4 The robustness of macroeconomic indicators of capital mobility

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1 Introduction

Financial capital has become highly mobile across countries as a result of the gradual globalisation of financial markets that followed from widespread deregulation and innovations in communication and transaction technologies in recent years. This development has renewed interest in the debate on the implications and measurement of international capital mobility. The controversial work of Feldstein and Horioka (1980) initiated the new stage of this debate by arguing that, because savings and investment are positively correlated, additions to savings are primarily allocated to the domestic economy, and hence there is little evidence of the arbitrage in world financial markets that the neoclassical paradigm predicts. These results raised doubts as to whether the efficiency and welfare gains, on the basis of which international financial deregulation was introduced, would materialise.

Further empirical work established the robustness of positive savings–investment correlations in time-series and cross-sectional studies for industrial and developing countries (see, for example, Dooley, Frankel and Mathieson, 1987; Tesar, 1991; Bayoumi and Sterne, 1992; Montiel, 1992; and Chapter IV of the May 1991 issue of *World Economic Outlook* (International Monetary Fund, 1991a). At the same time, however, the theoretical literature casts doubts on whether this stylised fact could be regarded as an indicator of the degree to which capital moves across countries (see Obstfeld, 1986; Zeira, 1987; Summers, 1988; Finn, 1990; Sinn, 1991). Simulations of dynamic stochastic equilibrium models demonstrated that, given productivity or terms of trade shocks of the magnitude observed in the data, these models mimic the same positive relationship between savings and investment that characterises actual economies (Mendoza, 1991a, 1992; Baxter and Crucini, 1993). The controversy surrounding savings–investment correlations motivated other

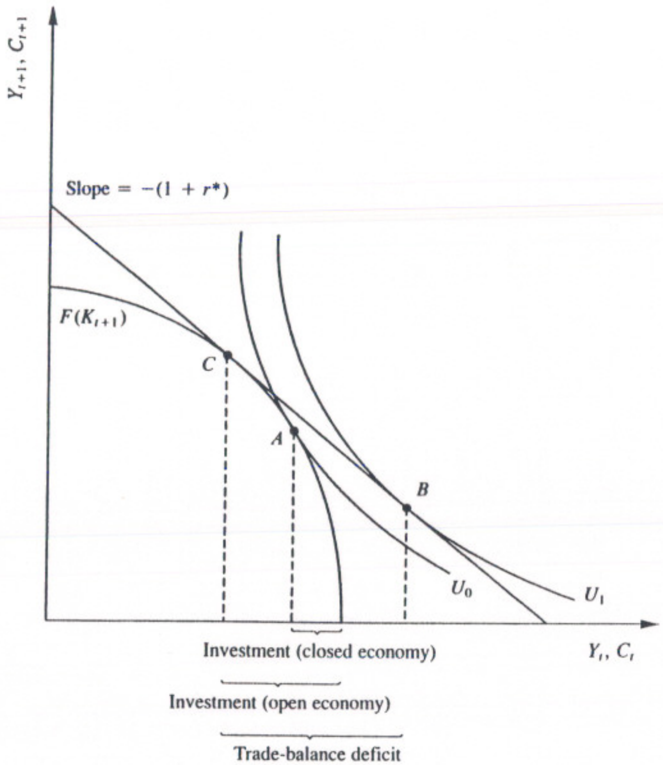

Figure 4.1 The neoclassical model of investment

researchers to focus on alternative indicators of capital mobility, such as the degree of consumption smoothing, the differential in asset returns, and the variability of investment, but the interpretation of these indicators has also been a controversial subject (see Obstfeld, 1986, 1989; Sachs, 1982; Frankel, 1992; Razin and Rose, 1992). Moreover, direct measures of financial capital flows and international portfolio diversification have also added to the debate by showing that, despite heavy trading in international financial markets, there is a significant home bias in portfolio allocation (see Tesar and Werner, 1992).

Perhaps the key element in the debate on the theory and measurement of capital mobility is the connection between the analytical framework from which indicators of capital mobility are obtained and the design of the

econometric tests used to study them. Consider the case of the savings–investment correlations. The empirical work advocating the use of this statistic as an indicator of capital mobility is based on the well-known neoclassical model of savings, originally developed in the pioneering work of Irving Fisher (1930) and illustrated in Figure 4.1. In a closed economy, savings and investment are identical and they are determined at the point where the indifference curve between consumption in two periods is tangent to the production possibilities frontier of output in two periods (point *A*). In contrast, when capital is mobile across countries, and households and firms are free to borrow and lend in world markets at the real interest rate r^*, savings and investment decisions are separated (points *B* and *C*). Investment and savings thus move together when capital is not mobile across countries, and hence the rationale for arguing that positive savings–investment correlations are evidence against capital mobility. Nevertheless, this statement is strictly correct only in a deterministic, or perfect-foresight, framework, and is only a rough first approximation in a stochastic economy. Under uncertainty, the marginal product of capital and the world's real interest rate are not equalised exactly each period; there is, instead, an equality that holds in terms of an expected value in which the return of foreign and domestic capital is weighted by the marginal utility of consumption in each state of nature. Shifts in either the indifference curve or the production possibilities frontier in Figure 4.1, given the agents' desire to smooth consumption, could result in movements of investment that coincide with movements in savings. Moreover, even in a deterministic setup, positive comovement between savings and investment could emerge as a result of population growth or technological change (Obstfeld, 1986).

The best approach to determine whether positive savings–investment correlations, as well as other macroeconomic indicators, are robust indicators of capital mobility under uncertainty is to impose a rigorous link between theoretical and empirical work. At the same time, however, deriving the quantitative implications of the intertemporal equilibrium, stochastic framework that has dominated the analytical work in this area in recent years is not straightforward. It is only under particular conditions that this framework produces closed-form solutions from which the properties of macroeconomic indicators can be derived and tested using available economic methods. An alternative, proposed by Obstfeld (1989), is to look for evidence that the optimality conditions, or Euler equations, that characterise consumption behaviour in an intertemporal model of integrated economies hold, instead of trying to extract information from macroeconomic indicators. Another alternative is to examine a dynamic stochastic model by using numerical methods to determine how capital mobility affects the behaviour of macroeconomic variables in general equilibrium. This is the approach proposed here.

This chapter examines various indicators of capital mobility in a stochastic intertemporal equilibrium model of a small open economy. The chapter derives the quantitative implications of the model – i.e., the properties of the equilibrium stochastic processes that characterise the model – and examines which of the model's empirical regularities are better indicators of capital mobility. In contrast with previous work, the exercise does not aim to show whether the data fit a specific prediction of the model, but rather to create macroeconomic time series for a model economy that mimic some properties of actual business cycles, and then to explore the implications of varying the degree of capital mobility on the stylised facts commonly used as measures of capital mobility.

