CAPITAL ACCUMULATION AND CHILD LABOR: CAN COMPULSORY SCHOOLING BE COUNTERPRODUCTIVE?*

Luis F. López-Calva

Centro de Estudios Económicos
El Colegio de México
lflopez@colmex.mx

and

Luis A. Rivas

Cornell University
and
Banco Central de Nicaragua
lar6@cornell.edu

Abstract

This paper analyzes the effect of compulsory schooling on the incidence of child labor, within a dynamic, overlapping-generations, general equilibrium setting. Parents in this model are altruistic. Both human and physical capital is accumulated and parents care about their own consumption and the human capital they bequeath to their children. It is shown that, under a certain class of parametric conditions, household welfare would be higher if compulsory schooling laws were eliminated and children could work more hours. The reason for this result is that the restriction on household income reduces the accumulation of physical capital without compensating the family with a high enough accumulation of human capital, preventing the economy from reaching the threshold beyond which child labor is eliminated endogenously.

JEL Classifications: D10, J22, O12, O17, O33

---

* We have benefited from discussions with Kaushik Basu, Gary Fields, Ravi Kanbur, Salvador Ortigueira, and Karl Shell. Huberto Ennis provided very insightful comments to an earlier draft. Comments from participants at the TWIPS Seminar and the Seminar on Labor Markets and Economic Development at Cornell are also highly appreciated. The usual disclaimer applies.

CAPITAL ACCUMULATION AND CHILD LABOR: CAN COMPULSORY SCHOOLING BE COUNTERPRODUCTIVE?

Luis F. López-Calva and Luis A. Rivas

1. Introduction

The discussion on the causes, effects, and policies regarding child labor has prompted a substantial research effort during the last years.[1] Among the main findings, there is a well-established fact that child labor is a phenomenon linked to underdevelopment. Current cross-country data, as well as observations on the evolution of child labor over time in relatively richer economies seem to support the idea that economic growth reduces the incidence of child labor. Evidence from micro data has also led to the conclusion that an improvement of the income-generation capabilities of parents results in lower child labor supply (Rosenzweig and Evenson, 1977; Goldin, 1979; Ray, 1998). One of the most important issues in this discussion is whether policy intervention could eliminate of child labor, through banning or compulsory schooling laws.[2]

The analysis of potential effects of policy intervention, however, requires a dynamic setting. Policies are only one ingredient in a more complicated process and there are changes that can be seen as affected by policy changes, though they respond to endogenous conditions in the economy. Nardinelli (1980), for example, analyzes the effect of the "Factory Acts" on child labor supply in England, the first act enacted in 1833, and explicitly states that the effect of such legislation was not as important as "rising real income and technological change" to explain the

[1] For a thorough survey of the theoretical and empirical literature, see Grootaert and Kanbur (1995) and Basu (1999a).
[2] Another policies that have been advocated consist of trade sanctions to countries that export goods with child labor.

decline of child labor at that time. There are two other elements that affect and are affected by policy, whose outcome is reflected in the observed data: technological conditions and the capacity of accumulation through income generation. Helping disentangle the role of each of them in the observed child labor pattern is one of the aims of this study. Paradoxically, the research effort on the economics of child labor has thus far focused almost exclusively on static models, with few exceptions (Baland and Robinson, 1999; Dessy, 1999). In addition, we feel that the impact of the introduction of compulsory schooling and child labor laws on the decline of the incidence of child work has not been established in the literature in a robust manner.[3]

This paper presents a dynamic, general equilibrium model of child labor in an overlapping generations setting. The model yields results that match the aforementioned regularities: child labor declines throughout the accumulation process, its incidence depends on technological parameters (Grootaert and Kanbur, 1995), and the economy does not necessarily converges to a steady state equilibrium with zero child labor. When the analysis of compulsory schooling laws is introduced, the model is used to show that such policy is not necessarily welfare improving and, under certain conditions, could actually drive the economy to a steady state with lower welfare than the one the economy would have converged towards, had the laws been eliminated. Moreover, such a policy is more likely to affect poorer economies or, in a valid interpretation, the poorer segments of the population.

This paper models the economy with a labor market in which both adults and children can supply physical labor, but with the difference that adults posses,

[3] See Nardinelly (1980), Grootaert and Kanbur (1995), Moehling (1998), and Basu (1999a).

in addition to physical labor, "embodied skills" which are acquired through schooling during their childhood. This follows Griliches (1970), who finds that as economies grow, the gap between skilled and unskilled labor widens. Thus, in the model below the accumulation of physical capital increases the returns to "skills" (human capital) without having an impact on "physical labor," Galor and Weil (1996) have used this idea, though in a slightly different manner, to explain the narrowing of the "gender gap". In addition, we model parents to be altruistic, in the sense that they care about their own consumption and about the human capital they bequeath to their children, as in Jacoby and Skoufias (1997) and Tamura (1994). The role of altruism will play a fundamental role in the model. Parents choose the amount of labor their children supply in the market, in the tradition of the unitary model of the household (Becker, 1965). The trade-off parents face lies on whether to sacrifice consumption, by reducing the amount of child labor supplied by the offspring, in exchange for the extra utility obtained from a higher bequest to their children --in units of human capital.

The rest of the paper is organized as follows. The following section presents a review of the related literature. Section 3 introduces the basic model by describing endowments, preferences, and technology. In this section, we study the conditions under which child labor could endogenously converge either to zero or to a positive level in the long-run. In addition, we describe the dynamic characteristics of the equilibria and provide comparative statics results. In Section 4, the potential effects of compulsory schooling laws are analyzed. Section 6 offers concluding remarks for this paper.

2. Pertinent Literature: A Brief Review

The paper presented herein builds upon previous literature on the economics of child labor and models on growth with human capital investment. The stylized facts in terms of the pattern of child labor incidence over time has been summarized in Basu (1999a). After a discrete jump in child labor during the industrial revolution, child labor declined steadily, petering out through time in most developed nations.

In terms of the causes of child labor, on the supply side, Basu (1999b) argues that strong link between the adults' labor markets conditions and children labor force participation has been established. Basu and Van (1998) show that the degree of substitutability between adult and child labor as production inputs, determined by technological conditions, plays a fundamental role in explaining child labor incidence.[4]

In relation to policy, the most widely discussed type of intervention is the imposition of a formal banning on child labor. Other types of potential intervention consist of the imposition of taxes and the introduction of public expenditures in education. Dessy (1999) proposes compulsory schooling as the effective solution, whereas Basu and Van (1998) suggest that a banning could have a permanent effect in the plausible case in which there exists multiplicity of equilibria in the labor market. Grootaert and Kanbur (1995) and others, as well as Basu (1999a) warn us that a banning of child labor could be both inneffective under certain

[4] Credit market imperfections and the distribution of wealth have also been shown to have an effect on the incidence of child labor (Ranjan, 1999a, b; Swinnerton and Rogers, 1998), as well as intergenerational contracting problems between parents and children, given that the former cannot fully internalize the returns from investing in the schooling of the latter (Baland and Robinson, 1999). Social interactions, like norms of filial obligations and social stigma costs imposed on parents who send their children to work, could also influence parents' decisions in terms of the allocation of their offsprings' time.

conditions and always costly to enforce. In summary, these studies suggest that the effect of a banning on child labor would not necessarily have optimal results, contrary to a common belief in policy circles and public opinion.

The endogenous elimination of child labor by improving the conditions in the adult labor market and promoting growth are effective alternatives, as shown by the evidence in Nardinelli (1980) and Moehling (1998), which document the hypothesis that economic conditions of the families, as well as technological change, had a greater impact than the legislation itself on child labor incidence.

