Session 1:
Welfare Analysis

The Economic Consequences of Alternative Exchange Rate and Monetary Policy Regimes in Canada

Tiff Macklem, Patrick Osakwe, Hope Pioro, and Lawrence Schembri

Introduction

For the better part of the last half-century, Canada has been remarkable for its commitment to a flexible exchange rate. In 1950, Canada abandoned the carefully crafted, but fundamentally flawed Bretton Woods "fixed, but adjustable" exchange rate system for a flexible rate. In 1962, Canada rejoined the system, under unusual political circumstances, only to jettison it again for a flexible rate in 1970, for almost the same reasons as in 1950, namely the fear of imported U.S. inflation (see Powell 1999). On the basis of longevity alone, the Canadian flexible exchange rate regime has had a very successful run. Few exchange rate regimes can claim a tenure of almost 50 years.

Recently, several critics have argued that the curtain should come down on Canada's flexible rate regime, primarily because it is seen as a hindrance to further economic integration, chiefly with the United States, and to the transformation of the Canadian economy away from its reliance on commodity-based production and exports.[1] In contrast, supporters point to the impressive performance of the flexible rate during the recent 1997–98

1. Courchene and Harris (1999), Crow (1999), Grubel (1999), Laidler (1999), McCallum (1999), and Murray (1999) are recent contributions to the Canadian debate.

Asian crisis, when it facilitated the necessary real exchange rate adjustment to maintain high rates of employment and output growth.[2]

The purpose of this paper is to investigate the choice between the current exchange rate and monetary regime, a flexible exchange rate with an inflation target, and a permanently fixed rate under a monetary union, by analyzing the economic and welfare implications for Canada, using a well-specified dynamic general-equilibrium (DGE) model. This set of alternatives is motivated by the Canadian debate that has crystallized around the current regime versus a monetary union with a common currency, which would include Canada, the United States, and possibly Mexico and other Latin American countries. A North American monetary union (NAMU) is preferred to a currency board or dollarization, because it is viewed as being more politically palatable to Canadians, and because it would likely produce the largest economic gains in terms of reduced transactions costs.[3]

The Canadian debate is part of a broader worldwide re-examination of exchange rate regimes, prompted by two phenomena: the successful adoption of the formation of the European monetary union by 11 European countries in 1999 and the disruptive currency crises of the 1990s. This re-examination also focuses on a smaller set of alternative exchange rate regimes: a flexible regime versus some form of permanent fixed regime, whether it be a currency board, dollarization, or a common currency.[4]

Although the theoretical literature on optimum currency areas and alternative exchange rate regimes is extensive—with long lists of relevant criteria, advantages, and disadvantages—it provides only limited guidance for making a practical choice between alternative regimes. In particular, the existing research has significant weaknesses: (i) none of the current models adequately captures the crucial trade-off between macroeconomic flexibility and microeconomic efficiency in a rigorous and general-welfare-analytic framework (Krugman 1994); (ii) few of the models are empirical, and of

---

2. Despite a 7.5 per cent fall in the terms of trade from the fourth quarter of 1996 to the last quarter of 1998, GDP in Canada grew by 6.8 per cent over the same period, well over 3 per cent per annum.

3. Panama and Ecuador are dollarized; Argentina and, to a lesser extent, Mexico, are considering it. However, the Argentinian proposal, as outlined by central bank President Pedro Pou (1999), moves in the direction of a monetary union, since it maintains that the U.S. authorities should return the seniorage and act as a lender of last resort.

4. Intermediate managed regimes, in particular, garden-variety fixed exchange rates (de facto adjustable pegs) are no longer seen as viable. The currency crises of the 1990s clearly demonstrated that such regimes are unsustainable, because market participants understand that most countries are unable or unwilling to take the measures necessary to maintain such regimes under intense speculative pressure and, thus, the pressure becomes self-fulfilling. See Obstfeld and Rogoff (1995).

those, most are calibrated to data at the most aggregate level; (iii) existing formal general-equilibrium (GE) models of optimum currency areas are either static or ignore international borrowing and lending driven by intertemporal consumption/savings and investment behaviour; (iv) most models do not allow agents to be heterogeneous in their ability to borrow.[5]

This paper overcomes these weaknesses by modelling the economic and welfare consequences of a flexible exchange rate and common currency using a calibrated stochastic DGE model for Canada with risk-averse and credit-constrained agents. At the model's core is the trade-off between the microeconomic efficiency gains (i.e., the reduction in transactions costs) resulting from a common currency versus the gains in macroeconomic stabilization provided by a flexible rate adjusting to asymmetric exogenous shocks.

A flexible exchange rate generates transactions costs because it, like any other forward-looking asset price, is inherently volatile; in particular, it will respond to the release of new (and therefore unexpected) information and to shifts in the expectations of investors about the future path of the underlying fundamentals.[6] This volatility raises two questions: is it excessive? and, more importantly, does it entail significant real costs? There has been much debate on both of these questions, but with rare consensus. In terms of the first question, models based on macroeconomic fundamentals cannot explain short- to medium-term exchange rate movements, but this may reflect the inadequacy of the models themselves.[7]

On the second question, certain types of transactions costs are well known—foreign exchange hedging and conversion costs, for example. Nonetheless, there is no compelling evidence that these exchange-rate-related transactions costs significantly impede international trade or investment flows. This lack of evidence was consistent with the beliefs of most economists, who felt that it was relatively inexpensive to manage exchange rate volatility. Recent evidence on the unexpectedly large impact of borders and common currencies on trade by two of the participants in this conference, John Helliwell and Andrew Rose, has challenged this long-held

---

5. For example, the Ricci (1997) model is static, and Beine and Docquier (1998) assume that agents do not save. Lafrance and St-Amant (1999) survey the recent literature.
6. Others have argued that exchange rates are not only subject to short-term volatility, but also to longer-term misalignment because of the existence of speculative bubbles and rational-noise traders. While these arguments may be appealing, there is limited empirical evidence to support them. See Murray, van Norden, and Vigfusson (1996).
7. Flood and Rose (1995), for example, find little evidence that exchange rate volatility is related to the volatility of the underlying macroeconomic fundamentals.

belief.[8] There are also other potential real costs associated with exchange rate volatility: segmented capital markets, higher interest rate risk premiums, and efficiency losses due to incomparable prices.

A common currency, however, produces more variable output and employment in the face of external real shocks than does a flexible exchange rate, because nominal wages and, to a lesser extent, prices, are sticky. In contrast, a flexible rate responds when these shocks hit the economy, accelerating the adjustment process. For example, sharp increases in the U.S. demand for Canadian exports during the Korean and Vietnam wars brought about the exchange rate regime changes in 1950 and 1970; in both cases, the flexible rates appreciated as expected, thus moderating Canadian demand and price pressures. In addition, the dramatic commodity price movements in 1972–74 (upwards) and in 1997–98 (downwards) caused the flexible rate to appreciate and depreciate respectively, thereby facilitating macroeconomic adjustment.

In the case of commodity price shocks, the crucial point is that they have asymmetric impact on the Canadian and U.S. economies because of their different industrial structures.[9] In particular, Canada's exports are more heavily based on commodities; they represent approximately 9.5 per cent of GDP and 28 per cent of exports, as opposed to 1.2 per cent of GDP and 10 per cent of exports for the United States.[10] Thus, the flexible bilateral exchange rate helps the Canadian economy adjust to the differential impact of such shocks. This is important because of the lack of labour mobility between the two countries and the absence of supranational fiscal transfers.

To evaluate the relative economic implications of the current flexible regime and inflation (price-level) targeting versus a common currency, we adapt the small open economy DGE model of Macklem (1993b).[11] The primary types of shocks analyzed in the model are terms-of-trade shocks, because of the

8. Côté (1994) provides a survey on the impact of exchange rate volatility on trade. McCallum (1995) and Helliwell (1996) find that the Canada-U.S. border is a significant barrier to trade. Engel and Rogers (1996) discover that it hinders price arbitrage, and Rose (2000) estimates that common currencies have a large and significant impact on trade flows.
9. Dupasquier, Lalonde, and St-Amant (1997) find evidence that the external shocks hitting the two economies are asymmetric.
10. These commodity export data are from the Organisation for Economic Co-operation and Development (OECD) two-digit trade data on primary exports. These data are intended to be comparable across countries. Statistics Canada data, which include commodity-based manufactured products, such as lumber and metals, would increase these ratios for Canada. That is, using these data, commodity-based exports are 11 per cent of GDP and 35 per cent of total exports.
11. Note that in the context of the model, inflation and price-level targeting are the same. In practice, they have different implications for monetary policy.

relative importance of exogenously determined commodity prices to the Canadian economy. The Macklem model is a useful starting point, because it explicitly addresses the structural features of the Canadian economy, which has a well-developed domestic manufacturing sector and an export-oriented resource sector.[12] However, we modify and extend the original Macklem model in several important ways: (i) we simulate the model with stochastic shocks (drawn from normal and extreme-value distributions) rather than deterministic shocks; (ii) the logarithmic utility function used in the Macklem model is generalized to a constant-relative-risk-aversion (CRRA) utility function that allows the degree of risk aversion to be varied; (iii) the model incorporates endogenous transactions costs due to exchange rate variability; (iv) some agents are assumed to be credit-constrained; (v) welfare-based comparisons of the different exchange rate regimes are performed.[13]

The main findings of the paper are that employment, output, and, to a lesser extent, consumption, are much more volatile under a fixed exchange rate when the economy is subject to terms-of-trade shocks. Because agents are risk-averse, this volatility has significant welfare costs. Moreover, transactions costs would have to be relatively high and agents almost risk-neutral for the welfare advantage of a flexible exchange rate to disappear.

Section 1 of this paper presents the benchmark model with nominal-wage rigidity and no trade-related costs. In section 2, we analyze results of the benchmark model, establish the case for a flexible exchange rate regime, and examine the economic consequences of introducing exchange-rate-related transactions costs, credit constraints, and extreme-value shocks, for the choice of exchange rate regimes in the model. Section 3 deals with the welfare effects of alternative regimes. The paper concludes with a summary of the interesting results and suggestions for future research.

1 The Benchmark Model

Consider a continuous-time model of a small open economy with three production sectors: non-tradables (good 0), resources (good 1), and manufactured goods (good 2). We assume that the country is a net exporter

---

12. Unlike the European Economic and Monetary Union (EMU) model of Beine and Docquier (1998), we do not incorporate supranational fiscal transfers or intercountry labour flows, because they are less likely to occur in the NAMU than in the EMU.

