

Child Labor and Economic Growth

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Abstract

We consider an overlapping generations model in which parents make schooling or working decisions for their children. Households are divided in two groups: the rich, who own the entire initial physical capital stock, and the poor. We establish that economic growth can be associated with the persistence of child labor, and possibly with an increase in the number of child workers. This is because the rich can accumulate indefinitely physical and human capital while the poor are caught in a poverty trap and have to make their children working to ensure the household's survival. This model features instantaneous multiple equilibria - one where poor children work and another one where poor adult wage is higher and children do not work. The last equilibria tend to disappear as inequality between the rich and the poor increases. We also establish some results about the connection between fertility and child labor and between technical change and child labor.

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1 Introduction

Although child labor has nearly disappeared in the OECD countries in contemporary time, its magnitude and incidence is still high in the rest of the world. For instance the International Labour Office (ILO) estimates in 1996 that 250 million children from 5 to 14 years are "economically active" - that is a child on four of this age group - and 120 million of them do full-time paid work. Moreover specialists in this field agree to recognize that these figures represent a minimal estimation of the phenomenon¹.

However, economists have for a long time failed to study analytically the role of child labor in the process of development. More precisely, they usually viewed child labor as a normal stage in the the process of development which would endogenously disappear thanks to the economic growth and the induced rise in real wages. The will to prohibit child labor, laudable in oneself, might also considered as counterproductive, because it might delay the normal process of development. The aim of this paper is to highlight the interaction between economic growth and child labor by putting together the literature on endogenous growth and the recent theoretical literature on child labor.

On the one hand, following the article of R. Lucas (1988), the literature on endogenous growth often makes accumulation of human capital the engine of growth. However, this literature does not explicitly account for child labor even though it is strongly correlated with the accumulation of human capital. Indeed, the deficit in education is the most obvious among the harmful consequences of child labor. Moreover, one common feature of the models issued from this literature is that each individual makes her/his own educa-

¹For discussion on this see, e.g., K. Ashagrie (1993), C. Grootaert and R. Kanbur (1995).

tional decision. Such an assumption might be appropriate for the decision to attend university but it is not appropriate for the decision to attend primary or secondary school. When an individual is a child, the decision of her/his time allocation is made by her/his parents rather than by her/him-self².

On the other hand, following the article of K. Basu and P. H. Van (1998), henceforth BV, a recent theoretical literature on child labor is emerging³. The models issued from it treat the child labor-supply decision either as a single decision-making or as a collective decision-making, but, in all the cases, as a household decision-making. However, they do not account for the long-run consequences of child labor⁴

Section II presents a basic framework for studying the interactions between economic growth and child labor. Parents have preferences showing intergenerational altruism and have to decide the allocation of child's time. If educated the child has a greater stock of human capital when adult, and parents' utility increases. But household's income decreases and so do consumption and possibilities of bequest. This trade-off is at the roots of the model.

Section III shows that economic growth is not always sufficient to eliminate child labor. Economic growth can be associated with the persistence of child labor when poor households are caught in a child labor trap⁵. Despite of the fact that theoretical work on child labor has favoured the poverty hypoth-

²G. Glomm (1997) proposed a model of growth in which the decision of investment in human capital is made by the parents. But his article compares the respective efficiency of private and public educational systems and child labor appears only between the lines.

³See, e.g., J.M. Baland and J. Robinson (2000), P. Rayan (1999), C. Rogers and K. Swinnerton (1999).

⁴K. Basu (1999) notes that "One big caveat in the large literature on child labor is the treatment of dynamics".

⁵This expression is used by K. Basu (1999).

esis (BV, ..:), there is no rigorous evidence that child labor arise as a result of household poverty rather than the low relative returns to alternatives like school attendance (see Bhalotra, 2000). Undoubtedly both poverty and low returns to education play a role in the parental child's labor-supply decision. These two kind of child labor explanations are examined separately.

Finally, section IV proposes some concluding remarks about the implications of fertility and technical change.

2 The basic framework

Consider an overlapping generations economy in which activity extends over infinite discrete time. In every period the economy produces a single homogeneous good that can be used for either consumption or investment. The good is produced using physical capital and human capital. The stock of physical capital in every period is the output produced in the preceding period net of consumption. Note that physical capital is not an input in the human capital production function.

Individuals live for two periods, first as a child and then as an adult. At the beginning of the second period of life, each individual gives birth to another so that the population remains constant over time. Each individual has a single parent and a single child.⁶ Hence, a household is a parent and a child. Each generation consists of a continuum of individuals of measure 1.

Individuals are endowed with one unit of time in both periods. Adults supply inelastically their unit of time in the labor market whereas child's unit of time can be allocated either to schooling or to working. This decision is

⁶As discussed in the Concluding Remarks, a more realistic household structure based upon endogenous fertility decisions would not affect the qualitative results.

made by the parent, and the child has to passively accept it. The behavior of the household is thus described by a single utility function. There is evidence that there may be divergence of interests within the household but this assumption can be made when the household's decision opposes parents and children⁷.

2.1 Production of ...nal output

Production occurs within a period according to a constant-returns-to-scale aggregate production function. The output produced at time t , Y_t , is

$$Y_t = F(K_t; H_t) \sim AK_t^\alpha H_t^{1-\alpha} \quad \alpha \in (0; 1) \quad (1)$$

where, K_t and H_t are the quantities of physical capital and efficiency units of labor employed in production at time t , and A represents the exogenously determined technological level.

This production function implies that the different levels of skill are perfect substitutes, and especially that child labor can be substituted by adult labor⁸.

Output per efficiency unit of labor produced at time t , y_t , is therefore

$$y_t = f(k_t) = Ak_t^\alpha \quad (2)$$

⁷For discussion on this see M. Browning et al. (1994).

⁸Some ILO's studies show that in most of the cases children and adults work together at the same tasks. Even the tasks carried out almost exclusively by children (packing, handling) do not require specialized skill.

A statistical study on more than 2000 workers employed in the carpet's weaving industry revealed that the proportion of child was not particularly high in this activity, even in the cases of carpets with high density of points. The ILO concludes that if one can do without the dexterity of child to weave the ...nest carpets, their "nimble ...ngers" can probably be substituted in all other activities (ILO, 1996).

Note this assumption is what BV call "the substitution axiom".

where $k_t = K_t/H_t$ is the capital-labor ratio.

The production function $f(k_t)$ is therefore strictly monotonically increasing and strictly concave. That ensures the existence of an interior solution to the producers' profit-maximisation problem.

In every period the two factors of production are supplied in competitive factor markets. The rate of return of capital, r_t , and the wage rate per efficiency unit of labor, w_t , are therefore equal to their marginal productivity:

$$\begin{aligned} r_t &= \alpha A k_t^{\alpha-1} f'(k_t); \\ w_t &= (1-\alpha) A k_t^\alpha f'(k_t) \end{aligned} \quad (3)$$

2.2 The formation of human capital

The basic skill of an adult, i.e. the skill of an adult who did not go to school and whose parent was only basically skilled, is normalized to 1. Hence, $h_t \in [1; +\infty)$:

It is assumed that child's unit of time can not be divided between schooling and working. Either the child goes to school or she/he works. So, time of education of a child born in period t , e_t , can only take on values 0 or 1. The number of efficiency units of labor of an adult born in period t , h_{t+1} , depends on her/his schooling and is an increasing function of the human capital stock of her/his parent:

$$h_{t+1} = h(h_t; e_t); \quad (4)$$

where $h(\cdot; \cdot)$ is a continuous function in h_t and $h_t \in [1; +\infty)$;

$$\frac{\partial h}{\partial h_t}(h_t; 1) > 0; \quad \frac{\partial h}{\partial h_t}(h_t; 0) > 0; \quad h(h_t; 1) > h(h_t; 0) \quad (5)$$

The educational system is public but, for simplicity, it is assumed to be

...nanced by exogenous resources⁹. All children have access to equal quality of education at zero price.

$h(h_t; 0)$ is the human capital directly inherited from parent. Define the production function of educational human capital in order to isolate human capital acquired at school at time t , Φh_{t+1} , from human capital inherited from parent

$$\Phi h_{t+1} = \Phi h(h_t; e_t) - h(h_t; e_t) + h(h_t; 0) \quad (6)$$

where $8h_t \geq [1; + 1)$;

$$\frac{\partial \Phi h}{\partial h_t}(h_t; 1) > 0 \quad (7)$$

Remark that $\Phi h(h_t; 0) = 0$

The positive correlation between human capital that the child acquires to school and her/his parent's human capital is a well-known fact.

Number of studies on child labor show that, allowing for exceptions, children work at simple repetitive manual tasks that do not require specialized skills nor provide any¹⁰. So, child's skill is assumed to be equal to λ (< 1) no matter what her/his parent's skill is. Hence, $1 = \lambda$ unit of time of child labor can be substituted by one unit of time of adult basic-skilled labor.

Finally, it is assumed that both production functions of total human capital and educational human capital exhibit non-decreasing returns in h_t when the child is sent to school¹¹

$$\frac{\partial^2 h}{\partial h_t^2}(h_t; 1) > 0 \quad \text{and} \quad \frac{\partial^2 \Phi h}{\partial h_t^2}(h_t; 1) > 0 \quad (\text{A.1})$$

⁹The government do not collect income tax. For example, the educational system is ...nanced by exploitation of natural resources and their sale abroad.

¹⁰See, e.g., A. Bequele and A. Boyden (1988) and M. Swaminathan (1998).

¹¹See Uzawa (1965) and R. Lucas (1988) for a justification of this assumption.

2.3 Individuals

All individuals, within as well as across generations are, identical in their preferences and innate abilities. However, they may be differentiated by the wealth and the stock of human capital of their parent.

2.3.1 Wealth and preferences

An individual i born in period $t-1$ (a member of generation $t-1$) supplies h_t^i efficiency units of labor at the competitive market wage w_t during his adulthood.

The household's total wealth at time t , I_t^i , is the sum of the household's labor income and the inheritance I_t^i that the adult receives from his parent at beginning of her/his adulthood,

$$I_t^i = [h_t + (1 - e_t)] w_t + I_t^i \quad (8)$$

This wealth is allocated between household's consumption, C_t^i , and savings, s_t^i . The household's budget constraint is therefore

$$C_t^i + s_t^i \leq I_t^i \quad (9)$$

Note that C_t^i is the sum of parent's and child's consumption. A child is assumed to consume θ of what her/his parent consumes. Let c_t be the adult's consumption, thus $C_t = (1 + \theta)c_t$ with $\theta \in (0; 1]$. Note also that the child's inheritance, I_{t+1}^i , is the return on the parental savings s_t^i

$$I_{t+1}^i = R_{t+1} s_t^i \quad (10)$$

where $R_{t+1} = 1 + r_{t+1} - \delta$, and the rate of depreciation of physical capital δ is for simplicity assumed to be equal to 1.

As education is freely accessible, the cost of schooling the child is only an opportunity cost, the loss of child labor income.

Define the total transfers from the parent to her/his child, g_t^i , as the sum of savings and the opportunity cost of education

$$g_t^i = s_t^i + e_{t,s}^i w_t; \quad (11)$$

and the household's maximum potential wealth, \bar{T}_t^i , as the amount that the household would dispose if child had worked

$$\bar{T}_t^i = h_t^i + e_{t,s}^i w_t + l_t^i; \quad (12)$$

Note \underline{l}_t^i the parental wealth, i.e. the amount that the household would dispose if the child does not work. Hence, $l_t^i \geq \underline{l}_t^i; \bar{T}_t^i$ and the household's budget constraint can be rewritten as

$$C_t^i + g_t^i \leq \bar{T}_t^i; \quad (13)$$

In this formulation, the parent allocates the household's maximum potential wealth between household's consumption and the transfers to the child.

Parents are altruistic in the sense that they care about child's consumption (which increases proportionally with parent's consumption) and child's future wealth (which depends on the amount of the transfer and its allocation). The common altruistic bequest motive in the recent literature on growth is the "joy-of-giving" motive¹², i.e. parental utility depends on the amount of the transfer to their offspring but does not depend on how their offspring use it. In this model, parents make themselves the decision of how do use the transfers. Hence, their preferences can not be defined over transfers g_t^i but have to be defined over the additional child's future wealth obtained from transfers. Call this value converted transfer and note it b_{t+1}^i . That is the sum of the child's inheritance and the additional labor income obtained

¹²See, e.g., O Galor and J Zeira (1993) and O. Galor and O. Moev (2000).

from education

$$b_{t+1}^i = s_t^i R_{t+1} + \phi h(h_t^i, e_t^i) : w_{t+1} \quad (14)$$

Following BV, the household's preferences are represented by an utility function of the Stone-Geary's form in order to account for what BV call "The Luxury Axiom"¹³ and S. Bhalotra (2000) "The Poverty Hypothesis". Indeed, there is some evidence (on the Western countries in nineteenth century and at present on the developing countries) that children work in order to gain economic independence from their parents and that the non-poor seldom work even in very poor countries. So¹⁴,

$$U^i(c_t^i; b_{t+1}^i) = \begin{cases} \delta < c_t^i - \bar{c} & \text{if } c_t^i < \bar{c} \\ \delta (c_t^i - \bar{c})^{-\alpha} : b_{t+1}^i & \text{if } c_t^i > \bar{c} \end{cases} \quad (15)$$

where $\alpha \in (0; 1)$ and $\bar{c} > 0$ is the level of subsistence consumption of the household. If the household's consumption is below this level, household members do not die but they endure malnutrition. That's why the transfer is 0 when the household's maximum potential wealth is lower than \bar{c} .

Lastly, we make the assumption that a parent can not guarantee a debt on the future incomes of her/his child, even if it acts to pay her/his schooling. As a consequence of this imperfection of the credit market, a household can not be involved in debt since the parents are dead (or do not work) when their children are adult:

$$s_t > 0; \quad \delta t: \quad (A.2)$$

¹³"A family will send the children to the labor market only if the family's income from non-child-labor sources drop very low"

¹⁴The second component of this utility function may also represent implicit concern about potential support from children in old age (in this case, individuals live for three period and do not work in the third period).

To sum up, the household's behaviour is described by the program

$$\begin{aligned}
 & \max U^i(C_t^i, b_{t+1}^i) \\
 & C_t^i + g_t^i = (h_t^i + \delta) w_t + l_t^i \\
 & b_{t+1}^i = (g_t^i - e_{t,\delta}^i w_t) R_{t+1} + \Phi h(h_t^i; e_t^i) : w_{t+1} \\
 & 0 \leq g_t^i \leq e_{t,\delta}^i w_t \\
 & e_t^i \geq f_0; 1g
 \end{aligned} \tag{P}$$

This program can be solved in two separate stages.

2.3.2 The schooling decision in the absence of borrowing constraints

Given g_t , so as to maximize the future wealth U_t^i of her/his child, the parent chooses the optimal use of her/his child's unit of time by comparing the rate of return to education (which depends on the parental human capital stock), $r_{e;t}^i = \Phi h(h_t^i; 1) : w_{t+1} - r_e(h_t^i; k_{t+1})$, with his opportunity cost (which is identical for all children), $p_{e;t} = \delta w_t R_{t+1} - p_e(k_t; k_{t+1})$.

Define the net rate of return to education as

$$R_{e;t}^i = \frac{r_{e;t}^i}{p_{e;t}} = R_e^i(h_t^i; k_t; k_{t+1}) \tag{16}$$

It follows from (3) and (5) that

$$\frac{\partial R_e^i}{\partial k_t} (h_t^i; k_t; k_{t+1}) < 0; \quad \frac{\partial R_e^i}{\partial k_{t+1}} (h_t^i; k_t; k_{t+1}) > 0; \quad \frac{\partial R_e^i}{\partial h_t^i} (h_t^i; k_t; k_{t+1}) > 0 \tag{17}$$

This rate decreases with the capital-labor ratio of the current period (due to the increasing opportunity cost) and increases with that of the following period (due to the increasing wage rate per efficiency unit of labor) and the parental human capital stock.

Note e_t^{is} the parental schooling decision in the absence of borrowing constraints, so then

$$e_t^{is} = \begin{cases} 0 & \text{if } R_{e;t}^i < 1 \\ 1 & \text{if } R_{e;t}^i > 1 \end{cases} \quad (18)$$

2.3.3 The child supply-labor and saving decisions

In this model children work when household's wealth without child earnings is below subsistence requirements or when the net return of education is lower than 1:

$$e_t^i = \begin{cases} 0 & \text{if } \underline{l}_t^i < \bar{c} \text{ and/or } e_t^{is} = 0 \\ 1 & \text{if } \underline{l}_t^i > \bar{c} \text{ and } e_t^{is} = 1 \end{cases} \quad (19)$$

As follow from the program (P), if child work, $l_t^i = \bar{l}_t^i$ and

$$s_t^i = \max \{ 0, \bar{l}_t^i - \bar{c} \} \quad (20)$$

and, if child do not work, $l_t^i = \underline{l}_t^i$ and¹⁵

$$s_t^i = \max \left\{ 0, \underline{l}_t^i - \bar{c} + (1 - \beta) \frac{\phi h(h_t; 1) : w_{t+1}}{R_{t+1}} \right\} \quad (21)$$

¹⁵In order to interpret this expression, let us notice that:

$$g_t^i = \bar{l}_t^i - \bar{c} + (1 - \beta) \frac{\phi h(h_t; 1) : w_{t+1}}{R_{t+1}}$$

$$C_t^i = \bar{c} + (1 - \beta) \bar{l}_t^i - \bar{c} + \frac{\phi h(h_t; 1) : w_{t+1}}{R_{t+1}}$$

So, the consumption is, in addition to subsistence consumption \bar{c} , a proportion $(1 - \beta)$ of the sum of the surplus of the potential maximum wealth on \bar{c} and the current value of income of education net of its opportunity cost. The household's consumption is thus positively correlated with the current value of the educational human capital of the child.

All occurs as if the household consume in anticipation a share of the future net income of the education of the child.

3 Child labor traps

Suppose that in period 0 the economy is divided in two homogenous groups of adult individuals - rich people and poor people - who differ in their initial physical capital ownership and eventually in their human capital stock. The rich people, denoted by R, are a fraction λ of all adult individuals who equally own the entire initial capital stock. The poor people, denoted by P, are a fraction $1 - \lambda$ of the adult individuals who have no ownership over the initial capital stock. Since individuals are ex-ante homogenous within a group, their offspring are homogenous as well, given that the solution to the optimization problem is unique.

The decisions in period t of all the adults of generation $t - 1$ determines the levels of both physical capital, K_{t+1} , and human capital, H_{t+1} , in period $t + 1$:

$$\begin{aligned} K_{t+1} &= \lambda s_t^R + (1 - \lambda) s_t^P \\ H_{t+1} &= \lambda h_t^R e_t^R + (1 - \lambda) h_t^P e_t^P \end{aligned} \quad (22)$$

3.1 Child labor and poverty trap

In this section it is showed that economic growth and sufficient returns of education can be associated with the persistence of child labor because of a poverty trap.

3.1.1 Initial conditions

In order to concentrate on the poverty explanation of child labor, it is assumed here that in every period the quality of education (which is exogenous) is sufficiently high in order to assure that the net return of education is higher than 1 for all individuals. That is,

$$R_{e;t}^i > 1; \quad i = R; P \quad (A.3)$$

Hence, all parents want to send their child to school, i.e. $e_t^{R^a} = e_t^{P^a} = 1$:

Suppose that in period 0 all individuals have only basic skills, i.e. $h_0^R = h_0^P = 1$, and that the initial physical capital stock, K_0 ; is such that the poor people can neither send their children to school nor save, i.e. $e_0^P = s_0^P = g_0^P = 0$, whereas the rich people can send their children to school, $e_0^R = 1$. That is,

$$(1 + \delta)w_0 < \bar{C} \quad \text{and} \quad w_0 + I_0^R > \bar{C} \quad (23)$$

where $w_0 = w(k_0)$; $I_0^R = (1 - \alpha)K_0R(k_0)$ and $k_0 = K_0/(2 + \delta)$:

Let k_s be the critical level of the capital-labor ratio below which the poor people can not allocate a transfer to their children, i.e. $g_0^P = 0$;

$$k_s = \frac{\mu \bar{C}}{(1 - \alpha)A(1 + \delta)} : \quad (24)$$

Hence, $w_s = w(k_s)$ is the rate of wage per efficiency unit of labor such that the maximum household's wealth is equal to the level of consumption of subsistence.

3.1.2 The dynamics of the economy when $k_t < k_s$

As long as the poor people are below the subsistence threshold, i.e. $e_t^P = s_t^P = 0$, as follows from (22), the dynamic of human capital accumulation is,

$$H_{t+1} = (1 - \alpha)h(h_t; 1) + H^P; \quad (25)$$

where $H^P = (1 - \alpha)(1 + \delta)$ is the constant number of efficiency units of labor supplied by poor households (adults and children), and the physical capital in period $t + 1$ is the saving of the rich people in period t , $K_{t+1} = (1 - \alpha)s_t^R$:

It follows from (20) that

$$s_t^R = (1 - \alpha)h_t^R w(k_t) + I_t^R - \bar{C} = (1 - \alpha) : \frac{\alpha h(h_t; 1) : w(k_{t+1})}{R_{t+1}} \quad (26)$$

and from (10) that the inheritance of the Richs in period t is the return on physical capital in this period, $1l_t^r = R(k_t) K_t$: Thus the dynamic of physical capital per efficiency unit of labor accumulation is given by

$$k_{t+1} = k^i k_t; h_t^R = \frac{(1h_t^r + H^p) Ak_t^i j^{-1} \bar{C}}{1 (\otimes h(h_t^r; 1) + (1 j^{-1}) (1 j^{-1} \otimes) \Phi h(h_t^r; 1)) + H^p} \quad (27)$$

Hence, as long as the capital-labor ratio is lower than k_s the evolution of the economy is determined by the sequence $k_t; h_t^R$ such that

$$\begin{aligned} k_{t+1} &= k^i k_t; h_t^R \\ h_{t+1} &= h^i h_t^R; 1 \end{aligned}$$

where $h_0^R = 1$, and k_0 is given.

In this case, the accumulation of human capital is determined independently from the accumulation of physical capital.

Lemma 1 Under the assumption A.1, A.2 and A.3 the capital-labor ratio k_t converges to a finite value k_1 :

Proof. It follows from (5) that h_t^R increases indefinitely. Divide the numerator and the denominator of the expression (27) of k_{t+1} . Lemma 1 follows from A.1. k_1 is 0 if both production functions of total human capital and educational human capital exhibit strictly increasing returns in h_t . Else, k_1 is a finite value different from 0.

Corollary 1 Under the assumption A.1, A.2 and A.3, there exists a upper bound to the capital-labor ratio, k_{max} ; such that $\forall t k_t \leq k_{max}$

Proof. $f(\cdot)$ is a continuous function and $h^i h_t^R; 1$ is continuous in h_t^R

Proposition 1 Poverty trap

If $k_{max} < k_s$, the poor people are trapped in a zero transfer asymptotically steady-state equilibrium whereas both the human capital stock of the rich people and the physical capital owned by the Richs increase indefinitely.

Child labor comes at the expense of schooling and so perpetuates poverty for children from poor families. If the rate of wage per efficiency unit of labor, w_t , increases sufficiently, poor parents can generate the subsistence level without child labor force participation and thus their children escape to the poverty trap. But if the stock of human capital of the rich people increase fastly, it is possible that w_t be always lower than w_s and thus Poores are never able to accumulate either human capital or physical capital. In this case the economy exhibits (very unequal) economic growth and persistence of child labor in the same time¹⁶.

3.1.3 Multiple equilibria

In this model the economy may exhibit at time t the same multiple equilibria as in BV's static model. BV demonstrated the possibility of multiple equilibria in the labor market due to the local negative wage elasticity of the household's labor supply. In one equilibrium children work and the rate of wage is low and in one another children do not work and adult wage is higher.

At time t , if poor children work, the total number of efficiency units of labor supplied in the economy is

$$\bar{H}_t \approx \bar{H}(h_t^r) = \lambda h_t^r + (1 - \lambda)(1 + \delta); \quad (28)$$

¹⁶M. Swaminathan (1998) shows that child labor increases in Bhavnagar (India, Gujarat) between 1987-88 and 1993-94 whereas the State Domestic Product of Gujarat grew at 6.4% annually during the same period.

while, if poor children are sent to school, the supply is lower

$$\underline{H}_t \leq \underline{H}(h_t^r) = \beta h_t^r + (1 - \beta) : \quad (29)$$

Let k_e be the critical level of the capital-labor ratio (slightly different from k_s) below which poor parents (who did not receive inheritance) can not send their children to school, i.e. $e_0^p = 0$

$$k_e = \frac{\mu \bar{c}}{(1 - \beta) A} : \quad (30)$$

Hence, $w_e = w(k_e)$ is the rate of wage per efficiency unit of labor such that the parental wealth is sufficient to generate the level of consumption of subsistence.

It follows from (3) that the withdrawal of children from the labor market increases the wage per efficiency unit of labor and it is possible that the economy exhibits multiple equilibria. That is the case if the wage per efficiency unit of labor is lower than w_e when children work and higher than w_e when they do not work, i.e. if the capital-labor ratio jumps over the critical value k_e when children are retired from the labor market.

When children work, the critical value k_e is reached for the quantity of capital

$$\bar{K}_{e;t} = \bar{K}_e(h_t^r) = k_e \bar{H}_t : \quad (31)$$

and when they do not work, it is enough that the quantity of capital is

$$\underline{K}_{e;t} = \underline{K}_e(h_t^r) = k_e \underline{H}_t \quad (32)$$

Proposition 2 If at time t the stock of physical capital and the stock of human capital of the Richs, K_t et h_t^r , are such that

$$K_t \geq \underline{K}_e(h_t^r) ; \bar{K}_e(h_t^r) \leq K_t \quad (33)$$

then there exists two equilibria in the economy like in the BV's model:

A bad equilibrium in which poor children work because the rate of wage per efficiency unit of labor is lower than w_e (and vice-versa);

A good equilibrium in which poor children do not work because the rate of wage per efficiency unit of labor is higher than w_e (and vice-versa):

In this cases, if the economy is at the bad equilibrium, a total ban on child labor (or a total compulsory schooling) allows the economy "to jump" at the good equilibrium (see BV for a discussion). But, in the other cases, i.e. when the good equilibrium do not exist, a total ban on child labor may have deleterious consequences for the poor households unless they are compensated for the loss in income.

The condition (33) is equivalent to $k_t \geq k_e \frac{H(h_t^r)}{H(h_t^p)} = \bar{H}(h_t^r) ; k_e$. Consider that the capital-labor ratio k_t is on the asymptotically steady-state equilibrium k_1 . As the ratio $\frac{H(h_t^r)}{H(h_t^p)} = \bar{H}(h_t^r)$ is an increasing function of h_t^r , it follows that the higher is the stock of human capital of the rich people the lower are the possibilities that condition (33) be satisfied. In other words, the higher is the inequality of wealth between the rich people and the poor people, lower are the possibilities that a total ban on child labor improve poor household's conditions.

3.2 Child labor and non-schooling trap

In this section it is shown that economic growth can be associated with the persistence of child labor even when the subsistence consumption constraint of households is not binding, because the return to schooling are too low.

3.2.1 Initial conditions

It is assumed that rich people accumulated human capital before period 0, $h_0^R > 1$ and that in every period the quality of education is sufficiently high in order to ensure that their net return to education is higher than 1, but that, on the contrary, poor people have only basic skill, i.e. $h_0^P = 1$, and their net return to education in period 0 is lower than 1. That is,

$$\forall t \quad R_{e;t}^R > 1 \quad \text{and} \quad R_{e;0}^P < 1 \quad (\text{A.4})$$

Hence, $e_0^P = 0$ and $\forall t \quad e_t^R = 1$:

In order to concentrate on the low-return-of-education explanation of child labor, it is also assumed that in every period parental wealth is sufficient to obtain the subsistence level of consumption (\bar{C} is exogenous) for all individuals. That is,

$$\forall t \quad \underline{I}_t^i > \bar{C}; \quad i = R; P \quad (\text{A.5})$$

Hence, rich children are always sent to school, $\forall t \quad e_t^R = 1$ ¹⁷:

3.2.2 The dynamics of the economy when $R_{e;t}^P < 1$

As long as the poor people do not send their children to school, i.e. $e_t^P = 0$, the dynamics of human capital accumulation is identical to the previous section, $H_{t+1} = \lambda h(h_t^R; 1) + H^P$.

The physical capital in period $t + 1$ is here the saving of the Richs and the Poors in period t , $K_{t+1} = \lambda s_t^R + (1 - \lambda) s_t^P$:

¹⁷It follows from the assumptions A.4 and A.5 that the initial physical capital stock, K_0 , is such that

$$w_0 > \bar{C} \quad \text{and} \quad w_0 + I_0^R > \bar{C}$$

where $w_0 = w(k_0)$; $I_0^R = \lambda^{-1} K_0 R(k_0)$ and $k_0 = K_0 / (2 + \lambda)$:

It follows from (10), (20) and (21) that the dynamics of physical capital per efficiency unit of labor accumulation is given by

$$k_{t+1} = k^0 i k_t; h_t^R = \frac{(1 + h_t^r + H^p) (1 + \theta) A k_t^\alpha i \bar{C}}{1 + \theta h (h_t^r; 1) + (1 + i^-) (1 + i^\theta) \phi h (h_t^r; 1) + \theta H^p} \quad (34)$$

Hence, as long as the net return to education of the poor people is lower than 1 the evolution of the economy is determined by the sequence $k_t; h_t^R$ such that

$$\begin{aligned} k_{t+1} &= k^0 i k_t; h_t^R \\ h_{t+1} &= h i h_t^R \end{aligned}$$

where $h_0^R = 1$, and k_0 is given.

This dynamical system is not qualitatively different from that in the previous section.

Lemma 2 Under Assumption A.1, A.2, A.4 and A.5, the net return to education of the poor people, $R_{e,t}^P$; converges to a finite value $R_{e,1}^P$

Proof: From lemma 1, k_t converges to a finite value. Thus the ratio $k_t^\theta = k_{t+1}$ and the net return of education of the poor people converge also to a finite value.

Corollary 2 There exists a upper bound to the net return to education of the poor people $R_{e,max}^P$ such that $\forall t R_{e,t}^P \leq R_{e,max}^P$

Proof: idem Corollary 1

Proposition 3 Non-Schooling trap

If $R_{e,max}^P < 1$, the poor people never send their children to school because the return of education is always lower than its opportunity cost, i.e. the child labor income.

As follows from (20) and lemma 1; poor people's savings converge to a finite value. Thus, like in the case of a poverty trap, the inequality between poor people and rich people increases indefinitely.

A total ban on child labor (or a total compulsory schooling) allows the poor people to escape the child labor trap and do not threaten their subsistence, but it may decrease several poor generations' well-being. An other evident policy intervention is to improve the quality of education.

4 Concluding remarks: fertility and technical progress

(forthcoming)

Accounting for the fertility enforces the results of this paper. The number of child worker can possibly increase. The fertility choices of the household (the well-known trade-off quantity-quality) can generate a multiplicity of equilibria.

It can be shown that the technical progress (the increasing of A) can eliminate the poverty trap. It can also be shown that endogenous technical progress may be unskilled-biased due to child labor and so perpetuates it.

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