The growth literature, on the other hand, has long discussed the importance of human capital investment on economic growth. In a model with infitely lived agents, Lucas (1988) showed that human capital externalities result in lower growth rates under the competitive scenario as opposed to the planner's problem. The analysis of human capital investment decisions and growth where agents have a finite life require an overlapping generations setting, as in Caballé (1995), Rangazas (1996), who followed Drazen (1978) and Becker(1981).[5] In those models, finitely lived agents are altruistic --they care about the utility of their descendants- and decide on two types of intergenerational transfers, namely human capital investment and a physical bequest. In some cases, parents cannot optimally invest in the schooling of their children because of the fact that such s decision would require a negative physical bequest --a transfer from children to parents in old age. This problem of "bequest constrained" economies, due to the contractual restrictions on negative bequests, derives in suboptimal investment in schooling. Caballé (1995) analyzes the effect of fiscal policy on steady state growth for the

[5] Rangazas (1996) discusses the difference between the infinetly-lived agents model and the overlapping generations setting in the analysis of human capital investment and growth.

cases of bequest constrained and bequest unconstrained economies and finds that in the former case there is a problem of over-accumulation that adds to the fact that parents do not internalize the externalities derived from human capital investment.

None of the models above, however, introduce the decision of how to allocate the time endowment of the children between schooling and work, as the model presented here. In the two-sector model presented below, the only way of bequests is human capital investment. Altruism is model here as parents caring about the human capital of their children directly, as in Tamura (1994), whereas in the models mentioned above parents care about their offspring's utility, which in turn depends on human capital through their earnings capacity in the labor market. One fundamental difference of the model developed hereby with respect to the existing literature is that the cost of schooling depends on the child's earnings possibilities, which in turn depend on technological conditions.

3. The Model

3.1 Households, Firms, and Human Capital

The economy is modeled as a variant of the Diamond (1965)-Samuelson (1958) overlapping generations model. The economy's horizon is infinite and time is denoted by $t = 0,1,...;$ however, the individuals who populate the economy have finite lives. For simplicity, in this model economy agents live three periods, which are chronologically referred to as childhood, middle age, and old age. Generations are indexed by the period in which they are

middle-aged. Also for simplicity, two simplifying assumptions are made in this section: first, there is no population growth and since there is a large number of identical households -all containing one parent and one child- the model can be thought of as having a representative household with one parent and one child. Second, there are no policy variables. This is done so that the basic properties of the model are shown in a simple way. The latter assumption is later modified in order to analyze the effect of compulsory schooling.

In their first period of life, childhood, individuals make no economic decisions. Although children are endowed with non-leisure time, normalized to unity, it is their parents who decide how to allocate the children's time between work and schooling.[6] In the second period of life, middle age, agents are also endowed with non-leisure time (also normalized to one). It will be assumed that parents supply their time inelastically to the sector of the economy producing the consumption good, which will be used as the *numeraire*. Thus, during middle age, parents decide how long should the children work and how much to save for themselves for old-age consumption. There is an initial middle-aged generation endowed with both physical and human capital (in per household terms), denoted by $k_0 > \underline{k}$ and $h_0 > \underline{h}$, where $(\underline{k}, \underline{h}) >> (0,0)$.[7] Parents are altruistic toward their children in the sense that they care about the future well being of their offspring. Thus economic decisions during parenthood must account for this kind of altruism. Accordingly, the individual's utility function is stipulated as follows

$$U_t(c_{t+1}, h_{t+1}) = g \ln(c_{t+1}) + (1-g)\ln(h_{t+1}) \qquad (1)$$

where c_{t+1} denotes consumption, h_{t+1} denotes human capital of the offspring, and $g \in (0,1)$. The second term represents intergenerational altruism. This type of

[6] Since agents make economic decisions during the last two periods of life only, the first period of life seems to be a dull period from the individual's point of view, since they just acquire human capital necessary for being productive when they become adults' but it is not from the household point of view, since the child could engage in income generating activities as well.
[7] Unless otherwise specified, upper-case and lower-case letters represent aggregate and per-household variables, respectively.

altruism, obtaining utility from giving a human capital bequest, is consistent with models where parents have ``dynastic" utility, in the sense that the children's consumption during middle age will depend on human capital, which determines their earnings potential. The specification used here assumes, in a way, that parents are aware of the relevance of human capital for the children's well-being, though they do not know the structure of preferences of the dynasty.[8] The fundamental trade-off analyzed here is that of parents choosing between their own consumption and their bequest --in the form of human capital-- to their children.[9]

Note that the utility function is strictly increasing and strictly quasiconcave. It is worth mentioning that the introduction of consumption during middle age would not change the main results. Using the logarithmic specification, the fraction of income saved would be constant.[10] Issues of parents' intertemporal substitution in consumption are thus put aside.

There are three factors that enter the aggregate technology for the production of the consumption good: physical capital, embodied skills (human capital), and physical labor, which we denote by L_t. Our technical assumption is that an increase in the human capital input raises the marginal product of physical capital more than it raises the marginal product of physical labor. Put in other words, skills complement physical capital more than physical labor does. This follows an idea proposed in Griliches (1970), which studies why the relative wage

---

[8] Galor and Weil (1998) justify this as an implicit ``bounded rationality" assumption. In dynastic models parents are assumed to be ``super-rational" and know the structure of preferences of future generations.

[9] An alternative formulation of the intergenerational altruism is the one in Galor and Weil (1998), in which parents care about their offspring's earnings capacity. This approach will complicate the model without changing the qualitative results.

[10] The dynamical system that governs the evolution of the system would be altered only be a multiplicative constant.

of educated workers fail to fall in the face of growth in the stock of physical capital. This idea is also exploited by Galor and Weil (1996), who use a similar idea to explain changes in the gender earnings gap in a dynamic setting.

The production of consumption goods incorporates the above assumption very simply by stipulating that physical and human capital could complement each other in production while physical labor substitutes for both. That is, goods are produced according to

$$Y = F(K_t, H_t, L_t) = AK_t^a H_t^{1-a} + BL_t \qquad (2)$$

where $A,B > 0$ are technological parameters, and $a \in (0,1)$..

Consistent with the unitary model, it is the parent who decides how long to send the child to school, $(1-\ell)$ when the child's non-leisure time is normalized to one, and how long must the child work, ℓ. The child's aquisition of human capital, which becomes effective in his middle age, depends on how long he attends school and on how large is the corresponding parent's stock of human capital. Following Glomm and Ravikumar (1992), the human capital evolves according to

$$h_{t+1} = Z(1-l_t)^j \, h_t^{1-j} \qquad (3)$$

where $Z > 0$ and $j \in (0,1)$. The intuition is that human capital is produced using schooling as an input, but also the human capital of the parent is productive in the process of accumulation. Notice that, according to (3), if the parent starts with no human capital, the child would never be able to accumulate. This problem, however, is easily avoided by the initial conditions in the problem (positive initial level of human capital). The rationale for ruling out such possibility is based on the fact that zero human capital is never an optimal choice, for as the human capital bequest goes to zero its marginal utility goes to infinity, which would induce the parents to always leave a strictly positive bequest. This completes the description of preferences, endowments, and technology in the basic model.

3.2 The Household's Problem and Equilibrium

Let us denote the returns to human capital and physical labor by w_t and q_t, respectively. Then, the household's potential income is $2w_t + q_t h_t$. Since the parent does not generate utility from consumption at date t, the household's potential income is divided between expenditures on schooling --foregone income from child labor-- and savings for future consumption, s_t, so as to maximize their intertemporal utility function. Thus the household faces the following budget constraint

$$(1 - l_t) w_t + s_t \leq 2w_t + q_t h_t \qquad (4)$$

During old age, the individual simply consumes the value of their savings with accrued interests, namely

$$c_{t+1} = s_t R_{t+1} \qquad (5)$$

where R_{t+1} is the gross interest earning between dates t and $t + 1$. Thus, the only economic decision within the household is made by the parent, who chooses how long to send the child to labor at the expense of acquiring human capital. More schooling, however, would increase his productivity as an adult.

