Explaining Saving–Investment Correlations

By Marianne Baxter and Mario J. Crucini*

National saving and investment rates are highly positively correlated in virtually all countries. This is puzzling, as it apparently implies a low degree of international capital mobility. This paper shows that the observed positive correlation between national saving and investment rates arises naturally within a quantitatively restricted equilibrium model with perfect mobility of financial and physical capital. The model is consistent with the fact that saving–investment correlations are larger for larger countries but are still substantial for small countries. Further, the model is consistent with the finding that current-account deficits tend to be associated with investment booms. (*JEL* F41)

In the field of international macroeconomics, temporally robust stylized facts are few and far between. One of the most stable regularities observed in the data is the fact that national saving rates are highly correlated with national investment rates, both in time-series analyses of individual countries and in cross sections in which each country is treated as a single data point.[1] High saving–investment correlations arise in small economies as well as in large economies, although the correlations tend to be lower for smaller economies.

These findings have been interpreted as indicating that the world is characterized by capital immobility, yet most economists believe that the world is characterized by an increasingly high degree of international capital mobility. In particular, Jeffrey D. Sachs (1981) presents empirical evidence that current-account deficits are associated with investment booms, implying that increases in domestic investment are at least partly financed by capital inflows. Taken together, these two strands of the literature constitute a puzzle: how can we reconcile Sachs's evidence with high time-series correlations between saving and investment?

This paper provides an explanation for this seemingly anomalous pair of empirical findings. We show, first of all, that high time-series correlations between saving and investment arise naturally within a plausibly parameterized equilibrium model with perfect mobility of financial capital and physical capital.[2] This model also predicts that current-account deficits should be associated with high levels of domestic investment. Our analysis is carried out within the context of a two-country, one-sector, stochastic growth model driven by exogenous shocks to productivity. Although sev-

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[1]Cross-sectional evidence is provided by Martin S. Feldstein and Charles Y. Horioka (1980), Feldstein (1983), Robert G. Murphy (1984), Alessandro Penati and Martin Dooley (1984), Dooley et al. (1987), and Linda T. Tesar (1991), among others. Time-series evidence is provided by Maurice Obstfeld (1986), Jeffrey Frankel (1986), and Tesar (1991).

[2]Previous work by Obstfeld (1986), Charles M. Engel and Kenneth M. Kletzer (1989), Mary G. Finn (1990), and Tesar (1990, 1991) has also provided analyses which demonstrate that it is possible to explain high saving–investment correlations within a well-specified equilibrium model with capital mobility. Contemporaneously with the writing of this paper, Emanuela Cardia (1989), Enrique Mendoza (1991), and David K. Backus et al. (1992) have also developed models in which high saving–investment correlations can arise.

eral authors have suggested that "policy reactions" are the explanation for observed saving–investment correlations (see e.g., Norman S. Fieleke, 1982; Uwe Westphal, 1983; Gerard A. Caprio, Jr., and David H. Howard, 1984; Nouriel Roubini, 1988; Lawrence H. Summers, 1988; Tamin Bayoumi, 1989), our model generates plausible correlations in the presence of completely passive fiscal policy.

The model is parameterized to generate realistic persistence and comovement of national outputs as well as realistic behavior of consumption and investment within each country. By varying the relative size of the two countries, we can examine the effect of country size on saving, investment, and current-account behavior. As will become apparent, country size is an important determinant of saving–investment correlations. The reason, of course, is that larger countries have larger effects on the world interest rate, and our model predicts that saving–investment correlations are higher for larger countries. However, it is generally *not* the case that one should expect a zero correlation between saving and investment in a small country, for two reasons. First, the usual measure of saving may diverge sharply from the true measure of saving. Second, models of small open economies generally assume that movements in the world interest rate are uncorrelated with events in the small open economies; we present empirical evidence that casts doubt on this assumption. In fact, our analysis demonstrates that modeling the underlying determinants of the world interest rate is central to understanding the cyclic behavior of small open economies.

The paper is organized as follows. Section I briefly reviews the stylized facts concerning saving–investment correlations. Section II presents our model. This section also discusses problems associated with the definition and measurement of saving and their implications for saving–investment correlations. Section III discusses the model's predictions along a number of dimensions and provides an informal comparison of these predictions with the data. Section IV concludes the paper with a brief summary of our results and a discussion of directions for future research.

I. The Correlation Between Saving and Investment

Many authors have investigated the magnitude and robustness of the correlation between saving and investment within a large sample of countries. This section briefly reviews this evidence. In a paper which sparked substantial subsequent research on this topic, Martin S. Feldstein and Charles Y. Horioka (1980) regressed long averages of the investment-to-output ratio on the saving-to-output ratio, using a cross-section of 16 OECD countries. Their estimate of the coefficient on the saving-to-output ratio was very close to 1, which Feldstein and Horioka interpreted as evidence against international capital mobility. Robert G. Murphy (1984) studied a cross section of 17 countries and found that saving–investment correlations were larger for larger countries. Using the Feldstein-Horioka methodology, Murphy found that the average coefficient on the savings ratio is only 0.59 for the ten smallest countries in his sample, compared with an average coefficient of 0.98 for the seven largest countries.

More recently, Linda L. Tesar (1991) has provided additional evidence on cross-sectional saving–investment correlations. She demonstrates that the high coefficient on the savings ratio in the Feldstein-Horioka regressions is robust to changes in the length of the interval over which the average is taken. Her sample includes 24 OECD countries. For data averaged over 25 years (1960–1984) the coefficient on the savings ratio was 0.93. For data averaged over five-year intervals the coefficient ranged from 0.79 to 0.95, depending on the five-year interval. For three-year averages the coefficient ranged from 0.76 to 0.95, and for one-year averages the coefficient ranged from 0.67 to 0.97.

Tesar also provides time-series plots of the saving and investment ratios over the full sample period. Within each country for which plots are provided, it is clear that

TABLE 1—COUNTRY SIZE AND SAVING–INVESTMENT CORRELATIONS

Country	GNP (1985 U.S. $)	Saving–investment correlation
United States	3,994	0.86
Japan	1,365	0.80
Germany	667	0.68
France	527	0.31
Italy	372	0.39
Canada	347	0.61
Australia	171	0.54
Switzerland	106	0.65

Notes: Saving is measured as output less private consumption less government consumption, all variables in per capita terms. The correlation is computed for HP-filtered logarithms of this measure of saving and gross fixed capital formation. Source for GNP: *World Development Report* (1987 table 1 [Basic Indicators]).

saving and investment are highly correlated at the annual frequency. Maurice Obstfeld (1986) computes time-series correlations between changes in saving and investment rates using quarterly data from seven OECD countries and finds correlations ranging from 0.13 to 0.91. Finally, Table 1 contains data on saving–investment correlations and country size (as measured by GNP) for eight OECD countries.[3] While the saving–investment correlations are largest for the largest countries, they are still substantial for the smallest countries listed. Thus, the time-series evidence demonstrates that the saving–investment correlation is not just a long-run or low-frequency phenomenon, as has sometimes been suggested.

II. Saving–Investment Correlations in the One-Sector Model

This section develops a two-country extension of the standard one-sector stochastic growth model. There is a single final good produced in each of the two countries; this good is used both for consumption and for investment. Because of the single-good nature of the model, international trade takes place only to smooth consumption and to equalize the cross-country after-tax returns to capital.

