INTERGENERATIONAL AND INTERNATIONAL WELFARE LEAKAGES OF A TARIFF IN A SMALL OPEN ECONOMY[*]

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ABSTRACT

A dynamic overlapping-generations model of a small open economy with imperfect competition in the goods market is constructed. A tariff increase reduces output and employment and leads to an appreciation of the real exchange rate both in the impact period and in the new steady state. The tariff shock has significant intergenerational distribution effects. Old existing generations gain less than both younger existing generations and future generations. Bond policy neutralizes the intergenerational inequities and allows the computation of first-best and second-best optimal tariff rates. The first-best tariff exploits national market power, but the second-best tariff contains a correction to account for the existence of a potentially suboptimal product subsidy.

February 1999

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1. Introduction

The desirability of industrial policy in an economy with increasing returns to scale industries has been on and off the research agenda's of both academic economists and policy practitioners at least since the debate in the 1920s between Frank Graham and Frank Knight (see Flam and Helpman (1987) for references). With the advent of the so-called New Trade Theory (Krugman, 1990), the debate has been given a new lease of life. At least two approaches can be distinguished in the recent literature. The first approach, which is mentioned but not pursued in this paper, is better known under the name of 'strategic trade policy.' In this branch of literature, the issue of industrial policy is studied in a setting of large duopolistic or oligopolistic firms battling for market share in the international economy (see Brander (1995) for an overview and references).

The second approach studies the issue of industrial policy in a world characterized by monopolistic competition. In such a setting there is no strategic interaction between firms, and trade in varieties of a differentiated product takes place between countries. Flam and Helpman (1987), for example, construct a static model of a small open economy with a monopolistically competitive production sector. They use the model to study the effects on allocation and welfare of tariffs, export subsidies, R&D subsidies, and output subsidies. Flam and Helpman (1987, pp. 90-91) identify three mechanisms by which welfare of domestic agents is increased in a monopolistically competitive setting. First, an increase in the number of domestic product varieties expands the range of choice by domestic consumers, who are better off as a result provided they exhibit a preference for diversity. Second, a policy that increases the home price of domestically produced varieties has a positive terms of trade effect which increases welfare of domestic residents. Third, an increase in the output level per domestic firm constitutes a 'pro-competitive' effect and thus increases welfare.

Our paper is a contribution to the second approach to industrial policy. Attention is restricted to the import tariff. In the static model of Flam and Helpman, the introduction of a tariff increases profits which prompts an increase in the number of domestic firms and raises the prices charged by domestic firms. The effects on output per firm is ambiguous, but the terms of trade and welfare of domestic residents both improve as a result (1987, pp. 91-92). Our first objective in this paper is to further study the precise conditions under which an import tariff is welfare-improving. Whilst we retain some of the modelling devices of Flam and Helpman (1987), we modify the analysis in several directions.

One of our modifications is motivated by a recent body of literature in which it has been shown that the conclusions based on static models can be highly misleading because the element of

time is missing in such models. In a world populated with infinitely-lived 'representative' agents, this is perhaps not such a problem, because the timing only affects 'when' (but not 'whether') the agents bears the costs of, or receives the benefits from, a particular policy measure. In a world with finitely-lived overlapping generations, however, the timing of the benefits and costs associated with a particular policy becomes vital. In such a setting a policy measure typically affects both existing and future generations differently, i.e. there are not only efficiency but also intergenerational distribution effects that must be considered. Broer and Heijdra (1996), for example, use a closed-economy model with monopolistic competition to show that stimulation of production by means of an investment tax credit is feasible but gives rise to a highly uneven distribution of costs and benefits over generations. In particular, they show that old existing generations lose out because they suffer a capital loss on their share holdings, whereas younger generations as well as future generations benefit as a result of the higher wages and larger number of product varieties on the market. The importance of intergenerational distribution effects in determining 'optimal' policy has been demonstrated in a small but growing number of papers on very diverse topics.[1]

The second major objective of our paper is therefore to study the import tariff in a dynamic overlapping-generations economy. We use the perpetual youth approach of Blanchard (1985), but extend it to a small open economy and endogenize the labour supply decision of households. Domestic households purchase domestic and foreign product varieties and use the current account in order to smooth their consumption profiles. The country is small in world financial markets and thus faces perfect capital mobility. The domestic real interest rate can vary in the transition period, however, because of movements in the real exchange rate. There are many small domestic firms producing varieties that are sold at home and abroad. Free exit/entry eliminates excess profits in the domestic economy and determines the equilibrium number of firms. Increasing returns to scale exist because an increase in the number of product varieties boosts the productivity of the variable labour input.

The analysis yields a number of conclusions. First, in contrast to Flam and Helpman's (1987) findings, an increase in the tariff reduces output and employment, both in the short run and in the long run. The reason is that in our model the tariff shock prompts a negative labour supply response which leads to a reduction in the number of firms. Like Flam and Helpman (1987), we find that the real exchange rate appreciates both at impact and in the long run.

Second, the import tariff affects generations unequally. Old existing generations gain less welfare than younger existing generations and future generations. In terms of the basic mechanisms identified by Flam and Helpman (1987), generations born in the new steady state lose welfare

because the number of domestic product varieties falls, but gain welfare because of the improvement in the terms of trade. Due to free entry/exit and the fixed markup, output per firm is fixed and thus does not contribute towards welfare. A fourth mechanism operates in our model via the stock of net foreign assets. It is shown that steady-state generations enjoy a net claim on the rest of the world as a result of the increase in the tariff. This also exerts a positive effect on the welfare of steady-state generations.

Third, our analysis shows that a suitable bond accompanying the tariff increase can neutralize the intergenerational distribution effects so that the pure efficiency effects of the tariff can be studied. In such an egalitarian setting it is possible to study the optimal tariff. It is shown that the optimal tariff depends not only on 'national market power' (as in Gros (1987)) but also on the pre-existing domestic distortion of monopolistic competition. To the extent that the policy maker has no instrument to combat the domestic monopoly distortion (such as a product subsidy), the second-best optimum tariff is reduced vis-à-vis its first-best value. Intuitively, output is already too low due to the domestic monopoly distortion and increasing the tariff only exacerbates this problem. In the absence of a domestic distortion and/or if the product subsidy is set optimally, the first-best tariff is aimed at exploiting national market power to the fullest extent possible. Our model thus yields precise and intuitively understandable prescriptions about the interaction between the optimum tariff and pre-existing domestic distortions. In this sense it is related to the earlier work by Johnson (1965) and Bhagwati (1967, 1971).

The remainder of the paper proceeds as follows. In section 2 the model of a small open economy is developed. In section 3 the macroeconomic allocation effects of an import tariff are studied, both at impact, during transition, and in the long run. Section 4 is dedicated to the welfare analysis both without and with bond policy. Finally, section 5 contains some concluding remarks.

2. A model of perpetual youth and imperfect competition

2.1. Households

The basic model of household behaviour builds on the work of Blanchard (1985) and the extension to the open economy by Giovannini (1988). Beside the endogeneity of labour supply, the main difference with these two models is the introduction of diversified consumption goods into the utility function of the agents. This in turn opens the scope for imperfectly competitive behaviour on the part of producers, which forms the major innovation of this paper.

In this model there is a fixed population of agents each facing a given constant probability

of death. During their entire life agents have a time endowment of unity which they allocate over labour and leisure. The utility functional at time t of the representative agent born at time v is denoted by $\Lambda(v,t)$ and has the following form:

$$\Lambda(v,t) \equiv \int_{t}^{\infty} \log U(v,\tau) \, \exp\left[(\alpha+\beta)(t-\tau)\right] d\tau, \tag{2.1}$$

where α is the pure rate of time preference ($\alpha>0$), β is the probability of death ($\beta\geq0$), and $U(v,\tau)$ is sub-utility which depends on leisure, $1-L(v,\tau)$, and consumption of domestic and foreign composite goods ($C_D(v,\tau)$ and $C_F(v,\tau)$, respectively):

$$U(v,\tau) \equiv \left[C_D(v,\tau)^{\gamma_D} C_F(v,\tau)^{1-\gamma_D}\right]^{\gamma}\left[1-L(v,\tau)\right]^{1-\gamma}, \tag{2.2}$$

with $0<\gamma\leq1$ and $0<\gamma_D<1$.[2]

The domestic economy consists of imperfectly competitive firms that each produce a single variety of a diversified good. These goods are close but imperfect substitutes in consumption. Following Spence (1976) and Dixit and Stiglitz (1977) the diversified goods can be aggregated over existing varieties $(1,2,..,N(\tau))$ in order to obtain $C_D(v,\tau)$:

$$C_D(v,\tau) \equiv N(\tau)^{\eta}\left[N(\tau)^{-1}\sum_{i=1}^{N(\tau)} C_{D,i}(v,\tau)^{(\sigma_c-1)/\sigma_c}\right]^{\sigma_c/(\sigma_c-1)}, \qquad \sigma_C>1, \ \eta\geq1, \tag{2.3}$$

where $C_{D,i}(v,\tau)$ is the consumption of domestically produced variety i in period τ by an agent born in period v ($\leq\tau$), σ_C is the elasticity of substitution between domestically produced varieties of the differentiated good, and η is a parameter regulating the preference for diversity effect. If $\eta>1$, the individual agents exhibit a love of variety, and setting $\sigma_C>1$ ensures that all existing varieties will in fact be demanded. For the imported composite consumption good the same specification is chosen.[3]

$$C_F(v,\tau) \equiv \left(N^*\right)^{\eta}\left[\left(N^*\right)^{-1}\sum_{j=1}^{N^*} C_{F,j}(v,\tau)^{(\sigma_c-1)/\sigma_c}\right]^{\sigma_c/(\sigma_c-1)}, \tag{2.4}$$

where $C_{F,j}(v,\tau)$ is the consumption of foreign variety j and N^* is the (fixed) number of foreign varieties. The true price deflators corresponding to (2.3) and (2.4) are:

$$P_D(\tau) \equiv N(\tau)^{-\eta}\left[N(\tau)^{-\sigma_C}\sum_{i=1}^{N(\tau)}P_{D,i}(\tau)^{1-\sigma_C}\right]^{1/(1-\sigma_C)}, \qquad P_F(\tau) \equiv \left(N^*\right)^{-\eta}\left[\left(N^*\right)^{-\sigma_C}\sum_{j=1}^{N^*}P_{F,j}(\tau)^{1-\sigma_C}\right]^{1/(1-\sigma_C)},$$

$$(2.5)$$

where $P_{D,i}(\tau)$ and $P_{F,j}(\tau)$ are, respectively, the price of domestic variety i and foreign variety j. The real exchange rate is defined as $E(\tau)\equiv P_F(\tau)/P_D(\tau)$.

The agent's budget restriction in terms of the domestic price deflator $P_D(\tau)$ is equal to:

$$\dot{A}(v,\tau) = \left[r(\tau)+\beta\right]A(v,\tau) + W(\tau)L(v,\tau) - T(\tau) - C_D(v,\tau) - E(\tau)\left[1+t_M(\tau)\right]C_F(v,\tau), \quad (2.6)$$

where $\dot{A}(\tau)\equiv dA(v,\tau)/d\tau$, $r(\tau)$ is the real rate of interest on domestic assets, $W(\tau)$ is the real wage rate (assumed age-independent for convenience), $T(\tau)$ are net lump-sum taxes, $t_M(\tau)$ is an *ad valorem* import tariff, and $A(v,\tau)$ are real tangible assets. All tangible assets are perfect substitutes:

$$A(v,\tau) \equiv B(v,\tau) + V(\tau)K(v,\tau) + E(\tau)F(v,\tau), \qquad (2.7)$$

where $V(\tau)K(v,\tau)$ is the real market value of $K(v,\tau)$ units of land in the hands of households of vintage v, $B(v,\tau)$ is the real stock of government bonds, and $F(v,\tau)$ denotes real net foreign assets measured in terms of the foreign good. Full consumption $X(v,\tau)$ is defined as the sum of real consumption of the composite differentiated goods and the opportunity cost of leisure:

$$X(v,\tau) \equiv C_D(v,\tau) + E(\tau)\left[1+t_M(\tau)\right]C_F(v,\tau) + W(\tau)\left[1-L(v,\tau)\right]. \qquad (2.8)$$

The domestic economy is small in world capital markets, so that the world *real* rate of interest r_F is fixed. The domestic real interest rate is then determined by the familiar no-arbitrage condition:

$$r(\tau) = r_F + \dot{E}(\tau)/E(\tau), \qquad (2.9)$$

where $\dot{E}(\tau)\equiv dE(\tau)/d\tau$.

