Child Quality, Child Labor, Fertility and Economic Growth[1]

Gaston Yalonetzky
University of Oxford

Resumen

Este paper estudia implicaciones dinámicas de aquellas decisiones del hogar que determinan la fecundidad y la acumulación de capital humano, vía la asignación de tiempo infantil y de recursos para componentes de calidad infantil como la nutrición; se concentra en los vínculos entre estas decisiones y el proceso de desarrollo económico. El énfasis se encuentra en la calidad infantil porque aun no ha sido tratado en un contexto dinámico junto con la asignación de tiempo infantil y debería ser considerado puesto que explícitamente permite contemplar la posibilidad de que el capital humano sea acumulado mas allá del punto en que el trabajo infantil es eliminado y aun mas allá de cuando la transición demográfica es concluida. El paper también ilustra un problema de equivalencia observacional por el cual tanto modelos unitarios basados en altruismo paterno como aquellos en el que esta ausente pueden generar cualitativamente los mismos diagramas de fase para la acumulación de capital humano así como otras decisiones del hogar. Finalmente, los dos modelos desarrollados en este paper son contrastados con la teoría de transición demográfica de Caldwell, la cual presta importancia a la dirección del flujo de intergeneracional de riqueza como determinante clave del régimen de fecundidad. El paper sugiere que en lugar de estar vinculados por una relación de causalidad, ambos fenómenos son mutuamente endógenos.

Palabras clave: Calidad infantil, capital humano, fertilidad, crecimiento económico
Códigos JEL: J13, O41

1. This article is based on an extended essay I submitted to obtain my degree of MSc in Economics for Development, in June, 2004. It received a special mention as «Proxime Accessit» to the Luca d'Agliano award for best extended essay of the MSc in Economics for Development. I appreciate the substantial comments made by Elizabeth Robinson and the positive review from the Editorial committee of Revista Apuntes (Research Centre of Universidad del Pacífico, CIUP, Lima, Perú), led by Professor Enrique Vásquez, as well as the helpful observations of his editorial assistants.

Abstract

In this paper I study the dynamic implications of household decisions that determine fertility and human capital accumulation with a theoretical model built on that of Hazan and Berdugo (2002). The links between the allocation of children's time, together with material resources towards child quality components, such as nutrition and the process of economic development, are explored. I give emphasis to investment in child quality because it has not previously been treated together with allocation of children's time in a dynamic setting. However these need to be dealt with together since they enable us explicitly to consider the possibility that human capital can be accumulated beyond the point at which child labor is effectively (rationally) eliminated, and even beyond that when fertility transition is concluded. I also show that this result can hold even in the absence of altruistic parents (in a unitary framework). Finally I show with these models that Caldwell's hypothesis about the correlation between intergenerational flows of resources and fertility regimes can be explained as being mediated by earning opportunities in educationally-intensive sectors which in turn influence parental incentives to invest in child quality.

Keywords: Child quality, human capital, fertility, economic growth
JEL Codes: J13, O41

MOTIVATION

The poorest countries in terms of per capita income tend to exhibit relatively high fertility rates, substantial incidence of child labor, low measures of schooling achievement, low child quality (as measured by child mortality rates or different indicators of malnutrition), and a sector composition of employment tilted towards agriculture and/or away from industry. The opposite is true of the richest countries: very low fertility rates, sometimes below replacement levels, nil child labor, high living standards for children, relatively high schooling achievement and a sector composition exhibiting an already advanced transition along the production Engel curve towards services. Many of these stylized facts[2] are clearly related to one another. For instance, as long as child labor is characterized by low productivity and hence is likely to be concentrated among households practicing traditional agriculture and among the urban poor, countries with more labor in industry and/or less labor in agriculture are less likely to exhibit significant child labor incidence. The literature has long acknowledged though that the aforementioned phenomena relate to each other in a complex manner[3].

This paper is concerned with the dynamic implications of household decisions that determine fertility and human capital accumulation (via the allocation of children's time and of resources towards components of child quality such as nutrition) and with the links between such decisions and the process of economic development, including technological change. The emphasis is placed on investment in child quality, because as yet it has not been treated together with allocation of children's time in a dynamic setting. This, as this paper seeks to show, needs to be taken into account since it explicitly allows us to consider the possibility that human capital can be accumulated beyond the point when child labor is effectively eliminated, and even beyond that when fertility transition is concluded, depending on parameters governing fertility decisions. Furthermore the inclusion of child quality sheds light on further complexities regarding household behavioral responses to policies aimed at lifting societies out of development traps by enforcing compulsory schooling with intergenerational transfers. Special attention is also placed on the importance of social norms because, as this paper proves, different implicit (or not) social norms underlying models of human capital accumulation, fertility behavior and economic growth, can lead to the same behavioral outcomes and development paths, even when neither of these may mesh with actual stages of historical experience, especially when

2. For an overview of them see *The World Bank, The World Development Indicators 2004*, Washington D.C.: The World Bank (2004).
3. For instance, in middle-income countries and former communist societies, fertility is quite low even without having reached the stages of economic development of developed, high-income countries.

these norms are deemed time-invariant. This paper proves this point by comparing the phase diagram for human capital of a unitary model based on parental altruism with that of a unitary model with social norms that stipulate old-age transfers to parents from children. Finally, I use these models to illustrate Caldwell's theory of demographic transition and show that the correlation between fertility regimes and intergenerational flows of wealth is mediated by earning opportunities in educationally-intensive sectors which in turn influence parental incentives to invest in child quality.

To make sense of such trends several studies have been published focusing on fertility, economic growth and human capital accumulation. That of Becker, Murphy and Tamura stresses the importance of human capital: «Since human capital is embodied knowledge and skills, and economic development depends on advances in technological and scientific knowledge, development presumably depends on the accumulation of human capital». (1990:13). Their emphasis on the inverse relationship between human capital accumulation and fertility, due in part to the time cost of child rearing, is a fundamental theoretical conclusion so far unchallenged. Yet the finest example hitherto of a unified theory of demographic transition, endogenous technological change and human capital accumulation can be found in Galor and Weil (2000), although their framework –as acknowledged by the authors– is better suited to explain European economic history. Unlike Becker et al., who regard human capital as education, health, on-the-job training, etc., Galor and Weil consider child quality as education, and thus an input of human capital, while Morand (1999) regards it as human capital itself. In this paper, child quality will be considered in the Becker tradition, as established in Becker (1983) and Becker and Lewis (1973), and followed up in Becker *et al.* (1990).

It is only recently that this literature on human capital accumulation has considered child labor in the context of discussions about economic growth. Most studies on child labor are static, micro-econometric assessments. They normally conclude that child labor should be considered jointly with school attendance and that, since the relationship usually turns out negative, it may affect schooling achievement[4]. Therefore, child wages can affect negatively the prospects for human capital accumulation while encouraging fertility, as confirmed empirically by Rosenzweig (1990). The author develops a model with parental altruism, child labor, child quality, human capital and intergenerational transfers from which he derives many testable implications of that sort. He also finds a positive effect of parental income on school attendance thus providing indirect evidence to one of two key assumptions made by Basu and Van (1998), namely, the luxury axiom whereby: «A family

4. Child labor stands as a major reason preventing children from attending school or compelling them to drop out according to Caldwell, Reddy and Caldwell (1985).

will send the children to the labor market only if the family's income from non-child-labor sources drops very low» (p. 416). Together with the substitution axiom, «From a firm's point of view, adult labor and child labor are substitutes», they can lead to multiple equilibria in the labor market, some of them featuring child labor. Hence, certain economic conditions may be conducive to the incidence of child labor, thereby probably hampering the process of human capital accumulation. This is the suggestion of many of these studies, such as Basu (1999), in which dynamic poverty traps are characterized by the intergenerational pervasiveness of child labor.

Few studies, however, analyze theoretically the dynamic consequences of child labor. Even models by Rosenzweig (1990), Baland and Robinson (2000), and Glewwe (2002) are static and assume a one-sector economy. Hazan and Berdugo (2002) made an attempt with a model which, as many others, assumes parental altruism ruling along different stages of development. Most models assume these rigid social norms, the exception being Becker et al. which assumes greater flexibility in their dynastic setting. More critically, Hazan and Berdugo's model does not consider investments in child quality and its effect on human capital accumulation.

