VI Investment

Simulations of the macroeconomic effects of various policy measures or other exogenous shocks depend importantly on how one models the responsiveness of the components of aggregate demand to changes in interest rates and exchange rates. In this regard, finding a realistic specification for the behavior of investment—one of the most volatile components of aggregate demand—is a key challenge in macroeconometric modeling. Unfortunately, the effort to characterize aggregate investment behavior has not been a highly successful endeavor in empirical economics.

This section describes the dynamics of investment behavior and capital accumulation in MULTIMOD Mark III, along with the production structure of the model. As in MULTIMOD Mark II, the Mark III model of capital and investment dynamics is based on the q theory of Tobin (1969). The major changes from the Mark II version include the integration of the q theory with the cost-of-adjustment model of Lucas (1967) and Treadway (1969), as well as a significant simplification in the treatment of historical costs, tax credits, and other details (see Meredith, 1991).

In the Mark III setup, firms maximize the expected net present value of future earnings subject to technological constraints. Let $\prod(K_{s-1})$ denote the revenue function of a representative firm, A_s adjustment costs, and I_s gross investment, all in period s. The representative firm is assumed to have the objective of maximizing the expected discounted sum of its future profits, defined as

$$E_t = \Big[\sum_{s=t}^{\infty}\rho^{t-s}\prod(K_{s-1}) - A_s - I_s\Big], \qquad (46)$$

where ρ denotes the firm's discount factor. The revenue function is based on the following Cobb-Douglas production function:

$$Y_t = \zeta_t\, K_{t-1}^{\beta} L_t^{1-\beta}, \qquad (47)$$

where Y_t is GDP, β is the share of capital, and ζ_t measures the level of total factor productivity.[109]

Following the tradition in the investment literature, adjustment costs are specified in terms of squared deviations from the steady-state level of the investment-to-capital ratio. The steady-state value of this ratio is determined by the sum of the depreciation rate (δ) and the growth rate of the real economy (g).[110] The exact specification used for adjustment costs is

$$A_t = \frac{\chi}{2}\left[\frac{I_t}{K_{t-1}} - (\delta + g)\right]^2 K_{t-1}, \qquad (48)$$

where K_{t-1} is the capital stock at the beginning of period t, and χ is a parameter that measures the size of the adjustment costs.

The firm maximizes the expected net present value of future profits with respect to capital and investment in equation (46), subject to the technical law of motion for the capital stock:

$$K_t = I_t + (1 - \delta)\, K_{t-1}. \qquad (49)$$

The first-order condition with respect to investment determines optimal investment as a function of Tobin's q:

$$I_t = \left(\delta + g + \frac{q_t - 1}{\chi}\right)K_{t-1}, \qquad (50)$$

where q_t is the shadow price of capital, or the ratio of the market value of a marginal unit of capital to its replacement cost.[111] According to this relationship, it will be profitable to increase the investment-to-capital ratio above its steady-state level as long as q_t is greater than one. Conversely, if q_t is less than one, the investment ratio will fall below its steady-state level. Equation (50) can be rewritten as follows:

$$q_t = \chi\left[\frac{I_t}{K_{t-1}} - (\delta + g)\right] + 1. \qquad (51)$$

The first-order condition with respect to the capital stock determines the law of motion for Tobin's q:

[109]It is assumed that the revenue function has already been maximized vis-à-vis other variable production factors.

[110]The growth rate of GDP is a composite variable comprising technological progress and labor force dynamics.

[111]Technically, q_t is the Lagrange multiplier on the constraint in equation (49).

$$q_t = (1-\delta)E_t\,\rho_{t+1}q_{t+1} + E_t\rho_{t+1}\left[\frac{\partial \Pi_{t+1}}{\partial K_t} - \frac{\partial A_{t+1}}{\partial K_t}\right]. \quad (52)$$

This equation indicates that q_t, the market value of the firm for each unit of capital at time t, is determined by the expected discounted value of q in period t+1, corrected for depreciation, plus the difference between the expected discounted marginal product of capital and the marginal cost of adding new capacity in period t+1.