Due to the separable structure of preferences, the choice problem for the representative agent can be solved in two steps. First, the dynamic problem is solved. This leads to an optimal time profile for full consumption which is described by the agent's Euler equation:

$$\frac{\dot{X}(v,\tau)}{X(v,\tau)} = r(\tau)-\alpha. \qquad (2.10)$$

In the second step full consumption is optimally allocated over its component parts:

where γ_D thus represents the (constant) share of total goods consumption that is spent on domestic

$$C_D(v,\tau) = \gamma\gamma_D X(v,\tau), \quad E(\tau)\big[1 + t_M(\tau)\big]C_F(v,\tau) = \gamma(1-\gamma_D)X(v,\tau),$$

$$(2.11)$$

$$W(\tau)\big[1 - L(v,\tau)\big] = (1-\gamma)X(v,\tau),$$

goods and 1-γ is the spending share of leisure in full consumption.[4] Furthermore, the different *varieties* of the domestically produced and imported goods are determined by:

$$\frac{C_{D,i}(v,\tau)}{C_D(v,\tau)} = N(\tau)^{-(\sigma_c+\eta)+\eta\sigma_c}\left(\frac{P_{D,i}(\tau)}{P_D(\tau)}\right)^{-\sigma_c}, \quad \frac{C_{F,j}(v,\tau)}{C_F(v,\tau)} = \left(N^*\right)^{-(\sigma_c+\eta)+\eta\sigma_c}\left(\frac{P_{F,j}(\tau)}{P_F(\tau)}\right)^{-\sigma_c}. \quad (2.12)$$

A crucial feature of the Blanchard (1985) model (and all models deriving from it) is the simple demographic structure, which enables the aggregation over all currently alive households. Assuming that at each instance a large cohort of size βS is born and that βS agents die, and normalising S to unity, the size of the population is constant and equal to unity and the aggregated variables can be calculated as the weighted sum of the values for the different generations. For example, aggregate financial wealth is calculated as $A(\tau)\equiv\int_{-\infty}^{\tau}\beta A(v,\tau)e^{\beta(v-\tau)}dv$. The aggregated values for the other variables can be obtained in the same fashion. The main equations describing the behaviour of the aggregated household sector are given (for period t) by equations (T1.2) and (T1.9) in Table 1. Equation (T1.2) is the aggregate Euler equation modified for the existence of overlapping-generations of finitely-lived agents. It has the same form as the Euler equation for individual households (equation (2.10)) except for the correction term due to the distributional effects caused by the turnover of generations. Optimal consumption *growth* is the same for all generations but older generations have a higher consumption *level* than younger generations.[5] Since existing generations are continually being replaced by newborns, who hold no financial wealth, aggregate consumption growth is reduced somewhat as a result. The correction term appearing in (T1.2) thus represents the difference in average full consumption and full consumption by newborns:[6]

$$\frac{\dot{X}(\tau)}{X(\tau)} = r(\tau) - \alpha - \beta(\alpha+\beta)\left(\frac{A(\tau)}{X(\tau)}\right) = \frac{\dot{X}(v,\tau)}{X(v,\tau)} - \beta\left(\frac{X(\tau) - X(\tau,\tau)}{X(\tau)}\right) \quad (2.13)$$

where $A(\tau)\equiv V(\tau)+E(\tau)F(\tau)+B(\tau)$ is aggregate financial wealth and the constant aggregate stock of land has been normalized to unity, i.e. $K(\tau)=K=1$. Throughout the paper we analyze the case in which initially both the government debt and the stock of foreign assets are zero, i.e. $B=F=0$ initially. This ensures that initial financial wealth is strictly positive, i.e. $A=V>0$ initially. Equation (T1.2) shows that this is consistent with a steady state provided the world interest rate exceeds the

rate of time preference, i.e. $r=r_F>\alpha$ initially. The rising full consumption profile that this implies ensures that financial wealth is transferred from old to young generations in the steady-state (see Blanchard, 1985).

2.2. Firms

The economy consists of a single sector characterized by monopolistic competition. Each firm in this sector faces a demand for its product, $Y_i^D(\tau)$, from two sources: the consumption demand from the households sector (represented by $C_{D,i}(\tau)$ which is obtained by aggregating the first expression in (2.12)), and the demand from the rest of the world (given by $C_{F,i}^*(\tau)$ in equation (2.20) below). There are $N(\tau)$ identical domestic firms that each produce one variety of the differentiated product. The typical firm's decision on how much inputs to use is based on profit maximisation. There are increasing returns to scale at the firm level and the gross production function is homogeneous of degree λ (≥ 1) in the two production factors land ($K_i(\tau)$) and labour ($L_i(\tau)$):

$$Y_i(\tau) + f \equiv F(K_i(\tau),L_i(\tau)) = L_i(\tau)^{\lambda\varepsilon_L}K_i(\tau)^{\lambda(1-\varepsilon_L)}, \tag{2.14}$$

where $Y_i(\tau)$ is marketable output, $0<\varepsilon_L<1$, and f is fixed cost ($f>0$) expressed in terms of the firm's own output. Representative firm i's profit is defined by:

$$\Pi_i(\tau) \equiv (1+s_P)P_{D,i}(\tau)Y_i^D(\tau) - W(\tau)P_D(\tau)L_i(\tau) - R_L(\tau)P_D(\tau)K_i(\tau), \tag{2.15}$$

where $W(\tau)P_D(\tau)$ is the nominal wage rate, $R_L(\tau)P_D(\tau)$ is the nominal rental rate on land, and s_P is an *ad valorem* subsidy on production.[7] The firm chooses its output and price in order to maximize (2.15) subject to the demand restriction $Y_i(\tau)=Y_i^D(\tau)=C_{D,i}(\tau)+C_{F,i}^*(\tau)$ and the production function (2.14). This essentially static decision problem yields the familiar marginal conditions for labour and land:

$$\frac{\partial Y_i(\tau)}{\partial L_i(\tau)} = \frac{\mu_i(\tau)W(\tau)P_D(\tau)}{P_{D,i}(\tau)(1+s_P)}, \qquad \frac{\partial Y_i(\tau)}{\partial K_i(\tau)} = \frac{\mu_i(\tau)R_L(\tau)P_D(\tau)}{P_{D,i}(\tau)(1+s_P)}, \tag{2.16}$$

where $\mu_i(\tau)\equiv\varepsilon_i(\tau)/[\varepsilon_i(\tau)-1]>1$ is the markup and $\varepsilon_i(\tau)>1$ is the (absolute value of the) elasticity of the demand curve faced by firm i. In this paper the assumption of *Chamberlinian* monopolistic competition is made: competitors' reactions are deemed to be absent and entry/exit is assumed to occur until each active firm makes zero excess profit; the well-known tangency solution. In terms of the present model this implies that $N(\tau)$ changes instantaneously such that existing firms make no excess-profits. This in turn implies that the markup equals the scale parameter divided by average productivity, i.e. $\mu_i(\tau)=\lambda(Y_i(\tau)+f)/Y_i(\tau)$.

2.3. The government

The government sector is modelled in a very simple fashion. We abstract from macro features of government behaviour such as government spending on goods and services, and distortionary taxes on labour income. The periodic budget identity of the government is:

$$\dot{B}(\tau) = r(\tau)B(\tau) + s_P Y(\tau) - t_M(\tau)E(\tau)C_F(\tau) - T(\tau), \tag{2.17}$$

where $T(\tau)$ is the real lump-sum tax levied on the households and $Y(\tau)$ is a quantity index for national income:

$$Y(\tau) \equiv \frac{\sum_{i=1}^{N(\tau)} P_{D,i}(\tau)Y_i(\tau)}{P_D(\tau)} = N(\tau)^\eta \left[N(\tau)^{-1} \sum_{i=1}^{N(\tau)} Y_i(\tau)^{(\sigma_c-1)/\sigma_c} \right]^{\sigma_c/(\sigma_c-1)}. \tag{2.18}$$

Since the government is expected to remain solvent, the following NPG condition is relevant:

$$\lim_{\tau \to \infty} B(\tau) \exp\left[-\int_t^\tau r(s)\,ds \right] = 0. \tag{2.19}$$

The government's budget restriction is obtained by integrating (2.17) forward subject to (2.19). The resulting expression is given (for period t) in equation (T1.5) in Table 1.

2.4. The foreign sector

The domestic economy has links with the rest of the world through the goods market (via imports and exports of differentiated products) and through the assets market (domestic households can hold foreign assets in their portfolios). Since it is assumed that the domestic economy is small relative to the rest of the world, domestic variables have no impact on foreign macroeconomic variables. Hence, the export equation contains mainly exogenous variables. For simplicity the following specification is adopted for the export demand equation:

$$\left[1/E(\tau)\right]^{\sigma_T} C_{F,i}^*(\tau) = C_F^* N(\tau)^{-(\sigma_c+\eta)+\eta\sigma_c} \left(\frac{P_{D,i}(\tau)}{P_D(\tau)} \right)^{-\sigma_c}, \quad \sigma_T \geq 1, \tag{2.20}$$

where C_F^* is the exogenous component of export demand. As before, the parameter σ_C summarizes how well domestically produced varieties can be substituted by the buyers in the rest of the world. There is also a separate effect of the real exchange rate on aggregate exports which is parameterised by σ_T. Note that equation (2.20) can be seen as the rest of the world's equivalent to the second expression in equation (2.12) (in aggregate form).[8] In view of the aggregate version of

the first expression in (2.12) and (2.20) it is clear that $\varepsilon_i(\tau)=\sigma_C$ so that the common markup of domestic firms is constant and equal to $\mu=\mu_i(\tau)=\sigma_C/(\sigma_C-1)>1$.

The change in net foreign assets is equal to the current account. Since net foreign assets, $F(\tau)$, are measured in terms of foreign goods, the balance of payments equation can be expressed (for period t) as in equation (T1.4) in Table 1. The first term on the right-hand side is foreign capital income, whilst the second term is real export earnings in terms of the foreign composite good.

2.5. Equilibrium and stability

The value of the fixed stock of land can be deduced by appealing to the arbitrage equation between the different tangible assets. The total stock of land is fixed (at $K=1$) and the market price of land in terms of the domestic composite good is denoted by $V(\tau)$. Land attracts the market rate of return:

$$\frac{\dot{V}(\tau) + R_L(\tau)}{V(\tau)} = r(\tau). \tag{2.21}$$

The return on land consists of a capital gain, $\dot{V}(\tau)$, plus the rental received from the imperfectly competitive sector, $R_L(\tau)$, all expressed in terms of the initial price of the land. By solving (2.21) forward (subject to a transversality condition), the real market price of land can be expressed as the appropriately discounted value of the stream of rental income:

$$V(t) \equiv \int_t^\infty R_L(\tau) \exp\left[-\int_t^\tau r(\mu)d\mu \right]d\tau. \tag{2.22}$$

As is conventional in the macroeconomic literature on imperfect competition, attention is restricted to the symmetric equilibrium in which all firms behave in an identical fashion, i.e. $P_{D,i}(\tau)=\bar{P}(\tau)$, $C_{D,i}(\tau)=\bar{C}_D(\tau)$, $Y_i(\tau)=\bar{Y}(\tau)$, $L_i(\tau)=\bar{L}(\tau)$, $K_i(\tau)=\bar{K}(\tau)$, and $C_{F,i}^*(\tau)=\bar{C}_F^*(\tau)$ for all domestic firms ($i=1,2,..,N(\tau)$), and $P_{F,j}(\tau)=\bar{P}_F$, and $C_{F,j}(\tau)=\bar{C}_F(\tau)$ for all foreign firms ($j=1,2,...,N^*$). Since the price and number of foreign varieties of the differentiated good are both fixed, a suitable normalisation ensures that the price index $P_F(\tau)$ equals unity. Under symmetry the model can be rewritten in aggregate terms.

The complete dynamic model is given in aggregated form in Table 1. The dynamic part of the model is given by equations (T1.1)-(T1.5). The value of one unit of land evolves according to (T1.1), which is obtained by rewriting (2.21). The movement of full consumption (T1.2), the uncovered interest parity condition (T1.3), the balance of payments equation (T1.4), and the

government solvency condition (T1.5) have all been discussed above.

The static part of the model is given by equations (T1.6)-(T1.10). The aggregate demand for labour depends positively on the output index (given in (2.18)), and negatively on the real wage rate. The expression for the rental rate on land is given in (T1.7). Land owners receive the output left over after the factor labour has been paid. The equilibrium condition for the domestic market for differentiated goods is written in aggregate form in (T1.8). The private demands for the composite domestic and foreign good and labour supply are given in (T1.9). Finally, the aggregate production function for the differentiated goods sector is given in (T1.10). It is the aggregated version of (2.14), where use has been made of the zero pure profit condition.[9]

The model is given in log-linearized form in Table 2. A tilde ('~') above a variable denotes its rate of change around the initial steady-state, *e.g.*, $\tilde{X}(t) \equiv dX(t)/X$. A variable with a tilde and a dot is the time derivative expressed in terms of the initial steady-state, for example, $\dot{\tilde{X}}(t) \equiv \dot{X}(t)/X$. The only exceptions to that convention refer to the tariff, the various financial assets, and lump-sum taxes: $\tilde{t}_M(t) \equiv dt_M(t)/(1+t_M)$, $\tilde{V}(t) \equiv r_F dV(t)/Y$, $\dot{\tilde{V}}(t) \equiv r_F \dot{V}(t)/Y$, $\tilde{B}(t) \equiv r_F dB(t)/Y$, $\dot{\tilde{B}}(t) \equiv r_F \dot{B}(t)/Y$, $\tilde{F}(t) \equiv r_F dF(t)/Y$, $\dot{\tilde{F}}(t) \equiv r_F \dot{F}(t)/Y$, and $\tilde{T}(t) \equiv dT(t)/Y$.

