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EXPORT PROMOTION AND GROWTH

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## RÉSUMÉ

Cet article analyse le lien existant entre les politiques commerciales et la croissance économique. Nous évaluons, de façon quantitative, l'importance de la promotion des exportations en utilisant un modèle calibré pour une petite économie en développement avec externalité due à l'accumulation du capital humain. Nous démontrons que les politiques commerciales peuvent mener à des hausses marquées dans le taux de croissance à l'état stationnaire (de l'ordre de cinq pour cent par année), et ce, avec des paramètres réalistes.

Mots clés : politiques commerciales, croissance.

## ABSTRACT

This paper explores the link between commercial policies and economic growth. We evaluate the quantitative importance of export promotion using a calibrated model of a small developing economy with a human capital accumulation externality. We show that commercial policy can lead to substantial increases in steady-state growth rates (on the order of five percent per year) for plausible parameter values.

Key words : export promotion, growth.



# 1 Introduction

Over the last thirty years, countries such as South Korea, Hong Kong, Taiwan and Singapore have had sustained high growth rates and have undergone substantial economic transformations. These newly industrializing economies have doubled their standards of living approximately every ten years and have in some instances grown four times as fast as other Asian countries. Lucas (1993), for instance, speaks of a miracle in the case of South Korea. Between 1960 and 1988, yearly real per capita growth averaged 6.2% in South Korea. This contrasts with a world average of 1.8% over the same period. For the 1960-1980 period, per capita incomes grew at rates of 7.5% for Singapore, 7.1% for Japan, 7% for South Korea, 6.8% for Hong Kong, 6.5% for Taiwan, 2.3% for the U.S., and 1.4% for India.<sup>1</sup>

Another empirical regularity shared by these four countries is their openness. In its 1987 classification of developing countries according to trade orientation, the World Bank lists only South Korea, Hong Kong and Taiwan as strongly outward oriented economies over the 1963-1985 period. During the 1980's, South Korea's ratio of exports to GDP averaged 40%, while those of Hong Kong, Taiwan and Singapore were above 100%. Examples of specific export promotion include South Korea's rationing of low interest rate loans to target export expansion (between 1972 and 1981, the annual provision of credit subsidies represented 10.2% of GDP), and Taiwan's provision of fiscal subsidies to exports.<sup>2</sup> According to Barro and

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<sup>1</sup> These data are taken from Lucas (1988, 1993) and Asian Development Bank (1993).

<sup>2</sup> These data are from Bradford and Branson (1987) and Edwards (1993). Taiwan was not included in the World Bank's sample.

Sala-i-Martin (1992), countries with a lower GDP should grow faster than other countries with similar equilibrium growth paths. This may provide an explanation for the rapid growth of these four countries thirty years ago. It cannot explain why they continue to grow quickly and to grow more quickly than countries with similar or lower incomes.

Lucas (1993) argues that neither policies to promote investment in physical capital nor policies to promote a direct investment in human capital can explain the sustained high growth rates that these countries have attained. Instead, he stresses the importance of human capital accumulation externalities in which learning is the by-product of applying labor and capital to new production processes.

In this paper, we develop a model of a small, open, developing economy in which a human capital accumulation externality permits second-best commercial policy which affects resource allocation and which can affect the growth rate in the short and the long run. We analyze the quantitative impact of optimal commercial policy in the steady state in such a setting. The main goal of the paper is to analyze the quantitative importance of commercial policy for attaining high growth rates, and the quantitative link between growth rates and export performance. In order to do this, we calibrate the model and calculate the economy's growth rate numerically, for different assumptions about the government's commercial policy. We find that commercial policy can lead to substantial increases in steady-state growth rates (on the order of five percent per year) for plausible parameter values.

Several other authors have analyzed the effects of learning by doing and trade on growth rates. Romer (1986) considers a closed economy, Lucas (1988) considers trade between a

continuum of small countries, and Young (1991) considers trade between two countries, one developed and the other less developed. All reach the conclusion that learning by doing can have a positive effect on growth. In Lucas (1988), countries with a comparative advantage in high-learning goods experience higher than average real growth with free trade. In Young (1991), the developed country experiences higher growth under free trade than in autarky. Grossman and Helpman (1991) consider the link between growth and trade, but use a model of learning by research and development rather than learning by doing. Other authors have also compared free trade with protection. For example, Rivera-Batiz and Romer (1991) show that in a two-country world, protection of knowledge intensive goods unambiguously reduces worldwide growth. To our knowledge, our paper is the first to consider optimal second best commercial policy in a model with a learning by doing externality and to examine the quantitative links between commercial policy and growth.

The paper is structured as follows. The model is set out in the following section, and the dynamic programming problems of the representative household and of the government are described. In the third section, the steady state solution of the model is derived and its calibration is discussed. The results are presented in the fourth section. Conclusions are drawn in the fifth section.

## 2 The Model

The basic structure of our model is conditioned by the main goal of our paper, to evaluate the quantitative link between export promotion and growth. In order to provide a lever for

welfare-improving intervention by the government, human capital accumulation is subject to a learning by doing externality. The rate of human capital accumulation depends on the allocation of labor across different sectors of the economy. We also build in a trade-off between static and dynamic comparative advantage. Optimal policy involves shifting resources out of the sector with a static comparative advantage, which means an import tariff or its equivalent. In order for this type of policy to also be export-promoting, we introduce differentiated goods and two-way trade so that commercial policy can increase gross exports. If the differentiated good is a final good that can be either consumed or invested, we have possibly two different aggregator functions for differentiated goods used as consumption goods and differentiated goods used as investment goods.

These considerations lead us to a goods market structure with three different types of goods. Final good  $Y_1$  is homogeneous, produced from differentiated intermediate goods, and can be either consumed or invested. Intermediate goods are produced from capital and labor subject to a fixed cost. There is monopolistic competition and two-way trade in this sector. The number of intermediate goods produced domestically is determined endogenously by a zero profit condition. Final good  $Y_2$  is homogeneous, produced from capital and labor, and is only consumed. All goods are tradable. The domestic markets for both final goods are small compared to the size of world markets, so the terms of trade between the two final goods are given. Final goods are produced both by the domestic economy and abroad. Intermediate goods are also produced at home and abroad, but each type is produced in only one location. The model is calibrated so that the economy, which is labor rich, is a net



exporter of  $Y_2$  (which is the labor-intensive good) under free trade, and a net importer of  $Y_1$  and of intermediate goods. Commercial policy that shifts resources into the intermediate goods sector will decrease net exports of  $Y_2$ , but causes an increase in the number of types of intermediate goods produced domestically and in gross trade flows in intermediate goods. The human capital accumulation externality is associated with the intermediate goods sector. The  $Y_1$  sector, which is perfectly competitive, can be reinterpreted as an aggregator along the lines of Armington (1969) without changing the results of the paper.

There are three sets of agents in the model; households, producers, and the government. We first analyze the decision problems of producers and characterize equilibrium in the goods markets. Since households accumulate capital and rent it to firms, the decision problems of the latter are static.