In order to avoid a corner solution in which the parent only desires to accummulate human capital at the expense of her own consumption, a bound on the degree of altruism is imposed, consisting of:

$$\frac{1-g}{g} < \frac{1}{j} \qquad (6)$$

This condition tells us that the relative degree of altruism (left hand side) is bounded from above by a constant, determined by the inverse of the elasticity of human capital production with respect to schooling. A violation of the condition above would imply the unrealistic result of zero child labor, regardless the level of development of the economy.

Maximizing (1) subject to (3), (4), and (5), one can determine the optimal level of child labor for the household. Let us denote $l \equiv \frac{(1-g)j}{g+(1-g)j}$.[11] Thus,

$$\begin{cases} 0 & if \quad \frac{q_t}{w_t} h_t \geq \frac{1-2l}{l} \end{cases} \tag{7}$$

Thus, as the return to human capital relative to the return to physical labor of the household increases, child labor declines and may eventually vanish as the relative income reaches certain threshold (see figure 1). This is consistent with one of the stylized facts the model is intended to match: as the economy grows --accumulating physical capital-- the observed incidence of child labor is lower (see Basu, 1999a). The next step is to construct the equilibrium for this economy. Since markets are assumed to be competitive, factors earn their marginal products. Hence,

$$w_t = B \tag{8}$$

$$q_t = (1-a)AK_t^a H_t^{-a} \equiv q(K_t, H_t) \tag{9}$$

[11] Note that in terms of l, assumption (14) can be expressed as $l < \frac{1}{2}$

Given that there is no population growth in this economy, $h_t = H_t$ and $k_t = K_t$, and the household's saving is given by

$$\Big| B + q(k_t, h_t)h_t \qquad\qquad if \quad q(k_t, h_t)h_t \geq \frac{1-2l}{l} B \tag{10}$$

where the second and third equalities follow from labor market clearing and from using equations (8) and (9). In addition, since the economy is closed, savings must exactly equal investment in equilibrium, clearing the goods market,

$$k_{t+1} = s_t \tag{11}$$

The equilibrium now obtains. Given positive physical and human capital stocks, the typical parent decides how long to send the child to work according to (7), supplies her non-leisure time inelastically, and receives income from the firms according to (8) and (9), from which she decides how much to save. While making these decisions, the parent takes into account the production function of human capital for the kid. At the end of the day, the next period capital stocks are determined by (3) and (11) respectively. The parent -now old- consumes all her savings, and the cycle starts over again with the new generation.

It is now possible to obtain the difference equations that any equilibrium must satisfy, which provide the dynamic evolution of the economy. Assuming, for simplicity that both kinds of capital fully depreciate, combining equations (7), (10), and (11) the dynamics for physical capital is obtained, as given by

$$_{t+1} \quad \Big\lfloor B + q(k_t, h_t)h_t \qquad if \quad q(k_t, h_t)h_t \geq \frac{1-2l}{l} B \qquad (12)$$

and using equations (3) and (7), the law of motion of human capital obtains,

$$\Big\lfloor Z h_t^{1-j} \qquad if \quad q(k_t, h_t)h_t \geq \frac{1-2l}{l} B \qquad (13)$$

Equations (12) and (13) constitute a system of nonlinear difference equations with an initial boundary condition $(k_0, h_0) >> (\underline{k}, \underline{h})$. The following result now follows.

3.3 Steady State

Equations (12) and (13) constitute a system of nonlinear difference equations with an initial boundary condition $(k_0, h_0) >> (\underline{k}, \underline{h})$. Any steady state (k^*, h^*) for the system must satisfy the following two equations simultaneously:

$$k^* = F(k^*, h^*) \qquad (14)$$

$$h^* = G(k^*, h^*) \qquad (15)$$

First notice that $q(k,h)h = (1-a)Ak^a h^{1-a}$, so that at $q(k,h)h = \frac{1-2l}{l} B$, we have,

$$h = \left(\frac{(1-2l)B}{l(1-a)A} \right) \frac{1}{k^{\frac{a}{1-a}}} \qquad (16)$$

which gives us a curve which we will call *RR* in Figures 2-5. This curve gives us the different combinations of human and physical capital at which the household's relative return to human capital, relative to physical labor, is sufficiently large that child labor becomes zero. That is, if it lies on or beyond the locus *RR*, the steady state is characterized by no child labor.

We now show how to construct the $k_{t+1} = k_t$ locus. The $h_{t+1} = h_t$ locus is constructed likewise. Let us define the functions $h \equiv f^1(k)$ and $h \equiv f^2(k)$ so that (14) is satisfied when the relative return to human capital is strictly less, and larger than, the threshold value $\frac{1-2l}{l}B$ respectively. For example

$$f^1(k) = \left(\frac{k^{1-a}}{(1-l)(1-a)A} - \frac{2B}{(1-a)Ak^a} \right)^{\frac{1}{1-a}}$$

whenever $(1-a)Ak^a h^{1-a} < \frac{1-2l}{l}B$. It is now straightforward to show that f^1 and f^2 can be depicted as in Figure 2, intersecting at the point $k = \frac{1-l}{l}B$.

Below the curve *RR*, the $k_{t+1} = k_t$ locus is formed by the function f^1. At the point $k = \frac{1-l}{l}B$ (on the curve *RR*) the $k_{t+1} = k_t$ locus has a kink, and from that point on it becomes the function f^2. Thus the steady state locus for physical capital is the lower envelope of f^1 and f^2 and is depicted as a bold line in Figure 2.

Similarly, Figure 3 shows how the $h_{t+1} = h_t$ locus is constructed, where the functions g^1 and g^2 are the analogues of f^1 and f^2. In the case of human capital, the intersection occurs at point

$$k = \left(\frac{}{l(1-a)AZ^{\frac{1-a}{j}}} \right) .$$

Under those initial conditions, the loci cross only once. The result below follows.

Proposition 1. *For any initial boundary condition* $(k_0, h_0) >> (\underline{k}, \underline{h})$, t*he dynamic system given by (12) and (13) has a unique, globally stable steady state*.

Once the steady state values of the relevant variables are obtained, it is possible to find the steady state values of factor prices and thus of child labor and consumption. Notice that the proposition above does not necessarily imply that the steady state of the economy is characterized by zero child labor. What can be said, however, is that for a definition of development based on initial stocks of both human and physical capital, less developed economies (low initial stocks of human and physical capital), child labor declines overtime.

In the long run, the relative return to human capital of the household converges to a constant value, and so does child labor. Under a specific restriction, as shown in proposition 2, the economy converges to a unique, globally stable steady state in which child labor is zero.

Proposition 2. *The steady state of the economy is characterized by zero child labor if and only if the following condition holds*

$$(1-2l)B^{1-a} \leq (1-a)A(1-l)^{a} \, l^{1-a} Z^{\frac{1-a}{j}} \qquad (17)$$

This is verified simply by plugging the equilibrium conditions on the threshold beyond which parents would not send their children to work. In Figure

4, we put together the physical and the human capital steady state loci for the parameter configuration given in (17). It is straightforward to see that in this case the steady state is given by $h^* = Z^{1/j}$ and k^*, which must satisfy $k^* = B + (1-a)A(k^*)^a (Z^{1/j})^{1-a}$.