The analysis shows that, for several simulations conducted using a set of reasonable preference and technology parameters, the macroeconomic indicators of capital mobility are not informative. In particular, savings–investment correlations do not provide information about the degree of capital mobility if the magnitude or the persistence of income disturbances changes; consumption variability is not very sensitive to the degree of integration of financial markets; and the stylised facts of investment are robust indicators of capital mobility only in cases in which capital controls are very tight. Most of the indicators are as equally sensitive to differences in structural parameters as to differences in the degree of mobility. Moreover, there is no evidence that preventing agents from accessing world capital markets limits their ability to smooth consumption significantly, suggesting that capital mobility may be difficult to determine using Euler equation tests. These results are consistent with the analytical work of Cole and Obstfeld (1991), the findings of the cross-country analysis undertaken by Razin and Rose (1992), and the simulation analysis of Mendoza (1991b) and Baxter and Crucini (1992).

The chapter is organised as follows. Section 2 describes the model, the parameter specification, and the numerical solution method. Section 3 compares the model's equilibrium comovements with the stylised facts of post-war business cycles in Canada and Mexico. Section 4 examines the performance of the different measures of capital mobility. Section 5 draws some conclusions.

2 The model

The model described here is the standard prototype of the intertemporal equilibrium framework for the small open economy developed by Obstfeld (1981), Helpman and Razin (1982), Svensson and Razin (1983),

Greenwood (1983) and other (see Frenkel and Razin, 1987 for a comprehensive literature review), with the modification that it incorporates stochastic disturbances affecting productivity or the terms of trade – as in the small open economy real business-cycle models of Mendoza (1991a) and Correia, Neves and Rebelo (1991).

2.1 *Production technology and financial structure*

Firms in the economy produce tradable goods using the following technology:

$$G(K_t, L_t, K_{t+1}) = \exp(e_t)\, K_t^{a} L_t^{1-a} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2,$$

$$0 < a < 1, \quad \phi > 0, \tag{1}$$

where L_t is labour services, K_t is the capital stock, e_t is a random shock affecting productivity or the terms of trade,[1] and $(\phi/2)(K_{t+1} - K_t)^2$ is the cost of adjusting the capital stock.[2] The law of motion for capital is

$$K_{t+1} = (1 - \delta)K_t + I_t, \qquad 0 \le \delta \le 1, \tag{2}$$

where I_t is gross investment and δ the rate of depreciation.

There are three representations of financial markets in the model that correspond to regimes with different degrees of capital mobility. In a regime of perfect mobility, households and firms exchange one-period noncontingent bonds, A_t, that pay the real interest rate r^*, with the rest of the world in a competitive international capital market.[3] Net holdings of foreign assets evolve according to

$$A_{t+1} = TB_t + A_t(1 + r^*), \tag{3}$$

where TB_t is the balance of trade.[4] In a regime of limited capital mobility, the accumulation of foreign assets faces *binding* constraints for some states of nature. Thus, in every period:

$$\hat{A}_l \le A_{t+1} \le \hat{A}_h \tag{4}$$

where $\hat{A}_h$ $(\hat{A}_l)$ is a constant lower (higher) than the stock of foreign assets agents would optimally choose to hold under perfect capital mobility in some states of nature. When the constraints are not binding, net foreign assets evolve as in the case of perfect mobility and (4) can be replaced by (3). Finally, in a regime that forcefully obstructs capital mobility by imposing strict capital controls, the range just described collapses into a constraint on foreign asset accumulation that is always binding:

$$A_{t+1} = \hat{A}. \tag{5}$$

In this case, $A_{t+1} = \hat{A}$ for all t and the balance of trade is $TB_t = -r^*\hat{A}$.

The resource constraint states that the sum of consumption, C_t, investment, and the balance of trade cannot exceed output net of adjustment costs:

$$C_t + I_t + TB_t \leq \exp(e_t) K_t^a L_t^{1-a} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2. \qquad (6)$$

2.2 Preferences

Households are all identical and infinitely-lived. They allocate C_t and L_t intertemporally so as to maximise stationary cardinal utility

(SCU):[5]

$$U = \mathrm{E}\left[\sum_{t=0}^{\infty}\left\{u(C_t - G(L_t))\exp\left(-\sum_{\tau=0}^{t-1} v(C_\tau - G(L_\tau))\right)\right\}\right]. \qquad (7)$$

The instantaneous utility and time-preference functions are:

$$u(C_t - G(L_t)) = \frac{\left[C_t - \frac{L_t^{\omega}}{\omega}\right]^{(1-\gamma)} - 1}{1-\gamma}, \qquad \omega > 1, \quad \gamma > 1, \qquad (8)$$

$$v(C_t - G(L_t)) = \beta \ln\left(1 + C_t - \frac{L_t^{\omega}}{\omega}\right), \qquad \beta > 0. \qquad (9)$$

As in Greenwood, Hercowitz and Huffman (1988), (8) and (9) are defined in terms of a composite good described by consumption minus the disutility of labour. The marginal rate of substitution between C and L is a function of the latter only, and hence labour is independent of the dynamics of consumption. This facilitates the quantitative analysis at the cost of neutralising the wealth effect on labour. Labour supply is determined by a condition that equates the marginal product of labour with the marginal disutility of providing labour services, independently of the marginal utility of consumption. This implies that the labour supply choice can be separated from optimal consumption plans in the dynamic programming problem described below.

2.3 The dynamic programming problem and the solution technique

Optimal intertemporal plans involve selecting, at each date t, K_{t+1}, A_{t+1}, C_t and L_t, given the state of the economy determined by K_t, A_t and e_t. The usual nonnegativity restrictions on C, K and L, apply and optimal plans must also be consistent with intertemporal solvency. As in Mendoza (1991a) and Imrohoroglu (1989), Ponzi-type schemes in regimes of perfect or limited capital mobility are ruled out by imposing an upper bound on debt, $A_t \geq \Delta$ for all t, where Δ is a negative constant. If Δ is small enough, the limiting probability of approaching the debt ceiling becomes infinitesimally small. The time-recursive nature of SCU, together with the simplified uncertainty environment described later, implies that the equilibrium of the economy with perfect capital mobility can be characterised by the following stochastic dynamic programming problem:

$$V(K_t, A_t, e_t^s) = \max\left\{\frac{\left(C_t - \frac{\hat{L}_t^{\omega}}{\omega}\right)^{(1-\gamma)} - 1}{1-\gamma} + \exp\left[-\beta\ln\left(1 + C_t - \frac{\hat{L}_t^{\omega}}{\omega}\right)\right]\left[\sum_{r=1}^{2}\pi_{s,r} V(K_{t+1}, A_{t+1}, e_{t+1}^r)\right]\right\}, \qquad (10)$$

subject to

$$C_t = \exp(e_t) Q K_t^a \hat{L}_t^{(1-a)} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2 - K_{t+1} + K_t(1-\delta) + (1+r^*)A_t - A_{t+1},$$

$$\hat{L}_t = \mathrm{argmax}_{(L_t)}\left\{\exp(e_t) K_t^a L_t^{(1-a)} - \frac{L_t^{\omega}}{\omega}\right\},$$

$$A_t \geq \Delta,\ K_t \geq 0,\ L_t \geq 0, \text{ and } C_t \geq 0.$$

Once parameter values for preferences, technology, and the shocks are determined, this problem is solved numerically by making use of an algorithm that iterates on the value function and the state-transition probability matrix using discrete grids to represent the state space.[6] This exact-solution algorithm requires that the dimension of the model's state space be minimised, and hence it often allows only for simple characterisations of the stochastic shocks. In this case, income disturbances are assumed to follow a two-point, symmetric Markov chain. Thus, in every period the shocks take one of two values:

$$e_t \in \mathrm{E} = \{e^1, e^2\}. \qquad (11)$$

One-step conditional transition probabilities, denoted as π_{sr}, satisfy the conditions that $0 \leq \pi_{sr} \leq 1$ and $\pi_{s1} + \pi_{s2} = 1$ for $s, r = 1, 2$. The symmetry conditions are $\pi_{11} = \pi_{22} = \pi$ and $e^1 = -e^2 = e$. These conditions simplify the analysis by making the asymptotic standard deviation, σ_e, and the first-order autocorrelation coefficient, ρ_e, of the shocks equal to e and $2\pi - 1$ respectively.