The importance of adjustment costs for the evolution of the market value of capital is best seen by differentiating equation (48) to obtain the derivative of adjustment costs with respect to capital:

$$\frac{\partial A_t}{\partial K_{t-1}} = \frac{\chi}{2}\left[\frac{I_t}{K_{t-1}} - (\delta + g)\right]^2 - \chi\frac{I_t}{K_{t-1}}\left[\frac{I_t}{K_{t-1}} - (\delta + g)\right]. \quad (53)$$

When χ equals zero, adjustment costs are zero as well, and this term drops out of the law of motion for Tobin's q. In that case, it can be seen from equation (51) that q always equals one and that at any point in time the value of the capital stock equals its replacement cost. This is so because it only makes sense to have less than full adjustment of the capital stock when adjustment is costly. If there are no adjustment costs, it is optimal to keep the capital stock at its equilibrium level in every period.[112]

In steady state, the above framework simplifies substantially. With the capital stock growing in line with GDP, gross investment as a percent of the capital stock equals the sum of the economy's growth rate and the depreciation rate. In that case, Tobin's q equals one and the real value of the capital stock equals its replacement cost. According to equation (48), moreover, adjustment costs are zero, reflecting the tradition of characterizing such costs as a quadratic function of the deviation of the investment-capital ratio from its steady-state value.

To implement this setup, a set of simplifying assumptions are needed. Defining the real market value of the capital stock as

$$WK_t = q_t K_{t-1}, \quad (55)$$

we use the following expression, based on an approximation to equation (52), for the law of motion of the real value of the capital stock in the numerical model:

$$WK_{t+1} = WK_t\,[1 + r_t + \delta_t + rprem_t + (K_t/K_{t-1} - 1)] - \left[(1-\tau)\beta Y_t - \frac{\partial A_t}{\partial K_{t-1}}K_{t-1}\right]. \quad (56)$$

This equation indicates that the real value of the capital stock at time t equals the discounted expected value of next period's capital stock plus the discounted after-tax income accruing to capital after netting out the real resources taken up to adjust the capital stock. The discount factor used incorporates the real short-term interest rate (r_t) plus the rate of depreciation, the yield premium on capital ($rprem_t$), and the growth rate of the capital stock. The yield premium, which is treated as a residual in the simulations, reflects the difference between the marginal product of capital and the real interest rate; τ is the tax rate on capital income.

Conceptually, the presence of the yield premium reflects a decision to use the marginal product of capital, rather than the "risk-free" real interest rate, to discount future market values of the capital stock. This is done to ensure that in steady state the replacement cost of the capital stock equals its market value and, hence, that q equals unity.[113]

Although equations (51) and (52) and their steady-state counterparts provide a fully determined model of the dynamic and steady-state behavior of investment, some important considerations are missing. Despite the theoretical appeal of the link between investment and Tobin's q, the particular form of the relationship described by equations (50) and (51) is only partially, if at all, reflected in historical data. One limitation of the model is that it does not take account of the irreversibility of investment—and the option value of waiting to invest—as analyzed in Bertola (1988), Bertola and Caballero (1990), and Dixit and Pindyck (1994). In addition, the theoretical framework ignores time-to-build features and the as-

[112]This model is a special case of a more general investment function that includes imperfectly competitive goods markets and imperfect capital markets. Substituting equations (51), (53), and the first derivative of (47) into equation (52) gives an equation that can be estimated in the following "flexible-accelerator" form:

$$\frac{I_t}{K_{t-1}} = \kappa_0 + \kappa_1\frac{I_{t-1}}{K_{t-2}} + \kappa_2\left(\frac{I_{t-1}}{K_{t-2}}\right)^2 + \kappa_3\frac{Y_t}{K_{t-1}} + \kappa_4 r_{t-1} + \nu_t, \quad (54)$$

where the parameters κ are functions of the rate of depreciation, the growth rate of the economy, the tax rate on capital income, and the value of χ in the adjustment-cost function. While the presence of the quadratic term in equation (54) indicates the presence of adjustment costs, the absence of an aggregate cash-flow measure and the aggregate business sector debt implies that there are no distortions (tax-induced or other) that would lead to meaningful financial policies (that is, preference for equity over debt finance, or paying dividends). See Bond and Meghir (1994) for an in-depth discussion and empirical implementation and Epstein and Denny (1983) for a rigorous analysis of the flexible-accelerator specification of the adjustment-cost model.

[113]To maintain the consistency of the national income accounts in MULTIMOD, the marginal product of capital is also used in evaluating household wealth. In particular, since the marginal product of capital is larger than the real interest rate and is used to calculate the share of capital income in total income, it needs to be incorporated in the wealth terms used in consumption behavior as described in Section V, to make sure that aggregate factor income is consistent with the value of production.

sociated impact of planning horizons on actual investment figures. These considerations suggest that the contemporaneous relationship described in equation (50) is unrealistic and that changes in q may have lagged effects on investment. This motivates us to estimate the following variant of equation (50):

$$\frac{I_t}{K_{t-1}} - \delta - g = k_1 q_t + k_2 q_{t-1} + \varepsilon_t. \tag{57}$$

Equation (57) is estimated for a panel of 17 industrial countries based on annual data for 1975–96. This requires the construction of synthetic data for q and WK, which is done in two steps. In the first step, a value of 12 for χ is used to calculate q and WK based on equations (51) and (55).[114] As a second step, intended to obtain time series that are more consistent with the full model and to attenuate the endogeneity problem stemming from the fact that q is a forward-looking variable, the first-stage measures of q are regressed on the following instruments lagged one period: the log of GDP, the log of the capital stock, the log of real money balances, and the nominal interest rate. The fitted values from the instrumental variables regressions are then used in the estimation of (57).

