Short and Long-Run Effects of Trade on Growth and Welfare

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Abstract

In this paper, we study the short and long-run effects of trade on growth and welfare for a small open economy in a general equilibrium model with four sectors or industries: two sectors produce consumption goods, one produces physical capital, and one produces human capital. The multi-sector framework is important because it is the basis for the endogenous growth mechanism in the model. In addition, it enables us to study the effects of an increase in the number of traded goods as well as the role of a non-traded good (human capital). If only consumption goods are traded, trade leads to complete specialization in one of the consumption goods but leaves unchanged the long-run autarky growth rate. If, however, there is trade in investment and consumption goods, long-run growth will be higher than in autarky provided that the country imports the investment and exports the consumption good. Finally, a revenue-neutral tariff and tax reform is likely to lower long-run growth rates but may improve welfare and raise transitional growth rates.

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1 Introduction

The question whether the removal of trade barriers will increase a country's GDP growth rate both in the short and the long run has always played a central role in the public debate about free trade policies. While those who believe in the "free trade = higher growth" equation rarely substantiate their argument by empirical facts, the rapid growth experience of a number of Asian countries since the 1960's has been credited to a large extent to their policy of outward orientation, notwithstanding the problem of how to measure outward orientation ([**?**]). From a theoretical standpoint, it is well established that free trade is better than no trade in Arrow-Debreu type economies, which explains why most economists oppose restrictions on trade. Oddly enough, a large fraction of the general public still remains to be convinced that free trade will raise their level of well-being or accelerate their increases in income. This seemingly paradoxical situation can be explained in different ways.

For one, most economists pay little attention to the distributional effects of free trade policies, i.e., they do not spell out how the losers are to be compensated by the winners, nor do they adequately model the transaction costs associated with free trade policies such as moving costs for workers who lost their previously tariff-protected jobs. In addition, economists tend to emphasize the long-run over the short-run effects of free trade policies. The welfare superiority of free trade over no trade, for example, is based on the fact that free trade generates higher present value utility in intertemporal general equilibrium models[2]. While higher present value utility is appealing from a theoretical perspective, it is compatible with lower levels of momentary utility in the early periods following the implementation of free trade policies. Although such a potential initial decline in utility would be optimal based on the assumption of an intertemporally optimizing agent, it is worthwhile to ask whether certain fiscal policies involving lower tariffs (but, possibly, higher domestic taxes) are better than others in avoiding a transitional decline in utility levels. The scepticism of the general public regarding the benefits of free trade would certainly be lessened if free trade policies would increase consumption levels and thus momentary utility even in the short run.

The purpose of this paper is to explore all three aspects of the free trade

[2]Equivalently, free trade increases instantaneous social welfare in static general equilibrium models.

debate mentioned above. First, we will tackle the question of when and how much growth we can expect from free trade policies both in the short and in the long run. Second, we pay special attention to the role of adjustment cost in affecting both growth and welfare gains from trade. Third, we examine the question whether free trade policies may indeed lead to lower levels of momentary utility in the short run, and if so, how long the short run will be. In this context, we investigate the potential for an optimal (second best) tax and tariff structure. In particular, starting from a given tax structure and a corresponding present value of government expenditures, we examine the question whether a revenue-neutral shift from the taxation of foreign to domestic goods may improve growth, present value utility and/or short-run momentary utility.

In recent decades, the literature on growth and trade has grown rapidly, mainly as a result of the new branch of endogenous growth models pioneered by the work of Romer [?] and Lucas [?] that breathed new life into a seemingly closed field. The message of the new trade models is dramatically different from the old models. While dynamic version of standard Heckscher-Ohlin or Ricardian type trade models predict that trade would have at most transitional growth effects, most new trade models predict steady state growth effects although not necessarily positive ones[3].

Our analysis of the effects of trade on growth and welfare departs from the literature in two major directions. First, we distinguish between long-run (steady state) and short-run (transitional) effects. Most contributions to the analysis of taxes and tariffs in open economies concentrate on steady state effects, thus ignoring important transitional effects (see, for example, Lee [?], Kaneko [?], and Corchon [?]). As a consequence, the focus is on long-run growth effects rather than welfare effects[4]. Second, we consider

[3] Some of the early new trade models that predict growth effects of trade are Feenstra [?], Grossman and Helpman [?], Jones and Manuelli [?], Lucas [?], Osang and Pereira [?], Rivera-Batiz and Romer [?] and Young [?]

[4] Notable exceptions are Turnovsky [?], Osang and Pereira [?] and Osang and Turnovsky [?]. Turnovsky's work, however, is confined to the special case of a one-sector AK-type model while Osang and Pereira and Osang and Turnovsky analyze two-sector models. In contrast, our multi-sector analysis extends some of their results, while adding new features to the model such as the role of non-traded goods. Bajona and Kehoe [?] include tran-

changes in taxes and tariffs under the condition of revenue neutrality, as in Osang and Turnovsky [?]. We define a revenue-neutral change in taxes and tariffs as the reduction of one tariff or tax and the offsetting increase of another, such that the present value of government revenues is kept constant. The rationale for keeping the size of the government constant is to isolate the effects of changing the structure of taxes and tariffs from the effects of changing the level of government revenues.

The growth and welfare effects of trade versus autarky as well as a changes in the tax and tariff structure are analyzed in the context of a dynamic model with endogenous accumulation of physical and human capital. The endogenous growth mechanism is most closely related to Rebelo [?]. Since both human and physical capital can grow without bounds, capital accumulation occurs without diminishing returns. This, in turn, allows for exponential growth in both types of capital as well as in the two consumption goods. Both consumption goods and one investment good (physical capital) are tradable. Human capital is assumed to be a non-tradable good. A balanced trade account is assumed. This assumption allows us to consider the effects of trade in investment and consumption goods in isolation from the effects through financial capital movements. Since we consider a small open economy, prices of imported goods are taken as given. The government imposes a number of domestic taxes and import tariffs. The primary reason for imposing taxes and tariffs is to raise revenues which are redistributed to households in lumpsum fashion. The government imposes an output tax on each sector of the economy, as well as import tariffs on traded goods.

The remainder of the paper is organized as follows. In section 2, we present the model of the economy and state the optimality conditions that hold along the equilibrium path. In section 3, we present some analytical results regarding the long-run growth effects of trade compared to autarky. In section 4, we investigate how free trade affects short-run growth as well as momentary and present value utility. Given the complexity of the model, our analysis is based on numerical solutions. In section 5, we discuss dif-

sitional dynamics in their analysis but leave out welfare considerations. For an empirical investigation of trade and growth models with sector specialization, see Mansour [?]

ferent types of revenue-neutral reforms of the tax and tariff structure. We summarize the main findings in section 6.

