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Terms-of-Trade Disturbances and Fiscal Policy in a Small Open Economy

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Abstract

This paper examines the steady-state and dynamic effects of shifts in the terms of trade and the level of the government debt in a growing, resource-based, small open economy. The study is based on a simulation model that is loosely calibrated to Canadian data. The model describes a small country that produces non-tradables and resources, and imports manufactured goods. Consumers optimize over their expected lifetime and do not care about the well-being of future generations. Consequently, Ricardian equivalence does not hold, and fiscal policy can have real effects by altering the mix of current and future taxes and deficits. Profit-maximizing, non-tradable-goods and resource-producing firms use inputs of labour, capital and resources, and face costs of adjusting capital. In general, the results highlight the role played by asset prices and the real exchange rate in the transmission of terms-of-trade and government debt shocks to investment and production decisions in both sectors, the importance of general equilibrium considerations, and the intertemporal aspects of consumer and firm behaviour in a dynamic setting.

Résumé

La présente étude traite des effets de régime permanent (*steady-state*) et des effets dynamiques qu'induisent les variations des termes de l'échange et du niveau de la dette publique dans une petite économie ouverte en expansion. Elle s'appuie sur un modèle de simulation adapté, en gros, à la taille des données canadiennes. La petite économie formalisée par le modèle produit des biens non exportables, exploite des ressources naturelles et importe des produits manufacturés. Les consommateurs y maximisent leur fonction d'utilité pour la durée prévue de leur vie et ne se soucient pas du bien-être des générations futures. Par conséquent, l'hypothèse d'équivalence de Ricardo ne tient pas, et la politique budgétaire peut avoir des effets réels en modifiant la composition de l'impôt et des déficits actuels et futurs. Vouées à la maximisation du profit, les entreprises, qui oeuvrent dans les secteurs de l'exploitation des ressources naturelles et de la fabrication de biens non exportables, emploient dans le processus de production trois facteurs : le travail, le capital et les ressources naturelles; elles doivent en outre supporter des coûts d'ajustement dans le cas du capital. Les résultats obtenus font généralement ressortir le rôle que jouent les prix des actifs et le taux de change réel dans la transmission des variations des termes de l'échange et de la dette publique aux décisions d'investissement et de production dans les deux secteurs; ils mettent également en lumière l'importance des considérations d'équilibre général ainsi que les aspects intertemporels que revêtent les comportements du consommateur et de l'entreprise dans un cadre dynamique.

1 Introduction

Since the early 1970s many of the world's industrialized and developing countries have experienced large fluctuations in their terms of trade. Over this same period, many countries have also had unusually large shifts in their government budget deficits. The Canadian data are illustrative. Figures 1 and 2 (see Appendix) plot Canada's terms of trade and real government budget deficit. As Figure 1 reveals, while Canada's terms of trade were by no means constant over the 1950s and 1960s, there was considerably more volatility over the next two decades, principally reflecting the oil shocks of the 1970s and the marked swings in non-oil commodity prices in the 1980s. Figure 2 shows the rise in Canada's government budget deficit which began in the mid-1970s and accelerated sharply in the early 1980s. These events raise a number of questions. In particular, what are the dynamic effects of shifts in the terms of trade and the government deficit on investment, output, consumption, and the current account? How do shifts in the terms of trade and the government deficit affect the real exchange rate, and what are the allocative and aggregate implications of changes in this relative price? Can government deficits be used to dampen the effects of terms-of-trade disturbances on consumers, and if so, what would be the impact of such a policy on factor allocations and current account dynamics?

This paper examines these and other questions in a growing, resource-based, small open economy. The study is carried out in the context of a simulation model that is loosely calibrated to the Canadian economy. The model describes a small country that produces non-tradables and resources, and imports manufactured goods. The behaviour of consumers and firms is derived from explicit optimization in an intertemporal setting. The insistence on choice-theoretic foundations reflects the fact that it is the savings decisions of consumers and investment decisions of firms that are central to the issues at hand. At the heart of these decisions are intertemporal trade-offs from which it is difficult to abstract while retaining the essence of the problem. Moreover, by describing the economic environment at the level of tastes and technology, the model can consistently account for how agents' decision rules respond to changes in policy. The model therefore provides a meaningful framework for the analysis of alternative policy interventions.

The policy authority or government in the model has exogenously given spending requirements that are financed by imposing taxes and issuing debt subject to a budget constraint. Government expenditures in the model do not affect productivity and crowd out private con-

sumption one for one. As a result, changes in government expenditures themselves have no aggregate or sectoral effects on output or employment. Nevertheless, fiscal policy can have a rich set of sectoral and aggregate effects in the model since Ricardo-Barro equivalence of public debt and taxation does not hold. The impact of fiscal policy on prices and outputs in the model therefore arises from the wealth effects associated with different mixtures of current and future taxes and deficits.

The non-equivalence of taxes and debt in the model stems from two related sources. First, following Weil (1987), economic growth is fuelled by the birth (or immigration) of new consumers who are economically disconnected from their predecessors. Consumers expect that they will not be responsible for the repayment of the entire government debt since part of the debt will be paid by future generations. Consequently, some portion of the government debt is regarded as net wealth. This first source of non-Ricardian equivalence is reinforced by assuming that consumers have finite lives and do not make bequests. This is accomplished using the uncertain lifetimes approach of Blanchard (1985) in which consumers face a constant probability of death throughout their lives. The attractive feature of Blanchard's framework is that it captures the effects of finite horizons in a setup that permits straightforward aggregation. The behaviour of consumers is influenced by their horizon, but since the probability of dying is independent of age, behaviour does not depend on age. Overlapping generations of consumers can therefore be easily aggregated to obtain macro variables of interest. Of course, nothing is gained without some cost; the cost of having the probability of death independent of age is that the model does not capture life cycle effects.

Two other important features of the model are that capital is costly to adjust, and that different sectors (can) have different factor intensities. In a small open economy, current investment can be financed by foreign borrowing as well as by domestic savings and does not therefore require a sacrifice of current consumption. Since the small economy faces a given world interest rate, in the absence of costs to adjusting capital, profit-maximizing firms would adjust capital instantaneously to its long-run equilibrium level. The introduction of installation costs is therefore necessary to permit the model to fit observed short-run data.[1] The differences between factor intensities across sectors introduces an important role for relative prices, such as the terms of trade and the real exchange rate, and allows aggregate

[1]The importance of costly adjustment of capital in a stochastic environment has recently been demonstrated by Mendoza (1989) in the context of a computational general equilibrium growth model that is calibrated to Canadian data.

shocks to generate a rich set of sectoral effects.

The dynamic multi-sector model presented in this paper draws on a number of previous studies and complements these studies in several respects. The model is similar to recent theoretical models developed by Buiter (1987,1988,1989) and Obstfeld (1989), but adds a number of features in an effort to make these models more empirically relevant. The cost of these additional features is that it is no longer generally possible to obtain analytical results with the model, so numerical procedures are used. This simulation approach provides a natural setting in which to begin to address questions of interest quantitatively as well as qualitatively. The study also complements the pioneering simulation models of Bruno (1982a,1982b), Sachs (1983), Lipton and Sachs (1983), and Bruno and Sachs (1985) by incorporating recent theoretical developments by Blanchard (1985) and Weil (1987). The Blanchard-Weil framework permits a determinant steady state in an open economy model with a given world interest rate and exogenous time preference, and introduces a role for fiscal policy via the wealth effects of government debt. The current paper does not consider the international linkages between interdependent world economies examined by Lipton and Sachs, Buiter, and Obsfeld. Rather, the focus is a small economy that takes the world interest rate and world prices for traded goods as given. The structure of the small open economy together with the model's calibration give the results a Canadian flavour. In this respect, the study also builds on Stuber's (1988) static multi-sector Canadian model.

Section 2 describes the model — the economic environment, the behaviour of consumers, firms and the government, and the economy's equilibrium conditions. In Section 3, the model is loosely calibrated to the Canadian economy, and in Section 4 the steady-state effects of shifts in the terms of trade and the level of government debt are studied. Sections 5 and 6 examine the dynamic effects of a temporary terms-of-trade shock and a government debt shock respectively. In Section 7 the interaction between changes in government debt and the terms of trade are investigated by studying an economy in which taxes are proportional to wage income. Brief conclusions and suggestions for future research are provided in Section 8.

2 The model

The model describes a growing, resource-based, small open economy. There are three types of goods in the economy: non-tradables (good 0), resource goods (good 1) and manufactured goods (good 2). The open economy is specialized in the production of resources and non-tradables, and imports manufactured goods. The country is assumed to be small relative to the rest of the world, and therefore takes the world prices for resource and manufactured goods as well as the real interest rate as given. Labour is not internationally mobile, but is free to migrate between the two production sectors.

The economy has a growing population of mortal consumers. These consumers purchase non-tradables, resources and manufactured goods, and supply labour to firms. Labour is supplied inelastically, and the population and the labour force are the same. Consumer behaviour is modelled following the uncertain lifetimes approach of Blanchard (1985) and Weil (1987). The consumer has constant probability of dying π throughout his life. His expected lifetime is therefore $1/\pi$. More generally, $1/\pi$ can be interpreted as the horizon index, with an infinite horizon being the special case of $\pi = 0$.

Profit-maximizing firms use inputs of capital, labour and resources to produce non-tradables and resources. Capital is formed from manufactured goods and must therefore be imported. Investment behaviour is modelled following the q approach associated with Tobin (1969) and the cost-of-adjusment analysis developed by Lucas (1967) and Treadway (1969).

Government behaviour is taken to be exogenous and is described by plausible, though admittedly *ad hoc*, rules.

