Schooling time decisions in closed and open economies*

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Abstract

We analyze a three-period OLG model, where a consumption good is produced by means of skilled labor and an intermediate good. Human capital accumulation depends on the aggregate stock of human capital and on the fraction of time that children spend at school, which is decided by their parents. The remaining time is used as the only input in the production of the intermediate good. We compare schooling time decisions in countries where they are privately made and in countries where they are collectively set through compulsory education laws. We study the dynamic behavior of these economies and find that human capital accumulation will always be larger in the latter case. With international trade, private schooling decisions change according to the initial pattern of comparative advantage. Instead, the outcome of collective schooling decisions does not necessarily follow the pattern of comparative advantage.

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1. Introduction

This paper develops a model where parents make schooling decisions for their children. This setting seems appropriate for analyzing educational decisions in most developing countries, where available data show that the number of years of schooling is so low that relevant schooling decisions are related to primary and, at most, secondary education.[1] These decisions are clearly made by parents and not by children. In the majority of recent models about human capital investment and growth, atomistic agents choose the optimal fraction of time allocated to their own education. Thus, these models may not be able to shed light on schooling decisions regarding primary and secondary education. Differently from this literature, this paper presents a framework where the only education choices are made by parents.

Primary and secondary education are related to compulsory schooling. Compulsory schooling legislations exist in every devoloped country, at least since the second World War. Although compulsory schooling laws have been introduced in most developing countries as well, few of them seem able to enforce such legislation, so that schooling time can in effect be seen as the result of private decisions in such countries.[2] We think that the lack of enforcement of compulsory schooling laws may play a role in explaining low average schooling years and, possibly, child labor in developing countries.[3]

To analyze these issues, we constructed an overlapping generations model where agents live for three periods. In the first period, their time is allocated to schooling or working in an intermediate good sector and this allocation is decided by parents. In the second period, adults supply labor inelastically in a final good sector. In the intermediate good sector, the only factor of production is the unskilled labor supplied by the young. The intermediate good is taken by parents and becomes productive with one period lag. In the final good sector available

[1] Table 1 in the appendix reports data on education variables for selected countries. The first column shows that the average number of years spent at school is below eight in most developing countries. African countries exhibit particularly low figures, ranging from a minimum of 0.2 in Burkina Faso and Niger to a maximum of 4.1 in Mauritius (data not shown).

[2] The last column of Table 1 shows that compulsory education covers primary and some secondary education in most developing countries. As shown by data reported in the second and third column, however, secondary gross enrollment ratios still fall below 100% in many developing countries, although universal primary gross enrollment has been generally achieved. Universal primary gross enrollment has not yet been achieved in almost half of the african countries. Primary gross enrollment ratios even fall below 50% in some subsaharian countries.

[3] In a study about India, Weiner [14] indicates the lack of commitment to a national compulsory schooling policy as a crucial explanation for high illiteracy rates.

technology uses two inputs, skilled labor supplied by the adults and the intermediate good. In their last period of life, individuals consume the income derived from selling the intermediate good to firms and a transfer received by the adults.

In this setting, we consider two polar educational regimes. In the first regime, there is no institution that can credibly enforce schooling regulations and laws. Here, human capital decisions are made *privately* by parents. In the second regime, adults make these decisions *collectively* by setting and enforcing compulsory schooling legislation. Here parents take into account how the amount of time that children spend at school affects future state variables (in particular, the aggregate stock of human capital) and therefore wages and prices.

Within this framework, we show that the time allocated to education is higher in the second regime, where positive externalities of the aggregate stock of human capital on individual human capital can be internalized. Thus, countries with enforceable schooling legislation reach a steady-state characterized by a higher level of human capital. In turn, this implies that output of the consumption good is also higher in such countries. This result is consistent with the observation that employment of children is low in rich countries and high in poor countries. Such association in our model stems from the enforceability of schooling regulations.

We then turn to the effects of trade on educational decisions. We concentrate on the case where countries with compulsory schooling, which are relatively skill-abundant, have a comparative advantage in the production of the final good. The opposite is true for countries where compulsory schooling is not enforceable. Contrary to the predictions of the traditional trade literature which suggests that, as a consequence of trade liberalization, countries that are skill-scarce should reduce investment in education and countries that are skill-abundant should increase investment in education,[4] we find that the latter countries may have shorter schooling time and reach a steady-state equilibrium characterized by lower human capital and consumption good under free trade than under autarky. These results may help to explain why, although most countries showed an upward trend in the duration of compulsory education, this has been reduced in some countries in the last thirty years.[5]

Recent debates on social dumping and child labor concentrate on static welfare and redistributive effects of trade between countries with different labor stan-

[4] See for example Findlay and Kierzkowski [6] and Stokey [11]. Cartiglia [4]obtains the opposite result in presence of capital market imperfections.