2 The Model

In this section we present a decentralized, intertemporal model with four sectors or industries. There are three agents in this economy, a representative household, a representative producer, and the government. Households and producers operate in competitive markets and take all prices as given. The government's sources of revenues are import tariffs and sector-specific taxes on output. Revenues are redistributed to households in lump sum fashion. Two different trade regimes are considered. In the first one, the country imports and exports only consumption goods. In the second one, trade occurs in consumption and investments goods. We assume a balanced trade account, thus ignoring the possibility of capital transfers to finance temporary imbalances in the trade account. As is usual in the literature on small open economies we assume that the country takes prices for all imports and exports as given. In each period, all prices are expressed in units of the first consumption good, the numeraire. To simply matters, the size of the labor force is set equal to unity.

2.1 Consumers

Assuming that tastes are homogenous across households, the household's maximization problem can be phrased in terms of a representative agent. The agent consumes two consumption goods, C_{1_t} and C_{2_t}. The agent rents out capital and labor at the competitive rental rate, r_t, and wage rate w_t, respectively. In addition to interest and wage income the agent receives dividend payments, π_t as well as lumpsum transfers from the government, T_t. To simplify matters, the agent does not supply labor and therefore does not receive any wage income. The intertemporal problem for the agent is to maximize her discounted future utility subject to a dynamic budget constraint, i.e.

$$Max \sum_{t=0}^{\infty} \beta^t U(C_{1_t}, C_{2_t})$$

subject to

$$Z_{t+1} = (1+r_t)Z_t + w_t + \pi_t + T_t - (1+\tau_{C1})C_{1_t} - (1+\tau_{C2})p_{c_t}C_{2_t} \qquad (1)$$

and the initial condition $Z(0) = Z_o$, where $\beta \quad (\equiv \frac{1}{1+\rho})$ is the constant discount factor and ρ is the agents pure rate of time discount, p_{c_t} is the relative price of the second consumption good, and τ_{C1}, τ_{C2} are tariffs on consumption good 1 and 2, respectively. The current utility function of the representative household is time-invariant and monotonic increasing. The household chooses the optimal path for C_{1_t}, C_{2_t} and Z_t, while taking the sequence of current and future prices as given. The optimality conditions derived from the current value Hamiltonian for the above problem are given by

$$U_1(C_{1_t}, C_{2_t}) = \frac{\mu_{t+1}}{1+\rho}(1+\tau_{C1}), \qquad (2)$$

$$U_2(C_{1_t}, C_{2_t}) = \frac{\mu_{t+1}}{1+\rho}(1+\tau_{C2})p_{c_t}, \qquad (3)$$

$$\mu_t = \frac{\mu_{t+1}}{1+\rho}(1+r_t), \qquad (4)$$

where μ_t is the shadow price of non-human wealth. Along the balanced growth path, the relationship between the growth rate of consumption and the interest rate is given by

$$\left(\frac{C_{t+1}}{C_t}\right)^{\sigma_t} = \frac{\mu_{t+1}}{\mu_{t+2}} = \frac{1+r_{t+1}}{1+\rho}, \qquad (5)$$

where $\frac{1}{\sigma_t}$ is the intertemporal elasticity of substitution. Equation (5) describes the growth rate of consumption as an increasing function of the real interest rate.

2.2 Producers

The representative firm operates four different plants, two of which produce consumption goods, while the other two produce investment goods. Each production process requires two inputs, firm-specific human capital (i.e., labor expressed in efficiency units), $u_t H_t$, and physical capital, $\phi_t K_t$. The production functions are given by

$$Y_i = F_i(\phi_{i_t} K_t, u_{i_t} H_t), \quad i = C_1, C_2, I \text{ and } IH,$$

All functions are linearly homogeneous in both inputs and satisfy the usual Inada conditions. Capital accumulation (including adjustment costs) follows the standard form, $K_{t+1} = I_t + G^K(I_t, K_t) + (1-\delta_K)K_t$, and $H_{t+1} = IH_t + G^H(IH_t, H_t) + (1-\delta_H)H_t$ with δ_K and δ_H denoting the depreciation rate of physical and human capital, respectively.

The adjustment cost functions, $G^i(.,.)$, $i = H, K$, are assumed to be linearly homogenous and strictly convex in gross investment, with $\frac{\partial G^i(.,.)}{\partial I} > 0$, $\frac{\partial^2 G^i(.,.)}{\partial I^2} > 0$, $G^i(0,0) = 0$ and $\frac{\partial G^i(0,0)}{\partial I} = 1$, $i = H, K$. Convexity of the installation function reflects the idea that the faster a firm wants to achieve the desired level of either capital stock, the higher the additional cost per unit of investment.

The intertemporal problem of the firm is to maximize the present value of its after tax cash flow subject to equations of motion and initial conditions for physical and human capital, i.e.,

$$\begin{aligned} \text{Max} \ \sum_{t=0}^{\infty} \prod_{s=0}^{t} \frac{1}{1+r_s} \Big[& (1-\tau_{Y_{C1}}) F_{C_1}(\phi_{C_{1_t}} K_t, u_{C_{1_t}} H_t) + (1-\tau_{Y_{C2}}) p_{C_t} F_{C_2}(\phi_{C_{2_t}} K_t, u_{C_{2_t}} H_t) \\ & + (1-\tau_{Y_I}) p_{I_t} F_I(\phi_{I_t} K_t, u_{I_t} H_t) + (1-\tau_{Y_{IH}}) p_{IH_t} F_{IH}(\phi_{IH_t} K_t, u_{IH_t} H_t) \\ & -(1+\tau_I) p_{I_t} I_t - p_{IH_t} IH_t - w_t \Big] \end{aligned}$$

subject to

$$K_{t+1} = I_t + G^K(I_t, K_t) + (1-\delta_K)K_t \tag{6}$$

$$H_{t+1} = IH_t + G^H(IH_t, H_t) + (1 - \delta_H)H_t \tag{7}$$

and the initial conditions $K(0) = K_o$ and $H(0) = H_o$, where τ_i, $i = Y_{C_1}, Y_{C_2}, Y_I, Y_{IH}$, are sector-specific taxes on output, τ_I represents an import tariff on foreign capital goods, I_t and IH_t measure investment demand for physical and human capital, respectively, while p_{I_t} and p_{IH_t} are the corresponding relative prices of these investment goods. Using the fact that the shares on physical and human capital in production add up to one, the current value Hamiltonian for the producer's maximization problem yields the following set of optimal conditions