## 2.1 Producers of Final Good 1

The production function of the representative final goods producer is given by:

$$Y_{1t} = \left( \sum_{i=1}^{\bar{N}_t} M_{it}^\rho \right)^{1/\rho} \bar{N}_t^{(1-1/\rho)}, \quad (1)$$

where  $Y_{1t}$  is the domestic output of the final goods producer and  $M_{it}$  is the input of the  $i^{\text{th}}$  type of intermediate good. There are  $N_t$  types that are produced domestically and  $N_t^*$  types that are produced abroad, for a total of  $\bar{N}_t$  types. There is free entry and exit, so the number of domestic types is determined endogenously by a zero profit condition.<sup>3</sup> The parameter  $\rho$  is related to the elasticity of substitution in production  $\sigma$  by  $\rho = (1 - 1/\sigma)$ . There are

<sup>3</sup> In this respect, the approach to monopolistic competition differs from that of Grossman and Helpman (1991), in which the number of firms is predetermined and can be expanded only by investing in R&D.

constant returns in the measure of intermediate goods, which restricts the exponent on  $\bar{N}_t$ .<sup>4</sup>

Final goods producers are price takers in both input and output markets. The price of the final good is taken as the numeraire in the economy, so the profit function of the final goods producer can be written as:

$$\Pi_{1t} = Y_{1t} - \sum_{i=1}^{\bar{N}_t} P_{it} M_{it}, \quad (2)$$

where  $P_{it}$  is the relative price of the  $i^{\text{th}}$  intermediate good. The first order conditions of the profit maximization problem give the following conditional demand function for intermediate inputs by domestic firms:

$$M_{it} = P_{it}^{-\sigma} Y_{1t} \bar{N}_t^{-1}. \quad (3)$$

If foreign final goods producers have the same production technology and also act as price takers, their conditional demand function for intermediate inputs has the same form, and we can easily aggregate together domestic and foreign demands to get the total world demand for a given intermediate good type:

$$\bar{M}_{it} = P_{it}^{-\sigma} \bar{Y}_{1t} \bar{N}_t^{-1}, \quad (4)$$

where  $\bar{Y}_{1t}$  is total world production of the first final good.

<sup>4</sup> Devereux, Head and Lapham (1993) develop a model which allows for constant or increasing returns in the measure of intermediate goods.

## 2.2 Intermediate Goods Producers

The production function of the representative intermediate goods producer is given by:

$$\bar{M}_{it} = Z_1 K_{it}^\alpha (H_t L_{it})^{(1-\alpha)} - \phi, \quad (5)$$

where  $Z_1$  is a parameter that affects the level of the intermediate goods producer's technology,  $H_t$  is the economy-wide stock of human capital, and  $\phi$  is a parameter which determines the importance of fixed costs. Intermediate goods producers are price takers in factor markets and behave as monopolistic competitors in the markets for their output. They take the total industry output as given as well as the conditional demand curve for their type of intermediate good as given in equation (4). Cost minimization gives the following conditional demand functions for labor and capital by each intermediate producer:

$$L_{it} = \frac{(\bar{M}_{it} + \phi) (r_t/w_t)^\alpha}{Z_1 H_t^{(1-\alpha)} \left(\frac{\alpha}{1-\alpha}\right)^\alpha}, \quad (6)$$

$$K_{it} = \frac{(\bar{M}_{it} + \phi) (w_t/r_t)^{(1-\alpha)}}{Z_1 H_t^{(1-\alpha)} \left(\frac{1-\alpha}{\alpha}\right)^{(1-\alpha)}}. \quad (7)$$

Here,  $w_t$  denotes the real wage rate and  $r_t$  is the real rental rate on capital. Labor is homogeneous so that there is one economy-wide labor market. Households do not have direct access to international capital markets (see below), so the rental rate of capital is endogenously determined. This gives the following conditional cost function for the representative intermediate goods producer:

$$E_{it} = \frac{(\bar{M}_{it} + \phi) w_t^{(1-\alpha)} r_t^\alpha}{Z_1 H_t^{(1-\alpha)} \alpha^\alpha (1-\alpha)^{(1-\alpha)}}. \quad (8)$$

The profit function of the  $i^{\text{th}}$  intermediate goods producer can then be written as

$$\Pi_{it} = P_{it} (\bar{M}_{it}, \bar{Y}_{1t}, \bar{N}_t) \bar{M}_{it} - E_{it}. \quad (9)$$

Maximizing this profit function with respect to  $M_{it}$  gives the familiar markup pricing formula

$$P_{it} = \frac{\partial E_{it}}{\partial M_{it}} \frac{1}{\rho}. \quad (10)$$

### 2.3 Producers of Final Good 2

The other final good is produced competitively with human-capital augmented labor and capital, with the following production function:<sup>5</sup>

$$Y_{2t} = Z_2 K_{2t}^\gamma (H_t L_{2t})^{(1-\gamma)}. \quad (11)$$

Returns to scale are constant. Cost minimization by the producers of final good 2 gives the following conditional demand functions for labor and capital:

$$L_{2t} = \frac{Y_{2t} (r_t / w_t)^\gamma}{Z_2 H_t^{(1-\gamma)} \left(\frac{1-\gamma}{\gamma}\right)^\gamma}, \quad (12)$$

$$K_{2t} = \frac{Y_{2t} (w_t / r_t)^{(1-\gamma)}}{Z_2 H_t^{(1-\gamma)} \left(\frac{1-\gamma}{\gamma}\right)^{(1-\gamma)}}. \quad (13)$$

### 2.4 Goods Market Equilibrium

Since firms' problems are static, and since final goods producers are price takers on world markets, the allocation of labor and capital does not depend on demand by domestic con-

<sup>5</sup> Without human capital in the production function for good 2, no steady state without complete specialization in the production of intermediates is possible.

sumers. The following conditions jointly determine the behavior of domestic firms. First of all, since intermediate goods producers have the same cost and demand functions, it is natural to impose a symmetric  $\bar{c}$  equilibrium, with each intermediate goods producer charging the same price and producing the same output. This gives

$$\bar{M}_t = P_t^{-\sigma} \bar{Y}_{1t} \bar{N}_t^{-1}, \quad (14)$$

where  $\bar{M}_t$  is the production of each type of intermediate good. Aggregating together the production of domestic and foreign producers of final good 1 gives

$$\bar{Y}_{1t} = \bar{N}_t^{1/\rho} \bar{M}_t \bar{N}_t^{(1-1/\rho)}. \quad (15)$$

Combining these two equations gives

$$\bar{Y}_{1t} = \bar{N}_t^{1/\rho} P_t^{-\sigma} \bar{Y}_{1t} \bar{N}_t^{-1} \bar{N}_t^{(1-1/\rho)}, \quad (16)$$

so we have immediately

$$P_t = 1. \quad (17)$$

Symmetric equilibrium pins down the relative price of intermediates and final good 1.