Child quality can be defined in a narrow sense to include nutrition, clothing and other determinants of health, or in a broader sense as all those different aspects of well-being which are likely to favor human capital accumulation in children. It has been studied in both static and dynamic settings, but seldom being combined with child labor as joint determinants of human capital, the exception being Rosenzweig (1990)[5]. The multiple implications of child quality for development have been discussed but with respect to health and nutrition, forms of human capital which are complementary to education as human capital (Becker 1983). But health, nutrition and education can also be regarded as inputs of human capital if the latter is understood as units of «efficiency» labour which is productive in modern sectors, as we do in this paper. The importance of components of child quality such as nutrition has been clearly established: health affects productivity (Strauss and Thomas 1998), nutrition improves schooling achievement (Behrman 1996), early nutrition improves subsequent productivity (Alderman *et al.* 2001) and current nutrition can affect labor «power» (Dasgupta and Ray 1986). Hence this paper's first objective is to account for the dynamic importance of investment in child quality for human capital accumulation and economic development. To this end, I extend Hazan and Berdugo's model (Hazan and Berdugo 2002), taking advantage of its two-sector framework. This is fundamental since child labor is confined to low-productivity «traditional» sectors like low-technology

5. Moav (2005) was published after this paper was originally written but it analyses the dynamics of child quality without simultaneous reference to child labor.

agriculture and some urban services, whereas human capital regarded as «efficiency» labor is more likely to be relevant in so-called modern sectors.

In a subsequent section, the importance of child quality and child labor when children are demanded as both «producer» (child labor) and «insurance goods», in Dasgupta's (1993) terms, is discussed. For that purpose, a second model is developed, keeping some of the traits of the first but resorting to a utility function specification more similar to that of Morand (1999). The focus will be on the trade-offs faced by families that demand children as young laborers and pension providers once child quality is considered together with child labor. This section provides yet another example of a well-known problem of observational equivalence whereby the stylized facts are consistent with either model and therefore do not provide conclusive evidence for either of the models' underlying social norms and/or preferences, namely, parental altruism or contributions to old-age.

The paper also addresses the implications of technological change. If population growth leads to a technological take-off at some point, then a development trap may just be a pseudo steady state followed eventually by economic growth (Galor and Weil 2000). The inclusion of child quality implies that human capital accumulation may continue beyond the elimination of child labor and even possibly beyond the fulfilment of the demographic transition; so two high-per-capita-income steady states are possible. Thus the results in this paper are different to those of technological change in Hazan and Berdugo. A policy exercise is also conducted, considering that child labor may prove dynamically Pareto-inefficient (however rational it may be from a household perspective), and therefore some sort of policy intervention could yield improved welfare[6]. This paper shows that policymakers attempting a Becker-Murphy transfer with compulsory schooling will need to take account of the household's optimal response in terms of child quality.

Finally, the two models developed in this paper are used formally to discuss Caldwell's theory of demographic transition. The relationship between fertility and intergenerational flows of wealth is addressed and shown to be mediated by the incentives to invest in children's human capital. Conclusions follow with a critique of the theoretical literature for assuming time-invariant social norms and preferences, which may be endogenous and dependent on stages of development.

6. For a discussion of the conditions under which child labor can be socially inefficient see Baland and Robinson (2000).

1. THE MODELS[7]

a. Common features

An economy of overlapping generations, open and hence subject to the international interest rate, is assumed as in Hazan and Berdugo (2002). A single composite good is either consumed or converted into capital so as to support future consumption; it can be produced in two perfectly substitute sectors. In the traditional sector only raw labor, L, is employed with constant marginal productivity, w_c, according to the production function:

$$Y_{T,t} = w_c L_t \tag{1}$$

The modern sector employs efficiency labor, H, physical capital, K, and is likely to benefit from technological improvement, reflected by changes in λ, the level of technology, which is normalized to unity in the absence of any change. Its production function satisfies all neo-classical properties:

$$Y_{M,t} = F(K_t \lambda H_t) \tag{2}$$

Therefore, if $k = \frac{K_t}{\lambda H_t}$, then:

$$\bar{r} = \frac{\partial Y_M}{\partial K} = F'(k) \tag{3}$$

And hence the exogenously given world interest rate, r, will fix the ratio of capital to efficiency labor.

Accordingly:

$$\bar{w} = \frac{\partial Y_M}{\partial \lambda H} = F(\bar{k}) - \bar{k}F'(\bar{k}) \tag{4}$$

So the wage in the modern sector for one unit of efficiency labor will also remain constant, provided the technological level is unaffected[8]. Now, given the perfect substitutability of sectors, individuals will opt to work in the sector that yields them the higher income. Hence their earnings will be determined by the following rule:

$$l_t = \max(\bar{w}h_t, w_c) \tag{5}$$

7. Some notation follows Hazan and Berdugo to allow for comparability.
8. Properly, $w_t = \lambda_t \bar{w}$, but, as stated, λ is normalized to unity if no change is assumed to happen.

Finally, people have a single parent and live through three periods. During their first period, «childhood», they can either work or attend school or both. During «adulthood» they choose a sector to work in, and decide on the number of children they will have, the allocation of their offspring's time, and resources devoted to them. Since child rearing consumes adult time, once the number of children is decided, the remaining time is exclusively assigned to work. And during the third, «elderly» period, they consume the savings they have amassed during adulthood.

b. Accounting for child quality

The model extends that of Hazan and Berdugo (2002) by including child quality as a new household's decision variable. In this model, unlike Becker and Lewis (1973), child quality is not directly desired by the parent but it is an indispensable input in the production of child human capital and hence for participating in the modern sector. Thereby the notion of child quality, embodying a nutritional dimension, is included to account for the impact of child wellbeing on human capital accumulation through its effect on the development of cognitive skills and, accordingly, school performance.

Parents are altruistic towards their offspring; they draw utility from both the number of children, n_t they have and from their children's welfare prospects as measured by future potential income, l_{t+1}. Consumption, C, is relegated to the elderly period for the sake of simplicity. Formally, the utility function of a member of the t cohort is given by:

$$U^t = \alpha Ln\,(C_{t+1}) + (1-\alpha)\,Ln\,(n_t l_{t+1}) \qquad (6)$$

All children are regarded equally by their parents, who allocate a fraction θ_t of their children's time to schooling and the remainder to work in the traditional sector. A version of Basu and Van's substitution axiom is also present, reflected by $0<\theta<1$[9]. Fertility is assumed to bear a fixed cost in terms of time needed to raise one child, z, which entails foregone earnings for parents. But, unlike Hazan and Berdugo, this is not regarded as the sole input for childrearing. Parents also face a decision regarding the investment they make in their children's life quality. Will they give their children no more than the resources required to subsist, or rather invest substantially in their human capital accumulation by securing the nutrition and health required to perform well at school? The expenditure associated with this decision is included in the budget constraint, following Becker and Lewis' simplest budget characterization of the interaction between the «quantity» and the quality of

9. Hazan and Berdugo do not state inequality explicitly, yet it becomes patent once they define their first assumption, which will be considered here as well (see Hazan and Berdugo 2002: 814-815).

children. Since all children are deemed «equal», they enjoy the same quality of life during childhood, q_t. Hence, the adulthood budget constraint is as follows:

$$(1-zn_t)\, l_t + \theta\ (1-\tau_t)\, n_t w_c = S_t + n_t q_t \pi \tag{7}$$

The left-hand side shows the two sources of income, i.e., adult earnings, net of time costs of childrearing, and child labor revenues. These are partly used to fund child quality, while the rest is saved in order to finance consumption in old-age. All variables are measured in terms of the single good with the exception of the expenditure on child quality, featuring a relative price, π, attached to it (Becker and Lewis 1973). This therefore acknowledges that the good consumed by children may be a different composite one as to that consumed by adults. In addition, both could be alternatively thought of as different bundles. Consider, for instance, the costs of schooling but also those of special health care, nutritional inputs, etc. Thus π could just be an expression of the «transformation ratio» between adult consumption goods and child quality build-up[10]. To complete the inter-temporal budget constraint, the old age component is added, basically stating that consumption is financed out of savings, including earned interest:

$$C_{t+1} = S_t(1+r) \tag{8}$$

Human capital acquisition of a member belonging to the t+1 cohort is a function of the time allocated to schooling and of child quality, both determined by the parent in period t[11]:

$$h_{t+1} = \tau_t^{\gamma} q_t^{\delta} \tag{9}$$

$$1-\gamma-\delta > 0^{12}$$

Consequently, investment in child quality, in this context, may be appealing as long as it can boost children's future well-being[13]. Considering the relevant constraints along with the human capital production function, the parent must choose during adulthood the quantity