A. *The Model*

The world comprises two countries: the home country and the foreign country. Residents of each country value leisure and consumption of the single produced good; labor is immobile across countries. Firms in each country produce the single good via identical constant-returns-to-scale production functions. These firms are subject to exogenous shocks to total factor productivity, which may be partly country-specific in origin.[4]

This model is described by the equations below. The foreign country is distinguished from the home country by means of a star attached to all foreign-country variables. Where stars are absent, the variable, parameter, or function in question is assumed to be identical across countries. The model is discussed in terms of the home country alone when there is no danger of confusion; all variables are in per capita terms unless otherwise stated.

Consumers in each country choose leisure L_t, and consumption, C_t, to maximize

$$(1) \qquad E\sum_{t=0}^{\infty}\beta^t\frac{1}{1-\sigma}\left(C_t^{\theta}L_t^{1-\theta}\right)^{1-\sigma}$$

in the case of the home country, and

$$(2) \qquad E\sum_{t=0}^{\infty}\beta^t\frac{1}{1-\sigma}\left[(C_t^*)^{\theta}(L_t^*)^{1-\theta}\right]^{1-\sigma}$$

[3]These data, together with all other data used in this paper, were filtered using a filter proposed by Robert J. Hodrick and Edward C. Prescott (1980), which we call the "HP filter." This filter was used in order to preserve comparability with the growing body of research which uses this filter. The HP filter will remove the nonstationary component of any series that is integrated of order four or less, so that nonstationarity of the filtered series should not be an issue. However, one's view of the "facts" can be highly colored by the filter, as demonstrated by Baxter (1991).

[4]At this point, we do not specify the sources of shocks to factor productivity. Variations in productivity could, for example, arise from shifts in exogenous technological possibilities or from shifts in policy variables under control of the government, as in Abel and Blanchard (1983).

in the case of the foreign country, subject to constraints that are spelled out below.

Firms produce output using constant-returns-to-scale technologies:

$$(3)\quad Y_t = F_t(K_t, N_t) = A_t K_t^{1-\alpha}(X_t N_t)^{\alpha}$$

in the home country, and

$$(4)\quad Y_t^* = F_t^*(K_t^*, N_t^*) = A_t^*(K_t^*)^{1-\alpha}(X_t^* N_t^*)^{\alpha}$$

in the foreign country, where Y_t denotes aggregate output and K_t denotes the capital stock utilized by the home-country firm. In general, K_t does not correspond to capital owned by residents of the home country, since individuals are permitted to rent capital to firms in either country. The variables X_t and X_t^* represent labor-augmenting technical change and are assumed to grow at the common constant (gross) rate γ_X. A_t and A_t^* are the stochastic components of the productivity variables. In order to focus on country size as a central determinant of a nation's cyclic response to exogenous productivity shocks, we have built a great deal of symmetry into the specification of the forcing processes. Letting a "hat" (^) over a variable denote percentage deviation from the steady state, ($\hat{A} = \Delta A / A$), the productivity shocks are assumed to follow the stationary Markov process given by

$$(5)\quad \begin{bmatrix} \hat{A}_t \\ \hat{A}_t^* \end{bmatrix} = \begin{bmatrix} \rho & \nu \\ \nu & \rho \end{bmatrix} \begin{bmatrix} \hat{A}_{t-1} \\ \hat{A}_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ \varepsilon_t^* \end{bmatrix}$$

where $E(\varepsilon_t) = E(\varepsilon_t^*) = 0$. Under this specification, innovations to productivity that originate in one country (ε_t or ε_t^*) are transmitted to the other country if the "diffusion" parameter, ν, is nonzero. The "persistence" parameter, ρ, is important for the serial correlation of the technology variable within a country. The variance-covariance matrix for the innovations to the productivity process is

$$(6)\quad E(\varepsilon_t, \varepsilon_t^*)(\varepsilon_t, \varepsilon_t^*)' = \begin{bmatrix} \sigma_\varepsilon^2 & \psi \\ \psi & \sigma_\varepsilon^2 \end{bmatrix}.$$

Thus the contemporaneous correlation of the innovations to productivity is determined by the parameter ψ.

Capital accumulates over time according to

$$(7)\quad K_{t+1} = (1-\delta)K_t + \phi(I_t / K_t)K_t$$

in the home country, and according to

$$(8)\quad K_{t+1}^* = (1-\delta)K_t^* + \phi(I_t^* / K_t^*)K_t^*$$

in the foreign country, where δ is the depreciation rate of capital, and where the function $(1/\phi')$ is Tobin's q, which gives the number of units of output which must be forgone to increase the capital stock in a particular location by one unit. This formulation has been used by Hirofumi Uzawa (1969) and Robert E. Lucas, Jr., and Prescott (1971). Near the steady-state point, we assume that $\phi > 0$, $\phi' > 0$, and $\phi'' < 0$.

A fraction π of the world population lives in the home country. The world resource constraint is therefore given by

$$(9)\quad \pi(Y_t - C_t - I_t - G_t) + (1-\pi)(Y_t^* - C_t^* - I_t^* - G_t^*) \geq 0.$$

Finally, work effort plus leisure cannot exceed the unit endowment of time:

$$(10)\qquad 1 - L_t - N_t \geq 0$$

in the home country, and

$$(11)\qquad 1 - L_t^* - N_t^* \geq 0$$

in the foreign country.

A government sector was included in the model for two reasons. First, governments of actual economies tax outputs at nonzero rates and purchase output for their own use. Second, nonzero levels of government purchases and distortionary taxation of output affect the steady-state properties of the model and, to a lesser extent, its dynamic properties. We assume that the government of the home country taxes national output at the rate τ (yielding tax revenues of τY_t), purchases and disposes of goods in the amount G, and transfers goods to private individuals in the amount T_t. Variations in tax revenues stemming from variations in national outputs are offset through variations in transfer payments. The government of the foreign country engages in similar activities. Thus, the budget constraints for the two governments are

$$G + T_t = \tau Y_t \tag{12}$$

for the home country, and

$$G^* + T_t^* = \tau^* Y_t^* \tag{13}$$

for the foreign country.

B. *Market Structure*

In our model economy, markets are complete: agents may trade any contingent claims they wish. Our decision to permit complete contingent-claims markets was motivated by the following observations. While Feldstein and Horioka (1980) and Feldstein (1983) are not specific about the market structure which they assume to characterize the world economy, their claim that small open economies ought to exhibit zero saving–investment correlations seems to be based on a model in which "Fisherian separation" obtains, so that saving decisions can be made independently of investment decisions. Without a sufficient menu of contingent securities, individuals will bear a certain amount of national idiosyncratic risk, and we would expect a positive correlation between saving and investment, even in very small economies. In order to avoid biasing our model in favor of predicting high saving–investment correlations, we have not imposed *any* restrictions on opportunities for international risk-pooling.

C. *Model Parameterization and Solution*

Given complete freedom in parameterizing this model, it would be easy to generate saving–investment correlations in the range observed in the data. However, we follow previous research in quantitative equilibrium macroeconomics by parameterizing our model so that it is consistent with the long-run experience of the U.S. economy with respect to growth rates, factor shares, proportion of time devoted to market activities, the average level of the real interest rate, and the rate of depreciation of capital. Our parameterization of preferences and technology is the same as that used by Robert G. King et al. (1988). Specifically, the steady-state share of time devoted to market work is 0.20; the representative agent's discount factor, β, is 0.9875; the growth rate of labor-augmenting technical change, γ_X, is 1.004; capital depreciates at the rate of 2.5 percent per quarter; and labor income as a fraction of GNP is 0.58. The steady-state share of government expenditures as a fraction of GNP is set at its approximate postwar average of 20 percent, and taxes as a fraction of GNP are set equal to their approximate current level of 30 percent.