The first-order conditions describing optimal intertemporal plans under perfect capital mobility have the usual interpretation, although with the caveat that changes in current consumption affect the rate of time preference at which future consumption is discounted. From the perspective of any period t, optimal savings are set so as to equate the stochastic marginal rate of substitution between C_t and C_{t+1} with the gross real rate of return on foreign assets $1 + r^*$. Optimal investment is set so as to equalise the expected values of the returns on capital and foreign assets, taking risk factors into account by weighting each possible occurrence of the marginal product of capital by the marginal utility of consumption in each state of nature. Fisherian separation thus holds as a rough approximation; investment is governed by an optimal portfolio allocation decision that equates the returns on alternative assets, and savings are determined by the desire to smooth consumption given its fixed intertemporal relative price. Any need for savings not covered by investment in domestic capital is covered by borrowing or lending in world capital markets.

2.4 *Parameter values and calibration*

Two sets of parameter values are defined so as to duplicate some of the empirical regularities that characterise business cycles in Canada and Mexico. Canada is viewed as a typical small open economy because of the relatively small set of capital controls in place and the high degree of integration of Canada's financial markets with those of the United States. Data for Mexico are examined to provide some evidence on the stylised facts of business cycles in middle-income developing countries which act as price takers in world markets.

The values of the parameters γ (coefficient of relative risk aversion), ω (1 plus the inverse of the intertemporal elasticity of substitution in labour supply), α (capital's share in output), δ (depreciation rate), β (the consumption elasticity of the rate of time preference), Q (efficiency constant), and r^* (the world's real interest rate), are selected using long-run averages of actual data, the restrictions imposed by the deterministic steady-state equilibrium of the model, and also by approximating some of the estimates obtained in the relevant empirical literature. The values of the parameters are as follows:

$$\text{Canada: } \alpha = 0.32, Q = 1.0, \delta = 0.1, r^* = 0.04, \\ \omega = 1.455, \gamma = 1.6, \beta = 0.11, \phi = 0.023, \\ \rho_e = 0.41, \text{ and } \sigma_e = 1.285\%. \quad (12)$$

$$\text{Mexico: } \alpha = 0.64, Q = 0.507, \delta = 0.1, r^* = 0.04, \\ \omega = 1.113, \gamma = 2.3, \beta = 0.56, \phi = 0.029, \\ \rho_e = 0.17, \text{ and } \sigma_e = 2.00\%. \quad (13)$$

The value of α is set as 1 minus the ratio of labour income to national income at factor prices. The efficiency parameter Q is a scale variable that does not affect equilibrium covariances in the model, but it is used for consistency to correct for relative economy size given the Cobb–Douglas technology and the fact that income per capita in Mexico, adjusted for purchasing power, is one-quarter of that in Canada. δ is the usual 10% depreciation rate of real business-cycle models. r^* at 4% is the real interest rate for the US economy in Prescott (1986). ω for both countries is in the range of estimates discussed in Greenwood, Hercowitz and Huffman (1988) and Mendoza (1991a). γ is set following Prescott's (1986) observation that γ is not much higher than 1, which is in line with some of the existing econometric evidence (see Hansen and Singleton, 1983), and taking into account that agents in developing countries seem to be more risk averse (see Ostry and Reinhart, 1992). β is determined by the steady-state equilibrium condition, considering that the post-war average of the ratio of net foreign interest payments to output, r^*A/Y, is 1.9% for Canada and 2.5% for Mexico. ϕ, ρ_e, and σ_e are calibration parameters set to mimic σ_I, ρ_y, and σ_y respectively as observed in Canada and Mexico for the post-war period (see Table 4.1 on p. 92).

3 The model and the stylised facts

This section establishes how useful the model proposed in the previous section is as a framework to model the implications of capital mobility, by comparing the properties of business cycles in the model with those obtained from Canadian and Mexican data. The data correspond to annual observations for the periods 1946 to 1985 for Canada and 1945 to 1984 for Mexico, expressed in per capita terms of the population older than 15 years, transformed into logarithms and detrended with a quadratic time trend. The statistical moments for the relevant macroeconomic times series are reported in Table 4.1.

Table 4.1 shows that business-cycle facts in Canada and Mexico are consistent with those observed in other industrial and developing countries (see Backus and Kehoe, 1992; Mendoza, 1992) and do not contradict the basic implications of a consumption-smoothing, intertemporal framework. In terms of standard deviations relative to the standard deviation of GDP, consumption is the least variable of all macroaggregates, while savings, investment, and the balance of trade are more variable than output. Regarding the coefficients of correlation with GDP, consumption, savings and investment are procyclical, while the trade balance and real net foreign interest payments are countercyclical or almost uncorrelated with GDP. In both countries savings and investment exhibit a

Table 4.1. *Canada and Mexico, properties of business cycles in the post-war period*[1]

	A			B		
	Canada			Mexico		
Variables	σ^2	ρ^3	ρy^4	σ^2	ρ^3	ρy^4
(1) *GDP*	1.00	0.615	1.000	1.00	0.543	1.000
(2) *C*	0.88	0.701	0.586	0.58	0.384*	0.836
(3) *S*	2.60	0.542	0.662	2.22	0.361	0.399
(4) *I*	3.49	0.314	0.639	3.93	0.524	0.853
(5) *TB*	3.01	0.666	− 0.172*	6.37	0.525	− 0.789
(6) $-r^*A$	5.43	0.727	− 0.175*	4.33	0.369*	− 0.382*
(7) *L*	0.72	0.541	0.799	n.a.	n.a.	n.a.
memo items:						
	SD(GDP) = 2.81			*SD(GDP)* = 3.50		
	CORR(S, I) = 0.445			*CORR(S, I)* = 0.426		

[1] Data measured in per capita terms of the 15 + population (Canada) and total population (Mexico), logged and detrended with a quadratic time trend. (1)–(6) are aggregates from national income accounts, except (6) for Mexico that is from current account data. (2) excludes durables and semidurables for Canada, and includes only food and services for Mexico. Savings are investment plus the balance of trade. Data for Canada are for the period 1946–85 in 1981 dollars (source: CANSIM data retrieval). Data for Mexico are for the period 1945–84, except (2) for 1960–84 and (6) for 1950–84, in 1970 pesos (source: *Indicadores Economicos*, Banco de Mexico).
[2] Standard deviation relative to the percentage standard deviation of output *SD(GDP)*.
[3] First-order autocorrelation coefficient (an asterisk indicates that the coefficient is not statistically significant at the 1% level).
[4] Coefficient of correlation with GDP (an asterisk indicates that the coefficient is not statistically significant at the 1% level).

similar degree of positive correlation, despite differences in the regime governing capital mobility to be detailed later. All macroeconomic aggregates in the two countries also exhibit some degree of positive persistence.