This condition in Proposition 2 is rather easy to interpret. Rearranging (17) one obtains

$$\frac{1-2l}{l} \le \frac{(\quad l \quad)(\quad)}{B}$$

which states that child labor in the economy will be zero if (and only if), the skill premium exceeds its threshold value, given that the child is sent to school fulltime. Under specific conditions, that physical labor is paid relatively high for example, the economy could settle in a steady state with positive levels of child labor.

The proposition above stresses the idea that a fundamental condition for child labor to converge to zero in the long run is that the returns to physical labor - as valued by the household in terms of extra consumption- are relatively low, or that the return to additional schooling is relatively large. Figure 4 gives a graphical representation of the dynamical system under (17).

In Figure 5, we depict the steady state of the economy when condition (17) fails to hold. In this case the steady state is given by

$$1-(1-a)A(1-l)^a\left(\frac{lZ^{1/j}}{B}\right)$$

$$1-(1-a)A(1-l)^{a}\left(\frac{lZ^{1/j}}{B}\right)$$

Recall that when (17) doesn't hold we have that

$$(1-2l)B^{1-a} > (1-a)A(1-l)^{a}\, l^{1-a} Z^{\frac{1-a}{j}}$$

To show that in this case the steady state is well defined, one needs to show that

$$1 > (1-a)A(1-l)^{a}\left(\frac{lZ^{1/j}}{B}\right) \quad .$$

Rearranging this yields,

$$B^{1-a} > (1-a)A(1-l)B^{1-a}\,.$$

It is then sufficient to show that $B^{1-a} > (1-2l)B^{1-a}$. Suppose that this doesn't hold, then $0 \geq 2l$. But this is a contradiction since l is positive.

3.4 Dynamics[12]

Consider now the transitional dynamics in the neighborhood of the steady state equilibrium. From (12), it is the case that whenever $q(k_t, h_t)h_t < \frac{1-2l}{l}B$, we have that $k_{t+1} \geq k_t$ if and only if

$$h_t \geq \left(\frac{k^{1-a}}{(1-l)(1-a)A} - \frac{2B}{(1-a)Ak^{a}}\right)^{\frac{1}{1-a}}$$

so above the f^1 physical capital is increasing. Similarly, whenever $q(k_t, h_t)h_t \geq \frac{1-2l}{l}B$ we have that $k_{t+1} \geq k_t$ if and only if

[12] A full description of the dynamics of the model is available from the authors upon request.

$$h_t \geq \left(\frac{k_t}{(1-a)A} - \frac{B}{(1-a)Ak_t^a} \right)^{a} \leq k_t$$

so above the f^2 physical capital is also increasing. Hence, above $k_{t+1} - k_t = 0$ locus, physical capital is increasing (and decreasing below).

In addition, notice that whenever $q(k_t, h_t)h_t < \frac{1-2l}{l} B$, we have that $h_{t+1} \geq h_t$ if and only if

$$\left(\frac{}{l(1-a)AZ^{\frac{1}{j}}} - \frac{}{(1-a)Ah_t^{1-a}} \right) \geq k_t$$

so below the g^1 human capital is increasing. Conversely, whenever $q(k_t, h_t)h_t \geq \frac{1-2l}{l} B$ we have that $h_{t+1} \geq h_t$ if and only if

$$h_t \leq Z^{\frac{1}{j}}$$

so that below g^2 human capital is also increasing. Hence, below the $h_{t+1} - h_t = 0$ locus, human capital is increasing (and decreasing above). We can now see that any equilibrium trajectory converges to the steady state, i.e., the steady state is a sink. Since the steady state is unique (under our assumptions), then they system is globally stable.

3.5 Comparative Statics

In this subsection, we study the comparative statics for the steady state under condition (17), i.e., when there is no child labor. Notice that in this case the steady state is given by $h^* = Z^{1/j}$ and k^*, satisfying $k^* = B + (1-a)A(k^*)^a (Z^{1/j})$. Define

$$H(k^*, B, Z, A) \equiv (k^*)^{1-a} - B(k^*)^{-a} - (1-a)AZ^{\frac{1-a}{j}} = 0$$

Consider first how the steady state human and physical capitals change when the returns to physical labor changes but condition (17) still holds. It is straightforward to see that

$$\frac{\partial h^*}{\partial B} = 0 \quad \text{and} \quad \frac{\partial k^*}{\partial B} = \frac{\partial H / \partial B}{\partial H / \partial k^*} > 0$$

This occurs because in a steady state in which there is no child labor a small increase in the returns to physical labor affects the income of the parent only, which in turn increases savings and thus the next period capital stock is higher. It is worth mentioning that in this case the relative return to human capital increases, and thus the threshold at which the household will not send the child to labor any longer, is higher. It should be clear that if the return to physical labor were to increase considerably, however, the inequality presented in (17) will be reversed. In such a case, the relative return to human capital declines and the parent will send the child to work.

Another important result, especially when analyzing exogenous growth in technology, is how the steady state values of human and physical capitals change when the parameter *A* changes. Notice that

$$\frac{\partial h^*}{\partial A} = 0 \quad \text{and} \quad \frac{\partial k^*}{\partial A} = -\frac{\partial H / \partial A}{\partial H / \partial k^*} > 0$$

so that starting from a steady state in which (14) holds, it is always the case that an increase in the technological parameter *A* increases the physical capital stock while leaving the human capital stock unchanged. This occurs because, as opposed to the case in which the returns to physical labor increase, technological change always increases skill premium. One could conjecture, then, that when condition (17) fails to hold -- the steady state of the economy is characterized by positive levels of child labor -- sustained technological change, by increasing the gap between the return to skills and the return to physical labor, will eventually drive the economy to a long-run equilibrium with no child labor.

Finally, note that $\frac{\partial H}{\partial A} = \frac{1}{j} Z^{\,j} > 0$ and $\frac{\partial k}{\partial Z} = -\frac{\partial H / \partial Z}{\partial H / \partial k^{*}} > 0$. That is, a more productive human capital technology, allows the steady state human capital to expand. This increases the relative return to human capital, which eventually results in higher savings and higher stock of physical capital.

We now derive the comparative statics for the case in which (17) does not hold. By inspection, if the technological parameters *A* or *Z* increases, the physical and human capital stocks increase. The implications are clear. An increase in *A*, by leaving the return to physical labor unaltered, unambiguously increases the skill premium. Since the individual only cares for old-age consumption and the human capital of the offspring, sending the child to school increases utility unambiguously. While child labor is positive, changes in technologies associated to the parameter *A* reduce steady state child labor. A similar argument can be made in the case of *Z*, except that the reduction in child labor occurs because now the human capital technology is more productive at all levels of schooling and parental knowledge.

As before, how changes in B affect the steady state are no so straightforward. It is easy to see that an increase in B decreases the steady state human capital stock, putting downward pressure on the skill premium. The effect on the steady state stock of physical capital is ambiguous. Under certain parametric restrictions on the return to physical labor, it could be that child labor actually increases. To see this, let us define $\overline{B}$ as the return to physical labor at which (17) holds with equality. Thus we have that in the case analyzed here $B > \overline{B}$. We also have that

$$\frac{\partial k^*}{\partial B} \overset{>}{\underset{<}{=}} 0 \Leftrightarrow B \overset{>}{\underset{<}{=}} \hat{B}$$

where $\hat{B}$ satisfies

$$\frac{1}{2-a}\hat{B}^{1-a} = (1-a)A(1-l)^a \, l^{1-a} Z^{\frac{1-a}{j}}$$

The following result follows.

Proposition 3. *Suppose that* $(1-2l)(2-a) > 1$ *then for any* $B \in (\overline{B}, \hat{B})$ *a marginal increase (decrease) in B will increase (decrease) the steady state level of child labor*.

Proof: See appendix 2.

