-1}$, $R_{j,t-2}$, $R_{j,t-3}$, $(X/Y)_{j,t-1}$, $(X/Y)_{j,t-2}$, $\hat{x}_{j,t-1}$, $\hat{x}_{j,t-2}$, $\hat{x}_{j,t-3}$, $(B/Y)_{j,t-1}$, $(B/Y)_{j,t-2}$, $(B/Y)_{j,t-3}$, $(B/Y)_{j,t-4}$, $\log y_{j,t-1}$, $\log y_{j,t-1}^P$, $Z_{j,t-1}$, $Z_{j,t-2}$, $Z_{j,t-3}$, $\{u_{j,t-1}$, $\log y_{j,t-2}$, $\log y_{j,t-3}$, $\log y_{j,t-4}$, $\log y_{j,t-5}$, $\log y_{j,t-6}$, $\log y_{j,t-7}$, $\log y_{j,t-8}\}^{\ddagger}$; plus any other lagged endogenous variables appearing in (N4.j).

Foreign Variables (endogenous in full model)# $\log P_j^R$, R_1, $\log y_j^R$

Lagged Foreign Variables $\log P_{j,t-1}^R$, $R_{1,t-1}$, $R_{1,t-2}$, $R_{1,t-3}$, $\log y_{j,t-1}^R$

†The unemployment equation appears only in the submodels for France and the United Kingdom.

§For the submodels other than France and the United Kingdom, the unemployment rate variables u_j are replaced with negative logarithmic transitory income $\log y_j^P - \log y_j$.

‡The variables in braces appear only in the submodels for France and the United Kingdom; see note † above.

#In estimating the submodels by principal-components 2SLS, we include in our instrument list fitted values for these foreign variables based on the foreign countries' domestic predetermined variables. See chapter 6 for details.

Table 5.4 Nonreserve Country Submodel: Floating Exchange-Rate Periods

EQUATIONS

(N1) $$\log y_j = \alpha_{j1} + \alpha_{j2}\log y^P_{j,t-1} + (1-\alpha_{j2})\log y_{j,t-1} + \sum_{i=0}^{3}\alpha_{j,3+i}\hat{M}_{j,t-i} + \sum_{i=0}^{3}\alpha_{j,7+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3}\alpha_{j,11+i}\hat{x}_{j,t-i} + \epsilon_{j1}$$

(N2) $$\log P_j = \log M_j + \beta_{j1} + \beta_{j2}\log y^P_j + \beta_{j3}(\log y_j - \log y^P_j) + \beta_{j4}R_j + \beta_{j5}[R_1 + (4\Delta\log E_{j,t+1})^*] + \beta_{j6}(\log M_{j,t-1} - \log P_{j,t-1}) + \sum_{i=0}^{3}\beta_{j,7+i}\hat{M}_{j,t-i} + \epsilon_{j2}$$

(N3)[†] $$u_j = u_{j,t-1} + \gamma_{j1} + \sum_{i=0}^{7}\gamma_{j,2+i}\Delta\log y_{j,t-i} + \epsilon_{j3}$$

(N4)[§] $$\begin{aligned}\Delta\log M_j = {} & \eta_{j1} + \eta_{j2}t + \eta_{j3}\hat{g}_j + \eta_{j4}(\hat{g}_{j,t-1} + \hat{g}_{j,t-2}) \\ & + \eta_{j5}(\hat{g}_{j,t-3} + \hat{g}_{j,t-4}) + \eta_{j6}(\log P_{j,t-1} - \log P_{j,t-3}) \\ & + \eta_{j7}[DF_j(\log P_{j,t-1} - \log P_{j,t-3})] \\ & + \eta_{j8}(\log P_{j,t-3} - \log P_{j,t-5}) + \eta_{j9}[DF_j(\log P_{j,t-3} - \log P_{j,t-5})] \\ & + \eta_{j,10}u_{j,t-1} + \eta_{j,11}u_{j,t-2} + \eta_{j,12}u_{j,t-3} + \eta_{j,13}u_{j,t-4} \\ & + \eta_{j,14}(B/Y)_j + \eta_{j,15}[DF_j(B/Y)_j] + \eta_{j,16}[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}] \\ & + \eta_{j,17}\{DF_j[(B/Y)_{j,t-1} + (B/Y)_{j,t-2}]\} + \eta_{j,18}[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}] \\ & + \eta_{j,19}\{DF_j[(B/Y)_{j,t-3} + (B/Y)_{j,t-4}]\} + \epsilon_{j4}\end{aligned}$$