Despite the difference in the size of economic fluctuations between Canada and Mexico – GDP is almost 3/4 of a percentage point more variable in Mexico than in Canada – the *qualitative* properties of business cycles in the two countries are similar. Canada and Mexico exhibit a similar ranking of the coefficients of relative variability, comovement with GDP, and first-order autocorrelation of all macroeconomic aggregates. Moreover, even some *quantitative* regularities appear to be common to the business cycles in the two countries, particularly with regard to the variability of savings, investment and consumption relative to the variability of GDP.

Despite these similarities, the specific characteristics of Mexico, a country with an export base and a production structure less diversified than Canada's and where access to world capital markets has been restricted with varying intensity during the post-war period, should be reflected in the country's stylised facts. The large fluctuations of the balance of trade, the strong negative comovement between the trade balance and GDP, and the lower variability of net foreign interest payments in Mexico compared with Canada may reflect in part some of these characteristics. For instance, the consumption-smoothing principle predicts that, assuming investment remains constant, net foreign assets should fluctuate more in an economy where GDP is more variable because holdings of foreign assets are adjusted more to prevent consumption from being affected by output changes. Nevertheless, real net foreign interest payments, which are used here to approximate the behaviour of net holdings of foreign assets, are more variable in Canada than in Mexico. One possible interpretation of this fact would be that capital controls or capital market imperfections have prevented the optimal adjustment of foreign assets in the Mexican economy.

The regime governing capital mobility currently prevailing in Canada and Mexico is described in detail in the *Annual Report on Exchange Arrangements and Exchange Restrictions* (International Monetary Fund, 1991b). This document suggests that distortions in the exchange arrangement and payments restrictions as of end-December 1990 were more pervasive in Mexico than in Canada. However, the report also notes that Mexico has in recent years introduced a number of reforms to reduce or eliminate many payments restrictions and most of the distortions affecting the foreign exchange market. As of 30 December 1990, there were no exchange controls, nor any prescriptions of currency requirements in Canada. There were no requirements to surrender export proceeds, and no controls over outward direct investment or over inward or outward portfolio investment. There were some import permits and a few quotas on commodities and manufactured goods, a few restrictions on inward foreign direct investment, and ceilings on the ratios of domestic assets to authorised capital of foreign-owned banks operating in Canada. By contrast, in Mexico there was a dual exchange rate system – although with a minimal difference between the controlled and the free-market rates – and there were also a few currency prescriptions, some restrictions on payments for capital transactions, and surrender requirements for export proceeds. Tariffs, licences, and quotas were still present, although at

Table 4.2. *Canada and Mexico, properties of business cycles in artificial economies*[1]

	A			*B*		
	Canada			Mexico		
Variables	σ^1	ρ^2	ρy^3	σ^1	ρ^2	ρy^3
(1) *GDP*	1.00	0.614	1.000	1.00	0.520	1.000
(2) *C*	0.76	0.688	0.943	0.93	0.689	0.931
(3) *S*	2.01	0.602	0.923	1.20	0.437	0.952
(4) *I*	3.57	− 0.045	0.554	3.41	− 0.166	0.433
(5) *TB*	0.98	0.039	0.009	1.38	− 0.220	− 0.092
(6) $-r^*A$	5.58	0.971	− 0.046	4.04	0.859	− 0.063
(7) *L*	0.69	0.614	1.000	0.89	0.520	1.000
memo items:						
	$SD(GDP) = 2.81$			$SD(GDP) = 3.59$		
	$CORR(S,I) = 0.585$			$CORR(S,I) = 0.508$		

[1] Standard deviation relative to the percentage standard deviation of output $SD(GDP)$.
[2] First-order autocorrelation coefficient.
[3] Coefficient of correlation with GDP.

much lower levels than in the past. Important restrictions also remained on foreign direct investment, including portfolio investment, but a major reform in this area was introduced in May 1989.

We turn now to examine the ability of the model to explain the stylised facts of business cycles in Canada and Mexico. The first step is to determine which of the three assumptions about capital mobility is most adequate. Given the historical record on capital controls and accessibility to external financing of each country, a reasonable first approximation is to assume that Canada conforms to the view of an economy that has enjoyed free trade in financial assets for most of the post-war period, while Mexico is best characterised as an economy where some capital controls have been in place and access to foreign loans has not always been on competitive terms. These assumptions imply that, for Canada, equation (3) describes the evolution of foreign assets, with Δ set at -1.14 as the upper bound on foreign debt. This limit on external borrowing ensures intertemporal solvency, but is not binding inside the ergodic set of foreign assets in the stochastic steady state. For Mexico, equation (4) is the law of motion of foreign assets, with *binding* upper and lower bounds set at -0.30 and -0.16 respectively. These bounds were determined by starting from non-binding limits under perfect capital mobility, defined as

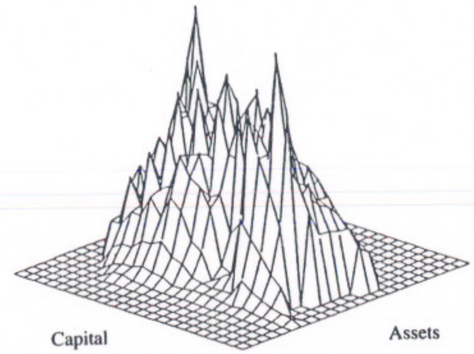

Figure 4.2 Limiting distribution of capital and foreign assets

in the case of Canada to capture the ergodic set of foreign assets, and then adjusting them gradually until the ratio of the standard deviation of net factor payments to the standard deviation of GDP in the model matches that observed in Mexican data (4.3%).

The properties of business cycles in the simulation models representing Canada and Mexico are listed in Table 4.2, and the joint marginal limiting probability distribution of capital and foreign assets in the Canadian benchmark model is depicted in Figure 4.2. Figure 4.2 illustrates clearly how the borrowing constraint is not binding in the stochastic steady state, so that intertemporal solvency is an equilibrium outcome. The statistical moments reported in Table 4.2 can be compared with the corresponding moments obtained from actual data reported in Table 4.1. In general, the model with perfect capital mobility mimics many of the Canadian business-cycle facts – including the positive correlation between savings and investment – except the GDP correlations of consumption and savings, and the first-order autocorrelations of investment and the balance of trade. As shown in Mendoza (1992), the assumption that the intertemporal relative price of aggregate consumption remains fixed at $1 + r^*$ is too strong, and a more realistic structure that decomposes consumption in tradable and nontradable goods would resolve these anomalies.