The preference parameter σ, which governs the degree of relative risk aversion and the degree of intertemporal substitution, has not been decisively pinned down by prior empirical analyses. In our benchmark parameterization, we set $\sigma = 2$ since this is in line with many empirical estimates. However, we also undertake a sensitivity analysis, investigating the implications of $\sigma = 10$. The effect of this perturbation is minimal, as discussed in Section III below.

In addition to matching the long-run growth characteristics of the U.S. economy, we shall require that the parameterized model also replicate the following patterns of correlation and relative volatility which have formed the basis for evaluation of other equilibrium business-cycle models (see, e.g., Finn E. Kydland and Prescott, 1982; Prescott, 1986; King et al., 1988). First, we observe that movements in national outputs are highly serially correlated and tend to be positively correlated across countries.[5] Sec-

[5]The Data Appendix provides data on these and other moments for a sample of eight OECD countries. David Backus, Patrick Kehoe, and Finn Kydland generously provided us with the data used in this paper.

ond, we typically observe that consumption is less volatile than output and investment is more volatile than output. As we shall see, a quantitatively restricted version of our model which is capable of producing these phenomena simultaneously predicts high saving–investment correlations and can also generate many other important "stylized facts" found in the data.

Relative country size plays an important role in our analysis; in the context of our model, country size is captured by population size. We have not incorporated cross-country differences in per capita income, by making smaller countries systematically richer (per capita) or poorer than larger countries. As with our symmetric parameterization of the productivity process, this decision allows us to isolate the exact source of any differences in equilibrium outcomes in small versus large economies.

Our model differs from most real-business-cycle models in that we impose costs of adjustment in capital.[6] Our near-steady-state analysis does not require that we specify a functional form for the adjustment cost function, ϕ. We need only specify three parameters which describe the behavior of ϕ near the steady state. The first two of these parameters govern (i) the steady-state value of Tobin's q and (ii) the steady-state share of investment in national product. Effectively, these amount to specifying $\phi(I/K)$ and $\phi'(I/K)$ at the steady state. We set these parameters so that the model with adjustment costs has the same steady state as the model without adjustment costs. Thus, the steady-state Tobin's q is 1, and the steady-state share of investment is the same as in the model without adjustment costs. A third parameter that must be specified is the elasticity of the marginal adjustment cost function, which governs the response of I/K to movements in q. We let η denote this elasticity. Previous empirical studies have not estimated a cost-of-adjustment parameter for an open-economy model such as ours. Consequently, we present results for a wide range of the adjustment-cost elasticity.

Finally, we must also specify the parameters of the productivity process: ρ, ν, and ψ. Direct estimation of these parameters has been hindered by the poor quality of international data on capital and labor input. Backus, Kehoe, and Kydland (1992) (henceforth, BKK) measure the productivity shocks as residuals from an aggregate production function. They find that movements in productivity are highly persistent ($\rho > 0.90$), that there is some evidence of cross-country "spillovers" of shocks ($\nu > 0$), and that innovations to productivity are positively correlated across countries ($\psi > 0$).

The BKK estimates, while providing a valuable starting point, have several problems. First, their estimates of Solow residuals do not use a measure of capital input. Since the cyclical volatility of capital input is small, omitting capital may not excessively bias estimates of the volatility of Solow residuals. However, there is no guarantee that this omission will not affect the critical cross-country covariance properties of the Solow residuals, as reflected in the parameters ν and ψ. In fact, recent evidence provided by Donna M. Costello (1990) suggests that measurement of capital is important. She computes sectoral Solow residuals using annual data for five two-digit industries in six countries and constructs two alternative measures of the capital input. She finds that the covariance properties of the Solow residuals are highly sensitive to the measure of capital input. A second problem with the BKK estimates of Solow residuals for the six European countries is the imposition of a common, constant labor share across all the European countries. Again, we do not know how this will affect the critical covariance properties of the estimated Solow residuals.

Third, and possibly most importantly, labor input was measured as employed persons, rather than the correct measure, which is total hours applied to productive activity. Quarterly data on hours are not available

[6] As noted in Baxter (1988), Crucini (1991), and Backus et al. (1992), *some* type of friction which inhibits capital mobility is necessary to prohibit extreme and highly unrealistic swings in national capital stocks in response to the exogenous shocks.

(except for the manufacturing sector) for most countries. This would not be problematic if variation in hours were small or if movements in hours were not correlated with the business cycle. However, a study by Kenneth Burdett and Randall Wright (1989) shows that exactly the opposite is true. While variation in labor input in the United States and Canada is primarily due to variation in employed persons, with little variation in hours per worker, this is not true of European countries. (Burdett and Wright argue that this can be explained by the structure of unemployment compensation.) In the United States, for example, employment variation explains 63 percent of the variation in labor input, with hours variation explaining only 8 percent (for Canada, the statistics are 94 percent and 5 percent). Compared with the United States and Canada, hours variation explains much more of the variation in total labor input in European countries (29–82 percent, depending on the country), and employment variation explains much less (18–89 percent). In fact, for six European countries, hours variation explains *more* of the variation in total labor input than employment variation.

Given that the measurement problem is so severe, we advocate taking an alternative approach to identification. The idea is to use moments that are sensitive to variation in particular parameters to identify those parameters. For example, to generate persistence in output, the model requires that the productivity shocks be highly persistent. To generate output comovement, it is necessary that there be a high degree of "commonness" in the shocks.[7] Finally, the cost-of-adjustment elasticity, η, primarily affects the volatility of investment. We therefore use this moment to restrict the value of η.

We use the method of King et al. (1987) to compute log-linear approximations to the equilibrium decision rules for this economy. This method has been shown to be quite accurate for the one-sector neoclassical model when shocks to the economy are not too large (see e.g., John B. Taylor and Harald Uhlig, 1990).

D. *Measurement of Saving*

In comparing the predictions of theory with data, it is necessary that theoretical constructs measure the same economic variables as the data. As previously noted by Obstfeld (1986) and Alan C. Stockman and Lars E. O. Svensson (1987), the national income accounts (NIA) measure of saving can differ markedly from true saving. The difference arises when foreigners own shares in domestic firms and when firms finance expenditure from retained earnings. Under these conditions, the discrepancy is larger when the share of foreign ownership is larger.[8]

A simple measure of national saving—and the only one that is invariant to different assumptions about firms' financing decisions—is the measure that defines national saving as national output minus the sum of private and government consumption. This measure can be readily computed for many countries for which the data are unavailable to construct other measures of saving. This is the measure of saving that was used by Feldstein and Horioka (1980) and subsequently used in most of the empirical literature on saving–investment correlations. We call this measure "basic saving." In the notation of our model, basic saving (per capita) is computed as:

$$S_{\mathrm{B}t} = Y_t - C_t - G \tag{14}$$

for the home country, and

$$S^*_{\mathrm{B}t} = Y^*_t - C^*_t - G^* \tag{15}$$

for the foreign country. Because of the complete risk-pooling inherent in our setup, true saving is generally very different from "basic

[7] Sergio T. Rebelo (1987) was the first to discuss the problem of generating comovement of output and hours across locations in a one-sector neoclassical model.