10. If child-rearing also entails costs in terms of this composite good by, say, stressing the importance of a minimum nutritional subsistence level, then the expression could be augmented with a $\bar{q}$ element added to q_t and standing for this minimum survival intake, which may be expected to show up only in the reduced form, behavioral equation of fertility.
11. Glewwe (2002) uses a very similar approach to define a function of cognitive skills depending on school quality and years of schooling (p. 440).
12. So as to avert non-stationary behavior. Notice that productivity-improving technological and institutional factors could also be included in that specification in order to address the theoretical implications of policies aimed at improving the quality of the educational system.
13. Thus the model replicates both the utility side and budget side of the quantity-quality interaction as laid out by Becker and Lewis (1973).

and quality of children as well as the allocation of their time which together solve the following optimization problem:

$$(n_t, \tau_t, q_t) = \text{argmax}\left\{\alpha \ln\left[(1+\bar{r})\left((1-zn_t)\,l_t + \theta\,(1-\tau_t)\,n_t w_c - n_t q_t \pi\right)\right] + (1-\alpha)\ln\left(n_t l_{t+1}\right)\right\}$$

s.t.

$$0 \leq \tau_t \leq 1$$

$$0 \leq n_t \leq \frac{1}{z} \qquad (10)$$

$$0 \leq q_t$$

The following assumption is required to ensure that the parent opts to work even at the highest level of fertility consistent with utility maximization:

$$z\left[\alpha + (1-\alpha)(\gamma + \delta)\right] > \theta$$

Moreover, if the upper bound for fertility is realistically set above one (so that $z<1$) then the left-hand side of inequality will be lower than one, as implied by the utility function and the properties attributed to the human capital production function. Hence the assumption rules out any alternative to Basu's substitution axiom.

The model is solved first by parents' sector choices. These are based on their human capital and are prior and so independent of the optimization problem defined in (10). The inverse, though, is not true. The optimization itself relies on a comparison between the prospective earnings of the offspring in each sector. The parent first maximizes (10) assuming that the children will work in the modern sector and so attempting to allocate a positive amount of resources and time to the accumulation of human capital needed to pursue that option. If that decision yields the highest income prospects for children, then the parent will have solved the optimization problem. Otherwise, the parent will opt not to invest in child quality and will devote all the children's time to work in the traditional sector. Consequently, the only choice left will be that of fertility and so accordingly the parent will maximize (10) with respect to n_t.

i. Results

Human capital accumulation depends on the magnitude of the exogenous parameters. If, at the lowest level of parental income, the optimal investment of time and resources in

human capital enables the children to work in the modern sector when grown up, then human capital accumulation takes place regardless of parental income and across all generations because children's human capital increases monotonically with parental income in that situation. However if, according to a given set of values of parameters, a minimum threshold of human capital accumulation is required to surpass the level of income provided by the traditional sector so as to render the investment worthwhile, then time devoted to schooling as well as investment on child quality may not be optimal at levels of household resources below that which is consistent (given the characteristics of the optimization process), with the minimum threshold level of human capital.

Formally the situation of allocation of resources to human capital build-up irrespective of parental income requires the following condition:

$$\bar{w}\left(\frac{z-\theta}{1-\gamma-\delta}\right)^{\gamma+\delta}\left(\frac{\gamma}{\theta}\right)^{\gamma}\left(\frac{\delta w_c}{\pi}\right)^{\delta} > w_c \qquad \text{(condition I)}$$

Notice that this condition is but a comparison between $\bar{w}\bar{h}_{t+1}$ and w_c, where the «hat» denotes the level of the offspring's human capital that would ensue from the optimal choices of fertility, child quality and time devoted to schooling made by the parent. In the case of the condition, the relevant choice in question is that made by the household with the lowest level of resources. If future income stemming from the modern sector is higher than that accrued in the traditional sector, even at the lowest level of parental income, then human capital accumulation occurs irrespective of parental income.

If that is the case, then optimal choices of child labor, child quality and fertility are given by equation (11):

If	(11a) $\tau_t^* =$	(11b) $q_t^* =$	(11c) $n_t^* =$
$h_t < \frac{w_c}{\bar{w}}$	$\frac{\gamma(z-\theta)}{\theta(1-\gamma-\delta)}$	$\frac{\delta(z-\theta)w_c}{\pi(1-\gamma-\delta)}$	$\frac{(1-\alpha)(1-\gamma-\delta)}{(z-\theta)}$
$\frac{w_c}{\bar{w}} \le h_t \le \frac{\theta w_c(1-\delta)}{\gamma z\bar{w}}$	$\frac{\gamma(z\bar{w}h_t-\theta w_c)}{\theta w_c(1-\gamma-\delta)}$	$\frac{\delta(z\bar{w}h_t-\theta w_c)}{\pi(1-\gamma-\delta)}$	$\frac{1-\alpha)(1-\gamma-\delta)\bar{w}h_t}{(z\bar{w}h_t-\theta w_c)}$
$\frac{\theta w_c(1-\delta)}{\gamma z\bar{w}} \le h_t$	1	$\frac{\delta z\bar{w}h_t}{\pi(1-\delta)}$	$\frac{(1-\alpha)(1-\delta)}{z}$

All three choices are continuous and also monotonic functions of parental income, which in turn becomes a linear function of the parent's human capital once it surpasses the sector-shift threshold given by $w_c/\bar{w}$. Specifically, the first two are non-decreasing functions while (11c) is non-increasing. A short-term interpretation of equation (11) indicates that as parental income increases household size decreases, child labor falls and eventually disappears. and more resources are directed to improving child quality. Another result, not included in Hazan and Berdugo (2002), is that even after child labor is eliminated human capital accumulation can continue by means of increased child quality.

Should condition I not be fulfilled, the monotonic relationship between parental human capital, parental income and choices on fertility and those directly determining children's human capital, will be affected by a threshold level of parental human capital below which no investment on child quality is made and children work all the time. Hence, as shown by equation 12, optimal resource allocation to children becomes discontinuous and the threshold level of parental human capital, denoted by $\tilde{h}_t$, now matters. Once that threshold is surpassed, the static functional response will be exactly the same as that when condition I holds, i.e. the behavior of a rich household in the second situation is indistinguishable from that of whatever household in the first situation, so long as the parent in the latter is already working in the modern sector. So if condition I is not fulfilled, then only parents who are engaged in the modern sector, and among them only those whose human capital is above the threshold, will have incentives to dedicate time and resources to the build-up of their children's human capital. Defined in terms of exogenous parameters, the threshold will stem again from the comparison between $\bar{w}\tilde{h}_{t+1}$ and w_c, but only that which is relevant for parents working in the modern sector. So a household's choice (and that of a whole cohort if households are identical) to devote resources to the heirs' human capital will depend on initial conditions; and so, say, the higher the unitary cost of child quality then the wealthier, in terms of accrued human capital, the household or cohort will have to be in order to find the investment in their children profitable.

$$\tilde{h}_t = \left(\frac{w_c}{\bar{w}}\right)^{\frac{1}{\gamma+\delta}} \left(\frac{\pi}{\delta}\right)^{\frac{\delta}{\gamma+\delta}} \left(\frac{\theta w_c}{\gamma}\right)^{\frac{\gamma}{\gamma+\delta}} \frac{(1-\gamma-\delta)}{z\bar{w}} + \frac{\theta w_c}{z\bar{w}} > \frac{w_c}{\bar{w}}$$

