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Capital Controls and the Gains from Trade in a Business Cycle Model of a Small Open Economy

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A dynamic stochastic model of a small open economy is used to quantify the macroeconomic effects of a policy that utilizes capital controls as an instrument to target the trade balance. The results show that, given the magnitude of actual business cycles, capital controls have negligible effects on agents' ability to smooth consumption and the level of welfare. These surprising results suggest that the benefits obtained from free trade as a mechanism that facilitates consumption smoothing are of secondary importance. A fiscal strategy that enforces capital controls by taxing foreign interest income is also studied. [JEL E32, N12]

> Social Experiments on the grand scale may be instructive and admirable, but they are best admired at a distance. The idea, if the marginal social product of economics is positive, must be to gain some confidence that the component parts of the program are in some sense reliable prior to running it at the expense of our neighbors.
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> —Robert E. Lucas, Jr. (1980, p. 710)

An important innovation of the 1980s in the area of open economy macroeconomics was the development of an extensive research program that followed the intertemporal equilibrium approach to study

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the effects of economic policy. With the exception of a few empirical studies, such as Ahmed (1986) or Hercowitz (1986), this research focused primarily on theoretical investigations covering a wide spectrum of models and policy applications. Models in which individuals live for two periods and are endowed with perfect foresight were used to study capital controls, dual exchange rates, and other monetary, fiscal, and commercial policies.[1] These studies were followed by more sophisticated extensions that incorporated overlapping generations, infinite life horizons, and uncertainty.[2]

One of the main conclusions obtained from this literature is that the effects of policies are largely determined by the nature, timing, and permanence of policy changes. For instance, a transitory increase in government expenditure worsens the current account of a small open economy because agents distribute intertemporally the impact of the fiscal expansion on private consumption by borrowing from abroad. Conversely, the current account improves if the fiscal expansion is expected to occur in the future, and remains roughly neutral in response to a permanent increase in government expenditure. The intertemporal equilibrium approach also provided new insights into the analysis of capital controls. Greenwood and Kimbrough (1985) studied the transmission of fiscal policies in a two-country, two-period model and found that capital controls have critical implications for Ricardian equivalence, the comovement of macroeconomic aggregates, and the magnitude of fiscal-induced business cycles. This and subsequent research also showed that the intertemporal implications of capital controls, taxes on capital flows, and dual exchange rates are equivalent (see Adams and Greenwood (1985)).

The predictions of policy analysis based on intertemporal equilibrium models contrast sharply with the predictions of the traditional income-expenditure framework. For instance, in this framework a fiscal expansion shifts the *IS* curve to the right and, if the exchange rate is flexible and capital is perfectly mobile, it produces an appreciation of the exchange rate that shifts the *IS* back to its original position. The economy

[1] Frenkel and Razin (1987) and Kimbrough (1987) provide thorough reviews of this literature. For two classical examples, see Aschauer and Greenwood (1985) and Razin and Svensson (1983).

[2] Obstfeld (1981, 1986) studied exchange rate dynamics, devaluations, dual exchange rates, and capital controls in an infinite-horizon, deterministic framework. Frenkel and Razin (1986, 1987) analyzed various aspects of fiscal and commercial policies using an overlapping generations model. Lucas (1982) and Stockman (1983) explored the real exchange rate and its connection with monetary and exchange rate policies in a two-country stochastic setup.

maintains the same equilibrium levels for the interest rate, income, and private consumption, and the current account worsens to make room for the enlargement in government consumption. Moreover, capital controls have a positive effect on output in as much as they induce larger trade surpluses and isolate the economy from external shocks.

Despite the challenging conclusions obtained from the theoretical work, the shortage of empirical research lessened the influence of the intertemporal equilibrium approach on the actual design of policies. Therefore, the methods for quantitative analysis of dynamic stochastic models developed recently in the real business cycle literature constitute a valuable innovation. These methods allow researchers to compute equilibrium stochastic processes for model economies affected by random shocks, given explicit configurations of preferences, technology, and policy regimes.[3] The analysis of economic policies is conducted by simulating policy scenarios using benchmark models that are roughly consistent with actual data, considering that individual behavior is not invariant to policy changes and that welfare assessments must follow from explicit intertemporal optimization—as the guidelines established by Lucas (1976, 1987) require. Cooley and Hansen (1989) and Greenwood and Huffman (1991) have used these methods to study monetary and fiscal policies in dynamic stochastic models of closed economies.

The purpose of this paper is to extend this line of research by undertaking a quantitative investigation of the effects of economic policy in the context of a dynamic stochastic model of a small open economy. The model is solved numerically in an attempt to measure the effects of a policy that uses capital controls as an instrument to target the trade balance. Borrowing from the principles established in the theoretical work, the numerical analysis determines the effects of capital controls on economic activity and welfare, and computes a schedule of taxes on foreign interest income that generates exactly the same outcome as capital controls.

The quantitative analysis undertaken in this paper can also be viewed as an attempt to measure the gains from trade that agents derive from free access to world markets for the purpose of smoothing consumption. This issue is interesting because many empirical studies based on static general equilibrium models have failed to produce evidence of significant gains from trade for the Canadian-U.S. Free Trade Agreement (see

[3] To date, use of these methods in open economy macroeconomics has focused mainly on analyses of business cycles. Backus, Kehoe, and Kydland (1990) and Stockman and Tesar (1990) studied two-country models with complete insurance markets, and Mendoza (1991) studied a small open economy with limited insurance.

Coughlin (1990)) and for the Europe 1992 project of economic integration (see Cecchini Report (1988)). This literature has argued that, in practice, significant gains from trade are reflected in the behavior of savings, investment, and the current account, and that because of their dynamic nature these variables are not well captured in static models. Dynamic gains from trade arise not only from the use of the current account as a mechanism to smooth consumption, but also from the positive effect that free trade has on economic growth. However, much of the research on this subject to date has focused on the benefits of trade related to consumption smoothing, and the few existing empirical investigations have not produced significant gains from trade.[4] Cole and Obstfeld (1989) found that prohibiting international asset trading induces an annual loss of only 0.15 percent of output in a model of an exchange world economy. Backus, Kehoe, and Kydland (1990) simulated a two-country real business cycle model and estimated the loss in average consumption induced by moving the two countries to autarky at only 0.31 percent. One contribution of this paper is to explore the robustness of these results in the context of a real business cycle model of small open economy.

The paper is organized as follows. Section I describes the structure of the model, which considers dynamic optimization in an economy where domestic capital and foreign assets act as vehicles of savings, and the rate of impatience increases with past consumption. Section II explores the potential usefulness of this model as a tool for policy analysis by determining its ability to mimic the behavior of an actual economy. Section III studies the effects of capital controls used to target the trade balance. The effects on welfare are determined by computing different measures of "compensating variations," as defined later, and the effects on economic activity are studied by comparing the stylized facts of business cycles in the model with and without capital controls. This section also examines a schedule of taxes on capital flows that produces the same outcome as capital controls. Section IV presents some concluding remarks.