The model calibrated to the Mexican economy is less successful, but is still capable of mimicking some important stylised facts. Qualitatively, the model is consistent with the data in indicating that savings, investment, and net foreign interest payments are more variable than output, while consumption is less variable. Moreover, consumption, savings, and investment are procyclical, and the trade balance and foreign interest payments are countercyclical, in the model as in the data. By contrast, some large quantitative discrepancies between moments in the model and in the data are observed. The only moments in the model that mimic closely moments in actual data are the standard deviations of investment and net foreign interest payments, the persistence of savings, and the correlation between savings and investment. However, there may be some problems of measurement error with the Mexican data. Some of the coefficients of persistence and GDP correlation calculated with these data are not statistically significant, as noted in Table 4.1, and consumption is defined as personal expenditures on food and services because data on nondurables consumption are not available before 1980.

To conclude, the comparison of Tables 4.1 and 4.2 suggests that the intertemporal equilibrium model proposed in section 2 rationalises several of the stylised facts of business cycles in Canada and Mexico. The model cannot mimic all the stylised facts, particularly for the case of Mexico, but it yields savings plans that embody a pattern of consumption smoothing and allocations of domestic capital and foreign assets similar to that present in the data. The model may thus be viewed as a useful benchmark for evaluating the performance of indicators of capital mobility.

4 Macroeconomic indicators of capital mobility

The extensive literature devoted to measuring capital mobility using data on macroeconomic flows is based on two generalisations of the principle of Fisherian separation of savings and investment already discussed. First, because in an open economy with perfect mobility investment is set to equalise the return on domestic and foreign capital independently of consumption-smoothing considerations, savings and investment should be uncorrelated. Second, because agents make use of the available vehicles of savings to smooth consumption, the variability of consumption relative to output should decline as the degree of capital mobility increases, reflecting the enhanced consumption-smoothing opportunities provided by world capital markets. These two arguments also imply that investment should be more variable and less correlated with output when capital is more mobile, because the resources needed to expand the capital stock according to optimal investment plans can be obtained from world markets and because the influence of consumption-smoothing on those investment plans is reduced.[7] Moreover, the variability of net foreign interest payments relative to output should decrease with the imposition of barriers to capital mobility reflecting suboptimal adjustments in the current account.

Following these arguments, the empirical literature on capital mobility has identified the following stylised facts as indicators of reduced capital mobility in time-series or cross-sectional studies (see Montiel, 1992; Razin and Rose, 1992): (1) an increase in the savings–investment correlation, (2) an increase in the variability of output, (3) an increase in the variability of consumption relative to output, (4) a decrease in the variability of investment relative to output, (5) a decrease in the variability of net foreign interest payments relative to output, and (6) an increase in the correlation between investment and output. The problem with these macroeconomic indicators, as the analysis that follows shows, is that the Fisherian separation argument on which they are based applies strictly only in a deterministic framework, or in tightly-controlled experiments based on stochastic models. Once stochastic elements are taken into account, Fisherian separation holds only as a first approximation and the variability and persistence of exogenous shocks affects the performance of the indicators even if the regime of capital mobility is unchanged. In cross-sectional studies, this problem is compounded by differences in preference and technology parameters across countries which also affect the behaviour of the indicators.

The performance of the above-mentioned indicators of the international mobility of capital is examined next by undertaking a series of experiments in which the model is simulated under alternative regimes of capital mobility and alternative parameter specifications. The benchmark for the analysis is the model parameterised and calibrated to Canadian data. Table 4.3 reports simulated savings–investment correlations that correspond to each of the three regimes of capital mobility discussed in section 2 under five different parameter scenarios; the benchmark model for Canada, an economy with higher risk aversion ($\gamma = 3$), an economy where labour supply is relatively inelastic ($\omega = 3$), an economy where income disturbances are larger ($\sigma_e = 2\%$), and an economy where income disturbances are more persistent ($\rho = 0.6$). Limited capital mobility is defined as a regime under which capital controls force the variability of net foreign interest payments relative to output to decline from 5.6%, as observed under perfect mobility, to 3.6%. Under immobile capital the relative variability of net foreign interest payments to output is set to zero. Tables 4.4–4.8 list the estimates that the same set of simulations produce for other indicators of capital mobility (output variability, consumption variability, investment variability, interest payments variability, and investment–output correlations). Tables 4.3–4.8 are designed so that rows represent alternative specifications of preference parameters and exogenous income disturbances, while columns represent alternative regimes of capital mobility. For a particular indicator of capital mobility to be robust, two

Table 4.3. *Savings–investment correlations in model economies*

	Regime of capital mobility		
Model economy	Perfect mobility	Limited mobility[1]	Immobile capital[2]
Canada benchmark	0.586	0.634	1.0
High risk aversion[3]	0.478	0.518	1.0
Inelastic labour[4]	0.505	0.582	1.0
Large shocks[5]	0.605	0.662	1.0
Persistent shocks[6]	0.457	0.506	1.0

[1] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments to zero.
[3] $\gamma = 3.0\%$.
[4] $\omega = 3.0\%$.
[5] $\sigma^e = 2.0\%$.
[6] $\rho^e = 0.6\%$.

conditions must be satisfied. First, as one moves from left to right in any given row, the indicator should move as predicted by theory. Second, as one moves from top to bottom in any given column, the indicators should remain relatively stable. As Tables 4.3–4.8 show, the first condition is satisfied – except in the case of output variability for simulations with large and persistent shocks – but the second one is not.

According to Tables 4.3–4.8, when the simulation experiments are controlled so as to keep all elements of the model unchanged except the degree of capital mobility, five of the six indicators respond to the imposition of barriers to mobility as theory would predict. As one moves from the regime of perfect mobility to the regime of immobile capital, the savings–investment correlation rises (Table 4.3), consumption variability rises (Table 4.5), investment variability falls (Table 4.6), the variability of net foreign interest payments falls (Table 4.7), and the investment–output correlation rises (Table 4.8). In contrast, output variability in Table 4.4 increases as capital mobility is restricted for the Canada benchmark, the high risk aversion, and the inelastic labour economies, but declines for the economies with large and persistent shocks. This result reflects the fact that, as the shocks become larger or more persistent, the decline in the covariance between the capital stock and the shocks – induced by the inability to borrow from abroad to finance investment – dominates the

Table 4.4. *Output variability in model economies[1]*

	Regime of capital mobility		
Model economy	Perfect mobility	Limited mobility[2]	Immobile capital[3]
Canada benchmark	2.81	2.82	2.83
High risk aversion[4]	2.80	2.82	2.94
Inelastic labour[5]	1.79	1.81	1.88
Large shocks[6]	4.32	4.30	4.29
Persistent shocks[7]	3.33	3.26	3.08

[1] Percentage standard deviations of GDP.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[3] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments to zero.
[4] $\gamma = 3.0\%$.
[5] $\omega = 3.0\%$.
[6] $\sigma^e = 2.0\%$.
[7] $\rho^e = 0.6\%$.