Aggregating over all domestic intermediate goods producers gives the following technological feasibility condition for the production of intermediate goods:

$$\frac{(\bar{M}_t + \phi)}{Z_1} = \frac{K_{1t}^\alpha (H_t L_{1t})^{(1-\alpha)}}{N_t}, \quad (18)$$

where we use  $K_{1t}$  and  $L_{1t}$  to denote the overall demand for capital and labor by intermediate goods producers. Differentiating the conditional cost function of intermediate goods producers with respect to  $\bar{M}_t$ , the markup pricing relation gives the following:

$$P_t = \frac{1}{\rho} \frac{1}{\alpha^\sigma (1-\alpha)^{(1-\sigma)}} \frac{r_t^\sigma w_t^{(1-\sigma)}}{Z_1 H_t^{(1-\sigma)}}. \quad (19)$$

With free entry and exit of intermediate goods producers, profits are zero at all times. This gives the following zero profits condition in the intermediates sector:

$$P_t \bar{M}_t = \frac{(\bar{M}_t + \phi) r_t^\sigma w_t^{(1-\sigma)}}{Z_1 H_t^{(1-\sigma)} \alpha^\sigma (1-\alpha)^{(1-\sigma)}}. \quad (20)$$

Capital demand in the intermediate goods sector is given by

$$\frac{K_{1t}}{N_t} = \frac{(\bar{M}_t + \phi) (w_t/r_t)^{(1-\sigma)}}{Z_1 H_t^{(1-\sigma)} \left(\frac{1-\alpha}{\alpha}\right)^{(1-\sigma)}}. \quad (21)$$

Equality between the marginal value products of capital in the intermediates sector and the sector that produces final good 2 implies

$$(1 - 1/\sigma) P_t (1 - \alpha) K_{1t}^\sigma H_t^{(1-\sigma)} L_{1t}^{-\sigma} Z_1 = (1 - \tau_t) e_t (1 - \gamma) K_{2t}^\gamma H_t^{(1-\gamma)} L_{2t}^{-\gamma} Z_2, \quad (22)$$

while equality between the marginal value products of labor in the two sectors gives:

$$(1 - 1/\sigma) P_t \alpha K_{1t}^{(\sigma-1)} H_t^{(1-\sigma)} L_{1t}^{(1-\sigma)} Z_1 = (1 - \tau_t) e_t \gamma K_{2t}^{(\gamma-1)} H_t^{(1-\gamma)} L_{2t}^{(1-\gamma)} Z_2. \quad (23)$$

Here,  $e_t$  is the relative price of final good 2, and  $\tau_t$  represents a per unit tax on the production of final good 2; this variable is used to model commercial policy, as explained in the next

paragraph. The terms of trade between the two final goods,  $e_t$ , are exogenous to the small open economy. The previous two equations tell us that resource allocation across the two sectors of the economy that employ primary factors of production depends on relative prices, on monopoly power in the intermediates sector, on the terms of trade, and on tax rates.

We choose to model the government's commercial policy via a production tax for technical reasons. There is also a per unit subsidy to consumption of good 2, at the same rate (see below). By the Lerner symmetry theorem, this is equivalent to a tax on the exports of good 2, which in turn is equivalent to a tariff on imports of final good 1 (see Dixit and Norman, 1980, p.150). This simplifies the solution of the intermediate producers' profit maximization problem. Since there is no wedge between producer prices in the home economy and the rest of the world, we can impose a symmetric equilibrium in which all intermediate goods producers charge the same price, which simplifies the algebra enormously.

Market clearing in the markets for primary factors gives the following two equations:

$$L_{1t} + L_{2t} = L, \quad (24)$$

$$K_{1t} + K_{2t} = K_t, \quad (25)$$

where  $L$  is the economy's per capita labor endowment and  $K_t$  is the per capita stock of capital, which is predetermined at time  $t$ .

Equations (17) through (25) determine the levels of the endogenous variables  $P_t$ ,  $w_t$ ,  $r_t$ ,  $K_{1t}$ ,  $K_{2t}$ ,  $L_{1t}$ ,  $L_{2t}$ ,  $N_t$ , and  $\bar{M}_t$  as functions of the parameters of the model, the state variables  $K_t$  and  $H_t$ , the exogenous variable  $e_t$  and the policy variable  $\tau_t$ . As noted above, equations (22) and (23) determine the equilibrium allocation of resources between the two sectors that

employ primary factors of production. Using the market clearing conditions for primary factors, the allocation of labor and capital between the two sectors depends on parameters, the terms of trade, policy variables, and aggregate state variables (the stocks of physical and human capital). The solutions for  $K_{1t}$  and  $L_{1t}$  respectively are given by

$$K_{1t} = \frac{a_1 K_t - 1}{a_1 - a_2}, \quad (26)$$

$$L_{1t} = a_2 \left( \frac{a_1 K_t - 1}{a_1 - a_2} \right), \quad (27)$$

with

$$a_1 = \left( \frac{Z_2 e_t (1 - \tau_t) \gamma}{Z_1 (1 - 1/\sigma) \alpha} \left( \frac{\alpha (1 - \gamma)}{(1 - \alpha) \gamma} \right)^{(1-\gamma)} \right)^{1/(\gamma-\alpha)},$$

and

$$a_2 = \left( \frac{\alpha (1 - \gamma)}{(1 - \alpha) \gamma} \right) a_1.$$

Given this allocation of resources, it is possible to solve analytically for the levels of  $\tau_t$ ,  $w_t$ ,  $\bar{M}_t$  and  $N_t$ . We have:

$$\bar{M}_t = \frac{\rho}{(1 - \rho)} \phi, \quad (28)$$

$$N_t = \frac{(1 - \rho)}{\phi} K_{1t}^\alpha H_t^{(1-\alpha)} L_{1t}^{(1-\alpha)} Z_1, \quad (29)$$

$$r_t = \rho Z_1 \alpha K_{1t}^{(\alpha-1)} H_t^{(1-\alpha)} L_{1t}^{(1-\alpha)}, \quad (30)$$

$$w_t = \rho Z_1 (1 - \alpha) K_{1t}^\alpha H_t^{(1-\alpha)} L_{1t}^{-\alpha}. \quad (31)$$

Equation (28) tells us that the equilibrium output of each type of intermediate good depends on technological and demand parameters only. Changes in the total production



of intermediate goods are along the extensive margin only.<sup>6</sup> Equation (29) says that any policy which draws resources into the intermediates sector will cause the number of firms to increase. Also, any policy which favors the accumulation of human capital will lead over time to the entry of firms into the intermediates sector.

## 2.5 Physical and Human Capital Accumulation

Households purchase final good one. They then allocate their purchases of the good between consumption and investment. The representative household's capital accumulation equation is:

$$k_{t+1} = (1 - \delta) k_t + i_t, \quad (32)$$

where  $i_t$  denotes the individual household's investment expenditures,  $k_t$  denotes the household's holdings of capital and  $\delta$  is the rate of depreciation of capital. Aggregating across individual households then gives the economy's capital accumulation equation:

$$K_{t+1} = (1 - \delta) K_t + I_t, \quad (33)$$

where  $I_t$  denotes per capita investment.