I. Structure of the Model

This section is divided in two parts. The first part describes the structure of preferences, technology, and financial markets that characterizes the model studied in the paper. Except for the introduction of capital

[4] Research on the measurement of growth-related gains from trade is at an initial stage. Baldwin (1989) provided some estimates using a model with increasing returns and exogenous technological progress.

controls and taxes on foreign interest income, the model is very similar to that analyzed in Mendoza (1991), and the presentation is therefore brief. The second part of the section characterizes the equilibrium of the model as a discrete-time, dynamic programming problem.

Preferences, Technology, and Financial Structure

Preferences. Agents are infinitely lived and identical, and preferences are given by stationary cardinal utility (SCU), as defined by Epstein (1983):

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

The instantaneous utility and impatience functions are as follows:

$$u(C_t - G(L_t)) = \frac{\left[C_t - \frac{L_t^{\omega}}{\omega}\right]^{(1-\gamma)} - 1}{1-\gamma}, \quad \omega > 1,\ \gamma > 1 \tag{2}$$

$$v(C_t - G(L_t)) = \beta \ln\left(1 + C_t - \frac{L_t^{\omega}}{\omega}\right), \quad \beta > 0. \tag{3}$$

In these expressions, C_t denotes private consumption, and L_t denotes labor services.

The SCU function is the stochastic analog of the utility function employed by Obstfeld (1981) to produce a well-defined deterministic stationary equilibrium for the holdings of foreign assets in a model of a small open economy. This steady state is attained when the accumulation of external assets moves the impatience rate to equalize the world's real interest rate. In contrast, the standard constant rate of time preference cannot produce a well-defined steady state. As Helpman and Razin (1982) explained, if the rate of interest is set higher (lower) than the constant rate of time preference, individuals accumulate (deplete) foreign assets to finance an ever-increasing (decreasing) consumption stream. If the two rates are set equal, the economy starts in a steady state fully determined by initial conditions. As in Mendoza (1991), SCU is introduced to produce a well-defined *stochastic* stationary equilibrium.

Expressions (2) and (3) simplify the analysis by making the marginal rate of substitution between C_t and L_t depend on the latter only, effec-

tively separating the labor
sumption. This allows the
between foreign assets and
the expense of eliminating the
utility and logarithmic time
ciency conditions established by
of a stochastic steady state.[5]

Technology. The economy
with the following production

$$G(K_t, L_t, K_{t+1}) = \exp(e_t) \ldots$$

Here, e_t is a random shock to
is a Cobb-Douglas production
and $(\phi/2)(K_{t+1} - K_t)^2$ is the cost
function of net investment.[6] The

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

where δ is a constant rate of

Financial Structure. The financial
alternative policy regimes with
of capital controls, agents enjoy
international capital market in which
ing the nonrandom real rate of
of the world.[7] The economy is a
hence, r^* is determined exogenously
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$$A_{t+1} = TB_t + A_t(1 + r^*),$$

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deviation have minimal effects on the

tively separating the labor supply decision from the dynamics of consumption. This allows the model to focus explicitly on the interaction between foreign assets and domestic capital as the means of savings, at the expense of eliminating the wealth effect on labor supply. Isoelastic utility and logarithmic time preference are adopted to satisfy the sufficiency conditions established by Epstein (1983) to ensure the existence of a stochastic steady state.[5]

Technology. The economy produces an internationally tradable good with the following production technology:

$$G(K_t, L_t, K_{t+1}) = \exp(e_t)K_t^{\alpha} L_t^{1-\alpha} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2, \qquad 0 < \alpha < 1, \ \phi > 0. \quad (4)$$

Here, e_t is a random shock to productivity or the terms of trade; $K_t^{\alpha} L_t^{1-\alpha}$ is a Cobb-Douglas production function; K_t is the domestic capital stock; and $(\phi/2)(K_{t+1} - K_t)^2$ is the cost of adjusting the capital stock as a function of net investment.[6] The capital evolution equation is given by

$$K_{t+1} = (1 - \delta)K_t + I_t, \qquad 0 \leq \delta \leq 1, \quad (5)$$

where δ is a constant rate of depreciation, and I_t is gross investment.

Financial Structure. The financial structure adopts two forms reflecting alternative policy regimes with regard to capital controls. In the absence of capital controls, agents enjoy unrestricted access to a competitive international capital market in which foreign assets, A_t, paying or charging the nonrandom real rate of return, r^*, are exchanged with the rest of the world.[7] The economy is a small participant in this market, and hence, r^* is determined exogenously. Holdings of foreign financial assets evolve according to

$$A_{t+1} = TB_t + A_t(1 + r^*), \quad (6)$$

[5] Theorem 5 in Epstein (1983) proves that under certain conditions SCU satisfies the requirements of dynamic programming and makes consumption in any period behave as a normal good. Theorems 3 and 4 (Epstein (1983)) establish that the same conditions, added to either a neoclassical or a linear technology, guarantee the existence of an invariant limiting distribution for the state variables.

[6] The relevance of adjustment costs in small open economy, real business cycle models is fully explored in Mendoza (1991).

[7] Although interest rate shocks introduce additional income and substitution effects, Mendoza (1991) showed that shocks to r^* of up to 5 percent standard deviation have minimal effects on the behavior of the free trade economy.

where TB_t is the balance of trade.[8] When capital controls are introduced, the accumulation of external assets is restricted to

$$A_{t+1} = \hat{A}. \tag{7}$$

Hence, the balance of trade is targeted at the level $TB_t = -r^*\hat{A}$.

The combination of domestic production with foreign borrowing, or lending, results in the following resource constraint:

$$C_t + I_t + TB_t \leq \exp(e_t)K_t^{\alpha}L_t^{1-\alpha} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2. \tag{8}$$

Equilibrium and the Dynamic Programming Problem

Free Trade. Equilibrium in the economy without capital controls is characterized by a set of state-contingent decision rules for consumption, labor supply, capital accumulation, and foreign asset accumulation that maximize equation (1), given K_0, A_0 and e_0, subject to equations (4)–(6), (8), an intertemporal solvency restriction—which takes the form of an upper bound, Δ, on foreign debt—and the usual nonnegativity restrictions on K, L, and C.[9] The state of the economy is fully described each period by the values of K_t, A_t, and e_t. Given these, and knowledge of the stochastic process of the shocks, individuals choose K_{t+1}, A_{t+1}, C_t, and L_t optimally, so as to solve the following problem:

$$V(K_t, A_t, e_t^s) = \max\left\{\frac{\left(C_t - \frac{\hat{L}_t^{\omega}}{\omega}\right)^{(1-\gamma)} - 1}{(1-\gamma)} + \exp\left[-\beta \ln\left(1 + C_t - \frac{\hat{L}_t^{\omega}}{\omega}\right)\right]\left[\sum_{r=1}^{2} \pi_{s,r} V(K_{t+1}, A_{t+1}, e_{t+1}^r)\right]\right\}, \tag{9}$$

subject to

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

[8] This financial structure does not incorporate complete contingent-claims markets. Although this could induce excessive consumption variability, Cole and Obstfeld (1989) show that incompleteness of financial markets does not necessarily result in noticeable inefficiencies. Moreover, Backus, Kehoe, and Kydland (1990) found that complete insurance markets produce close to perfectly pooled equilibria, causing two-country models to exaggerate the comovement of consumption across countries.