That is, if $(1-2l)(2-a) > 1$ then $\hat{B} > \overline{B}$. Since $B < \hat{B}$, $\frac{\partial k}{\partial B} < 0$, then for any $B \in \left(\overline{B}, \hat{B}\right)$, a small increase B reduces both k^* and h^*, then the relative return to human capital decreases and child labor goes up. This is a plausible case, as discussed in Grootaert and Kanbur (1995), who argue that certain characteristics of an economy prevent the relative return unskilled labor from falling. However, if

$(1-2l)(2-a)<1,$ when B goes up, h^* decreases and k^* increases. There is thus a case when the increase in the capital stock more than offsets the decline in human capital (coupled with the increase in B itself) and child labor would decline.

4. Policy: Compulsory Schooling

As mentioned above, in developed countries child labor steadily declined over time until it reached the low levels one observes today. There is an important debate in the literature, however, in terms of whether the establishment of legislation banning child labor and imposing compulsory schooling had the effect of reducing significantly the incidence of observed children labor, or whether this was a trend determined by other factors, like technological change and growth (Nardinelli, 1980; Moehling, 1998). The only dynamic model analyzing this type of intervention is Dessy (1999). Her main conclusion is that compulsory schooling laws are welfare improving, given that a free education regime results in an ``under-development'' trap with high incidence of child labor. Dessy (1999) argues that ``in reality'' the counterproductive effects may be a short-run issue, due to the fact that current generations are the ones who cannot adjust to the policy. The model discussed above presents the demand side of the labor market in a more realistic fashion, allowing us to analyze the dynamic effects of technological change and accumulation on the returns to schooling, in a general equilibrium setting.

Compulsory schooling is seen here as a stronger version of a ban. The policy is not only restricting the amount of time children can work, but also forcing their parents to send them to school during the time that is not devoted to work. Children can thus work at most $(1-b)$ fraction of their non-leisure time. This means that schooling must be at least b, which by normalization is between zero and one.

Under this policy, parents solve the same problem as before, with a new restriction, namely,

$$(1-l_t) \geq b > 0 \qquad (18)$$

The optimal choices of the household head will be the same when the restriction is not binding. In order to avoid the case in which the restriction never binds, it is necessary to modify the bound on relative altruism established above to:[13]

$$\frac{1-g}{g} < \frac{b}{2-b}\frac{1}{j}$$

The restriction will be binding only for levels of skill premium that are relatively low. In a valid interpretation, one could think of legislation as only affecting the poorest segment of the population. The optimal choice of child labor for the kid in this case will be thus,

$$\begin{cases} 0 & if \quad \frac{}{l} \leq \frac{}{w_t} h_t \end{cases} \qquad (19)$$

[13] This implies that $l < \frac{b}{2}$, as opposed to $l < \frac{1}{2}$ as before.

Under these choices by households, and given the same general equilibrium structured as above, the laws of motion for human and physical capital will now be,

$$B + q(k_t, h_t)h_t \qquad if \qquad \frac{b-2l}{l} \leq \frac{q(k_t, h_t)}{B} h_t$$

(20)

and

$$Zh_t^{1-j} \qquad if \qquad \frac{b-2l}{l} \leq \frac{q(k_t, h_t)}{B} h_t$$

(21)

The establishment of compulsory schooling opens the door to the possibility of a steady state with higher levels of child labor. Economies whose initial conditions place them below the threshold skill premium, $\frac{q(k_t, h_t)}{B} h < \frac{b-2l}{l}$, will end up at a steady state where there is always child labor, $l^* = (1-b)$. Another valid interpretation, as stated above, is that the restriction will be binding only for those households with relatively low income generation capabilities. It is then of special interest to analyze the implications for household welfare of the two following scenarios: the steady state with positive child labor in the case without compulsory schooling --in the section above, the case when condition (17) does not hold-- and the steady state with positive child labor under compulsory schooling. The intention is to investigate whether the introduction of compulsory schooling may be detrimental to household welfare for certain parameter values.

The thought experiment is as follows. Let us suppose the parameters of the economy are such that the compulsory schooling is actually effective. Indeed, in the case when the restriction is not binding, the introduction of the policy is innocuous. Moreover, it should be clear that the steady state with no child labor is superior in welfare terms to the other possibilities. Assume that the restriction on child labor and schooling is lifted. Given certain conditions, the economy will then converge to a steady state with positive child labor. The intention in what follows is to compare the welfare implications of the elimination of such a policy.

Lemma 4 *There exists a* $\bar{b} \in (0,1)$ *such that, for* $b \leq \bar{b}$ *, the income of the household is higher once compulsory schooling is eliminated and the economy settles in a steady state with positive child labor.*

Proof. See appendix 2.

The result above is particularly interesting, because it establishes certain restrictions on the required level of compulsory schooling in order for the policy to affect household income positively. The level $\bar{b}$ could also be thought of as a required level of enforcement of the compulsory schooling laws for them to be income-increasing. The imposition of restrictions on child labor with schooling requirements affects the capacity of the households to save. A level of enforcement below $\bar{b}$ would affect accumulation without having the required impact on the human capital increases so as to compensate for the reduction in accumulation of physical capital. This is also reflected in the steady state level of human capital, as the next result states.

Lemma 5 *Whenever* $0 < b < \bar{b}$ *the level of human capital is higher under the steady state with child labor as compared to the steady state under compulsory schooling.*

Proof. See appendix 2.

Individual welfare in this economy depends on consumption during old age, as well as the level of human capital bequest parents leave to their children. The following result establishes that compulsory schooling could be detrimental to individual's welfare in this economy under certain conditions.

Conjecture. *Whenever* $0 < b < \bar{b}$ *; the household's welfare would be higher if the restriction on individual's decision were lifted.*

Testing the validity of the conjecture above requires numerical simulations, though by simple exploration, using the results in Lemma 4 and Lemma 5 above, its plausibility can be easily explained. First, relative altruism --i.e., how much parents value consumption as opposed to the human capital bequest, is taken as given and does not play any role in the results above. As parents are relatively more altruistic, however, the conjecture would be obviously true, for the effect of the human capital bequest dominates. Second, the most important point, the one that introduces the possibility of the conjecture above not being true, relates to changes in the interest rate. The fact that both physical and human capital could be higher once the policy is lifted has an ambiguous effect on the interest rate. It is true that the marginal return to physical capital should fall as K increases, but that is only in a *ceteris paribus* fashion, whereas this change has to be thought of as *mutatis mutandis,* for the human capital is also increasing. The possibility of compulsory schooling being welfare decreasing requires thus that the interest rate either increases or decreases less than it is needed to reduce the consumption level, and do so in an amount sufficient to offset the increase in welfare from higher human capital. The conditions for the conjecture not to be true would be even stronger than those needed for it to be valid.

Even though the conjecture above might seem paradoxical, the economic intuition is simple. For initial conditions in which both human and physical capital are low -or, for that matter, for the poorest segment of the economy, compulsory schooling laws constrain individual's choices, reducing the level of income they could have generated by sending their children to work. The reduction in income reduces also the capacity to accumulate physical capital through savings. The latter prevents the system from reaching the threshold level of the skill premium beyond which child labor would fall endogenously.

There are several important implications from the result above, both in terms of the contribution to the literature on the subject and from the policy perspective. In terms of the former, this result contradicts the result in Dessy (1999), using a richer setting. Technological conditions play a fundamental role in our results, for they affect the relative return to human capital with respect to physical labor, which will change through the accumulation process. In terms of the policy debate, the main point to be derived from this paper is that compulsory schooling laws might be harmful for welfare, and particularly so in the case of the poorest economies --or households. Such laws, assuming they are enforced, constrain individual choice in a way that could affect accumulation and eliminate the possibility of child labor falling coupled with an increase in welfare. The idea that a ban on child labor is not necessarily welfare-improving, especially for low-income groups of the population, has been discussed in the literature (Basu and Van, 1998; Basu, 1999).