(N5) $$R_j = \delta_{j1} + \delta_{j2}t + \delta_{j3}(4\Delta\log P_{j,t+1})^* + \delta_{j4}R_{j,t-1} + \delta_{j5}(4\Delta\log P_j)^* + \sum_{i=0}^{3}\delta_{j,6+i}\hat{M}_{j,t-i} + \sum_{i=0}^{3}\delta_{j,10+i}\hat{g}_{j,t-i} + \sum_{i=0}^{3}\delta_{j,14+i}\hat{x}_{j,t-i} + \epsilon_{j5}$$

(N6) $$\begin{aligned}(X/Y)_j = {} & \theta_{j1} + \theta_{j2}t + \theta_{j3}\log P^{RO} + \theta_{j4}(\log y_j - \log y^P_j) \\ & + \sum_{i=0}^{1}\theta_{j,5+i}(X/Y)_{j,t-1-i} + \sum_{i=0}^{1}\theta_{j,7+i}\log y^R_{j,t-i} \\ & + \sum_{i=0}^{1}\theta_{j,9+i}\log P_{j,t-1} + \sum_{i=0}^{1}\theta_{j,11+i}\log P^R_{j,t-i} \\ & + \sum_{i=0}^{1}\theta_{j,13+i}\log E_{j,t-i} + \sum_{i=0}^{1}\theta_{j,15+i}DF_{j,t-i}\log E_{j,t-i} + \epsilon_{j6}\end{aligned}$$

(N7F) $$\begin{aligned}Z_j = {} & \frac{-\lambda_{j1}}{\lambda_{j6}} + \frac{1}{\lambda_{j6}}(I/Y)_j - \frac{\lambda_{j2}}{\lambda_{j6}}(I/Y)_{j,t-1} - \frac{\lambda_{j3}}{\lambda_{j6}}\log y^P_j \\ & - \sum_{i=0}^{1}\frac{\lambda_{j,4+i}}{\lambda_{j6}}(\log y_{j,t-i} - \log y^P_{j,t-i}) \\ & - \sum_{i=1}^{3}\frac{\lambda_{j,6+i}}{\lambda_{j6}}Z_{j,t-i} - \frac{\epsilon_{j7}}{\lambda_{j6}}\end{aligned}$$

(N8F) $$\begin{aligned}\log E_j = {} & \log E_{j,t-1} - \frac{\mu_{j1}}{\mu_{j7}} + \frac{1}{\mu_7}\Delta\log P^I_j - \frac{\mu_{j2}}{\mu_{j7}}\Delta\log P^I_{j,t-1} \\ & - \frac{\mu_{j3}}{\mu_{j7}}\Delta\log P^{RO} - \frac{\mu_{j4}}{\mu_{j7}}\Delta\log y^R_j - \frac{\mu_{j5}}{\mu_{j7}}\Delta(I/Y)_j \\ & - \frac{\mu_{j6}}{\mu_{j7}}\Delta\log P^R_j - \frac{\epsilon_{j8}}{\mu_{j7}}\end{aligned}$$

Table 5.4 (continued)

(N9) $(C/Y)_j = \xi_{j1} + \xi_{j2}t + \xi_{j3}\log P^{RO} + \xi_{j4}R_j + \xi_{j5}(4\Delta \log E_{j,t+1})^*$
$+ \xi_{j6}R_1 + \xi_{j7}[(X/Y)_j - (I/Y)_j] + \xi_{j8}(\log y_j - \log y_j^P)$
$+ \xi_{j9}\Delta \log y_j + \xi_{j10}\Delta \log y_j^R + \sum_{i=0}^{2} \xi_{j,11+i}\Delta R_{j,t-i}$
$+ \sum_{i=0}^{2} \xi_{j,14+i}\Delta R_{1,t-i} + \sum_{i=0}^{2} \xi_{j,17+i}\Delta(4\Delta \log E_{j,t+1-i})^* + \epsilon_{j9}$