2.1 Consumers

At each instant t, the objective of a consumer born at time v (for vintage) is to maximize the expected discounted value of lifetime utility. Assuming a constant probability of death and no other sources of uncertainty, the consumer's objective function may be written as:

$$\max_{\bar{c}(v,s)} \int_t^\infty u(\bar{c}_0(v,s), \bar{c}_1(v,s)\bar{c}_2(v,s)) \exp[-(\rho+\pi)(s-t)]ds \qquad (1)$$

where ρ is the pure rate of time preference, π is the consumer's probability of death, and $\bar{c}_j(v,s)$ is the consumption of type $j = 0,1,2$ goods at time s by an individual born at time

v.[2] The effect of introducing the probability of death is to increase the rate at which the individual discounts the future above the pure rate of time preference ρ. The momentary utility function $u(.)$ is assumed to be logarithmic:

$$u(\bar{c}) = \theta_0 \log \bar{c}_0 + \theta_1 \log \bar{c}_1 + (1 - \theta_0 - \theta_1) \log \bar{c}_2. \tag{2}$$

Let manufactured goods be the numeraire, and denote the relative prices of non-tradables and resources in terms of manufactured goods as $p_0(t)$ and p_1 respectively. Note that p_1 is the terms of trade and, as a result of the small open economy assumption, it is determined exogenously on world markets. The relative price of non-tradables $p_0(t)$ is the real exchange rate and is determined by demand and supply conditions in the small economy.[3] The consumer's total consumption expenditure measured in terms of the manufactured good is denoted by $\bar{c}(v,t)$ and defined as:

$$\bar{c}(v,t) = p_0(t)\bar{c}_0(v,t) + p_1\bar{c}_1(v,t) + \bar{c}_2(v,t). \tag{3}$$

Consumers hold financial assets $\bar{a}(v,t)$, from which they earn income of $(r+\pi)\bar{a}(v,t)$ where r is the exogenously determined world interest rate and the income $\pi\bar{a}$ is an insurance premium. The population is assumed to be large enough so that π is the rate at which consumers die. Since there is individual uncertainty but no aggregate uncertainty, it is assumed that an efficient insurance market exists that makes premium payments to the living in return for receipt of the consumer's estate upon death. This ensures that there are no unintentional bequests. In addition to this investment income, the consumer also earns wage income $\bar{w}(t)$ and pays lump-sum taxes $\bar{\tau}(t)$. Each consumer is endowed with a single unit of labour which is supplied inelastically. The consumer's intertemporal budget constraint is therefore:

$$\dot{\bar{a}}(v,t) = (r+\pi)\bar{a}(v,t) + \bar{w}(t) - \bar{\tau}(t) - \bar{c}(v,t) \tag{4}$$

[2]The bar over the quantity variables denotes that these variables are measured at the level of the individual.

[3]This definition of the real exchange rate is not the only definition in the literature. In an aggregate setting the real exchange rate is often defined as the ratio of an index of domestic prices to an index of foreign prices. If we use the consumption expenditures shares as the appropriate weights, this gives rise to the following definition:

$$e \equiv \frac{\theta_0 p_0 + \theta_1 p_1 + (1 - \theta_0 - \theta_1)}{\theta_0^* p_0^* + \theta_1^* p_1 + (1 - \theta_0^* - \theta_1^*)}$$

where e is the *aggregate* real exchange rate, and the stars denote the corresponding parameters and variables in the foreign country. Note that although $p_0 \neq e$, p_0 and e will tend to move together since $\partial e/\partial p_0 > 0$.

where $\dot{\bar{a}}(v,t) = d\bar{a}(v,t)/dt$. Note that wages $\bar{w}(t)$ and taxes $\bar{\tau}(t)$ are not indexed by the date of birth v since both are assumed to be independent of age.

The consumer's problem is to maximize (1) subject to (4) and the solvency condition that the present value of lifetime financial wealth is positive. The optimal spending plan that solves this problem is:

$$\bar{c}(v,s) = (\rho+\pi)[\bar{a}(v,s)+\bar{h}(v)] \tag{5}$$

$$\bar{h}(t) = \int_t^\infty (\bar{w}(v)-\bar{\tau}(v))\exp[-(r+\pi)(v-t)]dv \tag{6}$$

$$\bar{c}_0(v,s) = \theta_0\bar{c}(v,s)/p_0(t) \tag{7}$$

$$\bar{c}_1(v,s) = \theta_1\bar{c}(v,s)/p_1 \tag{8}$$

$$\bar{c}_2(v,s) = (1-\theta_0-\theta_1)\bar{c}(v,s). \tag{9}$$

Total consumption is a constant proportion of the consumer's total wealth, where total wealth is the sum of human wealth $h(t)$ and financial wealth $a(v,t)$. The factor of proportionality $(\rho+\pi)$ is the average propensity to consume out of wealth. Human wealth is the discounted sum of current and future after-tax wage income. Since all consumers earn the same wage, pay the same taxes and have the same probability of death, human wealth is independent of age and is not therefore indexed by v. Consumption expenditures on non-tradables, resources, and manufactured goods — all measured in terms of the manufactured good (the numeraire) — are proportional to total consumption.

Aggregate consumption is obtained by integrating over generations (or vintages) of consumers. Owing to the assumption that the probability of death is independent of age, aggregation is straightforward. Aggregate stock and flow variables in this economy grow because of both population and productivity growth. The population is assumed to grow at rate n and productivity increases at the rate ϕ. Aggregate variables can be transformed into stationary variables by expressing them on a per-labour-force basis where the labour force is measured in efficiency units. Using the convention that lower-case letters are aggregate quantities measured in efficiency units, optimal plans for consumption and the evolution of wealth are:[4]

$$c(t) = (\rho+\pi)[a(t)+h(t)] \tag{10}$$

[4]Aggregate variables in efficiency units are obtained as follows. The population L grows at a net rate of n: $L(t) = L(s)\exp[n(t-s)]$. Since consumers die at rate π, the size of the cohort arriving at each instant v is $(n+\pi)L(v)$. Assume without loss of generality that $L(0) = 1$. The size of the cohort at time t that arrived at time $v \le t$ is then $(n+\pi)L(v)\exp[-\pi(t-v)] = (n+\pi)\exp[-\pi t+(n+\pi)v]$. Assuming a positive

$$c_0(t) = \theta_0 c(t)/p_0(t) \tag{11}$$

$$c_1(t) = \theta_1 c(t)/p_1 \tag{12}$$

$$c_2(t) = (1-\theta_0-\theta_1)c(t) \tag{13}$$

$$\dot{a}(t) = (r-n-\phi)a(t) + w(t) - \tau(t) - c(t) \tag{14}$$

$$\dot{h}(t) = (r+\pi-\phi)h(t) + \tau(t) - w(t). \tag{15}$$

Aggregate consumption is a constant proportion of wealth and Friedman's permanent income hypothesis is intact, despite the fact that agents have finite lives. Financial wealth $a(t)$ is adjusted for population growth (n) and productivity growth (ϕ), and no longer includes the premium payment πa because, in aggregate, these transfers cancel out. Note also that while financial wealth is adjusted for population growth, human wealth is not. This reflects the fact that consumers are born with human wealth but not with financial wealth, since bequests are ruled out.

2.2 Firms

Firms combine inputs of labour, capital and resources to produce outputs of non-tradables and resources. Capital is formed from the manufactured good and is subject to convex and strictly increasing costs of adjustment. Since both non-traded goods-producing and resource-producing firms face a similar profit maximization problem, for expositional purposes it is convenient to focus on producers of non-traded goods.

Assume that there are a large number of identical and competitive firms producing non-traded goods, and normalize their number to unity. The representative non-traded-goods

arrival rate, the total population is obtained by integrating over the survivors of each cohort:

$$\begin{aligned} L(t) &= (n+\pi)\exp[-\pi t]\int_{-\infty}^{t}\exp[(n+\pi)v]dv \\ &= \exp[nt] \end{aligned}$$

By analogy, for any individual agent's stock or flow variable $\bar{x}(v,t)$ the corresponding population aggregate $X(t)$ is given by:

$$X(t) = (n+\pi)\exp[-\pi t]\int_{-\infty}^{t}\bar{x}(v,t)\exp[(n+\pi)v]dv$$

Aggregate consumption and wealth are obtained by straightforward application of (4) to (4) and (5)-(9). In order to express growing aggregate variables in a stationary form it is convenient to express aggregates on a per-efficient-labour-unit basis. If $X(t)$ is an aggregate stock or flow variable, the corresponding stationary variable $x(t)$ is defined as $x(t) = X(t)\exp[-(n+\phi)t]$, where ϕ is the rate of labour augmenting technical progress.

firm produces output Y_0 according to the constant returns to scale Cobb-Douglas technology:

$$Y_0(t) = \Phi_0 K_0^{\alpha_0}(t) Z_0^{\beta_0}(t)(\exp[\phi t] L_0(t))^{1-\alpha_0-\beta_0} \tag{16}$$

where K_0, Z_0 and L_0 are, respectively, the capital, labour and resource inputs, ϕ is the rate of labour augmenting technical progress, and Φ_0 is a scale parameter that captures the initial level of technology. Capital depreciates at the rate δ_0 according to the law of motion

$$\dot{K(t)} = I_0(t) - \delta_0 K_0(t) \tag{17}$$

where I_0 is gross investment. The firm faces adjustment costs when installing new capital, so the cost to the firm of investing is the sum of the cost of the investment good itself and the output foregone during installation. Adjustment costs are assumed to be a rising function of investment relative to the existing capital stock, and are only incurred when investment is above or below its steady state. The chosen functional form for adjustment costs $\Gamma_0(t)$ follows Summers (1981) quadratic specification:

$$\Gamma_0(t) = \frac{\eta_0}{2}\left(\frac{I_0(t)}{K_0(t)} - (\delta_0 + n + \phi)\right)^2 K_0(t) \tag{18}$$

where η_0 is the costs-of-adjustment parameter.

The representative firm's problem is to maximize the value of the firm $V(t)$ subject to (16)-(18) where

$$V(t) = \int_t^\infty \{p_0(s)(Y_0(s) - \Gamma_0(s)) - \bar{w}_0(s) L_0(s) - p_1 Z_0(s) - I_0(s))\exp[-(r+\psi)(s-t)]\} ds. \tag{19}$$

The firm is assumed to discount the future at the rate $(r + \psi)$ where ψ represents a premium. At a formal level, ψ is a transactions cost associated with obtaining investment funds. Heuristically, however, ψ may be thought of as a risk premium. The premium ψ is required to confront the observation that equity has paid an average real premium of 6 to 7 per cent over short-term government debt (see Mehra and Prescott (1985)), and cannot be ignored if the model is to mimic the observed capital-output ratio.[5] The solution to the firm's dynamic

[5]Since the firm is blessed with perfect foresight, there is no uncertainty for a risk premium to price in the model. In principle, observed risk premiums could be handled more satisfactorily in a stochastic version of the current model. To date, however, stochastic growth models have had difficulty in producing risk premiums with properties similar to those we observe. The seminal paper on the subject is Mehra and Prescott (1985). See also Backus, Gregory and Zin (1989), and Macklem (1991). The findings of these authors suggest that the increased complexity associated with adding uncertainty to the model is unlikely to pay dividends in terms of the model's ability to adequately handle risk premiums.

problem, expressed in efficiency units, is:

$$i_0(t) = \left(\frac{q_0(t)-1}{\eta_0 p_0(t)} + (\delta_0 + n + \phi)\right) k_0(t) \tag{20}$$

$$z_0(t) = p_0(t)\beta_0 y_0(t)/p_1 \tag{21}$$

$$w_0(t) = p_0(t)(1-\alpha_0-\beta_0)y_0(t) \tag{22}$$

$$y_0(t) = \Phi_0 k_0(t)^{\alpha_0} z_0(t)^{\beta} l_0(t)^{1-\alpha_0-\beta_0} \tag{23}$$

$$\dot{k}_0(t) = i_0(t) - (\delta_0 + n + \phi)k_0(t) \tag{24}$$

$$q_0(t) = \int_t^{\infty} \left(\frac{\alpha_0 p_0(t) y_0(t)}{k_0(t)} + \frac{(q_0(t)-1)^2}{2\eta_0 p_0(t)} - (\delta_0 + n + \phi)\right) \exp[-(r+\psi-n-\phi)(s-t)]ds. \tag{25}$$

Equations (20) to (25) use the convention that aggregate quantity variables measured in efficiency units are written with lower-case letters. The new variables q_0 and l_0 are, respectively, the ratio of the market value of equity capital in the firm to its replacement cost, and the fraction of the total labour force employed in the non-traded-goods sector. In addition, $w_0(t) = \bar{w}_0(t)L_0(t)/\exp[(\phi+n)t]$ is labour income in the non-traded-goods sector.