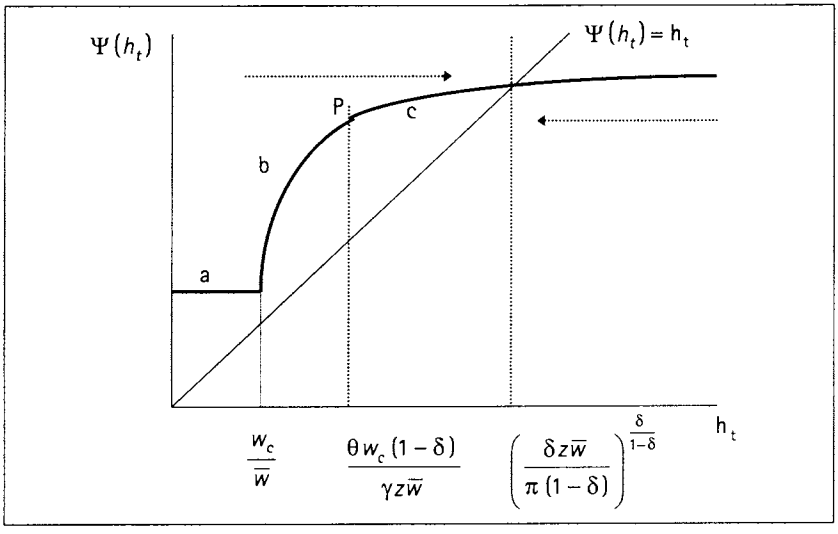
If	(12a) $\tau_t^* =$	(12b) $q_t^* =$	(12c) $n_t^* =$
$h_t < \frac{w_c}{\bar{w}}$	0	0	$\frac{(1-\alpha)(1-\gamma-\delta)}{(z-\theta)}$
$\frac{w_c}{\bar{w}} \leq h_t \leq \tilde{h}_t$			$\frac{(1-\alpha)\bar{w}h_t}{(z\bar{w}h_t-\theta w_c)}$
$\tilde{h}_t \leq h_t \leq \frac{\theta w_c(1-\delta)}{\gamma z\bar{w}}$	$\frac{\gamma(z\bar{w}h_t-\theta w_c)}{\theta w_c(1-\gamma-\delta)}$	$\frac{\delta(z\bar{w}h_t-\theta w_c)}{\pi(1-\gamma-\delta)}$	$\frac{(1-\alpha)(1-\gamma-\delta)\bar{w}h_t}{(z\bar{w}h_t-\theta w_c)}$
$\frac{\theta w_c(1-\delta)}{\gamma z\bar{w}} \leq h_t$	1	$\frac{\delta z\bar{w}h_t}{\pi(1-\delta)}$	$\frac{(1-\alpha)(1-\delta)}{z}$

As for the dynamic implications of the two situations concerning the accumulation of human capital and subsequent pattern of growth in living standards, assuming all households are identical, equations (9) and (11) prove that the human capital of the future generation will be a non-decreasing monotonic and continuous function of the current generation's human capital as long as condition I holds.

As shown in Graph 1 (function h_{t+1}^I), parents working in the traditional sector will allocate a constant amount of resources and children's time to human capital build-up (the first horizontal segment (a)). But once the sector shift occurs, future human capital becomes a positive function of current human capital although increasing at a decreasing rate (notice the $\gamma+\delta$ coefficient). Both these segments (a and b) lie above the 45 degree line according to the upholding of condition I. Therefore human capital accumulation will be positive over time. The trend, however, exhibits a discrete downward change in slope just at the point when child labor is eliminated (point P). Human capital will continue to grow, fuelled by further investment in child quality, though at an ever more decreasing rate (segment (c)). Thereby a steady state, characterized by relatively high human capital and living standards, will finally be reached, even in the absence of technological innovation[14].

14. The latter might provide further incentives to accrue human capital beyond that stead state by feeding the unitary remuneration of human capital, i.e., $\lambda\bar{w}$.

Graph 1 Dynamics of human capital accumulation when condition I holds

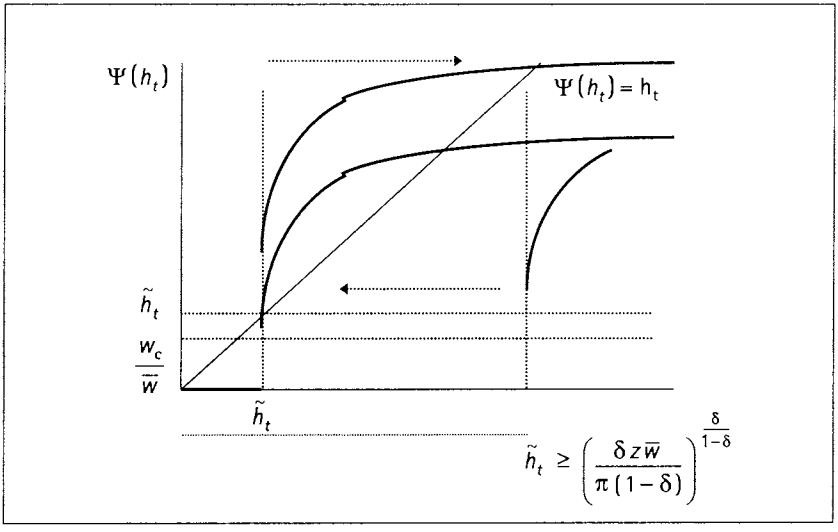


$$h_{t+1}^{I} = \Psi(h_t) = \begin{cases} \left(\frac{z-\theta}{1-\gamma-\delta}\right)^{\gamma+\delta}\left(\frac{\gamma}{\theta}\right)^{\gamma}\left(\frac{\delta w_c}{\pi}\right)^{\delta} & \text{if} \quad h_t < \frac{w_c}{\overline{w}} \\ \left(\frac{z\overline{w}h_t - \theta w_c}{1-\gamma-\delta}\right)^{\gamma+\delta}\left(\frac{\gamma}{\theta w_c}\right)^{\gamma}\left(\frac{\delta}{\pi}\right)^{\delta} & \text{if} \quad \frac{w_c}{\overline{w}} \le h_t \le \frac{\theta w_c(1-\delta)}{\gamma z \overline{w}} \\ \left(\frac{\delta z \overline{w} h_t}{\pi(1-\delta)}\right)^{\delta} & \text{if} \quad \frac{\theta w_c(1-\delta)}{\gamma z \overline{w}} \le h_t \end{cases}$$

When condition I does not hold, the path-dependence of human capital accumulation, derived from equations (9) and (12), is much more sensitive to the initial conditions (i.e. parameter values). And the threshold level of human capital proves critical in determining whether there will be any accumulation of human capital at all. As shown in Graph 2 (function h_{t+1}^{II}), all possible trends, each stemming from a specific vector of parameters, can be classified into three cases. The first two are characterized by a threshold level of human capital slightly above the sector-shift value, $\frac{w_c}{\overline{w}}$. If the first cohort has the threshold level then it will invest in future human capital. Yet a priori the next cohort's

human capital can be either higher or lower than that of its predecessor. The first case is precisely that when, at the threshold level, the immediate future human capital lies above the 45 degree line, a process of accumulation gets started and continues until a steady state is finally reached. In the second case the immediate future human capital could lie below the 45 degree line and a process of disinvestment could follow until another steady state is reached where society is stuck in a development trap with all the population lacking human capital and working in the traditional sector. Should that be the case, the implication is that in order to reach the alternative high-human-capital steady state, the first cohort will have to bear an initial level of human capital even higher than the threshold level. Finally, if the threshold level of human capital is too high, specifically when it is equal or higher than that at the steady state when condition I holds, a third case may arise in which the economy is bound to end up trapped in the long run regardless of the initial level of human capital.

Graph 2 Dynamics of human capital accumulation when condition I does not hold



So development traps characterized by people working on traditional sectors, large households, incidence of child labor, low child quality and human capital, can stem either from a combination of mildly adverse initial parametric conditions (i.e., low threshold level) with low initial human capital, or from severe initial parametric conditions likely to thwart the process of human capital accumulation even at relatively high initial levels.

$$h_{t+1}^{II} = \Psi(h_t) = \begin{cases} 0 & \text{if} \quad h_t < \tilde{h}_t \\ \left(\dfrac{z\bar{w}h_t - \theta w_c}{1-\gamma-\delta}\right)^{\gamma+\delta}\left(\dfrac{\gamma}{\theta w_c}\right)^{\gamma}\left(\dfrac{\delta}{\pi}\right)^{\delta} & \text{if} \quad \tilde{h}_t \leq h_t \leq \dfrac{\theta w_c(1-\delta)}{\gamma z\bar{w}} \\ \left(\dfrac{\delta z\bar{w}h_t}{\pi(1-\delta)}\right)^{\delta} & \text{if} \quad \dfrac{\theta w_c(1-\delta)}{\gamma z\bar{w}} \leq h_t \end{cases}$$

c. A model with reversed altruism

In this section the model is changed to accommodate the possibility of reverse altruism for two reasons: to assess the trade-offs faced by households demanding children as both «producer» and «insurance goods»; and to show that the results discussed in the previous subsection hold even when altruism is reversed and/or the social norm demands transfers from children to parents.

Reliance on the assumption of parent-to-children altruism in order to explain the incentives to invest in child quality and/or children's human capital is common in many models[15]. Even without seeking to challenge the sensibleness of that assumption, the empirical realization of the trends implied by such models[16] provides necessary yet insufficient evidence of the existence of that form of altruism. Parents might be devoting time and resources to the accumulation of human capital driven by different motivations, and should that be the case observational equivalence may render such evidence inconclusive.