(N10F) $(B/Y)_j = \psi_{j1} + \psi_{j2}(B/Y)_{j,t-1} + \psi_{j3}\Delta \log E_j + \psi_{j4}\Delta \log E_{j,t-1}$
$+ \psi_{j5}(\Delta \log P_{j,t-1} - \Delta \log P_{1,t-1}) + \epsilon_{j,10}$

IDENTITIES

(N11) $\log y_j^P \equiv \theta_{j1} + \theta_{j2}\log y_j + (1 - \theta_{j2})\log y_{j,t-1}^P$

(N12F) $(I/Y)_j \equiv (X/Y)_j - 4(B/Y)_j - (C/Y)_j$

(N13) $\hat{M}_j \equiv \log M_j - (\log M_j)^*$

(N14) $\hat{x}_j \equiv (X/Y)_j - (X/Y)_j^*$

(N15F) $\log P_j^I \equiv \log P_j + Z_j$

(N16) $(4\Delta \log P_{j,t+1})^*$: Varies according to country. See table 5.5 for a complete listing.

(N17) $(4\Delta \log E_{j,t+1})^*$: Varies according to country. See table 5.6 for a complete listing.

(N18) $\log y_j^R \equiv \frac{1}{1 - W_j} \sum_{\substack{i=1 \\ i \neq j}}^{8} W_i \log y_i - \text{base}y_j$

(N19) $\log P_j^R \equiv \frac{1}{1 - W_j} \sum_{\substack{i=1 \\ i \neq j}}^{8} W_i(\log P_i - \log E_i) - \text{base}P_j$

ENDOGENOUS VARIABLES

$\log y_j$, $\log P_j$, u_j, $\log M_j$, R_j, $(X/Y)_j$, Z_j, $\log E_j$, $(C/Y)_j$, $(B/Y)_j$;
$\log y_j^P$, $(I/Y)_j$, $\hat{M}_j$, $\hat{x}_j$, $\log P_j^I$, $(4\Delta \log P_{j,t+1})^*$, $(4\Delta \log E_{j,t+1})^*$

PREDETERMINED VARIABLES

Exogenous Variables
DF_j, $DF_{j,t-1}$, $\hat{g}_j$, $\hat{g}_{j,t-1}$, $\hat{g}_{j,t-2}$, $\hat{g}_{j,t-3}$, $\hat{g}_{j,t-4}$, $\log P^{RO}$, $\log P_{t-1}^{RO}$, t

Expected Values Based on Prior Information
$(\log M_j)^*$, $(X/Y)_j^*$

Lagged Endogenous Variables
$\log E_{j,t-1}$, $\log E_{j,t-2}$, $\log E_{j,t-3}$, $(4\Delta \log E_j)^*$, $(4\Delta \log E_{j,t-1})^*$,
$(4\Delta \log E_{j,t-2})^*$, $(I/Y)_{j,t-1}$, $\log M_{j,t-1}$, $\hat{M}_{j,t-1}$, $\hat{M}_{j,t-2}$, $\hat{M}_{j,t-3}$, $\log P_{j,t-1}$,
$\log P_{j,t-2}$, $\log P_{j,t-3}$, $\log P_{j,t-5}$, $\log P_{j,t-1}^I$, $\log P_{j,t-2}^I$, $R_{j,t-1}$, $R_{j,t-2}$,
$R_{j,t-3}$, $(X/Y)_{j,t-1}$, $(X/Y)_{j,t-2}$, $(B/Y)_{j,t-1}$, $(B/Y)_{j,t-2}$, $(B/Y)_{j,t-3}$, $(B/Y)_{j,t-4}$,
$\hat{x}_{j,t-1}$, $\hat{x}_{j,t-2}$, $\hat{x}_{j,t-3}$, $\log y_{j,t-1}$, $\log y_{j,t-1}^P$, $Z_{j,t-1}$, $Z_{j,t-2}$, $Z_{j,t-3}$,
$\{u_{j,t-1}$, $\log y_{j,t-2}$, $\log y_{j,t-3}$, $\log y_{j,t-4}$, $\log y_{j,t-5}$, $\log y_{j,t-6}$,
$\log y_{j,t-7}$, $\log y_{j,t-8}\}^{\ddagger}$; plus and other lagged endogenous variables appearing in (N4.j).