[5] Table 2 in the appendix reports data for countries that experienced a reduction in compulsory education.

dards.[6] By examining the choice between children education and employment in the context of an intertemporal general equilibrium model, our paper provides a framework to analyze the long-run consequences of trade on schooling decisions, which are virtually ignored in the literature on child labor. As we just discussed, international trade may result in reduced children education and increased child labor not only in countries that are skill-scarce, but also in countries that are skill-abundant. This outcome is reminiscent of the "race to the bottom" equilibrium, which is often invoked as an argument in favor of international harmonization of labor standards.

This paper is related to the recent literature on education and growth. Glomm and Ravikumar [8], Benabou [2] and Boldrin [3] analyze the effects of private and public education on economic growth when agents choose their own human capital investment. Glomm [7] and Eckstein and Zilcha [5] study parental choices of education. The latter explicitly consider how the provision of compulsory education by the government affects growth and welfare. This literature deals only with closed economies. Our paper contributes to this literature by setting up an intertemporal general equilibrium model which yields closed form solutions to the equilibrium when schooling decisions are made collectively by forward-looking parents. This model is used to shed light on the relationship between international trade, schooling decisions and child labor.

The paper is organized as follows. Section 1 sets out the model without trade and analyzes the endogenous choice of time devoted to education. Section 2 extends the model to incorporate international trade and Section 3 concludes.

2. The closed economy model

Consider a closed economy with overlapping generations which produces two types of goods: an intermediate and a final good. In each period, there are three generations alive: young, adults and old. We assume constant population and normalize the size of each generation to one. Young people are endowed with one unit of time, of which a fraction e is spent at school and the remaining time is used in the production of the intermediate good. Education decisions are taken by adults, who appropriate the entire amount of the intermediate good for use in production of the final good. We will assume that the intermediate good becomes productive with one period lag. The final good is non-storable and there are no

[6] Exhaustive discussions about international labor standards, child labor and trade can be found in Basu [1], Golub [9], Krueger [10] and Rodrick [12].

capital markets. Adults consume the entire disposable income earned by working in the final good sector, while the old consume the income they derive from the ownership of the intermediate good and a transfer received from their family's adults.

The intermediate good x is produced by means of unskilled labor supplied by the young, according to the following linear production function:

$$x_{t+1} = (1 - e_t) \tag{2.1}$$

As implied by the notation, the intermediate good produced at time t takes one period to become productive and is used with skilled labor in the production of the final good at time $t + 1$. Technology in the final good sector is given by:

$$y_{t+1} = h_{t+1}^{\alpha} H_{t+1}^{\eta} x_{t+1}^{\gamma} \tag{2.2}$$

where h_t is the effective labour force provided by a skilled worker at time t and H_t is the aggregate stock of human capital. The production function exhibits constant returns to scale in h and x, so that $\alpha + \gamma = 1$ and $\alpha + \gamma + \eta > 1$.

The technology for human capital accumulation depends on the stock of aggregate human capital and on the amount of time individually devoted to education:

$$h_{t+1} = H_t^{\mu} e_t^{\nu} \tag{2.3}$$

where $\mu + \nu < 1$.

The intertemporal utility function of an agent born at time $t - 1$ is given by:

$$U_{t-1} = \ln c_{t-1,t} + \beta \ln c_{t-1,t+1}$$

which implies that agents are non-altruistic.

At time t adults born at time $t - 1$ allocate their entire disposable income to consumption. Thus:

$$w_t (1 - \tau) h_t = c_{t-1,t} \tag{2.4}$$

where τ is the exogenous fraction of labor income that the adults transfer to their parents.[7] When old, agents born at $t - 1$ consume the transfer that they receive from the adults and the income that they derive from the ownership of the intermediate good:

$$\tau w_{t+1} h_{t+1} + p_{x,t+1} x_{t+1} = c_{t-1,t+1} \tag{2.5}$$

where $p_{x,t+1}$ is the price of x in terms of y at time $t + 1$.

[7] In this framework, if adults could choose their optimal tax rate, they would set $\tau = \frac{1}{2} - \frac{\gamma}{2\alpha\beta}$ which would be positive as long as $\gamma < \alpha\beta$.

2.0.1. Private schooling decisions

In this section we consider an economy where compulsory education is not enforceable and parents privately choose the amount of time that their children will spend at school.