From (20) investment depends on q_0 — Tobin's q. When q_0 is above (below) unity, investment is above (below) its steady-state level. From (25), the asset price q_0 is equal to the discounted present value of current and future marginal products of capital. The marginal product of capital is the sum of the marginal product of capital in production plus the reduction in the marginal cost of installing a given flow of investment owing to the increase in the capital stock. The dynamic behaviour of q_0 is obtained by differentiating (25) with respect to time:

$$\dot{q}_0(t) = (r+\psi-n-\phi)q_0(t) - \frac{\alpha_0 p_0(t) y_0(t)}{k_0(t)} - \frac{(q_0(t)-1)^2}{2\eta_0 p_0(t)} + (\delta_0 + n + \phi). \tag{26}$$

The change in q_0 is equal to the difference between the return on and the marginal product of capital.

From (21) the optimal expenditure on inputs of resources is proportional to the value of the output of the non-traded good. Optimal labour inputs are described by (22) which requires that labour be employed in the non-traded-goods sector until its value marginal product equals the competitive wage. Finally, (23) and (24) simply rewrite the production function and the law of motion for capital in efficiency units.

Since resource-producing firms are entirely identical to non-tradables producers, the behaviour of resource firms is also described by (20) to (24) with all zero subscripts replaced by ones.

2.3 Government

The government purchases non-tradables, resources and manufactured goods, and finances these expenditures by imposing lump-sum taxes and issuing debt. The government's budget constraint is

$$\dot{b}(t) = (r - n - \phi)b(t) + g(t) - \tau(t) \tag{27}$$

where $b(t)$ and $g(t)$ are the current stock of government debt and flow of government expenditures respectively measured in efficiency units. In addition, the government also faces the solvency condition that the present discounted value of current and future debt is zero.

Ideally, the behaviour of the government subject to the above constraints should be derived from a theory of government. This task, however, is beyond the scope of this project. Instead, government behaviour is described by *ad hoc* rules. Specifically, the government is assumed to have exogenously fixed total spending requirements $g(t)$. Total government spending is then allocated to non-tradables, resources and manufactured goods as follows:

$$g_0(t) = \xi_0 g(t)/p_0(t) \tag{28}$$

$$g_1(t) = \xi_1 g(t)/p_1 \tag{29}$$

$$g_2(t) = (1 - \xi_0 - \xi_1)g(t). \tag{30}$$

If $\xi_j = \theta_j$ for $j = 0, 1, 2$, then the government allocates its expenditures in exactly the same proportions as consumers.

In order to ensure that the government does not violate its solvency condition, a stabilizing rule for taxes is required. A plausible rule is that taxes are a positive function of the outstanding stock of government debt:

$$\tau(t) = \tau^*(t) + \mu b(t) \tag{31}$$

where τ^* is an exogenous component of taxes. Provided $\mu > r - n - \phi$, this rule satisfies the government's solvency condition.

2.4 Market clearing

Market clearing conditions in the goods, labour and assets markets are:

$$\check{y}_0(t) = c_0(t) + \gamma_0(t) + g_0(t) \tag{32}$$

$$\check{y}_1(t) - z_0(t) - z_1(t) = c_1(t) + g_1(t) + \gamma_1(t) + x_1(t) \tag{33}$$

$$m_2(t) = c_2(t) + g_2(t) + i_0(t) + i_1(t) \tag{34}$$

$$ca(t) \equiv \dot{f}(t) = (r - n - \phi)f(t) + [p_1(t)x_1(t) - m_2(t)] \tag{35}$$

$$1 = l_0(t) + l_1(t) \tag{36}$$

$$\bar{w}_0(t) = \bar{w}_1(t) \tag{37}$$

$$w_t = w_0(t) + w_1(t) \tag{38}$$

$$a(t) = q_0(t)k_0(t) + q_1(t)k_1(t) + b(t) + f(t) \tag{39}$$

$$y(t) = p_0(t)y_0(t) + p_1y_1(t) \tag{40}$$

$$\text{GDP} = p_0(t)\check{y}_0(t) + p_1\check{y}_1(t) - p_1[z_0(t) + z_1(t)]. \tag{41}$$

Conditions (32), (33) and (34) require that demand equal supply in the markets for non-tradables, resources and manufactured goods. The check over output (y) in (32), (33) and (41) denotes that the transactions costs (risk payments) associated with obtaining investment funds have been netted off of output: $\check{y}_j(t) = y_j(t) - \psi q_j(t)k_j(t)/p_j(t)$. Since non-tradables can be neither imported nor exported, (32) is the familiar closed-economy equilibrium condition with the addition of adjustment costs γ_0. Resources are tradable and are exported in the amount $x_1(t)$ as shown in (33). Manufactured goods are not produced in the small economy and therefore all the demand for manufactured goods must be satisfied by imports — $m_2(t)$. The presence of i_0 and i_1 on the right hand side of (34) reflects the fact that capital is formed only from manufactured goods and must therefore be imported. The current account net of the effects of growth $ca(t)$ is defined as the change in net foreign assets $f(t)$ where $f(t)$ is measured per efficiency-adjusted worker. From (35) $ca(t)$ is equal to the trade balance in efficiency units $[p_1(t)x_1(t) - m_2(t)]$ plus interest payments net of growth. Labour market equilibrium requires that the entire labour force be employed and that the wage rates in the non-tradables and resource sectors be equal. This latter condition follows from the fact that labour is perfectly mobile between sectors. Labour income is the sum of the wage payments in the non-tradables and resource sectors. Total assets $a(t)$ equal the sum of the value of equity capital in the non-traded goods and resource industries, plus the

government debt and foreign assets. Finally, equation (40) defines aggregate gross output and (41) defines GDP.

3 Parameters and the steady-state growth path

The dynamic equilibrium model described above cannot in general be solved analytically (except in the steady state). We therefore take recourse to numerical procedures. Specifically, the model is solved using the version of Ray Fair's 'extended path' algorithm available in TROLL. The first step in this numerical exercise is to assign values to the parameters in the model.

The model is loosely calibrated to capture the salient features of the Canadian economy. The resource sector in the model is substantially more capital-intensive than the non-tradables sector. Capital's share of income is set at 42 per cent in the resource sector, and 18 per cent in the non-tradables sector. As a result, while the resource sector is an important producer in the economy, it is less important as an employer and much more dependent on imported inputs. Depreciation is taken to be 5 per cent based on aggregate capital stock data. The adjustment-costs parameters (the γs) are set at 2.0 following Lipton and Sachs (1983). This choice is also consistent with econometric evidence reported by Brechling (1975) which suggests that adjustment costs are small relative to output. On the consumer demand side, non-traded goods in the model have the largest expenditure share in consumption, followed by manufactured goods and resource products. Government expenditure shares are similarly ordered across goods, but more concentrated in non-tradables. The growth rates of the population and productivity are both set at 1 per cent so aggregate variables in the economy grow at a steady-state rate of 2 per cent.

Two particularly important parameters in the model are the rate of time preference (ρ) and the probability of death (π). The probability of death is set at 5 per cent, which implies consumers have a horizon of 20 years. This choice was made on the basis that individuals typically work about 40 years, so the average worker has 20 remaining years. Lundvik (1990) has also recently used a value of π of 5 per cent in his study of Sweden's business cycle. Given π, the rate of time preference was then chosen to match Canada's current ratio of net foreign assets to GDP of about -0.35. The resulting value of ρ is 0.0224, which is well within the plausible range. A complete list of all the parameter choices is given in Table 1 (see Appendix). The resulting steady state of the model is summarized in Table 2.

The model's steady-state growth path is broadly consistent with the stylized features of the Canadian economy. In particular, the ratios to GDP of the aggregate capital stock, the government debt, consumption, investment, and government expenditures in the model all match the corresponding ratios obtained from Canadian data reasonably closely. In addition, labour's 66 per cent share of income in the model accords well with the average value for Canada. Although the model captures the principal features of the Canadian economy, it should be pointed out that the model does differ from the Canadian economy in at least one important respect. Canada has a sizable domestic manufacturing sector (about 19 per cent of GDP) from which the model abstacts. In an attempt to adjust for the absence of a domestic manufacturing sector, the share of manufactured goods in consumption expenditures is lower in the model than in Canada. Despite this adjustment, the model overstates the importance of resources relative to the Canadian economy. This should be kept in mind when viewing the quantitative predictions of the model.

4 The terms of trade and government debt in the steady state

Before considering the dynamic response of the model to shifts in the terms of trade and the government deficit, it is instructive to examine the model's predictions regarding the long-run effects of these shocks. The second column of Table 3 reports the model's steady-state response to a 10 per cent deterioration in the terms of trade. In order to isolate the effects of the terms-of-trade shock, government expenditures, taxes and the government debt are held constant as a proportion of GDP. The third column reports the steady-state effects of an increase in the ratio of government debt to GDP from 80 per cent to 90 per cent.[6] In this case only government expenditures are held constant as a proportion of GDP. The results are reported in terms of the percentage deviations from the original steady state or control.