Reverse altruism can be rationalized in terms of old-age security; a motivation to have children that is more prevalent in developing societies. Modeling the behavior of children willing to transfer resources to their parents when the former are adult and the latter are old is challenging. From a cultural materialistic perspective, it could be argued that societies where a market or a state arrangement for old-age security is missing tend to develop social norms encouraging concern among the offspring about the former cohort's wellbeing and a sense of duty conducive to the required transfer of resources[17]. Hence a

15. As discussed, for instance, by Becker and Lewis (1973), Becker et al. (1990), Galor and Zeira (1993), Galor and Weil (2000) and Hazan and Berdugo (2002).
16. See, however, Galor and Weil (2000) for a discussion of the empirical evidence.
17. For a discussion of enforcement and other issues regarding inter-generational contracts, see the unedited version.

successful modelling of social norms should be able to show how their «transference» implications evolve over time as background economic conditions change and societies move across stages of development.

In this section a model with a time-invariant social norm is developed to expose the observational equivalence of the results derived in the previous section and to explore the trade-offs faced by households once the old-age security motivation is considered. A contribution function linking the number of offspring and their average wealth with the transference of resources to the parent is added according to an implicit time-invariant social norm[18]. The overall contribution accruing to the parent is modelled so as to increase with the number of children but at a decreasing rate. Therefore both marginal and average individual contributions decrease with household size. By implication, the implicit social norm attributes a character of public good to the well-being of parents and specifically the larger the number of contributors the smaller the amount each one will deliver. The overall contribution function and the individual contribution function are respectively denoted by the following equations[19]:

$$T_{t+1} = n_t^{\phi} I_{t+1} \quad 0 < \phi < 1 \tag{13}$$

$$\frac{T_t}{n_{t-1}} = \frac{I_t}{n_{t-1}^{1-\phi}} \tag{14}$$

The contribution function reflects a new trade-off between quantity and quality of children confronted by parents, since they could increase the contribution by either having more of them or by dedicating more resources as well as children's time to building up human capital so as to enhance their future earnings. In fact this trade-off is more complex since it involves decisions regarding child labor. Hence, if parents opt for human capital

18. In a sense, it can be regarded as a disaggregated and dynamic extension of the generalized contribution function suggested by Dercon and Hoddinot (2003). Their general specification implicitly brings child labor together with old-age security transfers.

19. A generalized form capable of accounting for all possible situations and from which, accordingly, testable implications could be derived is the following:

$$T_{t+1} = (bn_t)^{\phi} I_{t+1}$$

Hence if $\phi=1$ then this generalized specification for the second model boils down to Morand's as regards transfer «technology», of course differing on the implicit assumption of $b=1$. The latter can be relaxed, i.e., $0<b<1$, in the second model without any significant change in qualitative results as long as $\phi<1$. Otherwise, that is if $\phi=b=1$, the assumption would imply that the offspring surrenders all prospective adulthood income to parents, which is implausible.

accumulation, they may find a further reason to limit fertility in the negative effect of school attendance on child labor[20].

Again the common features hold so each member of the adult cohort chooses the sector to work in according to the rule set by (5), and human capital production follows (9). People live during three periods, namely, childhood, adulthood and old age, but now there is consumption during both adulthood and old age, and people retire during their last period. Children, of course, still "consume" q_t. And parent-to-children altruism is discarded. Thus, the utility function of a member belonging to the t cohort will now be given by:

$$U_t = \alpha Ln\ (C_t) + (1-\alpha)\ Ln\ (C_{t+1}) \tag{15}$$

During adulthood the two sources of income are the same as in the former model. The change in the budget constraint appears on the expenditure side. In addition to savings and expenditure on child quality, income will now go to current consumption and to transfers to already old parents:

$$(1-zn_t)\ l_t + \theta\ (1-\tau_t)\ n_t w_c = \frac{T_t}{n_{t-1}} + S_t + n_t q_t \pi + C_t \tag{16}$$

During old age parents retire, hence relying on accrued savings and the overall contribution from all their already adult descendants to fund consumption:

$$C_{t+1} = S_t\ (1+r) + T_{t+1} \tag{17}$$

The optimization process is basically identical to that of the former model. Notice however that the individual contribution during adulthood is not a variable under control of the parent, who has opted for the sector before tackling the optimization problem and naturally has no command over the number of his/her siblings. The following assumptions are now required: (a) to ensure that the parent devotes some positive amount of time to work even at the highest level of fertility consistent with utility maximization, (b) to prevent non-stationary behavior, and finally (c) it is necessary to reconcile the first assumption with the substitution axiom.

20. According to Boserup (1985): «Given the high value placed on education in Africa, the great expectations of support from educated offspring probably more than counterbalanced the reductions in benefits from child labor in the parental calculus.» (p. 390).

Assumptions:

$$(a)\ z\left[1-\frac{\phi}{(1+rz)^{\phi}}\right]>\theta\ (b)\ 1>\phi>\gamma+\delta>0\ (c)\ (1+r)\,z^{\phi}>\phi$$

i. Results

If the prospective income from the modern sector is higher than that from the traditional one, then resources as well as children's time will be allocated to human capital build-up irrespective of parental human capital. The condition underpinning this situation is now the following:

$$\bar{w}\left(\frac{z-\theta}{\phi-\gamma-\delta}\right)^{\gamma+\delta}\left(\frac{\gamma}{\theta}\right)^{\gamma}\left(\frac{\delta w_c}{\pi}\right)^{\delta}>w_c \qquad \text{(Condition II)}$$

And the optimal choices of child labor, child quality and fertility are given by equation (18):

If	(18a) $\tau_t^*=$	(18b) $q_t^*=$	(18c) $n_t^*=$
$h_t<\frac{w_c}{\bar{w}}$	$\frac{\gamma(z-\theta)}{\theta(\phi-\gamma-\delta)}$	$\frac{\delta(z-\theta)w_c}{\pi(\phi-\gamma-\delta)}$	$\frac{\left[\frac{\bar{w}}{w_c(1+r)}\right]^{\frac{1}{1-\phi}}\left(\frac{\gamma}{\theta}\right)^{\frac{\gamma}{1-\phi}}\left(\frac{\delta w_c}{\pi}\right)^{\frac{\delta}{1-\phi}}}{\left[\frac{z-\theta}{\phi-\gamma-\delta}\right]^{\frac{1-\gamma-\delta}{1-\phi}}}$
$\frac{w_c}{\bar{w}}\le h_t\le\frac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}}$	$\frac{\gamma(z\bar{w}h_t-\theta w_c)}{\theta w_c(\phi-\gamma-\delta)}$	$\frac{\delta(z\bar{w}h_t-\theta w_c)}{\pi(\phi-\gamma-\delta)}$	$\left[\frac{\bar{w}}{(1+r)}\left(\frac{\gamma}{\theta w_c}\right)^{\gamma}\left(\frac{\delta}{\pi}\right)^{\delta}\left(\frac{\phi-\gamma-\delta}{z\bar{w}h_t-\theta w_c}\right)^{1-\gamma-\delta}\right]^{\frac{1}{1-\phi}}$
$\frac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}}\le h_t$	1	$\frac{\delta z\bar{w}h_t}{\pi(\phi-\delta)}$	$\left[\left(\frac{\phi-\delta}{zh_t}\right)^{1-\delta}\left(\frac{\bar{w}\delta}{\pi}\right)^{\delta}\frac{1}{(1+r)}\right]^{\frac{1}{1-\phi}}$

All three functions (equation 18) are continuous and monotonic with respect to parental human capital; but the first two are non-decreasing whereas (18c) is non-increasing. Thereby a first proof of observational equivalence is provided by this model when condition II holds: a static relationship between children's living standards, household size and parental human capital can be derived, yet without the need to resort to parent-to-children altruism. When condition II is overturned the discontinuity of the optimal choices is reflected by equation (19):

$$\tilde{h}_t = \left(\frac{w_c}{\bar{w}}\right)^{\frac{1}{\gamma+\delta}} \left(\frac{\pi}{\delta}\right)^{\frac{\delta}{\gamma+\delta}} \left(\frac{\theta w_c}{\gamma}\right)^{\frac{\gamma}{\gamma+\delta}} \frac{(\phi-\gamma-\delta)}{z\bar{w}} + \frac{\theta w_c}{z\bar{w}} > \frac{w_c}{\bar{w}}$$