Human capital accumulation is assumed to be the by-product of learning by doing and is a function of the level of activity in the intermediate goods sector:

$$H_{t+1} = (1 - \delta_h) H_t + \eta L_{it}^\eta H_t, \quad (34)$$

where  $\delta_h$  is the rate of depreciation of human capital,  $\eta$  is a parameter which captures the sensitivity of human capital accumulation to resource allocation, and  $0 < \eta \leq 1$  is a

<sup>6</sup> This is the same result as in Devereux, Head and Lapham (1993).

parameter which captures the idea that there are diminishing returns to the effects of resource allocation on human capital accumulation. Since private agents do not take into account the effects of their actions on human capital accumulation, this constitutes an externality which motivates government intervention in the model. We normalize the economy's total leisure endowment to equal one so that larger size does not automatically confer a higher growth rate.<sup>7</sup>

Lucas (1993) argues that we are unlikely to be able to account for growth rate differences by appealing either to different rates of schooling or to different rates of investment in physical capital. He says (p.257), "the fast growing Asian economies are not, in general, better schooled than some of their slow growing neighbors. Emphasis on formal schooling, then, seems to involve the application of a modest multiplier to very slight differences in behavior, leading to the same discouraging conclusion for human capital that I arrived at in the case of physical capital."<sup>8</sup> Lucas also argues that learning by doing may be closely linked to individual products or plants and that there are learning curves, so that the rate of productivity increase is higher for newer products and processes. One reason that we concentrate on steady state effects in this paper is that it gives us a constant age distribution of firms in the intermediates sector, with a lower average age the higher is the steady state growth rate. This allows us to abstract from learning curves and differences in rates of

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<sup>7</sup> Such a link between the level of employment and growth would be counterfactual. Normalizing by the total population is compatible with a model in which learning by doing is explicitly linked to specific plants and production processes (see below), which we do not consider in this paper.

<sup>8</sup> According to the World Bank (1993), the Philippines, with a tertiary education enrollment of 27% in 1990, had a per capita growth rate of 1.7%. The same year, Malaysia and Singapore had tertiary education enrollments of respectively 7% and 8% while their per capita growth rates were respectively 7.2% and 6%.

productivity change across firms that could have important effects on the dynamics of the economy outside the steady state.

## 2.6 Preferences

The utility function of the representative household is given by

$$V_t = E \left[ \sum_{i=0}^{\infty} \beta^i U(c_{1t+i}, c_{2t+i}) \right], \quad (35)$$

where  $E[\cdot]$  is the mathematical expectations operator conditional on information at time  $t$ ,<sup>9</sup>  $c_{it}$  is the household's consumption of final good  $i$  in period  $t$ , and  $\beta$  is a constant subjective discount factor.<sup>10</sup> Instantaneous utility is given by

$$U(c_{1t}, c_{2t}) = \ln(c_{1t}^\alpha c_{2t}^{1-\alpha}). \quad (36)$$

The household's flow budget constraint is given by

$$\psi_t + c_{1t} + e_t(1 - \tau_t)c_{2t} + i_t \left( 1 + \theta \left( \frac{i_t}{k_t} \right)^2 \right) = w(K_t, H_t, \tau_t, e_t)l_t + r(K_t, H_t, \tau_t, e_t)k_t, \quad (37)$$

where  $\psi_t$  denotes lump sum taxes. As noted above, consumption of good 2 is subsidized at the same per unit rate as its production is taxed.

Installation of capital equipment is subject to quadratic adjustment costs. This assumption is introduced for technical reasons. It is necessary for the existence of a well-behaved

<sup>9</sup> The expectations operator is retained for the sake of generality. Except for the world real interest rate shock experiment analyzed below, we do not consider the economy's response to exogenous stochastic shocks.

<sup>10</sup> Because the real rate of return on capital is determined endogenously, the model has a unique steady state for given levels of government policy variables. If the government optimizes using the same exogenous discount rate as the private agent, the time path of aggregate consumption will depend on the difference between the discount rate and the exogenous world interest rate. This issue is discussed further below.

decision rule for private investment, and the steady state properties of the model depend on the form of this decision rule (see equations (80) and (86) below). Without adjustment costs, if the model is calibrated so that both final goods are produced domestically at a given initial level of the capital stock, a version of the factor price equalization theorem applies. The marginal product of capital is not a diminishing function of the aggregate capital stock, since resources are reallocated towards the capital-intensive sector as the capital stock increases, in order to maintain constant capital to labor ratios in both sectors. Increasing the investment rate does not reduce the return to investment, and convex adjustment costs are needed to create a disincentive to investing at an extremely high rate.

Private agents do not have direct access to international financial markets. The government borrows on behalf of private agents on international capital markets, so that all foreign debt is sovereign debt. The government uses the proceeds of foreign borrowing and domestic lump sum taxation to finance its commercial policy. This financial structure of the economy captures in a stylized way the constraints faced by agents in developing economies. In addition, it serves a technical purpose. With perfect capital mobility and a constant subjective discount rate there is hysteresis; the model's steady state is history dependent.<sup>11</sup> We also abstract from domestic government debt: in a model in which private agents have infinite horizons, adding government bonds to the model would have only second order effects (due

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<sup>11</sup>

Other modeling strategies that eliminate the hysteresis problem suffer from important drawbacks. Introducing finite horizons necessitates considering the distributional effects of government policy changes. Endogenizing the discount rate as in Mendoza (1991) is incompatible with steady state growth unless the discount rate is made to depend past levels of consumption normalized by the level of human capital, which is implausible.

to the presence of distortionary commercial policy) on the model's equilibrium.

The aggregate production technologies in the model exhibit (except for the fixed costs associated with the production of each intermediate good type) constant returns to scale in reproducible factors (physical and human capital), making endogenous growth possible. Since the levels of the aggregate state variables will contain stochastic trends,<sup>12</sup> agents' maximization problems defined in terms of these variables are not stationary. Dividing key variables by the stock of human capital is the stationarity-inducing transformation that we use to render the private agent's and the government's problems stationary. For any variable  $X_t$ , we define the following normalization:

$$\tilde{X}_t \equiv X_t/H_t. \quad (38)$$

The household's intertemporal utility function can be written as

$$V_t^h = E \left[ \sum_{i=0}^{\infty} \beta^i \left\{ \ln \left( \tilde{c}_{1t+i}^a \tilde{c}_{2t+i}^{1-a} \right) + \ln (H_{t+i}) \right\} \right]. \quad (39)$$

From the point of view of the representative household, the level of human capital and its rate of accumulation are exogenous. Provided that the natural logarithm of human capital grows at a rate which is less than exponential, the terms in  $H_{t+i}$  can be dropped from the household's maximization problem. The household's normalized flow budget constraint can be written as

$$\tilde{\psi}_t + \tilde{c}_{1t} + e_t (1 - \tau_t) \tilde{c}_{2t} + \tilde{i}_t \left( 1 + \theta \left( \frac{\tilde{i}_t}{\tilde{k}_t} \right)^2 \right) = \tilde{w}_t l_t + r_t \tilde{k}_t. \quad (40)$$

<sup>12</sup>

The stochastic trends collapse to deterministic trends in the absence of stochastic shocks in the model.