As implied by the budget constraint in equation (2.4), the utility maximization problem of the adults reduces to maximization of their old age consumption, since their consumption when adults is predetermined. Therefore, taking prices and wages are given, e_t will be chosen in order to:

$$\max_{e_t} \ln c_{t-1,t+1} \tag{2.6}$$

$$s.to\ \tau w_{t+1} H_t^{\mu} e_t^{\nu} + (1 - e_t)\, p_{x,t+1} = c_{t-1,t+1}$$

First order condition yields:

$$\tau w_{t+1} \nu H_t^{\mu} e_t^{\nu-1} = p_{x,t+1} \tag{2.7}$$

As this equation shows, parents equalize the return from investment in education (i.e. higher future transfers) to the return from employing their children in the intermediate good sector. In equilibrium $h_t = H_t$. Profit maximization and the market clearing condition for good x imply:

$$p_{x,t+1} = \frac{\gamma Y_{t+1}}{X_{t+1}} = \gamma H_{t+1}^{\alpha+\eta} X_{t+1}^{-\alpha} = \gamma H_{t+1}^{\alpha+\eta} (1 - e_t)^{-\alpha} \tag{2.8}$$

$$w_{t+1} = \frac{\alpha Y_{t+1}}{H_{t+1}} = \alpha H_{t+1}^{\eta-\gamma} X_{t+1}^{\gamma} = \alpha H_{t+1}^{\eta-\gamma} (1 - e_t)^{\gamma} \tag{2.9}$$

Substituting these expressions in equation (2.7), we obtain:

$$e_t = \frac{\alpha\tau\nu}{\gamma + \alpha\tau\nu} = e \tag{2.10}$$

The optimal fraction of time spent for education is *constant* over time. Notice that e is increasing with α, τ, ν and decreasing with γ. The higher is α, the more productive is human capital in the production of the final good. Therefore, the more profitable is to invest in education to benefit in the next period from higher wages and transfers. On the contrary, the higher is γ , the higher is the productivity of the intermediate good. Since adults can only determine their old age consumption, the tax rate τ has an unambiguous effect on the level of education.

2.1. Collective schooling decisions

Now, let us assume that compulsory education is enforceable. In this case, parents set the schooling time collectively and take into account the effects of their decision on the future aggregate stock of human capital. Through this effect, they also anticipate the future level of equilibrium wages and prices.

Again, adults' objective is to maximize their consumption when old. Therefore, e_t^* will be chosen collectively in order to:

$$\max_{e_t^*} \ln c_{t-1,t+1}^* \tag{2.11}$$

$$s.to\ \tau w_{t+1}^* h_{t+1}^* + (1-e_t^*)\, p_{x,t+1}^* = c_{t-1,t+1}^*$$

$$(2.8)\ (2.9)$$

The choice of education influences prices and wages, since it affects the level of aggregate human capital. By taking into account the expressions for wages and prices that derive from profit maximization and $h_{t+1}^* = H_{t+1}^*$, the adults' problem reduces to:

$$\max_{e_t^*} \ln c_{t-1,t+1}^* \tag{2.12}$$

$$s.to\ \ (\alpha\tau + \gamma)\, Y_{t+1}^* = c_{t-1,t+1}^*$$

In words, utility maximization reduces to maximizing the future level of final good production with respect to e_t^*. By equation (2.2), we can write the first order condition as follows:

$$\frac{\partial Y_{t+1}^*}{\partial e_t^*} = 0 \Leftrightarrow \nu\,(\alpha+\eta)\, e_t^{*\nu(\alpha+\eta)-1}\,(1-e_t^*)^{\gamma} - \gamma e_t^{*\nu(\alpha+\eta)}\,(1-e_t^*)^{-\alpha} = 0 \tag{2.13}$$

which yields the optimal time devoted to education:

$$e_t^* = \frac{(\alpha+\eta)\,\nu}{\gamma + (\alpha+\eta)\,\nu} = e^* \tag{2.14}$$

Again, the solution for education time is constant. Since education is chosen collectively, the positive externality of the aggregate stock of human capital in the production of the final good is internalized by rational agents. This explains why η appears in the expression for e^* and not in the expression for e. The tax rate τ does not appear in equation (2.14) because in this case old age consumption can be written as a constant fraction $\alpha\tau + \gamma$ of the final good output.