If	(19a) $\tau_t^* =$	(19b) $q_t^* =$	(19c) $n_t^* =$
$h_t < \frac{w_c}{\bar{w}}$			$\left[\frac{\phi}{(1+r)(z-\theta)}\right]^{\frac{1}{1-\phi}}$
$\frac{w_c}{\bar{w}} \le h_t \le \tilde{h}_t$			$\left[\frac{\phi w_c}{(1+r)(z\bar{w}h_t-\theta w_c)}\right]^{\frac{1}{1-\phi}}$
$\tilde{h}_t \le h_t \le \frac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}}$	$\frac{\gamma(z\bar{w}h_t-\theta w_c)}{\theta w_c(\phi-\gamma-\delta)}$	$\frac{\delta(z\bar{w}h_t-\theta w_c)}{\pi(\phi-\gamma-\delta)}$	$\left[\frac{\bar{w}}{(1+r)}\left(\frac{\gamma}{\theta w_c}\right)^{\gamma}\left(\frac{\delta}{\pi}\right)^{\delta}\left(\frac{\phi-\gamma-\delta}{z\bar{w}h_t-\theta w_c}\right)^{1-\gamma-\delta}\right]^{\frac{1}{1-\phi}}$
$\frac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}} \le h_t$	1	$\frac{\delta z\bar{w}h_t}{\pi(\phi-\delta)}$	$\left[\left(\frac{\phi-\delta}{zh_t}\right)^{1-\delta}\left(\frac{\bar{w}\delta}{\pi}\right)^{\delta}\frac{1}{(1+r)}\right]^{\frac{1}{1-\phi}}$

The observational equivalence result is made patent again by the dynamic behavior of human capital accumulation: the introduction of old-age security makes a good replacement for parent-to-children altruism as an incentive for investing in future human capital. When condition II holds, the same reasons brought over to explain the existence of a single, high-human-capital steady state when condition I holds in the former section's model are valid to explain an outcome similar to that appearing in Graph 1. The functions are slightly different, including the presence of ϕ.

$$h_{t+1}^{III} = \Psi(h_t) = \begin{cases} \left(\frac{z-\theta}{\phi-\gamma-\delta}\right)^{\gamma+\delta}\left(\frac{\gamma}{\theta}\right)^{\gamma}\left(\frac{\delta w_c}{\pi}\right)^{\delta} & \text{if} \quad h_t < \frac{w_c}{\overline{w}} \\ \left(\frac{z\overline{w}h_t-\theta w_c}{\phi-\gamma-\delta}\right)^{\gamma}\left(\frac{\gamma}{\theta w_c}\right)^{\gamma}\left(\frac{\delta}{\pi}\right)^{\delta} & \text{if} \quad \frac{w_c}{\overline{w}} \le h_t \le \frac{\theta w_c(\phi-\delta)}{\gamma z\overline{w}} \\ \left(\frac{\delta z\overline{w}h_t}{\pi(\phi-\delta)}\right)^{\delta} & \text{if} \quad \frac{\theta w_c(1-\delta)}{\gamma z\overline{w}} \le h_t \end{cases}$$

As in the former section's model, the situation where condition II does not hold yields the basic three cases where development traps can occur depending on the combination of initial conditions determining the threshold level and the initial level of human capital. And the third case will exhibit a single steady state, namely, the long-run development trap. Now, in all cases, whenever the economy ends up in a development trap, households will find rational a regime of high fertility and nil human capital accumulation. In such circumstances child labor and old-age contributions will be complementary household resources since both will feasibly be enhanced by increasing fertility. However, once the economy enters the path of human capital accumulation that complementary relationship will turn to substitution: households will be able to increase the old-age contribution through investments in human capital, instead of resorting to increased fertility, but at the expense of less income from child labor.

$$h_{t+1}^{IV} = \Psi(h_t) = \begin{cases} 0 & \text{if} \quad h_t < \tilde{h}_t \\ \left(\dfrac{z\bar{w}h_t - \theta w_c}{\phi - \gamma - \delta}\right)^{\gamma+\delta} \left(\dfrac{\gamma}{\theta w_c}\right)^{\gamma} \left(\dfrac{\delta}{\pi}\right)^{\delta} & \text{if} \quad \tilde{h}_t \leq h_t \leq \dfrac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}} \\ \left(\dfrac{\delta z\bar{w}h_t}{\pi(\phi-\delta)}\right)^{\delta} & \text{if} \quad \dfrac{\theta w_c(\phi-\delta)}{\gamma z\bar{w}} \leq h_t \end{cases}$$

Finally, the observational equivalence arises because in the model the time-invariant contribution function finds its way indirectly into the utility function through the old-age consumption frontier. The enforcement of such a transfer can be accomplished either by social norms or by offspring-to-parents altruism or both, as long as other conditions such as labor mobility remain stable. So to the extent that the enforcement of young-to-old transfers is underpinned at least partially by «reversed» altruism, the model shows that the direction of altruism is irrelevant as a source of incentives to invest in the future generations, at least in some stages of development; what would matter is rather the presence of altruism itself. But reality is complex. Social norms may not be time-invariant, neither the enforcement of transfers. In fact, as societies tend to rely more on market or broad state arrangements to provide for old-age security, those sorts of social norms might wane gradually. What would happen with the incentives to have children and invest in them once that process is well on its way?. The decline in fertility rates across all developed nations could be explained in such terms, among many other factors stated in the classic literature. Yet the fact that people in those countries may still want to have children and opt to invest a generous amount of resources in them even without expecting a financial reward in the future bears witness to the existence, and consequent explanatory power, of some degree of parent-to-children altruism.

c. Time trends with technological progress

The impact of technological progress is assessed with these models along the lines set by Galor and Weil (2000) and Hazan and Berdugo (2002). If the rate of technological change, i.e., $\dot{\lambda}$ is an increasing function of the aggregate stock of human capital, H_t, then it will in turn depend on both population change and average individual human capital[21]. Once technological progress arises the choice of sector becomes affected by the new prospects of dynamic increase in modern sector wages. In fact it will now be based on the following comparison:

$$(\lambda + \dot{\lambda})\, \bar{w}h_t \gtrless w_c$$

21. The underlying model and the graphic representations appear in an unedited mimeograph.

So as long as the right-hand side of the equation is larger the economy will remain in a development trap. However, population will keep on growing and therefore there will come a moment when technological innovation as well as investment on future human capital will turn profitable. Henceforth, human capital accumulation starts, fuelling more technological innovation. Once technological innovation takes off the remuneration of a unit of human capital in the modern sector will rise, driving the threshold level of parental human capital downwards and so effectively enforcing conditions I or II but with a key difference: there may be two alternative steady states depending on whether the endogenous process of technological change and aggregate human capital accumulation is being driven by increased population growth or by increased individual human capital accumulation.

The consequences regarding households' and children's living standards will depend on the nature of the high-human-capital steady state. Once technological change begins, human capital accumulation starts as well by drawing children's time and resources, as made clear by the decline in child labor and the increasing trend towards child quality. The consequent change in the relative price of quantity with respect to quality leads to a reduction in fertility and household size. Human capital accumulation continues even after child labor is virtually eliminated by means of increased child quality until the high steady state where child quality and human capital remain constant is reached. Yet consumption per capita grows even at that stage since technological change is still worthwhile as long as population growth does not stall, i.e., to the extent that the first alternative holds. How is this possible? If technological innovation is possible via positive population growth even once the steady state has been reached, then there is no point in dedicating more resources to further human capital accumulation since, anyway, remunerations in the modern sector will keep on expanding fuelled by technological change. This first-alternative case requires an assumption whereby population does not stagnate when fertility transition is fully accomplished. If, however, that assumption is not upheld, ever-growing per capita consumption can still be sustained by relying on individual human capital accumulation. To that purpose child quality will have to be improved steadily beyond the steady state. Hence only fertility and children's allocation of time will remain constant once the steady state is reached and thereafter.

e. How do the models explain Caldwell's theory of demographic transition?

According to Caldwell's theory of demographic transition, there are only two possible fertility regimes depending on the nature of the net intergenerational flows of wealth. When net wealth flows from younger to older generations, high fertility is economically rational. In fact the upper bounds to fertility in such circumstances are given by reasons

related to pregnancy stress, the necessary space between births to prevent child mortality, incompatibility between maternal and grand-maternal roles, and problems related to control, noise and emotional deprivation among others. When net wealth flows in the opposite direction, low fertility becomes economically rational. And the lower bound preventing nil fertility arises from altruistic feelings toward children stemming from cultural emotional nucleation (Caldwell 1976). In his thesis, demographic transition in the developing world is not related to industrialization. In fact, as he showed in the case of Nigeria, high fertility and net flows from the younger to older cohort can persist in urban and modern settings where people become increasingly involved in the modern sector. Hence fertility decline is actually the consequence of imported «Westernization», specifically, the imported western notion of the nuclear family which prompts emotional nucleation leading subsequently to economic nucleation[22].