5. Concluding Remarks

The model presented in this paper assesses the dynamic implications of capital accumulation on child labor under an appropriate specification of the technology. We have succeeded at reproducing important empirical regularities, namely the declining pattern of child labor over time, the relevance of technology on the reduction of child labor, and the fact that an economy could converge to a steady state where child labor is not fully eliminated. Moreover, the model has allowed us to show that a compulsory schooling policy is not necessarily welfare-improving, and that it might affect negatively the poorest segments of the economy. Unlike other models of child labor in the literature, this one combines a realistic specification of preferences and technology, while allowing for both physical and human capital to be accumulated. Interesting extensions would be the addition of fertility decisions and the time allocation decisions of parents.

The main result of the paper should not be seen as a normative statement or a policy prescription, but rather as a warning. There is a well-accepted school of thought in economics that sees development as a relaxation of the constraints on individuals' feasible choices. In that sense, restrictive policies like the one analyzed here potentially constitute an extra restriction on such choices, whose effect, it has been hereby shown, may be detrimental to the household. Whether there are moral reasons to ban child labor, regardless the potentially harmful effect of such policy, is an issue not discussed in the analysis presented above.

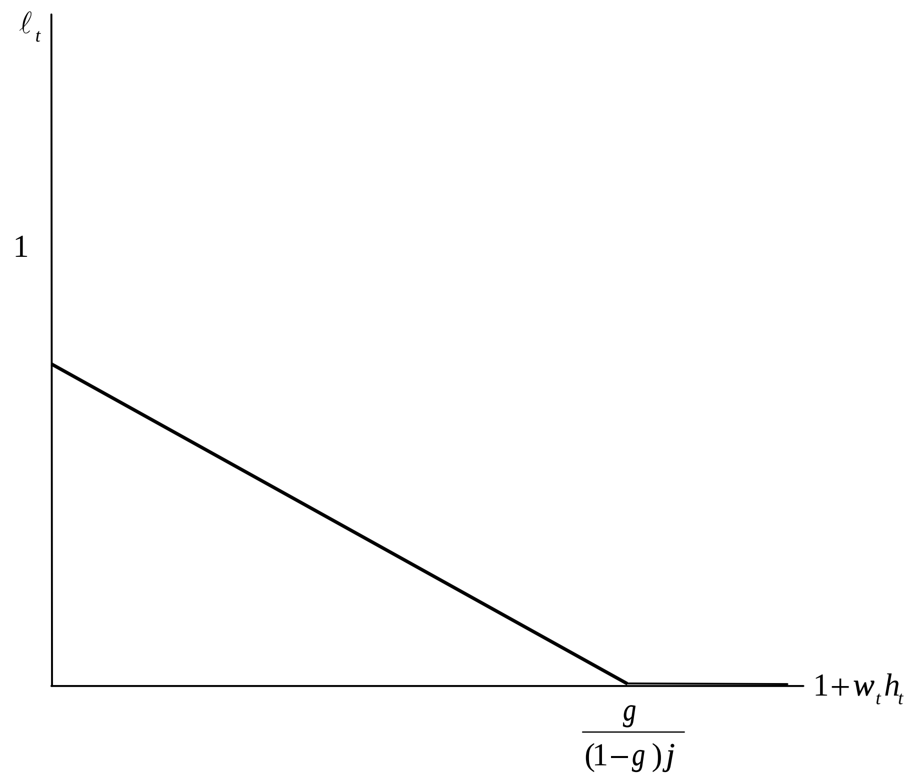

Figure 1
The Evolution of Child Labor Over Time

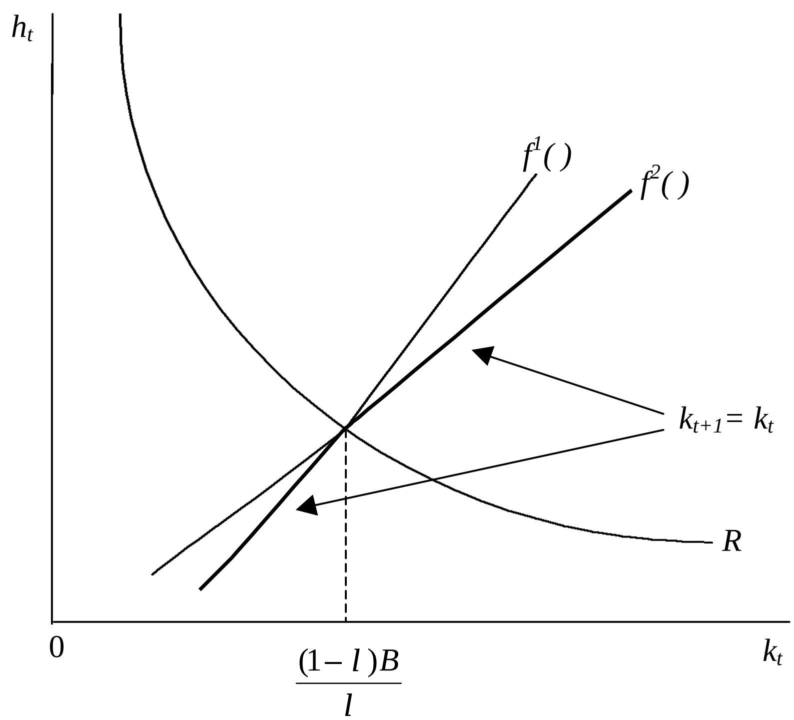

Figure 2
Dynamics of Human and Physical

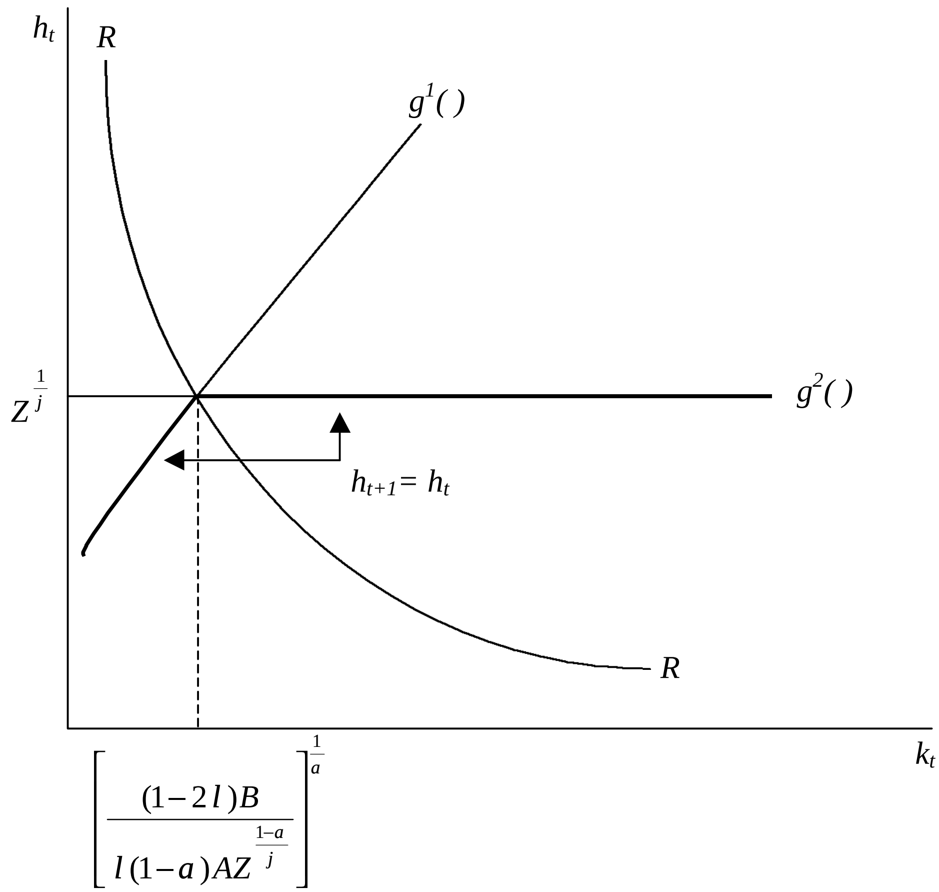

Figure 3: Human Capital Locus

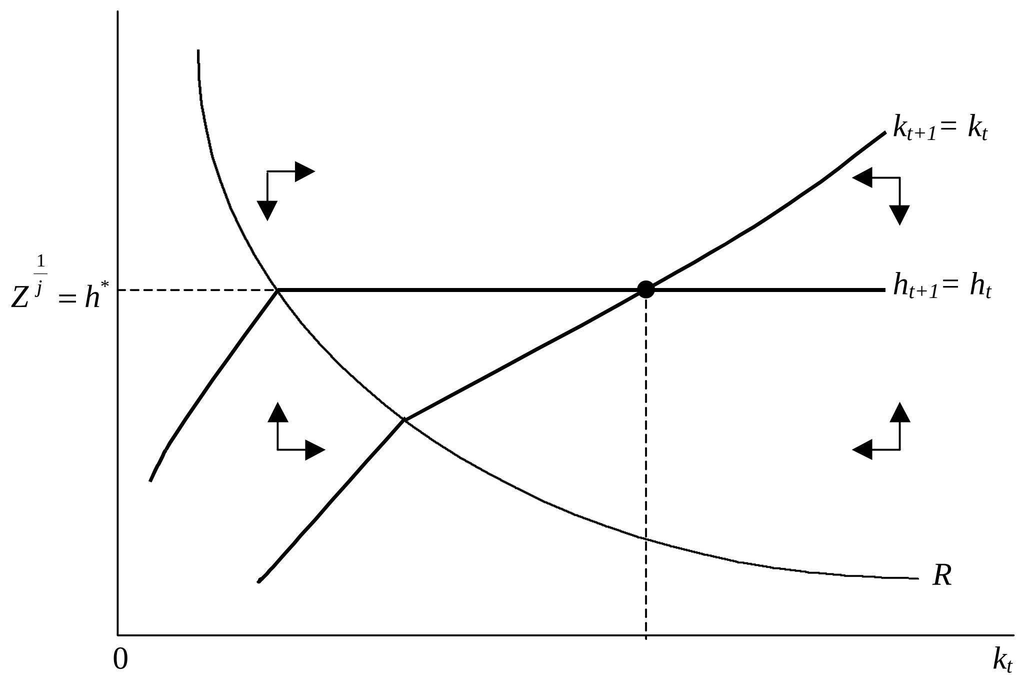

Figure 4
Steady State with no Child Labor

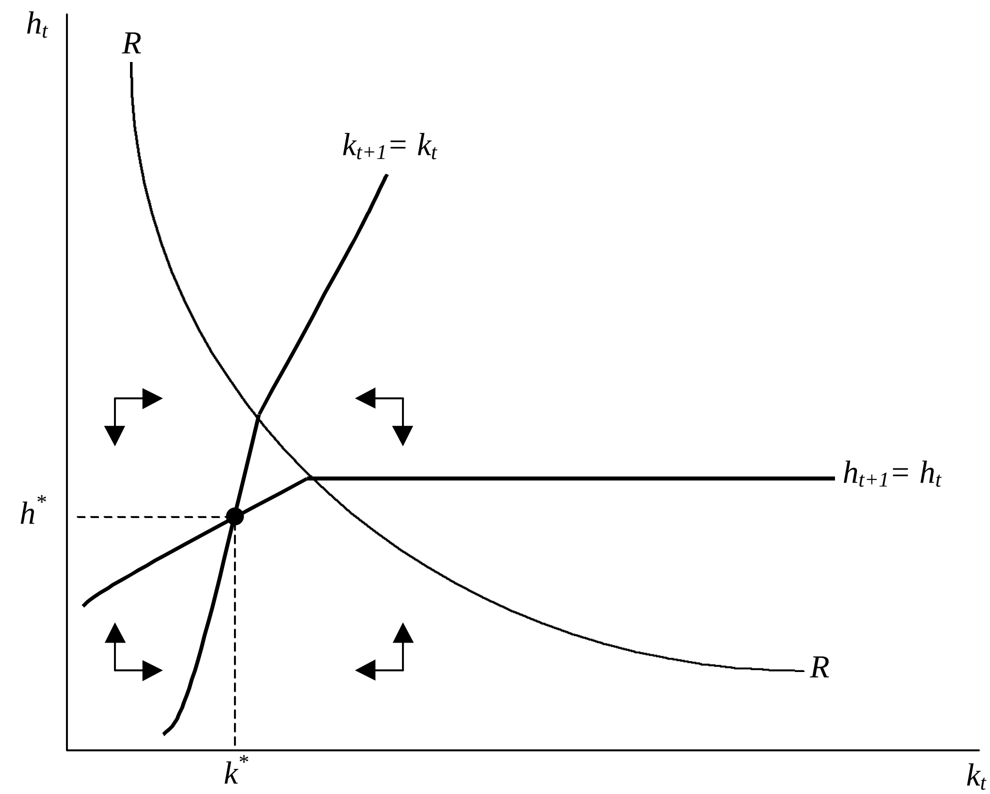

Figure 5
Steady State with Child Labor

Appendix

Proof of Proposition 3

To show that this is true, we first need to show that under the specified condition, the segment $(\overline{B}, \hat{B})$ is non-empty. By inspecting the conditions defining $\overline{B}$ and $\hat{B}$, we have that

$$[(1-2l)(2-a)]^{\frac{1}{1-a}} = \frac{\hat{B}}{\overline{B}}$$

Thus, if $(1-2l)(2-a)>1$ then $\hat{B}>\overline{B}$ and $(\overline{B}, \hat{B})$ is non-empty. Now, since $B<\hat{B}, \frac{\partial k^*}{\partial B}<0,$ then for any $B \in (\overline{B}, \hat{B}),$ a small increase B reduces both k^* and h^*, then the relative return to human capital decreases and child labor goes up. On the other hand, if $(1-2l)(2-a)<1,$ when B goes up, h^* decreases, while k^* increases. However, if the increase in the capital stock more than offset the decline in human capital (coupled with the increase in B itself) child labor would decline.