## 2.7 The Household's Maximization Problem

Using the budget constraint to eliminate  $c_{1t}$  from its utility function, the household's dynamic optimization problem can then be expressed as

$$V(e, \tau, \bar{\psi}, \bar{K}, \bar{k}) = \max_{c_2, i} \left\{ r(e, \tau, \bar{\psi}, \bar{K}, \bar{k}, \bar{c}_2, \bar{I}, \bar{c}_2, i) + EBV(e', \tau', \bar{\psi}', \bar{K}', \bar{k}') \right\}. \quad (41)$$

To economize on notation, time subscripts have been dropped and next-period values are denoted using primes.  $V(\cdot)$  denotes the value function of the representative household agent, and  $r(\cdot)$  is the household's one-period return function, which is given by

$$r(\cdot) = \ln \left( \left( \bar{w}l + r\bar{k} - e(1-\tau)\bar{c}_2 - \bar{i} \left( 1 + \theta \left( \frac{\bar{i}}{\bar{k}} \right)^2 \right) \right)^{\alpha} \bar{c}_2^{(1-\alpha)} \right). \quad (42)$$

The maximization is subject to the following constraints:

$$\bar{k}' = (1 - \delta) \bar{k} + \bar{i}, \quad (43)$$

$$\bar{K}' = (1 - \delta) \bar{K} + \bar{I}, \quad (44)$$

$$\bar{w} = \bar{w}(e, \tau, \bar{\psi}, \bar{K}), \quad (45)$$

$$r = r(e, \tau, \bar{\psi}, \bar{K}), \quad (46)$$

$$\bar{c}_2 = \bar{c}_2(e, \tau, \bar{\psi}, \bar{K}), \quad (47)$$

$$\bar{I} = \bar{I}(e, \tau, \bar{\psi}, \bar{K}). \quad (48)$$

The private agent also is aware of the government's budget constraint. The solution to the optimization problem gives feedback rules for investment and consumption of the form

$$\bar{c}_2 = \bar{c}_2(e, \tau, \bar{\psi}, \bar{K}, \bar{k}), \quad (49)$$

$$\bar{i} = \bar{i}(e, \tau, \bar{\psi}, \bar{K}, \bar{k}). \quad (50)$$

As additional equilibrium conditions, we impose compatibility between the household's feedback rule and the aggregate feedback rules,

$$\bar{c}_2(e, \tau, \bar{\psi}, \bar{K}, \bar{K}) = \bar{C}_2(e, \tau, \bar{\psi}, \bar{K}), \quad (51)$$

$$\bar{i}(e, \tau, \bar{\psi}, \bar{K}, \bar{K}) = \bar{I}(e, \tau, \bar{\psi}, \bar{K}), \quad (52)$$

and between the aggregate and individual capital stocks,

$$\bar{k} = \bar{K}. \quad (53)$$

Before considering the dynamic optimization problem of the government, it is convenient to analyze the national accounts of the economy, in order to make the constraints facing the government clearer.

## 2.8 National Accounting

Aggregating over private agents gives the following normalized flow budget constraint for the household sector:

$$wL + rK - \psi = C_1 + (1 - \tau)eC_2 + \hat{I}, \quad (54)$$

where we use  $\hat{I}$  as a shorthand notation for investment expenditure inclusive of adjustment costs. Since free entry and exit of firms eliminates pure profit, value added by all domestic firms equals payments to factors of production. We have

$$Y_1 + N\bar{M} + (1 - \tau)eY_2 - \bar{N}M = wL + rK. \quad (55)$$

The government's flow budget constraint is given by

$$\psi + e\tau Y_2 - e\tau C_2 + r^*B = B' - B. \quad (56)$$

The government receives revenue from lump sum taxes on households, from taxing the production of final good 2 and from its holdings of foreign bonds (which can be negative in the case of sovereign debt) at the exogenous world real interest rate  $r^*$ . It uses its revenue to subsidize households' purchases of final good 2 and to increase its holdings of foreign bonds. Beginning-of-period holdings of foreign bonds, whose value is denominated in terms of the numeraire, are given by  $B$ .

Adding together the constraints of households, firms and the government yields

$$Y_1 + N\bar{M} + eY_2 - \bar{N}M + r^*B = C_1 + eC_2 + \dot{I} + B' - B. \quad (57)$$

The left hand side of the equality is just GNP measured at world prices. Rearranging terms, we obtain

$$(Y_1 - C_1 - \dot{I}) + e(Y_2 - C_2) + NM^* - N^*M + r^*B = B' - B. \quad (58)$$

This is an identity equating the current account with the negative of the capital account. These budget constraints and identities can easily be normalized by dividing through by the level of human capital.

## 2.9 The Government's Problem

The government is benevolent and maximizes the utility of the representative private household, taking into account its own budget constraint and the overall resource constraint of



the economy. Its objective function is

$$V_t^g = E \left[ \sum_{i=0}^{\infty} \beta^i \{ \ln (\tilde{C}_{t+i}^a \tilde{C}_{2t+i}^{(1-\alpha)}) + \ln (H_{t+i}) \} \right]. \quad (59)$$

In contrast to the representative household, the government internalizes the effects of its policies on the growth rate of human capital. In order to write down a stationary version of the government's maximization problem, human capital at time  $t$  can be expressed as

$$H_t = \prod_{i=0}^{t-1} H_0 \Delta_i, \quad (60)$$

with

$$\Delta_t \equiv H_{t+1}/H_t.$$

After some algebraic manipulations, the government's objective function can be written as

$$V_t^g = E \left[ \sum_{i=0}^{\infty} \beta^i \{ \ln (\tilde{C}_{t+i}^a \tilde{C}_{2t+i}^{(1-\alpha)}) + \beta (1-\beta)^{-1} \ln (\Delta_{t+i}) \} \right] + (1-\beta)^{-1} H_0. \quad (61)$$

Given this transformation, the government's problem can be formulated as the following dynamic programming problem:

$$V(e, r^*, K, B) = \max_{\psi, \tau} \{ r(e, r^*, K, B, \psi, \tau) + \beta EV(e', r^{**}, K', B') \}, \quad (62)$$

$V(\cdot)$  and  $r(\cdot)$  are now used to refer respectively to the government's value function and its one-period return function. The latter is given by

$$r(\cdot) = \ln (\tilde{C}_1^a \tilde{C}_2^{(1-\alpha)}) + \beta (1-\beta)^{-1} \ln (\Delta), \quad (63)$$

where

$$\tilde{C}_1 = \rho Z_1 \bar{K}_1^\alpha L_1^{(1-\alpha)} + (1-\tau) e Z_2 \bar{K}_2^\gamma L_2^{(1-\gamma)} - \bar{\psi} - (1-\tau) \tilde{C}_2 - \bar{I} \left( 1 + \theta \left( \frac{\bar{I}}{\bar{K}} \right)^2 \right). \quad (64)$$

The maximization is subject to the following constraints:

$$\Delta = (1 - \delta_k) + \eta L_1^{\eta_1}, \quad (65)$$

$$\tilde{K}' = (1 - \delta) \tilde{K} + I, \quad (66)$$

$$\tilde{w} = \tilde{w}(e, \tau, \tilde{\psi}, \tilde{K}), \quad (67)$$

$$r = r(e, \tau, \tilde{\psi}, \tilde{K}), \quad (68)$$

$$\tilde{K}_1 = \tilde{K}_1(e, \tau, \tilde{\psi}, \tilde{K}), \quad (69)$$

$$\tilde{K}_2 = \tilde{K} - \tilde{K}_1, \quad (70)$$

$$L_1 = L_1(e, \tau, \tilde{\psi}, \tilde{K}), \quad (71)$$

$$L_2 = L - L_1, \quad (72)$$

$$C_2 = C_2(e, \tau, \tilde{\psi}, \tilde{K}), \quad (73)$$

$$I = I(e, \tau, \tilde{\psi}, \tilde{K}), \quad (74)$$

$$\tilde{B}' = \tilde{\psi} + erZ_2\tilde{K}_2^{\gamma}L_1^{(1-\gamma)} - er\tilde{C}_2 + (1 + r^*)B. \quad (75)$$

Since the aggregate decision rules of the private sector are constraints on the problem, the government indirectly takes into account the first order conditions of private households and acts as a Stackelberg leader. Private agents know that the government uses dynamic programming methods to optimize and they expect it to continue to do so. Therefore (cf. Blanchard and Fischer, 1989, pp.594-5) time inconsistency is not a problem, although the government could in general attain a superior outcome in terms of social welfare if it was able to precommit to its policy.