[9] The numerical simulations confirmed that the upper bound on debt is sufficient to rule out Ponzi-type schemes. The limiting probability of setting foreign asset holdings below -1.14 is infinitesimal.

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

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

The stochastic structure of the shocks is simplified by introducing a two-point Markov process. In every period the shocks can take one of two possible values:

$$e_t \in E = \{e^1, e^2\}. \tag{10}$$

The one-step conditional transition probabilities of the disturbances, denoted π_{sr}, must satisfy the conditions that $0 \leq \pi_{sr} \leq 1$ and $\pi_{s1} + \pi_{s2} = 1$ for $s, r = 1, 2$. It is also assumed for simplicity that the transition probabilities and the shocks are symmetric: $\pi_{11} = \pi_{22} = \pi$, and $e^1 = -e^2 = e$. Under these conditions, the asymptotic standard deviation, σ_e, and the first-order autocorrelation coefficient, ρ_e, of the disturbances are determined by $\sigma_e = e$, and $\rho_e = 2\pi - 1$, respectively.

The free trade model has been calibrated to mimic a subset of the stylized facts of an actual small open economy by setting ϕ to mimic the variability of investment, and σ and ρ to mimic the variability and first-order serial autocorrelation of gross domestic product (GDP). Canada has been selected as a prototype small open economy because of the high degree of integration of Canadian and U.S. financial markets, and because of the absence of capital controls in Canada's postwar history.

The values of the parameters γ (coefficient of relative risk aversion), ω (1 plus the inverse of the intertemporal elasticity of substitution in labor supply), α (capital's share in output), δ (depreciation rate), β (the consumption elasticity of the rate of time preference), and r^* (the world's real interest rate) are selected using long-run averages of Canadian data and the restrictions imposed by the deterministic steady-state equilibrium of the model, and also by approximating some of the estimates obtained in the empirical literature. These parameters are assigned the following values:[10]

[10] The parameter α is determined with the average of the ratio of labor income to national income; $\delta = 0.1$ is the value commonly used in the real business cycle literature, and with it the model mimics the average of the investment-output ratio; ω is in the range of the estimates of the intertemporal elasticity of substitution in labor supply $(1/(\omega - 1))$ obtained by MaCurdy (1981) and Heckman and MaCurdy (1980, 1982); r^* is set to the annual equivalent of the value suggested by Kydland and Prescott (1982) for the U.S. economy; γ is in the range of accepted estimates following Prescott (1986); and β is determined using the average of the gross national product (GNP) and GDP and the other parameter values, so as to ensure that in the deterministic steady state the rate of time preference equals r^*.

$$\alpha = 0.32 \qquad \delta = 0.1$$
$$r^* = 0.04 \qquad \omega = 1.455$$
$$\gamma = 1.6 \qquad \beta = 0.11. \tag{11}$$

The model is solved numerically using the method of successive iterations on the value function and the state-transition probability matrix inside a discrete approximation of the state space. This method calculates exactly the unique invariant limiting distribution of the state variables (foreign assets, domestic capital, and the shocks) and uses it to calculate the equivalent of population moments for all relevant aggregates. The procedure is thoroughly discussed in Mendoza (1991) and is summarized in the Appendix.

Capital Controls. The equilibrium of the economy with capital controls is characterized in a similar manner as in the free trade model, except that foreign assets are not a choice variable and equation (7) replaces (6). The dynamic programming problem defined in equation (9) is modified to incorporate this restriction, and the model is not subject to calibration. This problem is equivalent to the one that characterizes a closed economy, real business cycle model, except that a constant equal to the trade balance target is added into the resource constraint.

II. Simulations for the Economy Without Capital Controls

The classical work of Lucas (1976, 1987) identified two necessary conditions for a model to be useful for policy analysis: (1) it must fit actual data, so that it can be viewed as a fair approximation of the real world; and (2) it must separate those elements of economic behavior affected by policies from those left unaffected. Condition (2) is satisfied by the model studied here because it explicitly separates structural parameters from policy instruments. This section performs the calibration exercise described above in order to establish whether condition (1) can also be satisfied. This section also borrows heavily from the analysis of Mendoza (1991).

The free trade benchmark model is calibrated by setting $\sigma_e = 1.285$ percent, $\rho = 0.41$, and $\phi = 0.023$. The statistical moments for the model and the Canadian data are listed in Table 1, and a graph of the marginal limiting probability distribution of domestic capital and foreign assets in the model economy is produced in Figure 1. As Table 1 shows, the free trade model delivers a roughly accurate characterization of the actual stylized facts. First, the model mimics the ranking of variability of all aggregates, approximating closely each percentage standard deviation.

Table 1. *Statistical Moments: Canadian Data and Benchmark Economy*

Variable	Canadian Data 1946–85			Benchmark Economy: Free Trade		
	σ [a]	ρ [b]	ρ_y [c]	σ [a]	ρ [b]	ρ_y [c]
(1) *GDP*	2.810	0.615	1.000	2.807	0.614	1.000
(2) *GNP*	2.950	0.643	0.995	2.864	0.616	0.994
(3) *C*	2.460	0.701	0.586	2.140	0.688	0.943
(4) *S*	7.306	0.542	0.662	5.635	0.602	0.923
(5) *I*	9.820	0.314	0.639	10.028	−0.045	0.554
(6) *K*	1.380	0.649	−0.384	1.364	0.705	0.594
(7) *L*	2.020	0.541	0.799	1.929	0.614	1.000
(8) $-r^*A$	15.250	0.727	−0.175	15.672	0.971	−0.046
(9) *TB/Y*	1.875	0.623	−0.129	1.901	0.018	−0.019
	CORR(*S*, *I*) = 0.434			CORR(*S*, *I*) = 0.585		

Note: Data measured in per capita terms of the population aged 15 years and over, logged and detrended with a quadratic time trend. Variables (1)–(3), (5), and (8) are aggregates from national income accounts; (6) is total end-of-period net stocks of fixed nonresidential industrial capital. Labor is an index of man hours worked by paid workers. Savings are investment plus the balance of trade, which is equivalent to GDP minus consumption. Domestic, instead of national, savings are used to isolate the effects of fluctuations in GDP from the effects of changes in the world interest rate. All data are in 1981 dollars and were obtained from the CANSIM data retrieval.

[a] Percentage standard deviation.

[b] First-order autocorrelation coefficient.