The model can be reduced to a three-dimensional system of first-order differential equations in net foreign assets, $\tilde{F}(t)$, the value of land, $\tilde{V}(t)$, and full consumption, $\tilde{X}(t)$. Of these state variables, the net foreign asset position is predetermined, whilst the value of land and full consumption are non-predetermined 'jump' variables. Conditional upon the state variables, the static part of the log-linearized model, consisting of equations (T2.6)-(T2.10) in Table 2, can be used to derive the following 'quasi-reduced form' expressions:

$$\tilde{Y}(t) = \eta \, \varepsilon_L \tilde{L}(t) = \tilde{W}(t) + \tilde{L}(t) = \tilde{R}_L(t) = -(\phi - 1)\tilde{X}(t), \tag{2.23}$$

$$\sigma_T \omega_X \tilde{E}(t) = -(\phi - \omega_X)\tilde{X}(t), \tag{2.24}$$

$$\sigma_T \omega_X \left[\tilde{C}_F(t) + \tilde{t}_M(t) \right] = \left[\phi + (\sigma_T - 1) \omega_X \right] \tilde{X}(t), \tag{2.25}$$

where $\omega_X \equiv EC_F/Y = C_F^* E^{\sigma_T}/Y = (1-\gamma_D)/(1+\gamma_D t_M)$ is the initial share of international trade (viz. imports equals exports) in aggregate output. The composite parameter ϕ represents the strength of the labour supply effect (due to intertemporal substitution) on aggregate domestic output. It is defined as follows:

$$\phi \equiv \frac{1 + \omega_{LL}}{1 + \omega_{LL}(1 - \eta \varepsilon_L)} \geq 1, \qquad (2.26)$$

where ω_{LL} $(\equiv(1-L)/L \geq 0)$ is the ratio between leisure and labour, which also represents the intertemporal substitution elasticity of labour supply. Note that $\phi=1$ if labour supply is exogenous (since $L=1$ implies that $\omega_{LL}=0$). Since $\omega_{LL} \geq 0$, $\phi \geq 1$ is implied if $\eta \varepsilon_L \leq 1$. If $\eta \varepsilon_L < 1$, ϕ is a concave function of ω_{LL} with a positive asymptote of $(1-\eta \varepsilon_L)^{-1}$ as $\omega_{LL} \rightarrow \infty$, and if $\eta \varepsilon_L = 1$, $\phi = 1 + \omega_{LL}$. If $\eta \varepsilon_L > 1$, on the other hand, ϕ has a vertical asymptote at $\omega_{LL}=(\eta \varepsilon_L-1)^{-1}$, and for $0 < \omega_{LL} < (\eta \varepsilon_L-1)^{-1}$, ϕ is a convex and increasing function of ω_{LL} exceeding unity. In order to cover this remaining case, and thus to ensure that $\phi \geq 1$, we make the following convenient assumption regarding the range of admissible values for the intertemporal substitution elasticity of labour supply.

ASSUMPTION 1: *If $\eta \varepsilon_L > 1$ it is assumed that $0 \leq \omega_{LL} < (\eta \varepsilon_L-1)^{-1}$.*

Equation (2.24) shows that, since $\phi \geq 1$ and $0 < \omega_X < 1$, full consumption exerts a negative effect on the real exchange rate. The intuition behind this effect can be explained with the aid of Figure 1, which depicts the situation on the domestic goods market, conditional upon the level of full consumption. The real exchange rate is determined by the domestic goods market clearing condition (T1.8). Aggregate supply depends negatively on full consumption, via the labour supply effect, but does not depend on the real exchange rate.[10] Hence, the aggregate supply curve is represented by the vertical line $Y^S(X_0)$. Aggregate demand is defined as $Y^D \equiv C_D + C_F^* E^{\sigma_T} = \gamma \gamma_D X_0 + C_F^* E^{\sigma_T}$ and depends positively on the real exchange rate due to the effect on real export spending; see $Y^D(E,X_0)$ in Figure 1. The equilibrium real exchange rate, E_0, is given by the intersection of aggregate supply and demand at point e_0.[11]

Now consider what happens if full consumption falls, say from X_0 to X_1. Since full consumption is a normal good, the demand for domestic goods falls and the aggregate demand curve shifts to the left. At the same time, labour supply is increased, so that the aggregate supply curve shifts to the right. For the initial real exchange rate, there is an excess supply of goods, which causes the domestic price to fall and thus the real exchange rate to rise. Equilibrium is restored in point e_1, where both output and the real exchange rate are higher. Consequently, a reduction in full consumption results in an increase of the real exchange rate.

Equation (T2.3) in combination with the time derivative of (2.24) yields an expression for the change in the domestic interest rate (satisfying the uncovered interest parity condition) which can be substituted in (T2.1) and (T2.2). By also substituting (2.24)-(2.25) and the second expression in (T2.9) into (T2.4) and simplifying, the dynamical system for the economy is

obtained:

$$
\begin{bmatrix}
\dot{\tilde{F}}(t) \\
\dot{\tilde{V}}(t) \\
\dot{\tilde{X}}(t)
\end{bmatrix}
= \Delta
\begin{bmatrix}
\tilde{F}(t) \\
\tilde{V}(t) \\
\tilde{X}(t)
\end{bmatrix}
+ \Gamma(t),
\tag{2.27}
$$

where the Jacobian matrix on the right-hand side, Δ, is defined as:

$$
\Delta \equiv
\begin{bmatrix}
r_F & 0 & -\phi r_F \\
(r_F-\alpha)(1-\zeta) & r_F+(r_F-\alpha)(1-\zeta) & \omega_K[r_F(\phi-1)-(r_F-\alpha)(1-\zeta)] \\
-(r_F-\alpha)\zeta/\omega_K & -(r_F-\alpha)\zeta/\omega_K & (r_F-\alpha)\zeta
\end{bmatrix},
\tag{2.28}
$$

and where $\zeta \equiv \sigma_T \omega_X/[\phi+(\sigma_T-1)\omega_X]$, $0<\zeta<1$. The (potentially time-varying) shock term appearing in (2.27), $\Gamma(t)$, is defined as:

$$
\Gamma(t) \equiv
\begin{bmatrix}
\omega_X \\
0 \\
0
\end{bmatrix}
r_F \tilde{t}_M(t)
+
\begin{bmatrix}
0 \\
(1-\zeta) \\
-\zeta/\omega_K
\end{bmatrix}
(r_F-\alpha)\tilde{B}(t).
\tag{2.29}
$$

The model is saddle-point stable provided Δ has two positive (unstable) characteristic roots ($r_1^*>0$ and $r_2^*>0$) and one negative (stable) root ($-h^*<0$). Since the product of the characteristic roots equals the determinant of Δ, stability thus requires that $|\Delta|$ be negative. After some elementary operations we find that this is indeed the case:

$$
|\Delta| \equiv -h^* r_1^* r_2^* = -r_F^2 \phi(\zeta/\omega_K)(r_F-\alpha)(1-\omega_K) < 0,
\tag{2.30}
$$

where the feasible range for the initial product subsidy is such that the share of land owners in aggregate income lies strictly between zero and unity, i.e. $-1<s_P<\varepsilon_L/(1-\varepsilon_L)$ ensures that $0<\omega_K<1$. Proposition 1 summarizes some results that can be derived for the model.

PROPOSITION 1: *Let $-1<s_P<\varepsilon_L/(1-\varepsilon_L)$. The loglinearized model of Table 2 implies the following results: (i) The model is locally saddle-point stable; (ii) The characteristic roots are distinct and equal to $r_1^*=r_F$, $r_2^*>0$, and $-h^*<0$. (iii) The second unstable root satisfies $r_2^*>2r_F-\alpha$.* PROOF: See Bettendorf and Heijdra (1998).

3. The macroeconomic effects of an import tariff

In this section we study the allocation effects of an unanticipated and permanent increase of the import tariff. The time at which the policy shock occurs is normalized to zero (hence, $\tilde{t}_M(t) = \tilde{t}_M > 0$ for $t \geq 0$). We assume that no debt policy is used and that the tariff revenue is rebated in a lump-sum fashion to households. Since both public debt and net foreign assets are zero in the initial situation ($B = F = 0$), the trade balance is in equilibrium and the only durable asset that is used by agents to transfer resources intertemporally in the initial steady state consists of claims to domestic land.

In order to explain the intuition behind the results, we use the diagrammatic apparatus of Figure 2, in which the exact long-run model solution plus the approximate transitional dynamics are studied. The first equation in (2.27) explains the time path of net foreign assets and can be written as follows:

$$\dot{\tilde{F}}(t) = r_F\left[\tilde{F}(t) - \phi\tilde{X}(t) + \omega_X\tilde{t}_M\right], \tag{3.1}$$

where ϕ is given in (2.26). In the steady state, $\dot{\tilde{F}}(t) = 0$, and (3.1) represents the current account equilibrium locus, which has been drawn as the CA schedule in Figure 2. This schedule is upward sloping because, as net foreign assets rise the country receives more interest income from the rest of the world. In order to restore current account equilibrium domestic households must spend more on foreign goods. This is established via a rise in full consumption.

The second and third equations of (2.27) show that the dynamic paths for full consumption and the value of domestic land depend on all three state variables. A full graphical analysis of the transition path would thus necessitate a three-dimensional graph. To explain the basic intuition we reduce this dimensionality by basing the graphical analysis (but *not* the analytical results) on the assumption that adjustment in land values occurs fully at impact, i.e. $\tilde{V}(t) = \tilde{V}(\infty)$ for $t \geq 0$. The steady-state version of equation of (2.27) furnishes the expression for the steady-state effect of the tariff on the value of domestic land:

$$\tilde{V}(\infty) = -\frac{\omega_K\omega_X(\phi - 1)\tilde{t}_M}{\phi(1 - \omega_K)} < 0, \tag{3.2}$$

which shows that, provided labour supply is endogenous ($\phi > 1$), the value of domestic land decreases in the long-run. By substituting $\tilde{V}(t) = \tilde{V}(\infty)$ into the third equation in (2.27) the following expression for the modified Euler equation is obtained:

$$\dot{\tilde{X}}(t) = (r_F - \alpha)(\zeta/\omega_K)\left[\omega_K \tilde{X}(t) - \tilde{F}(t) - \tilde{V}(\infty)\right]. \tag{3.3}$$

In the steady-state, $\dot{\tilde{X}}(t)=0$, and (3.3) represents the modified Keynes-Ramsey rule, which has been drawn as the MKR schedule in Figure 2.[12] This schedule is upward sloping because, in the long run, the domestic rate of interest is equal to the exogenous world rate. This implies, by (2.13), that the long-run ratio of financial assets to full consumption, $A(\infty)/X(\infty)$, is constant also. Hence, ceteris paribus the value of land, an increase in net foreign assets must be accompanied by an increase in full consumption.

3.1. Long-run effects

Since an increase in the tariff decreases the long-run value of land (see (3.2)) the MKR locus shifts down as agents are poorer. The CA curve shifts to the left because ceteris paribus, an increase in the tariff reduces imports and thus creates a trade balance surplus. In terms of Figure 2, the old equilibrium e_0 lies below the new CA line. In the long run, the economy settles in the new equilibrium e_1 which features a positive net foreign asset position, i.e. a net claim on the rest of the world, and a higher level of full consumption:

$$\tilde{F}(\infty) = \frac{\omega_K \omega_X \tilde{t}_M}{1 - \omega_K} > 0, \qquad \tilde{X}(\infty) = \frac{\omega_X \tilde{t}_M}{\phi(1 - \omega_K)} > 0. \tag{3.4}$$

The long-run effects on employment, output, and the rental price of land can be obtained by using (3.4) and (2.23):

$$\tilde{Y}(\infty) = \eta \varepsilon_L \tilde{L}(\infty) = \tilde{R}_L(\infty) = -\frac{\omega_X(\phi - 1)\tilde{t}_M}{\phi(1 - \omega_K)} \leq 0, \tag{3.5}$$

which shows that the effects are strictly negative if labour supply is endogenous ($\phi>1$). Since there is no long-run effect on the domestic interest rate due to the perfect mobility of financial capital ($\tilde{r}(\infty)=0$), the long-run effect on the rental price of land is proportional to the effect on land values (given in (3.2)).

The long-run effect on the wage rate is theoretically ambiguous and depends on the relative strength of the diversity effect η. Indeed, by using (2.23) and (3.4) we obtain:

$$\tilde{W}(\infty) = -\frac{(\eta \varepsilon_L - 1)(\phi - 1)\omega_X \tilde{t}_M}{\phi \eta \varepsilon_L(1 - \omega_K)}. \tag{3.6}$$

With exogenous labour supply ($\phi=1$) or a sufficiently strong diversity effect ($\eta \varepsilon_L=1$), wages are unaffected by the tariff. In the first case, the labour supply curve is vertical and does not shift,

whereas in the second case the labour demand curve is horizontal as the marginal productivity of labour is constant. If the diversity effect is stronger ($\eta > 1/\varepsilon_L$) the demand for labour is upward sloping, and if labour supply is endogenous ($\phi > 1$), the real wage falls as a result of the tariff. Under perfect competition the diversity effect is absent ($\eta = 1$) and the real wage must rise in the long run.[13]

The long-run effect on the real exchange rate can be computed by using (2.24) and (3.4):

$$\tilde{E}(\infty) = -\frac{(\phi - \omega_X)\tilde{t}_M}{\phi \sigma_T (1 - \omega_K)} < 0. \tag{3.7}$$

The effect can be illustrated with the aid of Figure 3. If labour supply is exogenous ($\phi = 1$), output supply is fixed. Since full consumption rises, however, the aggregate demand curve is shifted to the right as the demand for home goods by domestic agents increases. As a result, equilibrium is restored with an unchanged output level and a lower (appreciated) real exchange rate. In terms of Figure 3, the equilibrium shifts from e_0 to e_1. If labour supply is endogenous ($\phi > 1$), the increase in the tariff shifts the aggregate supply curve from $Y^S(X_0)$ to $Y^S(X_1)$ and the net result of the tariff increase is a move from e_0 to e_2, where both output and the real exchange rate are lower.

3.2. Short-run and transition effects

In the impact period, the two unstable 'jump' variables full consumption and the value of land ensure that the economy settles onto the stable plane leading the economy towards the new steady-state equilibrium described above. It is shown in Bettendorf and Heijdra (1998) that the jumps can be written as follows:

$$0 \overset{>}{\underset{<}{=}} \tilde{X}(0) = \left[\frac{1}{\phi} - \frac{(r_F - \alpha)\zeta}{r_2^*}\right]\omega_X \tilde{t}_M < (\omega_X/\phi)\tilde{t}_M, \tag{3.8}$$

$$\tilde{V}(0) = -\omega_K \omega_X \left[\frac{\phi - 1}{\phi} - \frac{(r_F - \alpha)(1 - \zeta)}{r_2^*}\right]\tilde{t}_M \overset{>}{\underset{<}{=}} 0, \tag{3.9}$$

It is shown in Bettendorf and Heijdra (1998) that the impact effect falls short of the long-run effect for full consumption, whereas the opposite holds for the value of land, i.e. $\tilde{X}(0) < \tilde{X}(\infty)$ and $\tilde{V}(0) > \tilde{V}(\infty)$. Furthermore, it is straightforward to show that $\tilde{V}(0) < \omega_K \tilde{X}(0)$, a result which will prove useful in the welfare evaluation in section 4.1 below.