$$(1-\tau_{Y_{C1}})\frac{\partial F_{C_1}(\phi_{C_{1_t}}K_t, u_{C_{1_t}}H_t)}{\partial \phi_{C_{1_t}}} + (1-\tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(m_tK_t, n_tH_t)}{\partial \phi_{C_{1_t}}} = 0, \tag{8}$$

$$(1 - \tau_{Y_i})p_{i_t} \quad \frac{\partial F_i(\phi_{i_t}K_t, u_{i_t}H_t)}{\partial \phi_{i_t}}$$

$$+(1 - \tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(m_tK_t, n_tH_t)}{\partial \phi_{i_t}} = 0, \quad i = C_2, I,$$

$$(1-\tau_{Y_{C1}})\frac{\partial F_{C_1}(\phi_{C_{1_t}}K_t, u_{C_{1_t}}H_t)}{\partial u_{C_{1_t}}} + (1-\tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(m_tK_t, n_tH_t)}{\partial u_{C_{1_t}}} = 0, \tag{9}$$

$$(1 - \tau_{Y_i})p_{i_t} \quad \frac{\partial F_i(\phi_{i_t}K_t, u_{i_t}H_t)}{\partial u_{i_t}}$$

$$+(1 - \tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(m_tK_t, n_tH_t)}{\partial u_{i_t}} = 0, \quad i = C_2, I,$$

$$q_t = (1 - \tau_{Y_{C1}}) \quad \frac{\partial F_{C_1}(.,.)}{\partial K_t} + (1 - \tau_{Y_{C2}})p_{C_t}\frac{\partial F_{C_2}(.,.)}{\partial K_t}$$

$$+(1-\tau_{Y_I})p_{I_t}\frac{\partial F_I(.,.)}{\partial K_t}+(1-\tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(.,.)}{\partial K_t}$$
$$+\frac{q_{t+1}}{1+r_{t+1}}\left[\frac{\partial G^K(.,.)}{\partial K}+1-\delta_K\right]$$

$$\lambda_t=(1-\tau_{Y_{C1}})\quad\frac{\partial F_{C_1}(.,.)}{\partial H_t}+(1-\tau_{Y_{C2}})p_{C_t}\frac{\partial F_{C_2}(.,.)}{\partial H_t}$$
$$+(1-\tau_{Y_I})p_{I_t}\frac{\partial F_I(.,.)}{\partial H_t}+(1-\tau_{Y_{IH}})p_{IH_t}\frac{\partial F_{IH}(.,.)}{\partial H_t}$$
$$+\frac{\lambda_{t+1}}{1+r_{t+1}}\left[\frac{\partial G^H(.,.)}{\partial H}+1-\delta_H\right]$$

$$(1+\tau_I)p_I=\frac{q_{t+1}}{1+r_{t+1}}[1-G_I^K(I_t,K_t)] \tag{10}$$

$$p_{IH}=\frac{\lambda_{t+1}}{1+r_{t+1}}[1-G_{IH}^H(IH_t,H_t)] \tag{11}$$

where $m_t=1-\phi_{C_{1_t}}-\phi_{C_{2_t}}-\phi_{I_t}$, $n_t=1-u_{C_{1_t}}-u_{C_{2_t}}-u_{I_t}$, and q_t and λ_t are the shadow prices of physical and human capital, respectively. The interpretation of the optimal conditions is straightforward. Equations (8) to (10) ensure that the value of the marginal product of physical and human capital is the same across industries. Equations (10) and (10) state that the weighted average of the marginal revenue product of capital must be equal to the user cost of capital which in turn is defined as the sum of interest rate, depreciation rate and adjustment cost factor, adjusted for possible capital gains or losses. Equations (10) and (11) relate the price of new units of capital to the price of installed capital (Tobin's Q).

2.3 Government

The government redistributes all revenues back to the households keeping a balanced budget at any point in time,

$$\tau_{Y_{C1}} F_{C_1}(.,.) + \tau_{Y_{C2}} p_{C_t} F_{C_2}(.,.) + \tau_{Y_I} p_{I_t} F_I(.,.) + \tau_{Y_{IH}} p_{IH_t} F_{IH}(.,.)$$
$$+\tau_{C1} C_{1_t} + \tau_{C2} p_{C_t} C_{2_t} + \tau_I p_{I_t} I_t = T_t.$$

2.4 Market Equilibrium

The market equilibrium describes the path of the endogenous variables such that all markets clear at all points in time[5]. The market equilibrium is fully determined by combining the optimality conditions for households (1) to (4), and firms (6) to (10), with the balanced budget condition for the government (12), the market clearing condition (12) for the case of an autarkic economy, the balanced trade equation (13) for the case of an open economy, the period profit function (14), and the transversality conditions for physical capital (14), human capital (15) and domestic wealth (16)

$$Y_{C_{1_t}} = C_{1_t}, \quad Y_{C_{2_t}} = C_{2_t}, \quad Y_{I_t} = I_t; \quad Y_{IH_t} = IH_t, \tag{12}$$

$$Y_{C_{1_t}} - C_{1_t} + p_C (Y_{C_{2_t}} - C_{2_t}) + p_I (Y_{I_t} - I_t) = 0; \quad Y_{IH_t} = IH_t, \tag{13}$$

$$\pi_t = (1 - \tau_{Y_{C_1}}) F_{C_1}(.,.) + (1 - \tau_{Y_{C_2}})(1 + \tau_C) p_{C_t} F_{C_2}(.,.) + (1 - \tau_{Y_I})(1 + \tau_I) p_{I_t} F_I(.,.)$$
$$+(1 - \tau_{Y_{IH}})(1 + \tau_{IH}) p_{IH_t} F_{IH}(.,.) - uc_{K_t}\, K_t - w_t,$$

$$\lim_{t\to\infty} q_t\, K_t \sum_{t=0}^{\infty} \prod_{s=0}^{t} \frac{1}{1 + r_s} = 0, \tag{14}$$

[5]For the case of a closed economy, Dolmas [?] gives sufficient conditions for the existence of endogenously growing optimal paths in a (convex) dynamic general equilibrium model with n consumption goods and m capital goods, while Bond and Trusk [?] establish stability results for a model similar to the one in this paper with three sectors (one consumption and two investment goods) and two factors of production (human and physical capital). They also discuss the possibility of dynamic indeterminacy for certain factor intensity rankings.

$$\lim_{t\to\infty} \lambda_t \; H_t \; \sum_{t=0}^{\infty}\prod_{s=0}^{t} \frac{1}{1+r_s} = 0, \tag{15}$$

$$\lim_{t\to\infty} \mu_t Z_t \; \sum_{t=0}^{\infty}(\frac{1}{1+\rho})^t = 0, \tag{16}$$

where uc_{K_t} is the user cost of physical capital, implicitly defined by (10). Note that the discussion in the next two sections assumes zero taxes and tariffs, i.e., τ_{C1}, τ_{C2}, τ_I and τ_{Y_i} are set to zero.