The terms-of-trade deterioration represents a 10 per cent decline in the price of resources. Resource-producing firms therefore move down their supply curves resulting in a drop in output of resources and a decline in investment in this sector. Wages fall, as do consumption and imports. Faced with lower consumption demand, non-tradables producers also cut back

[6]To put this shock in historical perspective, from 1980 to 1988 Canada's debt-to-GDP ratio rose from 55 per cent to 80 per cent if we include both provincial and federal government debt. If we exclude provincial debt on the basis that much of it represents the debt of productive public corporations, Canada's debt-to-GDP ratio was 28 per cent in 1980 and 49 per cent in 1988.

production and investment. Exports decline both because of the drop in their price and the contraction of the resource sector. These results are relatively standard and have been obtained previously in a Canadian setting by Stuber (1988).

The response of the trade balance is perhaps more surprising. Despite the decline in both the price and output of the export good, the trade surplus increases in the steady state. This result reflects both the impact of the terms-of-trade deterioration on wealth, and the importance of general equilibrium. Following the terms-of-trade deterioration, consumers cut back consumption but not enough to maintain their initial level of financial wealth. Financial wealth therefore decreases leading to a further decline in consumption, since consumption depends on wealth. Consumption and wealth stabilize in the new steady state when wealth has fallen enough to reduce consumption to a sustainable level. The decline in wealth is principally achieved by reducing foreign assets or, more specifically, by increasing foreign liabilities. In order to support this larger foreign debt in the steady state, the small country must run a larger trade balance surplus. In this two-output-sector model, the value of the output of the export good must therefore rise as a proportion of total output, and this is achieved by shifting labour into the resource sector. Labour is attracted to the resource sector as a result of a large depreciation of the real exchange rate that leads to a rise in the price of resources relative to non-tradables. The percentage real exchange rate depreciation is 1.6 times the percentage change in the terms of trade.[7] [8]

To summarize, the negative terms-of-trade shock represents a fall in national wealth which shows up principally as an increase in external debt, and this larger external debt requires a larger trade surplus to be sustained. These predictions are consistent with the findings of Rose (1987) but contrast with the results of Stuber (1988). Using an aggregate

[7]It is straightforward to show that in the steady state the real exchange rate p_0 depends only on the world interest rate r and the terms of trade p_1:

$$\begin{aligned} p_0 &= \left[\frac{(1-\alpha_1-\beta_1)[p_1^{1-\beta_1}\beta_1^{\beta_1}\Phi_1(\alpha_1/(r+\delta_1+\psi))]^{(1/(1-\alpha_1-\beta_1))}}{(1-\alpha_0-\beta_0)[(\beta_0/p_1)^{\beta_0}\Phi_0(\alpha_0/(r+\delta_0+\psi))]^{(1/(1-\alpha_0-\beta_0))}}\right]^{1-\alpha_0-\beta_0} \\ &= f(r,p_1). \end{aligned}$$

Note that $\partial p_0/\partial p_1 > 0$ so a fall in the terms of trade will *always* result in a depreciation of the real exchange rate. The sign of $\partial p_0/\partial r$ is in general ambiguous and will depend on the structural parameters.

[8]In order to translate this fall in p_0 into a change in the aggregate real exchange rate (e), assumptions regarding the behaviour of the price of non-tradables in the foreign country and the foreign country's consumption expenditure share weights are required (see footnote 3). If we assume that the consumption weights are the same in both countries and that the foreign price of non-tradables is *unchanged* following the terms-of-trade shock, then the percentage change in e is 1.1 times the percentage change in the terms of trade.

model of the Canadian economy with an exogenous energy sector, Rose predicts that a fall in the world price of oil (which represents a deterioration in Canada's terms of trade) will lead to a large depreciation of the real exchange rate, an increase in foreign liabilities and a long-run increase in the trade surplus.[9] Stuber's static three-sector model, in contrast, predicts that the price of non-tradables relative to manufactured goods and the trade balance are unchanged following a terms-of-trade deterioration. These divergent predictions largely reflect the different roles for wealth in the various models. In both the current paper and in Rose, consumption depends on wealth, whereas in Stuber there is no explicit role for wealth.

Interestingly, the results reported in Table 3 also appear broadly consistent with the experience of a number of resource-based Latin American economies following the decline in world commodity prices in the first half of the 1980s. Chile, for example, encountered a 20 per cent terms-of-trade deterioration between 1980 and 1984 largely owing to a sharp drop in the world price of copper. Over the same period, Chile's external debt rose from 40 to 96 per cent of GDP and efforts to promote export growth were undertaken in an attempt to stem this expansion of the external debt.

If we turn next to the effects of a permanent rise in the level of the government debt, the third column of Table 3 reveals several similarities with the terms-of-trade shock. Since consumers in this non-Ricardian model perceive some portion of the government debt to be net wealth, the rise in government debt crowds out wealth in the form of foreign assets. The small country's foreign liabilities therefore rise. Once again the small country must increase its trade balance surplus in order to make the additional interest payments on its now-larger foreign debt. This is achieved by raising aggregate output and by lowering aggregate consumption. The total labour force is exogenous, so the rise in output requires the aggregate capital-labour ratio to increase. The increase in capital is concentrated in the export sector, which results in a shift of labour into resource production at the expense of non-tradables. Consumption falls because taxes must increase in order to sustain the the larger government debt. In equilibrium, the real exchange rate is unchanged, reflecting the fact that capital adjusts between the two sectors just enough in equilibrium to return

[9]Rose (1987) reports that a 30 per cent decline in the average price of energy results in a 12 per cent depreciation of the aggregate real exchange rate. Since the energy sector is about 40 per cent of the resource sector, this energy shock translates into a 12 per cent deterioration in the terms of trade. This gives rise to an elasticity of the aggregate real exchange rate (e) with respect to the terms of trade of unity, which is very close to the elasticity of 1.1 obtained in the current study (see footnote 8).

this price to its pre-shock level.[10] Since relative prices are unchanged, consumption of all three goods declines in proportion. In summary, as Obstfeld (1989) points out, the long-run effect of government debt is to 'crowd in' capital. The aggregate capital stock rises, but this additional capital is working to produce exports for foreigners. The model predicts a 0.4 per cent increase in the aggregate capital stock, and a 1.4 per cent rise in exports. Consumption of all three goods declines by 0.6 per cent.

5 Dynamic effects of a temporary terms-of-trade shock: I

The first shock considered with the dynamic model is a temporary deterioration in the terms of trade. Since the shock is temporary, the economy's steady state is unchanged but, as the simulation results make clear, this temporary shock can have important short- and medium-term effects. The specific shock considered is again a 10 per cent drop in the price of resources relative to manufactured goods, this time lasting for four years. Table 4 reports the simulation results, and Figure 3 summarizes the dynamics graphically.

The drop in the relative price of resources results in an immediate fall in the price of equity capital in resource firms. This drop in q_1 below its baseline value of unity leads to a 46 per cent reduction in investment in the resource sector. Labour leaves the resource sector, and inputs of resources in the resource sector also decline, despite the fact that the relative price of resources has fallen. Since all three inputs in the production of resources are cut back, output in the resource sector declines.

The effect of the deterioration in the terms of trade is transmitted to the non-traded-goods sector via the real exchange rate. The negative terms-of-trade shock leads to a fall in wages and this results in a drop in human wealth. Since all consumption goods are normal, this leads to a drop in consumer expenditures on all goods. The fall in demand for non-tradables requires a reduction in their relative price — the real exchange rate — to equilibrate demand and supply in this market. The resulting 6.7 per cent depreciation of the real exhange rate leads to a 1.2 per cent drop in the value of equity capital in non-traded-goods firms which in turn precipitates a 12.6 per cent drop in investment. Despite the fall in capital, output in the non-traded-goods sector rises because labour shifts into the non-tradables sector, and inputs of resources rise because their relative price has fallen. These short-run effects of a temporary terms-of-trade deterioration are markedly different from the steady-state effects

[10] As shown in footnote 7, the steady-state real exchange rate is independent of the government debt.

of the permanent shock examined above. In particular, the depreciation of the real exchange rate is now smaller than the percentage change in the terms of trade. As a result, the price of non-tradables relative to resources rises and labour now migrates to the non-tradables sector.

With respect to the economy's external balance, the deterioration in the terms of trade leads to a fall in both exports and imports. Exports decline both because of the drop in their price and the fall in resource production. The decline in imports reflects a drop in both investment and consumption expenditures on manufactured goods. Since the value of exports falls more than imports, the trade balance turns negative. This trade deficit is financed by foreign borrowing, which shows up as a current account deficit and a decline in foreign assets. Foreign borrowing during this temporary deterioration in the terms of trade finances consumption. As a result, consumption falls by less than output — 4.1 per cent as compared to 10.0 per cent.

After the shock is over, the economy moves back towards its initial steady state. This necessitates a surplus in the current account to repay foreign lenders. Notice, however, that the current account remains negative for a number of years after the shock — 9 years to be precise. This stems from the fact that, owing to costly adjustment of capital, output remains below control for some time following the shock. Therefore, consumption-smoothing households continue borrowing from abroad even after the terms of trade have returned to their initial level. This lasting effect of the terms-of-trade deterioration on the current account results in a large percentage decline in foreign assets. At their lowest point, foreign assets reach 66 per cent below control and this occurs 9 years after the terms-of-trade shock is over. The specific number of years it takes for foreign asssets to turn around following the shock is sensitive to the choice of π. The higher the value is for π, the shorter will be consumers' horizons, and the faster household assets will adjust to the steady state. Nonetheless, for any positive π the persistence of the current account imbalance is increasing in the costs of adjusting capital.

In general, the simulation results point out the role of asset prices and the real exchange rate in transmitting the terms-of-trade disturbance to investment and output in both sectors. In addition, the simulation results highlight the intertemporal nature of the optimization problems facing consumers and firms. The importance of consumption smoothing in the determination of the current account is well known thanks to a growing list of pa-

pers including Buiter (1981), Sachs (1981), Obstfeld (1981,1982,1983), Bruno (1982a,1982b), Svensson and Razin (1983), Greenwood (1983,1984), Persson and Svensson (1985), Frenkel and Razin (1986), and Stockman and Svensson (1987). The role of adjustment costs in current account dynamics has, however, received less attention. Faced with increasing costs of installing capital, profit-maximizing firms smooth investment to reduce these costs. The simulation results reveal that this investment smoothing, when combined with the consumption smoothing of households, adds persistence to current account imbalances. The outcome is that current account imbalances can take some time to turn around even after the initial shock has dissipated. This finding may shed some light on the ongoing debate regarding the causes of the persistence in the external imbalances of several of the world's major industrialized countries.[11] In particular, the simulation results suggest that this persistence may reflect the underlying structure of the economy.