Both jumps consist of a pure *efficiency effect* (the first term in square brackets in (3.8) and (3.9), respectively) and a *distributional effect* (second term).[14] Equation (3.8) shows that the sign

of the full consumption jump is theoretically ambiguous because the efficiency and distributional effects work in opposite directions. There are strong presumptions, however, that the first effect dominates and $\tilde{X}(0)$ is positive for all but extremely pathological cases. A number of non-pathological special cases can be shown in support of this claim. First, if labour supply is exogenous ($\phi=1$), then the term in square brackets on the right-hand side of (3.8) is positive, because $0<\zeta<1$ and $r_2^*>r_F-\alpha$ (see Proposition 1(iii)). The same conclusion holds if ϕ is not 'too large', which is the case if the diversity effect is not 'too strong'. Second, if $\sigma_T=1$ then $0<\zeta\phi=\omega_X<0$ so that $r_2^*>(r_F-\alpha)\zeta\phi$ regardless of the magnitude of the labour supply parameter ϕ. Again, the same conclusion holds for values of σ_T that are not too large. It can be demonstrated numerically that $\tilde{X}(0)<0$ if the diversity effect is extremely strong **and** the export elasticity is much larger than unity. In order to avoid having to deal with this theoretical curiosum, we make the following assumption regarding the product $\phi\zeta$:

ASSUMPTION 2: *If $\phi,\sigma_T>1$ it is assumed that the efficiency effect of a tariff dominates the distributional effect in full consumption, i.e. the parameters are such that $r_2^*>(r_F-\alpha)\zeta\phi$.*

In a similar fashion, the impact jump in the value of land is ambiguous because the efficiency effect is non-positive and the distributional effect is positive, so that the net effect depends on the magnitude of the labour supply parameter ϕ. If labour supply is exogenous ($\phi=1$), then output does not change as a result of the tariff shock, the efficiency effect is zero, and the value of land increases at impact due to the distributional effect. On the other hand, if labour supply is sufficiently elastic ($\phi>2$), then land values fall at impact because the efficiency effect dominates the distributional effect (see Bettendorf and Heijdra (1998)). Since $\phi>2$ does not represent a particularly outlandish scenario, we conclude that the impact effect on the value of land is inherently ambiguous for realistic values of the parameters.

Further intuition regarding the *exact* impact results of (3.8)-(3.9) can be obtained by appealing to the *approximate* transition dynamics illustrated in Figure 2, which is based on the assumption that the impact and long-run effects on the value of land are equal to each other (see above).[15] With that approximation, the phase diagram can be constructed as in Figure 2. From (3.3) it is clear that points above (below) the MKR curve are associated with a rising (falling) full consumption profile. Similarly, (3.1) shows that points to the right (left) of the CA line are associated with a current account surplus (deficit) and consequently with an increase (decrease) in net foreign assets. The approximate saddle path lies between the CA and MKR lines, and is upward sloping. At impact, the economy jumps from e_0 to e', at which point a current account

surplus is opened up. During adjustment, net foreign assets and full consumption gradually increase toward their respective long-run equilibrium levels associated with point e_1.

The impact effects on output, employment, and factor prices are obtained by using (2.23) and (3.8):

$$\tilde{Y}(0) = \eta \varepsilon_L \tilde{L}(0) = \tilde{R}_L(0) = \left[1 - 1/(\eta \varepsilon_L)\right]^{-1} \tilde{W}(0) = -(\phi - 1)\tilde{X}(0) \leq 0. \qquad (3.10)$$

With endogenous labour supply ($\phi > 1$), both output and employment fall at impact as a result of the increase in the tariff. The decrease in employment results in a reduction in the marginal product of land which explains the fall in the rental price of land. The impact effect on the wage rate is ambiguous and depends on the relative strength of the diversity effect, as was explained above for the long run. Irrespective of market configuration, however, with endogenous labour supply ($\phi > 1$) the wage-rental ratio unambiguously rises, i.e. the adverse effect on factor payments is worse for landlords than for labourers. Indeed, by using (3.10) we obtain:

$$\tilde{W}(0) - \tilde{R}_L(0) = \left(\frac{\phi - 1}{\eta \varepsilon_L}\right)\tilde{X}(0) > 0. \qquad (3.11)$$

The incidence of the import tariff on factor prices is thus largest for the production factor that is most elastic in supply which, in the present model, is the factor land.

The impact effect on the real exchange rate is computed by using (2.24) and (3.8):

$$\sigma_T \omega_X \tilde{E}(0) = -(\phi - \omega_X)\tilde{X}(0) < 0. \qquad (3.12)$$

In Figure 3, the impact effect on output and the real exchange rate is represented by the move from the initial equilibrium at e_0 to point e'. Ceteris paribus, the impact appreciation of the real exchange rate reduces exports and stimulates imports. Furthermore, the increase in full consumption boosts imports whilst the increase in the tariff reduces imports. Bettendorf and Heijdra (1998) show that the net impact effect on imports is negative. Since exports fall by less than imports, the effect on net exports is unambiguously positive. Indeed, by using (2.25) and (3.12) in (3.1) we obtain the following expression:

$$r_F^{-1}\dot{\tilde{F}}(0) = \omega_X\left[(\sigma_T - 1)\tilde{E}(0) - \tilde{C}_F(0)\right] = -\phi \tilde{X}(0) + \omega_X \tilde{t}_M > 0, \qquad (3.13)$$

where we have used the fact that the stock of net foreign assets is predetermined in the impact period ($\tilde{F}(0)=0$), as well as the upper bound for $\tilde{X}(0)$ in (3.8).

A similar type of reasoning can be used to show that the impact effect on the domestic real interest rate is negative. Indeed, by using (T2.3) and the time derivative of (2.24), the following

expression is obtained:

$$r_F \tilde{r}(0) = -\left(\frac{\phi - \omega_X}{\sigma_T \omega_X}\right)\dot{\tilde{X}}(0) < 0. \tag{3.14}$$

Since full consumption rises monotonously during transition (and thus *a fortiori* also at impact), the right-hand side of (3.14) is negative, so that the impact effect on the real interest rate is negative.

The exact expressions of the transition paths for net foreign assets, the value of land, and full consumption are:

$$\tilde{F}(t) = \left[1 - e^{-h^*t}\right]\tilde{F}(\infty), \tag{3.15}$$

$$\tilde{V}(t) = e^{-h^*t}\tilde{V}(0) + \left[1 - e^{-h^*t}\right]\tilde{V}(\infty), \tag{3.16}$$

$$\tilde{X}(t) = e^{-h^*t}\tilde{X}(0) + \left[1 - e^{-h^*t}\right]\tilde{X}(\infty), \tag{3.17}$$

where h^* represents the adjustment speed in the economy. Since $\tilde{X}(0) < \tilde{X}(\infty)$, full consumption gradually increases towards its new steady-state value. Furthermore, since $\tilde{V}(0) > \tilde{V}(\infty)$, the value of land gradually falls to its new equilibrium level. Since output, employment, the rental rate, the wage rate, imports, and the real exchange rate can all be expressed in terms of full consumption (see equations (2.23)-(2.25)), the transition paths for these variables all have the same form as the one for full consumption, i.e. they can all be written as a weighted average of the initial and long-run response. For the domestic interest rate, however, there is no long-run effect, due to interest parity, and the adjustment path is written as:

$$\tilde{r}(t) = (1/r_F)\dot{\tilde{E}}(t) = e^{-h^*t}\tilde{r}(0). \tag{3.18}$$

Following its fall at impact, the real interest rate gradually increases towards its long-run equilibrium value r_F. This of course implies that the real exchange rate decreases during transition.

4. Intergenerational welfare analysis

In order to evaluate the welfare effects during transition, we must take into account that different generations are affected differently by a change of the import tariff, as this changes the rental rate and hence the market value of land, which is owned by the elder generations. So welfare effects

contain both efficiency aspects and generational distribution aspects. In order to link the allocation effects of the previous section to the welfare effects in this section, the cost-of-living index, $P_U(\tau)$, is used to relate sub-utility to full consumption:

$$U(v,\tau) = \frac{X(v,\tau)}{P_U(\tau)}, \tag{4.1}$$

where $U(v,\tau)$ is sub-utility defined in (2.2), $X(v,\tau)$ is full consumption defined in (2.8) and $P_U(\tau)$ is the cost-of-living index:

$$P_U(\tau) \equiv \Omega_1 \Big[E(\tau)\big[1+t_M(\tau)\big]\Big]^{\gamma(1-\gamma_D)} W(\tau)^{1-\gamma}, \tag{4.2}$$

where Ω_1 is a positive constant. Equation (4.2) shows that increases in the real wage, the real exchange rate, or the tariff all lead to an increase in the cost-of-living index. In view of (4.1) a change in sub-utility can thus be decomposed into a term due to a change in full consumption and a change in the cost-of-living index. This decomposition is useful to explain the intuition behind the welfare effect on different generations.

4.1. Intergenerational welfare effects without bond policy

To bring out the main issues clearly, we first study the case where no debt policy is used, i.e. $\tilde{B}(t)=0 \ \forall t\geq0$. The welfare effect on generations that exist at the time of the shock ($t=0$) is denoted by $d\Lambda(v,0)$, with $v\leq0$. It is shown in Bettendorf and Heijdra (1998) that this effect can be written as follows:

$$(\alpha+\beta)d\Lambda(v,0) = \tilde{X}(v,0) + r_F\mathscr{L}\{\tilde{r},\alpha+\beta\} - (\alpha+\beta)\mathscr{L}\{\tilde{P}_U,\alpha+\beta\}, \qquad v\leq0, \tag{4.3}$$

where $\tilde{X}(v,0)\equiv dX(v,0)/X(v,0)$ is the jump at impact in the level of full consumption by a household of generation v, and $\mathscr{L}\{\tilde{r},\alpha+\beta\}$ and $\mathscr{L}\{\tilde{P}_U,\alpha+\beta\}$ represent the Laplace transforms of the paths of $\tilde{r}(t)$ and $\tilde{P}_U(t)\equiv dP_U(t)/P_U$, respectively, with $\alpha+\beta$ acting as the discount factor (see below).[16] The full-consumption effect, $\tilde{X}(v,0)$, can be re-written as follows:

$$\tilde{X}(v,0) = \tilde{V}(0)/\omega_K + (1/\omega_H)e^{(r_F-\alpha)v}\Big[\tilde{X}(0) - \tilde{V}(0)/\omega_K\Big], \quad v\leq0, \tag{4.4}$$

where ω_H is the initial economy-wide share of human wealth in total wealth ($0<\omega_H<1$) and $\tilde{V}(0)$ is the change in the value of land that occurs as a result of the change of the import tariff (see (3.9)). Equation (4.4) implies that the full-consumption jump is increasing in the generations index v, i.e. $\partial\tilde{X}(v,0)/\partial v>0$.[17] The intuition behind this result is as follows. The increase in the import tariff

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gives rise to additional lump-sum transfers. Since all generations have the same expected remaining lifetime the present value of these additional transfers is the same for all generations. This implies that all existing generations enjoy the same effect on human wealth and thus, on that account, increase their full consumption by the same absolute amount. Since old generations are, however, much wealthier than young generations, this human wealth effect is much more important to the latter generations.

The second and third terms on the right-hand side of (4.5) affect all existing generations equally. The second term represents the growth in full consumption. Since all generations are on an Euler equation of the form (2.10), the path of the interest rate affects all existing generations in the same way. Finally, the third term represents the cost-of-living effect which simply links full consumption to sub-utility (see (4.1) above).

In view of equation (4.3)-(4.4), $d\Lambda(v,0)$ can be written as a weighted average of the effect on an extremely old generation, $d\Lambda(-\infty,0)$, and the effect on a newborn, $d\Lambda(0,0)$:

$$d\Lambda(v,0) = \left[1 - e^{(r_F - \alpha)v}\right]d\Lambda(-\infty,0) + e^{(r_F - \alpha)v}d\Lambda(0,0), \quad v \leq 0. \tag{4.5}$$

Furthermore, in view of the fact that $\partial \tilde{X}(v,0)/\partial v > 0$, equation (4.5) implies that $d\Lambda(-\infty,0) < d\Lambda(0,0)$ as the welfare effect on existing generations is monotonically decreasing in age, i.e. $\partial d\Lambda(v,0)/\partial v > 0$.

Whilst it is thus straightforward to give a relative ranking of the effects on the different generations, it is not possible to determine analytically the absolute effects on the generations. The reason for this ambiguity can be clarified by studying the component parts that make up the total welfare effect. A close inspection of (4.4) reveals that the sign of the full consumption jump, $\tilde{X}(v,0)$, is ambiguous in general. On the one hand, if labour supply is exogenous ($\phi=1$), then $\tilde{V}(0)>0$ (see (3.9)) and $\tilde{X}(v,0)>0$ for all v, but on the other hand for higher values of ϕ, $\tilde{V}(0)$ will be negative and hence $\tilde{X}(v,0)<0$ for some generations v. In the latter case the effect on the level of full consumption of extremely old generations is negative due to the capital loss they suffer on land. Since aggregate full-consumption increases at impact (see (3.8) and note Assumption 2), this implies that the effect on newborns' full consumption must be positive.