[8] See Obstfeld (1986) for a detailed explanation of these considerations.

saving." In equilibrium, world saving equals world investment, and complete risk-pooling means that per capita saving is equated across countries. Thus, true saving is given by

$$S_{\mathrm{T}t} = \pi I_t + (1-\pi) I_t^* \tag{16}$$

in the home country, and by

$$S_{\mathrm{T}t}^* = \pi I_t + (1-\pi) I_t^* \tag{17}$$

in the foreign country.

Constructing a direct measure of true saving is prohibitively difficult, as it requires information on foreign ownership of shares on a firm-by-firm basis and information on firms' financing decisions (i.e., whether investment is financed by retained earnings). We nevertheless report the model's predictions for true saving in order to illustrate potential difficulties with using the more readily available "basic saving" measure.

E. *Saving – Investment Correlations*

To provide a basis for understanding the model results presented in the next section, we briefly discuss the central determinants of saving–investment correlations for our alternative measures of saving. Let σ_X denote the standard deviation of the variable X, and let $\rho(X,Y)$ denote the correlation between X and Y. Beginning with the "basic saving" measure, the correlation between saving and investment is

$$\begin{aligned} \rho(S_{\mathrm{B}}, I) &= \rho(Y - C - G, I) \\ &= \left(\frac{\sigma_Y}{\sigma_{S_{\mathrm{B}}}}\right)\left[\rho(Y,I) - \left(\frac{\sigma_C}{\sigma_Y}\right)\rho(C,I)\right] \end{aligned} \tag{18}$$

where (18) reflects our assumption that government expenditure is constant and is therefore uncorrelated with output, investment, or consumption. Thus the correlation between basic saving and investment depends on (i) the correlation between output and investment, (ii) the correlation between consumption and investment, (iii) the volatility of consumption relative to output, and (iv) the volatility of output relative to basic saving. Both $\rho(Y,I)$ and $\rho(C,I)$ tend to be positive (in the model and in the data), but the consumption–investment correlation tends to be weaker than the output–investment correlation because of international risk-pooling. Further, the relative volatility of consumption, σ_C / σ_Y is less than 1. The combination of these two factors means that the correlation between basic saving and investment is expected to be positive and that the output–investment correlation is the dominant term. In Section III below we explore how the magnitude of this correlation varies with (i) country size and (ii) perturbations of the key model parameters.

As discussed above, however, the basic saving measure may have little to do with true saving in a world economy with extensive trade in financial assets. The correlation between true saving and investment is

$$\begin{aligned} \rho(S_{\mathrm{T}}, I) &= \rho(\pi I + (1-\pi) I^*, I) \\ &= \left(\frac{\sigma_I}{\sigma_{S_{\mathrm{T}}}}\right)\left[\pi + (1-\pi)\left(\frac{\sigma_{I^*}}{\sigma_I}\right)\rho(I, I^*)\right]. \end{aligned} \tag{19}$$

From (19) we see that the correlation between true saving and investment, in a world with complete risk-pooling, depends on (i) country size (π); (ii) the cross-country correlation of investments; (iii) the volatility of domestic investment relative to the volatility of true saving (which primarily depends on the cross-country correlation of investments); and (iv) the volatility of foreign investment relative to the volatility of domestic investment. For an arbitrarily large country ($\pi \to 1$), the correlation between true saving and investment is approximately 1. For an arbitrarily small economy ($\pi \to 0$), the correlation between true saving and investment depends primarily on the cross-country correlation of investments.

Having studied the determinants of alternative measures of the saving–investment correlation, we turn now to an evaluation of the predictions of the parameterized model for these and other international business-cycle statistics.

III. Model Predictions: Theory and Evidence

In this section we examine the implications of our model for saving–investment correlations and the relationship among output, investment, and the current account and then compare the model's predictions with data from eight OECD countries. Some of the most interesting characteristics of the model lie in its predictions of the way in which the response to shocks depends on a country's size; the data also show that important stylized facts depend in a systematic way on country size. We therefore study two cases. In the first case, the world consists of two equal-sized countries. (Within our sample of eight OECD countries, the United States represents about half of total GNP; see Table 1.) The second case involves a world comprising a large country and a small country in which the large country accounts for 90 percent of the world's output and the small country accounts for the remaining 10 percent.

A. *Two Equal-Sized Countries*

This section considers two identical, equal-sized countries which are subject to random variations in productivity that are not perfectly correlated across the two countries.

Saving – Investment Correlations.—Table 2 presents the model's predictions for saving–investment correlations and key business-cycle statistics. Case 1 is our "benchmark" parameterization: $\sigma = 2$, $\rho = 0.93$, $\nu = 0.05$, $\psi = 0.4$, $\eta = 15$.[9] In our benchmark case, we find that saving–investment correlations are high both for the basic saving measure and for true saving. As discussed in Section II, we expected the model to generate a positive correlation between basic saving and investment. Recall that the dominant factor was the correlation between investment and output, which is quite high in the benchmark case (0.96); the correlation between basic saving and investment is close to this value (0.93). The correlation between basic saving and investment depends negatively on the correlation between consumption and investment and on the relative volatility of consumption. However, throughout Table 2 the correlation between investment and output is the most important determinant of the basic saving–investment correlation; in fact, the numerical values of these two correlations are often very close to each other.

In the benchmark case, the correlation between true saving and investment is lower than the correlation between basic saving and investment. Recall that the correlation between true saving and investment depends positively on relative country size and on the cross-country correlation of investments. Under the benchmark parameterization, the cross-country correlation of investments is negative (-0.13); this is the primary factor leading to the model's prediction that the correlation between true saving and investment is lower than the correlation between basic saving and investment. (This is discussed more fully below, where we contrast the predictions for a large economy versus a small economy.)

The benchmark model thus predicts basic saving–investment correlations in the range found in the data and predicts that true saving–investment correlations are lower than basic saving–investment correlations. How does this model do in terms of its business-cycle predictions? In the benchmark case, the model generates realistic within-country business-cycle behavior, along the following dimensions. First, relative consumption and investment volatility are in the range found in the data, as is the persistence of output. Second, the model predicts positive within-country correlations between (i) consumption and output and (ii) investment and output; and (iii) a negative correlation between output and the ratio of net exports to output. While all of these

[9] The variance of the innovations to productivity, σ_ε^2, is set equal to 1 for each country. Because of the certainty-equivalence property of the log-linear approximations, this variance simply scales the variances of the endogenous variables, leaving unchanged the relative-volatility statistics reported here. With $\sigma_\varepsilon^2 = 1$, the parameter ψ is the contemporaneous correlation of the productivity shocks.