Adjustment costs have two effects in this model. First, they slow down the return to a balanced growth path once the system is out of the steady state. Second, they reduce the steady state growth rate by making investment in physical capital more costly. It should be noted that even in the absence of adjustment costs the model displays transitional dynamics as discussed in the context of related models (Rebelo [**?**]).

3 Analytical Results

There is no analytical solution for the equilibrium path of the model described above. The steady state growth rate, however, can be derived for the special case of constant intertemporal elasticity of substitution, Cobb-Douglas utility and production functions, identical output elasticities across sectors, equal depreciation rates for both types of capital and no adjustment costs. In particular, we assume that the current utility function is of the constant relative risk aversion type, i.e., $U(C_1, C_2) = \frac{(C_1^{\alpha} C_2^{1-\alpha})^{1-\sigma}}{1-\sigma}$. In this case, $\frac{1}{\sigma}$ is equal to the intertemporal elasticity of substitution. The production functions take the form $F_i(.,.) = A_i(\phi_i K)^{\alpha_i}(u_i H)^{1-\alpha_i}$, $i = C_1,\ C_2,\ I,\ IH$, where A_i is a constant that measures total factor productivity in sector i.

As a benchmark case, we derive the steady state growth rate for the economy in autarky. We first solve equations (6) to (9) to find solutions for p_C, p_I, p_{IH}, u_C, u_I and u_{IH}. We then compute the ratio of human to physical capital as well as the steady state growth rate from (9) and (10),

$$g^A = \left[\frac{k(1-\tau_{Y_I})^{\alpha} A_I^{\alpha} (1-\tau_{Y_{IH}})^{1-\alpha} A_{IH}^{1-\alpha} + 1 - \delta}{1+\rho} \right]^{\frac{1}{\sigma}},$$

where $k = \alpha^{\alpha}(1-\alpha)^{1-\alpha}$. In autarky, total factor productivity and output taxes in the two consumption good sectors have no impact on long-run growth. In contrast, total factor productivity and sector-specific taxes on output in the two investment good sectors affect long-run growth, a result that is consistent with the findings in Pecorino [**?**].

Next, we derive the steady state growth rate in free trade. As pointed out by Baxter [**?**], multi-sector models with constant returns to scale, reproducible capital, and optimizing agents are characterized by a linear long-run production possibilities frontier. Hence, with free trade, countries become completely specialized in production according to technical comparative advantage. If only consumption goods are traded, the steady state growth rate is identical to (17), thus there are no long-run growth effects of trade. With trade in one consumption and one investment good (here C_1 and I), there are two possible outcomes. If the economy specializes in production of the investment good, free trade has, again, no effect on steady state growth. In the case of specialization in consumption, however, free trade leads to higher steady state growth given by

$$g^T = \left[\frac{k(1-\tau_{Y_{C1}})^{\alpha} A_{C1}^{\alpha} (1-\tau_{Y_{IH}})^{1-\alpha} A_{C2}^{1-\alpha} + (1+\tau_I)^{\alpha} p_I^{*\alpha} (1-\delta)}{(1+\tau_I)^{\alpha} p_I^{*\alpha} (1+\rho)} \right]^{\frac{1}{\sigma}},$$

where p_I^* is the price of physical capital in the world market and k is defined as above. To see why growth is higher with free trade note that $p_{IH} = \frac{(1-\tau_{Y_{C1}})A_{C1}}{(1-\tau_{Y_{IH}})A_{IH}}$ both in free trade and autarky. Similarly, the autarky price of physical capital, p_I^A, is given by $\frac{(1-\tau_{Y_{C1}})A_{C1}}{(1-\tau_{Y_I})A_I}$. Using these expressions in the above growth rates, one can show that growth in free trade is higher than in autarky if and only if $p_I^A > (1+\tau_I)p_I^*$[6]. The inverse of this condition requires the domestic autarky price of C_1 to be lower than the corresponding world market price for the country to grow faster with trade. But this is exactly the necessary condition for specialization in production of C_1. The intuition for the result is simple. With complete specialization in the production of the consumption good, the economy starts importing the investment good at a (given) world price that is lower than the domestic autarky price. The lower price of the investment good affects the domestic interest rate through (10) which in turn increases long run growth through (5).

If the world price for physical capital is higher than the domestic autarky price the country specializes in the production of the investment good. In this case the world price is irrelevant for growth since it cannot affect the domestic productivity of human and physical capital leaving unchanged the domestic interest and growth rate. In this case, the country's autarky and free trade growth rates are identical along the balanced growth path.

4 Simulation Results

To describe short-run growth effects as well as changes in present value and momentary utility we need to consider the transitory effects of free trade. Since an analytical solution for the entire equilibrium path of the model is not available, we proceed numerically. A numerical solution has the additional advantage to allow for adjustment costs for capital. The adjustment cost functions are defined in the standard way as $G^K(.,.) = \frac{s_K I^2}{2K}$ and $G^H(.,.) = \frac{s_H IH^2}{2H}$.

[6]The assumption that the investment good is cheaper abroad implies that the rest of the world grows at a higher rate in the absence of international trade. With trade, however, the home country will be able to catch up and will ultimately grow at the same rate as the rest of the world. Assuming that the home country was sufficiently small to begin with, the convergence in growth rates will not violate the small open economy assumption made in this paper.

4.1 Computational Methods

In order to solve the infinite horizon problem numerically, we proceed as follows. First, we use a sequential programming method, each iteration of which solves a linear approximation of the nonlinear problem. (See Gill, Murray and Wright [?] and Murtagh and Saunders [?] for a discussion of these techniques). We used the MINOS algorithm to numerically solve for a truncated version of the model with T periods. Second, we add a number of steady state conditions at time T that assure a solution along the steady state path until the last period. This way, we avoid the kind of truncation problem encountered in similar numerical models. Third, we use numerical steady state results for the initial values of all endogenous variables, a strategy which greatly enhances the efficiency of the solution process.[7] We simulate the model for 55 periods. This is a sufficiently large time horizon since it takes only between 25 and 30 periods for the economy to reach the balanced growth path for the particular functional forms and parameter values chosen above.