Table 4.5. *Consumption variability in model economies[1]*

	Regime of capital mobility		
Model economy	Perfect mobility	Limited mobility[2]	Immobile capital[3]
Canada benchmark	0.76	0.79	0.85
High risk aversion[4]	0.76	0.79	0.84
Inelastic labour[5]	0.61	0.62	0.70
Large shocks[6]	0.77	0.81	0.87
Persistent shocks[7]	0.80	0.83	0.89

[1] Percentage standard deviation of consumption relative to the percentage standard deviation of GDP.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[3] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments to zero.
[4] $\gamma = 3.0\%$.
[5] $\omega = 3.0\%$.
[6] $\sigma^e = 2.0\%$.
[7] $\rho^e = 0.6\%$.

Table 4.6. *Investment variability in model economies*[1]

Model economy	Regime of capital mobility: Perfect mobility	Limited mobility[2]	Immobile capital[3]
Canada benchmark	3.57	3.37	1.76
High risk aversion[4]	3.81	3.51	1.77
Inelastic labour[5]	3.57	3.39	2.48
Large shocks[6]	3.33	3.07	1.70
Persistent shocks[7]	4.00	3.64	1.60

[1] Percentage standard deviation of investment relative to the percentage standard deviation of GDP.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[3] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments to zero.
[4] $\gamma = 3.0\%$.
[5] $\omega = 3.0\%$.
[6] $\sigma^e = 2.0\%$.
[7] $\rho^e = 0.6\%$.

Table 4.7. *Variability of interest payments in model economies*[1]

Model economy	Regime of capital mobility: Perfect mobility	Limited mobility[2]	Immobile capital[3]
Canada benchmark	5.59	3.61	—
High risk aversion[4]	9.04	4.21	—
Inelastic labour[5]	9.91	6.22	—
Large shocks[6]	5.61	2.72	—
Persistent shocks[7]	5.70	3.43	—

[1] Percentage standard deviation of net foreign interest payments relative to the percentage standard deviation of GDP.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[3] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments to zero.
[4] $\gamma = 3.0\%$.
[5] $\omega = 3.0\%$.
[6] $\sigma^e = 2.0\%$.
[7] $\rho^e = 0.6\%$.

Table 4.8. *Investment–output correlations in model economies*

Model economy	Regime of capital mobility: Perfect mobility	Limited mobility[1]	Immobile capital[2]
Canada benchmark	0.555	0.588	0.938
High risk aversion[3]	0.480	0.502	0.948
Inelastic labour[4]	0.488	0.548	0.919
Large shocks[5]	0.584	0.609	0.933
Persistent shocks[6]	0.441	0.471	0.930

[1] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments from 5.6% under perfect capital mobility for the Canada benchmark to 3.6% under limited capital mobility.
[2] Borrowing and lending ceilings set to reduce the standard deviation of net foreign interest payments zero.
[3] $\gamma = 3.0\%$.
[4] $\omega = 3.0\%$.
[5] $\sigma^e = 2.0\%$.
[6] $\rho^e = 0.6\%$.

increase in the variance of capital that results from the need to use it as the main vehicle of savings.[8]

The usefulness of the macroeconomic indicators of capital mobility is much less clear when slight variations in preference parameters and in the magnitude and duration of income disturbances are taken into account, as one moves from one row to the next in each table. Consider the case of the savings–investment correlations. Table 4.3 shows that an economy where shocks are more persistent would appear to restrict capital mobility less than the Canada benchmark, because savings and investment are less correlated. However, the correlation between savings and investment is smaller, not because of barriers to capital mobility but because, as explained below, the more persistent shocks lengthen the period during which savings decline and investment rises in response to real shocks. Similarly, Table 4.3 shows that economies with higher risk aversion or relatively inelastic labour supply also produce less correlation between savings and investment than the Canada benchmark, while an economy with larger shocks produces the opposite.

The other macroeconomic indicators of capital mobility are also affected by changes in the specification of parameters. Tables 4.4–4.8 show that the variability of output, the output–correlation of investment, and the variability ratios of consumption, investment, and net foreign interest

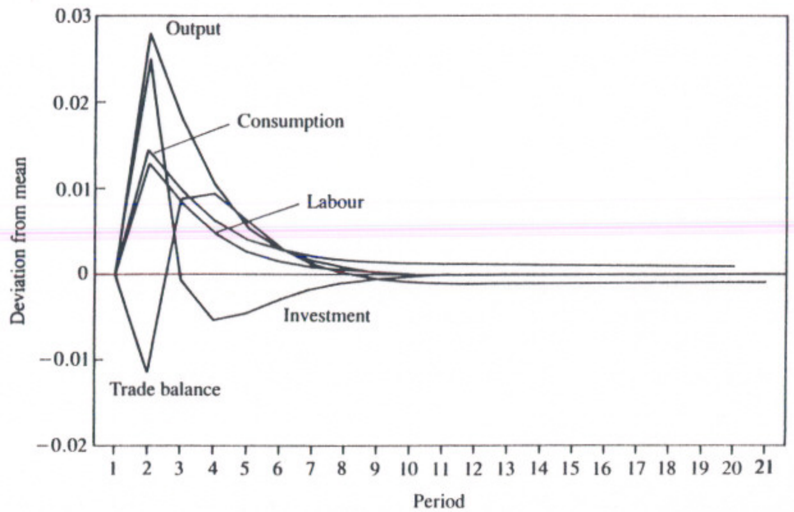

Figure 4.3 Impulse responses under perfect capital mobility

payments relative to output tend to be just as sensitive to changes in parameters as to the imposition of limits on capital mobility. Hence, all countries in the sample of a cross-section study could have identical regimes of capital mobility, and yet be judged as allowing financial capital to flow more or less freely on the basis of differences in macroeconomic indicators that could merely reflect differences in the structure of the economies. Tables 4.3 and 4.8 show that it is only in the extreme case in which capital mobility is totally obstructed that indicators based on savings–investment correlations or investment–output correlations are robust to parameter specifications. However, in a world where neither perfect mobility or absolute immobility are found very frequently, this robustness property may not be useful.

The performance of the indicators of capital mobility in the various experiments summarised in Tables 4.3–4.8 can be examined further by studying the differences in the pattern of adjustment of the economy in response to exogenous shocks due to the imposition of barriers to capital mobility. This is illustrated in Figures 4.3 and 4.4, which depict impulse responses of macroeconomic aggregates to a 1% productivity shock in the regimes of perfect capital mobility and immobile capital respectively.