Table 5.4 (continued)

Foreign Variables (endogenous in full model)[#]
$\log P_j^R$, R_1, $\log y_j^R$

Lagged Foreign Variables
$\log P_{1,t-1}$, $\log P_{1,t-2}$, $\log P_{j,t-1}^R$, $R_{1,t-1}$, $R_{1,t-2}$, $R_{1,t-3}$, $\log y_{j,t-1}^R$

[†]The unemployment equation appears only in the submodel for France and the United Kingdom.

[§]For the submodels other than France and the United Kingdom, the unemployment-rate variables u_j are replaced with negative logarithmic transitory income $\log y_j^P - \log y_j$.

[‡]The variables in braces appear only in the submodels for France and the United Kingdom; see note † above.

[#]In estimating the submodels by principal-components 2SLS, we include in our instrument list fitted values for these foreign variables based on the foreign countries' domestic predetermined variables. See chapter 6 for details.

Table 5.5 **Expected-Inflation Transfer Functions**

(R16) $$\begin{aligned}(\Delta \log P_{1,t+1})^* \equiv & - 0.754 - 1.704(\log M_1)^* + 1.001 \log M_{1,t-1} \\ & + 0.850 \log M_{1,t-2} - 0.063\Delta \log y_{1,t-1} \\ & + 0.248R_1 - 0.038R_{1,t-1} + 0.008[R_2 - (4\Delta \log E_{2,t+1})^*] \\ & - 0.009[R_{2,t-1} - (4\Delta \log E_2)^*] + 0.158 \log P_{1,t-1} \\ & - 0.279 \log P_{1,t-2} + 1.711\hat{M}_{1,t-1} + 0.222\hat{M}_{1,t-2} \\ & + 0.020\hat{M}_{1,t-3} + 0.160\epsilon_{1,16,t-1} - 0.230\epsilon_{1,16,t-2}\end{aligned}$$

(N16.2) $$\begin{aligned}(\Delta \log P_{2,t+1})^* \equiv & - 0.09655 + 2.315(\log M_2)^* - 4.655 \log M_{2,t-1} \\ & + 2.382\log M_{2,t-2} + 0.186\Delta \log y_{2,t-1} + 0.030R_2 \\ & + 0.146R_{2,t-1} + 0.043[R_1 + (4\Delta \log E_{2,t+1})^*] \\ & - 0.035[R_{1,t-1} + (4\Delta \log E_2)^*] + 0.385 \log P_{2,t-1} \\ & - 0.408 \log P_{2,t-2} + 2.052\hat{M}_{2,t-1} - 0.407\hat{M}_{2,t-2} \\ & + 0.284\hat{M}_{2,t-3} - 0.238\epsilon_{2,16,t-1} + 0.416\epsilon_{2,16,t-2}\end{aligned}$$

(N16.3) $$\begin{aligned}(\Delta \log P_{3,t+1})^* \equiv & - 0.060 - 1.002(\log M_3)^* + 1.053 \log M_{3,t-1} \\ & - 0.008 \log M_{3,t-2} + 0.065\Delta \log y_{3,t-1} + 0.301R_3 \\ & - 0.460R_{3,t-1} + 0.012[R_1 + (4\Delta \log E_{3,t-1})^*] \\ & - 0.033[R_{1,t-1} + (4\Delta \log E_3)^*] + 0.433 \log P_{3,t-1} \\ & - 0.459 \log P_{3,t-2} + 0.434\hat{M}_{3,t-1} - 0.162\hat{M}_{3,t-2} \\ & - 0.019\hat{M}_{3,t-3} - 0.618\epsilon_{3,16,t-1} - 0.382\epsilon_{3,16,t-2}\end{aligned}$$