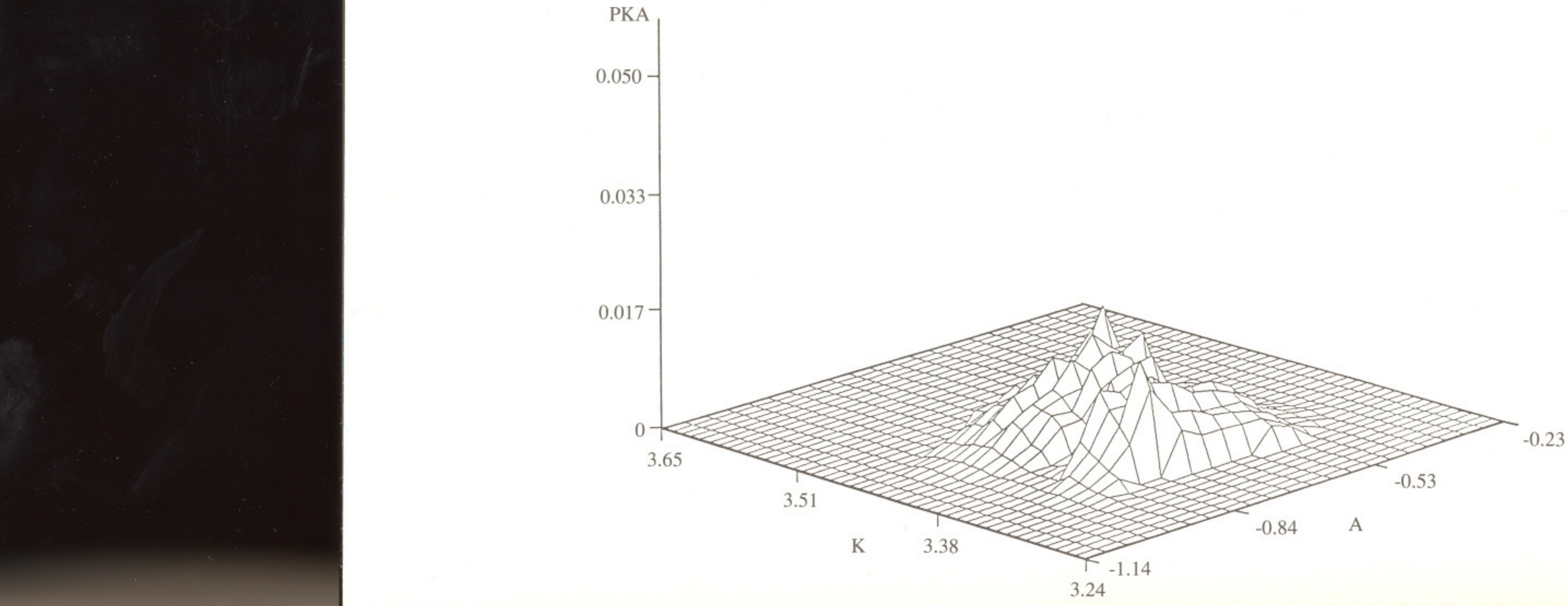
[c] Coefficient of correlation with GDP.

Second, although the model exaggerates the GDP correlations of consumption, savings, and labor, it reproduces a similar pattern of comovements as that observed in the data, as well as the correlation between savings and investment.[11] Third, the model approximates the ranking of the first-order serial autocorrelations, although it underestimates the autocorrelations of investment and the ratio of the trade balance to output.

Among the important regularities that the model mimics well are those that characterize foreign interest payments and the ratio of the trade balance to output. Although in Canada net foreign interest payments are only 2 percent of GDP on average, the country does participate actively

[11] The model predicts almost perfect correlation between *C*, *S*, and *GDP*, because the small open economy assumption and the nonrandom interest rate eliminate the intertemporal consumption-substitution effect; *L* exhibits the same persistence and output correlation as *GDP* because of the Cobb-Douglas structure of the production function and the instantaneous utility and time preference functions defined in equations (2) and (3).

Figure 1. *Limiting Probability Distribution of Capital and Foreign Assets in the Benchmark Economy*



in world financial markets—debt service fluctuates countercyclically, with about 15.3 percent standard deviation, which is more variability than that experienced in any other aggregate. The artificial economy mimics this behavior by showing that debt service exhibits 15.7 percent standard deviation, 0.97 first-order autocorrelation, and −0.05 correlation with GDP.

III. Simulations for Economies with Capital Controls

This section studies the effects of capital controls introduced with the aim of targeting the balance of trade. The model studied in the previous section views these controls as additional restrictions that necessarily reduce welfare and, hence, should not be imposed. Yet, governments usually dislike unfavorable and fluctuating trade balances and capital flows. Section 3004 of the 1988 U.S. Trade Act, for example, requires the Treasury to review commercial and exchange rate policies of countries that have large bilateral trade surpluses with the United States. Moreover, at the end of 1988, 79 percent of the 152 member countries of the International Monetary Fund (IMF) had capital controls in place.[12] This attitude is justifiable on the basis of alternative models that can be traced back to the mercantilist school. The *IS-LM-BP* prototype, for instance, predicts that larger trade surpluses induce an expansion of domestic output, which may be offset or magnified depending on the degree of capital mobility and the exchange rate regime. Thus, the experiment conducted here is best viewed as providing an alternative assessment of a policy that may appear as optimal from a different perspective, political or academic.

Effects on Economic Activity

The effects of capital controls on economic activity are determined by comparing the results of simulations of the model with capital controls with the results produced by the benchmark model. As discussed in Section I, capital controls take the form of a restriction on foreign asset accumulation, according to which $A_{t+1} = \hat{A}$ for all t, which implies that

[12] This figure was obtained from the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions, 1989* (International Monetary Fund (1989)), following the criterion used by Greenwood and Kimbrough (1985). Five of the seven largest industrialized countries are part of the 21 percent of IMF members without capital controls. Canada, Germany, and the United States have not had capital controls since 1966.