Under perfect capital mobility (Figure 4.3), the impact effect of the productivity shock on output, consumption, labour supply, and investment is positive, while that on the trade balance is negative. The increase

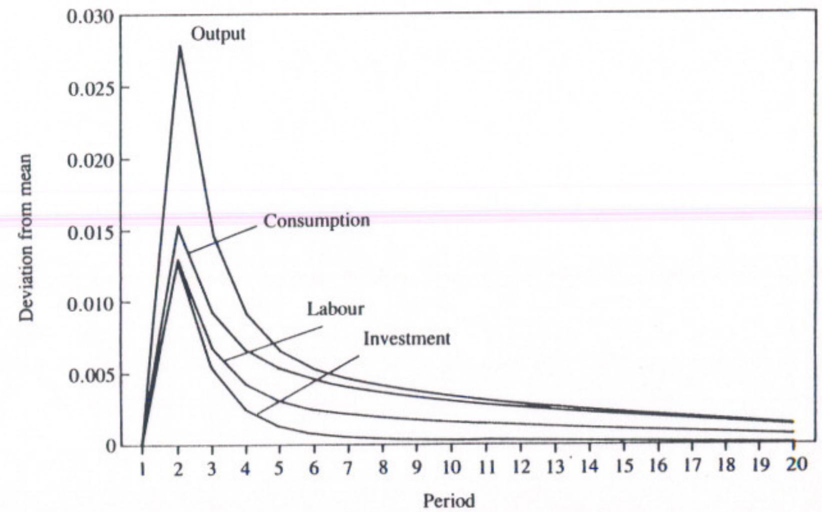

Figure 4.4 Impulse responses under the regime of immobile capital

in labour and consumption is smaller than the surge in output, reflecting the agents' desire to smooth consumption of the composite good C-$G(L)$. The trade balance worsens to finance additional investment needed to equalise the expected returns on foreign assets and domestic capital. As the effect of the shock fades, output, consumption, and labour revert to their long-run mean values following a downward, monotonic pattern. In contrast, investment declines sharply and becomes negative after the second period, and then it returns to its long-term mean from below zero following upward, monotonic trend. This reflects the extent to which Fisherian separation is still a useful approximation under uncertainty, the volatile behaviour of investment resulting from the agent's ability to borrow and lend as necessary to equalise the expected returns of available assets. The sharp improvement of the trade balance after the negative impact effect is approximately a mirror image of the changes in investment, with the exception that trade surpluses also reflect the accumulation of foreign assets to sustain savings.[9] Savings correspond to the difference between output and consumption; thus, the impulse response of savings would also display a positive impact effect and a downward, monotonic adjustment to the initial equilibrium. Savings and investment are positively correlated, despite perfect capital mobility, because the impact effect on both variables is positive. The correlation is not perfect, however, because after the impact effect savings decline while investment increases. The duration of the disturbances is crucial for this result. If the productivity shock had zero autocorrelation, investment would have little incentive to move – since the expected profitability of future capital is unchanged – and the correlation between savings and investment would be negligible. Hence, a necessary condition for high savings–investment correlations to be interpreted as evidence of imperfect capital mobility is that income disturbances be purely transitory. However, as the analysis that follows shows, this condition is necessary but not sufficient.

The impulse responses under the regime of immobile capital (Figure 4.4) show that in this case output, consumption, labour, and investment all react positively when the shock occurs, and then revert to their initial equilibrium following a downward, monotonic path. The trade balance does not move because the regime of immobile capital prevents any adjustments in the holdings of foreign financial assets. The striking difference in the impulse responses of investment under perfect capital mobility and the regime of immobile capital is again a reflection of Fisherian separation. When international capital mobility is prohibited, agents are forced to formulate savings plans as in a closed economy. Investment must be allocated so as to smooth consumption and not to balance the returns paid by foreign and domestic assets. It is interesting to note, however, that the patterns and magnitudes of the mean deviations of output, consumption, and labour induced by the 1% shock are similar under the two regimes. Moreover, increases in the variability of output and consumption that result from restricting capital mobility in Tables 4.4 and 4.5 are marginal. Thus, as noted by Mendoza (1991b), the agents' ability to smooth consumption is not significantly affected by the imposition of barriers to capital mobility – given the relatively small magnitude of observed business cycles and the assumed low degree of risk aversion. This result suggests that measures of capital mobility based on the variability of output and consumption may be less useful than those based on the cyclical behaviour of investment. The simulation exercises show, however, that the latter are not very informative either.

These results suggest that cross-country studies of capital mobility based on business-cycle volatility indicators may be affected by the noise introduced by differences in risk aversion, labour–leisure preferences, and duration and persistence of random income shocks. To illustrate this point further, the standard deviations of consumption in the 15 simulations reported in Tables 4.3–4.8 are used to construct a simplified version of the test conducted by Razin and Rose (1992). Razin and Rose used direct evidence on the regimes of capital mobility in place in 133 countries, combined with factor analysis, to construct factor variables that measured the openness of the various economies, and then estimated regressions of business-cycle volatility measures on those factors. They concluded that the regressions did not provide strong support for the hypothesis that consumption is less variable and investment more variable as the degree of openness increases. In the experiment conducted here, the standard deviation of consumption is regressed first on a qualitative variable that measures the degree of mobility – this variable is assigned a value of 0 for artificial economies with perfect mobility, 1 for economies with limited mobility, and 2 for economies with immobile capital. Despite the fact that the regimes of capital mobility are identified without error, this regression fails to produce a statistically significant coefficient. However, if additional binary variables are introduced to control for risk aversion, labour elasticity of substitution, and variability and persistence of output shocks, the coefficient on the capital mobility variable is estimated at 0.13 with a t-statistic of 6.5.

In summary, the numerical analysis suggests that cross-country and time-series studies of capital mobility based on macroeconomic indicators are not likely to be illustrative unless differences in preferences, technology, and the nature of shocks across countries and through time periods are taken into account. Otherwise, savings–investment and output–investment correlations, as well as business-cycle variability measures, cannot be interpreted as providing information useful for determining the degree of capital mobility. Given the complexity involved in identifying and incorporating into empirical tests the many differences in economic structure across countries, it is perhaps best to opt for direct measures of mobility such as the transactions and capital account data examined by Tesar and Werner (1992) and Calvo, Leiderman, and Reinhart (1992), or for econometric tests that evaluate directly the implications of the neoclassical framework as the Euler equation tests of Obstfeld (1989).

The results of the numerical simulations also suggest, however, that the results of Euler equation tests of capital mobility should be interpreted with caution. These tests, as proposed in Obstfeld's (1989) work, attempt to establish whether there are systematic differences in the intertemporal marginal rates of substitution in consumption across countries – assuming that agents in different countries have identical preferences, represented by isoelastic-utility functions, and that countries issue one-period, risk-free financial assets. If there is perfect capital mobility, arbitrage in these assets would equalise marginal rate of substitution across countries and, hence, as of date t, variables dated t or earlier should be orthogonal to the difference of the marginal rates of substitution between any two countries. In the context of the model presented in section 2, the Euler equation test can be interpreted as follows. Economies with perfect capital mobility participate in the world's capital market, and hence in equlibrium the intertemporal marginal rates of substitution for economies A and B equal the world real rate of return:

$$\left[\frac{U'(t)}{\exp(-v(t))\mathrm{E}_t[U'(t+1)]}\right]_a = (1+r^*)$$
$$= \left[\frac{U'(t)}{\exp(-v(t))\mathrm{E}_t[U'(t+1)]}\right]_b. \quad (14)$$

Economies under a regime of immobile capital cannot access world financial markets, and hence the domestic capital stock is the only vehicle of savings. The Euler equations for these economies imply that *each* has a domestic one-period, risk-free real interest rate given by:

$$\frac{U'(t)}{\exp(-v(t))\mathrm{E}_t[U'(t+1)]} = \mathrm{E}_t[(F_k(t+1)+1-\delta)] + \frac{\mathrm{cov}[U'(t+1), F_k(t+1)+1-\delta]}{\mathrm{E}_t[U'(t+1)]}. \quad (15)$$

A researcher can test whether there is perfect capital mobility between two countries by testing the null hypothesis that there are no systematic differences in their marginal rates of substitution, as implied by (14). However, this hypothesis presumes that there are statistically significant differences between the one-period, risk-free interest rates under perfect capital mobility and the regime of immobile capital – i.e. $(1 + r^*)$ and the right-hand side of (15). This implies that the mean return on capital in an economy where capital is immobile must differ from that paid in world markets, and that the economy's risk premium, as measured by the covariance between the marginal utility of consumption and the net marginal product of capital, must be different from zero. If this is the case, one should expect that the equilibrium stochastic process of consumption, in the presence of the same income disturbances, should reflect the limited insurance possibilities of the regime with immobile capital.