(N16.4) $$\begin{aligned}(\Delta \log P_{4,t+1})^* \equiv & - 0.023 + 0.095(\log M_4)^* + 0.250 \log M_{4,t-1} \\ & - 0.344 \log M_{4,t-2} + 0.003\Delta \log y_{4,t-1} + 0.055R_4 \\ & + 0.214R_{4,t-1} + 0.003[R_1 + (4\Delta \log E_{4,t+1})^*] \\ & + 0.011[R_{1,t-1} + (4\Delta \log E_4)^*] + 0.102 \log P_{4,t-1} \\ & - 0.110 \log P_{4,t-2} - 0.287\hat{M}_{4,t-1} \\ & - 0.042\hat{M}_{4,t-2} - 0.073\hat{M}_{4,t-3} + 0.545e_{4,t-1} \\ & - 0.164e_{4,16,t-2}\end{aligned}$$

(N16.5) $$\begin{aligned}(\Delta \log P_{5,t+1})^* \equiv & 1.727 - 79.865(\log M_5)^* + 79.905 \log M_{5,t-1} \\ & - 0.022 \log M_{5,t-2} + 0.132\Delta \log y_{5,t-1} - 0.012R_5 \\ & + 0.075R_{5,t-1} + 0.019[R_1 + (4\Delta \log E_{5,t+1})^*] \\ & + 0.014[R_{1,t-1} + (4\Delta \log E_5)^*] + 0.027 \log P_{5,t-1} \\ & - 0.056 \log P_{5,t-2} + 8.540\hat{M}_{5,t-1} + 21.966\hat{M}_{5,t-2} \\ & + 28.536\hat{M}_{5,t-3} + 0.187\epsilon_{5,16,t-1} + 0.555\epsilon_{5,16,t-2}\end{aligned}$$

Table 5.5 (continued)

$$\begin{aligned}
\text{(N16.6)}\quad (\Delta \log P_{6,t+1})^* \equiv\ & 1.858 - 75.036(\log M_6)^* + 85.887 \log M_{6,t-1} \\
& - 10.820 \log M_{6,t-2} - 0.103\Delta \log y_{6,t-1} + 0.069 R_6 \\
& + 0.154 R_{6,t-1} - 0.031[R_1 + (4\Delta \log E_{6,t-1})^*] \\
& - 0.018[R_{1,t-1} + (4\Delta \log E_6)^*] - 0.218 \log P_{6,t-1} \\
& + 0.165 \log P_{6,t-2} + 0.974 \hat{M}_{6,t-1} + 27.169 \hat{M}_{6,t-2} \\
& + 8.456 \hat{M}_{6,t-3} + 0.133 \epsilon_{6,16,t-1} + 0.640 \epsilon_{6,16,t-2}
\end{aligned}$$

$$\begin{aligned}
\text{(N16.7)}\quad (\Delta \log P_{7,t+1})^* \equiv\ & 0.131 - 0.281(\log M_7)^* + 0.455 \log M_{7,t-1} \\
& - 0.180 \log M_{7,t-2} - 0.026\Delta \log y_{7,t-1} + 1.658 R_7 \\
& - 2.219 R_{7,t-1} + 0.044[R_1 + (4\Delta \log E_{7,t-1})^*] \\
& + 0.004[R_{1,t-1} + (4\Delta \log E_7)^*] + 0.092 \log P_{7,t-1} \\
& - 0.060 \log P_{7,t-2} + 0.107 \hat{M}_{7,t-1} + 0.153 \hat{M}_{7,t-2} \\
& + 0.034 \hat{M}_{7,t-3} + 0.131 \epsilon_{7,16,t-1}
\end{aligned}$$

$$\begin{aligned}
\text{(N16.8)}\quad (\Delta \log P_{8,t+1})^* \equiv\ & - 0.641 + 10.564(\log M_8)^* - 5.440 \log M_{8,t-1} \\
& - 5.046 \log M_{8,t-2} + 0.244\Delta \log y_{8,t-1} - 0.050 R_8 \\
& + 0.180 R_{8,t-1} - 0.039[R_1 + (4\Delta \log E_{8,t+1})^*] \\
& - 0.027[R_{1,t-1} + (4\Delta \log E_8)^*] - 0.234 \log P_{8,t-1} \\
& + 0.116 \log P_{8,t-2} - 8.937 \hat{M}_{8,t-1} - 7.000 \hat{M}_{8,t-2} \\
& - 5.788 \hat{M}_{8,t-3} - 0.343 \epsilon_{8,16,t-1} + 0.248 \epsilon_{8,16,t-2}
\end{aligned}$$