By observation of equation (2.10) and equation (2.14), we can immediately establish the following result:

Proposition 1. *In the closed economy case, the amount of time devoted to education is at any point in time* higher *when compulsory education is enforceable. As a consequence, the stock of human capital, the output of the final good and the price of the intermediate good in terms of the final good are also* higher *with compulsory education.*

Next, consider equations (2.2) and (2.3). Since education is constant over time and $\mu < 1$, each economy converges to a unique steady-state. The steady state levels of aggregate human capital, final good output and intermediate good price in the two cases are given by:

$$\begin{array}{ll} H = e^{\frac{\nu}{1-\mu}} & H^* = e^{*\frac{\nu}{1-\mu}} \\ Y = e^{\frac{(\alpha+\eta)\nu}{1-\mu}}\left(1-e\right)^{\gamma} & Y^* = e^{*\frac{(\alpha+\eta)\nu}{1-\mu}}\left(1-e^*\right)^{\gamma} \\ p_x = e^{\frac{(\alpha+\eta)\nu}{1-\mu}}\left(1-e\right)^{-\alpha} & p_x^* = e^{*\frac{(\alpha+\eta)\nu}{1-\mu}}\left(1-e^*\right)^{-\alpha} \end{array} \qquad (2.15)$$

It should be noted that, though higher than the privately selected schooling time, the duration of compulsory eduaction does not maximize the steady state level of final good output. This is due to the fact that agents are finitely lived in our model. In order to maximize steady state output, schooling time should be set at the higher level $(\alpha + \eta\nu)/[(1-\mu)\gamma + (\alpha+\eta)\nu]$. This, however, would hurt all generations along the transition to the higher steady state.

3. The open economy model

Let us consider two countries, one where compulsory education is enforceable (that we call foreign) and one where it is not (home). We study how international trade affects education choices in both countries. Two assumptions are introduced here. First, we assume that the two countries are small and face an exogenous international relative price of the intermediate good in terms of the final good, p_x^w. Second, we assume that countries open up to trade starting from their closed economy steady-state equilibrium and we concentrate our attention on the case where, at the opening of trade, $p_x < p_x^w < p_x^*$. In this case, the home country has a comparative advantage in the production of the low-education intermediate good.

3.1. The home economy

In the open economy case, adults in the home country take wages and prices as given and solve the following problem:

$$\max_{x_{t+1}^s, e_t} \ln c_{t-1,t} + \beta \ln c_{t-1,t+1}$$

$$s.to \qquad c_{t-1,t} = (1-\tau) w_t h_t - p_x^w \left[x_{t+1}^s - (1-e_t)\right]$$

$$c_{t-1,t+1} = \tau w_{t+1} h_{t+1} + p_x^w x_{t+1}^s$$

where x_{t+1}^s is the amount of intermediate good stored by adults at time t. At time t, net imports of good x productive at $t+1$ are given by $x_{t+1}^s - (1-e_t)$. In the same period, the difference between demand of intermediate good by domestic firms x_t^d and the amount stored by the current old x_t^s represents net imports of the intermediate good available for production at time t.

Adults at time t can sell or buy the intermediate good in the world markets. If they become exporters, export revenues are then used to finance additional current consumption. On the contrary, if adults reduce current consumption and become importers, they can employ a larger amount of intermediate good to increase future consumption. Solving the first order condition for x_{t+1}^s we obtain:

$$x_{t+1}^s = \frac{1}{1+\beta}\left[\frac{\beta(1-\tau) w_t h_t}{p_x^w} + \beta(1-e_t) - \frac{\tau w_{t+1} h_{t+1}}{p_x^w}\right] \tag{3.1}$$

$$c_{t-1,t} = \frac{1}{1+\beta}\left[(1-\tau) w_t h_t + p_x^w (1-e_t) + \tau w_{t+1} h_{t+1}\right] \tag{3.2}$$

$$c_{t-1,t+1} = \frac{\beta}{1+\beta}\left[(1-\tau) w_t h_t + p_x^w (1-e_t) + \tau w_{t+1} h_{t+1}\right] \tag{3.3}$$

The level of education will be chosen to maximize the term between square brackets in equations (3.2) and (3.3), which represents the lifetime income of adults at time t. The first order condition with respect to e_t is:

$$e_t^{\nu-1} \tau \nu H_t^{\mu} w_{t+1} = p_x^w \tag{3.4}$$

By profit maximization, the level of wages can be written as:

$$w_{t+1} = \alpha \frac{Y_{t+1}}{H_{t+1}} = \alpha \gamma^{\frac{\gamma}{\alpha}} H_t^{\frac{\eta\mu}{\alpha}} e_t^{\frac{\eta\nu}{\alpha}} \left(p_x^w\right)^{-\frac{\gamma}{\alpha}} \tag{3.5}$$