4.2 Parameterizations of the Model

In choosing parameter values we rely, in part, on values that are frequently used in the relevant literature. The remaining values are arbitrarily chosen to reproduce plausible ranges of growth rates, interest rates, etc. Parameter values that belong to the first category are: $\alpha_C = .5$, $\alpha_{C_1} = .4$, $\alpha_{C_2} = .35$, $\alpha_I = .3$, $\alpha_{IH} = .25$, $\delta_K = .08$, $\delta_H = .05$, $\sigma = 1.1$, and $\rho = .028$. We choose the adjustment cost parameters, s_K and s_H, to be .5, which is equivalent to adjustment costs in the neighborhood of 3% of total investment. We specify a uniform value of .2 for the sector-specific productivity parameters, A_i. Recall that all tax and tariff rates are set to zero at this point.

We first simulate the model for the bench mark case of a completely autarkic economy. By design, transitional dynamics are absent in the bench

[7] We obtain the numerical steady state results as follows. Imposing steady state conditions, we eliminate time from market equilibrium equations as well as from the optimality conditions for households and firms. We then derive a numerical solution for the transformed system.

mark case.

4.3 Steady State Results

In this section, we analyze the long-run impacts on growth, welfare and the size of the government sector caused by a policy change from complete isolation to free trade. In particular, we compare the results for autarky with two trade regimes, trade in consumption goods, and trade in consumption and investment goods.

Table 1 displays steady state values for the balanced growth rate, g, the interest rate, r, a welfare indicator measuring present value utility of any consumption path relative to present value utility in autarky[8], and the present value of government revenues, T^{PV}. We report the autarky bench mark values in the first column of Table 1, while the second and third column contain the values for complete specialization in C_2 and C_1, respectively, assuming trade in consumption goods only. Column four and five contain the values for complete specialization in I and C_1, respectively, given free trade in C_2 and I. The table also lists the endogenously determined autarky prices for C_2 and I as well as the exogenously chosen free trade prices.

The results in Table 1 confirm the analytical results from the previous section: trade in consumption goods does not increase steady state growth, nor does trade in one consumption and one investment good if the country specializes in production of the investment good. Only if the country seizes production of physical capital, trade will have a lasting growth effect. This result is somewhat surprising insofar only one of the four trade combinations delivers the promised increase in long-run growth.[9] Not surprisingly,

[8]The relative welfare indicator is defined as

$$\frac{\sum_{t=0}^{\infty}(\frac{1}{1+\rho})^t U(\tilde{C}_{1_t}, \tilde{C}_{2_t})}{\sum_{t=0}^{\infty}(\frac{1}{1+\rho})^t u(\tilde{C}_{1_t}^A, \tilde{C}_{2_t}^A)}$$

where $\tilde{C}_{i_t}$ and $\tilde{C}_{i_t}^A$ are the optimal level of consumption at time t in free trade and autarky, respectively.

[9]The result is biased, though, since the model is not completely symmetric. In a symmetric model with trade among all four goods, it can be shown that free trade would

Table 1: Steady state results: trade in 2 goods

	Autarky	Trade in C_1 and C_2		Trade in C_1 and I	
	$Y_{C_1} > 0, Y_{C_2} > 0$	$Y_{C_1} = 0, Y_{C_2} > 0$	$Y_{C_1} > 0, Y_{C_2} = 0$	$Y_{C_1} = 0, Y_I > 0$	$Y_{C_1} > 0, Y_I = 0$
	$p_C^A = .959$, $p_I^A = .909$	$p_C^T = .989$	$p_C^T = .929$	$p_I^T = .938$	$p_I^T = .878$
g	2.16%	2.16%	2.16%	2.16%	2.25%
r	5.24%	5.24%	5.24%	5.24%	5.35%
Welfare	100.00	100.154	100.159	100.161	100.292

the trade combination that leads to higher long-run growth also causes the highest increase in welfare compared to autarky.

Next, we extend the number of traded goods to three. By comparing growth and welfare results of trade in three goods with the previous results we are able to identify the marginal effects caused by an increase in the number of traded goods. In particular, we are interested in the question whether an increase in the number of traded goods leads to additional growth effects both in the short and the long run. Table 2 summarizes the steady state growth and welfare effects of trade with three goods for three cases: complete specialization in production of consumption good one, good two and the investment good.

The last column in Table 2 shows that there are no additional growth effects from trade in a third good if the country continues to be specialized in production of good I. Importing a second consumption good, however, will lead to additional welfare gains based on static arbitrage opportunities. In contrast, importing a cheaper investment good while the country remains specialized in C_2 stimulates long-run growth and improves welfare for reasons discussed above. Finally, whether a third traded good is growth-enhancing or not in the case of specialization in C_1 depends on the initial situation. Assume that, initially, the country is specialized in production of C_1 and imports C_2. Adding trade in the investment good will then lead to higher long-run growth as discussed above. If, however, the country initially

lead to higher steady state growth in 6 out of 12 cases.

Table 2: Steady state results: trade in 3 goods

	Specialization in C_1	Specialization in C_2	Specialization in I
	$Y_{C2} = 0, Y_I = 0$	$Y_{C1} = 0, Y_I = 0$	$Y_{C1} = 0, Y_{C2} = 0$
	$p^*_C = .931$, $p^*_I = .879$	$p^*_C = .991$, $p^*_I = .879$	$p^*_C = .989$, $p^*_I = .979$
g	2.25%	2.33%	2.16%
r	5.35%	5.45%	5.24%
Welfare	100.445	100.722	100.586

imports the investment good, then trade in a second consumption good will have no additional growth effect. Independent of the impact on growth, an increase in the number of traded goods will always lead to higher welfare levels (i.e., $100.445 > [100.159, 100.292]$) since the country benefits from the efficiency gains of reallocating production and consumption pattern driven by static or dynamic comparative advantage.

4.4 Transitional Dynamics

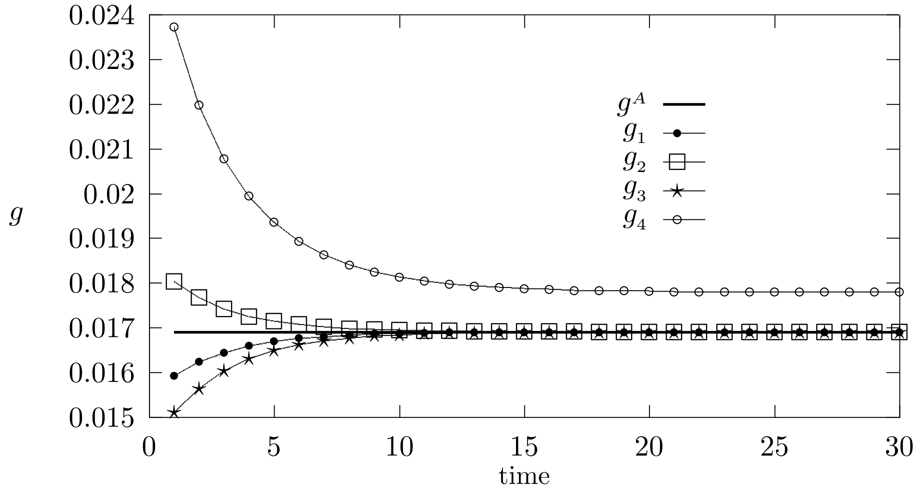
We now study the transition of the system from autarky to free trade by focusing on the time path of GDP growth[10] and momentary utility. We report all results for 30 periods, which is a sufficient time horizon to capture the transitional dynamics of the system.