Table 2. *Statistical Moments for Alternative Artificial Economies*

				Restricted Economies											
	A. Benchmark economy: free trade			B. Trade balance improvement: 0 percent			C. Trade balance improvement: 12 percent			D. Trade balance improvement: 30 percent			E. Trade balance improvement: 60 percent		
Variable	μ	σ	ρ_y	μ	σ	ρ_y	μ	σ	ρ_y	μ	σ	ρ_y	μ	σ	ρ_y
GDP	1.487	0.042	1.000	1.487	0.042	1.000	1.492	0.042	1.000	1.497	0.042	1.000	1.507	0.042	1.000
GNP	1.459	0.042	0.994	1.458	0.042	1.000	1.460	0.042	1.000	1.460	0.042	1.000	1.461	0.042	1.000
C	1.119	0.024	0.943	1.119	0.027	0.976	1.118	0.027	0.976	1.116	0.027	0.977	1.114	0.027	0.977
S	0.368	0.021	0.923	0.368	0.017	0.939	0.373	0.017	0.939	0.381	0.017	0.940	0.393	0.017	0.941
I	0.340	0.034	0.554	0.340	0.017	0.939	0.342	0.017	0.939	0.343	0.017	0.940	0.347	0.017	0.941
K	3.399	0.046	0.594	3.397	0.064	0.544	3.415	0.064	0.543	3.434	0.064	0.542	3.472	0.064	0.539
L	1.008	0.019	1.000	1.008	0.020	1.000	1.010	0.020	1.000	1.012	0.020	1.000	1.017	0.020	1.000
$-A$	0.711	0.111	−0.046	0.708	0.000	0.000	0.795	0.000	0.000	0.926	0.000	0.000	1.142	0.000	0.000
TB	0.028	0.028	0.009	0.028	0.000	0.000	0.032	0.000	0.000	0.037	0.000	0.000	0.046	0.000	0.000
	CORR(S,I) = 0.585			CORR(S,I) = 1.000			CORR(S,I) = 1.000			CORR(S,I) = 1.000			CORR(S,I) = 1.000		

Note: The moments listed are the mean (μ), the standard deviation (σ), and the correlation with GDP (ρ_y).

$\hat{A}$ is related to the trade balance target by the equation $TB_t = -r^*\hat{A}$. Four trade balance targets are considered in order to obtain a clear picture of the effects of capital controls. In the first case, $\hat{A}$ is set so as to stabilize the trade balance at its mean value in the benchmark economy. In the other three cases, $\hat{A}$ is set to produce trade surpluses 12 percent, 30 percent, and 60 percent higher than the average obtained in the benchmark economy. The model is solved using the same method as before, except that the set of possible initial values for the holdings of foreign assets collapses to the single point $\hat{A}$ exactly one period after capital controls are introduced. Panels A–E of Table 2 list the means, standard deviations, and GDP correlations corresponding to simulations of the benchmark model and each of the models with capital controls.[13]

Consider first the mean (μ) listed in the first column of each panel. Capital controls have minimal effects on the means of all variables except foreign assets and the trade balance—which are directly determined by the capital controls. If the goal is only to stabilize the balance of trade at its mean value in the free trade economy, the means of all aggregates remain practically unchanged (panels A and B). The means of GDP, GNP, S, I, K, and L increase slightly, and the mean of C falls slightly as the trade balance target is increased. The largest fall in average consumption is only 0.5 percent, and that occurs when the trade surplus is set 60 percent higher than the mean trade balance of the benchmark model.

The standard deviations (σ) listed in the second column of each panel illustrate two findings. First, when capital controls are used to stabilize the trade balance at its mean in the benchmark model, the only standard deviations altered significantly are those of S, I, and K. The variability of S and I is the same because in economies with capital controls changes in savings are equivalent to changes in investment. Restricting trade in foreign assets reduces the standard deviation of I from 0.034 to 0.017, and increases that of K from 0.046 to 0.064. Prohibiting the use of foreign trade as a means to smooth consumption forces the dynamics of investment and capital to behave as in a closed economy. Investment becomes the only vehicle that can be used to smooth and substitute consumption intertemporally, and the accumulation of capital is no longer determined by the relative returns paid on capital and foreign assets, as in an open economy with free trade. As a result, investment faces an increasing supply price of capital and shows less variability than in a small open economy, where the supply price of K is constant at the level of r^*.

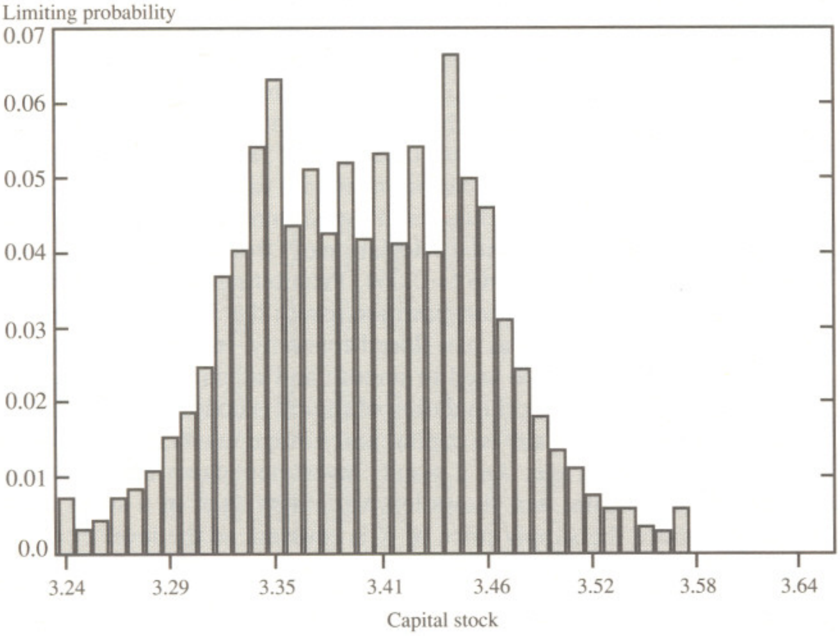
[13] Standard deviations, instead of percentage standard deviations, have been considered to isolate the effect of changes in the variability from changes in the mean.

The second finding obtained from comparing the standard deviations is that *increasing* the target for the trade balance does not cause additional changes in the variability of the aggregates. Thus, the standard deviations appear to be independent of the *size* of the target set for the balance of trade. Individuals simply scale down their average consumption and experience a similar pattern of fluctuations around this new mean.

The GDP correlations (ρ_y)listed in the third column of panels A–E in Table 2 illustrate observations similar to those for the standard deviations. First, when controls are used to stabilize the trade balance, the only noticeable change is that the correlation between *I* and *GDP* increases substantially from 0.554 to 0.939. Second, the GDP correlations are not affected by the *size* of the trade balance target. Investment is highly correlated with output, because agents wishing to smooth consumption increase (reduce) savings in response to positive (negative) output shocks and, under capital controls, investment is the only vehicle for savings. Moreover, although the domestic real interest rate now differs from the

Figure 2. *Limiting Probability Distribution of the Capital Stock in the Restricted Economy*

(With 0 percent increment in trade surplus)