Equation (58) reports the coefficients for this regression. Investment reacts positively to increases in q and its lag, with lagged q having a slightly larger impact:

$$\frac{I_t}{K_{t-1}} - \delta - g = \underset{(32.92)}{0.033}\, q_t + \underset{(54.06)}{0.048}\, q_{t-1}. \tag{58}$$

Some implications of this specification for the co-movements of investment, output, and real interest rates are illustrated in the appendix.

Appendix. Investment, Output, and Interest Rate Responses to Demand and Supply Shocks

It has proved difficult in small samples to find stable reduced-form equations for investment that depend on output and real interest rates, in part because the co-movements of these three variables are sensitive to the nature of the underlying shocks. To illustrate the potential problems with reduced-form models of investment, the U.K. bloc of MULTIMOD is used to simulate the effects of demand and supply shocks. This terminology is somewhat misleading because most shocks perturb both demand and supply; here, we simply follow the literature and define supply shocks to be shocks that have permanent effects on real variables, while demand shocks are those shocks that have only temporary, but often persistent, effects on real variables.

A Demand Shock Induced by Monetary Policy

The left column of Figure 6 shows the impulse responses of investment, real GDP, and the real short-term interest rate following a permanent 10 percent increase in the target money supply. Because prices are sticky in MULTIMOD, an increase in the target money supply results in a reduction in the short-term real interest rate. In the short run, investment and real GDP rise in response to the easing in monetary conditions. However, in the long run, prices adjust one for one with the increase in the money supply, and all three variables shown here return to their baseline paths.

A Demand Shock Induced by Fiscal Policy

The middle column of Figure 6 shows the impulse responses of investment, real GDP, and the real short-term interest rate following a temporary increase in government expenditures of 1 percent of baseline GDP. In the short run, there is a tendency for the real short-term interest rate to rise, which results in some crowding out of investment expenditures.[115] However, because the shock is short lived, real GDP and investment return to their baseline paths in the long run.