13. To perform welfare comparisons under different exchange rate regimes, we simplified the fiscal side of the original Macklem model to preclude tax- or expenditure-based shifts in purchasing power across generations. Thus, for the purpose of analyzing the welfare effect of different exchange rate regimes, we can focus on a single generation because the impact would be symmetric.

of resources, a net importer of manufactured goods, and that it is inhabited by three sets of agents: consumers, firms, and a government. Population is assumed to grow at the exogenous rate, υ, and labour-augmenting technical change occurs at the rate ϕ. The rest of the world is assumed to grow at the same rate as the small country; consequently, the small country remains so in the sense that it takes the world real interest rate and the world prices of tradable goods as given. The prices of non-tradables, p_0, and resources, p_1, as well as the world real interest rate, *r*, are defined in terms of the manufactured good (the numeraire). Since the small country exports resources and imports manufactured goods, p_1 is also the terms of trade.

1.1 Consumption

The economy is inhabited by a growing population of overlapping generations (OLGs) of consumers. The consumer maximizes the expected discounted value of utility over his or her lifetime. Consumer behaviour is modelled following the Blanchard-Weil uncertain-lifetimes approach, in which consumers face a constant probability of death, π, throughout their lives.[14] Relative to the standard infinitely-lived representative-agent model, the impact of introducing uncertain lifetimes is to increase the rate at which the consumer discounts the future above the pure rate of time preference, ρ. Labour is supplied inelastically. In each period, consumers receive an endowment of one unit of time from which they take Λ units in leisure and work the remaining $1 - \Lambda$ units.

Aggregate consumption is obtained by integrating over generations of consumers. To induce stationarity, aggregate variables are deflated by the labour force, which is measured in efficiency units. Assuming a momentary utility function of the CRRA class with risk-aversion parameter, φ, optimal consumption plans give rise to the following equations:[15]

$$c = \frac{1}{\Delta}[a + h], \tag{1}$$

$$\Delta = \int_t^{\infty} \exp - \left[\left(1 - \frac{1}{\varphi}\right)r + \pi + \frac{\rho}{\varphi}\right](s - t)\left[\frac{p_0(s)}{p_0(t)}\right]^{\frac{\theta_0(\varphi - 1)}{\varphi}} ds, \tag{2}$$

14. For a more detailed description of the uncertain-lifetimes model of consumption behaviour, see Blanchard (1985) and Weil (1989).

15. Time subscripts are suppressed except in cases where confusion could result. A complete list of the variable and parameter definitions is provided in Appendix 1.

$$h = \int_t^\infty \{(1-\Lambda)w(s) - \tau(s)\}\exp[-(r+\pi-\phi)(s-t)]ds, \qquad (3)$$

$$a = \sum_{i=0}^{2} (q_{i0}k_{i0} + q_{i2}k_{i2}) + b + f + p_L L, \qquad (4)$$

$$c_0 = \theta_0 c / p_0, \qquad (5)$$

$$c_1 = \theta_1 c / p_1, \qquad (6)$$

$$c_2 = (1 - \theta_0 - \theta_1)c. \qquad (7)$$

In equation (1), total consumption, c, is proportional to total wealth, which is the sum of human wealth, h, and non-human wealth, a. The inverse of the marginal propensity to consume, Δ, is given by equation (2). Human wealth, given in equation (3), is the present value of wage income $(1-\Lambda)w$ net of consumer taxes, τ. In equation (4), non-human wealth is the value of capital in firms (the *qk*'s), plus government debt, b, foreign assets, f, and the value of land, $p_L L$. Land, L, is in fixed total supply and has value, p_L, because land is used in the production of resources. In equations (5) to (7), consumption expenditures on non-tradables, c_0, resources, c_1, and manufactured goods, c_2, are proportional to total consumption expenditures where the θ's are the share weights in the CRRA utility function.

1.2 Production

There are three types of firms: non-tradables producers, resource producers, and manufacturers. Each firm maximizes the value of the firm. This problem is dynamic because capital is costly to adjust. Firms are assumed to discount the future at the world real interest rate, r, plus a premium, ψ.[16] Firms producing non-tradables and manufactured goods are modelled symmetrically, although their behaviour can differ substantially because of different factor intensities. Resource production is modelled slightly differently to capture the importance of natural-resource endowments for the production of resource-based goods.

16. The risk premium is a transactions cost associated with obtaining investment funds.

1.2.1 Non-tradable and manufactured goods

Producers of non-tradables and manufactured goods combine inputs of capital, labour, and resources to produce output, using a constant returns to scale (CRS) Cobb-Douglas technology. There are two types of capital: structures that are formed from the non-tradable good and machinery that is formed from the manufactured good. As in the literature, investment in both types of capital is subject to quadratic installation costs (following the *q* and the cost-of-adjustment approach).

The behaviour of firms producing non-tradables and manufactured goods is described by the following equations. Again, quantity variables that exhibit trend growth are measured per efficiency unit of labour to induce stationarity.

$$y_j = \Phi_j k_j^{\alpha_j} z_j^{\beta_j} n_j^{1-\alpha_j-\beta_j}, \tag{8}$$

$$k_j = k_{j0}^{\sigma_j} k_{j2}^{1-\sigma_j}, \tag{9}$$

$$\dot{k}_{jm} = i_{jm} - (\delta_{jm} + \upsilon + \phi) k_{jm}, \tag{10}$$

$$i_{j0} = \left(\frac{q_{j0} - p_0}{\eta_{j0} p_j} + (\delta_{j0} + \upsilon + \phi) \right) k_{j0}, \tag{11}$$

$$i_{j2} = \left(\frac{q_{j2} - 1}{\eta_{j2} p_j} + (\delta_{j2} + \upsilon + \phi) \right) k_{j2}, \tag{12}$$

$$q_{j0} = \int_t^{\infty} \left(\frac{\sigma_j \alpha_j p_j(s) y_j(s)}{k_{j0}(s)} + \frac{(q_{j0}(s) - p_0(s))^2}{2\eta_{j0} p_j(s)} - p_0(s)(\delta_{j0} + \upsilon + \phi) \right) \exp[-(r + \psi - \upsilon - \phi)(s-t)] ds, \tag{13}$$

$$q_{j2} = \int_t^{\infty} \left(\frac{(1-\sigma_j)\alpha_j p_j(s) y_j(s)}{k_{j2}(s)} + \frac{(q_{j2}(s) - 1)^2}{2\eta_{j2} p_j(s)} - (\delta_{j2} + \upsilon + \phi) \right) \exp[-(r + \psi - \upsilon - \phi)(s-t)] ds, \tag{14}$$

$$\gamma_{jm} = \frac{\eta_{jm}}{2} \left(\frac{i_{jm}}{k_{jm}} - (\delta_{jm} + \upsilon + \phi) \right)^2 k_{jm}, \tag{15}$$

$$z_j = \beta_j p_j y_j / p_1, \tag{16}$$

$$n_j(t) = (1 - \alpha_j - \beta_j) p_j(t) y_j(t) / w_j(t). \tag{17}$$

Output in the non-tradables sector, $j = 0$, and the manufacturing sector, $j = 2$, is produced using inputs of an index of the capital stock, k, resources, z, and labour, n, according to equation (8). The index of capital is a CRS Cobb-Douglas function of capital formed from non-tradables, k_{j0}, and capital formed from manufactured goods, k_{j2}. Capital of both types, $m = 0,2$, depreciates at rate δ_{jm} according to equation (10). From equations (11) and (12), investment in sector j in type m capital i_{jm}, depends on the difference between the market value of type m capital in sector j (q_{jm}) and the spot price of new type m capital. If this difference is positive, investment is above its steady-state level, while if it is negative, investment is below its steady-state level. The value of type m capital in place in sector j is given by the asset-pricing relationships (13) and (14). The value of capital is equal to the present value of the current and future marginal products of capital where this marginal product is the sum of the marginal product of capital in production and the marginal reduction in the cost of installing a given flow of investment. As specified in equation (15), adjustment costs, γ, are assumed to be an increasing function of investment relative to the existing capital stock and are only incurred when investment is above or below its steady state. From equations (16) and (17), resource inputs are used until their marginal product equals their relative price, and labour is hired until its marginal product equals the real wage.

1.2.2 Resource sector

Firms in the resource sector have the same objective as those in the non-tradables and manufacturing sectors. However, as indicated earlier, they differ in one significant respect. In addition to labour and capital, resource production requires the input of a fixed factor called land. This fixed factor is best interpreted broadly to include natural-resource endowments such as forests, minerals, fish, and hydroelectric potential, as well as arable land in the case of agriculture. Land is in fixed total supply, but its productivity is assumed to increase over time as a result of exogenous technical progress associated with improved methods of finding and extracting natural resources. To obtain a balanced growth path in the model, it is further assumed that the productivity of land grows at the rate of labour-augmenting technical progress in production plus the rate of population growth. This assumption is motivated largely by the practical benefits of obtaining a balanced growth path for the solution of the model, but may be justified by the fact that, over the horizon of interest in this paper, the resource sector can be reasonably expected to have the same average growth rate as the other sectors. With the introduction of land in this form, the production function for resources expressed per efficiency units of labour is:

$$y_1 = \Phi_1 k_1^{\alpha_1} L^{\omega} n_1^{1-\alpha_1-\omega}. \qquad (18)$$

The production function is CRS in the three inputs, but in terms of the variable factors—capital and labour—production exhibits decreasing returns to scale. It is worth noting that the presence of a fixed factor in resource production plays an important role in determining the equilibrium structure of this economy. In the absence of a fixed factor in the resource sector, the small economy would specialize in the production of a single tradable good—either resources or manufactured goods (as in Macklem 1993a). The presence of land limits the ability of the resource sector to expand and permits both resource production and manufacturing to coexist in equilibrium for a range of parameter values.

In other respects, resource firms are the same as non-tradables producers and manufacturers. The behaviour of resource firms is therefore also described by equations (9) to (15), with $j = 1$. The labour-demand equation is slightly different, reflecting the presence of land in the production function:

$$n_1(t) = (1-\alpha_1-\omega)p_1(t)y_1(t)/w_1(t). \qquad (19)$$

1.3 Government

The government is assumed to have exogenously fixed total spending requirements, g. Expenditures are allocated to non-tradables, g_0, resources, g_1, and manufactured goods, g_2, according to the decision rules:

$$g_0 = \xi_0 g/p_0, \qquad (20)$$

$$g_1 = \xi_1 g/p_1, \qquad (21)$$

$$g_2 = (1-\xi_0-\xi_1)g, \qquad (22)$$

where the ξs are fixed-share weights. These decision rules are not derived from a theory of government, but they are symmetric with consumer behaviour and the share weights are easily calibrated to the data.