In particular, we are interested in two questions. First, in the absence of growth-enhancing steady-state effects, will free trade lead at least to higher transitional growth rates? And second, is there a trade off between short-run and long-run welfare gains from free trade?

We report the time path of GDP growth in Figure 1. Starting with initial stocks of human and physical capital that reflect autarky conditions, free trade leads to transitional growth rates that are either above or below

[10]We define GDP growth as the value of total output (i.e., the value of output produced by all active sectors) at time $t + 1$, divided by the value of total output at time t, minus 1.

Figure 1: Transitional growth rates: trade in 2 goods



the autarky rate (depicted by the solid horizontal line). With complete specialization in C_2 (C_1), the economy will initially grow below (above) its long-run potential, as depicted by line g_1 (g_2). We thus observe that the growth-neutrality of free trade in the long-run is independent of its short-run growth effects. In the worst possible case (from a growth perspective) trade has no impact on long-run growth but reduces growth in the short run. With trade in one consumption and one investment good, here C_1 and I, transitional growth will be below its long run value if the economy specializes in production of the investment good (line g_3). If, however, the economy specializes in production of C_1, short-run growth will be even above the higher steady state growth rate (over-shooting; line g_4).

To understand why the economy grows below or above its long run rate during the transition period we need to look at the relative importance of human and physical capital in the production process. In general, free trade will lead to an adjustment in the optimal ratio between physical and human capital. Thus, either human or physical capital needs to be accumulated at a higher rate during the transitional period. Adjustment in either type of capital is costly (and hence growth-reducing) due to existence of adjustment costs. Since the two capital stocks are of unequal size, adjustment costs will vary depending on which capital stock needs to be increased at an accelerated pace. If free trade causes rapid accumulation of human capital, the larger of the two capital stocks, adjustment costs will generally be higher causing a decline in the short-run marginal product of capital (as a weighted average of both types of capital). As a result, the interest rate declines which in turn reduces the growth rate. The opposite occurs if free trade triggers faster accumulation of physical capital. In this case total adjustment costs will be lower during the transition period and the economy grows faster.

It is noteworthy that the results in Figure 1 do not depend on the relative capital intensities of the four industries. It can be shown that for a reversed order of factor intensities (in which case the IH industry is the most capital intensive one) the short-run growth paths are similar to Figure 1. Different capital intensities between industries are necessary for transitional dynamics to exist in the absence of adjustment costs. If all industries had identical capital intensities, changing capital stocks would be costless and firms would adjust both capital stocks in the first period thus eliminating transitional effects. It is therefore not surprising that free trade

Figure 2 presents the different paths for momentary utility for autarky (represented by the u^A line) and the various trade regimes. With the exception of case four (trade in I and C_1 with complete specialization in C_1), free trade leads to an immediate increase in utility compared to autarky. This result is interesting since, in one these cases, transitional GDP growth rates are higher than in autarky. The results thus prove that strong static efficiency gains from trade (with their positive effect on consumption levels at any point in time) can dominate the decline in consumption levels caused by higher growth rates. Not surprisingly, this situation can be reversed as shown in case four (the u_4 line). Here, trade initially reduces momentary utility levels (compared to autarky) as higher levels of investment in capital (triggered by the lower world price of the investment good) are matched by higher levels of household saving. The higher supply of loanable funds is guaranteed by a higher interest rate which corresponds to the increase in the productivity of capital. However, as time goes on, the faster overall growth of the economy allows for faster consumption growth as well and, as a result, momentary utility in free trade overtakes momentary utility in autarky after five to six periods.

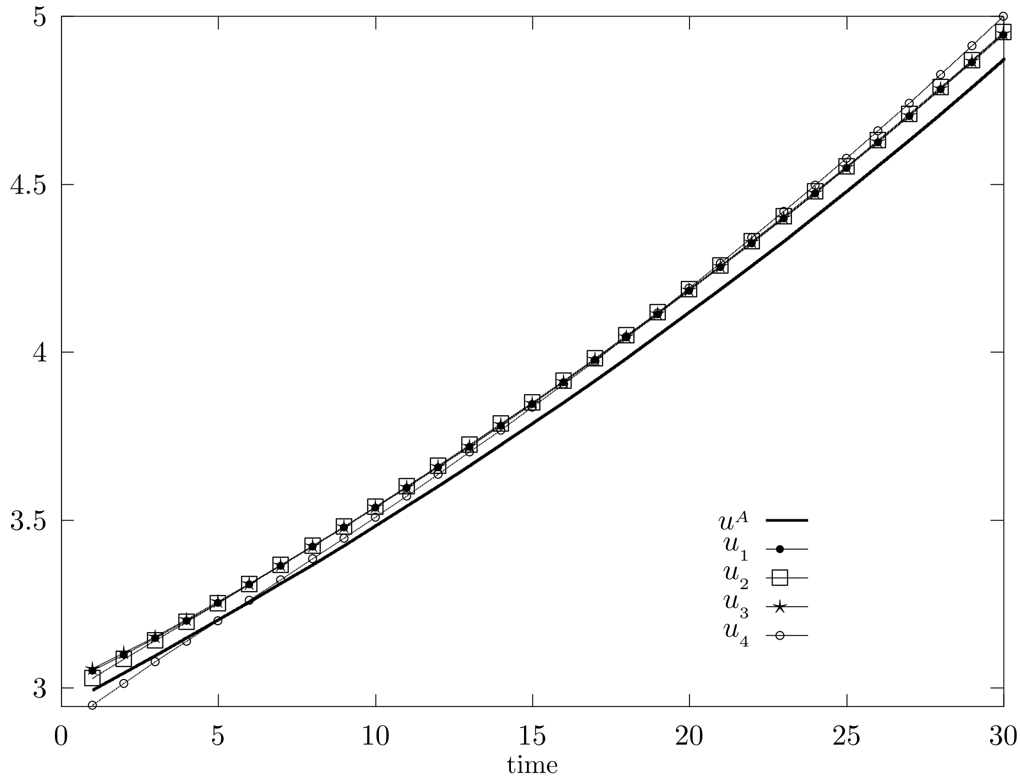
We now concentrate on the transitional growth path if the country trades all three goods. Figure 3 (see appendix) displays transitional growth rates for the three cases of specialization reported in Table 2. Comparing Figure 1 and 3 reveals that the range of the initial free trade growth rates is larger in Figure 3. This would indicate that the transitional effects of trade on growth are more pronounced the larger the number of traded goods.