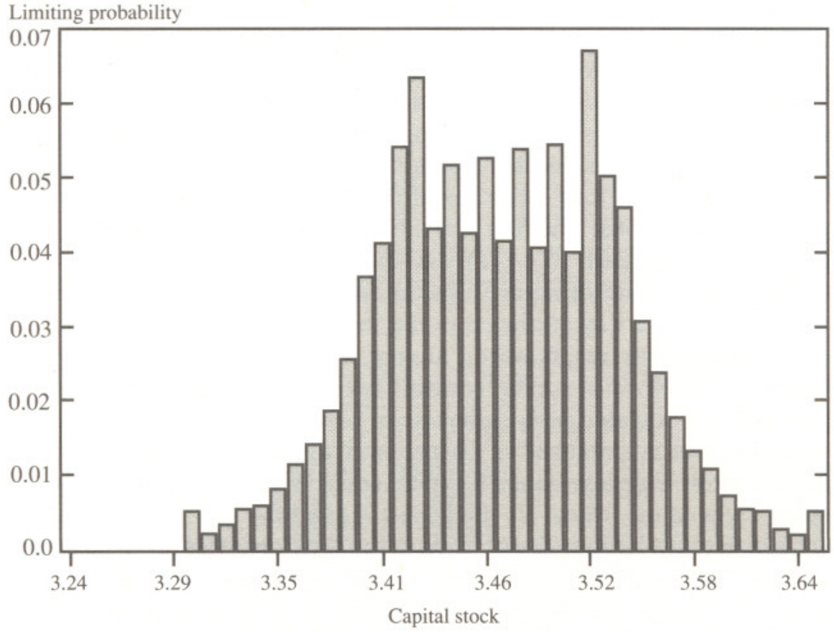
world interest rate, the productivity disturbances considered do not induce procyclical movements in the interest rate sufficient to lessen the comovement between investment, or savings, and output.

The fact that the tightness of capital controls affects only the means of the variables suggests that the limiting distribution of the domestic capital stock is shifting but preserving its variance. This conclusion is reaffirmed by the graphs depicting the marginal limiting distribution of K in Figures 2 and 3. As the target for the trade surplus increases, the limiting distribution of K shifts to the right, inducing an increase in the mean of the capital stock. This rightward shift occurs because a higher trade surplus reduces consumption and the rate of time preference in the deterministic steady state, and since in the steady state the marginal product of capital and the rate of time preference are equal, the mean capital stock increases to reduce the productivity of capital to the level of the rate of impatience.

To summarize, the moments reported in Table 2 suggest that capital

Figure 3. *Limiting Probability Distribution of the Capital Stock in the Restricted Economy*

(With 60 percent increment in trade surplus)



controls do not have significant effects on economic activity. Although the dynamics of savings work in an entirely different manner, with investment instead of the current account being used as the main vehicle for consumption smoothing, the behavior of output, consumption, and labor is almost unchanged. The exogenous shocks to productivity or the terms of trade that enable the benchmark model to mimic Canadian business cycles do not represent a risk sufficiently large for capital controls to seriously impair the ability of individuals to smooth consumption.

Effects on Economic Welfare: The Dynamic Gains from Trade

The welfare effects of capital controls are determined by computing compensating variations in consumption in the following manner. The solutions to the dynamic programming problems for the benchmark model (b) and the restricted models (rs) include solutions for the value functions $V^b(K,A,e)$ and $V^{rs}(K,A,e)$ for each triple (K,A,e) in the state space. Using equation (1), a nonlinear equation can be written to calculate a constant consumption path that yields the same lifetime utility expressed by $V^b(K,A,e)$ and $V^{rs}(K,A,e)$. The consumption level associated with $V^{rs}(K,A,e)$ is lower than the one representing $V^b(K,A,e)$, because the former is a more constrained representation of a frictionless environment. The percentage difference between these two consumption levels, for each triple in the state space and for each value of $\hat{A}$, is the compensating variation that measures the welfare loss induced by capital controls. These compensating variations also measure the gains from trade that agents obtain by borrowing and lending freely in world capital markets in order to smooth consumption during business fluctuations.

Table 3 presents four measures of the welfare loss according to compensating variations. The first two measures consider that for a given $\hat{A}$ there is a V^{rs} for each (K,A,e), and thus focus on compensating variations for each state of nature. Maximum and minimum welfare losses calculated in this way are listed in the second and third columns of the table. These measures, however, are not accurate indicators of the long-run welfare effects of capital controls because they ignore the limiting probability associated with each state of nature. For example, when the trade balance is stabilized at its mean in the benchmark economy, a 35 percent welfare loss occurs if capital controls are introduced when the economy is at the lowest K, the lowest A, and the low value of e. But, according to the limiting distribution of the state variables in the economy without controls (Figure 1), the probability of the economy being at this point prior to implementing capital controls is infinitesimal. In general, the largest welfare losses occur when A on the date the controls are introduced is driven the longest way to reach $\hat{A}$; but this implies that A is located at one of the tails of the distribution, and thus the odds of implementing the policy in this particular situation are almost nil.

Expected welfare losses, which are an average of the state-by-state compensating variations weighted by their associated limiting probabilities, are more illustrative than maximum and minimum welfare losses. The fourth column of Table 3 reports an expected welfare loss calculated using the limiting probability of occurrence of each triple (K, A, e) in the benchmark model. This ex ante welfare loss considers the odds of introducing the policy when the economy begins from a situation of free trade. The last column lists an expected welfare loss calculated with the limiting probabilities of the state variables in the economies with capital controls. This ex post welfare loss considers the probability of the economy being at some state $(K, \hat{A}, e)$ with capital controls in place, and compares the welfare level obtained in this environment with what similar triples would have provided under free trade. The ex ante measure is more accurate to the extent that it captures the average welfare cost induced by moving the economy *from* free trade *to* capital controls—note that the ex post welfare loss always underestimates the ex ante loss. The ex ante measure suggests that welfare losses associated with capital controls are surprisingly small. If $\hat{A}$ is set to stabilize the trade balance at its mean in the benchmark model, the welfare loss is only 0.019 percent. Even with capital controls set to achieve an increase of 60 percent in the trade balance surplus, the welfare loss in terms of constant consumption is only 0.386 percent.

The shocks to productivity or the terms of trade that produce business cycles of the same order of magnitude observed in the Canadian economy are not large and persistent enough for capital controls to produce significant welfare losses. Risk-averse agents seek protection against the risk of domestic business cycles by participating in the world financial market,

Table 3. *The Long-Run Welfare Effects of Capital Controls*

Change in Trade Balance[a]	Percentage Welfare Loss			
	Maximum	Minimum	Ex ante	Ex post
0	35.00	0.006	0.019	0.008
12	7.00	0.006	0.022	0.009
30	2.15	0.009	0.072	0.015
60	3.29	0.016	0.386	0.038

[a] Relative to the mean of the trade balance in the benchmark economy.

but since the risk is not large, having unrestricted access to world markets does not appear to be essential. By investing in moderately risky domestic capital, agents can smooth consumption in approximately the same manner as by trading riskless foreign financial assets. Even if the disturbances are set to produce business cycles of the order of 5 percent standard deviation in GDP, almost twice the actual magnitude, the ex ante welfare loss for a 30 percent trade balance improvement rises from 0.072 percent to only 0.166 percent.

The small welfare costs induced by capital controls are consistent with the findings of Lucas (1987) for the welfare costs of business cycles. Lucas found that when γ is set to 1 or 5 and the variability of consumption is set to 1.3 or 3.9 percent, the largest cost of consumption instability is about 0.38 percent. Moreover, the result is also consistent with the findings of Cole and Obstfeld (1989) and Backus, Kehoe, and Kydland (1990), suggesting that the gains from trade related to consumption smoothing are negligible.