And although he only suggested a limited indirect influence of modernization on fertility decline via increased resources to fund schools, media and other cultural-transmission means, Caldwell conceded that family nucleation cannot flourish in «the non-monetized economy» (p. 358). This remark fits well with a criticism from a cultural materialist perspective which would point out that, however significant the importation of the western notion of family may be, the embrace of such concepts by indigenous people can ultimately be possible if the economic conditions are compatible and hence permissive. In other words, the spread of parental altruism alone might not be sufficient to reverse the direction of intergenerational net flows of wealth and to bring fertility decline. It might not even be the ultimate cause starting the process. In this context, parental altruism, as any other cultural construction, could be deemed the consequence of major economic developments. And finally, cultural materialist anthropologists like Harris are skeptical of the possible long-term coexistence of a regime of high fertility and human capital accumulation even when the flow of wealth still favors the older generation. The reason being that they agree with Becker and others in the contribution of fertility to the shadow price of investing in child quality and human capital[23], even acknowledging that, unlike in most models, in practice children are not regarded equally by parents.

In light of these phenomena, Caldwell, in a collaborative article, (Caldwell, Reddy and Caldwell 1985), reappraised his theory taking into account ethnographic work in rural India. The authors acknowledged that the reduction of land size, together with lower child mortality

22. For the argument here see Caldwell (1976)
23. For instance, according to Harris: «Parents, in effect, substitute a strategy of rearing only a few well-educated but potentially well-paid and influential children for a strategy of raising a lot of poorly educated farm hands.» (Harris, 1990, p. 218).

and changing rural technology, had been yielding surplus child labor. At the same time, increasing demand for schooling was reflecting emerging positive returns to education driven by enhanced labor market opportunities, especially in urban settings. These, meanwhile, provided a way to diversify household income through off-farm sources, often requiring migration. In turn «keeping many children at school» (Caldwell et al. 1985, p. 47) was putting households under financial strain. Thus there was an observed increase in demand for family planning and fertility control. In this way Caldwell et al. reached the conclusion that: «Education offers at best only a partial explanation of demographic transition.» (p. 29). Key to this reconsideration was an implicit acknowledgement of the importance borne by the trade-off between the quantity and quality of children, in line with the ideas of both economists and cultural materialist anthropologists: «...the number of children a family can afford to educate is restricted, particularly over a limited number of years.» (p. 45).

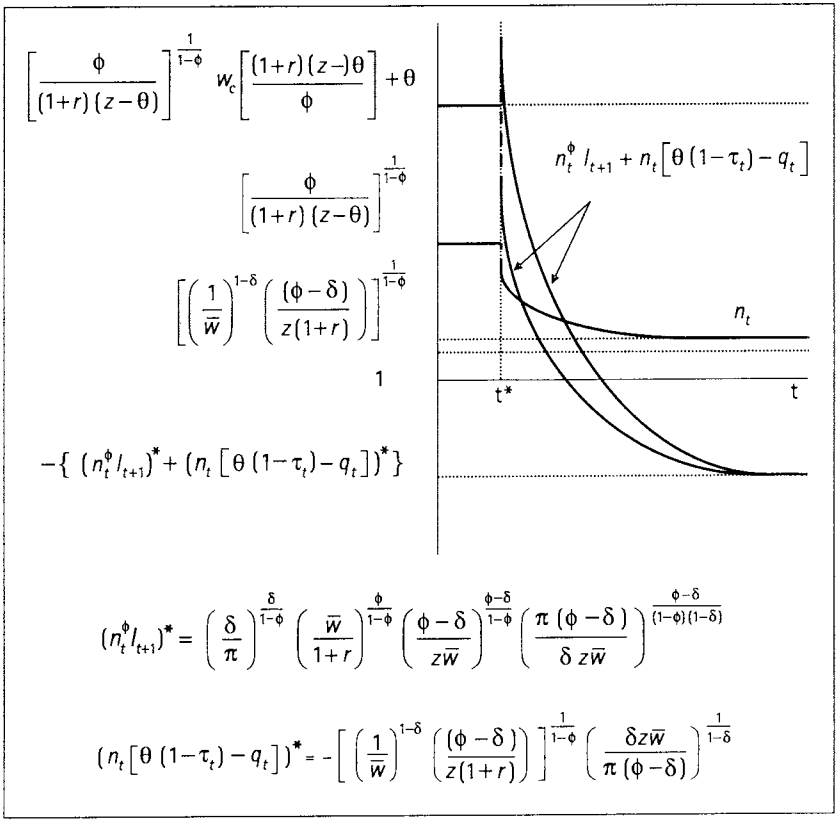
In the cultural materialist perspective, the widespread assumption of time-invariant patterns of parent-to-children altruism is unrealistic since the latter can be deemed to be a consequence of development in economic conditions. Likewise, the second model assumes an implicit social norm as to the contribution to old-age security which again may not be exogenous and time-invariant[24]. In other words, all these models attempt to explain different features of the overall process of economic development but relying on fixed assumptions that may be shaped by the specific stages of the process. That is, these assumptions on cultural traits and «preferences» are, ultimately, endogenous and conditional on the stage of economic development.

In spite of these caveats, the models in this paper can be compared with Caldwell's theory. In fact, they both predict fertility decline along a change in the direction of intergenerational net flows of wealth. In the first section's model, assuming parental altruism, the basic flows of wealth are income from child labor and investment in child quality and a clear positive relationship between fertility and net flows of wealth is derived if the latter are defined in terms of net transfers accruing to the older cohort. In the second section's model, parental altruism is discarded and contribution for old-age security is added to the intergenerational flow of wealth. The ensuing relationship between the latter and fertility is similar to that stemming from the first model, with the difference that there is an ambiguous change when technological progress takes off at time t^* since the

24. Coleman provides a good illustration when he points that: «With social changes in the United States, such as the advent of social security and pension funds, the parents' need for their children to care for them as they become dependent is greatly reduced. The decline in community norms that children should care for their dependent parents in part reflects the growth of these pension and social security sources of support, and in part results from the overall decline in community.» (Coleman 1995, p. 68).

contribution can either increase or decrease in its aftermath depending on whether the consequent fertility decline is higher or lower than the increased income of the next younger cohort (Graph 3).[25]

Graph 3 Intergenerational flows of wealth and fertility in the second model when technological progress is driven by population growth in the steady state



There is however a common underlying process driving these results, namely, the pace of technological development and the subsequent increase in the relative productivity of the modern sector. So the key question is whether fertility decline is exclusively a response to the reversal in the direction of the net flows of wealth, as Caldwell's early hypothesis would

25. It must be stressed though that the second model's result may be dependent on the functional form attributed to the contribution for old-age consumption.

suggest, or both phenomena stem from a common pool of economic transformations, even allowing for an impact of net flow reversal on fertility; a possibility which would fit better with the reappraisal in Caldwell et al (1985). The testing implications of this question are that in the presence of economic processes underpinning both fertility decline and net flow reversal a simple regression of fertility on net flows of wealth would suffer from endogeneity bias if variables representing the discussed economic transformations are omitted.

II. WELFARE-ENHANCING POLICY OPTIONS

The development traps described in models in this paper constitute Pareto-dominated situations to the extent that some policy measures may pull the economy out of them while improving overall welfare across all cohorts. A set of policies that could achieve that aim was originally suggested by Becker and Murphy (1988) whereby the public authority enforces compulsory schooling but compensating the affected household parents for the foregone child-labor income with a transfer funded by taxes levied on their offspring, i.e., the cohort benefited by the compulsory measure, once it grows up and starts working in the modern sector.

The first attempt to model that policy was made by Hazan and Berdugo (2002) and their conclusion was that there was a range of parameters for which the Becker-Murphy package was feasible. Their model though did not assess households' reaction in terms of investment in child quality when faced with this policy. Would they opt to invest enough in child quality so as to enable human capital accumulation process to start? And if so, would it be at the expense of a short-term welfare loss?