The growth term for full consumption is unambiguously negative. It was shown in the previous section that the domestic interest rate falls at impact after which it returns to its initial level during transition (see (3.18)). This implies that the Laplace transform for the path of the interest rate has the following form:

$$\mathcal{L}\{\tilde{r}, \alpha + \beta\} \equiv \frac{\tilde{r}(0)}{\alpha + \beta + h^*} < 0. \tag{4.6}$$

The cost-of-living term can be written as a weighted average of the initial and long-run effect on the cost-of-living index:

$$\mathcal{L}\{\tilde{P}_U, \alpha + \beta\} \equiv \frac{\tilde{P}_U(0) - \tilde{P}_U(\infty)}{\alpha + \beta + h^*} + \frac{\tilde{P}_U(\infty)}{\alpha + \beta} \gtrless 0. \tag{4.7}$$

The ambiguity of the sign of the cost-of-living term is obvious in view of the fact that the impact and long-run effects on both the wage and the tariff-inclusive real exchange rate are ambiguous. Only for some special cases more can be said about the components of $\mathcal{L}\{\tilde{P}_U, \alpha + \beta\}$. For example, if labour supply is exogenous ($\phi=1$) or the diversity effect is sufficiently strong ($\eta\varepsilon_L>1$) it can be demonstrated that the cost-of-living index falls over time, i.e. $\tilde{P}_U(\infty)>\tilde{P}_U(0)$ in that case.

The results in (4.4)-(4.7) thus show that the welfare effect on existing generations is difficult to sign unambiguously due to the fact that the different components are themselves ambiguous or work in different directions from each other. It is possible, however, to determine a relative ranking of the welfare effects on present *and* future generations. Future generations are born in a world that is different from the initial steady state as a result of the shock. The change in welfare that future generations experience is evaluated at birth, i.e. the relevant indicator is $d\Lambda(t,t)$ for $v=t\geq0$. It is shown in Bettendorf and Heijdra (1998) that this welfare indicator can be written as a weighted average of the effect on a newborn, $d\Lambda(0,0)$, and the effect on a generation born in the new steady state, $d\Lambda(\infty,\infty)$:

$$d\Lambda(t,t) = e^{-h^*t}d\Lambda(0,0) + \left[1 - e^{-h^*t}\right]d\Lambda(\infty,\infty), \quad t=v\geq0, \tag{4.8}$$

where $d\Lambda(0,0)$ is obtained from (4.3)-(4.4) by setting $v=0$, and $d\Lambda(\infty,\infty)$ is given by:

$$(\alpha + \beta)d\Lambda(\infty,\infty) = \tilde{X}(\infty) - \tilde{P}_U(\infty). \tag{4.9}$$

It is shown in Bettendorf and Heijdra (1998) that the generations born in the new steady-state are better off than very old generations, i.e. $d\Lambda(-\infty,0)<d\Lambda(\infty,\infty)$. The reason is that these generations experience a higher full consumption level ($\tilde{X}(\infty)>\tilde{X}(0)$) which is not offset by cost-of-living changes. Numerical simulations strongly suggest that $d\Lambda(0,0)<d\Lambda(\infty,\infty)$ although we have been unable to prove this result unambiguously.[18]

The main characteristics of the path of (the change of) utility have been summarised in Proposition 2.

PROPOSITION 2. *The solution paths for utility given in* (4.5) *and* (4.8) *satisfy the following properties: (i) The change in welfare of an existing generation depends negatively on its year of*

birth v, i.e., dΛ(-∞,0)<dΛ(0,0); *(ii) Old existing generations gain less than future steady-state generations, i.e.,* dΛ(-∞,0)<dΛ(∞,∞). PROOF: See Bettendorf and Heijdra (1998).

4.2. Some numerical illustrations

As was shown in section 3 above, the macroeconomic effects of an import tariff consist of a gradual accumulation of foreign assets, and a gradual increase in full consumption. However, it is not in general possible to determine the sign of the welfare effects on current and future generations. For that reason, we further illustrate Proposition 2 with the aid of some numerical simulations with a plausibly calibrated version of the model.

Since we wish to study the effects on the intergenerational distribution of the initial tariff (t_M), the strength of the preference for diversity effect (as summarized by η), the export elasticity (σ_T), the degree of 'openness' of the economy (as summarized by $1-\gamma_D$), and the pre-existing product subsidy (s_P), the model is calibrated in such a way that these parameters can be freely varied. The parameters that are held fixed throughout the simulations are the rate of pure time preference (α=0.02), the birth rate (β=0.06), and the efficiency parameter of labour (ε_L=0.7). The world interest rate (r_F) and the productivity index (Ω_0) are used as calibration parameters. For given values of t_M, η, σ_T, γ_D, and s_P, it is then possible to compute all relevant remaining information.[19]

Table 3 presents a number of welfare indicators for different values of t_M in the different rows. Panel (a) of Table 3 is devoted to investigating the effect of the diversity parameter η on the distribution of welfare, whilst panels (b) through (e) do the same for σ_T, γ_D, and s_P, respectively. Consider panel (a) for t_M=0 initially. The intergenerational distribution of welfare is very uneven. Very old existing agents lose substantially (dΛ(-∞,0)<0) but newborns at the time of the shock as well as all future generation gains unambiguously (dΛ(0,0)>0 and dΛ(∞,∞)>0, so that (4.8) shows that dΛ(t,t)>0 for all t≥0). This pattern is preserved for all values of η considered provided the pre-existing tariff is not too high (t_M≤0.3, see the first three rows of Table 3, panel (a)).

Hence, the simulations demonstrate that, for a wide range of values of η and t_M, very old generations lose whereas young generations gain as a result of an increase in the tariff. But how does the change in the import tariff affect the population alive at the time of the shock? In order to answer that question we compute σ(%), which represents the percentage of the population (alive at the time of the shock) which is no worse-off as a result of the tariff shock. In view of equation (4.5), σ(%) can be written as:

This variable can be interpreted as the degree of political support that exists for the introduction of a tariff (if t_M=0 initially), or for a marginal increase of the tariff (if t_M>0 initially). Indeed, if σ(%)

$$\sigma(\%) \equiv 100\left[1 - \left(\frac{d\Lambda(-\infty,0)}{d\Lambda(-\infty,0) - d\Lambda(0,0)}\right)^{\beta/(r_F - \alpha)}\right] \qquad (4.10)$$

exceeds fifty percent one would expect the existing population to vote in favour of introducing (or increasing) the tariff. The information in panel (a) of Table 3 suggests that the degree of political support decreases with the diversity parameter η. For example, if $t_M=0$ initially, political support is above fifty percent for $\eta \leq 1.2$ but is below fifty percent for larger values of η. This shows that, provided the diversity effect is sufficiently strong, the uneven intergenerational burden can make the introduction of a tariff unattractive to existing generations.

The second conclusion that can be drawn from panel (a) of Table 3 concerns the effect of a pre-existing tariff. Raising the initial value of t_M drags down the welfare profile for most present generations and all future generations. As a result, political support declines as the pre-existing tariff is raised. For example, if $t_M=0.1$ and $\eta=1.0$, there is not enough political support for a further increase in the tariff. Even though the young continue to gain from such a further increase, too many older generations lose out in this case.

In panel (b) of Table 3 the effect of the export elasticity on the intergenerational welfare distribution is studied. Three main conclusions emerge from these simulation results. First, raising σ_T decreases the gains to all generations. The intuition behind this result is that a higher value for σ_T reduces the terms of trade gains. The second conclusion that can be drawn is that for low values of σ_T there exists quite substantial political support for a high tariff. For example, if $\sigma_T=1$ (first column), even if $t_M=0.9$ initially, there is still a majority among existing generations in favour of a higher tariff. In that case the country as a whole has a lot of market power (in the sense of Gros (1987)), and can therefore obtain a substantial appreciation of its real exchange rate at the expense of foreigners. The third conclusion is that, like in the previous case, political support declines with the pre-existing tariff.

In panel (c) of Table 3, the effect of the degree of openness of the economy is investigated numerically. Two major conclusions can be drawn from these results. First, reducing the trade share (raising γ_D) reduces the welfare loss for extremely old generations, and reduces the welfare gain by generations born in the new steady-state. The effect on newly-born generations is ambiguous. If t_M is low initially, these generations' gains are reduced as γ_D rises, whereas the opposite conclusion holds if t_M is high. Political support increases with γ_D. The intuition behind this result is that a relatively closed economy has a smaller scope to obtain a welfare transfer from the rest of the world by means of terms of trade gains that are caused by the tariff. The second conclusion that can be drawn is that, as in the previous two cases, raising the initial tariff reduces

political support.

In panel (d) of Table 3 the effect of the pre-existing product subsidy s_P is investigated. The main conclusions is that an increase in s_P leads to an upward shift of the welfare change for all generations, i.e. it reduces the welfare losses to old generations, and increases the gains to both newborns and all future generations. The reason is that the product subsidy helps to boost employment and output and thus leads to a reduction in the severity of the domestic distortion due to monopolistic competition (see Bettendorf and Heijdra (1996)). This suggests that there exists a complementarity between the instruments of trade policy (t_M) and industrial policy (s_P).

4.3. Intergenerational redistribution policy

In the previous section it has been demonstrated that the welfare effect of a supposedly 'efficiency-improving' policy measure is generation-dependent, and may be negative for most or all present generations. This finding demonstrates the need for a mechanism that provides for a more even distribution of welfare over generations. Indeed, since most or all 'gainers' are yet-unborn and all 'losers' are alive at the time of the shock, the political system of majority rule would seem to have an inherent bias against a tariff. The present generations in effect produce an intergenerational externality by not supporting the introduction of (or further increase in) the tariff. Generations born in the new steady state are better off both because there are terms of trade gains and because they enjoy a net claim on the rest of the world.[20]

In this section we endow the policy maker with the ability to use bond policy in order to neutralize the intergenerational welfare effects. In doing so the pure 'efficiency effects' of the import tariff are brought to the fore. Obviously, since old existing generations lose and future generations gain in the absence of bond policy, the natural choice is to accumulate public debt by granting a once-off subsidy to the owners of land at the time of the shock. Since land holdings are predetermined in the impact period, the proper scheme links the once-off subsidy (s_K) to the value of land, i.e. a member of generation v (<0) receives a subsidy of $s_K V(0)K(v,0)$, the aggregate outlays on the subsidy is $s_K V(0)$, and the discrete change in the government's debt position at impact is given in log-linearized form by $\tilde{B}(0)=-s_K\tilde{V}(0)$. It is shown in Bettendorf and Heijdra (1998) that, provided the subsidy is set at the appropriate level, no further debt policy is needed to ensure that the welfare of all generations is affected equally, i.e. $\tilde{B}(t)=\tilde{B}(0)$ for $t\geq0$. The appropriately conducted bond policy ensures that $\tilde{B}(0)=\omega_X\omega_K\tilde{t}_M$, which in turn eliminates all transitional dynamics from the model.

The allocation effects of the change in the tariff accompanied by the bond policy can be computed by substituting $\tilde{B}(t)=\omega_X\omega_K\tilde{t}_M$ into (2.29) and solving for the (impact, transition, and long-

run) effects on the state variables:

$$\tilde{F}(t) = 0, \qquad \tilde{V}(t) = -\omega_X \omega_K [(\phi-1)/\phi] \tilde{t}_M < 0, \qquad \tilde{X}(t) = (\omega_X/\phi) \tilde{t}_M > 0, \qquad (4.11)$$

for all $t \geq 0$. The expression for full consumption can be combined with (2.23)-(2.25) to obtain the effects on the other endogenous variables:

$$\tilde{Y}(t) = \eta \varepsilon_L \tilde{L}(t) = \tilde{R}_L(t) = [1 - 1/(\eta \varepsilon_L)]^{-1} \tilde{W}(t) = -\omega_X [(\phi-1)/\phi] \tilde{t}_M < 0, \quad \tilde{r}(t) = 0,$$
$$\qquad (4.12)$$

$$\sigma_T \phi \tilde{E}(t) = -(\phi - \omega_X) \tilde{t}_M < 0, \quad \phi \sigma_T \tilde{C}_F(t) = -(\phi - \omega_X)(\sigma_T - 1) \tilde{t}_M < 0,$$

for all $t \geq 0$.

The intuition behind these results can be explained with the aid of Figure 2. As before, the increase in the tariff shifts the CA and MKR loci from CA_0 to CA_1 and from MKR_0 to MKR_1, respectively. The upward jump in the public debt ($\tilde{B}(0) = \omega_X \omega_K \tilde{t}_M > 0$) does not affect the CA locus but the MKR locus is shifted to the left, i.e. from MKR_1 to MKR_2. Due to the once-off subsidy to landowners the increase in the tariff does not only leave the domestic interest rate unaffected (see (4.12)) but also raises full consumption by the same *relative* amount for all generations (see (2.13)). This neutralizes the differential welfare effect on all existing generations, i.e. $d\Lambda(v,0) = \pi$ for all $v \leq 0$, where π is the common welfare gain.

Since the policy also eliminates any transitional dynamics from the economy, all future generations are affected in exactly the same manner, i.e. $d\Lambda(v,v) = \pi$ for all $v = t \geq 0$. The level of the common gain to all generations under this egalitarian policy can thus be computed by using (4.9), (4.11)-(4.12), and the log-linearized version of (4.2):

$$\pi = \Gamma(t_M, s_P) \tilde{t}_M, \qquad (4.13)$$

where $\Gamma(t_M, s_P)$ is a complicated function of the parameters and the pre-existing tariff and product subsidy. In order to build up intuition concerning this function, it is useful to consider some special cases. First, if labour supply is exogenous ($\phi = \gamma = 1$), output is fixed and independent of the product subsidy, and s_P drops out of $\Gamma(t_M, s_P)$ altogether:

$$\Gamma(t_M, s_P) \equiv \frac{(1 - \gamma_D)\gamma_D [1 - t_M(\sigma_T - 1)]}{\sigma_T(1 + \gamma_D t_M)}, \qquad \text{for } \phi = 1. \qquad (4.14)$$

This expression immediately suggests that introducing a tariff is beneficial (as $\Gamma(0, s_P) > 0$) and that the first-best optimal tariff (for which $\Gamma(t_M^F, s_P) = 0$) is aimed at fully exploiting the 'national market power' resulting from the upward sloping export function, i.e. $t_M^F = 1/(\sigma_T - 1)$.