## 2.10 Solution Methodology

The model does not lend itself to analytical solution. We use a numerical solution method based on Hansen and Prescott (1991), which involves computing the steady state of the model with all random variables equal to their unconditional mean and taking quadratic approximations of the dynamic programming problems around the steady state. The method has been modified to take into account the dynamic Stackelberg game which is played between the private sector and the government. The necessary modifications are summarized in detail in Ambler and Paquet (1994). Even though we analyze only the steady state properties of the model, we need a numerical solution since the government's optimal policy depends on the coefficients of the household's decision rules.

## 3 Steady State and Calibration

Taking the first order conditions of the household's dynamic programming problem gives

$$r_d + \beta EV_{s'} \frac{\partial s'}{\partial d} = 0. \quad (76)$$

Here, we use  $d$  to denote the vector of control variables of the household and  $s$  to denote the household's state variables. Differentiating the value function with respect to the household's state variables gives

$$V_s = r_s + r_d \frac{\partial d}{\partial s} + \beta E \left\{ V_{s'} \frac{\partial s'}{\partial s} + V_{s'} \frac{\partial s'}{\partial d} \frac{\partial d}{\partial s} \right\}, \quad (77)$$

which by virtue of the first order conditions simplifies to

$$V_s = r_s + \beta EV_{s'} \frac{\partial s'}{\partial s}. \quad (78)$$

Evaluating this equality at the model's steady state, so that  $V_s = V_{s'}$ , we have

$$V_s = r_s \left( I_s - \beta \frac{\partial s'}{\partial s} \right)^{-1} \quad (79)$$

Substituting back into the first order conditions and aggregating, we have at the steady state that

$$r_d + \beta r_s \left( I_s - \beta \frac{\partial s'}{\partial s} \right)^{-1} \frac{\partial s'}{\partial d} = 0. \quad (80)$$

The first order conditions give  $\eta_d$  equations to solve for the steady state levels of the control variables  $D$ , where  $\eta_d$  gives the dimension of the vector of control variables of the representative household. In addition, the following relation holds at the steady state between state variables and controls:

$$\bar{S} = B(\bar{z}, \bar{g}, \bar{S}, \bar{D}, \bar{D}), \quad (81)$$

where bars over variables denote their steady state levels,  $z$  denotes the vector of exogenous state variables of the model,  $g$  denotes the vector of government policy variables, and  $S$  and  $D$  denote the aggregate or per capita levels of the representative household's state and control variables. For given levels of the policy variables, we have  $\eta_d + \eta_s$  equations to solve for the same number of unknowns, conditional on the steady state levels of  $z$  and  $g$ , where  $\eta_s$  gives the number of elements of the state vector  $s$ .

Finding the steady state levels of the government's controls is slightly more complicated. The government takes into account its affect on the behavior of the private sector. Taking the first order conditions of the government's problem, we have

$$r_s + r_D \frac{\partial D}{\partial g} + \beta EV_{s'} \left( \frac{\partial S'}{\partial g} + \frac{\partial S'}{\partial D} \frac{\partial D}{\partial g} \right) = 0. \quad (82)$$

Differentiating the value function with respect to the aggregate state variables  $S$  gives

$$V_s = r_s + r_D \frac{\partial D}{\partial S} + r_g \frac{\partial g}{\partial S} + r_D \frac{\partial D}{\partial g} \frac{\partial g}{\partial S} + \beta EV_{s'} \left\{ \frac{\partial S'}{\partial S} + \frac{\partial S' \partial D}{\partial D \partial S} + \frac{\partial S' \partial D}{\partial D} \frac{\partial D}{\partial g} \frac{\partial g}{\partial S} + \frac{\partial S' \partial g}{\partial g \partial S} \right\}. \quad (83)$$

By virtue of the first order conditions, this simplifies to

$$V_s = r_s + r_D \frac{\partial D}{\partial S} + \beta EV_{s'} \left\{ \frac{\partial S'}{\partial S} + \frac{\partial S' \partial D}{\partial D \partial S} \right\}. \quad (84)$$

Evaluating this at the model's steady state gives

$$V_s = r_s + r_D \frac{\partial D}{\partial S} \left( 1 - \beta \left( \frac{\partial S'}{\partial S} + \frac{\partial S' \partial D}{\partial D \partial S} \right) \right)^{-1}. \quad (85)$$

The first order conditions evaluated at the steady state then give:

$$r_g + r_D \frac{\partial D}{\partial g} + \beta V_s \left( \frac{\partial S'}{\partial g} + \frac{\partial S' \partial D}{\partial D \partial g} \right) = 0. \quad (86)$$

This equality gives  $\eta_g$  equations to solve for the steady state levels of the government control variables. The partial derivatives of the  $D$  variables with respect to the state variables  $S$  and the government's control variables  $g$  can be evaluated by using the coefficients from the linear feedback rules calculated numerically from the quadratic approximations to the dynamic programming problems. In addition, the laws of motion for the exogenous variables of the model take the form:

$$z' = A(z). \quad (87)$$

Evaluating these laws of motion at the steady state gives us  $\eta_z$  equations to solve for the steady state levels of these exogenous variables. Combining the first order conditions of the

private agent and government plus the laws of motion for  $S$  and  $z$  gives us a simultaneous system to solve for  $S$ ,  $z$ ,  $D$ , and  $g$ .

### 3.1 Model Calibration

We choose some parameter values on the basis of arbitrary normalizations, some on the basis of prior information and others so that the steady state of the model respects a certain number of desirable properties. For certain key parameter values, we also conduct an extensive sensitivity analysis. Base-case parameter values are given in Table 1. The base case corresponds to a regime of free trade with a particular set of structural parameter values.