Expenditures are financed by imposing taxes, τ, and issuing government debt, b. The government is assumed to target a fixed level of debt in efficiency units (so the debt-to-GDP ratio remains constant along the steady-state growth path). Taxes are set to cover the net service cost on the outstanding stock of government debt and government spending on goods and services:

$$\tau = (r - \upsilon - \phi)b + g. \tag{23}$$

1.4 Market-clearing conditions

Market clearing requires that demand equals supply in goods, labour, and asset markets:

$$\tilde{y}_0 = c_0 + i_{00} + i_{10} + i_{20} + \gamma_{00} + \gamma_{02} + g_0, \tag{24}$$

$$\tilde{y}_1 = c_1 + z_0 + z_2 + \gamma_{10} + \gamma_{12} + g_1 + x_1, \tag{25}$$

$$\tilde{y}_2 = c_2 + i_{02} + i_{12} + i_{22} + \gamma_{20} + \gamma_{22} + g_2 + x_2, \tag{26}$$

$$1 - \Lambda = n_0 + n_1 + n_2, \tag{27}$$

$$w_0(t) = w_1(t) = w_2(t), \tag{28}$$

$$\dot{p}_L = (r + \psi - \upsilon - \phi)p_L - \omega p_1 y_1 / L, \tag{29}$$

$$ca \equiv \dot{f} = (r - \upsilon - \phi)f + x, \tag{30}$$

$$x = p_1 x_1 + x_2. \tag{31}$$

Equations (24) to (26) set demand equal to supply in the goods markets for non-tradables, resources, and manufactured goods, where $\tilde{y}_j$ is gross output net of the transactions costs associated with financing investment.[17] Since non-tradables are neither imported nor exported, equation (24) is the familiar closed-economy equilibrium condition with the addition of adjustment costs (the γs).[18] Equilibrium in the labour market requires that labour is fully employed and that the real wage is equal in all three sectors. The demand for land equals its fixed supply when the price of land equals the expected present discounted value of the current and future marginal products of land. In the steady state, the relative price of land grows at the rate at which land becomes more productive; p_L in equation (29) is the

17. In terms of the algebra of the model, $\tilde{y}_j = y_j - \psi(q_{j0}k_{j0} + q_{j2}k_{j2}) / p_j$.

18. In the steady state, adjustment costs are zero, hence the goods-market equilibrium condition is consistent with national accounts concepts. In the short run, adjustment costs can be included as part of investment to be consistent with the structure of the national accounts, but since installation costs are generally very small (relative to output), this adjustment has little practical importance.

relative price of land, adjusted for productivity growth. The model is closed by equations (30) and (31), which describe the evolution of foreign assets and define the trade balance, x.

The model cannot be solved analytically, therefore numerical solutions are used. A static or steady-state version of the model is solved as a non-linear system using Newton's algorithm. The saddle-path dynamics resulting from shocks to the model are solved using the stacked Newton algorithm available in TROLL (see Armstrong et al. 1998). The model has eight non-predetermined variables (or jumpers): human wealth, the price of land, and the prices for the two types of capital in each of the three sectors. The standard Blanchard and Kahn (1980) stability and uniqueness conditions are satisfied for a linearized version of the model, but all simulations use the full non-linear model.

Before turning to calibration issues, it is useful to define several macro variables of interest in the context of the model. Since both non-tradables producers and manufacturers use inputs of the resource (intermediate) good in production, output in these sectors as defined above is gross output. The more familiar value-added concept, y_j^{va}, can be constructed by subtracting resource inputs:

$$y_j^{va} = \hat{y}_j - p_1 z_j / p_j . \tag{32}$$

Aggregate income or output at current prices, y^{va}, is determined by summing the value added of each sector, measured in terms of the manufactured good, the numeraire. This yields:

$$y^{va} = p_0 y_0^{va} + p_1 y_1^{va} + y_2^{va} . \tag{33}$$

In similar fashion, other macro aggregates, such as total investment or investment in structures, can be obtained by pricing them in terms of manufactured goods and summing across sectors.

Note that the choice of manufactured goods as the numeraire is arbitrary. An alternative approach is to measure macro aggregates in terms of the consumption basket. In the economy described above, there is a natural real consumer price index, *rcpi*, which is embodied in the expenditure function associated with the solution to the consumer's problem:

$$rcpi = \left(\frac{p_0}{\theta_0}\right)^{\theta_0}\left(\frac{p_1}{\theta_1}\right)^{\theta_1}\left(\frac{1}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1} . \tag{34}$$

The *rcpi* is the relative price of the consumption basket in units of the manufactured good. Relative prices and aggregate quantities measured in terms of the manufactured good can therefore be converted into units of the consumption basket by dividing by *rcpi*.

The *rcpi* also provides a convenient means of defining the real exchange rate. In empirical work, the real exchange rate is typically measured as the ratio of a foreign aggregate price index to the corresponding domestic aggregate price index, all measured in a common currency. If we use consumption-based price indexes, the corresponding definition of the real exchange rate in the model is:

$$er \equiv \frac{rcpi^*}{rcpi}, \qquad (35)$$

where *rcpi** is the real consumer price index in the rest of the world. If we assumed that *rcpi** has the same form as *rcpi* and the share weights in utility (the θs) are the same at home and abroad, the real exchange rate simplifies to:

$$er = \left(\frac{p_0^*}{p_0}\right)^{\theta_0}, \qquad (36)$$

where p_0^* is the (exogenously determined) relative price of non-tradables in the rest of the world. For a given p_0^*, movements in the real exchange rate will therefore reflect supply-and-demand conditions for non-tradables in the domestic economy.

1.5 Model parameterization: Summary

For the purpose of simulation, the model is calibrated to capture the salient features of the Canadian economy based on three types of evidence: the input-output and final demand structure of the Canadian economy, average shares or ratios from aggregate time-series data, and econometric evidence from micro and macro studies. The details of the parameterization can be found in Appendix 2, and a complete list of the chosen parameter values is provided in Table 1.

The Canadian final-demand tables are used to compute the expenditure shares for both consumption and government purchases, and the input-output tables form the basis of the share parameters in production. Shares

Table 1
Simulation parameters

$\alpha_0 = 0.284$	$L = 1.000$	
$\alpha_1 = 0.416$	$\chi_1 = 0.040$	
$\alpha_2 = 0.256$	$\rho = 0.009$	
$\beta_0 = 0.057$	$\pi = 0.035$	
$\beta_2 = 0.109$	$\phi = 0.010$	
$\omega = 0.200$	$\Phi_0 = 0.895$	
$\theta_0 = 0.583$	$\Phi_1 = 1.331$	$\varphi = 2.000$
$\theta_1 = 0.060$	$\psi = 0.145$	$r = 0.040$
$\theta_2 = 0.357$	$\delta_{i0} = 0.030$	for $i = 0,1,2$
$\xi_0 = 0.880$	$\delta_{i2} = 0.120$	for $i = 0,1,2$
$\xi_1 = 0.040$	$\eta_{i0} = 2.500$	for $i = 0,1,2$
$\xi_2 = 0.080$	$\eta_{i2} = 1.500$	for $i = 0,1,2$
$\upsilon = 0.010$	$\sigma_{ij} = 0.648$	for $i = 0,1,2; j = 0,2$

are obtained from 1996 current-dollar figures at the *M*-level of aggregation.[19]

1.6 Nominal-wage rigidity

A well-known result in the economics literature is that nominal price or wage rigidity is necessary for the choice of an exchange rate regime to matter in the short run. However, the market-clearing model described above assumes that prices and wages are perfectly flexible. In this section, we overcome this limitation by assuming that consumer-workers and firms enter into nominal-wage contracts.[20] The optimization problems facing firms and consumers are not solved subject to the nominal contracts. Instead, the nominal contracts are simply overlaid on the market-clearing model. The basic form of the contract is that workers and firms set nominal wages to clear the labour market ex ante and, in return for a fixed nominal wage for the duration of the contract, workers agree to supply as much labour as the firm demands ex post. Let $W_{j,\,t-s}(t)$ be the nominal wage for transactions at time t set at time $t-s$ in sector j. At time t, non-tradables producers and manufacturers demand labour inputs:[21]

19. The *M*-level of aggregation is the “medium” level in the input-output and final-demand tables, and disaggregates into 50 industries and 50 goods.
20. The form and implementation of the contracts considered in the model draw on work by King (1990), Cho and Cooley (1995), and Rankin (1998), and are closely related to the earlier work of Gray (1976) and Fischer (1977). For a review of the literature on nominal-price and wage setting, see Taylor (1998).
21. With nominal-wage contracts, equation (17) changes to equation (37).

$$n_j(t) = \frac{P_2(t)p_j(t)[1-\alpha_j-\beta_j]y_j(t)}{W_{j,\,t-s}(t)}, \tag{37}$$

where P_2 is the nominal price of manufactured goods. Recall that manufactured goods are the numeraire in the model, so $P_2 p_j$ is the nominal price of good j and $W_{j,\,t-s}/P_2 p_j$ is the producer real wage. Resource firms demand labour inputs:

$$n_1(t) = \frac{P_2(t)p_1(t)[1-\alpha_1-\omega]y_1(t)}{W_{j,\,t-s}(t)}. \tag{38}$$

The nominal wage for transactions at time *t* is set as the expectation at time $t - s$ of the nominal wage that would prevail in the market-clearing model at time *t*. For the non-tradables and manufacturing sectors, this gives:

$$W_{j,\,t-s}(t) = E_{t-s}\hat{P}_2(t)\hat{p}_j(t)[1-\alpha_j-\beta_j]\hat{y}_j(t)/\hat{n}_j(t), \tag{39}$$

where the hats over the right-hand-side variables denote market-clearing quantities and prices. A similar wage-setting equation is required for the resource sector. In equilibrium, nominal wages must be equal across sectors because labour is assumed to be perfectly mobile.

To make the nominal-wage contracts more realistic, the basic contract is embedded into a system of overlapping contracts. In each period, half of the contracts are set and are assumed to last two years. At any time *t*, half of the workers will therefore have one year left in their contract, and the other half will have two years. Nominal wages are set as in equation (40) to clear the labour market in an expected sense. Labour demand in each sector is then determined by the average wage:

$$W(t) = [W_{t-1}(t) + W_{t-2}(t)]/2, \tag{40}$$

and $W(t)$ replaces $W_{j,\,t-s}(t)$ in equations (38) and (39).

Finally, the model is closed by an exogenous monetary authority that controls the value of the nominal anchor. Several choices for the nominal anchor are possible. The monetary authority can fix the nominal exchange rate, thereby setting domestic inflation equal to foreign inflation in the long run. Alternatively, the monetary authority can allow the nominal exchange rate to float and achieve other goals, such as a constant nominal-price level or a given path for inflation. The analysis does not include important issues associated with the credibility and implementation of monetary policy; the monetary authority is assumed to be capable of achieving its target, providing that it targets a nominal variable.

1.7 Stochastic simulation procedure

To simulate the model, we choose a time horizon of 145 years for the economy and introduce random terms-of-trade shocks into the model in each period. We drop the first 10 years, so that the starting point does not affect the results, and then compute the means and standard deviations of aggregate employment, real income, consumption, and net foreign assets. Finally, we perform 100 replications of history and compute the average of the relevant moments across replications. Thus, the total number of simulations is 13,500. The shocks used in the experiments are the same across exchange rate regimes. Therefore, the results are comparable across exchange rate regimes. Although the shocks are unanticipated, it is assumed that agents know the path of each shock after it has occurred.