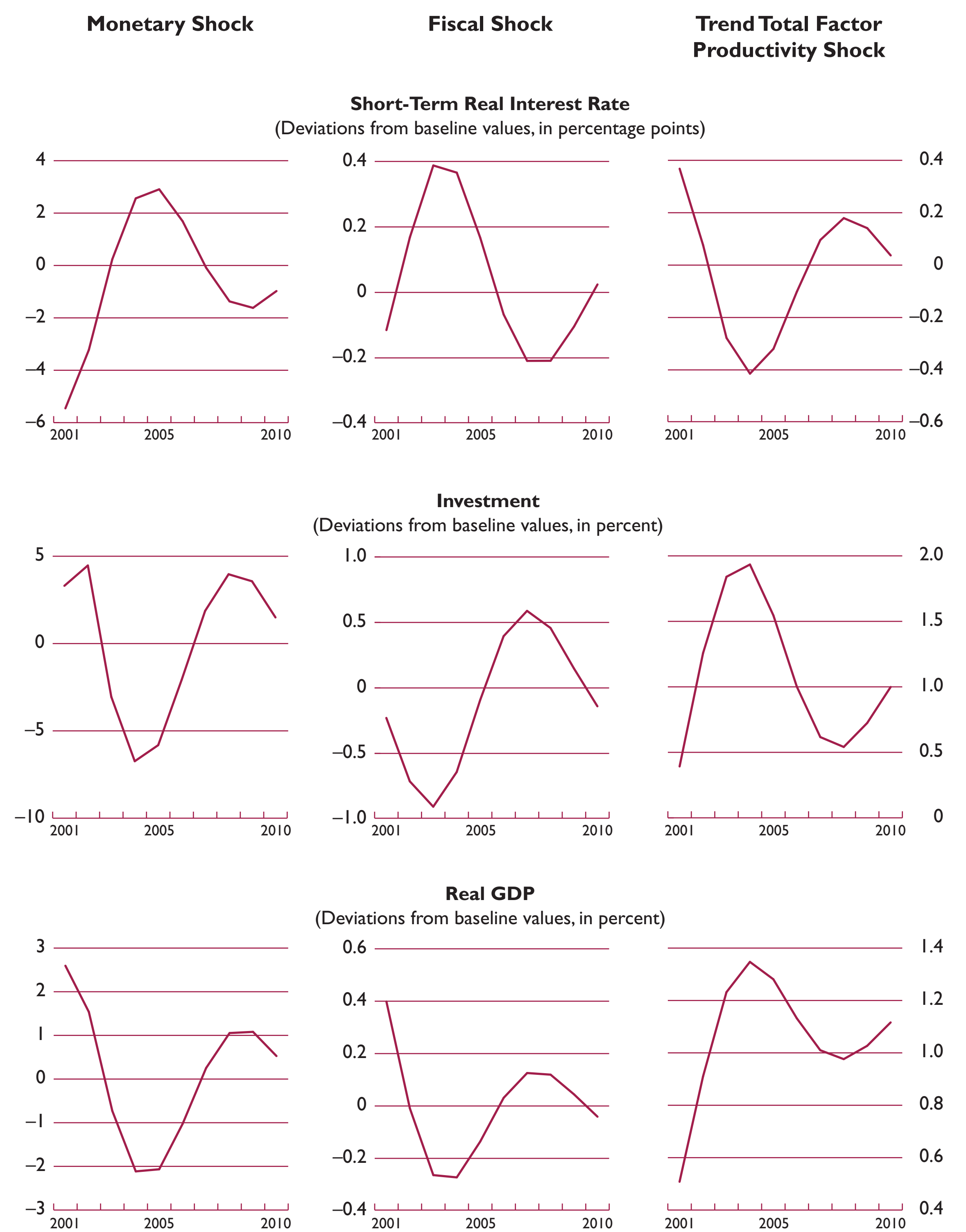
A Supply Shock

The right column of Figure 6 shows the impulse responses of investment, real GDP, and the real short-term interest rate following a permanent 1 percent increase in total factor productivity. In MULTIMOD, an increase in total factor productivity results in an increase in the desired capital stock; the investment-to-GDP ratio must rise above its new steady-state level in the short run in order to achieve this higher level of capital. In the short run, investment, GDP, and the real interest rate will tend to rise. In the long run, GDP and investment are higher and the real interest rate returns back to baseline.

[114]The literature provides a range of estimates. Summers (1981) estimates χ to equal 16.1. Eberly (1997) estimates linear and nonlinear investment equations on firm-level and aggregate data for 11 industrial countries. Based on aggregate measures constructed from the firm-level data in her sample, she finds estimates for χ between 1.4 and 3. Her instrumental variable estimates for firm-level equations are between 1.75 for Belgium and 9 for the Netherlands. Cummins, Hassett, and Oliner (1997) provide estimates on the order of 5–10 based on firm-level data in the United States.

[115]In the first year, the short-term real interest rate falls because the expected increase in the price level more than offsets the increase in the nominal short-term interest rate.

Figure 6. Impulse Responses in Relation to the Investment Block



VII International Trade

This section describes the equations that MULTIMOD uses to explain international trade in countries' main composite goods.[116] The disaggregation of trade flows in the Mark III model remains essentially the same as in Mark II. Imports and exports of goods and nonfactor services are measured according to the national income accounts definition. Imports of oil and non-oil primary commodities, and exports of oil, are then excluded to obtain measures of imports and exports of the main composite goods. A novel feature of Mark III is the use of information from input-output tables (compiled by the OECD) to calculate separate import propensities for consumption, investment, government purchases, and exports. For most countries, the different components of domestic absorption have substantially different import contents. Allowing for these differences enhances MULTIMOD's analysis of the macroeconomic effects, especially on external sector variables, of changes in government expenditure and a variety of other shocks.

Imports

To allow for differences in import propensities for different components of domestic absorption, separate import propensities for each category of absorption (private consumption, private fixed investment, and government purchases) and for exports were calculated using data from the most recent input-output matrices for each country.[117] These import propensities were then used to create weighted measures of aggregate activity (*ACT*) for each country as follows:

$$ACT_t = \gamma_c C_t + \gamma_G G_t + \gamma_I I_t + \gamma_x X_t. \qquad (59)$$

Figure 7 plots, for each of the major industrial countries and for the block of small industrial countries, the volume of imports as a share of these activity variables, as well as the inverse of the relative price of imports. This figure suggests that, over the last three decades, the trend increase in imports relative to the weighted activity variable has been associated with declines in the price of imports (relative to the price deflator for non-oil GNP). This pattern appears to hold in all cases except for the United States, where import prices rose relatively sharply in the early 1970s.