■

Proof of Lemma 4

Let us first solve for the income of the household at the steady state with positive child labor once the ban has been lifted. Define

$h \equiv \frac{(1-a)lA\left(\frac{1-l}{l}B\right)^{a}\left(Z^{\frac{1}{j}}\right)^{1-a}}{B}$. Thus, the steady state levels of human and physical capital at the steady state with positive child labor, k^{cl} and h^{cl}, are

$$k^{cl} \equiv \frac{2(1-l)B}{1-h} \qquad \text{(L4.1)}$$

$$h^{cl} \equiv \frac{2lZ^{\frac{1}{j}}}{1-h} \qquad \text{(L4.2)}$$

Using (L4.1), the income of the parent is $B + qh = B\left(\frac{1+h}{1-h}\right)$, whereas the income of the child is $Bl^* = B\left(\frac{1-h-2l}{1-h}\right)$. The sum of the two is total income of the household in this steady state, HI^{cl}, is

$$HI^{cl} \equiv \frac{B}{1-h}[2(1-l)]$$

In order to compare HI^{cl} with the income of the household under compulsory schooling, HI^{cs}, we proceed as follows. We define HI^{t} as follows

$$HI^{t} \equiv (2-b)B + \frac{b-2l}{l}B = \frac{b(1-l)}{l}B$$

What the lemma states is that there exists a $\bar{b} \in (0,1)$ such that for $b \le \bar{b}$, the following holds: $HI^{cl} \equiv \frac{B}{1-h}[2(1-l)] > \frac{b(1-l)}{l}B.$ Simplifying this, we obtain

$$2l > b(1-h)$$

Multiplying both sides by *B* and using the definition of η, the following obtains:

$$\frac{(1-a)A\left(\frac{1-l}{l}B\right)^{a}\left(Z^{\frac{1}{j}}\right)^{1-a}}{B} > \frac{b-2l}{lb}$$

Notice that when $b = 1$, from the conditions for the steady state with child labor without compulsory schooling, it must be that ,

$$\frac{(1-a)A\left(\frac{1-l}{l}B\right)^{a}\left(Z^{\frac{1}{j}}\right)^{1-a}}{B} > \frac{1-2l}{l}$$

As $b \to 0$, however, $\frac{b-2l}{lb} \to -\infty$. Hence, by continuity, there exists a $\bar{b} \in (0,1)$ such that $HI^{cl} > HI^{t}$ but we know that under compulsory schooling, it is the case that $q(k,h) < \frac{b-2l}{l}B$.. Thus $HI^{cl} > HI^{t} > HI^{cs}$ as required. Notice that $\bar{b}$ is indeed the one that solves the following expression:

$$\frac{(1-a)A\left(\frac{1-l}{l}B\right)^{a}\left(Z^{\frac{1}{j}}\right)^{1-a}}{B} = \frac{\bar{b}-2l}{l\bar{b}} \qquad \blacksquare$$

Proof of Lemma 5

The steady state level of human capital under child labor and no compulsory schooling is $h^{cl} = \frac{2l}{1-h}Z^{\frac{1}{j}}$, where h is defined as in lemma 4. Under compulsory schooling, it is $h^{cs} = bZ^{\frac{1}{j}}$. Given that $0 < b < \bar{b}$, and using the value of $\bar{b}$ from Lemma 4,

$$bZ^{\frac{1}{j}} < \bar{b}Z^{\frac{1}{j}} = \frac{2l}{1-h}Z^{\frac{1}{j}}$$

which establishes that for those values of b, $h^{cl} > h^{cs}$. $\blacksquare$

References

Baland, J.M. and J. Robinson (1999); "Is Child Labor Inefficient?," *Journal of Political Economy*, Forthcoming.

Basu, K. (1999a); "Child Labor: Cause, Consequences, and Cure, with Remarks on International Labor Standards," *Journal of Economic Literature* vol. 37, 1067-1082.

Basu, K. (1999b); "The Intriguing Relation Between Adult Minimum Wage and Child Labor," *Economic Journal*, Forthcoming.

Basu, K. (2000); The Social and Political Foundations of Economics: A Prelude to Political Economy, Oxford University Press, Forthcoming.

Basu, K. and P. Van (1998); "The Economics of Child Labor," *American Economic Review*, vol. 88, 412-427.

Becker, G. (1965); "The Theory of the Allocation of Time," *The Economic Journal*, vol. 75, 493-517.

Becker, G. (1981); *A Treatise on the Family*, Harvard University Press.

Becker, G. (1993); Human Capital, The University of Chicago Press.

Becker, G., K. Murphy, and R. Tamura (1990); "Human Capital, Fertility, and Economic Growth," *Journal of Political Economy*, vol. Vol. 98, S12-S37.

Caballe, J. (1995); "Endogenous Growth, Human Capital, and Bequests in a Life Cycle Model," *Oxford Economic Papers*, vol. 47, 156-181.

Dessy, S. (1999); "In Defence of Compulsory Measures to Eliminate Child Labor," Département d'Économique et CRÉFA, Université Laval, Québec, Canada.

Diamond, P. (1965); "National Debt in a Neoclassical Growth Model," *American Economic Review*, vol. 55, 1126-1150.

Drazen A. (1978); "Government Debt, Human Capital, and Bequests in a Life Cycle Model," *Journal of Political Economy*, vol. 86, 505-516.

Galbi, D. A. (1997); "Child Labor and the Division of Labor in the early English Cotton Mills," *Journal of Population Economics*, vol. 10, 357-375.

Galor, O. and Weil, D.N. (1996); "The Gender Gap, Fertility and Growth," *The American Economic Review*, vol. 86, 374-387.

Galor, O. and Weil, D.N. (1998); "From Malthusian Stagnation to Modern Growth," *American Economic Review*, Forthcoming.

Glomm, G. and B. Ravikumar (1992); "Public vs. Private Investment in Human Capital: Endogenous Growth and Income Inequality," *Journal of Political Economy*, vol. 100, 818-834.

Goldin, C. (1979); "Household and Market Production of Families in a Late Nineteenth Century American City," *Explorations in Economic History*, vol. 16, 111-131.

Griliches, Z. (1970); "Notes on the Role of Education in Production Functions and Growth Accounting," in Hansen, W. L. (1970).

Grootaert, C. and R. Kanbur (1995); "Child Labour: An Economic Perspective," *International Labor Review*, vol. 134, 187-203.

Hansen, W. L. (ed.) (1970); Education, Income, and Human Capital, New York, Columbia University Press.

Jacoby, H. G. and E. Skoufias (1997); "Risk, Financial Markets, and Human Capital in a Developing Country," *Review of Economic Studies*, vol. 64, 311-335.

Lucas, R. (1998); "On the Mechanics of Economic Development," *Journal of Monetary Economics*, vol. 22, 3-42.

Moehling, C. (1998); "State Child Labor Laws and the Decline of Child Labor," mimeo, Ohio State University.

Moersch, J. (1902); "The Wage-Earners in the Manufacturing and Mechanical Industries in the Northwestern States," *Journal of Political Economy*, Vol. 11, 98-107.

Nardinelli, C. (1980); "Child Labor and the factory Acts," *Journal of Economic History*, vol. 40, 739-755.

Parsons, and Goldin, C. (1989); "Parental Altruism and Self-Interest: Child Labor among Nineteenth-Century American Families," *Economic Inquiry*, vol. 27, 637-659.

Rangazas, P. (1996); "Fiscal Policy and Endogenous Growth in a Bequest-Constrained Economy,"*Oxford Economic Papers*, vol. 48, 52-74.

Ranjan, P. (1999a); "An Economic Model of Child Labor," *Economics Letters*, vol. 64, 99-105.

Ranjan, P. (1999b); “Credit Constraints and the Phenomenon of Child Labor,” mimeo, University of California, Irvine.

Ray, R. (1998); “Child Labor, Child Schooling, and Their Interaction with Adult Labor: The Empirical Evidence and Some Analytical Implications,” mimeo, University of Tasmania.

Rozensweig, M. and R. Evenson (1977); "Fertility, Schooling, and the Economic Contribution of Children in Rural India," *Econometrica*, vol. 45, 1065-1079.

Samuelson, P. (1958); “An Exact Consumption-Loan Model of Interest With or Without the Social Contrivance of Money,” *Journal of Political Economy*, vol. 66, 467-482.

Swinnerton, and Rogers (1998); “The Economics of Child Labor: A Comment,” *American Economic Review*, Forthcoming.

Tamura, R. (1991); “Human Capital, Fertility, and Economic Growth,” *Journal of Political Economy*, vol. 98, S12-S37.

Tamura, R. (1994); “Fertility, Human Capital and the Wealth of Families,” *Economic Theory*, 593-603.