The terms of trade, p_1, is assumed to follow an AR(2) process. The distribution of the shock is based on the properties of the residuals from a regression of the terms of trade, proxied in the data by the relative price of non-energy commodities to manufacturing import prices, on a constant and two lags of the terms of trade, using annual Canadian data for the period 1975 to 1998. Since the residual from the estimated AR(2) model is i.i.d. with a standard error of 0.05, the shocks used in the model were constructed to capture this feature. The coefficients for the first and second period lags of the terms-of-trade variable in the estimated equation are 0.93 and –0.56, respectively.[22]

2 Analysis of Results

To isolate the economic consequences of introducing transactions costs in the economy under different exchange rate regimes, we begin with a stochastic version of the model with no transactions costs. Then we introduce endogenously determined transactions costs and compare the results. In each case, we focus on the volatilities of aggregate employment, real output, consumption, and net foreign assets under a fixed exchange rate and a flexible exchange rate regime with a consumer price index (CPI) inflation target. Finally, we examine the welfare costs of the introduction of a common currency in Canada.

2.1 Benchmark model

Simulation results for the stochastic version of the model with no transactions costs are presented in Table 3. They show that there is a trade-off

22. Table 2 reports selected ratios describing the initial steady state of the model.

Table 2
Steady-state ratios

	Aggregate	Non-tradables	Resources	Manufacturing
Share of output	1.00	0.59	0.23	0.18
Share of employment	1.00	0.64	0.15	0.21

Ratios of GDP			
Consumption	0.65	Government debt	0.78
Investment	0.12	Foreign assets	–0.39
Government	0.22	Capital	1.72
Exports	0.11	Imports	0.10

Table 3
Benchmark model

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.24	2.20
Employment	1.63	0.54
Consumption	1.15	0.79
Net foreign assets	24.89	14.30

between the variance of the nominal exchange rate and that of key macroeconomic variables. In particular, aggregate income, employment, consumption, and net foreign assets are more volatile under a fixed exchange rate regime. The intuition for this result is as follows. Suppose that there is a temporary terms-of-trade deterioration. Under both regimes, the value of land and wealth fall as a result of the fall in the price of resources. This results in a decrease in the consumption of the non-tradable good, a fall in its price and, from equation (36), a real exchange rate depreciation.

In the flexible exchange rate regime with a CPI inflation target, the domestic price level (in terms of the manufactured good) rises; therefore, the real depreciation is achieved through a nominal exchange rate depreciation that is larger than the increase in the domestic price level.[23] Because wages are sticky, the increase in the domestic price level results in a decrease in real wages, thereby creating an incentive for firms in the non-tradable and

23. To understand why the domestic price level in terms of the manufactured good must rise when the monetary authority targets the inflation rate measured in terms of the CPI, note that the nominal CPI is the product of the real CPI and the domestic price level in terms of the manufactured good. The real CPI is increasing in the prices of resources and non-tradables. Therefore, when the prices of resources and non-tradables fall, the real CPI falls, implying that the domestic price level in terms of the manufactured good must rise to maintain the CPI inflation target.

manufactured goods sectors to absorb labour displaced from the resource sector. There is an increase in aggregate investment because of the decrease in the price of the non-tradable investment good and because the use of more inputs in the manufactured and non-tradable goods sectors increases the marginal product of capital. Aggregate income and consumption will also decline.

In the fixed exchange rate regime, however, the real depreciation of the exchange rate required to clear the non-tradable goods market can be realized only through a decrease in the domestic price level. Because nominal wages are sticky, the decrease in the domestic price level results in an increase in the real wage and a decrease in aggregate employment, consumption, and investment. Although aggregate employment and consumption decline, as in the case of a flexible exchange rate with a CPI inflation target, the decrease in the two variables is larger under a fixed exchange rate regime.

The result that a fixed regime has a higher variance of employment has been emphasized in the literature. More interesting are the quantitative differences between the fixed and flexible regimes. In particular, employment is three times more variable under a fixed regime. This suggests that there are high costs to fixing the exchange rate in a small open economy. Unlike employment, the volatility of consumption in a fixed exchange rate regime is one and a half times that of a flexible exchange rate regime. The smaller difference in the volatility of consumption across regimes can be explained by the fact that agents are smoothing consumption in response to the shocks; they have perfect access to global capital markets at a fixed rate of interest. Because consumption is more volatile under the fixed exchange rate regime, consumers need to adjust their foreign asset positions more to smooth consumption. This explains the result that the volatility of net foreign assets is higher under a fixed exchange rate regime.

2.2 Adding transactions costs

To incorporate the microeconomic benefits of a permanently fixed exchange rate regime under a common currency, we assume that there are transactions costs associated with trade under flexible regimes. In particular, we assume that for every unit of a good imported or exported (under a flexible exchange rate regime), a certain percentage is lost by the economy (as in the familiar iceberg model) as a result of currency-conversion costs or costs associated with exchange rate uncertainty.[24] Ideally, the percentage of transactions

24. Because the home country is a price taker in world markets, it is assumed to absorb transactions costs on both imports and exports.

costs paid by any agent would depend on the proportion of the traded goods used or exported by the agent. However, since there is no way of pinning down the proportion of the traded goods used or exported by any agent, we introduce the transactions costs as a loss to the economy as a whole. This implies that all agents in the economy share the costs equally.

Suppose x_1 and x_2 are net exports of goods 1 and 2, respectively, where x_2 is negative because the small country is assumed to import good 2 (manufactured goods). To sell x_1 units of good 1 on the world market, the resource sector would have to ship $\hat{x}_1 = (1+\chi)x_1$ units of good 1, since χx_1 represents transactions costs. Similarly, if the economy imports x_2 units of good 2, it pays χx_2 in transactions costs so that the amount available to agents for consumption or investment is actually $\hat{x}_2 = (1-\chi)x_2$. Because these costs are incurred only in flexible regimes, χ is a function of the exchange rate regime. To make this dependence explicit, we assume that $\chi = \chi_1 \sigma_{EN}$, where σ_{EN} is the standard deviation of the nominal exchange rate.

The inclusion of transactions costs alters the market-clearing conditions for goods 1 and 2 (tradables). The modified equations are:

$$\tilde{y}_1 = c_1 + z_0 + z_2 + \gamma_{10} + \gamma_{12} + g_1 + (1+\chi)x_1, \tag{41}$$

$$\tilde{y}_2 = c_2 + i_{02} + i_{12} + i_{22} + \gamma_{20} + \gamma_{22} + g_2 + (1-\chi)x_2. \tag{42}$$

In the calibration experiments, the transactions costs parameter, χ_1, was determined as follows. Laidler and Robson (1991) suggest that the transactions costs associated with a flexible exchange rate are about 0.2 per cent of GDP in Canada.[25] In addition, net exports of resources and net imports of manufactured goods represent about 21 per cent of GDP in the model. In the model, there is no intra-industry trade: resources are not imported and manufactured goods are not exported. In practice, however, this is not the case. Therefore, the trade-GDP ratio of 21 per cent obtained in the model (11 per cent resource exports and 10 per cent manufactured imports) has to be grossed upwards to 41 per cent to reflect the volume of intra-industry trade. Transactions costs of about 0.2 per cent of GDP and an adjusted trade-GDP ratio of 41 per cent imply that transactions costs represent roughly 0.5 per cent of trade in Canada. Setting the ratio of transactions costs to trade, χ, at 0.005, we can compute χ_1 given the

25. Although transactions costs are difficult to quantify, Grubel (1999) suggests that for Canada, the United States, and Mexico, they are 0.1 per cent of national income. Therefore, the 0.2 per cent figure used in this paper is probably an overestimate and may bias the results against flexible exchange rate regimes.

observed standard deviation of the nominal exchange rate, σ_{EN}. Between 1990 and 1999, the standard deviation of the nominal exchange rate in Canada was 0.12. Therefore, the transactions costs parameter, χ_1, is 0.04.[26]

For most variables of interest, the simulation results for the model with endogenous transactions costs are similar to those of the model without transactions costs. For example, aggregate income, employment, and consumption are still more variable under the fixed exchange rate, compared with the flexible exchange rate regime (see Table 4). The similarity between the volatilities of key macroeconomic variables in the model with and without transactions costs is not surprising. Transactions costs are essentially a tax on trade that affects the mean level of consumption and not the volatilities of macroeconomic variables.

2.3 Adding credit constraints

Thus far, we have assumed that consumers have access to an international capital market and can borrow to smooth consumption. In practice, however, many consumers cannot borrow and lend to insulate themselves from terms-of-trade shocks at a fixed rate of interest. In this section, we introduce more realism into the model by imposing restrictions on borrowing. We assume that younger agents are initially denied access to credit markets, because agents are born without wealth and, hence, can consume only from current disposable income. If we assume that a generation "graduates" out of this pool just as another is born into it, then in each period, a proportion, Ω, of credit-constrained agents exists in the economy. Relative to the benchmark model, the introduction of credit constraints changes the structure of the aggregate consumption function in equation (1). Specifically, if c^{cc} and c^{ncc} represent aggregate consumption for credit-constrained and non-credit-constrained agents, respectively, the aggregate consumption equation in the economy takes the form:

$$
\begin{aligned}
c &= c^{cc} + c^{ncc}, \\
c^{cc} &= \Omega[(1-\Lambda)w - \tau], \\
c^{ncc} &= \frac{1}{\Delta}[a + (1-\Omega)h]. \qquad (43)
\end{aligned}
$$

In equation (43), aggregate consumption is the sum of consumption by credit-constrained and non-credit-constrained agents. Agents with the

26. The standard deviation of the nominal exchange rate in the model is obtained using an iterative procedure that takes the observed value in the data as its starting value.

Table 4
Transactions costs

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.24	2.20
Employment	1.63	0.54
Consumption	1.15	0.79
Net foreign assets	24.89	14.11

ability to borrow consume based on permanent income, while credit-constrained agents consume their current disposable income.

In the simulations, the credit-constraint parameter, Ω, was set equal to 0.5, based on the work of Wirjanto (1995). Simulation results for the model with credit-constrained consumers are presented in Table 5. There are two important points to note here. First, relative to the benchmark model, the introduction of capital-market imperfection increases the magnitude of the difference in the volatilities of employment, output, and consumption between the two exchange rate regimes. In particular, employment is 3.5 times more volatile in a fixed exchange regime as compared with 3 in the benchmark model, and consumption is 2 times more volatile compared with 1.5 in the benchmark model. Also, income is 1.6 times more volatile, rather than 1.5, as in the benchmark model. Second, the volatility of consumption in a fixed exchange rate regime is now closer to that of employment, because some agents in the model can no longer smooth consumption by borrowing.