Table 11 presents estimates of a parsimonious error-correction specification for the import volume equations. This specification reflects the view (supported by Figure 7) that the activity variable and the relative price of imports are likely to be the main determinants of the trend in imports. The parameter γ_{m2} captures the speed of adjustment to the long-run equilibrium relationship. The long-run elasticity of import volumes with respect to the relative price of imports is denoted by the parameter γ_{m3}. The specification also includes changes in the relative price of imports. The parameter γ_{m1} represents the short-run price elasticity of imports. In addition, for countries other than the United States, the regression includes a term specified as the difference between domestic potential output growth and U.S. potential output growth.[118] This term, $F(x)$, allows for the possibility that, in the process of convergence of productivity levels across countries, countries with relatively low productivity levels may have required a transfer of technology in the form of imported investment goods. This term could also reflect the expansion (by foreign producers) of distribution networks for imports, spurred by the expansion of productive capacity abroad.[119]

[116]We do not elaborate here on international trade in oil and non-oil primary commodities, which was discussed in Section II.

[117]The OECD has compiled input-output tables for the seven major industrial countries and also for Australia, Denmark, and the Netherlands. The latest versions of these tables (1990 for most countries) were used to compute import propensities for the components of domestic absorption as well as for exports. The last set of numbers reflects exports of goods and services that have a significant content of imported inputs.

[118]Potential output growth rates were computed using smoothed levels of potential output obtained from the World Economic Outlook database.

[119]In the core version of Mark III, this term is turned off in simulation mode. Future extensions of the model will incorporate endogenous total factor productivity growth, along the lines of the analysis in Bayoumi, Coe, and Helpman (1996).