If labour supply is endogenous ($\phi > 1$), matters are much more complicated. Bettendorf and

Heijdra (1996) show that an increase in the product subsidy (under an egalitarian bond policy) boosts full consumption, output, employment, the number of product varieties, wages, and the rental on land, and induces a depreciation of the real exchange rate. The consequence of this is that the pre-existing product subsidy affects $\Gamma(t_M, s_P)$ directly, so that the issue of the optimal tariff is complicated by second-best considerations, because s_P may be sub-optimal itself. In order to get a handle on this problem, we compute the second-best optimal egalitarian product subsidy which takes into account the existence of pre-existing tariffs. In Bettendorf and Heijdra (1998) we derive the following expression for $s_P^S(t_M)$:

$$1 + s_P^S(t_M) = \frac{\eta(1 + t_M)[\sigma_T - 1 + \gamma_D]}{\sigma_T(1 + t_M \gamma_D)} \quad \Leftrightarrow \quad s_P^S(t_M) = s_P^F + \frac{\eta \omega_X [t_M - t_M^F]}{1 + t_M^F}. \qquad (4.15)$$

If there is no pre-existing tariff ($t_M = 0$), s_P^S reduces to the expression derived by Bettendorf and Heijdra (1996), and part of the benefits of the product subsidy leak away to the rest of the world in the form of a real exchange rate depreciation. Interestingly, equation (4.15) suggests that $\partial s_P^S / \partial t_M > 0$, which suggests that the industrial policy stance can be more ambitious, the higher is the initial tariff.

Of course, s_P^S in (4.15) is itself second-best since it still depends on the pre-existing tariff, which may or may not be optimal. The first-best social optimum can be computed, however, by noting that it satisfies (4.15) and ensures that $\Gamma(t_M, s_P) = 0$. Bettendorf and Heijdra (1998) derive the following expressions for t_M^F and s_P^F:

$$t_M^F = \frac{1}{\sigma_T - 1}, \qquad s_P^F = \eta - 1. \qquad (4.16)$$

The important conclusion which can be drawn is that in the first-best optimum, the product subsidy is fully aimed at exploiting the increasing returns due to Ethier-style productivity effects whereas the tariff is aimed at fully exploiting national market power (as in the case of exogenous labour supply discussed above). Note that the expression for the optimal product subsidy does not depend on any parameters relating to the rest of the world. Indeed, it is not difficult to show that the same expression also holds for a closed economy.[21]

The egalitarian welfare effect of a tariff can be further illustrated by eliminating the domestic distortion due to monopolistic competition from consideration. Indeed, by substituting the first-best optimal product subsidy, $s_P^F = \eta - 1$, into the expression for $\Gamma(t_M, s_P)$ we obtain:

and it is furthermore possible to prove that $\partial t_M^S / \partial s_P > 0$ around $s_P = s_P^F$ (see Bettendorf and Heijdra (1998)).[22] Hence, provided the product subsidy is set at its first-best optimum value, it is always

$$\Gamma(t_M, s_P^F) = \frac{\gamma\gamma_D(1-\gamma_D)\left[1-t_M(\sigma_T-1)\right]}{\sigma_T(1+\gamma_D t_M)}, \tag{4.17}$$

beneficial to introduce a tariff, and as long as the product subsidy is close to its first-best optimum, the second-best optimal tariff depends positively on the pre-existing product subsidy.

We now return to the simulations reported in Table 3. An interesting conclusion that emerges from this table is that the prudent use of debt policy allows for a more ambitious trade policy by spreading the costs and benefits equally over all generations. Take, for example, the third column in panel (a) of Table 3. The diversity effect is equal to $\eta=1.3$, and present generations do not gain sufficiently to vote in favour of even an introduction of a tariff as $\sigma(\%)=46.9$ for $t_M=0$. With an egalitarian policy, however, the common gain to all generations is in fact positive ($\pi=0.333$ for $t_M=0$), suggesting that the tariff should be introduced. By shifting some of the benefits from young and future generations to the older generations, everybody can be made better off. The same conclusion holds for $t_M=0.1$, and in fact the optimal egalitarian tariff lies somewhere between $t_M=0.1$ and $t_M=0.3$. The same pattern is observed in the other panels of Table 3.

5. Conclusions

A dynamic overlapping-generations model of a small open economy with monopolistic competition in the goods market is constructed and analyzed. Industrial policy in the form of an import tariff reduces output and employment and leads to an appreciation of the real exchange rate both in the impact period and in the new steady state. An increase in the tariff has important intergenerational distribution effects. Old existing generations gain less than younger existing generations as well as future generations. The prudent use of bond policy neutralizes these intergenerational inequities and suggests first-best and second-best optimal tariff rates. The first-best tariff exploits national market power, but the second-best tariff contains a correction to account for the existence of a potentially suboptimal product subsidy.

This paper can be extended in a number of different directions. First, by constructing a two-country version of the present model the optimal tariff issue can be studied both with and without international coordination. This would lead to a further clarification of the role of domestic and foreign scale economies and international market power. It would also forge a link with the strategic trade policy literature mentioned in the introduction. Our paper, like the traditional literature, strongly suggests that a tariff increase constitutes a 'beggar-thy-neighbour policy' which suggests that international cooperation may lead to a lower optimal tariff. Second, it would be

desirable to introduce physical capital as a production factor in the present model. A number of thorny issues must, however, be confronted in such a generalized model. For example, in the absence of installation costs physical capital is perfectly mobile, leading to implausible impact and transition effects. See Giovannini (1988) for such a model. Introducing convex installation costs for investment 'solves' this problem for the perfectly competitive case (see Buiter (1987)) but opens an analytically intractable can of worms in a monopolistically competitive world.[23] The reason is that making physical capital imperfectly mobile also breaks the symmetry of the model because incumbent firms and potential entrants face different costs of producing. The former possess installed capital and hence face lower costs of adjusting their capital stock than the latter, who must build up their capital stock from scratch. It is conjectured that a number of first insights into the effect of capital accumulation on our conclusions can nevertheless be obtained by studying a version of the model in which there is no entry/exit of firms at all.

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Table 1: Short-Run Version of the Model

$$\dot{V}(t) = r(t)V(t) - R_L(t) \tag{T1.1}$$

$$\dot{X}(t) = \left[r(t) - \alpha\right]X(t) - \beta(\alpha + \beta)\left[V(t) + E(t)F(t) + B(t)\right] \tag{T1.2}$$

$$r(t) = r_F + \dot{E}(t)/E(t) \tag{T1.3}$$

$$\dot{F}(t) = r_F F(t) + C_F^* E^{\sigma_T - 1} - C_F(t) \tag{T1.4}$$

$$B(t) = \int_t^\infty \left[T(\tau) + t_M(\tau)E(\tau)C_F(\tau) - s_P(\tau)Y(\tau)\right]\exp\left[-\int_t^\tau r(\mu)\,d\mu\right]d\tau \tag{T1.5}$$

$$\varepsilon_L\left(1 + s_P\right)Y(t) = W(t)L(t) \tag{T1.6}$$

$$(1 - \varepsilon_L)\left(1 + s_P\right)Y(t) = R_L(t) \tag{T1.7}$$

$$Y(t) = C_D(t) + C_F^* E(t)^{\sigma_T} \tag{T1.8}$$

$$C_D(t) = \gamma\gamma_D X(t), \quad E(t)\left[1 + t_M(t)\right]C_F(t) = \gamma(1 - \gamma_D)X(t), \quad W(t)\left[1 - L(t)\right] = (1 - \gamma)X(t) \tag{T1.9}$$

$$Y(t) = \Omega_0 L(t)^{\eta\varepsilon_L} \tag{T1.10}$$

Notes: (a) $P_F(t) \equiv 1$ and $E(t) \equiv P_F(t)/P_D(t)$ is the real exchange rate.

      (b) $\Omega_0 \equiv (\lambda/\mu)^{\eta/\lambda}((\mu-\lambda)/\lambda f)^{(\eta-\lambda)/\lambda} > 0$.

$$\dot{\tilde{V}}(t) = r_F\,\tilde{V}(t) + r_F\,\omega_K\big[\tilde{r}(t) - \tilde{R}_L(t)\big]$$

(T2.1)

$$\dot{\tilde{X}}(t) = \big[r_F - \alpha\big]\tilde{X}(t) + r_F\,\tilde{r}(t) - \big[(r_F - \alpha)/\omega_K\big]\big[\tilde{V}(t) + \tilde{F}(t) + \tilde{B}(t)\big]$$

(T2.2)

$$\dot{\tilde{E}}(t) = r_F\,\tilde{r}(t)$$

(T2.3)

$$r_F^{-1}\dot{\tilde{F}}(t) = \tilde{F}(t) + \omega_X\big[(\sigma_T - 1)\tilde{E}(t) - \tilde{C}_F(t)\big]$$

(T2.4)

$$r_F^{-1}\tilde{B}(0) = \mathcal{L}\{\tilde{T}, r_F\} + (1 + t_M)\left[\mathcal{L}\{\tilde{t}_M, r_F\} + \left(\frac{t_M}{1 + t_M}\right)\mathcal{L}\{\tilde{X}, r_F\}\right]$$

(T2.5)

$$\tilde{L}(t) = \tilde{Y}(t) - \tilde{W}(t)$$

(T2.6)

$$\tilde{R}_L(t) = \tilde{Y}(t)$$

(T2.7)

$$\tilde{Y}(t) = (1 - \omega_X)\tilde{C}_D(t) + \omega_X\sigma_T\tilde{E}(t)$$

(T2.8)

$$\tilde{C}_D(t) = \tilde{X}(t), \quad \tilde{C}_F(t) = \tilde{C}_D(t) - \tilde{E}(t) - \tilde{t}_M(t), \quad \tilde{L}(t) = \omega_{LL}\big[\tilde{W}(t) - \tilde{X}(t)\big]$$

(T2.9)

$$\tilde{Y}(t) = \eta\,\varepsilon_L\,\tilde{L}(t)$$

(T2.10)

Shares:

ω_{LL}	$(1-L)/L$	Initial leisure/work ratio.
ω_K	R_L/Y	Initial share of rental income in national income.
ω_X	EC_F/Y	Initial share of imports (and exports) in national income.

Notes: (a)   We have used the normalization $E=1$ and $B=F=0$ initially. The total (constant) stock of land equals $K=1$.

(b)   Relationship between shares: $\omega_K=(1-\varepsilon_L)(1+s_P)$, $\omega_X=(1-\gamma_D)/(1+\gamma_D t_M)$.

Table 3. The Efficiency and Intergenerational Distribution Effects of an Import Tariff

Panel (a): The effect of the diversity parameter

		η=1.0	η=1.2	η=1.3	η=1.4	η=1.6
t_M=0.0	π	0.637	0.434	0.333	0.231	0.029
	dΛ(-∞,0)	-5.304	-5.513	-5.617	-5.722	-5.932
	dΛ(0,0)	1.339	1.156	1.065	0.974	0.795
	dΛ(∞,∞)	2.025	1.736	1.591	1.447	1.157
	σ(%)	56.0	50.0	46.9	43.6	36.8
t_M=0.1	π	0.484	0.286	0.187	0.087	-0.111
	dΛ(-∞,0)	-5.169	-5.372	-5.474	-5.576	-5.780
	dΛ(0,0)	1.068	0.888	0.799	0.710	0.534
	dΛ(∞,∞)	1.838	1.555	1.413	1.271	0.988
	σ(%)	48.9	42.2	38.6	34.9	27.1
t_M=0.3	π	0.220	0.031	-0.063	-0.158	-0.347
	dΛ(-∞,0)	-4.932	-5.124	-5.220	-5.317	-5.510
	dΛ(0,0)	0.632	0.459	0.374	0.288	0.118
	dΛ(∞,∞)	1.511	1.241	1.106	0.971	0.702
	σ(%)	34.2	25.8	21.4	16.8	7.1
t_M=0.5	π	0.000	-0.179	-0.269	-0.359	-0.538
	dΛ(-∞,0)	-4.731	-4.913	-5.004	-5.095	-5.277
	dΛ(0,0)	0.294	0.129	0.047	-0.035	-0.197
	dΛ(∞,∞)	1.236	0.980	0.852	0.723	0.467
	σ(%)	18.5	8.4	3.1	0.0	0.0
t_M=0.7	π	-0.186	-0.357	-0.442	-0.527	-0.698
	dΛ(-∞,0)	-4.559	-4.731	-4.817	-4.903	-5.076
	dΛ(0,0)	0.024	-0.133	-0.211	-0.290	-0.445
	dΛ(∞,∞)	1.002	0.759	0.637	0.515	0.272
	σ(%)	1.8	0.0	0.0	0.0	0.0
t_M=0.9	π	-0.346	-0.508	-0.589	-0.670	-0.832
	dΛ(-∞,0)	-4.411	-4.574	-4.655	-4.737	-4.900
	dΛ(0,0)	-0.196	-0.347	-0.422	-0.496	-0.645
	dΛ(∞,∞)	0.801	0.569	0.453	0.337	0.106
	σ(%)	0.0	0.0	0.0	0.0	0.0

Note: Parameter values are α=0.02, β=0.06, $γ_D$=0.5, $ε_L$=0.7, s_P=0, $σ_T$=3, and $ω_{LL}$=2.0. σ(%) is the percentage of the population (alive at the time of the shock) that does not lose as a result of a marginal increase in the tariff. The efficiency gain under egalitarian redistributive bond policy is given by π.