2.4 Extreme-value shocks

Recent experience with the collapse of fixed exchange rate regimes has shown that the stabilization benefits of flexible exchange rate regimes are more noticeable in economies subject to extremely large shocks, as observed during the 1997–98 Asian currency crises. However, the stochastic-simulation experiments performed with the benchmark model assumed that shocks were drawn from a normal distribution. To capture the impact of the type of shock that hit the Canadian economy during the Asian crisis, this section examines the economic consequences of the introduction of extreme-value (or fat-tailed) shocks, with low probabilities of occurrence, for the choice of exchange rate regimes in the model. The fat-tailed shocks we consider are drawn from a *t*-distribution with three degrees of freedom.[27]

27. The *t*-distribution was chosen because it has been widely used in the economics and finance literature to capture fat-tailed shocks. Andrews (1993) and Nankervis and Savin (1996) have used this distribution.

Table 5
Credit constraints

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	3.57	2.20
Employment	2.01	0.57
Consumption	1.94	0.98
Net foreign assets	8.87	5.61

The degree of freedom was chosen to generate shocks of approximately the same order of magnitude as observed during the Asian currency crisis.

Table 6 presents results for the model with extreme-value shocks. As expected, the introduction of extreme states increases the volatilities of aggregate income, employment, and consumption relative to versions of the model with normally distributed shocks.

3 Welfare Analysis

We have argued that transactions costs are lower under a fixed exchange rate regime, but that a fixed rate regime generates volatility of real macroeconomic variables that are higher than what would be observed under a flexible regime. The next question, therefore, is how to map these differences in the behaviour of macroeconomic variables between the two regimes into a welfare measure. The OLG structure of our model implies that different generations of consumers exist in the economy in each period. This makes welfare analysis difficult, because it is not clear what the most appropriate method of aggregating welfare across generations is in this context.[28]

We deal with this problem by focusing on the welfare of an average consumer. The welfare concept adopted is that of equivalent variation, i.e., the percentage of consumption an average consumer would have to receive in the fixed exchange rate regime to be as well off as in a flexible regime. Specifically, to compute the welfare cost of a common currency, we find the value of λ satisfying equation (44) and then average across 100 replications.

$$\sum_{j=1}^{T}\left(\frac{1}{1+\rho}\right)^{j}\frac{[u_j(c_{fix}(1+\lambda))]^{1-\varphi}}{1-\varphi} = \sum_{j=1}^{T}\left(\frac{1}{1+\rho}\right)^{j}\frac{[u_j(c_{flex})]^{1-\varphi}}{1-\varphi}, \quad (44)$$

28. For further details, see Calvo and Obstfeld (1988).

Table 6
Fat-tailed distribution

Standard deviation (x 100)	Fixed	Flexible
Aggregate income	5.67	3.59
Employment	3.21	1.33
Consumption	3.11	1.71
Net foreign assets	14.12	9.21

where $u_j(c_{fix})$ and $u_j(c_{flex})$ represent utility of an average consumer at time j in a fixed exchange rate and in a flexible exchange rate regime, respectively. In the simulations, we set T equal to 100.

The welfare costs of a common currency for different versions of the model are presented in Table 7. The first row shows that the welfare cost of a common currency in the benchmark model is about 0.12 per cent of consumption. Introducing transactions costs into the model results in a decrease in the welfare cost of a common currency from 0.12 to 0.11 per cent of consumption. This makes sense, because transactions costs are essentially a tax on trade and hence reduce the level of consumption under a flexible regime. For the model with credit constraints and transactions costs, the welfare cost of a common currency is about 0.12 per cent. Comparing this result with the model with transactions costs but no credit constraints, we see that the welfare cost of a common currency is higher in an economy with credit constraints. This can be attributed to the fact that credit constraints limit the ability of consumers to smooth consumption. Turning to the model with an extreme-value distribution, we see that the welfare cost of a common currency is now 0.15 per cent. This supports our initial contention that the benefit of a flexible exchange rate regime is more noticeable in economies that are subject to large shocks.

An experiment was performed to determine the sensitivity of our results to the risk-aversion parameter. In this case, we increased the parameter from 2 (the benchmark value) to 5. This resulted in an increase in the welfare cost of a common currency to 0.17 per cent of consumption, which suggests that the cost of losing the nominal exchange rate as an instrument of adjustment is likely to be higher in economies with highly risk-averse agents and capital-market imperfections.

Since our welfare results may depend on the value of the transactions costs parameter—and there is no consensus on the true value of this parameter—we decided to approach the welfare issue from another perspective. Specifically, we asked the following question: what would the transactions costs parameter have to be for consumers to be indifferent between a common currency and a flexible exchange rate regime? It turns out that in

Table 7
Welfare costs of a common currency

Model	Welfare cost (% of consumption)
Benchmark	0.12
Transactions costs	0.11
Credit constraints	0.12
Fat-tailed distribution	0.15
Higher risk aversion ($\varphi = 5$)	0.17

the model with credit constraints (row 1 of Table 8), transactions costs would have to be at least 1.9 per cent of total trade, equivalent to about 0.8 per cent of GDP, given a trade-to-GDP ratio of 41 per cent.

For the model with credit constraints and high risk aversion (row 2 of Table 8), our simulation results suggest that transactions costs would have to be about 2.4 per cent of total trade (about 1 per cent of GDP) for consumers to be indifferent between a common currency and a flexible exchange rate regime. Given that the estimated savings in transactions costs for the 11 countries in the European monetary union is about 0.5 per cent of GDP, it is unlikely that the ratio of transactions costs to GDP in Canada would be more than 0.5 per cent. Since the ratio of transactions costs to GDP required for an average consumer to be indifferent between the two exchange rate regimes is more than 0.5 per cent of GDP, we are left with the conclusion that welfare is higher under a flexible exchange rate regime.

Concluding Remarks

This paper analyzes the economic and welfare consequences for Canada of two alternative exchange rate and monetary policy rules—a flexible exchange rate regime with a price-level target, which is similar to the existing regime, and a permanent fixed exchange rate, which might occur with the formation of a North American monetary union—using a stochastic DGE model of a small open economy with three sectors—resources, non-traded goods, and manufactures. The model is calibrated to recent Canadian data and then simulated to determine the impact of stochastic terms-of-trade shocks on key macroeconomic variables, including output, employment, consumption, and welfare under the two regimes. To examine the robustness of the results, a wide range of scenarios are considered: different assumptions are made concerning nominal-wage rigidities, transactions costs in international trade, credit constraints, the magnitude of the shocks, and risk aversion. At the heart of this comparison is the critical trade-off between the macro-stability benefits provided by a flexible rate and the

Table 8
Transactions costs required for consumer indifference

	Transactions costs (% of trade)	Transactions costs (% of GDP)
Credit constraints model	1.9	0.8
Higher risk-aversion model $(\varphi = 5)$	2.4	1.0

micro-efficiency gains resulting from the elimination of exchange rate uncertainty under a fixed rate. The basic result is that the flexible regime dominates under most assumptions: macroeconomic aggregates are less volatile and welfare is marginally higher.

In the benchmark model, two-period nominal-wage contracts are overlaid on the market-clearing version of the model. The simulation of a series of stochastic terms-of-trade shocks produces the standard result that a permanently fixed exchange rate produces more variable employment, output, and consumption, as well as lower welfare (0.12 per cent of consumption measured by the equivalent variation) as compared with the flexible rate. Under the nominal-wage rigidity, the flexible exchange rate generates a more flexible real exchange rate and real wage rate that facilitate adjustment to the shocks.

Small transactions costs in international trade are then added to the model: these costs are assumed to be positively related to exchange rate volatility. Approximately 0.5 per cent of imports and exports are consumed by such costs, and they lower the mean levels of consumption under the flexible rate. The welfare differential, however, is reduced only slightly to 0.11 per cent of consumption. Indeed, transactions costs would have to be relatively high—almost 1.9 per cent of trade for the welfare differential to be eliminated.

Next, we assume that 50 per cent of agents are credit-constrained. This premise makes the model more realistic, because it departs from the initial assumption that agents have unfettered access to the international capital market—which allows them to borrow and lend at a fixed world interest rate to smooth consumption—and from the assumption that agents are identical—which implies that there is no idiosyncratic terms-of-trade risk, only aggregate risk. Hence, when employment falls, for example, no one agent or group of agents lose their job, since the employment loss is shared equally. The effect of imposing the credit constraint is to increase the welfare differential in favour of the flexible rate to approximately 0.12 per cent of consumption.

Finally, extreme values of the terms-of-trade shocks are used in an effort to mimic the impact of a commodity price shock like the one that occurred during the East Asian financial crisis of 1997–98. This again has the effect of widening the welfare differential in favour of the flexible exchange rate to 0.15 per cent of consumption.

In the next version of the paper, we want to examine the impact a reduction in reliance on commodity exports would have on the choice of exchange rate regimes in Canada. Our results thus far imply that the transactions costs associated with a flexible rate do not exceed the losses resulting from volatility of output and employment under a fixed exchange rate. However, it is possible to envision ongoing processes that could reverse this inequality sometime in the future. In particular, exchange-rate-related transactions costs could increase over time as trade flows between Canada and the United States increased.[29] Furthermore, it is likely that Canada's endowment of productive factors, and therefore its industrial base, will come to more closely resemble that of the United States, as human and physical capital accumulate and technology is transferred. Consequently, Canada's relative reliance on natural resources would diminish, and the external shocks affecting the two economies would become less asymmetric. Hence, the benefit of having a flexible exchange rate serve as a macroeconomic buffer would be reduced. To capture this process, we will extend the model by incorporating a third manufacturing sector that could export. With this modification, terms-of-trade shocks would generate less macroeconomic instability, and the macroeconomic adjustment benefits of a flexible exchange rate would be reduced.

This paper makes an important contribution, because it represents one of the first attempts to quantify the macroeconomic costs and benefits of alternative exchange rate regimes in Canada, using a calibrated stochastic DGE model. It also provides important insights into the impact of different market rigidities. Indeed, it provides a useful framework for other small open economies considering entry into a monetary union.

29. We are assuming here that as the volume of trade increases (i.e., the country becomes more open), the asymmetric nature of the shocks remains unchanged. Krugman (1993) and others have argued that as openness increases, the asymmetry of the shocks may rise as countries become more specialized in production.

Appendix 1
Variable and Parameter Mnemonics

Conventions

good 0	non-tradables
good 1	resources
good 2	manufactured goods

All relative prices are measured in units of manufactured goods.

All quantity variables are measured per productivity adjusted worker.