Unfortunately, given the parameterisation of preferences, technology, and exogenous shocks, the simulations of the model with immobile capital produce negligible differences in the intertemporal equilibrium allocations for consumption. In the case of the Canada benchmark model, the mean of consumption is neutral to the regime of capital mobility, the standard deviation increases from 0.024 under perfect mobility of 0.027 under immobile capital, and the consumption–output correlation increases by 0.033 from one regime to the other.[10] It thus appears that the ability of agents to smooth consumption is not limited significantly by changes in the regime of capital mobility, and hence it is possible that capital may not move across countries for which the differential in marginal rates of substitution is not statistically different from zero. This result is consistent with previous findings by Cole and Obstfeld (1991), Mendoza (1991b), and Backus, Kehoe and Kydland (1992), suggesting that under particular specifications of preferences and technology, the completeness of financial markets does not significantly affect competitive allocations.

5 Concluding remarks

This chapter examined the performance of several well-known macroeconomic indicators of capital mobility in the context of an intertemporal equilibrium framework of a small open economy. Recursive numerical solution methods were used to compute the equilibrium comovements of a model economy subject to stochastic disturbances affecting productivity or the terms of trade. These equilibrium comovements were compared with the stylised facts of business cycles in Canada and Mexico so as to establish the model's ability to serve as a useful tool for assessing the implications of different regimes of capital mobility. Once it was established that the model rationalises some key characteristics of actual business cycles, several simulation exercises were conducted to examine the performance of the mobility indicators under different regimes of capital mobility and different specifications of the parameters that measure the degree of relative risk aversion, the price elasticity of labour supply, and the variability and persistence of the stochastic shocks.

The results showed that the principle of strong Fisherian separation of savings and investment that holds in a deterministic environment, on which the use of macroeconomic comovements as indicators of capital mobility is based, is only a rough first approximation in a setting with uncertainty. The quantitative implications of this fact affect significantly the robustness of macroeconomic indicators of capital mobility. These indicators generally behave as predicted by theory when the simulation experiments are controlled to modify exclusively the regime of capital mobility, but they prove to be unstable in the presence of small changes in structural parameters. In particular, high savings–investment correlations are found to be a necessary but not sufficient condition for establishing the immobility of capital. Moreover, savings–investment correlations, as well as other indicators based on the cyclical behaviour of output, consumption, and investment, are equally sensitive to slight variations in the parameters that describe preferences and the stochastic process of the disturbances as to changes in the degree of capital mobility.

The findings of this analysis suggest that the evidence presented to date on capital mobility based on macroeconomic indicators cannot be interpreted as showing that the welfare and efficiency gains resulting from the integration of world capital markets have not materialised. Furthermore, empirical tests aimed at establishing the mobility of capital across countries using macroeconomic indicators may be affected by the noise attributed to differences in the structure of the economies under study. Unless this information can be properly incorporated into the tests, an approach based on direct measurement of international flows of financial capital, or the Euler equation tests that evaluate directly the implications of the optimality principles that characterise the neoclassical model, may be the best alternative. The results of the latter should be interpreted with caution, however, because numerical simulations suggest that they can produce favourable results even for economies where capital is in fact immobile.

NOTES

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1 The shock e_t incorporates the effects of fluctuations in the terms of trade because output is a tradable commodity (see Greenwood, 1983). However, the model ignores the existence of nontraded goods and does not model separately importable and exportable commodities. Mendoza (1992) examines a model that relaxes these assumptions.

2 With these adjustment costs, the cost of changing the capital stock by a fixed amount increases with the speed of the desired adjustment, giving agents an incentive to undertake investment changes gradually. This prevents the model from exaggerating the variability of investment relative to what is observed in the data (see Mendoza, 1991a for details).

3 The world's real interest rate is assumed to be fixed for simplicity. This reduces the model to the minimum framework in which to assess the performance of capital mobility indicators under uncertainty. Mendoza (1991a) finds that interest rate shocks do not have significant implications for the model examined here under conditions of perfect capital mobility.

4 Implicit in this financial structure is the assumption that contracts with payment contingent on the realisations of the disturbances cannot be written. Impeding trade in these contingent claims limits the ability of agents to insure

themselves completely against country-specific risks. However, Cole and Obstfeld (1991), Mendoza (1991b) and Baxter and Crucini (1992) found that market incompleteness may not have drastic effects on competitive allocations. This financial structure also assumes that foreigners do not own domestic capital, although it is possible for domestic agents to borrow from world markets to finance investment projects.

5 In this utility function, the rate of time preference, $\exp[v(\cdot)]$, increases with the level of past consumption in order to obtain a well-defined unique invariant limiting distribution of the state variables – as demonstrated by Epstein (1983). Obstfeld (1981) used the deterministic analogue of this utility function, following Uzawa (1968), to obtain a well-defined steady state for foreign asset holdings in a small open economy. Epstein also showed that SCU is suitable for dynamic programming, that with it consumption in every period is a normal good, and that the conditions it requires restrain the variability of the rate of time preference so that major deviations from the standard time-separable setup are avoided.

6 This method is due to Bertsekas (1976) and was introduced to macroeconomic models by Sargent (1980). Greenwood, Hercowitz and Huffman (1988) used it to simulate a closed-economy real business-cycle model and Mendoza (1991a) used it to solve a small open-economy model. The technique calculates exactly the unique invariant joint limiting distribution of the state variables, using an algorithm that solves the functional equation problem for a discrete version of the state space.

7 Razin and Rose (1992) also argue that output variability increases with trade liberalisation because of the specialisation trends that follow from perfect mobility of goods.

8 Note that, because of the Cobb–Douglas technology and the separation of consumption and labour in the utility function, the variance of output can be expressed as a linear function of the variance of the shocks, the variance of the capital stock, and the covariance between the capital stock and the shocks.

9 The present value of the trade balance must be zero to satisfy the resource constraint. Hence the initial worsening of the trade balance is offset with several periods of improvement.

10 Even if the exercise is altered to allow for the use of capital controls to target the trade balance, and hence alter the mean of the capital stock, the effects on consumption and welfare are negligible (see Mendoza, 1991b for details).

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