6 Dynamic effects of a government debt shock

The next shock to be considered is an increase in the level of government debt. The rise in the government debt is achieved by a temporary tax cut. Specifically, taxes are cut by 10 per cent for four years. Since government expenditures are held constant, the tax cut results in a shortfall in government revenues that must be financed by running budget deficits. This results in a rise in the ratio of government debt to GDP from 80 per cent to 90 per cent. At the end of the four years, taxes rise above control according to the rule $\tau = \tau^* + \mu b$. Since μ is relatively low (6 per cent), this tax rule results in a very slow payoff of the additional debt stemming from the temporary tax cut. Forty years after the shock, the debt is still 4 per cent above control, and it is within 1 per cent of control by year ninety. The tax-cum-debt shock therefore gives current consumers a short-term tax break that is paid off over the following 100 or so years. Table 5 and Figure 4 present the simulation results.

To the extent that the temporary tax cut shifts taxes to the unborn, the tax cut raises the wealth of those currently alive, thereby stimulating current consumption. In a closed economy, this rise in consumption requires an increase in the equilibrium real interest rate in order to reduce human wealth and dampen consumer demand. In an open economy facing a given world interest rate, it is the real exchange rate that must rise to choke off consumer

[11]See Hooper and Mann (1987) and Helkie and Hooper (1987,1989) for a discussion of the causes of the persistence of the U.S. external deficit.

demand. This appreciation of the real exchange rate has reallocative effects. Investment in the non-traded-goods sector rises, and labour and resource inputs shift into the production of non-tradables. The resulting decline in labour in the resource sector lowers the marginal product of capital in this sector and investment therefore declines. The short-run effect of the tax cut is thus to crowd out the export sector. Note that while these effects are all present in the model, quantitatively they are small. The real exchange rate appreciates by only 0.4 per cent, and output in the resource and non-tradable sectors changes by -0.4 and +0.3 per cent respectively. The short-run effects on aggregate output are even smaller, since the opposite movements in the two sectors largely cancel each other out.

The rise in the wealth of those currently alive results in a 0.9 per cent increase in the consumption of manufactured goods and resources, and a 0.5 per cent increase in consumption of non-tradables. The impact of the rise in the consumption of manufactured goods on the domestic demand for imports is dampened by a fall in aggregate investment. Nevertheless, imports increase following the tax cut. Exports, on the other hand, fall because consumption of resources is up and production is down. The trade balance therefore turns negative, and the current account runs a deficit, resulting in a decline in foreign assets. The model's short-run response to the debt-cum-tax shock is thus consistent with the positive 'twin deficits' relationship found by Feldstein (1982) for the United States, Leiderman and Razin (1988) for Israel, and Johnston (1986) for Canada.

Four years after the initial tax cut, taxes rise slightly above control and the economy begins the slow payoff of the additional government debt stemming from the temporary tax cut. Despite the rise in taxes, consumption remains above control for a number of years. This persistence in consumption reflects the fact that consumption depends on household wealth, which has been augmented by the net wealth component of the additional government debt. Persistence in consumption shows up as persistence in the current account deficit and continued growth of foreign liabilities. Essentially, consumers finance current consumption by selling their holdings of domestic government debt to foreigners. As a result of this sell-off, the wealth of domestic consumers eventually declines below control, and consumption is cut back.

These simulation results have interesting implications for the voluminous empirical literature that tests the validity of the Ricardian equivalence proposition. Although this literature has produced very mixed results, a pattern is apparent. Tests of Ricardian equivalence that

focus on the relationship between government deficits and relative prices generally find no significant effects of deficits. Tests on consumption data are about equally split for and against, and tests that examine the relationship between the government deficit and the current account deficit typically reject debt neutrality.[12] The simulation results reported in Table 4 offer a possible explanation for this pattern. Ricardian equivalence does not hold in the model studied in this paper owing to the assumptions of growth with disconnected agents and finite horizons. Government deficits in this forward-looking optimizing model will in general have real effects on the exchange rate, consumption and the current account. The simulation results, however, suggest government deficits have very small short-run effects on the real exchange rate, but slightly stronger effects on consumption, and larger effects on the current account. This suggests that it may be more difficult to identify statistically significant effects of government budget deficits on relative prices as compared with current account deficits. This hypothesis could be more thoroughly investigated by conducting Monte Carlo experiments with a stochastic version of the model, but this is beyond the scope of the current paper.

7 Dynamic effects of a temporary terms-of-trade shock: II

The temporary terms-of-trade shock considered in Section 5 held both tax revenues and government expenditures constant. The deterioration in the terms of trade therefore had no impact on the government's fiscal stance. This constancy of tax revenues and government expenditures implies that the effective tax rate facing consumers rose when incomes fell following the deterioration in the terms of trade. A more reasonable assumption might be that taxes are held constant as a proportion of income. If this is the case, and government expenditures remain constant, shifts in the terms of trade will affect the government deficit, and the resulting shifts in the deficit will themselves have real effects.

To study the interaction between terms-of-trade shocks and government deficits, the

[12]In a series of papers using data from a number of countries, Evans (1985,1986,1987a,1987b) finds no evidence to support the view that government deficits affect either interest rates or exchange rates. In contrast, Feldstein (1982), Leiderman and Razin (1988) and Johnston (1986) all find a statistically significant positive relationship between government budget deficits and current account deficits. An exception is Ahmed (1987) who finds no affects of government deficits on the trade balance using British data, although he does find that deficits in this large country affect the terms of trade. As for the consumption data, papers finding no significant wealth effects of government debt include Kormendi (1983), Seater and Mariano (1985), Aschauer (1985), and Evans (1985,1988). Papers on the other side of the fence include Yarwitz and Meyer (1976), Reid (1985), Modigliani and Sterling (1986), and Bernheim (1987).

government's tax rule (equation (31)) is replaced with:

$$\tau = \lambda w + \mu b. \tag{42}$$

Taxes are therefore proportional to wage income as well as to the level of the government debt. Note that since labour is supplied inelastically, this tax rule does not distort the labour-leisure decision. The tax rate λ was chosen so that the steady state of the new model would be exactly the same as with the original tax rule. This resulted in a choice for λ of 22.4 per cent. The temporary deterioration in terms of trade studied in Section 5 is then reconsidered. Table 6 reports the results and Figure 5 depicts the economy's short-run dynamics.

Qualitatively, the results are very similar to the pure terms-of-trade shock considered in Section 5. Quantitatively, however, there are some important differences. The decline in wages following the deterioration in the terms of trade now results in a fall in government tax revenues which must be financed by issuing government debt. This debt-financed reduction in tax revenues dampens the effect of the terms-of-trade deterioration on human wealth, so consumption falls by less than it did with the pure terms-of-trade shock— 3.6 per cent compared with 4.1 per cent. Demand for non-tradables therefore drops by less, so the depreciation of the real exchange rate is also dampened. This reduced response of the real exchange rate has the effect of magnifying the reallocation of the factors of production between sectors, because the change in the price of resources relative to non-traded goods is now larger. Output in the resource sector drops by 8.7 per cent compared with 8.4 per cent in the case of the pure terms-of-trade shock, and output of non-tradables now rises by 4.2 per cent compared with 4.0 per cent. The smaller drop in consumption, together with the larger decline in output of the export good, results in both larger and longer-lasting trade balance and current account deficits, and a larger change in foreign liabilitites. Note also the important role of costly adjustment of capital in the dynamics of the government deficit. As a result of costly adjustment of capital, wages remain below control for several years after the terms-of-trade shock has dissipated. The effect of the negative terms-of-trade shock on tax revenues and thus on the budget deficit therefore persists longer than the shock itself.

Table 7 reports the welfare effects of the terms-of-trade deterioration on consumers who are alive at the time of the shock. Welfare is expressed in terms of consumption and reported using two different measures. The first column of Table 7 reports the change in welfare in terms of the permanent change in steady-state consumption that it implies. The second

column reports the same change in welfare in terms of the change in consumption that it implies over a single year. The pure terms-of-trade shock results in a welfare loss equal to a 12.6 per cent drop in consumption in one year. When the government runs a deficit during the downturn associated with a negative terms-of-trade shock, this welfare loss is reduced to a 10.5 per cent drop in consumption over one year. This represents an improvement in welfare equal to a 2.1 per cent increase in consumption for one year. This welfare gain for those currently alive is achieved at the expense of future generations.

8 Conclusions

This paper constructs an intertemporal model of a growing, resource-based small open economy. The model is loosely calibrated to the Canadian economy and solved numerically. The simulations focus on the steady-state and dynamic effects of shifts in the terms of trade and the government debt. In general the results highlight the role played by asset prices and the real exchange rate in the reallocation of the factors of production between sectors, the importance of general equilibrium considerations, and the intertemporal aspects of consumer and firm behaviour in a dynamic setting. A number of more specific conclusions also emerge.

In the steady state, a deterioration in the terms of trade results in an increase in the small country's external debt which necessitates a larger trade surplus to be sustained. The export sector must therefore expand as a proportion of output. This is achieved by a depreciation of the real exchange rate that is larger than the deterioration in the terms of trade and by an increase in employment in the resource sector at the expense of non-tradables. A steady-state increase in the government debt also results in higher foreign debt and a larger trade surplus. Government debt crowds in capital and the export sector. Thus, although the aggregate capital stock and output increase, domestic consumption falls. The increase in capital is concentrated in the export sector and is essentially working for foreigners.

In the short run, a temporary terms-of-trade deterioration results in a contraction in the export sector as a proportion of output, and a rise in foreign liabilities. The depreciation of the real exchange rate is now less than the change in the terms of trade. The simulations also reveal that costly adjustment of capital affects not only the economy's short-run dynamics, but also its medium-term behaviour. Investment smoothing by firms, when combined with consumption smoothing by households, adds persistence to current account imbalances.

The short-run effects of an increase in the government debt include an appreciation of

the real exchange rate, increases in consumption, imports and foreign debt, and a fall in exports. The appreciation of the real exchange rate crowds out the export sector, and the capital stock is run down. These short-run effects are reversed in the medium term since the burden of both higher government and foreign debts requires both lower consumption and a shift in production towards the capital-intensive export good.

Efforts by the government to smooth the burden of taxes in the face of a temporary shift in the terms of trade will result in temporary government deficits. These deficits smooth consumption but magnify both current account imbalances and the reallocation of the factors of production between sectors. By magnifying current account imbalances, this tax-smoothing policy adds persistence to the real effects of this temporary disturbance.