TABLE 2—MODEL RESULTS, TWO EQUAL-SIZED COUNTRIES

Case	Parameter varied relative to benchmark	Saving–investment correlations		Output persistence	Relative volatility		Contemporaneous correlations						Sachs regressions	
		Basic	True		c	i	c, y	i, y	nx/y, y	y, y^*	c, c^*	i, i^*	α_1	α_2
Benchmark Parameterization ($\rho = 0.93$, $\nu = 0.05$, $\psi = 0.40$, $\sigma = 2$, $\eta = 15$):														
1	—	0.93	0.66	0.78	0.64	2.43	0.77	0.96	−0.95	−0.02	0.97	−0.13	−0.89	−0.12
Sensitivity Analysis, Intertemporal Substitution Parameter:														
2	$\sigma = 10$	0.93	0.66	0.78	0.74	2.22	0.88	0.96	−0.97	0.06	0.87	−0.13	−0.85	−0.20
Sensitivity Analysis, Productivity Parameters:														
3	$\rho = 0.99$, $\nu, \psi = 0$	0.77	0.18	0.87	0.42	4.62	0.60	0.76	−0.82	−0.66	0.90	−0.93	−0.59	−0.22
4	$\rho = 0.70$	0.84	0.98	0.61	0.38	2.89	0.84	0.89	−0.89	0.26	0.94	0.92	−0.67	−0.14
5	$\rho = 0.50$	0.79	1.00	0.42	0.33	2.98	0.86	0.84	−0.86	0.25	0.92	0.98	−0.60	−0.15
6	$\nu = 0.00$	0.92	0.65	0.80	0.48	3.20	0.79	0.94	−0.95	−0.02	0.95	−0.15	−0.65	−0.20
7	$\psi = 0.00$	0.93	0.50	0.78	0.50	2.48	0.68	0.95	−0.94	−0.41	0.94	−0.50	−0.82	−0.16
8	$\psi = 0.60$	0.93	0.76	0.78	0.71	2.39	0.84	0.97	−0.96	0.25	0.98	0.14	−0.93	−0.09
Sensitivity Analysis, Cost-of-Adjustment Parameter:														
9	$\eta = 1$	0.45	0.97	0.76	0.84	0.75	0.72	0.82	−0.74	−0.16	0.98	0.87	−0.90	−0.67
10	$\eta = 5$	0.79	0.87	0.77	0.70	1.56	0.77	0.95	−0.87	−0.03	0.98	0.51	−0.86	−0.25
11	$\eta = 100$	0.64	0.25	0.85	0.51	5.95	0.72	0.62	−0.72	−0.28	0.95	−0.87	−0.82	−0.19
12	$\eta = 100{,}000$	−0.09	0.04	0.84	0.30	23.53	0.62	−0.08	0.06	−0.77	0.78	−1.00	−0.74	−0.21

Notes: Variables are defined as follows: c, consumption; y, output; i, investment; nx, net exports. See the Data Appendix for more detail. All business-cycle statistics have been filtered with the HP filter. Persistence is defined as the first-order autocorrelation of output; relative volatility is the standard deviation relative to output; and Sachs regression coefficients are computed from unfiltered model moments.

correlations carry the correct sign, most of them are higher (in absolute value) in the model than in the data.[10]

The predictions of the benchmark model for cross-country business-cycle statistics are more problematic. First, the benchmark model predicts that output movements are roughly uncorrelated across countries but that consumption movements are almost perfectly correlated. This is clearly inconsistent with the data; in our sample, the typical pair of countries shows a positive output correlation (of about 0.40) and a positive but weak consumption correlation. Second, the benchmark model predicts a negative international correlation of investments, which is inconsistent with the data. (The model also predicts strongly negative international correlations of labor inputs, which is similarly counterfactual. Space considerations prohibit reporting these additional statistics.)

The lower panels of Table 2 report the findings of a sensitivity analysis performed with respect to the parameters for which it has proved impossible to obtain good econometric estimates: σ, ρ, ν, ψ, and η. These are also the parameters to which the model's predictions are most sensitive. Case 2 explores the implications of setting σ equal to 10, with the parameters otherwise as in the benchmark case. Increasing σ has only minor effects on the implications of the model; saving–investment correlations rise with increases in σ (although for some measures the effects are lost in the rounding error).

Cases 3–8 explore the sensitivity of the model's predictions to variations in the parameters of the productivity process. To begin, case 3 explores the implications of productivity shocks that are uncorrelated across countries ($\nu = \psi = 0$). The basic saving–investment correlation is still substantial in this case (0.77), reflecting the substantial correlation between investment and output (0.76). However, the true saving–investment correlation is much weaker than the basic saving–investment correlation, because the completely nation-specific character of the shocks leads to cross-country investment movements that are almost perfectly negatively correlated.

Variation in the parameter ρ (with other parameters at their baseline settings) is explored in cases 4–5. Basic saving–investment correlations decline with decreases in ρ, essentially because the correlation between investment and output falls with decreases in ρ. When shocks are less persistent, the incentive to move investment goods in response to a shock is decreased, implying that $\rho(I, I^*)$ increases. Since $\rho(I, I^*)$ is the primary determinant of the correlation between true saving and investment, this latter correlation increases with decreases in ρ. In our sensitivity analysis, we consider values of ρ as low as 0.50 (case 4): in this case we find that basic saving–investment correlations are still substantial (0.79), and true saving–investment correlations have climbed to 1.00. However, output persistence has fallen to 0.42, a level that is far too low to be consistent with the data. The relative volatility of consumption declines with ρ while relative investment volatility increases; however, the magnitudes involved are small. Case 6 explores the effect of shutting down just the international transmission of shocks, $\nu = 0$. The effects of this perturbation are quite minor; the most notable difference is that the relative volatility of consumption declines, while the relative volatility of investment increases.

Cases 7 and 8 explore the effects of altering ψ, the contemporaneous correlation of the productivity shocks. As discussed earlier, variations in this parameter primarily affect the international correlation of outputs. With $\psi = 0$, output fluctuations are negatively correlated across countries (-0.41); with $\psi = 0.60$, the correlation rises

[10]The strength of these correlations in our model is due to the one-good, one-shock nature of the model (i.e., the "stochastic singularity"). The introduction of more goods or additional sources of shocks to the world economy would be necessary for the model to generate weaker correlations between macroeconomic aggregates.

to a more reasonable 0.25. Because output correlations (and little else) are sensitive to variation in this parameter, data on international output correlations can be used to restrict this parameter. Our model suggests that reasonable values for ψ lie between 0.40 and 0.80.

Cases 9–12 explore the effect of changes in the adjustment-cost elasticity. Of all the parameters in our model, the adjustment-cost elasticity is the one for which prior research has provided the least information. In cases 9–11, the parameter η ranges from 1 to 100, while basic saving–investment correlations remain in the range found in the data. Only in case 12, in which adjustment costs are effectively zero, do we find a negative correlation between basic saving and investment; this reflects the negative correlation between investment and output. However, with $\eta = 100{,}000$, we find that the model behaves poorly in many respects. Most strikingly, investment is more than 23 times as volatile as output! The economics behind this result is straightforward. With two locations in the world producing the same good, and with high persistence in relative productivity differentials, the equilibrium response to a productivity disturbance is a rapid reallocation of capital toward the more productive location. With no impediments to capital movements (no adjustment costs), the strong accelerator mechanism present in the neoclassical model produces this extreme response of investment to international rate-of-return differentials. In this case, consumption is less volatile relative to output than observed in the data. At the high end of the range, with $\eta = 1$ (case 9), the pendulum has swung the other way. Investment is now only about three-fourths as volatile as output, although the data show that it is actually 2–3 times as volatile. With $\eta = 1$, changes in investment are so costly that the investment response to favorable shocks is much less than is observed in the data.

The central finding from Table 2 is that, for all parameter configurations that generate realistic business cycles, one also finds substantial saving–investment correlations. In fact, in two cases for which the business-cycle statistics generated from the model are patently unrealistic (cases 9 and 11) the model still generates realistic correlations between basic saving and investment.