Figure 7. Import-Activity Ratios and Relative Import Prices

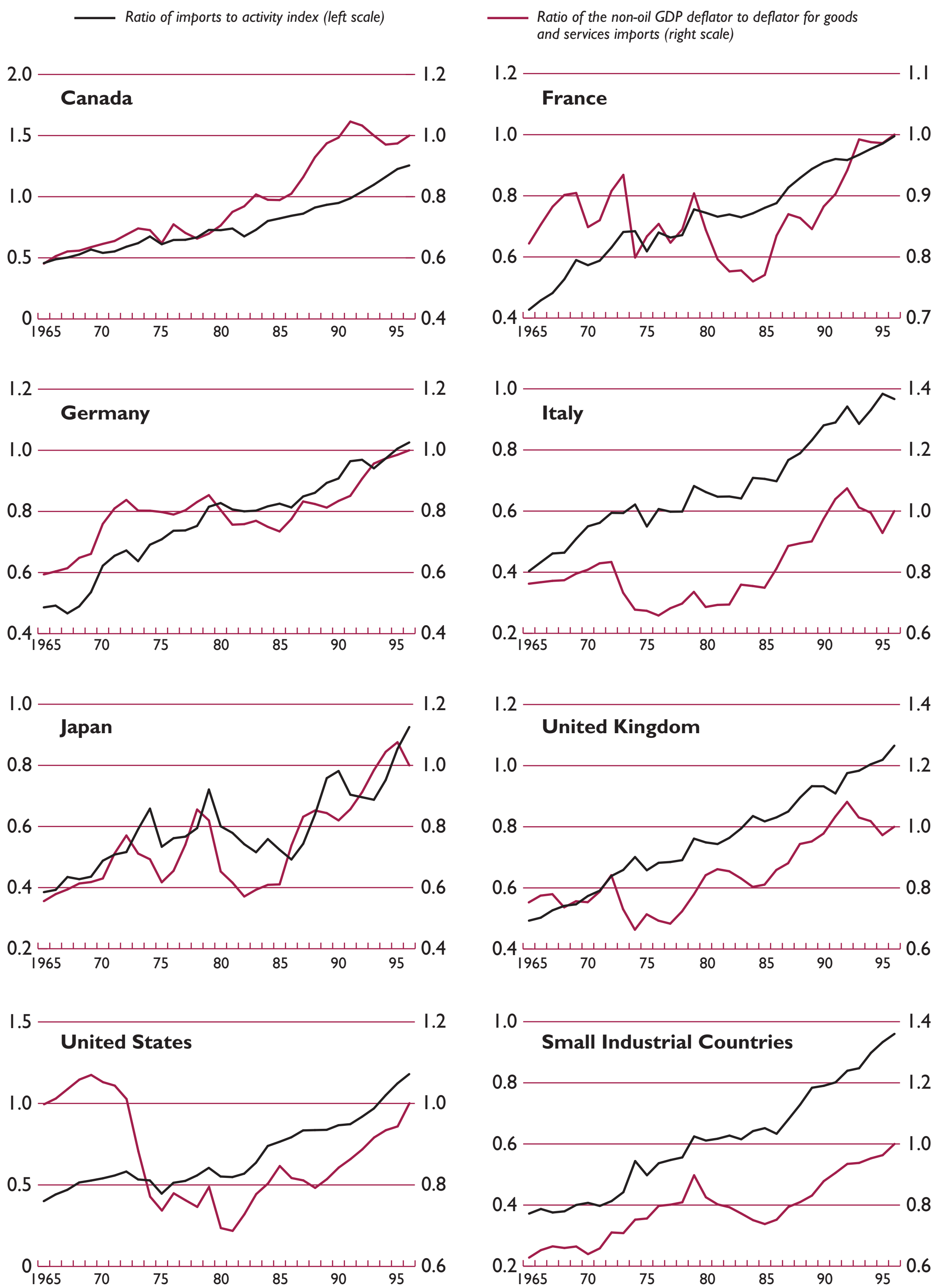


Table 11. Volume Equations for Imports

$$\Delta\log(MGSLOC_t) - \Delta\log(ACT_t) = \gamma_{m0} + \gamma_{m1}\,\Delta PMREL_t + \gamma_{m2}\,[\log(MGSLOC_{t-1}) - \gamma_{m3}\,PMREL_{t-1} - \log ACT_{t-1}] + F(x)$$

MGSLOC: imports of goods and nonfactor services, excluding oil and non-oil commodities.
ACT: weighted activity variable based on import propensities from input-output tables.
F(*x*): contribution of variables included to control for variation in imports not accounted for by weighted domestic activity and relative prices.[1]
PMREL: relative price of imports in logs.

Estimation period: 1972–96

	γ_{m0}	γ_{m1}	γ_{m2}	γ_{m3}	R^2	SE
Canada	0.01	–0.33**	0.06	–0.99**	0.56	0.045
	(0.01)	(0.04)	(0.07)	(0.12)		
France	0.00	–0.33**	0.14**	–0.99**	0.69	0.037
	(0.01)	(0.04)	(0.05)	(0.12)		
Germany	0.01*	–0.33**	0.13**	–0.99**	0.60	0.028
	(0.01)	(0.04)	(0.05)	(0.12)		
Italy	–0.02	–0.33**	0.34**	–0.99**	0.66	0.048
	(0.02)	(0.04)	(0.07)	(0.12)		
Japan	–0.07**	–0.33**	0.35**	–0.99**	0.56	0.077
	(0.03)	(0.04)	(0.07)	(0.12)		
United Kingdom	–0.00	–0.33**	0.25**	–0.99**	0.64	0.034
	(0.01)	(0.04)	(0.05)	(0.12)		
United States	0.03**	–0.33**	0.06**	–0.99**	0.73	0.046
	(0.01)	(0.04)	(0.03)	(0.12)		

Note: Standard errors reported in parentheses. ** (*) indicates statistical significance at the 5 percent (10 percent) level.
[1]For all countries other than the United States, the specification includes the term *F*(*x*), defined as domestic potential output growth minus U.S. potential output growth.

Note that the short-run elasticity of imports with respect to activity is constrained to be unity. This restriction, although not supported by the data, is necessary in order to obtain reasonable price elasticities. In the absence of this restriction, the trend in the level of imports would result in estimates of a large elasticity with respect to activity (which also has a trend) and, consequently, a small and often imprecise estimate of the price elasticity.

To minimize the global trade discrepancy (see discussion below), it is assumed that all countries have identical long-run price elasticities. The pooled estimate of this price elasticity (γ_{m3}) is –0.99. The estimated parameters on the error-correction terms (γ_{m2}) vary from a low of 0.06 for Canada and the United States to a high of about 0.35 for Italy and Japan. These parameter estimates are statistically significant for all countries, corroborating the evidence presented in Figure 7 that the upward trend in the volume of imports is associated with the decline in the relative price of imports. The coefficient on the contemporaneous change in relative import prices (γ_{m1}) is also restricted to be the same for all countries. The estimated coefficient is negative and statistically significant.

Import prices are determined in the model as weighted averages of other countries' export prices. The average price of imports of country *i*, denoted PIM_i, is given by

$$PIM_i = \sum_{j \neq i} s_{ji}\,(PXM_j E_{ij}), \tag{60}$$

where s_{ji} denotes the share of exports from country *j* to country *i* in the total exports to country *i*, PXM_j is the price of exports of country *j*, and E_{ij} is an index of the value of currency *j* in terms of currency *i*.

Exports

The econometric specification for the export equation is similar to that of the import equation.