5 Tax Policy Experiments

In this section, we analyze the growth and welfare implications of revenue-neutral changes in the composition of taxes and tariffs (tariff and tax reform). We define such a reform as the reduction of tariffs and the offsetting increase of domestic taxes such that the present value of government revenues is equal to the base case value. In this assumption we follow Turnovsky and Brock [?] who show that intertemporal revenue-neutrality, as opposed to equal revenues for each period, is the correct approach when comparing the effects of different government policies in a dynamic model. For each change in the tariff structure, we use the corresponding equilibrium interest rate as the discount rate. There are two reasons for this. First, it creates a symmetry between the behavior of the firm and that of the government. Second, it reflects, more precisely, the interdependence between any change in the tariff structure and the resulting costs or benefits to households and firms.

We concentrate on the case of trade in three goods. For each of the three types of specialization in Table 2 we start from a base case with a uniform

Figure 2: Transitional path of momentary utility



tariff of 10% on all imports and a uniform sector-specific output tax of 5% on all domestically produced goods. We report the base case results for the steady-state growth and interest rate as well as for welfare and present value of government revenues in the upper half of Table 3, 4, and 5 (in the appendix). Next, we assume that some uni- or multilateral trade agreement forces the government to cut import tariffs by 50%. We thus reduce the uniform import tariff to 5% and increase the uniform domestic taxes to offset the decline in revenues. We report the results of the tariff and tax reform in the lower half of each table. Below each table, we also display the transitional growth rate of output before and after the tax/tariff reform (as indicated by the g^{old} and g^{new} line, respectively).

Table 3 contains the results for the case of specialization in production of C_1. The results indicate that reducing tariffs and increasing domestic taxes has a negative effect on long-term growth but stimulates growth in the short run. The effect on long-run growth is negative because the growth-enhancing effect of a lower tariff on investment good imports is dominated by the adverse growth-effect of higher sector-specific taxes on C_1 and IH. In the short run, however, the economy grows faster as the higher tax on human capital production requires a higher ratio of physical to human capital. During the transition, accumulation of human capital slows down, while accumulation of physical capital accelerates. This change in the accumulation process lowers the overall adjustment cost of the economy which in turn raises the marginal product of capital. The resulting increase in the real interest rate leads to less consumption by households. Higher saving levels provide the additional funds needed for the higher transitional growth rates. Since the negative impact of the tariff reform on long-run growth is very modest, while the transitional growth gains are substantial, the short-run dominate the long-run effects and the welfare of the country improves.

Table 4 contains the results for the case of specialization in production of C_2. Since the nature of a tariff reform with specialization in C_2 is similar to the case with specialization in C_1, it is not surprising that the two cases lead to essentially identical results.

Table 5 contains the results for the case of specialization in production of I. In this case, lower import tariffs on the two imported consumption goods fail to stimulate long-term growth while higher domestic taxes on the two capital goods reduce growth. As a result, the long-run growth rate must decline. In this case, both the decline in import tariffs and the increase in domestic taxes leaves the optimal ratio of physical to human capital unchanged, and as a result the economy jumps immediately to its new steady state growth rate. Interestingly, although the tariff reform reduces growth in any given period, welfare is higher than in the base case as a consequence of higher consumption levels following the reduction of import tariffs on both consumption goods.

6 Summary and Conclusion

In this paper, we study the growth and welfare effects of free trade in a small open economy with production of two consumption and two investment goods. We derive several important results. First, we show that free trade leads to higher steady state growth rates only if trade involves at least one investment good exclusively imported from abroad. Second, we show that free trade has transitional growth effects regardless of which goods are traded. Third, we demonstrate that an increase in the number of traded goods leads to more pronounced transitional growth effects. Fourth, we show that free trade which involves at least one investment good exclusively imported from abroad may cause a decline in initial levels of momentary utility (below the autarky level). Finally, we show that a revenue-neutral tariff and tax reform is likely to lower long-run growth rates but may stimulate growth during the transition. In addition, tariff reforms tend to be welfare-improving even in the case of adverse growth effects.

Our findings have important implications for policy makers. First, they demonstrate that trade in investment goods is a necessary but not a sufficient condition for long-run growth effects of trade. Second, they show that in the short run free trade policies may actually lower GDP growth. Third, they point out that free trade policies may entail a trade-off between short-run and long-run welfare gains. In particular, they suggest that the strongest gains from trade in terms of growth and welfare may involve lower transitory levels of well-being. Finally, they indicate that free trade agreements are beneficial for consumers but are less likely to be the engines of growth that politicians have made them out to be.