Output, Investment, and the Current Account.—Sachs (1981) presents regression analyses of the relation between current-account deficits and investment. Using data from 14 OECD countries for the time period 1960–1979, he regressed the ratio of the current account to GNP on two variables: (i) the GNP "gap" (computed as the deviation from a trend line) and (ii) the ratio of investment to GNP. Sachs reports a negative coefficient on the investment ratio for 12 of the 14 countries and interprets this as evidence that international investment movements are the dominant short-run influence on the current account. Further, he finds a negative coefficient on the GNP "gap" for nine of the 14 countries.[11]

We investigate a similar relationship within the context of our model. Specifically, we compute the model's predictions of the coefficients in a regression of the log of the ratio of the current account to output on (i) the log of the deviation of output from the steady state and (ii) the log of the investment-to-output ratio. The last two columns of Table 2 present our results. To maximize comparability with Sachs's analysis, the model has not been HP-filtered. We find that the model is consistent in its prediction of negative coefficients on both the GNP "gap" and the investment ratio.[12] That is, in all 12 cases, the model predicts that

[11]In order to update Sachs's (1981) findings, we ran the "Sachs regressions" for all the countries in our sample, for the time period 1960–1988. Our trend line (for computation of the GNP gap) was the Hodrick and Prescott (1980) trend with $\lambda = 1{,}600$. For each country, we found negative coefficients on both the GNP "gap" and the investment-to-output ratio.

[12]The coefficients reported in Table 2 are nonlinear combinations of the population moments computed for the parameterized model economy. Thus there are no standard errors attached to the coefficients, and the R^2 of the "regression" is 1.

current-account deficits are associated with investment booms, after controlling for cyclic movements in output. In all cases reported in Table 2, the coefficients on the investment-to-output ratio are in the range found by Sachs. As discussed above, the model overpredicts the strength of the correlation between the ratio of net exports to output and output itself; this is due to the one-sector, one-shock nature of the model. However, the "Sachs regressions" shed light on a more restricted question, and a more reasonable one given the simplicity of the model: holding output fixed, what is the partial correlation between I/Y and the ratio of the current account to output? Both the model and the data say that this partial correlation is negative. Thus, the ability of the model to predict the response summarized by Sachs's empirical work is a strong point in the model's favor.

In fact, we view these results as being particularly important, since Sachs's empirical findings have traditionally been interpreted as evidence in favor of international capital mobility, while high values of saving–investment correlations have been interpreted as evidence against capital mobility. Our model starts from the assumption of highly mobile capital and simultaneously accounts for both of these phenomena.

B. *A Large Country and a Small Country*

The preceding section showed that national saving and national investment are highly positively correlated in our model economy when the two countries are equally sized. In response to a positive productivity shock, two effects take place. The first is a desire to increase investment in the high-productivity country in order to take advantage of the enhanced productivity (which is rationally expected to persist for some time). The second effect is an increase in desired saving by individuals who hold claims to the country's output: these individuals are made wealthier by the shock, and they wish to smooth over time the additional consumption made possible by this increase in wealth. Thus there is a natural mechanism relating saving to investment within a country, regardless of the country's size.

In a large country, however, there is a secondary effect which stems from the fact that technology shocks in a large country have a nontrivial short-term effect on the world interest rate. At a point in time (i.e., holding fixed the world supply of capital), a large country faces an upward-sloping supply curve for new capital as a function of the rental rate, while the textbook "small open country" faces a perfectly elastic supply curve for capital. Because the large country faces an imperfectly elastic point-in-time supply curve for capital, and because saving rises with the interest rate under our assumptions about preferences, national saving and national investment are more highly correlated for larger countries. This section explores the ways in which the implications of our model depend on country size, by studying a two-country world economy in which the smaller country (representing 10 percent of steady-state world GNP) has a trivial effect on the world interest rate. Except for this change, the parameterization of the benchmark model is exactly the same as before.

Saving – Investment Correlations.—Table 3 presents the predictions of this model for saving–investment correlations in the large country and in the small country. We find that the model again provides a robust prediction of high basic saving–investment correlations whenever the model produces realistic business-cycle statistics. Further, in all cases the model predicts that these correlations are lower for the smaller country, which is consistent with the data (see Table 1).

Looking first at the benchmark case we find a correlation between basic saving and investment of 0.99 for the large country and 0.85 for the small country, which primarily reflects the substantial correlation between investment and output within each country. While true saving is highly correlated with investment in the large country, this correlation is zero in the small country, which can be understood as follows. Recall that true saving is proportional to world saving, which in turn equals world investment. For an

TABLE 3—MODEL RESULTS, A LARGE COUNTRY AND A SMALL COUNTRY

Case	Parameter varied relative to benchmark	Saving–investment correlations: Basic	Saving–investment correlations: True	Output persistence	Relative volatility: c	Relative volatility: i	Contemporaneous correlations: c, y	i, y	$\text{nx}/y, y$	y, y^*	c, c^*	i, i^*	Sachs regressions: α_1	Sachs regressions: α_2
Benchmark Parameterization ($\rho = 0.93$, $\nu = 0.05$, $\psi = 0.40$, $\sigma = 2$, $\eta = 15$):														
1	—	0.99	0.99	0.78	0.76	2.62	0.95	0.98	−1.00	0.01	0.98	−0.12	−0.99	0.00
		0.85	0.00	0.79	0.57	2.26	0.49	0.93	−0.85				−0.79	−0.26
Sensitivity Analysis, Intertemporal Substitution Parameter:														
2	$\sigma = 10$	1.00	0.99	0.77	0.83	2.45	0.96	0.97	−1.00	0.07	0.87	−0.10	−1.00	0.00
		0.83	0.00	0.78	0.68	2.04	0.77	0.92	−0.90				−0.81	−0.27
Sensitivity Analysis, Productivity Parameters:														
3	$\rho = 0.99$, $\nu = \psi = 0$	0.94	0.91	0.81	0.83	2.73	0.98	0.93	−0.98	−0.50	0.94	−0.83	−0.83	−0.16
		0.72	−0.53	0.90	0.31	5.36	0.00	0.68	−0.71				−0.52	−0.21
4	$\rho = 0.70$	0.99	1.00	0.61	0.44	3.43	0.94	0.99	−1.00	0.26	0.95	0.94	−0.96	−0.01
		0.50	0.95	0.60	0.36	2.70	0.62	0.63	−0.64				−0.61	−0.17
5	$\rho = 0.50$	0.99	1.00	0.43	0.38	3.54	0.95	0.99	−1.00	0.26	0.94	0.99	−0.92	−0.02
		0.36	0.99	0.42	0.31	2.97	0.64	0.49	−0.53				−0.57	−0.17
6	$\nu = 0.00$	0.99	0.99	0.78	0.62	3.02	0.97	0.98	−1.00	0.03	0.96	−0.07	−0.91	−0.05
		0.86	0.09	0.81	0.42	3.34	0.39	0.88	−0.87				−0.55	−0.24
7	$\psi = 0.00$	0.99	0.99	0.77	0.68	2.78	0.93	0.98	−1.00	−0.38	0.95	−0.49	−0.98	0.00
		0.86	−0.39	0.78	0.43	2.25	0.24	0.91	−0.82				−0.72	−0.30
8	$\psi = 0.60$	1.00	0.99	0.78	0.81	2.52	0.96	0.98	−1.00	0.27	0.99	0.15	−1.00	0.00
		0.85	0.26	0.79	0.66	2.27	0.63	0.94	−0.88				−0.84	−0.22
Sensitivity Analysis, Cost-of-Adjustment Parameter:														
9	$\eta = 1$	0.91	1.00	0.77	1.16	1.08	0.98	1.00	−0.99	−0.08	0.99	0.90	−0.84	−1.08
		−0.01	0.92	0.75	0.71	0.59	0.26	0.40	−0.29				−0.91	−0.64
10	$\eta = 5$	0.98	1.00	0.77	0.88	2.07	0.97	0.99	−0.99	0.00	0.98	0.57	−1.00	0.03
		0.49	0.62	0.76	0.63	1.23	0.42	0.78	−0.58				−0.80	−0.43
11	$\eta = 100$	0.95	0.95	0.79	0.68	3.58	0.92	0.89	−0.97	−0.17	0.95	−0.72	−0.95	−0.06
		0.48	−0.46	0.88	0.40	7.37	0.43	0.48	−0.53				−0.75	−0.21
12	$\eta = 100{,}000$	0.32	0.48	0.83	0.59	10.11	0.87	0.31	−0.44	−0.55	0.79	−0.97	−0.86	−0.19
		−0.17	−0.25	0.82	0.19	27.02	0.52	−0.17	0.16				−0.66	−0.21