Table 12. Bilateral Total Exports, 1996
(In billions of U.S. dollars)

	Importer								
Exporter	United States	Japan	Germany	Canada	France	Italy	United Kingdom	Smaller industrial countries	Developing countries
United States	—	67.5	23.5	132.6	14.4	8.8	30.9	73.6	271.6
Japan	113.1	—	18.2	5.1	5.4	3.4	12.5	35.9	217.6
Germany	39.9	14.1	—	2.8	55.9	38.1	41.0	188.5	132.6
Canada	164.8	7.5	2.3	—	1.2	1.0	2.8	5.6	15.0
France	17.3	5.4	49.1	1.9	—	26.4	26.9	92.6	68.3
Italy	18.4	5.6	43.7	1.8	31.4	—	16.2	60.1	73.6
United Kingdom	31.4	6.7	29.5	3.1	24.2	11.5	—	84.0	68.0
Smaller industrial countries	53.9	31.8	183.5	7.6	100.6	51.1	91.1	240.9	205.2
Developing countries	365.2	180.9	103.1	20.6	56.1	50.1	65.7	178.4	716.7

The scale variable used in this equation is foreign activity, and the relative price variable is the real competitiveness index (*RCI*).

The foreign activity variable is constructed as a weighted sum of the import volumes of other countries. The weights are equal to the base period shares of the home country's exports accounted for by the foreign countries and are based on the pattern of trade flows in 1996; see Table 12.

The real competitiveness index (*RCI*) is defined as a weighted sum of the logarithms of export prices of a country's trading partners relative to home-country export prices. This competitiveness index is constructed in a manner consistent with the use of partner countries' imports as the foreign activity variable that enters into the export equations.[120]

Consider the following identity that relates the exports of a given country (X_i) to the imports of each of its trading partners (M_j), weighted by its share in each of their markets (s_{ij}):

$$X_i \equiv \sum_{j \neq i} s_{ij} M_j. \tag{61}$$

The base-period export share of country i to country j is denoted by

$$\bar{x}_{ij} = \left(\frac{\bar{M}_j}{\bar{X}_i}\right) \bar{s}_{ij}, \tag{62}$$

where the bar above a variable indicates the base-period value of that variable. It can then be shown that an appropriate set of weights for constructing country i's competitiveness index is as follows:[121]

$$w_{ik} = \sum_{j \neq i,k} \bar{x}_{ij} \bar{s}_{kj}, \quad i \neq k$$
$$w_{ii} = -\sum_{k \neq i} w_{ik}. \tag{63}$$

The weights w_{ik} indicate the sensitivity of the exports of country i to competition in third markets from country k. The weights are normalized to sum to one for each country. The foreign activity variable for country i is defined as follows:

$$FACT_i = \sum_{j \neq i} \bar{s}_{ij} \bar{M}_j \bar{E}_{ij}, \tag{64}$$

where $\bar{E}_{ij}$ denotes the base-period price of currency j in terms of currency i.

The export volume equation is specified in first differences but includes an error-correction term. The estimated export equations constrain the coefficients on the lagged level of the real exchange rate to be the same for all countries. Also, the short-run elasticity of exports with respect to foreign activity is constrained to be unity. This restriction is imposed since, as in the import equation, the elasticity of ex-

[120]Measures of nominal and real effective exchange rates based on direct trade shares are also computed in the model. These weights take into account competition in third markets and also the differences among countries in the relative importance of international trade. The methodology for computing the weights is similar to that of the IMF's Information Notice System described in McGuirk (1987) and Zanello and Desruelle (1997).

[121]See Meredith (1997) for details on the derivation of these weights.

Table 13. Volume Equations for Exports

$\Delta \log (XGSLO_t) - \Delta \log (FACT_t) = \gamma_{X0} + \gamma_{X1} \Delta \log (RCI_t) + \gamma_{X2}[\log (XGSLO_{t-1}) - \gamma_{X3} \log (RCI_{t-1}) - \log (FACT_{t-1})]$

XGSLO: exports of goods and nonfactor services, excluding oil.
FACT: weighted sum of import volumes in other countries/regions.
RCI: real competitiveness index.

Estimation period: 1972–96

	γ_{x0}	γ_{x1}	γ_{x2}	γ_{x3}	R^2	SE
Canada	–0.00	–0.41**	0.01	–1.74**	0.76	0.032
	(0.01)	(0.10)	(0.01)	(0.29)		
France	0.00	–0.48**	0.01	–1.74**	0.64	0.028
	(0.01)	(0.08)	(0.03)	(0.29)		
Germany	–0.00	–0.40**	0.06*	–1.74**	0.57	0.033
	(0.01)	(0.07)	(0.03)	(0.29)		
Italy	–0.02**	–0.38**	0.17**	–1.74**	0.50	0.035
	(0.01)	(0.10)	(0.06)	(0.29)		
Japan	–0.02**	–0.45**	0.36**	–1.74**	0.46	0.044
	(0.01)	(0.11)	(0.09)	(0.29)		
United Kingdom	0.00	–0.45**	0.13**	–1.74**	0.72	0.025
	(0.01)	(0.08)	(0.03)	(0.29)		
United States	0.03**	–0.42**	0.08**	–1.74**	0.77	0.026
	(0.01)	(0.06)	(0.02)	(0.29)		

Note: Standard errors reported in parentheses. ** (*) indicates statistical significance at the 5 percent (10 percent) level.

ports with respect to foreign activity would otherwise be dominated by the trends in these two variables and result in very low estimates of the price elasticity.