Substituting equation (3.5) into equation (3.4) and defining $\xi \equiv 1 - \nu$, we obtain:

$$e_t = (\alpha\tau\nu)^{\frac{\alpha}{\alpha\xi-\eta\nu}} \gamma^{\frac{\gamma}{\alpha\xi-\eta\nu}} H_t^{\frac{\mu(\alpha+\eta)}{\alpha\xi-\eta\nu}} \left(p_x^w\right)^{-\frac{1}{\alpha\xi-\eta\nu}} \tag{3.6}$$

Therefore, the equation for the accumulation of human capital is given by:

$$H_{t+1} = (\alpha\tau\nu)^{\frac{\alpha\nu}{\alpha\xi-\eta\nu}} \gamma^{\frac{\gamma\nu}{\alpha\xi-\eta\nu}} H_t^{\frac{\alpha\mu}{\alpha\xi-\eta\nu}} \left(p_x^w\right)^{-\frac{\nu}{\alpha\xi-\eta\nu}} \tag{3.7}$$

Assuming $\frac{\alpha}{\alpha+\eta} > \nu$ yields $\alpha\xi - \eta\nu > 0$ and $\frac{\alpha\mu}{\alpha\xi-\eta\nu} < 1$. These parameter constraints ensure that the stock of human capital reaches a unique steady state equilibrium:

$$H = (\alpha\tau\nu)^{\frac{\alpha\nu}{\alpha(\xi-\mu)-\eta\nu}} \gamma^{\frac{\gamma\nu}{\alpha(\xi-\mu)-\eta\nu}} \left(p_x^w\right)^{-\frac{\nu}{\alpha(\xi-\mu)-\eta\nu}} \tag{3.8}$$

Given H, the steady state time devoted to education is equal to:

$$e = (\alpha\tau\nu)^{\frac{\alpha(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} \gamma^{\frac{\gamma(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} \left(p_x^w\right)^{-\frac{1-\mu}{\alpha(\xi-\mu)-\eta\nu}} \tag{3.9}$$

Notice that $\frac{\alpha\mu}{\alpha\xi-\eta\nu} < 1$ implies $\alpha(\xi - \mu) - \eta\nu > 0$. Thus, the steady-state level of education decreases with the relative price of the intermediate good. An increase in p_x^w induces specialization in the production of the intermediate good and therefore reduces human capital accumulation. The qualitative effects of changes in α, τ, ν on e are the same as in the closed economy case. Increases in γ will now increase the real wage rate $\frac{w_{t+1}}{p_x^w}$ and induce an increase in the level of education.

Let us now analyze how the opening of trade affects the decision about the time spent for education in the home country. At the time of the opening of trade, the first order condition for e in the open economy can be written as follows:

$$\alpha\tau\nu\gamma^{\frac{\gamma}{\alpha}} H^{\frac{\mu(\alpha+\eta)}{\alpha}} e^{\frac{\nu(\alpha+\eta)-\alpha}{\alpha}} = \left(p_x^w\right)^{\frac{1}{\alpha}} \tag{3.10}$$

where H and e are given by equations (2.15) and (2.10) respectively. Notice that this would also be the first order condition in the closed economy if we substituted

p_x^w with p_x. From $\frac{\alpha}{\alpha+\eta} > \nu$, it descends that the exponent of e is negative. Since we are considering the case where $p_x < p_x^w$, the transition from the closed to the open economy brings about a *decrease* in the amount of time spent for education. Given that the stock of human capital in the open and in the closed economy tends to a unique stable steady state, we can now write the following:

Proposition 2. *In the home country, the time allocated to education in the open economy is* always lower *than the time allocated to education in the closed economy.*

3.2. The foreign economy

In the foreign economy, adults solve the same maximization problem that we analyzed in the home economy. However, they take into account the effect of the collective choice of education on the aggregate stock of human capital and do not take the wage rate as given.