Variables

a	non-human wealth
b	government debt
c	total consumption
c_j	consumption of good j
ca	current account
en	nominal exchange rate
er	real exchange rate
f	foreign assets
g	total government expenditure
g_j	government purchases of good j
h	human wealth
i	total investment
k_j	index of capital in sector j
k_{ij}	type i capital used in sector j
L	fixed stock of land
n_j	labour employed in sector j
p_0	relative price of non-tradables
p_1	relative price of resources = the terms of trade
P_j	nominal price of good j
p_L	price of land (detrended)
q_{ij}	the value of type j capital in sector i
r	world real interest rate
$rcpi$	real consumer price index
w	real wage

W	nominal wage
$W_{t-s}(t)$	nominal wage at time t set at time $t-s$
x_j	exports of good j
y_j	gross output of sector j
$\tilde{y}_j$	gross output of sector j net of transactions-cost cum risk premium
y_j^{va}	value added of sector j
y^{va}	aggregate income
z_j	resource inputs in sector j
γ_{ij}	adjustment costs in the installation of type j capital in sector i
τ	taxes
E_{t-s}	expectation conditional on time $t-s$ information

Parameters

α_j	capital's share in sector j
β_j	resource input's share in sector j
δ_{ij}	depreciation rate of type j capital in sector i
η_{ij}	adjustment costs parameter for type j capital in sector i
θ_j	expenditure share weight for consumption of good j
Λ	amount of time consumers take in leisure
μ	parameter in government's consumer tax rule
υ	rate of population growth
ξ_j	expenditure share weight for government consumption of good j
π	probability of death
ρ	pure rate of time preference
σ_0	share of structures in total capital
ϕ	rate of labour-augmenting technical progress
Φ_j	level of productivity in sector j
ψ	premium in the firm's discount rate
ω	share of land in resource production
χ_1	transactions costs parameter
Ω	liquidity-constraint parameter

Appendix 2
Parameterization of the Model

The expenditure and input shares used in the calibration are based on the following classification of non-tradables, resources, and manufactured goods. The non-tradables sector includes construction; transportation and storage; communications; insurance, finance, and real estate;[1] community and personal services; and the unallocated portion of final demand (almost all of which is government services). This definition of non-tradables is consistent with the international classification adopted by Summers, Kravis, and Heston (1980), except that they do not include government services, but do include utilities (electricity, gas, and water). In the context of the Canadian economy, utilities would seem to fit more naturally in the resource sector, since Canada exports electricity.[2]

The resource sector is defined to include primary industries, resource processing, and utilities. The primary industries are agriculture, fishing, forestry, and mining; and resource processing includes pulp and paper, wood products, primary metals, chemicals, and petroleum and coal refining. The decision to include processing in the resource sector reflects the integrated nature of many resource industries and the view that including processing in manufacturing (as in the national accounts) understates the importance of the resource sector. The manufacturing sector is defined residually as anything that is neither non-tradables nor resources.

As shown in Table 1, the share of non-tradables in consumption is 58.3 per cent, followed by manufacturing goods at 35.7 per cent, while the government spends 88 per cent of its budget on non-tradables. The input-output tables do not explicitly account for inputs of land. Following Stuber (1988), the share of land in the production of resources is set at 20 per cent, implying returns to scale in this sector of 80 per cent. The stock of land is normalized to unity.

The parameters governing the evolution of capital and labour are based on average ratios in the data, or they draw on other studies. Capital is assumed to depreciate at the same rate in all three sectors and, following Macklem (1993b), the depreciation rates for structures and machinery are set at 3 per cent and 12 per cent, respectively. Capital of both types is defined to include private sector and government capital, and structures is defined to include housing as well as non-residential construction. Although the sectors differ

---

1. Real estate includes the imputed return to owner-occupied dwellings.
2. Unallocated demand is included in non-tradables so that the production of all three sectors sums to GDP.

in their capital intensities, all three sectors are also assumed to combine structures and machinery in the same proportion to form the composite capital good that enters the production function. From 1986 to 1999, the stock of structures averaged about three times the stock of machinery. The share parameter σ in the model is chosen to deliver this 3-to-1 ratio; this requires a value for σ of 0.648. Following Macklem (1993b), the adjustment-cost parameters for structures are set at 2.5 and those for machinery are set at 1.5.

The initial levels of productivity in the resource and manufacturing sectors (the Φs) are chosen so that the small economy exports resources and imports manufactured goods in the initial steady state. In Canada, net exports of resources and net imports of manufactured goods have both averaged between 11 per cent and 12 per cent of GDP. In the model, the initial level of productivity in the manufacturing sector is normalized to unity, and the initial level of productivity in the resource sector is set at 1.331 to deliver a steady-state exports-to-GDP ratio of 11 per cent. The initial level of productivity in the non-tradables sector is normalized such that the price of non-tradables relative to manufactured goods is unity. Since the terms of trade is also normalized to unity, all three goods have the same relative price in the initial steady state.

The government sector in the model is calibrated to match average shares obtained from aggregate time-series data. Consumer taxes are set at a level sufficient to sustain government expenditures at 22 per cent of GDP with a debt-to-GDP ratio of 78 per cent.

This leaves three unassigned parameters in the model—the probability of death, rate of time preference, and the premium in the firm's discount rate. The probability of death is set at 3.5 per cent, which implies that consumers have a horizon of about 30 years. The rate of time preference is chosen so that the ratio of foreign assets to GDP in the model is –39 per cent, which, based on historical experience, is roughly consistent with a government debt-to-GDP ratio of 78 per cent. The rate of time preference required to deliver the –39 per cent ratio is about 1 per cent, which is well within the plausible range. The premium that enters the firm's discount rate and the capital-to-GDP ratio were set at 14 and 172 per cent, respectively, to match the values used in the Quarterly Projection Model (QPM) of the Bank of Canada.

References

Andrews, D.W.K. 1993. "Exactly Median-Unbiased Estimation of First Order Autoregressive/Unit Root Models." *Econometrica* 61 (1): 139–65.

Armstrong, J., R. Black, D. Laxton, and D. Rose. 1998. "A Robust Method for Simulating Forward-Looking Models." *Journal of Economic Dynamics and Control* 22 (4): 489–501.

Beine, M. and F. Docquier. 1998. "A Stochastic Simulation Model of an Optimum Currency Area." *Open Economies Review* 9 (3): 227–55.

Blanchard, O.J. 1985. "Debt, Deficits, and Finite Horizons." *Journal of Political Economy* 93 (2): 223–47.

Blanchard, O.J. and C.M. Kahn. 1980. "The Solution of Linear Difference Models Under Rational Expectations." *Econometrica* 48 (5): 1305–11.

Calvo, G.A. and M. Obstfeld. 1988. "Optimal Time-Consistent Fiscal Policy with Finite Lifetimes." *Econometrica* 56 (2): 411–32.

Cho, J.-O. and T.F. Cooley. 1995. "The Business Cycle with Nominal Contracts." *Economic Theory* 6 (1): 13–33.

Côté, A. "Exchange Rate Volatility and Trade: A Survey." Bank of Canada Working Paper No. 94–5.

Courchene, T. and R. Harris. 1999. "From Fixing to NAMU: Redressing Canada's Sinking Float." C.D. Howe Institute *Commentary*. Toronto: C.D. Howe Institute.

Crow, J. 1999. "Any Sense in a Canadian Dollar?" *Policy Options* (March): 29–34.

Dupasquier, C., R. Lalonde, and P. St-Amant. 1997. "Optimum Currency Areas as Applied to Canada and the United States." In *Exchange Rates and Monetary Policy*, 131–70. Proceedings of a conference held by the Bank of Canada, October 1996. Ottawa: Bank of Canada.

Engel, C. and J.H. Rogers. 1996. "How Wide Is the Border?" *American Economic Review* 86 (5): 1111–25.

Fischer, S. 1977. "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule." *Journal of Political Economy* 85 (1): 191–205.

Flood, R.P. and A.K. Rose. 1995. "Fixing Exchange Rates: A Virtual Quest for Fundamentals." *Journal of Monetary Economics* 36 (1): 3–37.

Gray, J.A. 1976. "Wage Indexation: A Macroeconomic Approach." *Journal of Monetary Economics* 2 (2): 221–35.

Grubel, H.G. 1999. *The Case for the Amero: The Economics and Politics of a North American Monetary Union*. Vancouver: The Fraser Institute.

Helliwell, J.F. 1996. "Do National Borders Matter for Quebec's Trade?" *Canadian Journal of Economics* 29 (3): 507–22.

King, R.G. 1990. “Money and Business Cycles.” University of Rochester. Photocopy.

Krugman, P.R. 1993. “Lessons of Massachusetts for EMU.” In *Adjustment Growth in the European Monetary Union*, edited by F. Torres and F. Giavazzi, 241–69. Cambridge: Cambridge University Press.

———. 1994. “What Do We Need to Know about the International Monetary System?” In *Understanding Interdependence: The Macroeconomics of the Open Economy,* edited by P. Kenen, 509–29. Princeton: Princeton University Press.

Lafrance, R. and P. St-Amant. 1999. “Optimum Currency Areas: A Review of the Recent Literature.” Bank of Canada Working Paper No. 99–16.

Laidler, D. 1999. “The Exchange Rate Regime and Canada’s Monetary Order.” Bank of Canada Working Paper No. 99–7.

Laidler, D.E.W. and W.P. Robson. 1991. *Two Nations, One Money? Canada’s Monetary System following a Quebec Secession*. The Canada Round 3. Toronto: C.D. Howe Institute.

Macklem, R.T. 1993a. “Terms-of-Trade Disturbances and Fiscal Policy in a Small Open Economy.” *The Economic Journal* 103 (419): 916–36.

———. 1993b. “Terms-of-Trade Shocks, Real Exchange Rate Adjustment, and Sectoral and Aggregate Dynamics.” In *The Exchange Rate and the Economy,* 1–60. Proceedings of a conference held by the Bank of Canada, June 1992. Ottawa: Bank of Canada.

McCallum, J. 1995. “National Borders Matter: Canada-U.S. Regional Trade Patterns. *American Economic Review* 85 (3): 615–23.

———. 1999. “Seven Issues in the Choice of an Exchange Rate Regime.” *Current Analysis.* Royal Bank of Canada.

Murray, J. 1999. “Why Canada Needs a Flexible Exchange Rate.” Bank of Canada Working Paper No. 99–12.

Murray, J., S. van Norden, and R.Vigfusson. 1996. *Excess Volatility and Speculative Bubbles in the Canadian Dollar: Real or Imagined?* Bank of Canada Technical Report No. 76.

Nankervis, J.C. and N.E. Savin. 1996. “The Level and Power of the Bootstrap *t* Test in the AR(1) Model with Trend.” *Journal of Business and Economic Statistics* 14 (2): 161–68.

Obstfeld, M. and K. Rogoff. 1995. “The Mirage of Fixed Exchange Rates.” *Journal of Economic Perspectives* 9 (4): 73–96.

Pou, P. 1999. “An Accord on Monetary Association.” Banco Central de la Republica Argentina. Photocopy.

Powell, J. 1999. *A History of the Canadian Dollar.* Ottawa: Bank of Canada.

Rankin, N. 1998. “Nominal Rigidity and Monetary Uncertainty.” *European Economic Review* 42 (1): 185–99.

Ricci, L. 1997. “A Model of an Optimum Currency Area.” International Monetary Fund Working Paper No. 97/76.