To be successful, in the context of the first section's model, such a policy of intergenerational transfers, consisting of a subsidy for parents at old age, σ_{t+1}, a tax for every child when grown up, ρ_{t+1}, and a level of compulsory schooling, τ_t^{cs}, must fulfil the following four conditions, based on those put forward by Hazan and Berdugo (2002)[26]:

1: $n_t\,(\tau_t^{cs}, \sigma_{t+1})\;\rho_{t+1} = \sigma_{t+1}$
(balanced budget)

2: $\bar{w}h_{t+1}\;(\tau_t^{cs}, \sigma_{t+1}) - \rho_{t+1} > \bar{w}\tilde{h}$
(next cohort's income higher than threshold required to start human capital accumulation)

26. A similar notation is used to allow for some degree of comparability.

3: $\alpha w_c \leq \left\{\left[1-zn_t(\tau_t^{cs}, \sigma_{t+1})\right] w_c + n_t(\tau_t^{cs}, \sigma_{t+1})\,\theta\,(1-\tau_t^{cs})\, w_c - n_t(\tau_t^{cs}, \sigma_{t+1}) \ldots\right.$

$\left. \ldots\ q_t(\tau_t^{cs}, \sigma_{t+1})\,\pi\right\}(1+r)+\sigma_{t+1}$

(consumption of older cohort equal or higher than without the policy)

4: $\left(\frac{1-\alpha}{z-\theta}\right) w_c \leq n_t(\tau_t^{cs}, \sigma_{t+1})\,(\overline{w}h_{t+1}(\tau_t^{cs}, \sigma_{t+1}) - \rho_{t+1})$

(potential per-capita income equal or higher than without the policy)

Households must choose both the number of children and the amount of resources to be invested in them, which, together with the compulsory schooling rule, will determine the accrued level of child human capital. Depending on the value of parameters, the ensuing household decisions might not be sufficient to pull the economy out of the development trap, i.e., condition 2 might not be fulfilled. Alternatively, condition 2 might be fulfilled but at the expense of a short-term loss of welfare in terms of reduced consumption and income prospects for either parents or their children, or for both. In that case condition 3 and/or 4 would not be fulfilled and the policy measures would only yield a Pareto-dominating situation in the long term.

The public authority is assumed to choose those sets of policies which ought to be successful considering households' optimal responses to them. Its scope for maneuver, however, will depend specifically on the values of exogenous parameters. Now, if the public authority seeks complete compulsory schooling in one generation by setting $\tau_t^{cs}=1$, households will respond with the following decisions concerning fertility and investment in child quality:

$$q_t(\tau_t^{cs}=1, \sigma_{t+1}) = \frac{\delta z w_c}{\pi\,(1-\delta)}$$

$$n_t(\tau_t^{cs}=1, \sigma_{t+1}) = \frac{\left[(1-\alpha)\, w_c + \sigma_{t+1}\right](1-\delta)}{(1+r-r\alpha)zw_c} + \frac{\left[\pi(1-\delta)\right]^{\delta}\alpha\sigma_{t+1}}{(1+r-r\alpha)\,\overline{w}\,(\delta z w_c)^{\delta}}$$

Notice that, unlike fertility, investment in child quality will be independent of the level of compensatory subsidy chosen by the public authority. Therefore, as long as it targets complete compulsory schooling, the policy will yield a single outcome of human capital accumulation irrespective of the amount involved in the publicly disposed intergenerational transfer. And the effectiveness of the policy will be impossible to judge a

priori since it depends on the actual vector of parameters. To provide an illustration as to that feature, consider the hypothetic situation depicted by the following parameters' values:

$\alpha = 0.4,\ \pi = 20,\ z = 0.18,\ w = 10.5,\ \delta = 0.2\ \ \theta = 0.06,\ \ w_c = 3.3,\ \gamma = 0.07,\ r = 0.3$

In such circumstances, a public authority attempting to secure a Pareto-dominating situation paving the way out of the development trap should target complete compulsory schooling and a subsidy to the older generation in a range between about 2 and 2.1. Any different level may either fail to pull the economy out or generate short-term welfare losses, or both. Now, should the public authority choose $\sigma_{t+1} = 2$, parents would enjoy a compensating subsidy of about 61% of their income while their offspring would face an individual tax of about 11% of their respective remuneration.

CONCLUDING REMARKS

This paper's foremost purpose is to emphasize the importance of child quality in the relationship between household behavior and economic development. Firstly, even in a situation without technological change, the first model showed that human capital accumulation can continue beyond the point where child labor is eliminated by means of increased investment in child quality. Therefore, the earliest moment at which children's time is fully allocated to school attendance is not a steady state.

The inclusion of child quality also sheds light on the nature of the threshold level of human capital that is required to escape a development trap. One of its main determinants in the models is the relative income per unit of labor (efficiency labor in the case of the modern sector) that could be accrued in the traditional sector with respect to the modern one. But the threshold level also depends positively on the relative unitary price of child quality: the higher the latter the higher the minimum parental human capital required for pulling the economy out. The policy implications are thus clear: aid targeted at reducing the price of child quality inputs (vaccines and medicines, subsidized school breakfasts, etc.) can help to lift significant groups of people out of a low-income, high-fertility regime.

The inclusion of child quality provides further implications for policy. The Becker-Murphy package of compulsory schooling and state-enforced intergenerational transfers does not intend to operate through changes in the relative price of child quality. However, households will react to different state-imposed allocations of children's time and transfers with different levels of investment in child quality. Whether the latter will be

enough to pull out of the development trap is not assured a priori. It will critically depend on the magnitude of policy variables combined with that of underlying structural parameters.

In the context of technological change, the incorporation of child quality is not trivial either. It could lead to two different high-income steady states depending on whether or not technological change can be sustained via an ever-growing population at the stage of completed fertility transition or not. In the latter case, the welfare frontier could still be pushed further away by way of increasing investment in child quality so in that situation the only steady variables would be full school attendance and fertility.

Another objective of the paper is to assess the nature of the trade-offs faced by households when they demand children as «producer» as well as «insurance goods». The message here is that when households find high levels of fertility as a rational option, i.e., when the modern sector is not seen as an attractive source of future income, child labor and old-age contributions become complementary household resources: a larger number of children will increase both. However, once households start undergoing the path of human capital accumulation these sources become substitutes: as fertility declines the alternative to make up for the implied loss in old-age contribution is to build up child human capital by investing in child quality and increasing school attendance. The latter can only come about at the expense of foregone child labor income. These sources end up being somewhat complementary again, for at higher stages of development they may decline together leading to a reversal in the direction of the intergenerational flows of wealth.

The models in this paper also highlight the need for further research, especially oriented toward measuring intergenerational wealth flows in different societies, as advocated by Caldwell (1976), in order to test the relative importance of them in driving fertility decline in the face of other factors affecting both outcomes simultaneously, as predicted by the models.

One final message this paper attempts to convey, although informally, refers to the nature of social norms and the way they are typically regarded in models. The very fact that Galor and Weil (2000) consider that time-invariant parental altruism may well explain why their model is better suited to explain European history since only there, across the world, did emotional and economic nucleation, in Caldwell's terms, last for so long. This is not an issue to be overlooked. In fact, the dynamic behavior of social norms may be the underlying reason underpinning the problem of theoretical, and plausibly empirical, observational equivalence. In early moments of modern stages of development the old-age security

motivation itself may sustain household's motivation to invest in human capital when it becomes worthwhile. Yet once better market or state alternatives turn up economic nucleation (either brought about by economic transformations or by direct importations of foreign culture) may take the lead in ensuring that investment on child quality as well as on human capital continues. Thus as long as one motivation follows the other over time and the more so if there is overlapping as all households will continuously be tempted to substitute towards child quality to the extent that investment in human capital is attractive. If social norms respond dynamically to changes in economic conditions indeed, then these characteristics should be accounted for in any model attempting to provide a unified theory of economic growth and demographic transition throughout the world.

Finally, a formal proposal for dealing with changing parental altruism, considering endogenous old-age transfers (which depending on their direction may amount for net bequests) could be brought up by combining Hazan and Berdugo (2002) with transfers as in Rosenzweig (1990) and Baland and Robinson (2000) and endogenous paternal altruism as in Becker et al. (1990):

In a dynastic families framework:

$$U_t = V_t \left[S_t (1+r) + x_{t+1} \right] + a(n_t)\, n_t V_{t+1} (l_{t+1} - x_{t+1})$$

In a non-dynastic framework:

$$U_t = \alpha Ln \left[S_t \ (1+r) + x_{t+1} \right] + a(n_t)\, Ln \left[n_t (l_{t+1} - x_{t+1}) \right]$$

Common budget constrain in both cases:

$$S_t = (1 - z n_t)\, l_t + \theta (1 - \tau_t) - n_t\, q_t \pi - X_t$$

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