Adults in the foreign economy solve the following maximization problem:

$$\max_{e_t^*} \quad \left[(1-\tau)\, w_t^* h_t^* + p_x^w \left(1 - e_t^*\right) + \tau w_{t+1}^* H_{t+1}^* \right] \tag{3.11}$$

$$s.to \qquad w_{t+1}^* H_{t+1}^* = \alpha \gamma^{\frac{\gamma}{\alpha}} H_t^{*\frac{\mu(\alpha+\eta)}{\alpha}} e_t^{*\frac{\nu(\alpha+\eta)}{\alpha}} \left(p_x^w\right)^{-\frac{\gamma}{\alpha}}$$

The first order condition is given by:

$$e_t^{*\frac{\nu(\alpha+\eta)-\alpha}{\alpha}} \left(\frac{\alpha+\eta}{\alpha}\right) \gamma^{\frac{\gamma}{\alpha}} \alpha \nu \tau H_t^{*\frac{\mu(\alpha+\eta)}{\alpha}} = \left(p_x^w\right)^{\frac{1}{\alpha}} \tag{3.12}$$

Rearranging, we get:

$$e_t^* = (\alpha\tau\nu)^{\frac{\alpha}{\alpha\xi-\eta\nu}} \gamma^{\frac{\gamma}{\alpha\xi-\eta\nu}} H_t^{*\frac{\mu(\alpha+\eta)}{\alpha\xi-\eta\nu}} \left(p_x^w\right)^{-\frac{1}{\alpha\xi-\eta\nu}} \left(\frac{\alpha+\eta}{\alpha}\right)^{\frac{\alpha}{\alpha\xi-\eta\nu}} \tag{3.13}$$

Given this expression for the level of education, we obtain:

$$H_{t+1}^* = (\alpha\tau\nu)^{\frac{\alpha\nu}{\alpha\xi-\eta\nu}} \gamma^{\frac{\gamma\nu}{\alpha\xi-\eta\nu}} H_t^{*\mu+\frac{\mu\nu(\alpha+\eta)}{\alpha\xi-\eta\nu}} \left(p_x^w\right)^{-\frac{\nu}{\alpha\xi-\eta\nu}} \left(\frac{\alpha+\eta}{\alpha}\right)^{\frac{\alpha\nu}{\alpha\xi-\eta\nu}} \tag{3.14}$$

Our parameter restrictions imply that $0 < \mu + \frac{\mu\nu(\alpha+\eta)}{\alpha\xi-\eta\nu} < 1$. Thus, the level of human capital reaches a unique steady state given by:

$$H^* = (p_x^w)^{-\frac{\nu}{\alpha(\xi-\mu)-\eta\nu}} (\alpha\tau\nu)^{\frac{\alpha\nu}{\alpha(\xi-\mu)-\eta\nu}} \gamma^{\frac{\gamma\nu}{\alpha(\xi-\mu)-\eta\nu}} \left(\frac{\alpha+\eta}{\alpha}\right)^{\frac{\alpha\nu}{\alpha(\xi-\mu)-\eta\nu}} \tag{3.15}$$

Finally, the steady-state time allocated to education is given by:

$$e^* = (p_x^w)^{-\frac{(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} (\alpha\tau\nu)^{\frac{\alpha(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} \gamma^{\frac{\gamma(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} \left(\frac{\alpha+\eta}{\alpha}\right)^{\frac{\alpha(1-\mu)}{\alpha(\xi-\mu)-\eta\nu}} \tag{3.16}$$

By comparing equation (3.6) with equation (3.13), we can see that the solutions for the optimal education time in the two countries differ for one term which captures the positive externality of the aggregate human capital on the individual human capital. This externality is taken into account only by foreign agents, who decide collectively the amount of time that their children must spend at school. This discussion can be summarized in the following:

Proposition 3. *In the open economy case, the amount of time spent for education, the stock of human capital and the final good output are* always higher *in the foreign economy than in the home economy.*

Similarly to the case of the home economy, let us now analyze the effects of trade on the optimal time devoted to education in the foreign country. First of all, notice that the first order condition in the closed economy can be rewritten as follows:

$$\alpha\tau\nu\frac{(\alpha+\eta)}{\alpha}\gamma^{\frac{\gamma}{\alpha}} H_t^{*\frac{\mu(\alpha+\eta)}{\alpha}} e_t^{*\frac{\nu(\alpha+\eta)}{\alpha}-1} + (1-e_t^*)\frac{\partial p_{x,t+1}^*}{\partial e_t^*}\left(p_{x,t+1}^*\right)^{\frac{\gamma}{\alpha}}$$

$$-\frac{\gamma}{\alpha}\frac{\partial p_{x,t+1}^*}{\partial e_t^*}\left(p_{x,t+1}^*\right)^{-1}\left[\alpha\tau\gamma^{\frac{\gamma}{\alpha}} H_t^{*\frac{\mu(\alpha+\eta)}{\alpha}} e_t^{*\frac{\nu(\alpha+\eta)}{\alpha}}\right] = \left(p_{x,t+1}^*\right)^{\frac{1}{\alpha}} \tag{3.17}$$