Rose, A.K. 2000. “One Money, One Market? The Effect of Common Currencies on International Trade.” *Economic Policy* 7–45.

Stuber, G. 1988. “A Terms of Trade Model.” Research Department, Bank of Canada.

Summers, R., I.B. Kravis, and A. Heston. 1980. “International Comparison of Real Product and Its Composition: 1950–77.” *Review of Income and Wealth* 26 (1): 19–66.

Taylor, J.B. 1998. “Staggered Price and Wage Setting in Macroeconomics.” National Bureau of Economic Research Working Paper No. 6754.

Weil, P. 1989. “Overlapping Families of Infinitely-Lived Agents.” *Journal of Public Economics* 38: 183–98.

Wirjanto, T.S. 1995. “Aggregate Consumption Behaviour and Liquidity Constraints: The Canadian Evidence.” *Canadian Journal of Economics* 28 (4b): 1135–52.

Discussion

Steven Ambler

Introduction

I congratulate the authors on a tour de force of dynamic general-equilibrium (DGE) modelling. The paper takes as its starting point the basic intuition (well summarized by the authors on page 5 of this volume) that the choice of exchange rate regime is a "trade-off between the microeconomic efficiency gains (i.e., the reduction in transactions costs) resulting from a common currency versus the gains in macroeconomic stabilization provided by a flexible rate adjusting to asymmetric exogenous shocks." As the authors note, the existing literature does not adequately capture the trade-off in a rigorous theoretical framework.

The authors set out to do just this by creating a calibrated DGE model of the Canadian economy. The model includes nominal rigidities and a disaggregation of the economy into non-tradables, resources, and manufactured goods. It allows them to capture the terms-of-trade shocks that have hit the Canadian economy and to model the possibility of credit constraints affecting a subset of consumers. The authors simulate the model under flexible and fixed exchange rates and evaluate the welfare improvement under flexible rates from the economy's improved ability to absorb terms-of-trade shocks. They show that the savings in transactions costs from a fixed exchange rate regime would have to be implausibly large to outweigh the macroeconomic benefits of a flexible rate arrangement.

The paper's basic intuition also underpins the classic paper by Mundell (1961) on optimal currency areas and much of the theoretical literature on exchange rate regime choice. Since the granting of the 1999 Nobel prize in economics to Robert Mundell, there has been a re-examination of his ideas and their evolution. How can the Mundell of the optimal-currency-areas paper have been such a fervent supporter of European monetary union, to the extent that he has been dubbed by some as the “father of the euro”? According to McKinnon (2000), the answer is that there are, in fact, two Mundells: the 1960s version, author of the paper on optimal currency areas and of papers on the workings of fiscal and monetary policy under alternative exchange rate regimes; and the 1970s incarnation, advocate of European monetary union and author of two papers (1973a, 1973b) that have not enjoyed the high profile of the earlier work. The later Mundell recognized the importance of expectations and (implicitly) the existence of many types of shocks other than asymmetric real shocks. My criticisms of the paper and its results should be seen as coming from the perspective of the second Mundell.

Section 1 of this discussion summarizes the model’s structure. I try to motivate some of the assumptions that are not explicitly motivated in the paper. I underline the assumptions that I believe crucial for the results, and I also point out several assumptions that may render the model needlessly complicated. In section 2, I attempt to provide intuition for the main results of the paper in regard to the effects of terms-of-trade shocks on the market-clearing nominal wage under different exchange rate regimes. In section 3, I criticize the model for what it does not accomplish. The final section concludes.

1 Model Structure and Key Assumptions

1.1 Production and stochastic shocks

The economy produces three goods: resources (“good one” in the model), manufactures (“good two”), both of which are tradable at given prices on world markets; and a non-tradable good (“good zero”). Resources are produced with a constant returns to scale (CRS) production function with labour, capital, and land as inputs. The other two goods are produced with CRS production functions, using labour, capital, and resources. Productivity parameters and relative prices are calibrated so that resources are exported and manufactures are imported in equilibrium. The main results of the model arise from terms-of-trade shocks between manufactures and resources. I’m not sure how much the addition of non-traded goods adds to the model, other than implying that the real exchange rate as defined in equation (35) and simplified in equation (36) becomes a constant as the share of non-tradables shrinks to zero. Since the authors do not use the model’s predictions concerning real exchange rate variability to evaluate its performance, they could probably dispense with non-tradables altogether.

Capital in each sector is an aggregate of a capital good from the non-tradables sector and a capital good from the manufacturing sector. Investment is subject to convex adjustment costs, and the resource constraints (24), (25), and (26) tell us that the adjustment costs are paid in units of the good produced by the sector in which investment takes place. There is always a modelling choice to be made in multi-sector models about how the output of different sectors is aggregated into consumption and investment goods. The authors have made one possible choice, but do not tell us what considerations led to this choice or whether the results are sensitive to it. The choice does lead to a large number of asset-pricing relationships, and there are six Tobin's q's, one for each type of capital good in each sector. This must make obtaining the desired saddle-point stability properties much more difficult.

The economy is a small open economy, thus the terms of trade between resources and manufactured goods are exogenous. Fluctuations in the terms of trade are the only source of uncertainty in the model, therefore it is appropriate to discuss them here. The terms of trade are modelled as a second-order autoregressive process, with either normal errors or errors drawn from a *t*-distribution with three degrees of freedom to capture the possibility of fat-tailed shocks. One thing the authors could easily do, but don't, is test the normality of the errors in their estimated equation.

1.2 Consumers

There is a growing population of consumers in the model who face a constant probability of death, as in Blanchard (1985). This assumption is clearly needed to map preference parameters into the steady-state level of net foreign assets when the model is calibrated. With infinite horizons and a rate of time preference equal to the gross world real interest rate, agents save any positive shock to current income and live off of the interest. Net foreign assets follow a random walk. When the model is simulated, they can wander arbitrarily far from their calibrated initial level.

1.3 Government

Government spending grows exogenously at a fixed rate equal to the economy's overall growth rate. The government allocates fixed proportions of total spending to the three types of goods. Once trend growth is removed, government spending in each sector acts as little more than a negative constant in the production function, making less output available for private sector use. The model could be simplified by omitting government spending altogether, especially since the interaction between the fiscal and monetary authorities is not modelled at all. I conjecture that the authors chose to incorporate government spending to simplify the calibration exercise. This inclusion opens up the possibility of examining the effects of fiscal spending shocks in future work.

1.4 Prices

How prices are determined in the model is absolutely crucial to the results, therefore this feature is worth summarizing.

Manufactured goods are taken as the numeraire in the model. The relative price of resources, p_1, is exogenous and measures the terms of trade for the Canadian economy. The relative price of non-tradables, p_0, is endogenous and determined by supply-and-demand conditions in the market for non-tradables.

The monetary authority in the model merely provides a nominal anchor to the system. Under fixed exchange rates, the anchor is obviously the exchange rate itself. Under flexible exchange rates, the monetary authority is assumed to fix (either in levels or in rates of change) the overall consumer price index.

The nominal price of manufactured goods is given by $P_2 = eP_2^*$, where e is the nominal exchange rate, and P_2^* is the nominal price of foreign manufactures. The nominal prices of non-tradables and resources are, respectively, $P_0 = p_0 P_2$ and $P_1 = p_1 P_2$. The nominal price level is:

$$P = \left(\frac{P_0}{\theta_0}\right)^{\theta_0}\left(\frac{P_1}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1},$$

$$\rightarrow P = \left(\frac{p_0 P_2}{\theta_0}\right)^{\theta_0}\left(\frac{p_1 P_2}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_0-\theta_1}\right)^{1-\theta_0-\theta_1}.$$

Under fixed exchange rates, P_2 is unaffected by a terms-of-trade shock, while under flexible rates, the price level, P, is fixed, and P_2 is determined endogenously as the solution to the above equation.

1.5 Labour market

Consumers have a given labour endowment, and they supply labour inelastically. This assumption clearly makes solving the model much simpler, but it must have important consequences for the welfare analysis that the authors undertake. Without leisure in the utility function, there are no direct welfare consequences of unexpected movements in employment due to wage rigidity. Any impact of shocks on welfare due to wage rigidity must arise from the indirect effects of shocks on consumption, capital accumulation, and other variables. I suspect this is why the introduction of credit constraints makes such a difference in welfare terms. For agents who are credit-constrained, involuntary changes in hours worked lead directly to large changes in current consumption, since the impact of changes in current income on consumption cannot be smoothed by lending and borrowing.

My guess is that if leisure were to be put in the utility function, the direct impact of unintended fluctuations in hours on welfare would dominate any of the indirect effects. For this reason, the authors may be understating the impact of the choice of exchange rate regime on welfare. Given the small quantitative differences between welfare levels under different exchange rate regimes (fractions of 1 per cent of aggregate consumption), it would be important to extend the model to include leisure in the utility function.

2 Understanding the Results

The model's welfare gains from a flexible exchange rate are large enough that they swamp any possible estimate of the transaction cost savings of going to a fixed exchange rate. This is a strong result. The model is a relatively complex DGE model that cannot be solved analytically, therefore the features driving the results may seem unclear. But, I believe the basic thrust of the results could be understood in terms of a much simpler model.

Consider a simple two-sector model where both goods are tradable. Call sector one the exportable good or resources and sector two the importable good or manufactures. Production is based on CRS functions, using only capital and labour as inputs.[1] These sectoral production functions can be written as:

$$y_1 = \Phi_1 k_1^{\alpha_1} l_1^{1-\alpha_1},$$

$$y_2 = \Phi_2 k_2^{\alpha_2} l_2^{1-\alpha_2},$$

using notation similar to that of the paper. Given these assumptions, it is possible to compute the equilibrium or market-clearing nominal wage without reference to the demand side of the model other than the equation for the price level. Compared with the authors' model, the latter is quite simple and can be written as:

1. I assume that factor prices are such that complete specialization is not an equilibrium.

$$P = \left(\frac{p_1 P_2}{\theta_1}\right)^{\theta_1}\left(\frac{P_2}{1-\theta_1}\right)^{1-\theta_1} .$$

Labour demand in each sector is a function of the (common) nominal wage, the sectoral capital stock, and the nominal price of sectoral output. The sectoral labour demand curves are shown in the first two panels of Figure 1. The third panel shows labour market equilibrium, determined by the intersection of labour supply and labour demand curves at point *A*, assuming that the aggregate labour supply curve is inelastic, as it is in the paper.

The impact on the equilibrium nominal wage under a fixed exchange rate regime is illustrated in Figure 2. Under a fixed exchange trade, an increase in the relative price of exportables leads to no increase in the nominal price of importables (assuming that the terms-of-trade shift comes about through an increase in the foreign price of exportables), leaving the labour demand curve in sector two unaffected. The nominal price of exportables increases proportionally to the relative price increase. This, in turn, shifts the labour demand curve in the exportables sector to the right. The aggregate labour demand curve also shifts to the right, and the equilibrium in the labour market shifts from point *A* to point *B*. The equilibrium nominal wage increases unambiguously. If wages are predetermined at the expected market-clearing level, a disequilibrium in the labour market results. Workers are forced to work more than anticipated. There are no direct effects on welfare, since leisure is not in the utility function, but there are indirect effects via the impact on consumption and other variables.