Panel (b): The effect of the export elasticity

		$\sigma_T=1$	$\sigma_T=2$	$\sigma_T=3$	$\sigma_T=5$	$\sigma_T=10$
$t_M=0.0$	π	1.727	0.681	0.333	0.054	-0.155
	$d\Lambda(-\infty,0)$	-4.019	-5.196	-5.617	-5.975	-6.263
	$d\Lambda(0,0)$	2.374	1.382	1.065	0.821	0.647
	$d\Lambda(\infty,\infty)$	3.584	2.090	1.591	1.193	0.894
	$\sigma(\%)$	81.6	57.7	46.9	37.4	30.1
$t_M=0.1$	π	1.636	0.549	0.187	-0.103	-0.321
	$d\Lambda(-\infty,0)$	-3.831	-5.042	-5.474	-5.840	-6.134
	$d\Lambda(0,0)$	2.167	1.131	0.799	0.543	0.362
	$d\Lambda(\infty,\infty)$	3.484	1.931	1.413	0.999	0.688
	$\sigma(\%)$	79.9	51.5	38.6	27.3	18.5
$t_M=0.3$	π	1.480	0.322	-0.063	-0.372	-0.603
	$d\Lambda(-\infty,0)$	-3.502	-4.771	-5.220	-5.600	-5.905
	$d\Lambda(0,0)$	1.841	0.731	0.374	0.098	-0.098
	$d\Lambda(\infty,\infty)$	3.311	1.657	1.106	0.665	0.335
	$\sigma(\%)$	77.0	39.1	21.4	5.8	0.0
$t_M=0.5$	π	1.351	0.136	-0.269	-0.593	-0.836
	$d\Lambda(-\infty,0)$	-3.223	-4.540	-5.004	-5.395	-5.708
	$d\Lambda(0,0)$	1.598	0.426	0.047	-0.245	-0.454
	$d\Lambda(\infty,\infty)$	3.167	1.430	0.852	0.389	0.041
	$\sigma(\%)$	74.6	26.3	3.1	0.0	0.0
$t_M=0.7$	π	1.244	-0.021	-0.442	-0.779	-1.032
	$d\Lambda(-\infty,0)$	-2.985	-4.341	-4.817	-5.218	-5.538
	$d\Lambda(0,0)$	1.410	0.185	-0.211	-0.519	-0.738
	$d\Lambda(\infty,\infty)$	3.045	1.239	0.637	0.155	-0.206
	$\sigma(\%)$	72.5	13.0	0.0	0.0	0.0
$t_M=0.9$	π	1.152	-0.154	-0.589	-0.937	-1.199
	$d\Lambda(-\infty,0)$	-2.779	-4.169	-4.655	-5.063	-5.389
	$d\Lambda(0,0)$	1.260	-0.010	-0.422	-0.741	-0.970
	$d\Lambda(\infty,\infty)$	2.941	1.075	0.453	-0.044	-0.417
	$\sigma(\%)$	70.8	0.0	0.0	0.0	0.0

Note: Parameter values are $\alpha=0.02$, $\beta=0.06$, $\gamma_D=0.5$, $\varepsilon_L=0.7$, $s_P=0$, $\eta=1.3$, and $\omega_{LL}=2.0$. $\sigma(\%)$ is the percentage of the population (alive at the time of the shock) that does not lose as a result of a marginal increase in the tariff. The efficiency gain under egalitarian redistributive bond policy is given by π.

Panel (c): The effect of the trade share

		γ_D=0.1	γ_D=0.3	γ_D=0.5	γ_D=0.7	γ_D=0.9
t_M=0.0	π	0.353	0.370	0.333	0.241	0.094
	$d\Lambda(-\infty,0)$	-10.625	-8.086	-5.617	-3.239	-1.006
	$d\Lambda(0,0)$	1.705	1.407	1.065	0.677	0.240
	$d\Lambda(\infty,\infty)$	2.513	2.091	1.591	1.013	0.357
	$\sigma(\%)$	41.9	44.3	46.9	49.9	54.1
t_M=0.1	π	0.149	0.190	0.187	0.140	0.056
	$d\Lambda(-\infty,0)$	-10.729	-8.020	-5.474	-3.103	-0.950
	$d\Lambda(0,0)$	1.212	1.032	0.799	0.517	0.186
	$d\Lambda(\infty,\infty)$	2.322	1.895	1.413	0.881	0.304
	$\sigma(\%)$	31.4	34.9	38.6	42.6	47.8
t_M=0.3	π	-0.215	-0.125	-0.063	-0.025	-0.004
	$d\Lambda(-\infty,0)$	-10.896	-7.882	-5.220	-2.880	-0.864
	$d\Lambda(0,0)$	0.399	0.421	0.374	0.266	0.103
	$d\Lambda(\infty,\infty)$	1.978	1.547	1.106	0.663	0.220
	$\sigma(\%)$	11.3	16.2	21.4	26.9	33.5
t_M=0.5	π	-0.530	-0.394	-0.269	-0.155	-0.050
	$d\Lambda(-\infty,0)$	-11.019	-7.744	-5.004	-2.704	-0.799
	$d\Lambda(0,0)$	-0.248	-0.056	0.047	0.077	0.042
	$d\Lambda(\infty,\infty)$	1.677	1.246	0.852	0.490	0.157
	$\sigma(\%)$	0.0	0.0	3.1	9.3	16.7
t_M=0.7	π	-0.806	-0.626	-0.442	-0.260	-0.085
	$d\Lambda(-\infty,0)$	-11.108	-7.610	-4.817	-2.562	-0.750
	$d\Lambda(0,0)$	-0.777	-0.440	-0.211	-0.071	-0.006
	$d\Lambda(\infty,\infty)$	1.411	0.983	0.637	0.350	0.108
	$\sigma(\%)$	0.0	0.0	0.0	0.0	0.0
t_M=0.9	π	-1.051	-0.830	-0.589	-0.347	-0.113
	$d\Lambda(-\infty,0)$	-11.171	-7.481	-4.655	-2.445	-0.710
	$d\Lambda(0,0)$	-1.221	-0.757	-0.422	-0.189	-0.043
	$d\Lambda(\infty,\infty)$	1.172	0.752	0.453	0.234	0.068
	$\sigma(\%)$	0.0	0.0	0.0	0.0	0.0

Note: Parameter values are α=0.02, β=0.06, η=1.3, ε_L=0.7, s_P=0, η=1.3, and ω_{LL}=2.0. $\sigma(\%)$ is the percentage of the population (alive at the time of the shock) that does not lose as a result of a marginal increase in the tariff. The efficiency gain under egalitarian redistributive bond policy is given by π.

Panel (d): The effect of the pre-existing product subsidy

		$s_P=0$	$s_P=0.1$	$s_P=0.2$	$s_P=0.3$	$s_P=0.4$
$t_M=0.0$	π	0.333	0.429	0.516	0.593	0.664
	$d\Lambda(-\infty,0)$	-5.617	-5.502	-5.397	-5.302	-5.215
	$d\Lambda(0,0)$	1.065	1.173	1.268	1.352	1.426
	$d\Lambda(\infty,\infty)$	1.591	1.853	2.118	2.390	2.674
	$\sigma(\%)$	46.9	49.6	51.9	53.8	55.4
$t_M=0.1$	π	0.187	0.283	0.371	0.450	0.521
	$d\Lambda(-\infty,0)$	-5.474	-5.358	-5.254	-5.158	-5.071
	$d\Lambda(0,0)$	0.799	0.906	1.000	1.084	1.158
	$d\Lambda(\infty,\infty)$	1.413	1.670	1.930	2.197	2.475
	$\sigma(\%)$	38.6	42.0	44.7	47.0	49.0
$t_M=0.3$	π	-0.063	0.035	0.124	0.204	0.276
	$d\Lambda(-\infty,0)$	-5.220	-5.105	-5.001	-4.905	-4.818
	$d\Lambda(0,0)$	0.374	0.479	0.572	0.656	0.730
	$d\Lambda(\infty,\infty)$	1.106	1.355	1.607	1.865	2.132
	$\sigma(\%)$	21.4	26.1	30.0	33.3	36.1
$t_M=0.5$	π	-0.269	-0.170	-0.081	0.000	0.074
	$d\Lambda(-\infty,0)$	-5.004	-4.889	-4.785	-4.690	-4.603
	$d\Lambda(0,0)$	0.047	0.151	0.244	0.327	0.402
	$d\Lambda(\infty,\infty)$	0.852	1.094	1.338	1.588	1.846
	$\sigma(\%)$	3.1	9.6	14.8	19.1	22.8
$t_M=0.7$	π	-0.442	-0.343	-0.253	-0.171	-0.097
	$d\Lambda(-\infty,0)$	-4.817	-4.703	-4.560	-4.505	-4.418
	$d\Lambda(0,0)$	-0.211	-0.108	-0.016	0.068	0.143
	$d\Lambda(\infty,\infty)$	0.637	0.873	1.111	1.353	1.604
	$\sigma(\%)$	0.0	0.0	0.0	4.5	9.2
$t_M=0.9$	π	-0.589	-0.490	-0.400	-0.317	-0.242
	$d\Lambda(-\infty,0)$	-4.655	-4.542	-4.439	-4.345	-4.258
	$d\Lambda(0,0)$	-0.422	-0.319	-0.227	-0.143	-0.068
	$d\Lambda(\infty,\infty)$	0.453	0.684	0.916	1.152	1.396
	$\sigma(\%)$	0.0	0.0	0.0	0.0	0.0

Note: Parameter values are $\alpha=0.02$, $\beta=0.06$, $\gamma_D=0.5$, $\varepsilon_L=0.7$, $\eta=1.3$, $\sigma_T=3$, and $\omega_{LL}=2.0$. $\sigma(\%)$ is the percentage of the population (alive at the time of the shock) that does not lose as a result of a marginal increase in the tariff. The efficiency gain under egalitarian redistributive bond policy is given by π.

*Panel (e): The effect of the export elasticity if the
product subsidy is set optimally*

		$\sigma_T=1$	$\sigma_T=2$	$\sigma_T=3$	$\sigma_T=5$	$\sigma_T=11$
$t_M=0$	π	1.780	0.890	0.593	0.356	0.162
	$d\Lambda(-\infty,0)$	-3.902	-4.927	-5.302	-5.627	-5.922
	$d\Lambda(0,0)$	2.490	1.630	1.352	1.135	0.966
	$d\Lambda(\infty,\infty)$	4.336	2.876	2.390	2.001	1.682
	$\sigma(\%)$	81.3	62.2	53.8	46.5	40.2
$t_M=0.1$	π	1.687	0.759	0.450	0.202	0.000
	$d\Lambda(-\infty,0)$	-3.720	-4.774	-5.158	-5.490	-5.791
	$d\Lambda(0,0)$	2.274	1.375	1.084	0.857	0.680
	$d\Lambda(\infty,\infty)$	4.225	2.704	2.197	1.792	1.460
	$\sigma(\%)$	79.6	57.0	47.0	38.3	30.9
$t_M=0.25$	π	1.564	0.587	0.261	0.000	-0.213
	$d\Lambda(-\infty,0)$	-3.476	-4.569	-4.965	-5.305	-5.613
	$d\Lambda(0,0)$	2.010	1.060	0.752	0.511	0.323
	$d\Lambda(\infty,\infty)$	4.079	2.476	1.942	1.515	1.165
	$\sigma(\%)$	77.3	49.3	36.8	25.9	16.7
$t_M=0.5$	π	1.395	0.349	0.000	-0.279	-0.507
	$d\Lambda(-\infty,0)$	-3.132	-4.279	-4.690	-5.042	-5.360
	$d\Lambda(0,0)$	1.682	0.660	0.327	0.068	-0.135
	$d\Lambda(\infty,\infty)$	3.875	2.160	1.588	1.130	0.756
	$\sigma(\%)$	74.2	36.4	19.1	4.1	0.0
$t_M=1$	π	1.148	0.000	-0.383	-0.689	-0.939
	$d\Lambda(-\infty,0)$	-2.612	-3.839	-4.272	-4.641	-4.971
	$d\Lambda(0,0)$	1.262	0.134	-0.235	-0.523	-0.750
	$d\Lambda(\infty,\infty)$	3.572	1.690	1.062	0.560	0.150
	$\sigma(\%)$	69.9	9.9	0.0	0.0	0.0

Note: Parameter values are $\alpha=0.02$, $\beta=0.06$, $\gamma_D=0.5$, $\varepsilon_L=0.7$, $s_P=\eta-1=0.3$, $\eta=1.3$, and $\omega_{LL}=2.0$. $\sigma(\%)$ is the percentage of the population (alive at the time of the shock) that does not lose as a result of a marginal increase in the tariff. The efficiency gain under egalitarian redistributive bond policy is given by π.

Footnotes

1. Recent examples include Bovenberg (1993) on investment stimulation measures, Bovenberg (1994) on capital taxation, as well as Engel and Kletzer (1990) and Galor (1994) on tariffs. All these papers analyse a small open economy with universal perfect competition. Bovenberg and Heijdra (1996) analyse environmental taxes in a closed economy. Bettendorf and Heijdra (1996) use the model of this paper to study the macroeconomic and distributional effects of a product subsidy. See also the recent study by Keuschnigg and Kohler (1996).

2. Hence, it is assumed that the Armington substitution elasticity between domestic and foreign composite consumption goods (say σ_A) equals unity. This assumption is made for simplicity. A non-unitary Armington elasticity, $\sigma_A \neq 1$, does not substantially affect the arguments in this paper.

3. Hence, it is assumed that domestic and foreign varieties substitute equally well among themselves. This assumption helps in keeping the model as simple as possible.