Consider equation (3.17) and compare it with equation (3.12). It is clear that, *at the opening of trade*, a necessary and sufficient condition for an increase in the time allocated to education is:

$$(p_x^*)^{\frac{1}{\alpha}} - \left[(1-e^*)\frac{\partial p_x^*}{\partial e^*}(p_x^*)^{\frac{\gamma}{\alpha}} - \frac{\gamma}{\alpha}\frac{\partial p_x^*}{\partial e^*}(p_x^*)^{-1}\left[\alpha\tau\gamma^{\frac{\gamma}{\alpha}} H^{*\frac{\mu(\alpha+\eta)}{\alpha}} e^{*\frac{\nu(\alpha+\eta)}{\alpha}}\right]\right] > (p_x^w)^{\frac{1}{\alpha}} \tag{3.18}$$

Next, let us define $\varepsilon \equiv \dfrac{\partial p_x^*}{\partial e^*}\dfrac{e^*}{p_x^*}$. It can be easily verified that $\varepsilon = \dfrac{\nu(\alpha+\eta)}{\gamma}$. After some algebra, the inequality in 3.18 reduces to:

$$(p_x^*)^{\frac{1}{\alpha}}\left[\varepsilon\frac{(1-e^*)}{e^*}\right] - \tau\gamma^{\frac{1}{\alpha}}\varepsilon H^{*\frac{\mu(\alpha+\eta)}{\alpha}}e^{*\frac{\nu(\alpha+\eta)}{\alpha}-1} < (p_x^*)^{\frac{1}{\alpha}} - (p_x^w)^{\frac{1}{\alpha}} \tag{3.19}$$

Substituting the expression for ε, we obtain:

$$\tau\nu(\alpha+\eta)\gamma^{\frac{\alpha}{\alpha}}H^{*\frac{\mu(\alpha+\eta)}{\alpha}}e^{*\frac{\nu(\alpha+\eta)}{\alpha}-1} > (p_x^w)^{\frac{1}{\alpha}} \tag{3.20}$$

Finally, using equation 2.8, we get:

$$p_x^*\tau^{\alpha} > p_x^w \tag{3.21}$$

If and only if the above condition is satisfied, the foreign country will increase the fraction of time allocated to education immediately after the opening of trade. Once again, the existence of a unique and stable steady-state equilibrium for the human capital stock ensures that the time devoted to education in the open economy will *at any point in time* be higher than in the closed economy.

Summarizing the previous discussion, we can write the following:

Proposition 4. *In the foreign country, the time allocated to education in the open economy is* always higher *than the time allocated to education in the closed economy, if and only if* $p_x^*\tau^{\alpha} > p_x^w$.

As Proposition 4 makes clear, it is possible that after trade liberalization a country, which is initially skill-abundant and has a comparative advantage in the high-tech good, will decrease the amount of time that children are required to spend at school. This possibility becomes more likely the lower is τ. The intuition is the following. In the closed economy, the collective choice of schooling time does not depend on τ, since adults realize that their old age consumption is a constant fraction of the final good output. In the open economy, relative prices must be taken as given so that old age consumption is perceived as deriving from two alternative sources of income. In this case, as equation (3.13) shows, the lower is τ, the lower is the optimal schooling time.

We now turn to analyze trade flows. After opening up to trade, a country will export the intermediate good if and only if

$$x_{t+1}^s - (1-e_t) + x_t^d - x_t^s < 0 \tag{3.22}$$

If we substitute for x_{t+1}^s and x_t^s the expressions obtained from the budget constraints and recalling that $x_t^d = \gamma \frac{Y_t}{p_x^w}$ equation (3.22) can be rewritten as:

$$Y_t - c_{t-1,t} - c_{t-2,t} < 0 \tag{3.23}$$

which implies that in each period exports of the intermediate good are equal to imports of the final good, that is, trade balance is equal to zero in each period.

At steady-state, the first inequality reduces to $x^d - (1 - e) < 0$. In closed economies, this difference is always equal to zero. In the home country, the steady-state level of e is lower in the open economy than in the closed economy. Since x^d is going to decrease due to the increase in the relative price of the intermediate good, the inequality will certainly hold, that is the home country will certainly export the intermediate good and import the final good when she opens up to trade. With regard to the foreign country, such clearcut conclusions can not be drawn, since the effect of trade libralization on e^* is ambiguous. If international trade brings about an increase in schooling time, since x^d is going to increase due to the reduction in the relative price of the intermediate good, the foreign country will certainly import the intermediate good and export the final good. However, if education decreases with trade, the opposite result may occur. In particular, we can establish the following result:

Proposition 5. *At the steady-state equilibrium, the foreign country exports the intermediate good and imports the final good if and only if* $e^* < \dfrac{\nu\tau(\alpha+\eta)}{\gamma + \nu\tau(\alpha+\eta)}$.