The value of  $Z_1$  has been normalized to equal 1.0, and we set the terms of trade  $e$  equal to 1.0 as well. We assume that the production intermediate goods and therefore of final good 1 is more capital intensive than that of final good 2, so that  $\alpha > \gamma$ , and we choose the levels of  $\alpha$  and  $\gamma$  so that labor's average share of income in the long run is approximately equal to 0.65; the numerical simulation results are not sensitive to the degree of difference between the capital intensities. The value of  $\sigma$  is set at 6.5 on the basis of empirical results by Morrison (1990). The value of the adjustment cost parameter  $\theta$  (0.025) is taken from Mendoza (1991). Given a restriction on the value of the real interest rate in the steady state, equation (30) can be used to back out the capital-to-labor ratio in the intermediates sector. Given the capital-to-labor ratio in intermediates production, we can calculate the equilibrium wage rate. The efficiency conditions (22) and (23) together imply a relationship between the capital-to-labor ratios in the intermediates sector and sector 2, which gives us the capital-to-labor ratio in the latter sector. In the base-case scenario, half of the work

force in the steady state under free trade is concentrated in the intermediates sector. Since the overall labor endowment of the economy is normalized to equal 1, we can now derive the equilibrium capital stock and its allocation across sectors. Either one of the efficiency conditions (22) or (23) can now be used to derive the implied value of the constant  $Z_2$ . The equilibrium capital stock also gives us the equilibrium rate of investment for a depreciation rate  $\delta$  which we set equal to 0.025. We have no strong priors on the rate of depreciation of human capital, so we also set  $\delta_h$  equal to 0.025. For a given level of  $\eta_1$  in the human capital accumulation equation (arbitrarily set equal to 0.5 in the base-case scenario), we can use the human capital accumulation equation (34) to back out the implied value of  $\eta$  compatible with a steady-state gross quarterly growth rate under free trade of 1.005, (a net per capita growth rate of two percent per year). The numerical results are potentially sensitive to the assumed allocation of labor across sectors and to the parameters in the human capital equation, so these are subjected to sensitivity analysis.

Preference parameters have been chosen so that the economy is a net exporter of final good 2 and a net importer of final good 1 in the steady state under free trade. The subjective discount rate has been chosen so that the household's dynamic efficiency condition for investment is satisfied in the steady state given the real interest rate.

We set the steady-state level of foreign debt equal to zero.<sup>13</sup> This allows us to calculate.

<sup>13</sup>

Since the government uses a constant subjective discount rate and can borrow at a given world interest rate, the model is hysterical and the level of consumption depends on the historically-given level of foreign indebtedness. Restricting the steady-state level of foreign indebtedness is compatible with the results of Marcat and Marimon (1993), who show that consumption-smoothing possibilities are severely limited when sovereign borrowing is subject to incentive compatibility constraints.

the level of lump sum transfers that achieves a balanced budget for a given level of the production tax and consumption subsidy. The steady-state values of various endogenous variables (with all trended variables normalized by dividing by the level of human capital) under free trade are given in Table 2.

## 4 Results

We first summarize the main results with the base-case parameter values and then describe the results of our sensitivity analysis.

In the base case, it is optimal for the government to induce a big shift in resources into the intermediates sector. The optimal tariff rate is the one that just shifts all capital and labor into the intermediates sector. A further increase in the tariff rate is suboptimal since it increases the static distortion in consumption choices without an offsetting benefit in the form of increased growth rates. Furthermore, a fairly small tariff rate is required to induce such a shift of resources. With a tax cum tariff rate of 0.094, all of the economy's productive resources shift into the intermediates sector. This result comes about for two reasons. First, the static production possibility frontier is not very convex. Driving the economy to a corner solution does not involve a large reduction in GDP measured at world prices compared to the free trade equilibrium. Second, the trade-off between the steady state level of consumption (normalized by the level of human capital) and the steady state growth rate is also not very convex. This trade-off is illustrated in Figure 1. It shows the attainable combinations of consumption and growth rates for different levels of  $\tau$ , with the base-case parameter values.



From equation (61), the government's indifference curves between consumption and growth are linear in the log of consumption and the log of the gross rate of growth.

With the base-case parameter values, the increase in the growth rate is substantial. The gross quarterly growth rate under free trade is 1.005 and increases to 1.017 under the optimal commercial policy. This represents an increase in the rate of economic growth of 1.2% per quarter or of close to five percent in annual terms. The increase in growth is also associated with a substantial increase in gross exports. The effect of increasing tariff cum tax rates on gross exports is illustrated in Figure 2 (all parameters are kept at their base-case levels except for  $\tau$ , which varies along the horizontal axis of the graph). To calculate gross exports, we note that the equilibrium of the economy does not depend on  $\bar{N}_i$ , the total number of varieties of intermediate good produced by the world economy. If  $\bar{N}_i$  is large compared to  $N_i$ , which is reasonable for a small open economy, then the economy will export a large fraction of the total production of each of the intermediate good types that it produces. We therefore take gross exports to be equal to the total production of intermediate goods plus the net exports of the final good for which net exports are positive (we assume that there is no two-way trade in homogeneous final goods). Under free trade this is always good 2 by construction. Since the optimal commercial policy involves allocating all resources to the production of final good 1, this good is exported in the second-best optimum.

The results in Tables 3 and 4 indicate the maximum attainable increase in the economy's growth rate with respect to a free-trade steady state with the allocation of labor given in the first column of the table. The  $Z_2$  parameter is adjusted to generate this allocation of

resources under free trade. In Table 3, as the  $\eta_1$  parameter is varied along the first row of the table, the  $\eta$  parameter is varied to maintain a rate of growth of 1.005 in the free trade steady state equilibrium. In Table 4, as  $\delta_h$  is varied along the first row,  $\eta$  is once again adjusted to keep a steady-state growth rate of 1.005 under free trade. In all cases in both of these experiments, the second-best optimum involves complete specialization in the production of intermediates and final good 1.

Table 3 shows how the maximum attainable increase in the growth rate varies as the initial allocation of labor and the degree of diminishing returns in the effect of the allocation of labor on human capital accumulation vary. The numbers in bold in the lower left hand corner of the table indicate parameter values for which the increase in the growth rate is less than one percent per year.

Table 4 shows how the maximum attainable increase in the growth rate varies with the rate of human capital depreciation. This parameter is important since it strongly influences the value of the  $\eta$  parameter. A smaller value of  $\delta_h$  makes it possible to attain a free-trade growth rate of 1.005 with a lower value of  $\eta$ , so that the economy's growth rate is less sensitive to the allocation of resources across sectors. Once again, the numbers in bold in the lower left hand corner of the table indicate parameter values for which the increase in growth is less than one percent per year.

## 5 Discussion and Conclusions

We have shown that, in a calibrated model of a small open economy with a human capital accumulation externality, second-best optimal commercial policy can have large quantitative effects on growth rates. The effects are quantitatively unimportant (an increase in the economy's annual growth of less than one percent) only when most resources are already allocated under free trade to the sectors with strong human capital externalities, when there are strong economy-wide diminishing returns to human capital accumulation, and when human capital accumulation is insensitive to the allocation of resources. Even in such cases (given in the lower left hand corners of Tables 3 and 4), commercial policy can still lead to growth rate increases on the order of one half of one percent per year, and, given the convexity of the production possibility frontier used in our model, it is optimal to generate such increases.

We make a sharp distinction in the model between the productive sector of the economy associated with strong human capital accumulation externalities and a second sector where such externalities are completely absent. Furthermore, industries with human capital externalities are particularly easy to identify since only they are associated with two-way trade. It is clear that the problem of identifying such industries in real life is much more complex. It is a moot point whether this task should be left to governments or to the private sector. What is clear from our model is that there may be large rewards to such efforts, and the private incentives for shifting resources into these sectors may be absent.