The model presented in this paper abstracts from a number of important features of real world economies. In the Canadian context, the assumption that the small economy is entirely dependent on imports to satisfy domestic demand by consumers and firms for manufactured goods is somewhat extreme. Canada has an important domestic manufacturing sector, and although it is a net importer of manufactured goods, manufactured goods also form a significant component of exports. By diversifiying the economy, the effect of introducing a domestic manufacturing sector into the model would be to reduce the impact of terms-of-trade disturbances on the current account, foreign indebtedness and welfare. On a broader level, the role of government in the model also demands greater attention. This paper makes no attempt to characterize benefits of various government spending programs which, presumably, explain the need for governments and taxes in the first place. In general the effects of government budget deficits may depend on what types of programs they are used to finance. Finally, perhaps the most unrealistic assumption is that, with the exception of uncertain lifetimes, consumers and firms in the model are blessed with perfect foresight. In the absence of perfect foresight, consumers form expectations about the future on the basis of available information and only learn the actual time path of the various shocks they face as history unfolds. In general, uncertainty will affect the economy's dynamic response to disturbances and, if agents are risk-averse, it will also affect the economy's (stochastic) steady state. In recent years a great deal of progress has been made in modelling behaviour in stochastic dynamic environments, but solving a stochastic version of a multi-sector small open economy model such as the one studied in this paper remains an ambitious task.

APPENDIX

Table 1

Values for the Structural Parameters and Exogenous Variables

$n = 0.01$	$\phi = 0.01$	$\delta_0 = 0.05$	$\delta_1 = 0.05$
$\alpha_0 = 0.18$	$\alpha_1 = 0.42$	$\beta_0 = 0.07$	$\beta_1 = 0.20$
$\eta_0 = 2.00$	$\eta_1 = 2.00$	$\psi = 0.09$	$\rho = 0.0224$
$\pi = 0.05$	$\theta_0 = 0.75$	$\theta_1 = 0.08$	$\xi_0 = 0.85$
$\xi_1 = 0.08$	$\mu = 0.06$	$\tau^* = \nu_\tau \text{GDP}$	$\nu_\tau = 0.176$
$g = \nu_g \text{GDP}$	$\nu_g = 0.20$	$r = 0.05$	$p_1 = 1.00$

Table 2

Selected Ratios Describing the Model's Initial Steady State

k/GDP=2.1	$l_0 = 0.68$
b/GDP=0.8	$k_0/k = 0.31$
f/GDP=-0.35	$k_1/k = 0.69$
c/GDP=0.64	$p_0 y_0/y = 0.52$
i/GDP=0.15	$p_1 y_1/y = 0.48$
g/GDP=0.20	$p_0 = 0.75$

Table 3

Steady-State Effects of Terms-of-Trade and Government Debt Shocks

	Shock	
Variables	T-O-T†	*Debt*‡
i_0	-20.3	-0.4
i_1	-19.0	0.8
i	-19.4	0.4
k_0	-20.3	-0.4
k_1	-19.0	0.8
k	-19.4	0.4
z_0	-11.4	-0.4
z_1	-10.0	0.8
l_0	-0.5	-0.4
y_0	-5.2	-0.4
y_1	-10.0	0.8
y	-19.7	0.2
w	-19.8	0
h	-25.2	-0.6
p_0	-15.9	0
c_0	-10.9	-0.6
c_1	-16.6	-0.6
c_2	-25.1	-0.6
c	-25.1	-0.6
τ	-6.8	1.4
b	-6.8	12.6
g_0	10.9	0.1
g_1	3.6	0.1
g_2	-6.8	0.1
g	-6.8	0.1
$p_1 x_1$	-18.4	1.3
m_2	-21.0	0.0
$p_1 x_1 - m_2$	48.2	34.4
f	-48.2	-34.4
a	-24.8	-0.5
GDP	-6.8	0.1
k/GDP	-13.5	0.3
b/GDP	0.0	12.5
f/GDP	-59.0	-34.3
c/GDP	-19.6	-0.7

† The terms of trade deteriorate permanently by 10 per cent.
‡ The government debt-to-GDP ratio rises from 0.80 to 0.90.

Table 4

Dynamic Effects of a Temporary Deterioration in the Terms of Trade: I†

	Years							
Variables	1	2	3	4	5	10	25	40
q_0	-1.2	-0.9	-0.6	-0.4	-0.3	0.1	0.1	0
q_1	-5.8	-3.8	-1.8	0.2	2.5	1.3	-0.2	-0.1
i_0	-12.6	-10.2	-8.0	-6.2	-4.7	-1.7	-0.7	-0.9
i_1	-46.0	-32.2	-19.1	-4.5	10.7	7.4	0.2	-0.4
i	-35.7	-25.3	-15.7	-5.1	5.9	4.6	-0.1	-0.5
k_0	0	-0.9	-1.5	-2.0	-2.3	-2.5	-1.4	-1.0
k_1	0	-3.2	-5.3	-6.2	-6.1	-1.4	1.4	0.1
k	0	-2.5	-4.1	-4.9	-4.9	-1.8	0.5	-0.2
z_0	8.1	7.9	7.8	7.8	-2.9	-2.5	-1.4	-1.0
z_1	-3.7	-6.1	-7.6	-8.4	-3.4	0.1	1.7	0.6
l_0	3.6	4.4	4.8	5.1	0.2	-0.9	-1.0	-0.5
y_0	3.3	3.6	3.9	4.0	-0.5	-1.3	-1.1	-0.6
y_1	-3.7	-6.1	-7.6	-8.4	-3.4	0.1	1.7	0.6
y	-7.9	-9.0	-9.7	-10.0	-3.2	-1.2	0.1	-0.2
w	-6.1	-7.0	-7.4	-7.7	-3.1	-1.7	-0.4	-0.5
h	-4.0	-3.9	-3.4	-2.8	-2.0	-1.0	0.1	0.1
p_0	-5.8	-6.3	-6.6	-6.7	-2.4	-1.2	-0.3	-0.4
c_0	2.1	2.4	2.6	2.8	-1.6	-2.2	-1.6	-1.0
c_1	6.8	6.6	6.6	6.6	-4.0	-3.4	-1.9	-1.3
c_2	-3.9	-4.1	-4.1	-4.1	-4.0	-3.5	-1.9	-1.3
c	-3.9	-4.1	-4.1	-4.1	-4.0	-3.5	-1.9	-1.3
τ	0	0	0	0	0	0	0	0
def^*	0	0	0	0	0	0	0	0
b	0	0	0	0	0	0	0	0
g_0	6.1	6.7	7.0	7.1	2.4	1.2	0.3	0.4
g_1	11.1	11.1	11.1	11.1	0	0	0	0
g_2	0	0	0	0	0	0	0	0
g	0	0	0	0	0	0	0	0
p_1x_1	-21.6	-24.9	-27.2	-28.9	-3.5	1.4	3.3	1.5
m_2	-21.2	-15.5	-10.2	-4.4	1.6	1.1	-0.8	-0.8
$p_1x_1 - m_2$	-34.7	-263.6	-462.5	-656.8	-135.9	7.0	108.7	60.8
ca^*	-1.8	-14.0	-25.0	-36.1	-9.5	-3.5	3.0	1.4
f	0	-1.0	-9.0	-23.1	-43.5	-62.3	-53.0	-33.2
a	-3.6	-4.5	-5.8	-7.2	-8.8	-9.3	-6.9	-4.8

† The terms of trade deteriorate by 10 per cent for four years.

* The variable $def = db/dt$ is the government's budget deficit. Since the deficit and the current account must be zero in the steady state (when variables are measured in efficiency units), reported values for ca and def are level changes ($\times 10^{-3}$) shock minus control. All other variables are reported as the percentage change shock minus control.

Table 5

Dynamic Effects of an Increase in the Government Debt†

	Years							
Variables	1	2	3	4	5	10	25	40
q_0	0.3	0.1	0.1	0	0	0	0	0
q_1	-0.2	-0.2	-0.1	-0.1	-0.1	0	0	0
i_0	3.0	1.6	0.8	0.5	0.2	-0.2	-0.4	-0.2
i_1	-1.4	-1.4	-1.2	-1.0	-0.9	-0.1	0.8	0.6
i	0	-0.5	-0.6	-0.5	-0.5	-0.1	0.5	0.4
k_0	0	0.2	0.3	0.3	0.4	0.2	-0.1	-0.2
k_1	0	-0.1	-0.2	-0.3	-0.3	-0.4	0.2	0.6
k	0	0	0	-0.1	-0.1	-0.2	0.1	0.3
z_0	0.6	0.6	0.5	0.5	0.4	0.3	-0.2	-0.2
z_1	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	0.3	0.6
l_0	0.3	0.3	0.3	0.3	0.3	0.2	-0.1	-0.3
y_0	0.3	0.3	0.3	0.3	0.3	0.2	-0.1	-0.2
y_1	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	0.3	0.6
y	0.2	0.1	0.1	0	0	-0.1	0	0.2
w	0.3	0.3	0.2	0.2	0.2	0	0	0
h	1.3	0.9	0.4	0	-0.4	-0.4	-0.3	-0.2
p_0	0.4	0.3	0.2	0.2	0.1	0	0	0
c_0	0.5	0.5	0.5	0.5	0.4	0.3	-0.2	-0.3
c_1	0.9	0.8	0.7	0.7	0.6	0.3	-0.2	-0.3
c_2	0.9	0.8	0.7	0.7	0.6	0.3	-0.2	-0.3
c	0.9	0.8	0.7	0.7	0.6	0.3	-0.2	-0.3
τ	-10.0	-10.0	-10.0	-10.0	2.5	2.2	1.4	0.9
def^*	11.2	11.5	11.8	12.2	-1.4	-1.2	-0.8	-0.5
b	0	2.8	5.7	8.7	11.7	10.1	6.4	4.0
g_0	-0.4	-0.3	-0.2	-0.2	-0.1	0	0	0
g_1	0	0	0	0	0	0	0	0
g_2	0	0	0	0	0	0	0	0
g	0	0	0	0	0	0	0	0
$p_1 x_1$	-0.7	-0.6	-0.8	-0.8	-0.8	-0.7	0.4	0.9
m_2	0.3	0.1	0	0	0	0	0.1	0.1
$p_1 x_1 - m_2$	-28.2	-21.9	-20.4	-21.2	-21.6	-18.6	6.6	20.8
ca^*	-1.5	-1.2	-1.2	-1.3	-1.3	-1.3	-0.4	0
f	0	-0.8	-1.5	-2.2	-2.9	-6.7	-14.7	-15.4
a	0	0.7	1.5	2.3	3.1	2.1	0.2	-0.6

† Taxes are cut by 10 per cent for four years and then rise above control to pay off the additional debt over the next 100 or so years.