It must be emphasized that the neutrality of capital controls and the negligible dynamic gains from trade encountered in this model *are not* a general result. The model focuses only on the role of international trade as a vehicle to optimally smooth consumption in an economy with one good and identical agents. It does not consider other instances of international economic relations, such as growth-related dynamic gains from trade or the benefits of trade for heterogeneous agents or multisector economies with nontraded goods, in which restricting access to world markets could have very harmful effects. Moreover, the model is set to mimic an economy in which foreign debt may not play as critical a role in consumption smoothing as in heavily indebted countries. Still, the investigation is a useful starting point, because it illustrates that under these particular conditions the welfare costs of capital controls and the dynamic gains from trade are quite modest.

Capital Controls and Taxes on Financial Flows

It has been demonstrated theoretically that the intertemporal implications of capital controls and taxes on capital flows are essentially identical (see Greenwood and Kimbrough (1985) and Adams and Greenwood (1985)). Therefore, a schedule of taxes on foreign interest income can be used as an alternative instrument to achieve the same target for the trade balance and the accumulation of external assets attained with capital controls. When properly set, the tax induces individuals to hold voluntarily the target level of foreign assets, $\hat{A}$. Under this fiscal regime, the optimization problem includes the following resource constraint:

$$C_t = \exp(e_t) K_t^{\alpha} \hat{L}_t^{(1-\alpha)} - \left(\frac{\phi}{2}\right)(K_{t+1} - K_t)^2 - K_{t+1} + K_t(1-\delta) + (1 + r^*(1-\tau_t))A_t - A_{t+1} + T_t, \tag{12}$$

where τ_t is the tax on foreign interest income, and T_t is a lump-sum transfer. The government budget constraint sets $T_t = r^* \tau_t A_t$, but individuals take both taxes and transfers as exogenously given. It is assumed that the proceeds of the tax are rebated as a lump-sum transfer, so that the price and quantity distortions resulting from a tax-induced change in relative prices can be studied without a detailed specification of government behavior.

The procedure used to calculate the tax schedule that induces agents to set $A_{t+1} = \hat{A}$, starting from any triple (K_t, A_t, e_t), is the following. First, the solution to the dynamic programming problem of the economies with capital controls delivers an optimal decision rule for the accumulation of domestic capital, $K_{t+1}(K_t, A_t = \hat{A}, e_t)$, that, combined with the resource constraint (9) and the intertemporal equilibrium condition for consumption, determines the implicit rate of return of a risk-free asset r_t:

$$\frac{U_C^{rs}(t)}{[\exp(-\nu(t)) E\{U_C^{r=\hat{A}}(t+1)\}]} = 1 + r_t, \tag{13}$$

where $U_C^{rs}(t)$ is the lifetime marginal utility of consumption at date t, which includes instantaneous marginal utility as well as the marginal change in the rate of time preference and its effect on the valuation of expected future consumption benefits (that is, the impatience effect).[14] Next, if taxes on foreign interest income are introduced in an economy without controls, individuals allocate consumption intertemporally so as to equate the marginal rate of substitution between C_t and C_{t+1} with its effective intertemporal relative price, $1 + r^*(1 - \tau_t)$. Since (13) is the intertemporal relative price of consumption that must prevail for A_{t+1} to be set voluntarily at $\hat{A}$, it follows that setting τ_t to make $1 + r^*(1 - \tau_t) = 1 + r_t$ produces the same outcome as capital controls. Thus, the tax should be set at $\tau_t = 1 - r_t / r^*$.

[14] Since the standard deviation of the subjective discount factor in the economies with capital controls is less than 0.01 percent, the impatience effect is likely to be negligible.

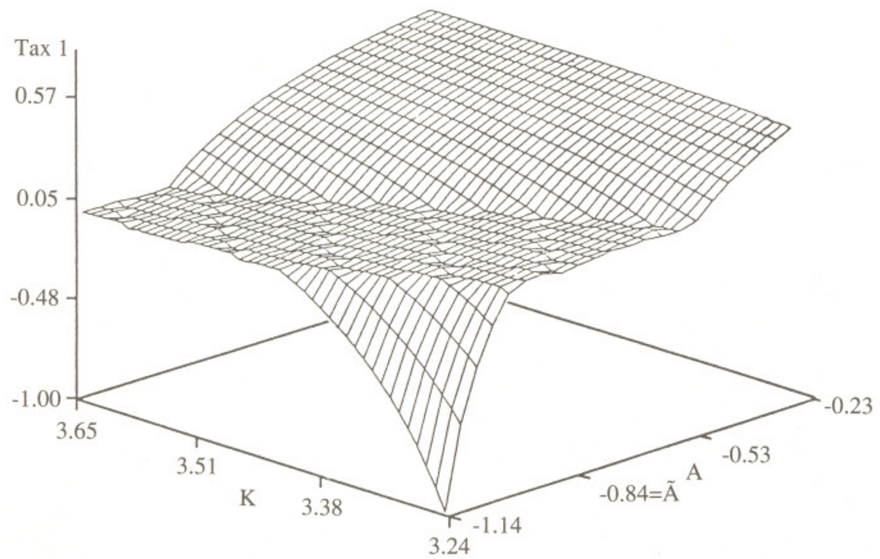
Table 4. *Taxes on Foreign Interest Income: Statistical Moments*

Statistical Moments	Percentage Change in Balance of Trade[a] 0	12	30	60
Mean	−0.0002	0.0054	0.0145	0.0292
Standard deviation	0.1672	0.1681	0.1690	0.1704
First-order autocorrelation	−0.0691	−0.0712	−0.0729	−0.0758
Correlation with GDP	−0.1403	−0.1294	−0.1173	−0.0932

[a] Relative to the mean of the trade balance in the benchmark economy.