Notes. These identities are for expected inflation rates per quarter; the rates per annum in the model are simply $(4\Delta \log P_j)^* \equiv 4(\Delta \log P_j)^*$.

$$\begin{aligned}
e_{j,16} &\equiv (\Delta \log P_{j,t+1}) - (\Delta \log P_{j,t+1})^* \\
\epsilon_{1,16} &\equiv e_{1,16} - .160\epsilon_{1,16,t-1} + .230\epsilon_{1,16,t-2} \\
\epsilon_{2,16} &\equiv e_{2,16} + .238\epsilon_{2,16,t-1} - .416\epsilon_{2,16,t-2} \\
\epsilon_{3,16} &\equiv e_{3,16} + .618\epsilon_{3,16,t-1} + .382\epsilon_{3,16,t-2} \\
\epsilon_{5,16} &\equiv e_{5,16} - .187\epsilon_{5,16,t-1} - .555\epsilon_{5,16,t-2} \\
\epsilon_{6,16} &\equiv e_{6,16} - .133\epsilon_{6,16,t-1} - .640\epsilon_{6,16,t-2} \\
\epsilon_{7,16} &\equiv e_{7,16} - .131\epsilon_{7,16,t-1} \\
\epsilon_{8,16} &\equiv e_{8,16} + .343\epsilon_{8,16,t-1} - .248\epsilon_{8,16,t-2}
\end{aligned}$$

The fitted ARMA error processes by country are:

1 (0,2)	5 (0,2)
2 (0,2)	6 (0,2)
3 (0,2)	7 (0,1)
4 (2,0)	8 (0,2)

Table 5.6 **Expected Exchange-Rate Growth**
$(4\Delta \log E_j)^* \equiv 4(\Delta \log E_j)^*$

a) Floating Exchange-Rate Periods

$$(\text{N17F})\ (\Delta \log E_{j,t+1})^* \equiv \omega_{j1} + \omega_{j2}\Delta \log P_j^I + \omega_{j3}\Delta \log P^{RO} + \omega_{j4}\Delta \log y_j^R + \omega_{j5}\Delta(I/Y)_j + \omega_{j6}\Delta \log P_j^R + \omega_{j7}\Delta \log E_j$$

The parameters (estimated by OLS) are:

Country	ω_{j1}	ω_{j2}	ω_{j3}	ω_{j4}	ω_{j5}	ω_{j6}	ω_{j7}	Floating Periods
2, UK	.00597	.80037	−.02808	1.20971	−2.03867	−.98978	−.20116	1971III–76IV
3, CA	−.00314	.05183	−.00683	.07509	−.30121	.18038	.31538	1956I–62III, 1970II–76IV
4, FR	.06315	.13361	−.06955	−1.13931	1.42566	−3.15593	−.39385	1971III–76IV
5, GE	.00064	−.95133	.05737	−.73465	2.98731	−.13434	.18685	1971II–76IV
6, IT	.02320	−.08897	−.02900	.76727	.15530	−.35833	.15115	1971III–76IV
7, JA	.00323	−.03233	−.03956	−.87177	3.92447	−.02198	.20401	1971III–76IV
8, NE	.02739	.11611	−.07818	−.66181	−.10364	−1.97462	−.35813	1971II–76IV

Note. The first $(\Delta \log E_j)^*$ defined as above is for the second quarter in each floating period. The previous quarter value is defined by the pegged rate period.

b) Pegged Exchange-Rate Periods

(N17P.2) $(\Delta \log E_{2,t+1})^* \equiv 0.0014 - 0.5398(B/Y)_2 + 29.8764[(B/Y)_2|(B/Y)_2|] + 0.1369(\log E_2 - \log \bar{E}_2) + 0.5283\Delta \log E_2 - 0.0197DR_{2,t-1}$

(N17P.3) $(\Delta \log E_{3,t+1})^* \equiv -0.0002 - 0.4222(B/Y)_3 + 33.9022[(B/Y)_3|(B/Y)_3|] - 0.0089(\log E_3 - \log \bar{E}_3) + 0.3183\Delta \log E_3 - \epsilon_{3,17,t-1}$