7 Appendix

Figure 3: Transitional growth rates: trade in 3 goods

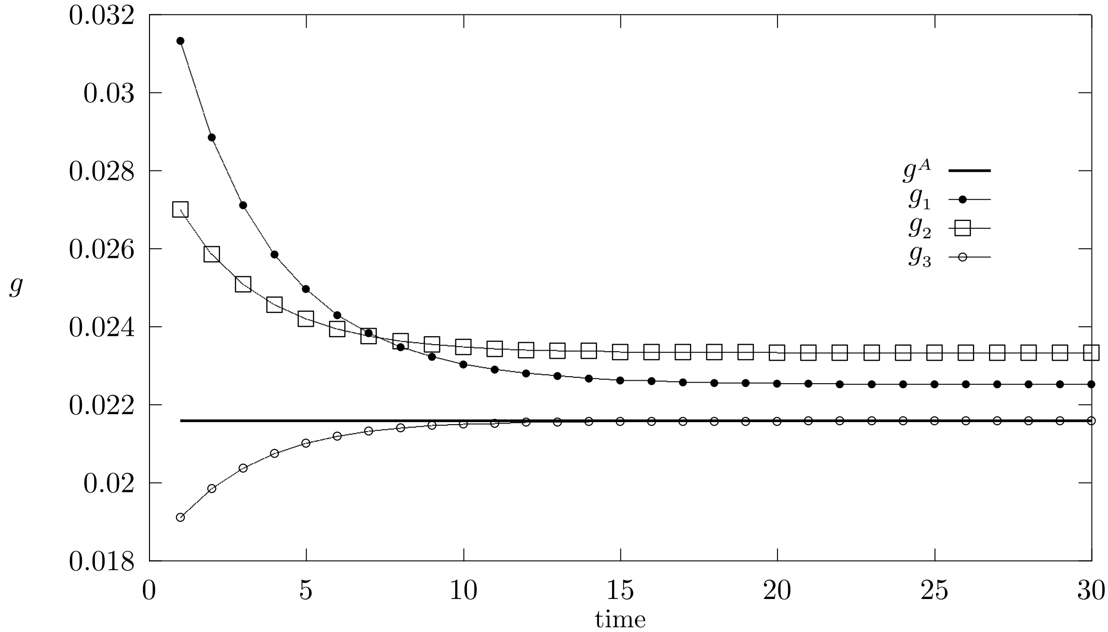


Table 3: Tax policy experiment: trade in 3 goods

	Base Case (Specialization in C_1)
	$\tau_{C2} = 0.10, \tau_I = 0.10$
	$\tau_{Q_{C1}} = 0.05, \tau_{Q_{IH}} = 0.05$
g	1.53%
r	4.53%
Welfare	100.00
Gov. Budget	58.42
	Uniform Reduction of Import Tariffs
	$\tau_{C2} = 0.05, \tau_I = 0.05$
	$\tau_{Q_{C1}} = 0.067, \tau_{Q_{IH}} = 0.067$
g	1.49%
r	4.48%
Welfare	100.246
Gov. Budget	58.46

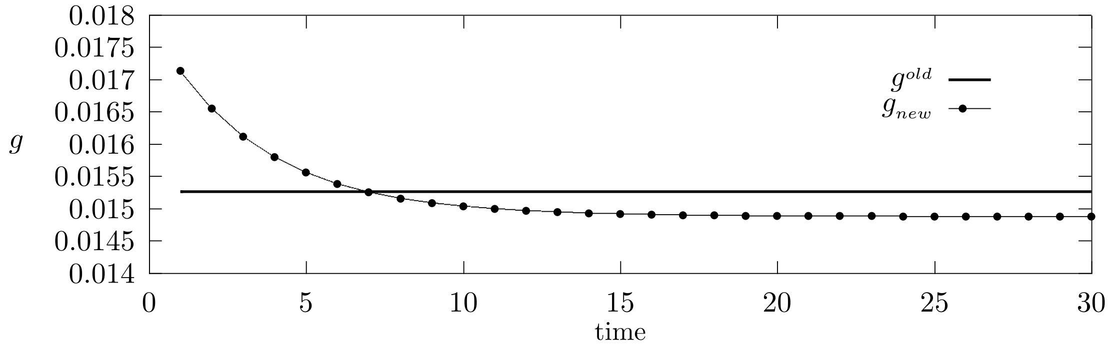


Table 4: Tax policy experiment: trade in 3 goods

	Base Case (Specialization in C_2)
	$\tau_{C1} = 0.10, \tau_I = 0.10$
	$\tau_{Q_{C2}} = 0.05, \tau_{Q_{IH}} = 0.05$
g	1.62%
r	4.64%
Welfare	100.00
Gov. Budget	63.714
	Uniform Reduction of Import Tariffs
	$\tau_{C1} = 0.05, \tau_I = 0.05$
	$\tau_{Q_{C2}} = 0.0665, \tau_{Q_{IH}} = 0.0665$
g	1.58%
r	4.59%
Welfare	100.24
Gov. Budget	63.802

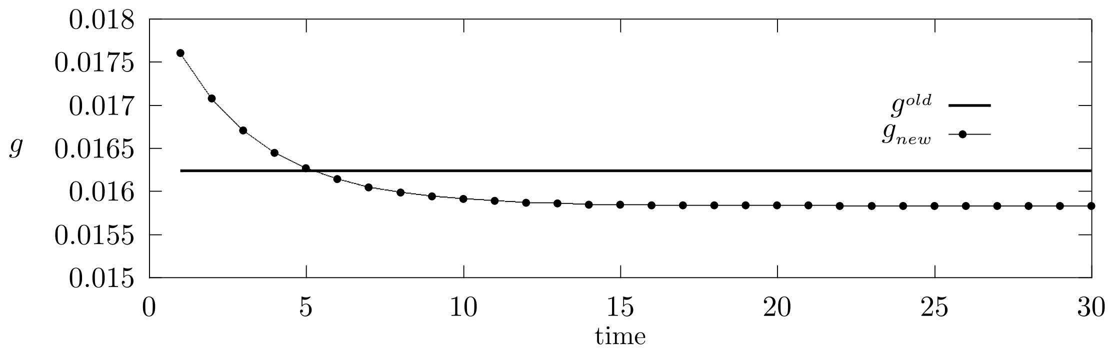
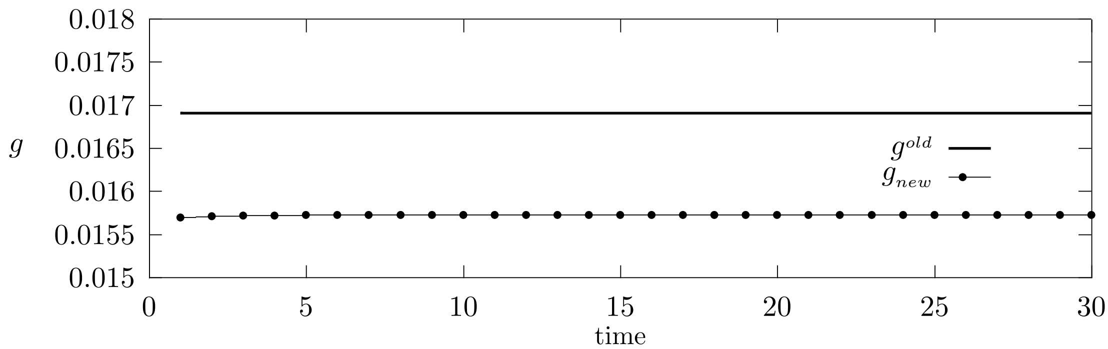


Table 5: Tax policy experiment: trade in 3 goods

	Base Case (Specialization in I)
	$\tau_{C1} = 0.10, \tau_{C2} = 0.10$
	$\tau_{Q_I} = 0.05, \tau_{Q_{IH}} = 0.05$
g	1.69%
r	4.71%
Welfare	100.00
Gov. Budget	65.75
	Uniform Reduction of Import Tariffs
	$\tau_{C1} = 0.05, \tau_{C2} = 0.05$
	$\tau_{Q_I} = 0.0626, \tau_{Q_{IH}} = 0.0626$
g	1.57%
r	4.58%
Welfare	100.205
Gov. Budget	65.69



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