*The variables *def* and *ca* are reported in terms of their level change ($\times 10^{-3}$) shock minus control. All other variables are reported as the percentage change shock minus control.

Table 6

Dynamic Effects of a Temporary Deterioration in the Terms of Trade: II†

	Years							
Variables	1	2	3	4	5	10	25	40
q_0	-1.1	-0.8	-0.6	-0.4	-0.3	0.1	0.1	0
q_1	-6.0	-4.0	-2.0	0.1.2	2.5	1.3	-0.1	-0.1
i_0	-10.8	-8.9	-7.2	-5.7	-4.5	-1.9	-0.9	-0.8
i_1	-47.4	-33.5	-20.2	-5.5	10.0	7.3	1.0	-0.3
i	-35.9	-25.8	-16.1	-5.5	5.5	4.5	0.5	-0.5
k_0	0	-0.8	-1.3	-1.7	-2.0	-2.3	-1.5	-1.1
k_1	0	-3.3	-5.4	-6.5	-6.4	-1.7	1.7	0.6
k	0	-2.5	-4.1	-5.0	-5.0	-1.9	0.7	0
z_0	8.5	8.3	8.2	8.2	-2.6	-2.4	-1.5	-1.1
z_1	-3.9	-6.4	-8.0	-8.7	-3.7	-0.2	2.0	1.0
l_0	3.8	4.6	5.1	5.3	0.4	-0.7	-1.2	-0.6
y_0	3.5	3.9	4.1	4.2	-0.2	-1.1	-1.4	-0.8
y_1	-3.9	-6.4	-8.0	-8.7	-3.8	-0.2	2.0	1.0
y	-7.7	-8.9	-9.6	-10.0	-3.2	-1.3	0.2	-0.1
w	-5.9	-6.8	-7.3	-7.5	-3.0	-1.7	-0.4	-0.4
h	-3.2	-3.2	-2.9	-2.5	-2.0	-1.3	-0.3	-0.1
p_0	-5.6	-6.1	-6.4	-6.5	-2.3	-1.3	-0.3	-0.3
c_0	2.4	2.7	3.0	3.1	-1.2	-2.0	-1.8	-1.1
c_1	7.4	7.2	7.1	7.1	-3.5	-3.2	-2.1	-1.5
c_2	-3.3	-3.5	-3.6	-3.6	-3.5	-3.2	-2.1	-1.5
c	-3.3	-3.5	-3.6	-3.6	-3.6	-3.2	-2.2	-1.5
τ	-4.7	-5.0	-5.1	-5.0	-1.1	0.3	1.2	0.8
def^*	5.2	5.8	6.1	6.1	1.9	0.6	-0.5	-0.3
b	0	1.3	2.8	4.3	5.8	7.4	6.8	5.3
g_0	5.9	6.5	6.9	7.0	2.3	1.3	0.3	0.3
g_1	11.1	11.1	11.1	11.1	0	0	0	0
g_2	0	0	0	0	0	0	0	0
g	0	0	0	0	0	0	0	0
p_1x_1	-22.1	-25.4	-27.8	-29.5	-4.2	0.8	3.7	2.0
m_2	-21.1	-15.6	-10.3	-4.5	1.6	1.2	-0.6	-0.8
$p_1x_1 - m_2$	-48.7	-277.1	-476.5	-671.3	-153.1	-10.3	113.8	75.2
ca^*	-2.6	-14.8	-25.8	-36.9	-10.5	-4.1	2.6	1.5
f	0	-1.5	-9.8	-24.4	-45.3	-67.2	-65.4	-46.1
a	-3.7	-4.2	-5.1	-6.2	-7.3	-7.8	-6.3	-4.7

† The terms of trade deteriorate by 10 per cent for four years. Taxes are proportional to wages.

* The variables def and ca are reported in terms of their level change ($\times 10^{-3}$) shock minus control. All other variables are reported as the percentage change shock minus control.

Table 7

Welfare Effects of Various Shocks

Shock	Δ *Lifetime consumption %*	Δ *1-year consumption %*
(1) Terms-of-trade I	-1.22	-12.64
(2) Government debt	0.27	2.97
(3) Terms-of-trade II	-1.01	-10.52
Difference (3)-(1)	0.21	2.12