Proof. A necessary and sufficient condition for the foreign country to become exporter of the intermediate good in the steady-state equilibrium is:

$$x^d - (1 - e^*) < 0$$

By substituting the expression for x^d and rearranging, this inequality can be rewritten as:

$$\gamma^{\frac{1}{\alpha}} H^{*\frac{\alpha+\eta}{\alpha}} < (1 - e^*)\,(p_x^w)^{\frac{1}{\alpha}}$$

Substituting the expression for H^* and using equation (3.12), we obtain:

$$e^* < \frac{\nu\tau(\alpha+\eta)}{\gamma + \nu\tau(\alpha+\eta)}$$

■

Notice that in the closed economy:

$$e^* = \frac{\nu(\alpha+\eta)}{\gamma+\nu(\alpha+\eta)}$$

If the time allocated to education increases with trade, the foreign country will certainly become an importer of the intermediate good, since in this case in the open economy:

$$e^* > \frac{\nu(\alpha+\eta)}{\gamma+\nu(\alpha+\eta)} > \frac{\nu\tau(\alpha+\eta)}{\gamma+\nu\tau(\alpha+\eta)} \tag{3.24}$$

If after trade liberalization schooling time decreases by a sufficient amount, the foreign country may become an importer.

4. Conclusion

This paper studies how parents choose the amount of time their children should spend at school under two different regimes. In the first regime, legislation about compulsory education cannot be enforced so that schooling time is chosen privately by each parent. In the second regime, compulsory education is enforced and schooling time decisions are made collectively by all parents in the economy. Within this framework, we show that the fraction of time devoted to education is lower (and as a consequence child labor is higher) when agents are not committed to compulsory education. When countries are allowed to trade on international markets, the effects on education choices are different in the two regimes. When there is no compulsory education, comparative advantage is the only determinant of how schooling time decisions are affected by trade. When compulsory education is enforced, equilibria may arise which depart from comparative advantage predictions.

We think that our model could be usefully extended to study the welfare effects of trade among countries with different educational attainments and labor standards, especially with respect to minimum working age. Our dynamic setup may also prove to be valuable to shed light on the short-run impact and long-run consequences of trade policies oriented toward international labor standards harmonization.

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Appendix

Table 1

Country[8]	**Av. School. Years (1992)**	**Prim. Gross Enrollment (1995)**	**Sec. Gross Enrollment (1995)**	**Comp. Education**
OECD		**100.5**	**98.7**	$\geq$ **9**
China, Hong Kong	5.86	96	75	9
Rep. of Korea	8.70	101	101	9
Chile	7.69	99	69	8
Venezuela	8.13	94	35	10
Mexico	7.12	115	58	6
Colombia	5.69	114	67	5
Malaysia	6.92	91	57	11
Brazil	4.95	112	45	8
Libya	3.5	106	97	8
Algeria	2.8	107	62	9
Philippines	8.34	116	79	6
Zimbabwe	3.1	116	44	9
India	4.1	100	49	8
Nigeria	1.2	89	30	8
Guinea	0.9	48	12	6

Source: for the first three columns, Human Development Report, United Nations Development Program, 1994, 1998; for the last column, .

[8] Countries are ranked according to the Human Development Index, Human Development Report, United Nations Development Program, 1998.

Table 2

Country	Year of legislation	Age limits	Duration
Belarus	1993/94	$6-17$	11
	1996/97	$6-15$	9
Equatorial Guinea	1968/69	$6-14$	8
	1996/97	$6-11$	5
Italy	1960/61	$6-15$	9
	1984/85	$6-13$	8
Madagascar	1960/61	$6-15$	9
	1989/90	$6-13$	5
Poland	1960/61	$7-16$	9
	1985/86	$7-14$	7
Swaziland	1960	$7-16$	8
	1995	$6-13$	7
Switzerland	1960/61	$6-15, 16$	9, 10
	1990/91	$7-15$	8
Turks and Caicos	1968/69	$6-14$	8
	1989/90	$7-14$	7
United States	1960/61	$6, 7, 8-16, 17, 18$	$10-12$
	1994/95	$7-16$	10
Zambia	1960	$7-15$	8
	1988	$7-14$	7

Source: