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Child Labour and Resistance to Change

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We study the interaction between technological innovation, investment in human capital and child labour. In a two-stage game, first firms decide on innovation, then households decide on education. In equilibrium the presence of inefficient child labour depends on parameters related to technology, parents' altruism and the diffusion of firms' property. Child labour is due either to firms' reluctance to innovate or to households' unwillingness to educate, or both. In some cases, compulsory schooling laws or a ban on child labour are welfare-reducing, whereas a subsidy for innovation is the right tool to eliminate child labour and increase welfare.

Introduction

According to International Labour Organization statistics (see ILO 1998), in 1995 at least 120 million children between the ages of 5 and 12 worked full time in paid jobs, mostly in underdeveloped regions. This figure would at least double if we took into account children working part-time. These impressive statistics awake concern in both developing and developed countries and command theoretical as well as policy-oriented analysis. In June 1999 the 174 member nations of the ILO passed an international convention, upon ratification of which member states are pledged to eliminate the worst forms of child labour immediately and ultimately to end all forms of child labour.

A central question for national governments and international organizations is therefore how to intervene in order to reduce the extent of the phenomenon. Indeed, from the point of view of economic theory, public intervention should be justified either by efficiency arguments (for example in the presence of some kind of externalities or coordination failures) or by social preferences that call for some form of redistribution in favour of children and possibly poor households. Moreover, whatever the justification is, it is clear that any government intervention aimed at reducing or eliminating child labour will affect the current and future welfare of children and is likely to have relevant spillovers on others. It is therefore very important to better understand the determinants of child labour and design policy interventions upon careful analysis and research.

Since the publication of a recent paper by Basu and Van (1998), there has been a surge of interest among economists in the theoretical investigation of the causes of child labour with the aim of assessing the desirability and efficacy of alternative remedies. However, almost all contributions have so far dealt with the determinants of the supply of (child) labour, focusing mainly on the role of poverty, fertility and liquidity constraints.[1] Furthermore, many of these contributions fail to give a clear-cut argument on the efficiency properties of child labour and the welfare effects of government intervention in this area.

This paper contributes to the literature on the economics of child labour by focusing on the analysis of the determinants of the firm's demand for unskilled (child) labour versus more skilled labour and its interaction with the educational choices of households. In fact, it is widely recognized by economic historians that in many circumstances the reduction or elimination of child labour has been driven by technological progress and the substitution of adult and educated workers for young and unskilled workers (for historical examples, see Galbi 1997; Levy 1985; Weiner 1991).

In order to tackle these issues, we develop a model that studies the relationship between technological innovation, child labour and investment in human capital. In a two-period economy, we analyse the joint decisions of altruistic parents (who must decide whether to send their children to work or to school) and firms (which must decide whether or not to switch to a new technology). These decisions are closely interrelated, since the returns to education depend on the level of technology and, in turn, the profitability of innovation depends on the quality and skills of the labour force. Specifically, we assume that technological innovation is decided by the owners of a monopolistic firm. Innovation entails the adoption of a new-vintage technology with lower marginal costs of production. However, for the new vintage to become operative, it is necessary that the labour force acquire the adequate skills—in other words, that children go to school.

The equilibrium of the model is defined as the outcome of a sequential game where the owners of the monopolistic firm ('capitalists') move first and decide simultaneously whether or not to innovate and whether to send their children to school or to work. After observing the capitalists' move, workers decide whether to send their own children to school or to work. We show that our economy always displays a unique subgame-perfect equilibrium, whose features depend on the value of parameters related to the technology, the degree of parents' altruism and the degree of diffusion of a firm's property. When child labour appears in equilibrium, it is due to either firms' reluctance to innovate or workers' unwillingness to educate, or both.

Focusing on situations in which child labour is inefficient, we argue that the adequate policy intervention (compulsory schooling laws, a ban on child labour, subsidies to innovation or to education, etc.) depends crucially on the underlying causes. In particular, we point out circumstances in which the introduction of compulsory schooling laws or a ban on child labour are both welfare-reducing, while a subsidy to innovation succeeds in both eliminating child labour and increasing welfare.

Recent work by Dessy and Pallage (2001) also stresses the complementarity between simultaneous decisions on technology adoption and skill accumulation. In their case, such complementarity gives rise to a multiplicity of Pareto-rankable Nash equilibria, so that a coordination failure between firms and households may support a suboptimal outcome with technological stagnation and child labour. In our case, multiple equilibria are not part of the story. On purpose, they are avoided by the sequential structure of the game: there is always a unique subgame-perfect equilibrium. Accordingly, self-fulfilling 'bad' expectations are not the cause of child labour. Consequently, we are able to push our policy analysis beyond helping 'good' expectations to coordinate.

The rest of the paper is organized as follows. Section I introduces the model. Section II characterizes the efficient outcome. Section III describes the equilibrium outcome. Section IV presents comparative statics results. Section V discusses policy implications, and Section VI concludes.

I. The Model

We consider a two-period economy, populated by a continuum of identical households of measure 1. In the first period (period t) each household consists of 1 adult and $n \geqslant 1$ children for a total of $n+1$ individuals. Adults live for one period, children for two, so that only children are alive in the second period (period $t+1$) and the household dimension shrinks to n. Each individual is endowed with 1 unit of time per period. While adults supply their units of time inelastically to the labour market, children can either work or go to school. The decision on children's time use is made by their altruistic parents. Education is free of charge, so that its only (indirect) cost is the forgone labour income of children. The benefit of education comes from human capital accumulation, which in the second period, will allow grown-up children to operate more sophisticated technologies.

On the demand side, owing to altruism, the preferences of a typical adult (and thus of the corresponding household) are represented by an intertemporal utility function defined over the consumption of a unique homogeneous good. Specifically, utility is assumed to be linear in the amounts consumed in the two periods:

$$(1) \qquad U = (1+n)c_t + \rho n c_{t+1},$$

where c_t is consumption at time t and $\rho \in (0,1)$ is the discount factor. There are no capital markets, so in each period expenditures equal income.[2]

On the supply side, we adopt the dual-technology model of Murphy *et al.* (1989) and adapt it to our intertemporal setting. In the first period two technologies, 'traditional' and 'modern', are available for the production of the unique consumption good. Both technologies are linear and use labour as their only input. They differ, however, in terms of productivity, the modern technology being more productive than the traditional one. While the traditional technology is freely disposable, the modern one is the exclusive property of one firm only. Owing to free disposal, when active, the traditional technology is operated by perfectly competitive firms that are publicly and equally owned by all households. On the contrary, the ownership of the modern firm is shared equally only by a fraction θ of the households ('capitalists'), with $\theta \in [0,1]$.

Specifically, we assume that, when employed in the traditional technology, one unit of labour produces α_0 units of good, while it produces $\alpha_1 > \alpha_0$ units of good when employed in the modern one. Choosing labour as numeraire, this implies that in the former case the marginal cost of production is $1/\alpha_0$ while in the latter it is $1/\alpha_1 < 1/\alpha_0$.

Profit maximization leads the modern firm to exploit its cost advantage in order to prevent traditional firms from entering the market at all. In particular, this is achieved through limit pricing, i.e. by setting a price at which traditional firms are just indifferent between operating or not. That implies that in equilibrium the modern firm's price equals the marginal cost of traditional firms:

$$(2) \qquad P_t = \frac{1}{\alpha_0}.$$

The result is, thus, that the modern firm operates as a monopolist and earns nominal profits:

$$(3) \qquad \Pi_t = \left(P_t - \frac{1}{\alpha_1}\right) y_t,$$

where y_t is its output and the term in parentheses is the price–cost margin. In real terms, profits can be rewritten as

$$(4) \qquad \pi_t = \frac{\Pi_t}{P_t} = \frac{1/\alpha_0 - 1/\alpha_1}{1/\alpha_0} y_t = \frac{\alpha_1 - \alpha_0}{\alpha_1} y_t.$$

This leads to aggregate nominal and real incomes that are, respectively,

$$(5) \qquad Y_t = P_t y_t = \left(\frac{1}{\alpha_0}\right) y_t = \Pi_t + N_t,$$

$$(6) \qquad y_t = \pi_t + \alpha_0 N_t,$$

where N_t is the total number of individuals (adults and children) who work at time t.

Solving the system formed by (4) and (6), we obtain the following expressions for profits and income in real terms:

$$(7) \qquad \pi_t = (\alpha_1 - \alpha_0) N_t,$$

$$(8) \qquad y_t = \alpha_1 N_t.$$

In the first period the monopolist, and thus the capitalists also, face an intertemporal decision, in that they can decide whether to update the modern technology or not. If they do, the 'updated' technology will be ready for production in the second period with productivity $\alpha_2 > \alpha_1 > \alpha_0$. However, its operation by grown-up children will be possible only if they have attained an adequate level of human capital through education in the first period. In other words, the capitalists as well as the other households (henceforth called simply 'workers') face a second intertemporal decision on whether or not to educate their children, and the updated technology will be implementable only if the innovation decision of the monopolist is matched by the education decision of the households.

More precisely, we assume that the capitalists move first in anticipation of households' choices. The exact timing of events is as follows. At the beginning of period t, the capitalists as a group decide whether to update (*I*) or not (*NI*) as well as whether to send their children to school (E^0) or not (NE^0). Then, the workers decide whether to send their children to school (E) or not (NE). After that, during period t production, education (if any) and consumption take place. Finally, at the end of period t adults pass away. At the beginning of period $t+1$, if capitalists have previously decided to update, the new technology becomes available to the monopolist only. Lastly, production and consumption by grown-up children take place.

To close the model, some modelling choice has to be made on what happens to the outdated technology once the capitalists have innovated. One option would be to assume some exogenous patent duration. For example, a patent could last for one or two periods, regardless of whether or not innovation takes place. We prefer, instead, to follow Dinopoulos and Segerstrom (1999), who assume that previously patented products can be competitively produced by firms when further innovation occurs in the same industry. The underlying idea is that the duration of patents is endogenous in the presence of enforcement costs. In particular, we consider a situation in which the costs of enforcing two subsequent patents are prohibitively high so that only the state-of-the-art technology is defended. Accordingly, the adoption of a new technique by the monopolist at the beginning of period t means that the old technique will be freely available to competitors at the beginning of period $t+1$. As we shall see, such a hypothesis leads to a larger set of possible outcomes and will have the advantage of allowing us to assess the equilibrium implications of exogenous patent duration as a special case of our 'endogenous' duration.

II. The Efficient Outcome

We are interested in investigating child labour as a market failure. To do so, we need to assess the conditions under which child labour is inefficient. Our welfare measure is the sum of the indirect utilities of all capitalists and workers. Given linear utility, this corresponds to the present value of aggregate output, $y_1 + \rho y_2$.

Straightforward calculations lead us to the following Proposition.

Proposition 1. Aggregate welfare is maximized at either (I, E^0, E) or (NI, NE^0, NE). The former dominates the latter if and only if

$$\frac{\alpha_2}{\alpha_1} > 1 + \frac{1}{\rho}. \tag{9}$$

Intuitively, a planner would choose to send all children to school and to update the technology whenever the present value of the increase in future output resulting from innovation offsets the current loss of production due to education. Notice that the parameter α_0 is irrelevant for the planner's choice because it affects the distribution of income, but it does not affect the output increase.

In what follows we assume that (9) holds; that is, we focus on situations in which, when child labour emerges in equilibrium, it is inefficient, so that there is scope for welfare-improving policy intervention.

III. The Equilibrium

We are now ready to investigate the conditions under which the market outcome is characterized by inefficient child labour. Specifically, we look for the subgame-perfect equilibrium (SPE) of the two-stage game of complete and perfect information between capitalists and workers. As discussed above, capitalists move first. Their chosen action will be denoted by a^0. After having observed the action of the capitalists, workers choose their own favourite action a. Clearly, $a^0 = (a_1^0, a_2^0)$ where $a_1^0 \in A_1^0$, $a_2^0 \in A_2^0$ $A_1^0 = \{I, NI\}$ and $A_2^0 = \{E^0, NE^0\}$. Similarly, $a \in A$ where $A = \{E, NE\}$.

Figure 1 summarizes the tree of the strategic interaction between capitalists and workers with the eight possible outcomes. The associated payoffs are the indirect utilities of the two interest groups, capitalists (labelled again by ^{0}) and workers (no label), calculated from (1). To derive them, the crucial thing to keep in mind is that, for the updated technology to be operative in the second period, some children must attend school in the first period, in which case their current real labour income ($\alpha_0 n$) is traded against higher future real labour income ($\alpha_1 n$). Obviously, this also implies trading off current real profit against higher future real profit for the monopolist, since children attending school are withdrawn from production in the first period. The eight payoffs of workers (A, B, C, D, E, F, G, H, K) and the eight payoffs of capitalists (A^0, B^0, C^0, D^0, E^0, F^0, G^0, H^0, K^0) are reported in the Appendix.

The choice of workers

Let us characterize the SPE by backward induction, taking into account the extensive form depicted in Figure 1. After observing capitalists' decisions regarding innovation and education, workers must decide whether to send their children to school ($a = E$) or not ($a = NE$). Here we can distinguish between three cases.

1. Given $a^0 = (NI, E^0)$ or $a^0 = (NI, NE^0)$ workers' optimal response is $a = NE$ since $C > A$ and $D > B$. Intuitively, when capitalists do not innovate, the future real wage is equal to the current one (α_0), since the output price remains constant ($1/\alpha_0$). Workers therefore have no incentive to send children to school, since this would mean a loss in current labour income against a zero gain in future labour income.

2. Given $a^0 = (I, NE^0)$, workers' optimal response is $a = NE$ since $F < H$. If capitalists innovate but do not send their children to school, they will be unable to operate the updated technology unless workers send their children to school. However, workers have no incentive to do so, since they anticipate that the

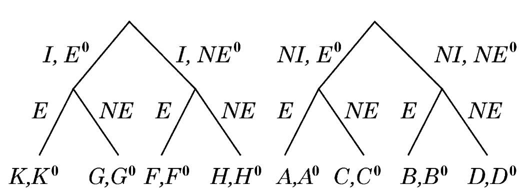

Figure 1. The extensive-form representation of the game

future real wage will be higher in any case. The reason is as follows. If workers' children get educated at time t, the monopolistic firm will be able to operate the updated technology at time $t+1$ and set the product price at $1/\alpha_1$, so that the real wage will be equal to α_1. Otherwise, the monopolistic firm will be unable to operate the updated technology at time $t+1$. None the less, since innovation makes the modern technology freely disposable, a competitive fringe of firms will step in using that technology and the real wage will be still equal to α_1.

3. Given $a^0 = (I, E^0)$, workers' optimal response is $a = E$ if and only if $K > G$, that is if and only if $\rho\alpha_1 > \alpha_0$. If capitalists innovate and send their children to school, they will operate the updated technology at time $t+1$ no matter what workers do. In order to decide whether to send their children to school or to work at time $t+1$, workers must compare the loss in terms of current labour income (opportunity cost of education), α_0, with the discounted net gain in terms of future labour income, which is given by $\rho\alpha_1$ since in this case only educated workers can be employed at time $t+1$.

Thus, for workers to be willing to send their children to school, it must be $\rho\alpha_1 > \alpha_0$.

The choice of capitalists

We can now turn to the characterization of capitalists' best course of action, given workers' best responses. Capitalists must take two simultaneous decisions: whether to adopt the new vintage technology ($a_1^0 = I$) or not ($a_1^0 = NI$) and whether to send their children to school ($a_2^0 = E^0$) or not ($a_2^0 = NE^0$).

It is immediately verifiable that, anticipating workers' best responses, capitalists always prefer $a^0 = (NI,\, NE^0)$ to $a^0 = (NI,\, E^0)$, since $D^0 > C^0$ and $B^0 > A^0$. Intuitively, if capitalists decide not to update the modern technology, in their role of workers they will have no incentive to send their children to school, since this would imply a loss in terms of current labour and profit income against a zero gain in terms of future labour and profit income.

By the same token, $a^0 = (NI,\, NE^0)$ is preferred to $a^0 = (I,\, NE^0)$ since $D^0 > H^0$. As we know, if capitalists innovate but do not send their children to school, workers will not send their children to school either, so that capitalists will be unable to operate the new technology in period $t+1$ but, at the same time, will also be unable to prevent the entry of the competitive fringe. For $\theta < 1$, the ensuing loss in terms of discounted profit income, $\rho(\alpha_1 - \alpha_0)n$, will always be larger than the gain in terms of discounted wage income, $\theta\rho(\alpha_1 - \alpha_0)n$.

Therefore, we can conclude as follows.

Remark 1. In equilibrium, children never attend school in the absence of innovation and innovation is impossible unless some children go to school.

Once we have eliminated actions $a^0 = (NI,\, E^0)$ and $a^0 = (I,\, NE^0)$, we can finally analyse the capitalists' choice between action $a^0 = (I,\, E^0)$ and $a^0 = (NI,\, NE^0)$. Different scenarios emerge depending on workers' willingness to send their children to school, that is depending on the relation between $\rho\alpha_1$ and α_0.

1. When $\rho\alpha_1 > \alpha_0$, capitalists prefer $a^0 = (I, E^0)$ to $a^0 = (NI, NE^0)$ if and only if $K^0 > D^0$, that is if and only if

$$(10) \qquad (1/\theta)[\rho(\alpha_2 - \alpha_1) - (1+\rho)(\alpha_1 - \alpha_0)]n + [\rho\alpha_1 - (1+\rho)\alpha_0]n > 0.$$

In words, if the discounted future income gain in terms of higher profits, i.e. $\rho[(\alpha_2 - \alpha_1) - (\alpha_1 - \alpha_0)]n$, and higher wages, i.e. $\rho(\alpha_1 - \alpha_0)\theta n$, is larger than the opportunity cost of innovation in terms of current income, $[(\alpha_1 - \alpha_0) + \theta\alpha_0]n$, capitalists will innovate and will send their children to school. As we know, this in turn implies that workers will also send their children to school, so that (*I*, E^0, *E*) would be the SPE of the game.

If condition (10) is not satisfied, capitalists do not innovate and nobody sends their children to school, so that (*NI*, NE^0, *NE*) is the SPE of the game. Notice that in this case child labour emerges as a consequence of capitalists' resistance to innovation as well as to education, and hurts workers who would have been better off had the firm innovated.

2. When $\rho\alpha_1 < \alpha_0$ (i.e. when workers never send their children to school), capitalists prefer $a^0 = (I, E^0)$ to $a^0 = (NI, NE^0)$ if and only if $G^0 > D^0$, that is if and only if

$$(11) \qquad (1/\theta)[\rho\theta(\alpha_2 - \alpha_1) - (\theta+\rho)(\alpha_1 - \alpha_0)]n + [\rho\alpha_1 - (1+\rho)\alpha_0]n > 0.$$

The net gain from profits following innovation is different with respect to the preceding case, since only capitalists' children go to school at time t (implying a smaller loss in current profit) and work at time $t+1$ (implying a smaller gain in future profits). In this case, the SPE equilibrium of the game would be (*I*, E^0, *NE*), implying innovation and 'partial' child labour: only capitalists' children go to school.

If condition (11) is not satisfied, capitalists do not innovate and nobody sends their children to school, so that (*NI*, NE^0, *NE*) is the SPE of the game. In this case, both workers and capitalists resist education.

In order to summarize the above results, it is useful to provide a graphical representation of the possible equilibrium outcomes. Denote with *EE*, *II* and IE^0 the loci defined respectively by the following equations:

$$(12) \qquad \frac{\alpha_1}{\alpha_0} = \frac{1}{\rho},$$

$$(13) \qquad \frac{\alpha_2}{\alpha_1} = 1 - \theta + \frac{1+\rho}{\rho} - (1-\theta)\frac{1+\rho}{\rho}\frac{1}{\alpha_1/\alpha_0},$$

$$(14) \qquad \frac{\alpha_2}{\alpha_1} = \frac{\rho+\theta}{\rho\theta} - \frac{1-\theta}{\theta}\frac{1}{\alpha_1/\alpha_0},$$

in the $(\alpha_1/\alpha_0, \alpha_2/\alpha_1)$ space. Notice that *II* and IE^0 are derived by equations (10) and (11). Figure 2 depicts the three loci for $0 < \theta < 1$ and $\theta + \rho < 1$ in the relevant area defined by (9). By inspection of this figure, we can restate the above results as follows:

Proposition 2. The *II*, *EE* and IE^0 loci identify four regions. To the left of *EE*, there is partial child labour (only capitalists' children go to school) above the

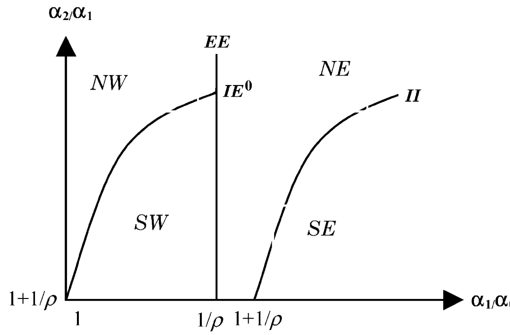

FIGURE 2. The equilibrium ($0<\theta<1$)

IE^0 locus (region *NW*) and complete child labour below it (region *SW*). To the right of *EE*, there is no child labour above the *II* curve (region *NE*) and complete child labour below it (region *SE*).

Notice that while in region *SE* child labour is the result of firm's resistance to innovation (since the price–cost margin after innovation is low relative to the current one), in region *SW* both workers and capitalists resist education and innovation (the wage increase is also low). Moreover, even if in region *NW* the (profit) gain from innovation is high enough to make updating beneficial for the capitalists, wage growth following innovation is not high enough to make education beneficial for the workers. In this case child labour occurs among workers notwithstanding the firm's willingness to innovate.

As anticipated, some discussion of exogenous patent duration should be granted as some of the foregoing results may not hold in that case. In particular, since we do not model enforcement costs explicitly, it is worthwhile highlighting precisely which results would not stand. First, a patent could last for one period only, regardless of whether or not innovation takes place. In this case the monopolist would always innovate, and this would reduce the set of possible outcomes by eliminating regions *SE* and *SW*. Second, a patent could last for two periods. Then workers would never invest in education and this would also reduce the set of possible equilibria by ruling out regions *NE* and *SE*. Thus, the crucial inefficiency that survives alternative modelling choices is the one associated with region *NW*, where child labour occurs despite the firm's propensity to innovate.

IV. The Role of Property Diffusion

Let us now analyse how the equilibrium characterization depends on the degree of property diffusion of the monopolistic firm θ. Comparative statics results are summarized by Figure 3.

On the one hand, as θ increases, making property more diffuse and each owner's share smaller, the *II* locus rotates clockwise around point $(1+1/\rho, 1+1/\rho)$ and becomes flatter, reaching $\alpha_2/\alpha_1 = 1+1/\rho$ as θ tends to 1. *Ceteris paribus*, this makes region *NE* larger (and region *SE* smaller). On the other hand, the IE^0 locus rotates clockwise around point $(1, 1+1/\rho)$ and becomes

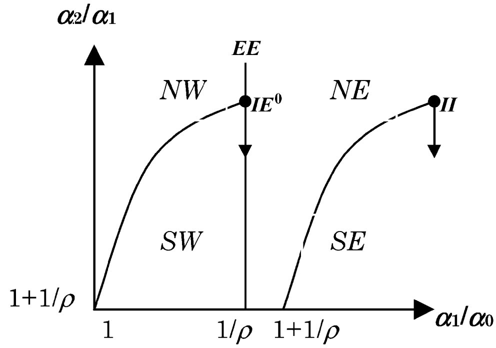

FIGURE 3. The equilibrium (θ grows)

flatter, also reaching $\alpha_2/\alpha_1 = 1 + 1/\rho$ as θ tends to 1. *Ceteris paribus*, this makes region *NW* larger (and region *SW* smaller).

In order to understand the effect of changes in θ on the *II* locus, notice that (13) can be rewritten as

$$[\rho\alpha_1 - (1+\rho)\alpha_0] + (1/\theta)[\rho(\alpha_2 - \alpha_1) - (1+\rho)(\alpha_1 - \alpha_0)] = 0, \tag{15}$$

where the first term represents the net discounted gain (or loss) from innovation for capitalist households deriving from wage growth and the second term represents the net gain (loss) deriving from profit growth.

When the first term is negative (positive), an increase in θ implies that a higher (lower) net gain from profit growth is required for the above equation to be satisfied. For example, in region *SE* innovation favours capitalists in terms of wages, but hurts them in terms of profits. Thus, when the weight of profit income decreases (θ increases), a smaller gain from wage growth is necessary to compensate capitalists for the profit loss. Hence region *SE* shrinks as θ increases (given $(\alpha_1 - \alpha_0)$, $(\alpha_2 - \alpha_1)$ must decrease).

In the limit case where $\theta = 1$ (i.e. the property of the firm is perfectly diffused), the IE^0 and *II* loci both collapse to $\alpha_2/\alpha_1 = 1 + 1/\rho$, and the *EE* locus becomes irrelevant since there are no 'pure' workers. Therefore, innovation always takes place and child labour disappears. In other words, an egalitarian distribution of the firm's ownership would enhance efficiency by eliminating child labour and implementing the efficient outcome.

In a different framework, Rogers and Swinnerton (2001) and Swinnerton and Rogers (1999) also discuss the relationship between firm property diffusion (equality) and child labour incidence. In their analysis, a reduction in inequality can raise poor families' incomes above the subsistence level and permit them to withdraw chidren from work. Our point is quite different. More diffused property of the firm reduces child labour because it tends to remove the distributional conflict regarding innovation and education between workers and capitalists.

In the limit case where $\theta = 0$, the IE^0 locus is no longer relevant and the *EE* and *II* loci divide the space in three regions (see Figure 4). An equilibrium with (complete) child labour and no innovation occurs in all regions but one, that is the region to the right of *EE* and above *II* (region NE'), where the monopolistic firm innovates and workers send children to school. In region SE', that is to the

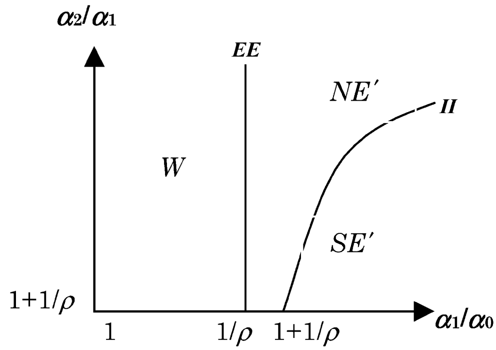

FIGURE 4. The equilibrium ($\theta = 0$)

right of *EE* and below *II*, child labour occurs because the monopolist resists innovation (profits after innovation are low relative to the current level). In region *W*, that is to the left of *EE*, child labour occurs because workers are not willing to educate their children (wage growth following innovation is small).

V. POLICY ANALYSIS

Figure 2 reveals that there are three sources of inefficient child labour, depending on the combinations of α_1/α_0 and α_2/α_1. In region *NW* in equilibrium there is technological update but only capitalists educate their children ('elitarian push'). In region *SW*, workers' opposition to education forces all children to work ('educational impasse'). In region *SE*, it is capitalists' opposition to innovation that forces all children to work ('technological impasse'). Therefore, in all three regions there is scope for government intervention.

To analyse government intervention, let us add an initial stage to the previous two-stage game. In the initial stage the government announces its economic policy (to which it is committed) in order to achieve the efficient allocation (I, E^0, E). In the second and third stages, after being informed about government policy, capitalists and workers choose their optimal actions, in order to maximize their welfare.

As discussed above, in each region of Figure 2 the inefficiency of the equilibrium originates from different sources; thus, the appropriate government policy will depend on parameter values. In particular, since in regions *NW* and *SW* the inefficiency stems from the fact that workers do not find it worthwhile to educate their children, optimal intervention entails a subsidy to education financed through lump-sum taxation on capitalists (or, equivalently, on profits). Indeed, in both cases universal education would allow the capitalists fully to reap the benefits of technological innovation, in terms of higher profits.

Meanwhile, in region *SE* the source of inefficiency is the capitalists' unwillingness to innovate. In this case optimal intervention entails a subsidy to innovation funded through lump-sum taxation on workers (or, equivalently, on wages).

Let us now calculate the minimum subsidy that implements the efficient allocation.

Region NW: Elitarian push

Assume that the government announces that it will pay a subsidy to *every* household (whether capitalist or worker) that sends its children to school. The minimum net subsidy received by workers must be such that they are indifferent between outcome (*I*, E^0, *NE*) and outcome (*I*, E^0, *E*). Given the payoffs associated with these outcomes, straightforward calculations show that the total subsidy that has to be paid to all households is $S = n(\alpha_0 - \rho\alpha_1)$. Since this subsidy is financed through lump-sum taxation on profits, the *net* amount paid by capitalists (that is, the subsidy received by workers) is $(1-\theta)n(\alpha_0 - \rho\alpha_1)$. Formally, if we denote the action of the government with a^g, we can write $a^g = (S,\ T_\pi) = [n(\alpha_0 - \rho\alpha_1), n(\alpha_0 - \rho\alpha_1)]$, where T_π is the tax on profit. We see immediately that, given a^g, the equilibrium outcome of the three-stage game is (*I*, E^0, *E*) and every player is at least as well off as in the two-stage game in which the government was inactive.

Region SW: Educational impasse

Again, assume that the government pays a subsidy to *every* household that sends its children to school. The net subsidy received by workers must be such that they are indifferent between outcome (*NI*, NE^0, *NE*) and outcome (*I*, E^0, *E*). Thus, the total amount of the subsidy to be paid is $S = n(\alpha_0 - \rho\alpha_1 + \rho\alpha_0)$. This subsidy is financed through lump-sum taxation on profits. Thus the *net* amount paid by capitalists is $(1-\theta)n(\alpha_0 - \rho\alpha_1 + \rho\alpha_0)$. In this case, $a^g = (S,\ T_\pi) = [n(\alpha_0 - \rho\alpha_1 + \rho\alpha_0), n(\alpha_0 - \rho\alpha_1 + \rho\alpha_0)]$. Again, given a^g, the equilibrium outcome of the three-stage game is (*I*, E^0, *E*) and every player is at least as well off as in the two-stage game.

Region SE: Technological impasse

Now assume that the government pays a subsidy to capitalists who innovate. The net subsidy received by capitalists must be such that they are indifferent between outcome (*NI*, NE^0, *NE*) and outcome (*I*, E^0, *E*). Since this subsidy is financed through lump-sum taxation on wages, it can be easily verified that the total amount of the subsidy to be paid is $S'/(1-\theta)$, where

$$(16) \qquad S' = (\alpha_1 - \alpha_0)(1 + \rho - \theta\rho) + \theta\alpha_0 - \rho(\alpha_2 - \alpha_1).$$

Once again, given $a^g = (S, T_w) = [S'/(1-\theta), S'/(1-\theta)]$, the equilibrium outcome of the three-stage game is (*I*, E^0, *E*) and every player is at least as well off as in the two-stage game.[3]

Our previous analysis can be used to evaluate one of the most commonly used form of intervention against child labour: compulsory education laws.

On the one hand, in regions *NW* and *SW*, the implementation of legislative measures to eliminate child labour provides the firm with the right incentives to innovate.[4] However, the resulting technological upgrade will benefit the owners of the monopolistic firm at the expense of the workers who are forced to send their children to school. In this case, without any compensation to workers, legislative measures are not Pareto-improving but imply a redistribution of income from workers to capitalists, where the latter enjoy the welfare gain from universal education at zero cost.

From a political economy perspective, the opportunity of such redistribution may justify the political (and economic) support of these measures by the owners of the firms. Weiner (1991) discusses a historical example where the owners of the firms were in favour of the introduction of legislative measures against child labour. According to him, 'in India the proprietors of large businesses have not opposed child-labour laws. One of the complaints of managers of large firms is that their labour force is not sufficiently educated, that too many workers are unable to read manuals or follow the simple instructions written on machines.' Galor and Moav (2000) provide several historical examples to argue that in the second phase of the Industrial Revolution 'the capitalists were among the prime beneficiaries of the potential accumulation of human capital by the masses', so that they had the incentives to support public education financially. Indeed, in our model the capitalists could attain the efficient outcome (I, E^0, E) in the absence of any government intervention by voluntarily devoting part of their income to financing education.

On the other hand, notice that in region SE compulsory schooling legislation alone would bring about a welfare loss for *all* agents, since every child would be forced to go to school but firms would still not find it profitable to innovate. In this case, from a political point of view, legislative measures aimed at reducing the incidence of child labour would be hard to implement in the absence of innovation subsidies.[5]

VI. Conclusions

By focusing on poverty and the determinants of the supply of child labour, the recent literature has tried to assess the welfare consequences of government intervention aimed at the reduction or elimination of the phenomenon. This paper adds to the literature by supplementing the analysis with an investigation of the determinants of the demand of the firm for child labour. More specifically, we have studied the relationship between technological innovation, education and child labour in a setting where the returns to education depend on the level of technology and the profitability of technological upgrade depends on the quality of the labour force.

Our framework allows us to derive clear-cut welfare implications of public intervention in the area of child labour. In general, we have shown that legislative intervention (i.e. child labour bans and compulsory education laws) cannot be Pareto-improving unless some kind of redistribution from the owners of the firm to the workers also takes place. Moreover, there are cases where legislation alone decreases the welfare of *all* agents, since it does not provide the right incentives for the firm to innovate. In this case the optimal policy would be to subsidize technological upgrade. We have also shown that a larger diffusion of firm ownership could reduce child labour and enhance efficiency by mitigating the distributional conflict between workers and firm owners.

The simplicity of the framework also shows a potential for fruitful extensions. First, our model could be extended to a multi-period setup. This would allow one to fully capture the long-run consequences of child labour and public intervention on human capital accumulation and economic development. Second, it could be enriched from a political economy point of view to investigate the role of different institutional mechanisms in mediating the conflicting interests of households and firms.

APPENDIX: THE PAYOFFS OF THE GAME

Workers' payoffs

$A \equiv (1-\theta)\alpha_0(1+\rho n)$ associated to outcome (NI, E^0, E)
$B \equiv (1-\theta)\alpha_0(1+\rho n)$ associated to outcome (NI, NE^0, E)
$C \equiv (1-\theta)\alpha_0[1+(1+\rho)n]$ associated to outcome (NI, E^0, NE)
$D \equiv (1-\theta)\alpha_0[1+(1+\rho)n]$ associated to outcome (NI, NE^0, NE)
$K \equiv (1-\theta)(\alpha_0+\rho\alpha_1 n)$ associated to outcome (I, E^0, E)
$F \equiv (1-\theta)(\alpha_0+\rho\alpha_1 n)$ associated to outcome (I, NE^0, E)
$G \equiv (1-\theta)\alpha_0(1+n)$ associated to outcome (I, E^0, NE)
$H \equiv (1-\theta)[\alpha_0(1+n)+\rho\alpha_1 n]$ associated to outcome (I, NE^0, NE)

Capitalists' payoffs

$$A^0 \equiv \theta\alpha_0(1+\rho n)+(1+\rho n)(\alpha_1-\alpha_0)$$
$$B^0 \equiv \theta\alpha_0[1+(1+\rho)n]+(\alpha_1-\alpha_0)[1+(\rho+\theta)n)]$$
$$C^0 \equiv \theta\alpha_0(1+\rho n)+(\alpha_1-\alpha_0)[1+(1+\rho-\theta)n]$$
$$D^0 \equiv \theta\alpha_0[1+(1+\rho)n]+(\alpha_1-\alpha_0)[1+(1+\rho)n]$$
$$K^0 \equiv \theta(\alpha_0+\rho\alpha_1 n)+(\alpha_1-\alpha_0)+\rho(\alpha_2-\alpha_1)n$$
$$F^0 \equiv \theta\alpha_0(1+n)+(\alpha_1-\alpha_0)(1+\theta n)+\rho(\alpha_2-\alpha_1)(1-\theta)n$$
$$G^0 \equiv \theta(\alpha_0+\rho\alpha_1 n)+(\alpha_1-\alpha_0)[1+n(1-\theta)]+\rho(\alpha_2-\alpha_1)\,\theta n$$
$$H^0 \equiv \theta\alpha_0(1+n)+(\alpha_1-\alpha_0)(1+n)+\rho\theta\alpha_1 n$$

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NOTES

1. See e.g. Baland and Robinson (2000), Dessy (2000), Ranjan (2001), Rogers and Swinnerton (2001) and Swinnerton and Rogers (1999). An exhaustive survey of the literature on the economics of child labour can be found in Basu (1999).
2. Given linear utility, in our model the absence of capital markets is not the source of child labour but only a simplifying (realistic) assumption. For an analysis in which child labour arises because of credit constraints, see Ranjan (2001).
3. In all three cases, the Pareto improvement has been achieved by government intervention. In principle, it could be achieved also through private initiative. For example, when the inefficiency arises because of the workers' unwillingness to invest in education, capitalists could solve the problem by directly funding education. In practice that may be difficult to achieve, owing to a free-rider problem among the capitalists.
4. In this paper we abstract from the problem of enforceability and implementability of legislative measures. For an analysis of the role of legislation enforcement in the fight against child labour, see Bellettini and Berti Ceroni (2004).
5. Indeed, subsidies alone would achieve efficiency even without compulsory schooling legislation.

REFERENCES

BALAND, J-M. and ROBINSON, J. A. (2000). Is child labour inefficient? *Journal of Political Economy*, **108**, 663–79.

BASU, K. (1999). Child labour: cause, consequence, and cure, with remarks on international labour standards. *Journal of Economic Literature*, **37**, 1083–1119.

——— and VAN, P. H. (1998). The economics of child labour. *American Economic Review*, **88**, 412–27.

BELLETTINI, G. and BERTI CERONI, C. (2004). Compulsory schooling laws and the cure against child labour. *Bulletin of Economic Research*, **56**, 227–39.

DESSY, S. E. (2000). A defense of compulsory measures against child labour. *Journal of Development Economics*, **62**, 261–75.

——— and PALLAGE, S. (2001). Child labour and coordination failures. *Journal of Development Economics*, **65**, 469–76.

DINOPOULOS, E. and SEGERSTROM, P. (1999). A Schumpeterian model of protection and relative wages. *American Economic Review*, **89**, 450–72.

GALBI, D. A. (1997). Child labour and the division of labour in the early English cotton mills. *Journal of Population Economics*, **10**, 357–75.

GALOR, O. and MOAV, O. (2000). *Das Human Kapital*. Brown University Working Paper no. 2000-17.

ILO (1998). *Report VI (1): Child Labour: Targeting the Intolerable*. Geneva: ILO.

LEVY, V. (1985). Cropping pattern, mechanization, child labour, and fertility behavior in a farming economy: rural Egypt. *Economic Development and Cultural Change*, **33**, 777–91.

MURPHY, K. M., SHLEIFER, A. and VISHNY, R. W. (1989). Industrialization and the Big Push. *Journal of Political Economy*, **97**, 1003–26.

RANJAN, P. (2001). Credit constraints and the phenomenon of child labour. *Journal of Development Economics*, **64**, 81–102.

ROGERS, C. A. and SWINNERTON, K. A. (2001). Inequality, productivity, and child labour: theory and evidence. Mimeo.

SWINNERTON, K. A. and ROGERS, C. A. (1999). The economics of child labour: comment. *American Economic Review*, **89**, 1382–5.

WEINER, M. (1991). *The Child and the State in India: Child Labour and Education Policy in Comparative Perspective*. Princeton: Princeton University Press.