Notes: Variables are defined as follows: c, consumption; y, output; i, investment; nx, net exports. See the Data Appendix for more detail. All business-cycle statistics have been filtered with the HP filter. Persistence is defined as the first-order autocorrelation of output; relative volatility is the standard deviation relative to output; and Sachs regression coefficients are computed from unfiltered model moments. For each case, the first row gives statistics for the large country, and the second row gives statistics for the small country.

arbitrarily large country (i.e., an approximately closed economy), the correlation between true saving and investment approaches 1. For a very small country, the correlation between true saving and investment depends primarily on the cross-country correlation of investments. In the benchmark case, the combined effect of small country size and a small negative correlation of investment across countries is a zero correlation between true saving and investment in the smaller country. This contrasts sharply with a 0.85 correlation between basic saving and investment in the small country! These results caution against the use of basic saving as a proxy for true saving, especially for small open economies trading a rich menu of contingent assets.

As in Table 2, cases 2–12 report the results of a sensitivity analysis conducted with respect to the critical parameter values. Case 2 sets $\sigma = 10$; as before, the effects of this perturbation are minor. Case 3 explores the implications of completely nation-specific shocks: $\nu = \psi = 0$. Under this parameterization, shocks to productivity in the small open economy are approximately uncorrelated with shocks to world productivity (if the country were infinitesimal, this would hold exactly). Since shocks to productivity in the small country do not represent risk at the world level, and since markets are complete, neither country's consumption responds to shocks in this economy. (In Table 3, this can be seen in the zero correlation between consumption and output in the small country.) However, the time-series correlation between basic saving and investment is largely a function of the within-country correlation between investment and output, which is substantial in both countries. As discussed above, the investment–output correlation primarily depends on the persistence of shocks, which must be substantial for the model to generate realistic persistence of output. This can be seen in cases 4 and 5, which investigate the effects of altering ρ. As expected, the correlation between basic saving and investment declines with ρ (especially for the small country), although (as before) the correlation between true saving and investment increases with decreases in ρ. As in Table 2, we see that decreases in ρ lead to decreases in relative consumption volatility and increases in relative investment volatility, but these changes are modest. As before, the primary effect of decreasing ρ below about 0.90 is to generate insufficient persistence of output relative to the data.

Setting $\nu = 0$ (case 6) continues to have little effect on the model's predictions; variations in ψ (cases 7 and 8) continue to affect primarily the international output and investment correlations. Finally, cases 9–12 explore the effect of changes in the adjustment elasticity, η. As in Table 2, basic saving–investment correlations are positive for a wide range of values for η. The correlations for the small country are more sensitive than the correlations for the large country, as one would expect. Except for very inelastic adjustment ($\eta = 1$) and extremely elastic adjustment ($\eta = 100{,}000$) the correlation between basic saving and investment remains positive in the small economy. As before, investment volatility exhibits the greatest sensitivity to variations in η. Table 3 shows that this sensitivity is higher, the smaller the country. With essentially zero adjustment costs ($\eta = 100{,}000$), the relative volatility of investment is about 10 for the large country and about 27 for the small country. However, relative investment volatility in the data is only about 2 or 3, so that extremely large values for η are empirically implausible. For both countries to exhibit reasonable relative investment volatility, η must be roughly between 7 and 20. In summary, we find once again that high saving–investment correlations are among the most robust predictions of the model and are more robust to parameter variation than are the business-cycle statistics.

Output, Investment, and the Current Account.—Sachs (1981) provides evidence that the negative correlation between investment movements and the current account is larger for smaller countries. Looking at a combined sample of OECD, NIC's, and LDC's, he discusses in detail the recent period in which swings in current-account deficits have been particularly large for some of the smallest countries in his sample. He found that it is precisely the smaller and less-industrialized countries in which the most investment is taking place and which have simultaneously experienced the largest current-account deficits. The final columns of Table 3 give the results for the model's predictions for the coefficients in the "Sachs regressions." Comparing Tables 2 and 3, we find that the smaller the country, the stronger is the relationship between international investment flows and current-account deficits. This derives from the fact that the smaller country faces a more elastic point-in-time supply schedule for capital. In summary, our model is consistent with Sachs's (1981) evidence on the relationship among country size, investment, and the current account.

IV. Summary and Conclusions

This paper presents evidence which refutes a widely held view that high time-series correlations between saving and investment are inconsistent with a world in which capital is highly mobile. We construct a two-country, one-good version of the standard neoclassical model. In this simple model, the only interesting questions that can be addressed concern the international determination of saving, investment, and capital flows. Our main results are as follows. First, we find that positive correlations between basic saving and investment are a robust prediction of the quantitatively restricted model and that the model correctly predicts that these correlations are higher for larger countries. Second, we explore the links among output, investment, and the current account. We find that our model is consistent with the empirical results obtained by Sachs (1981). In a regression of the current-account-to-GNP ratio on the GNP gap and the investment-to-GNP ratio, the coefficient on the investment ratio was negative for 12 of the 14 countries in Sachs's sample. Our model predicts this negative regression coefficient, supporting Sachs's view that international investment flows are important short-run determinants of current-account movements. Further, our model predicts that this effect is stronger (the coefficient should be larger in absolute value) for smaller countries, which is also in line with Sachs's (1981) evidence. Sachs's results have typically been interpreted as providing evidence that capital *is* highly internationally mobile, while high time-series correlations of saving and investment have typically been interpreted as evidence that capital *is not* highly mobile. Our analysis starts from the assumption that capital is highly mobile and simultaneously provides an explanation for both of these phenomena.

Since our model permits international trade in a rich menu of contingent securities, basic saving (measured as $Y - C - G$) typically is not a good measure of true saving. Generally, the correlation between basic saving and investment is much higher than the true correlation, and this distortion is more important for smaller countries. In fact, it is almost impossible to generate a low correlation between basic saving and investment if one maintains the integrity of the model in terms of its predictions for the central, within-country business-cycle statistics. This is because the basic saving–investment correlation depends almost entirely on the correlation between output and investment, which is quite high in the data and in our quantitatively restricted model.