Further work should be directed towards characterizing the optimal transition to the

steady state for given initial levels of human and physical capital, and to increasing our understanding of the human capital accumulation process. The degree to which learning is done by individual workers, managers, and organizations, and the degree to which learning has external effects on the rest of the economy, are important for our understanding of economic growth and for assessing the quantitative importance of commercial policy.

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**TABLE 1**  
**Base Case Parameter Values**

Parameter	Value	Remarks
$\alpha$	0.45	capital share in intermediates sector
$\gamma$	0.25	capital share in sector 2
$Z_1$	1.00	constant in intermediates production
$Z_2$	1.76	constant in production of good 2
$\phi$	0.10	fixed cost in intermediates production
$\sigma$	6.50	substitutability between intermediates
$\epsilon$	1.00	terms of trade
$\delta$	0.025	capital depreciation rate
$\delta_h$	0.025	human capital depreciation rate
$\eta$	0.042	impact of employment on human capital
$\eta_1$	0.50	human capital accumulation parameter
$a$	0.90	weight on $c_1$ in utility function
$\theta$	0.025	investment adjustment cost parameter
$\beta$	0.99	subjective discount rate

**TABLE 2**  
**Base Case Steady State**

Variable	Value	Remarks
$\tau$	0.0	tax/tariff rate
K	42.33	capital stock
$K_1$	30.08	capital in intermediates
$L_1$	0.50	employment in intermediates
$L_2$	0.50	employment in sector 2
NM	2.67	production of intermediates
$Y_2$	1.96	production of good 2
GDP	4.63	total value added produced by economy
$r$	0.04	real interest rate
$w$	2.94	real wage rate
$C_1$	3.03	consumption of good 1
$C_2$	0.34	consumption of good 2
I	1.27	investment
$\bar{M}$	0.55	production per type of intermediate
N	4.86	number of intermediate types
$\beta$	0.99	discount rate
$\Delta$	1.005	gross growth rate

**TABLE 3**  
**Maximum Increase in Growth Rate**

		$\eta_1$									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$L_1$	0.1	0.008	0.018	0.030	0.045	0.065	0.089	0.120	0.159	0.208	0.270
	0.2	0.005	0.011	0.019	0.027	0.037	0.049	0.063	0.079	0.098	0.120
	0.3	0.004	0.008	0.013	0.019	0.025	0.032	0.040	0.049	0.059	0.077
	0.4	0.003	0.006	0.009	0.013	0.017	0.022	0.027	0.032	0.038	0.045
	0.5	0.002	0.004	0.007	0.009	0.012	0.015	0.019	0.022	0.026	0.030
	0.6	0.002	0.003	0.005	0.007	0.009	0.011	0.013	0.015	0.018	0.020
	0.7	0.001	0.002	0.003	0.005	0.006	0.007	0.009	0.010	0.011	0.013
	0.8	0.001	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.007	0.007
	0.9	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003

$L_1$  indicates the fraction of the total labor force in the intermediates sector in the free trade equilibrium. In these experiments, the rate of depreciation of human capital is held constant at 0.025. The  $\eta$  parameter is varied to give a growth rate of 1.005 in the free-trade steady state.

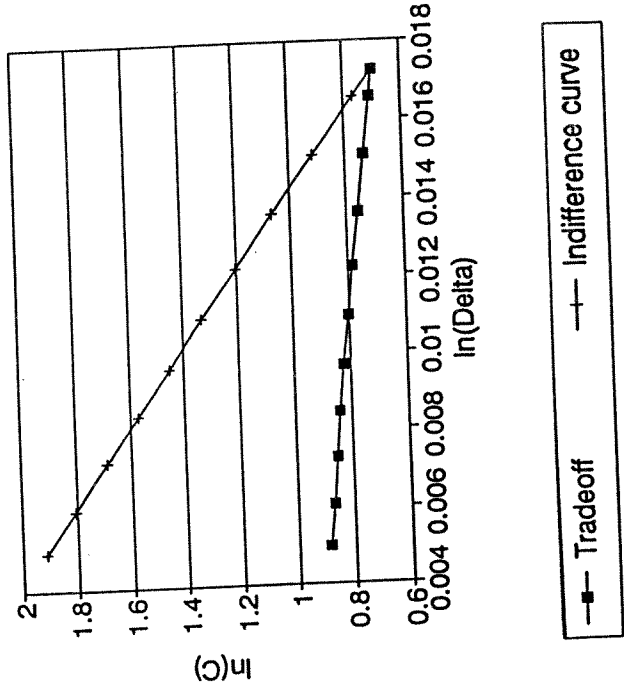


**TABLE 4**  
**Maximum Increase in Growth Rate**

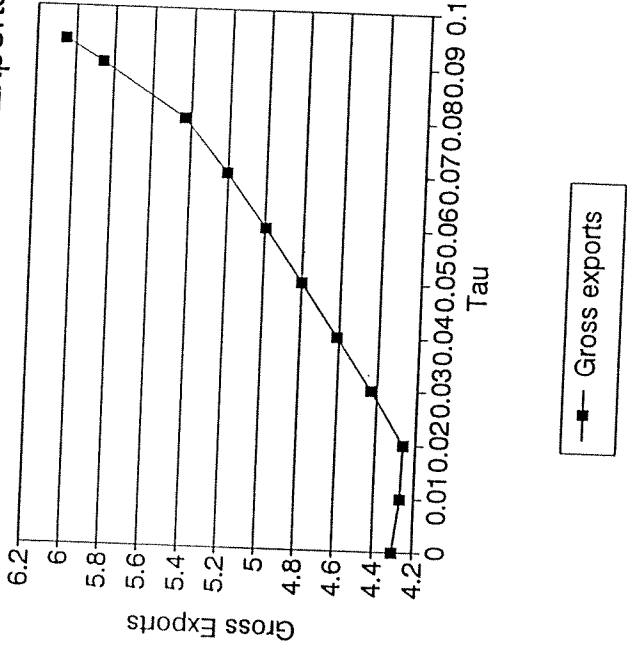
		$\delta_h$							
		0.000	0.005	0.010	0.015	0.020	0.025	0.030	0.035
$L_1$	0.1	0.011	0.022	0.032	0.043	0.054	0.065	0.076	0.086
	0.2	0.006	0.012	0.019	0.025	0.031	0.037	0.043	0.049
	0.3	0.004	0.008	0.012	0.017	0.021	0.025	0.029	0.033
	0.4	0.003	0.006	0.009	0.012	0.015	0.017	0.020	0.023
	0.5	0.002	0.004	0.006	0.008	0.010	0.012	0.014	0.017
	0.6	0.001	0.003	0.004	0.006	0.007	0.009	0.010	0.012
	0.7	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008
	0.8	0.001	0.001	0.002	0.002	0.003	0.004	0.004	0.005
	0.9	0.000	0.001	0.001	0.001	0.001	0.002	0.002	0.002

$L_1$  indicates the fraction of the total labor force in the intermediates sector in the free trade equilibrium. In these experiments, the  $\eta_1$  parameter is held constant at 0.5. The  $\eta$  parameter is varied to give a growth rate of 1.005 in the free-trade steady state.

Figure 1  
Tradeoff between Growth and Consumption



**Figure 2**  
Commercial Policy and Gross Exports





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