Since r_t depends on the initial state (K_t, A_t, e_t), τ_t is a state-contingent random variable—even though individuals take it as exogenously given. Table 4 presents some of the statistical moments that characterize the stochastic process of taxes on foreign interest income for each $\hat{A}$ target. Graphs illustrating the complete tax schedule that induces a 30 percent trade balance improvement under favorable and unfavorable disturbances are produced in Figures 4 and 5. According to Table 4, the average

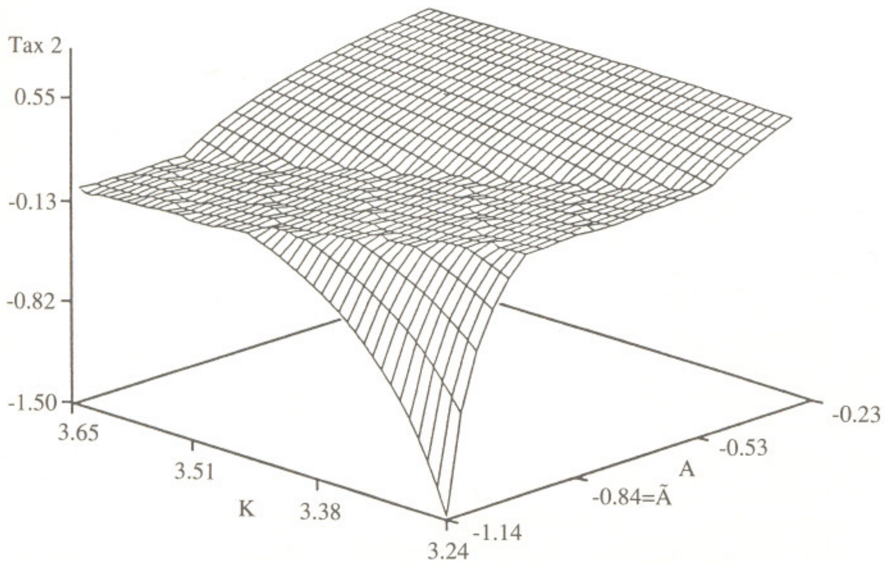
Figure 4. *Tax Rates with Favorable Shock*
(For 30 percent increment in trade surplus)



tax increases slightly as the trade balance target rises. If the goal is simply to stabilize the balance of trade at its mean value in the benchmark economy, the average tax is close to zero. As capital controls are tightened, the mean tax rises to reach about 3 percent in the case of an improvement of 60 percent in the balance of trade. Thus, on average, the taxes required to target the trade balance in the same manner as with capital controls appear to be quite small.

The small average tax rates contrast with some of the high tax rates depicted in Figures 4 and 5. These graphs plot the tax, or subsidy, that needs to be imposed in order to achieve the trade balance target starting from every possible state of nature in the benchmark economy. For example, if the economy starts at $K = 3.65$, $A = -0.23$ and experiences a favorable shock, Figure 4 shows that approximately a 57 percent tax must be imposed. However, this high tax is needed only for one period, because the next date the economy starts at $A = \hat{A} = -1.14$ and never deviates from this coordinate. In the long run, only points where $A = \hat{A}$ have nonzero probability of occurrence, so one-time large taxes or sub-

Figure 5. *Tax Rates with Unfavorable Shock*
(For 30 percent increment in trade surplus)



sidies do not affect the statistical moments reported in Table 4. As the graphs show, the tax schedule is relatively flat and close to zero in the neighborhood of $A = \hat{A}$.

The other moments reported in Table 4 indicate that the limiting distribution of taxes on foreign interest income approximately preserves its variability, comovement, and persistence as the trade balance target increases. The standard deviation increases marginally, although it is somewhat large compared with that of the macro-aggregates listed in Table 2, and the first-order autocorrelation is close to zero and tends to fall slightly. The tax exhibits weakly countercyclical behavior, due to the fact that the trade balance in the benchmark economy is also weakly countercyclical (see Table 1). The negative correlation between τ and GDP increases from -0.14 to -0.09 as the target for the trade surplus rises.

This analysis shows that in the long run capital flows can be easily controlled to target the trade balance by taxing interest on foreign assets instead of imposing capital controls. Although high taxes or subsidies may be needed initially, in the stochastic steady state taxes on foreign interest income are low, almost serially uncorrelated, and weakly countercyclical.

IV. Concluding Remarks

This paper attempts to measure the macroeconomic effects of a policy that uses capital controls as an instrument to target the trade balance in a dynamic stochastic model of a small open economy. Numerical solution methods recently developed in the real business cycle literature are used to quantify the effects of capital controls on economic activity and welfare, and to construct a schedule of taxes on foreign interest income that produces the same outcome as capital controls.

The results show that capital controls have almost no effect on the dynamics of output, consumption, and labor. However, savings, investment, and the capital stock are significantly altered, because once trade in foreign assets is restricted, the capital stock is the only vehicle that can be used to reallocate consumption intertemporally. The analysis also shows that capital controls have minimal welfare effects and that the gains derived from free trade in foreign assets with the aim of smoothing consumption are negligible. These results suggest that, since the kind of productivity or terms of trade disturbances that could explain Canadian business cycles represent a small risk, capital controls do not impair significantly the agent's ability to smooth consumption and, hence, cannot cause large distortions. Similarly, when taxes on foreign interest income are used as substitutes for capital controls to target the trade balance, high taxes are only necessary at an initial stage, and in the long run minimal taxes suffice.

These results are robust to changes in the targets of foreign asset holdings and the surplus in the balance of trade, and are also robust to the magnification of business cycles for up to twice the variability of GDP observed in actual data. However, the inability of this model to produce significant dynamic gains from trade cannot be regarded as a general result because it focuses only on the role of international trade as a consumption-smoothing mechanism. Further research is necessary to incorporate other important functions of world trade, especially to introduce the gains from trade that result in faster growth and the ones exploited by economies with nontraded goods and heterogeneous agents.

APPENDIX

The Numerical Solution Method

The numerical solution method, originally suggested by Bertsekas (1976), takes advantage of the contraction property of value function iteration and uses a discrete grid of points to approximate the state space.

First, two evenly-spaced grids containing the values of domestic capital $\mathbf{K} = \{K_1, \ldots, K_M\}$ and foreign assets $\mathbf{A} = \{A_1, \ldots, A_N\}$ are defined. The state space is given by the set $\mathbf{K} \times \mathbf{A} \times \mathbf{E}$ that contains $2MN$ elements. The next step is to construct an algorithm that performs successive iterations in the functional equation (9). The algorithm iterates starting from the initial guess $V(K_t, A_t, e_t) = 0$, using the set of numbers included in $\mathbf{K} \times \mathbf{A} \times \mathbf{E}$. Since the functional equation typically behaves as a contraction mapping, the iterations converge to a function that solves the equation (that is, the value function). The resulting decision rules are combined with the conditional probabilities π_{sr}, for $s, r = 1, 2$, to define one-step transition probabilities of moving from any triple (K_t, A_t, e_t) to any triple $(K_{t+1}, A_{t+1}, e_{t+1})$. These probabilities are condensed in a matrix P, of dimensions $2MN \times 2MN$, which is used to calculate the limiting probabilities of each triple (K, A, e). The limiting probabilities are calculated by iterating on the sequence $p^1 = p^0 P$, where p^0 is an initial-guess vector of dimensions $1 \times 2MN$. These iterations converge to a fixed point p^*, which is the limiting probability distribution of K, A, and e. This distribution is used to compute population moments of variability, comovement, and persistence of all endogenous variables in the model.

The simulations were carried out in an ETA-10P supercomputer with a Vector-Fortran compiler; $\mathbf{K}$ contained 45 elements and $\mathbf{A}$ contained 22, so that the state space $\mathbf{K} \times \mathbf{A} \times \mathbf{E}$ included 1,980 combinations, and the state transition probability matrix contained $1{,}980^2$ elements.

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