4. If $\gamma = 1$, labour supply is exogenous and each agent inelastically supplies one unit of labour.

5. Provided financial wealth is positive, which is ensured throughout the paper. See below.

6. We use the fact that $X(\tau) = (\alpha + \beta)[A(\tau) + H(\tau)]$ and $X(\tau, \tau) = (\alpha + \beta)H(\tau)$ in the second step.

7. We include a pre-existing product subsidy to capture the notion that the policy maker may be engaged in industrial policy aimed at correcting for the monopoly distortions in the economy. Below we demonstrate the interaction between the optimal tariff and the pre-existing product subsidy. In Bettendorf and Heijdra (1996) we study the allocation and welfare effects of the product subsidy.

8. This explains the appearance of the term involving $N(\tau)$ in (2.20).

9. Free exit and entry implies that average cost curve is tangent to the demand curve. It is straightforward to show that marginal cost of any active firm (MC_i) equals total cost (TC_i) divided by λ times gross production ($\bar{Y} + f$), i.e., $MC_i = TC_i / \lambda(\bar{Y} + f)$. The expressions in (2.16) imply the usual mark-up pricing rule, i.e., $\bar{P} = \mu MC_i$. The tangency condition requires $\bar{P} = AC_i = TC_i / \bar{Y}$. Combining these conditions yields the zero pure profit condition $\mu \bar{Y} = \lambda(\bar{Y} + f)$. For obvious reasons, this expression is only meaningful if the markup exceeds the scale parameter λ, i.e. $\mu > \lambda$ is assumed throughout the paper. This condition has been used to derive (T1.10).

10. If the substitution elasticity between broad consumption and leisure (say σ_{CM}) is unequal to unity, the real exchange rate also affects labour supply directly. Indeed, if $\sigma_{CM} > 1$, labour supply and hence output depend negatively on the real exchange rate, rendering the aggregate supply curve downward sloping in Figure 1. Nothing of substance is affected by restricting attention to the Cobb-Douglas case with $\sigma_{CM} = 1$.

11. Note that Y^D does not directly depend on the tariff, t_M. If the Armington substitution elasticity between domestic and foreign composite consumption goods (σ_A) is unequal to unity, the tariff also affects aggregate demand directly. Indeed, if $\sigma_A > 1$, the home demand for domestic goods and hence aggregate demand depend positively on the tariff. Nothing of substance is affected by restricting attention to the Cobb-Douglas case with $\sigma_A = 1$.

12. The slope of the MKR curve is $\partial\tilde{X}/\partial\tilde{F}=1/\omega_K$ and the slope of the CA curve is $\partial\tilde{X}/\partial\tilde{F}=1/\phi$. Hence, since $0<\omega_K<1$ and $\phi\geq1$, the MKR locus is steeper than the CA locus.

13. Under perfect competition $\lambda=\mu=1$ and $f=0$ and the diversity effect is not operative as the number of firms is not determined in the model. Hence, the perfectly competitive solutions are obtained from our model by setting $\eta=1$ and $\Omega_0=1$. See Heijdra (1994) and Heijdra and van der Ploeg (1996) for further details.

14. In the representative-agent version of the model, $\beta=0$ and $r_F=\alpha$, and only the efficiency effect remains.

15. Below we give the expressions for the exact transition paths. See equations (3.15)-(3.17).

16. Intuitively, the Laplace transform $\mathcal{L}\{x,s\}$ denotes the present value of the time path $x(t)$ using s as the discount factor:

$$\mathcal{L}\{x,s\} \equiv \int_0^\infty x(t)\,e^{-st}\mathrm{d}t.$$

17. We use the fact that $\tilde{X}(0)-\tilde{V}(0)/\omega_K>0$. A proof for this result is found in Bettendorf and Heijdra (1998).

18. Despite trying a very wide array of (sometimes very unrealistic) parameter values, we have been unable to produce a counterexample to the claim that $d\Lambda(0,0)<d\Lambda(\infty,\infty)$. See also Table 3.

19. Specifically, $\omega_K=(1-\varepsilon_L)(1+s_P)$, $\omega_X=(1-\gamma_D)/(1+\gamma_D t_M)$, $1/\gamma=1+\omega_{LL}\varepsilon_L\theta_M(1+s_P)$, $1/L=1+\omega_{LL}$, $\theta_M\equiv(1+t_M\gamma_D)/(1+t_M)$, and

$$r_F = r = \tfrac{1}{2}\left[\alpha + \sqrt{\alpha^2 + 4\beta\gamma(\alpha+\beta)\omega_K}\,\right].$$

20. These terms of trade gains are needed to create a steady-state deficit on the trade account in the new steady state. This deficit is covered by interest income received from the rest of the world. It is tempting (but incorrect) to view the terms of trade effect and the net foreign asset effect as one and the same thing. It is shown below, however, that it is socially optimal not to allow present generations to accumulate a net claim on the rest of the world. It that sense, the terms of trade effect in the absence of bond policy is 'excessive', a phenomenon that is represented by the net foreign asset effect.

21. This can be seen by setting $\gamma_D=1$ in (4.15). See also the related paper by Broer and Heijdra (1996).

22. The numerical simulations in Table 3(d) suggest that $\partial t_M^*/\partial s_P>0$ may in fact hold globally. We have been unable to prove this conjecture, however.

23. The installation cost approach to investment has itself been subjected to severe criticism in recent years. See, for example, Dixit and Pindyck (1994).
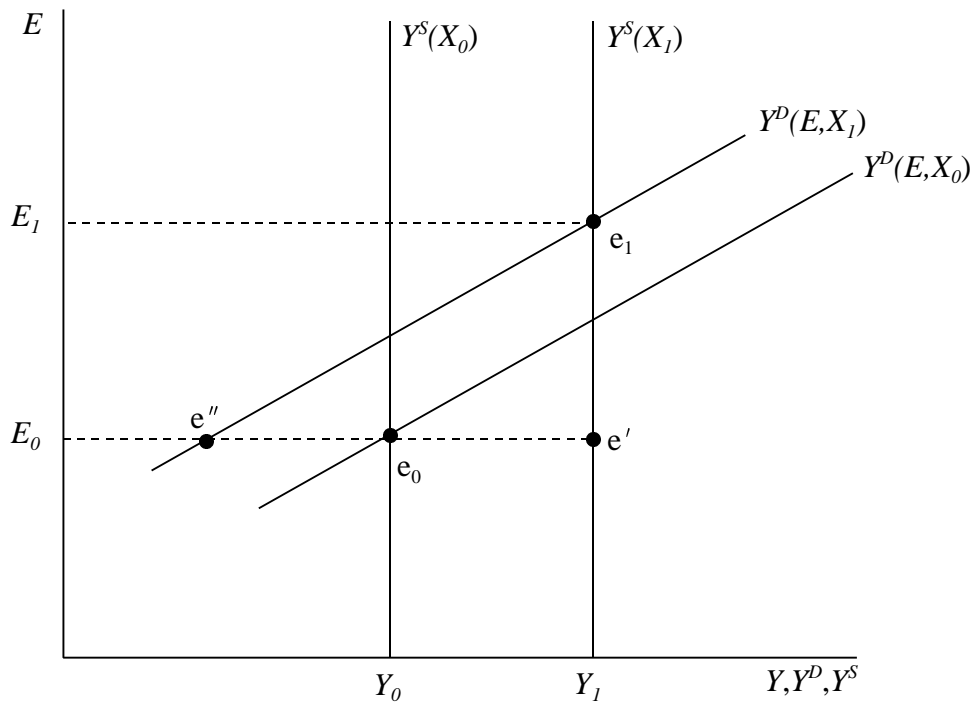
Figure 1. Determination of the real exchange rate

Key: E is the real exchange rate, Y is aggregate output, Y^D is aggregate demand, Y^S is aggregate supply, and X is full consumption. A decrease in full consumption, say from X_0 to X_1, stimulates labour supply, and the supply curve for goods shifts to the right. Aggregate demand is reduced, as goods are normal in consumption. At the old real exchange rate E_0 there is excess supply of goods, and the real exchange rate depreciates. Equilibrium is restored in e_1.
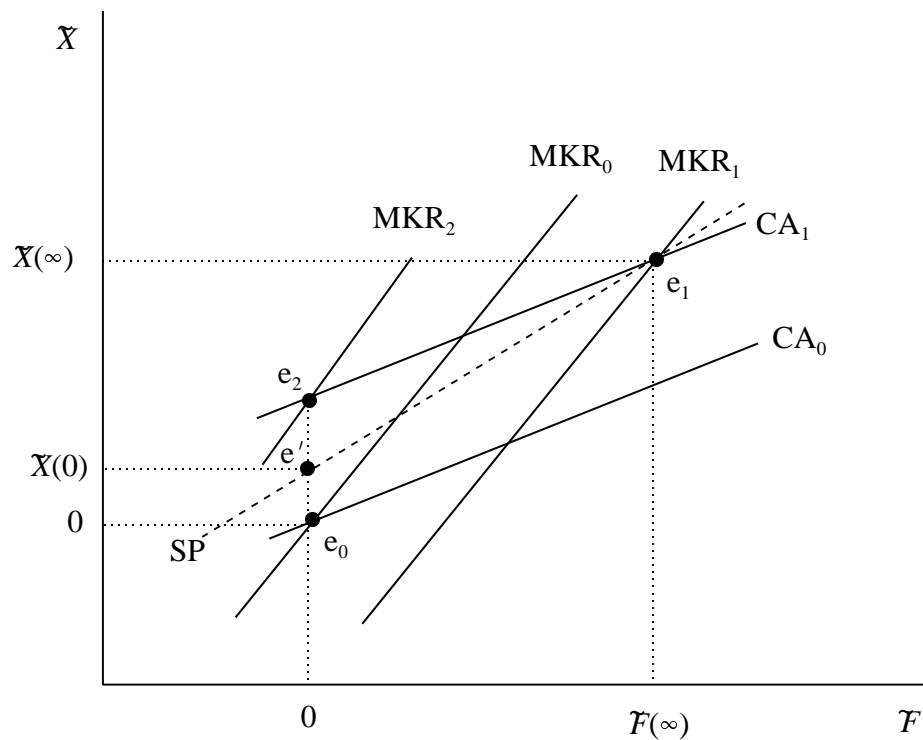
Figure 2. The dynamic effects of an import tariff

Key: F is net foreign assets, X is full consumption, MKR is the modified Keynes-Ramsey rule, CA is the current account equilibrium locus, and SP is the saddle path. An increase in the tariff shifts the long-run equilibrium from e_0 to e_1, and full consumption and net foreign assets both rise. The transition path is a jump at impact from e_0 to e', followed by gradual adjustment along the saddle path SP towards e_1. With an egalitarian policy the MKR curve shifts to the left and impact and long-run effects occur at point e_2.
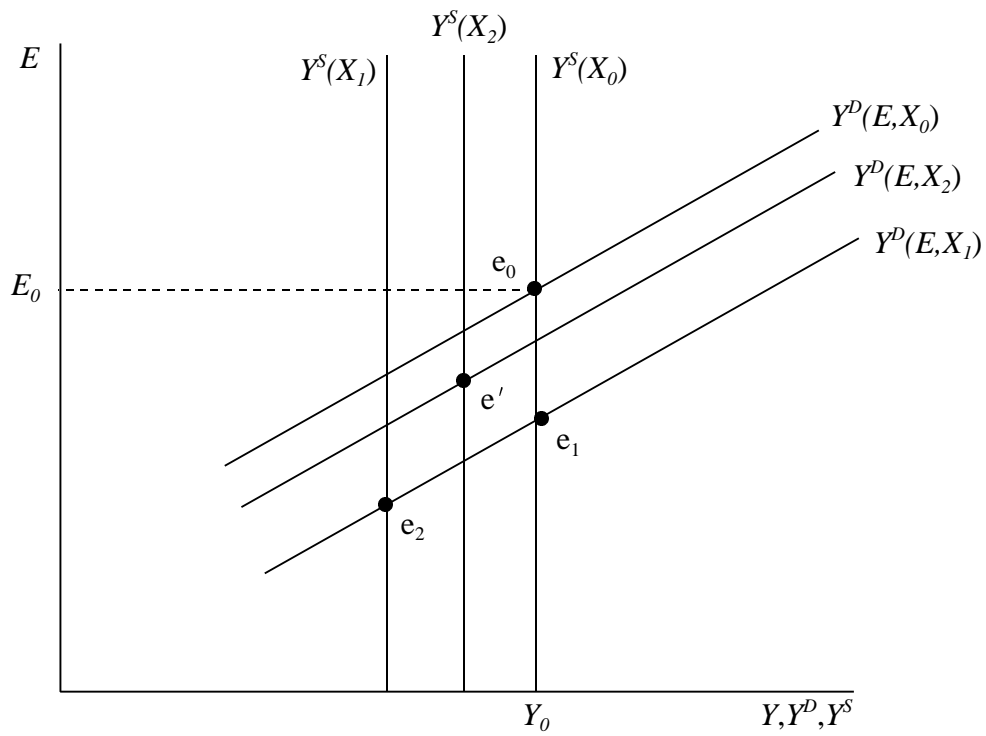
$Y^S(X_2)$

E

$Y^S(X_1)$ $Y^S(X_0)$

$Y^D(E,X_0)$

$Y^D(E,X_2)$

$Y^D(E,X_1)$

e_0

E_0

e'

e_1

e_2

Y_0 Y,Y^D,Y^S

Figure 3. The effects of the tariff on output and the real exchange rate

Key: E is the real exchange rate, Y is aggregate output, Y^D is aggregate demand, Y^S is aggregate supply, and X is full consumption. With exogenous labour supply ($\varphi=1$), output is fixed and the tariff only affects aggregate demand via its effect on full consumption which rises in the long run. The exchange rate appreciates as the equilibrium shifts from e_0 to e_1. With endogenous labour supply ($\varphi>1$), there is also a negative effect on the supply of domestic output. The equilibrium shifts from e_0 to e_2 in that case.