Figure 1
Canada's Terms of Trade

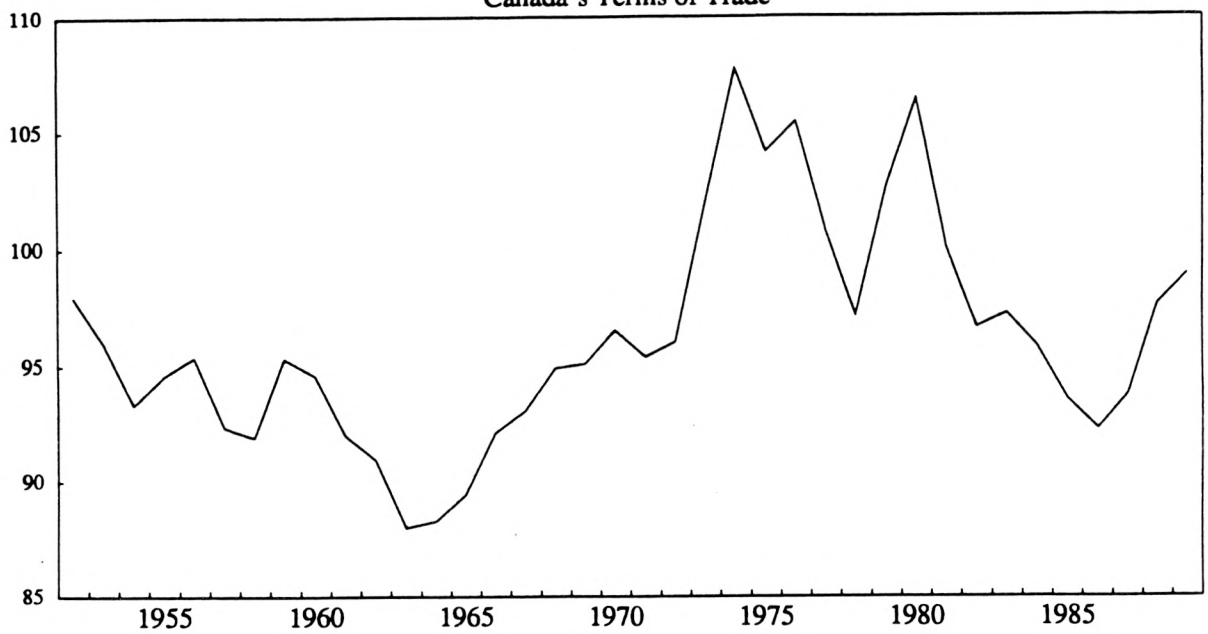


Figure 2
Canada's Consolidated Real Government Budget Deficit

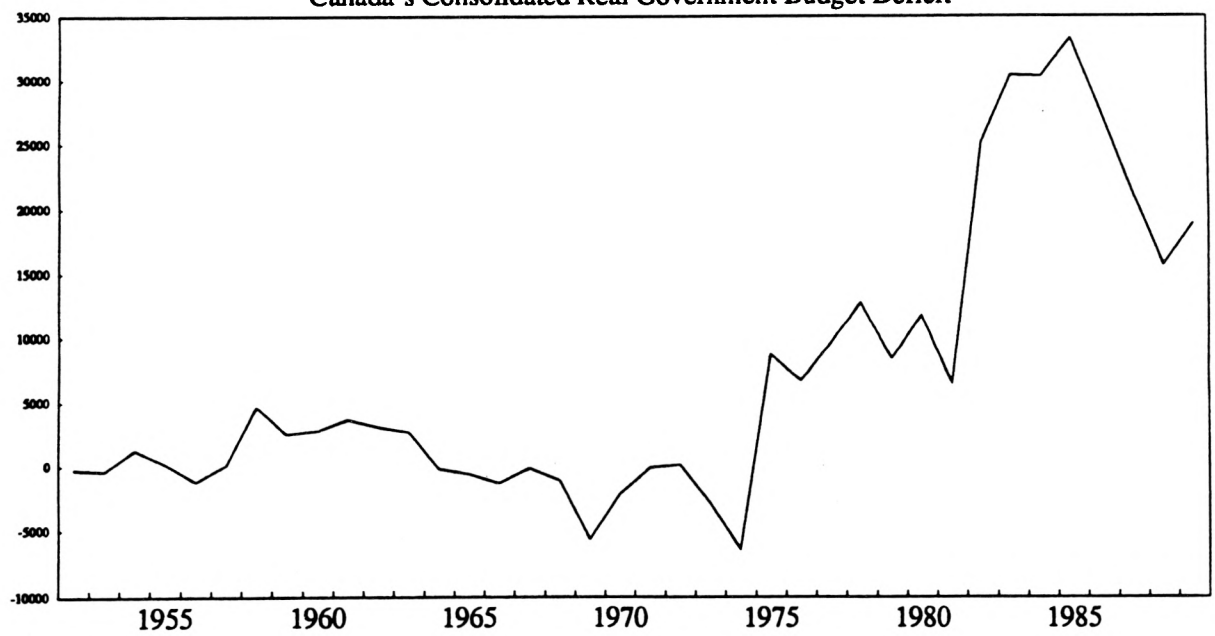


Figure 3
Dynamic Effects of a Temporary Deterioration in the Terms of Trade: I

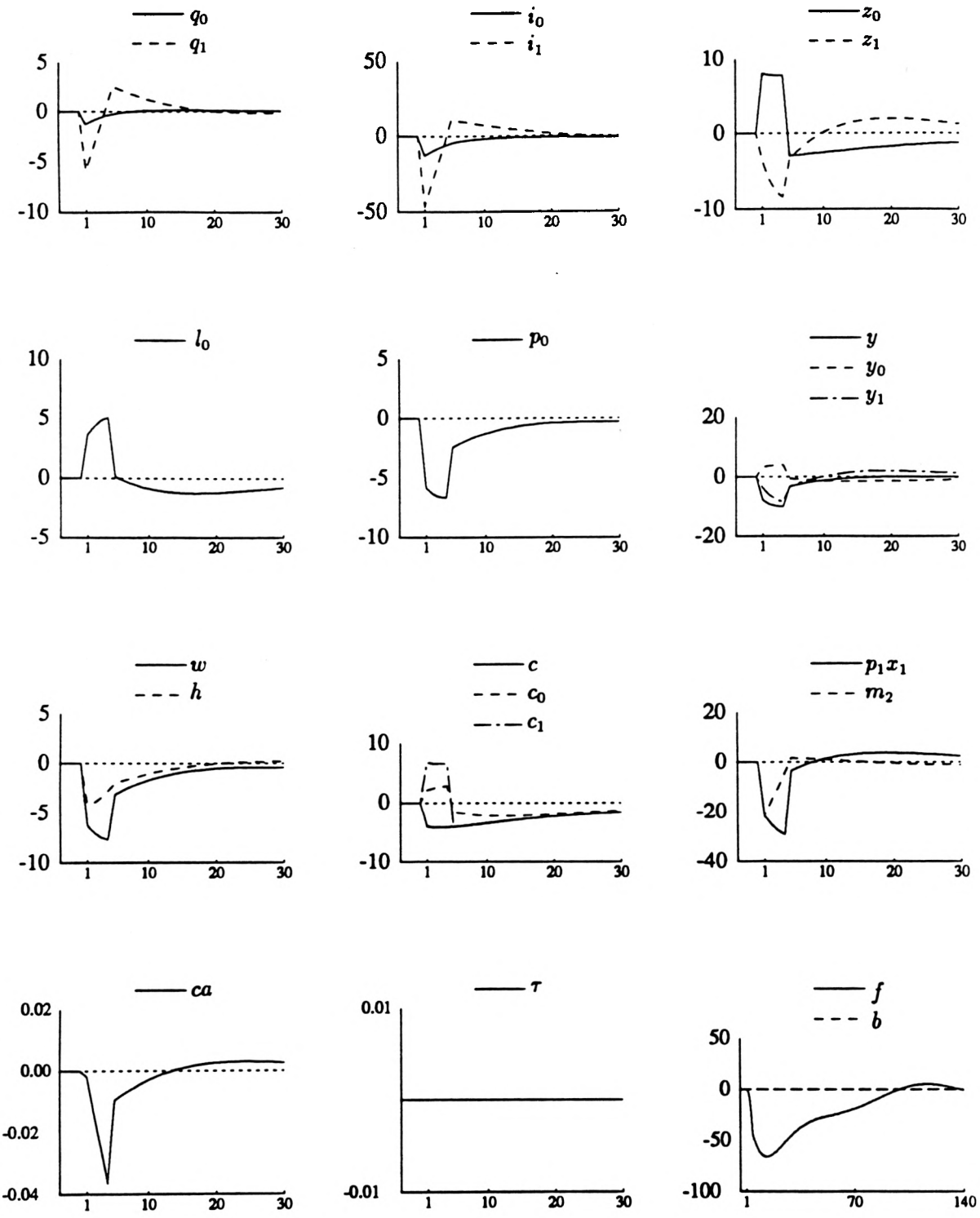


Figure 4
Dynamic Effects of an Increase in the Government Debt

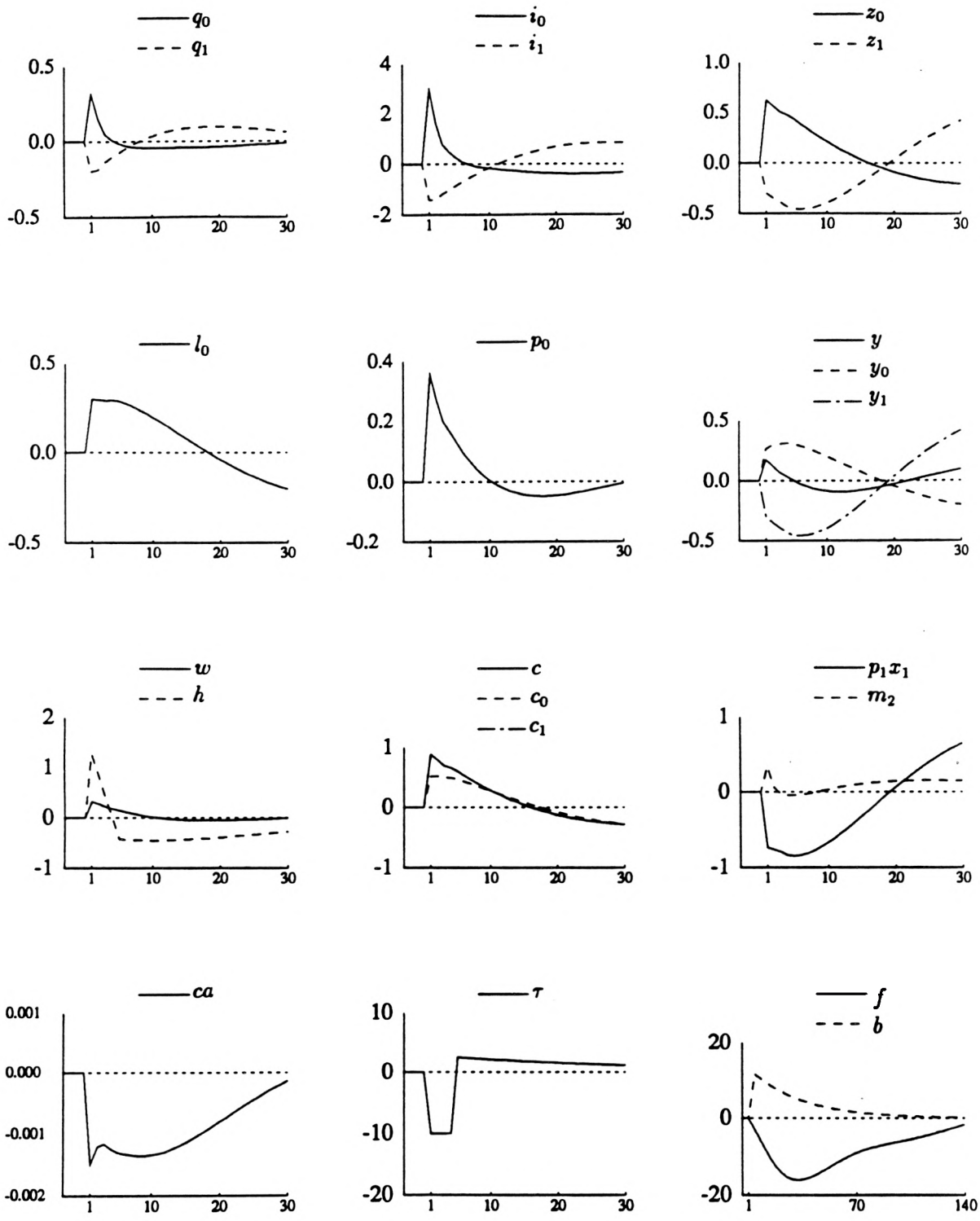
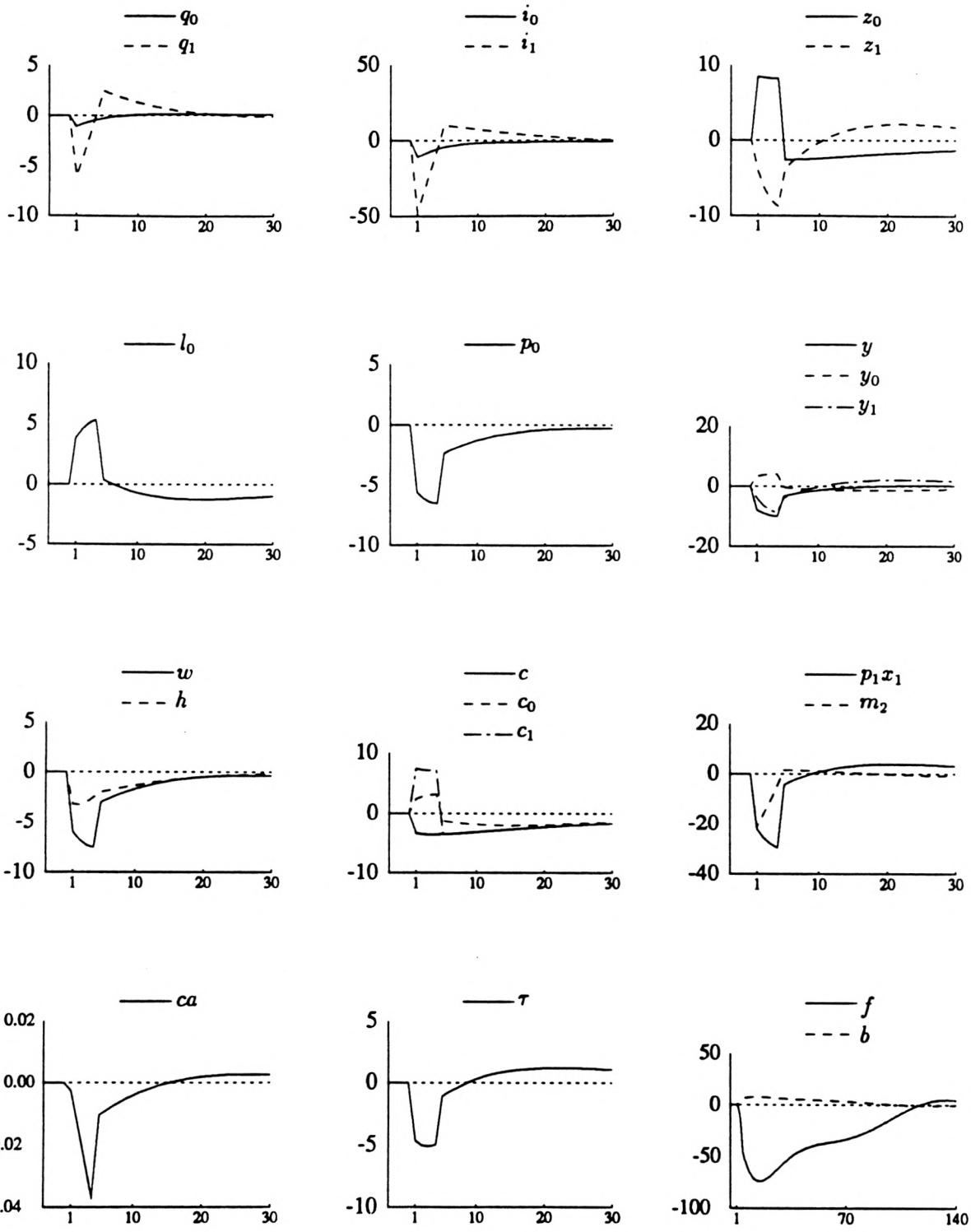


Figure 5
Dynamic Effects of a Temporary Deterioration in the Terms of Trade: II



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