The impact on the equilibrium nominal-wage rate is quite different under flexible exchange rates, as illustrated in Figure 3. If the monetary authority has some fixed target for the overall price level that is not sensitive to the terms-of-trade shock, the price of importables must decrease (or at least increase by less than expectations), and the price of exportables must increase less than proportionally to the change in the terms of trade. It is easy to show that:

$$\frac{dP_2}{P_2} = -\theta_1 \frac{dp_1}{p_1},$$

and

$$\frac{dP_1}{P_1} = (1-\theta_1)\frac{dp_1}{p_1}.$$

Figure 1
Labour market equilibrium

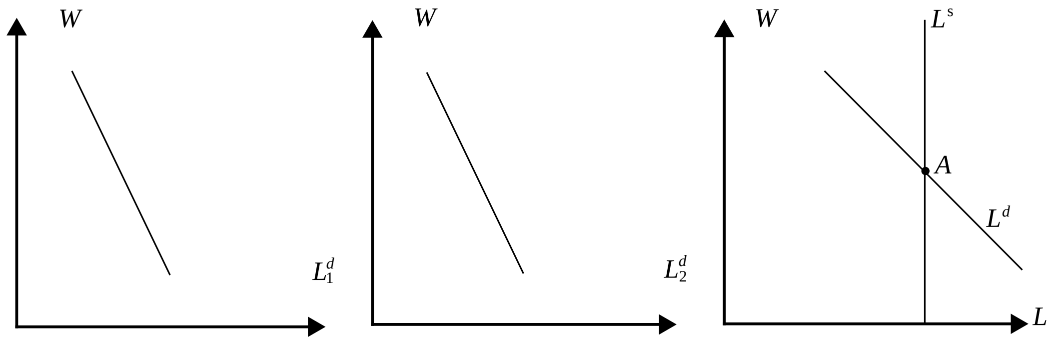


Figure 2
Terms-of-trade shock—fixed rates

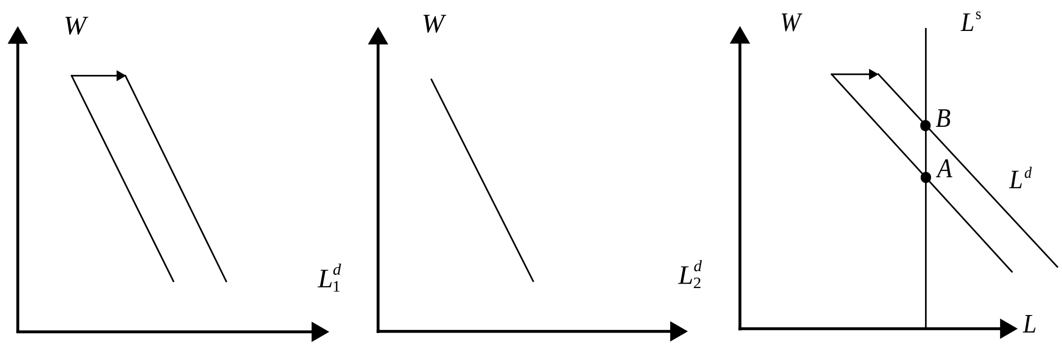
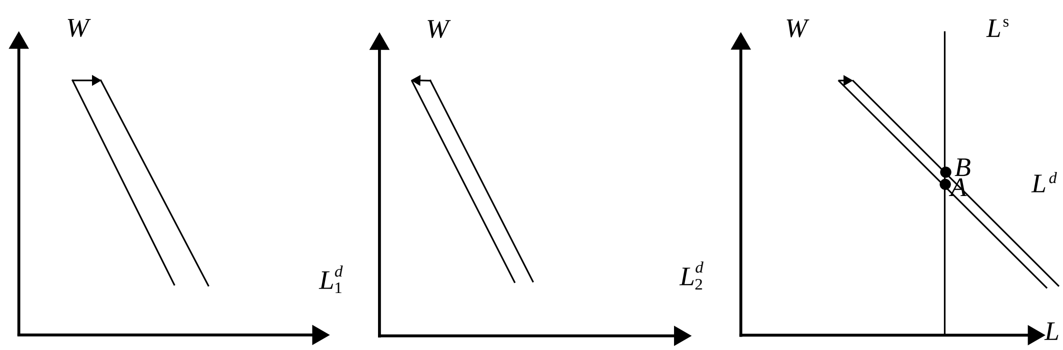


Figure 3
Terms-of-trade shock—flexible rates



The labour demand curve in the importables sector shifts to the left, and the labour demand curve in sector one shifts to the right, but by less than the shift under a fixed exchange rate regime. The increase in aggregate labour demand must be less than under a fixed exchange rate, so that the increase in the equilibrium nominal wage is also less. This is the sense in which flexible exchange rates facilitate macroeconomic adjustment to terms-of-trade shocks. In fact, there is a value of θ_1 for which the shifts in the two sectoral labour demand curves offset one another, leaving the equilibrium (market-clearing) nominal wage completely unaffected by terms-of-trade shocks. Consequently, if the equilibrium nominal wage is unaffected, the welfare costs of wage rigidity under flexible exchange rates vanish completely.

The preceding paragraphs illustrate why the impact of a terms-of-trade shock on the market-clearing nominal wage is important, and why the nominal anchor of the monetary authority and the model's parameter values are important factors in determining the size of this shift. It would be extremely useful if the authors could measure the volatility of the market-clearing nominal wage under their fixed and floating-rate regimes, by running simulations in which contracts are turned off, in addition to simulations in which they are operative. This would help to show whether the intuitive arguments of the preceding paragraphs are correct, and to measure the intuition's quantitative importance. The authors only compare the welfare levels of fixed and flexible exchange rate regimes with wage contracts. It would also be interesting to compare the level of welfare under flexible rates and wage contracts with the first-best equilibrium when wages are perfectly flexible.

3 What's Missing

In the model, fluctuations in real exchange rates are optimal responses to real shocks. Nominal wage rigidities act as sand in the works, dampening the response of real exchange rates under fixed exchange rates. This is most certainly not what is in the minds of those who advocate fixed exchange rates because of the "excessive" volatility of real exchange rates under flexible rates. Mundell states this view very forcefully in his Nobel prize lecture, when he talks about "the dysfunctional volatility of exchange rates that could sour international relations in time of crisis" (2000, 339). This is also clear in the writings of other Canadian advocates of a North American currency union (for example, Courchene and Harris 1999). Although the authors do not report this, I am sure that the model doesn't reproduce the observed variability of the Canadian real exchange rate.[2]

One of the arguments put forward by the "1970s Mundell" in support of the superiority of single-currency areas is that they afford increased possibilities to share risks when private-capital markets have limited ability to facilitate consumption insurance. Ching and Devereux (2000) construct a simple model that captures the arguments of both Mundell (1961) and Mundell (1973) in a simple, unified framework. In response to a temporary negative domestic productivity shock under a fixed common-currency regime, domestic agents can draw down their cash balances to smooth their consumption. World prices rise, reducing the real value of foreign agents' cash balances. Consumption at home and abroad falls, and the common currency provides for some degree of risk-sharing in the face of asymmetric productivity shocks.

It is also possible to consider the impact of monetary shocks given the structure of the model under review, even though there is no explicit monetary sector in the model. We know that in response to any type of monetary shock, the equilibrium real wage rate does not change. If wages are pre-set at expected market-clearing levels, anything that enhances predictability of the aggregate price level must be a good thing. If the foreign price level is perfectly predictable, and internal monetary shocks are the dominant source of fluctuations, then a fixed exchange rate regime is clearly optimal.[3] If there are only domestic monetary shocks, wage rigidity has no welfare costs under fixed exchange rates, since the fixed nominal wage always turns out to clear the labour market ex post. However, monetary shocks are a two-edged sword. It could be argued, and I'm quite sure the Bank of Canada would want to agree, that the Bank is doing a better job of stabilizing prices (or inflation) than the Federal Reserve Bank or other foreign central banks. If this is the case, then flexible rates are preferable even when monetary shocks are the most important source of fluctuations.

Conclusions

I believe that understanding the true relative importance of different types of macroeconomic shocks is the key to determining the optimal exchange rate regime. We are almost there in terms of our ability to construct DGE models

---

2. Backus, Kehoe, and Kydland (1995) point out that most open economy DGE models predict a variance of the real exchange rate that is substantially below that in the data on industrialized countries.

3. If we allow for phenomena like rational speculative bubbles in foreign exchange markets, the welfare costs of flexible rates could be considerably magnified.

that capture the aspects of reality that are relevant to the analysis for a complex economy like Canada's. This paper takes a giant step in the right direction. I think that the structure of the model, except for the lack of a true monetary sector and a trade-off between labour and leisure, provides almost the right level of abstraction for meaningful welfare analyses.

This type of model should be used with sophisticated econometric analysis to pin down structural parameters and the variance-covariance matrix of the underlying shocks.

References

Backus, D.K., P.J. Kehoe, and F.E. Kydland. 1995. "International Business Cycles: Theory and Evidence." In *Frontiers of Business Cycle Research*, edited by T. Cooley. Princeton: Princeton University Press.

Blanchard, O.J. 1985. "Debt, Deficits, and Finite Horizons." *Journal of Political Economy* 93 (2): 223–47.

Ching, S. and M.B. Devereux. 2000. "Mundell Revisited: A Simple Approach to the Costs and Benefits of a Single Currency Area." Hong Kong Institute for Monetary Research/University of British Columbia. Photocopy. < http://www.arts.ubc.ca/econ/devereux/cd2.pdf >.

Courchene, T.J. and R.G. Harris. 1999. "From Fixing to Monetary Union: Options for North American Currency Integration." C.D. Howe Institute Commentary No. 127. < http://www.cdhowe.org/pdf/harris.pdf >.

McKinnon, R. 2000. "Mundell, the Euro, and Optimum Currency Areas." Stanford University Working Paper No. 9. < http://www-econ.stanford.edu/faculty/workp/swp00009.pdf >.

Mundell, R. 1961. "A Theory of Optimum Currency Areas." *American Economic Review* 51 (4): 657–65.

———. 1973a. "Uncommon Arguments for Common Currencies." In *The Economics of Common Currencies*, edited by H.G. Johnson and A.K. Swoboda, 114–32. London: Allen and Unwin.

———. 1973b. "A Plan for a European Currency." In *The Economics of Common Currencies*, edited by H.G. Johnson and A.K. Swoboda, 143–72. London: Allen and Unwin.

———. 2000. "A Reconsideration of the Twentieth Century." *American Economic Review* 90 (3): 327–40.