Estimates of the export volume equations are presented in Table 13. The long-run price elasticity of exports (γ_{x3}) is estimated to be –1.74. Short-run price elasticities (γ_{x1}) differ across countries and are lower than the long-run price elasticity, but are still quite large and statistically significant for all countries. The estimated parameters on the error-correction terms (γ_{x2}) are positive in all cases and statistically significant for all countries except Canada and France. This suggests that, in the long run, exports are generally closely tied to the foreign activity and real exchange rate variables. This is confirmed by Figure 8, which plots, for each country, the ratio of export volume to the foreign activity variable as well as the real competitiveness index.

Export price equations were estimated for the major industrial countries. The rate of change of export prices is assumed to be linearly related to the rates of change of the price of domestic non-oil output and the prices of foreign non-oil exports, where foreign prices use the same weighting scheme as the real competitiveness index, reflecting competition in all export markets. In addition, the lagged logarithmic difference between domestic prices and home-country export prices is included in the specification, thereby forcing export prices to change in proportion to the change in domestic output prices over the long run. The coefficient on this term was restricted to be the same for all countries; this restriction was not rejected by the data. The estimates of the export price equations are reported in Table 14. The sensitivity of export prices to the rate of change of foreign prices is quite similar across the major industrial countries.

Adding Up of World Trade and Current Account Balances

The existence of a global trade discrepancy, which implies that exports and imports summed across all countries are not equal, is a well-known problem. The discrepancy is even larger when the current account, which includes factor incomes, is aggregated across all countries. Although such a discrepancy might exist in the baseline, it is desirable for the

Figure 8. Export-Activity Ratios and Real Competitiveness Indices

Table 14. Export Price Equations

$$\Delta\log(PXM_t) = \gamma_{px0} + \gamma_{px1}\,\Delta\log(PGNPNO_t) + (1-\gamma_{px1})\,\Delta\log(PFM_t) + \gamma_{px2}\log(PGNPNO_{t-1}/PXM_{t-1})$$

PXM: export price of the composite good that excludes oil and primary commodities.

PGNPNO: non-oil GDP deflator.

PFM: a weighted average of competitors' prices in foreign markets.

	γ_{px0}	γ_{px1}	γ_{px2}	R^2	SE
Canada	–0.01*	0.64**	0.03**	0.59	0.032
	(0.01)	(0.05)	(0.01)		
France	–0.00	0.71**	0.03**	0.92	0.016
	(0.00)	(0.03)	(0.01)		
Germany	–0.00	0.81**	0.03**	0.17	0.047
	(0.01)	(0.10)	(0.01)		
Italy	0.00	0.66**	0.03**	0.90	0.024
	(0.00)	(0.05)	(0.01)		
Japan	–0.00	0.65**	0.03**	0.92	0.028
	(0.01)	(0.02)	(0.01)		
United Kingdom	–0.00	0.63**	0.03**	0.87	0.019
	(0.00)	(0.04)	(0.01)		
United States	–0.00	0.64**	0.03**	0.54	0.034
	(0.01)	(0.04)	(0.01)		

Note: Standard errors reported in parentheses. ** (*) indicates statistical significance at the 5 percent (10 percent) level.

model to have the property that incremental exports and imports be equal.

The new weighting scheme used to construct the price and activity variables for the trade equations ensures that this discrepancy is very small, although not exactly zero. Adding up of world trade is, therefore, imposed by allocating real and nominal trade discrepancies to export volumes and import prices, respectively.[122] Given the adding up of world trade, the adding up of current account balances across all countries is then imposed on the simulations by constructing estimates of net foreign asset positions that sum to zero globally and by assuming that all claims pay the same U.S. dollar interest rate.[123]

[122]The model contains equations for adjusted exports that are equal to unadjusted exports, determined using the export equations described above, plus, for each country, a coefficient times the excess relative to baseline of world import volumes over export volumes. This coefficient reflects the share of the country in total world trade in goods and nonfactor services excluding oil. The remaining discrepancy in nominal trade flows is allocated across countries in a similar fashion by adjusting import prices.

[123]As described in Masson, Symansky, and Meredith (1990), for all countries and country groups except the main developing country bloc, estimates of net foreign asset positions are constructed by cumulating measured current account balances. The net foreign asset position of the main developing country bloc is then constructed as a residual.