In this general-equilibrium model, relative country size can be varied parametrically. This approach, which builds on prior work by Crucini (1991), permits us to study small economies while retaining a general-equilibrium framework. General-equilibrium considerations appear to be important, even for questions involving small open economies, for our analysis (and that of Backus et al. [1992]) shows that there must necessarily be high cross-country correlation of shocks if this class of models is to reproduce the central stylized facts of business cycles. A key implication, therefore, is that movements in the world interest rate are correlated with shocks impinging on the small open economy. Thus, the traditional "small open economy" assumption that the world interest rate is (i) constant or (ii) at least uncorrelated with shocks in the small open economy is empirically indefensible. As a practical matter, working with a general-equilibrium model obviates the need for the researcher to specify the correct exogenous process for the world interest rate. In the general-equilibrium framework, the interest rate is determined endogenously.

Despite its successes, the model falls short in two dimensions as a model of the international business cycle. First, this model contains the prediction that consumption should be nearly perfectly correlated across countries. Second, the one-sector international trade model has difficulty generating the positive international comovement of investments, labor inputs, and outputs which we observe in the data. Much current research is directed at investigating the reasons for the low international correlation of consumption. For example, Tesar (1990) and Stockman and Tesar (1991) have incorporated nontraded goods and preference shocks in a setting with complete contingent claims markets. They find that these model modifications are helpful in reducing cross-country consumption correlations. More recently, Baxter and Crucini (1991) investigated the implications of restricting asset trade to noncontingent bonds alone, maintaining the one-good, general-equilibrium character of the present model. We find that restrictions on asset trade tend to decrease the international correlation of consumption and tend to increase the international correlation of output. Related research on asset-market restrictions and international comovement of output, investment, and labor input has been carried out by Antoine Conze et al. (1990) and Robert Kollman (1990). They also find that asset-market restrictions improve the one-sector model's predictions for international consumption correlations.

In summary, we have shown that an equilibrium model with highly mobile capital is capable of explaining many features of international macroeconomic linkages. In particular, we find that one long-standing "puzzle" is not a puzzle at all. However, we view this work as largely preliminary to the very important research of analyzing the international macroeconomic effects of monetary and tax policies. It is possible, for example, that future research will prove false some of Feldstein's (1983) predictions about the effects of policy interventions in an open economy: "Perfect capital mobility implies...that the burden of corporate income taxes falls primarily on labor, that government deficits do not crowd out private investment, that increases in saving do not raise domestic investment, and that monetary and tax policies cannot alter the real net rate of return on domestic capital." Whether these statements are true depends on the size of the economy in which the policies originate, the character of international financial linkages in the world economy, and on the extent of international coordination of changes in fiscal policy. These questions will form the foundation for our future research.

Data Appendix

The data used to compute business-cycle statistics are from the International Monetary Fund's *International Financial Statistics* (IFS). All data except population are quarterly data. The population data are mid-year estimates that were log-linearly interpolated to obtain quarterly estimates. All variables are converted to per capita quantities using these population numbers. Data are transformed to logarithms with the exception of the ratio of net exports to income, which is measured in level form. The method of detrending used throughout was the Hodrick-Prescott filter.

The variables (table mnemonic for Tables A1–A5; IFS mnemonic) are as follows. The measure of real output is GDP for Australia, France, Italy, and Switzerland (y; 96b.r) and real GNP for Canada, Germany, Japan, and the United States (y; 99a.r). The remaining economic aggregates are in current dollars and were converted into real terms using GDP or GNP deflators computed as the ratio of nominal GNP (99a) or GDP (99b) to real GNP or GDP as available. The remaining aggregates are: personal consumption expenditures (c; 96f); government consumption (g; 91f); basic savings (s; the logarithm of the level of savings computed as $S = Y - C - G$); gross fixed capital formation (i; 93e); ratio of net exports to output (NX/Y; ratio of exports of goods and services [90c] less imports of goods and services [98c] to income, in level form).

The sample periods are: 1960:1–1985:4 for Australia, Canada, Germany, and Japan; 1965:1–1985:4 for France; 1970:1–1982:4 for Italy; 1967:1–1985:4 for Switzerland; and 1957:1–1986:2 for the United States.

TABLE A1—BUSINESS-CYCLE STATISTICS: STANDARD DEVIATIONS

Country	y	c	g	s	i	$\frac{NX}{Y}$
United States	1.84	1.24	2.04	7.41	5.52	0.41
Japan	1.71	1.92	2.20	4.50	3.95	0.93
Germany	1.70	1.19	2.09	5.47	5.78	0.88
France	0.99	0.88	1.23	3.62	1.90	0.81
Italy	2.21	1.81	3.12	8.15	5.51	0.83
Canada	1.66	1.47	2.17	6.22	4.71	1.76
Australia	1.70	1.17	2.80	5.79	3.69	1.46
Switzerland	2.15	1.64	1.81	5.72	6.20	1.50

TABLE A2—BUSINESS-CYCLE STATISTICS: FIRST-ORDER AUTOCORRELATIONS

Country	y	c	g	s	i	$\frac{NX}{Y}$
United States	0.84	0.83	0.85	0.75	0.89	0.79
Japan	0.74	0.79	0.31	0.75	0.83	0.84
Germany	0.71	0.50	0.45	0.65	0.68	0.65
France	0.79	0.49	0.10	0.67	0.70	0.72
Italy	0.78	0.66	0.82	0.44	0.86	0.71
Canada	0.79	0.75	0.61	0.74	0.87	0.60
Australia	0.67	0.47	0.49	0.63	0.74	0.75
Switzerland	0.70	0.52	0.11	0.41	0.81	0.71

TABLE A3—BUSINESS-CYCLE STATISTICS: CROSS-CORRELATIONS WITH OUTPUT

Country	y	c	g	s	i	$\frac{NX}{Y}$
United States	1.00	0.88	0.06	0.90	0.90	−0.39
Japan	1.00	0.47	−0.29	0.77	0.60	−0.04
Germany	1.00	0.64	−0.03	0.90	0.80	−0.22
France	1.00	0.58	0.10	0.78	0.45	−0.10
Italy	1.00	0.70	0.17	0.80	0.80	−0.69
Canada	1.00	0.72	−0.21	0.82	0.62	−0.31
Australia	1.00	0.62	−0.17	0.88	0.55	−0.09
Switzerland	1.00	0.74	0.29	0.87	0.73	−0.66

TABLE A4—CROSS-COUNTRY OUTPUT CORRELATIONS

	Country							
Country	United States	Japan	Germany	France	Italy	Canada	Australia	Switzerland
United States	1.00	0.42	0.44	0.50	0.47	0.77	0.24	0.28
Japan		1.00	0.55	0.52	0.30	0.28	0.15	0.32
Germany			1.00	0.65	0.57	0.43	0.47	0.51
France				1.00	0.59	0.36	0.36	0.51
Italy					1.00	0.57	0.35	0.67
Canada						1.00	0.41	0.38
Australia							1.00	0.34
Switzerland								1.00

TABLE A5—CROSS-COUNTRY CONSUMPTION CORRELATIONS

	Country							
Country	United States	Japan	Germany	France	Italy	Canada	Australia	Switzerland
United States	1.00	0.41	0.45	0.28	0.23	0.65	0.11	0.22
Japan		1.00	0.40	0.15	−0.13	0.24	0.09	−0.04
Germany			1.00	0.32	0.02	0.31	0.21	0.22
France				1.00	0.32	0.12	0.11	0.21
Italy					1.00	−0.05	−0.16	0.53
Canada						1.00	0.23	0.03
Australia							1.00	0.06
Switzerland								1.00

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