(N17P.4) $(\Delta \log E_{4,t+1})^* \equiv 0.0058 - 1.1289(B/Y)_4 + 131.5500[(B/Y)_4|(B/Y)_4|] + 0.6546(\log E_4 - \log \bar{E}_4) + 0.7406\Delta \log E_4 - 0.0384DR_{4,t-1} - 0.65\epsilon_{4,17,t-1} - 0.35\epsilon_{4,17,t-2}$

(N17P.5) $(\Delta \log E_{5,t+1})^* \equiv -0.0026 + 0.9585(B/Y)_5 - 116.8350[(B/Y)_5|(B/Y)_5| - 0.2109(\log E_5 - \log \bar{E}_5) + 0.4755\Delta \log E_5 + 0.0106DR1_{5,t-1} - 0.0086DR2_{5,t-1}$

(N17P.6) $(\Delta \log E_{6,t+1})^* \equiv -0.0001 + 0.0660(B/Y)_6 - 9.7561[(B/Y)_6|(B/Y)_6|] - 0.0321(\log E_6 - \log \bar{E}_6) + 0.9541\Delta \log E_6 - \epsilon_{6,17,t-1}$

(N17P.7) $(\Delta \log E_{7,t+1})^* \equiv -0.0013 + 1.9035(B/Y)_7 - 405.337[(B/Y)_7|(B/Y)_7|] + 0.2366(\log E_7 - \log \bar{E}_7) + 0.2636\Delta \log E_7 - 0.5\epsilon_{7,17,t-1} - 0.5\epsilon_{7,17,t-2}$

(N17P.8) $(\Delta \log E_{8,t+1})^* \equiv -0.0014 - 0.1362(B/Y)_8 + 10.9493[(B/Y)_8|(B/Y)_8|] - 0.2170(\log E_8 - \log \bar{E}_8) + 0.6339\Delta \log E_8 + 0.0253DR_{8,t-1}$

Notes. $\bar{E}_j$ is the official parity value. For France only this is set equal to E_j through 1958IV, when a fixed official parity value was established. DR_j, $DR1_5$, and $DR2_5$ are revaluation dummies with value of 1 in the indicated quarter and 0 otherwise:

DR_2	1967IV	$DR1_5$	1961I
DR_4	1969III	$DR2_5$	1969IV
		DR_8	1961I

$e_{j,17} \equiv (\Delta \log E_{j,t+1}) - (\Delta \log E_{j,t+1})^*$ for all j

$\epsilon_{3,17} \equiv e_{3,17} + \epsilon_{3,17,t-1}$

$\epsilon_{4,17} \equiv e_{4,17} + .65\epsilon_{4,17,t-1} + .35\epsilon_{4,17,t-2}$

$\epsilon_{6,17} \equiv e_{6,17} + \epsilon_{6,17,t-1}$

$\epsilon_{7,17} \equiv e_{7,17} + .5\epsilon_{7,17,t-1} + .5\epsilon_{7,17,t-2}$

The fitted ARMA error processes by country are:

3 (0,1)   6 (0,1)

4 (0,2)   7 (0,2)

Table 5.7 **Parameter Values for Foreign Real Income and Foreign Price Index Identities** (R18), (R19), (N18), **and** (N19)

Country	j	W_j[†]	base y_j[§]	base P_j[§]
US	1	0.531464	7.40946	−2.53058
UK	2	0.063287	7.36068	−1.32478
CA	3	0.046296	7.26361	−1.24117
FR	4	0.077221	7.18014	−1.14182
GE	5	0.107001	7.20584	−1.17274
IT	6	0.048061	6.93985	−0.920318
JA	7	0.107898	6.64583	−0.617771
NE	8	0.018771	7.17908	−1.183800

[†]Nominal income shares are computed as follows, where the time summation is from 1955I–76IV:

$$W_j = \frac{\sum_t (Y/E)_{j,t}}{\sum_{i=1}^{8} \sum_t (Y/E)_{i,t}}$$

[§]The values of base y_j and base P_j are such that the mean values of the logarithmic indices are 0 for our base year 1970. This is equivalent to the 1970 geometric means being 1.