Experience, Education, and Human Capital Accumulation

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Abstract

The ability to accumulate human capital through formal education and through a learning-by-doing process that occurs on the job affects the dynamic behavior of the human capital stock under both liquidity and non-liquidity constrained cases. When there are alternatives to formal schooling in the accumulation of human capital, investing resources in increasing school enrollment ratios in low-income countries will have a different effect than investing resources in increased schooling in high income countries: more schooling in low income countries may even lead to a decrease in human capital in the short to intermediate term. Removal of liquidity constraints may not be sufficient to escape a development trap.

Keywords: human capital, economic growth, on-the-job experience, education, overlapping generations

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1 Introduction

A survey of the recent growth literature would reveal at least one consistent policy prescription: invest in human capital. Although the importance of human capital has been established, the crucial question of how this policy should be implemented still remains to be answered. This paper takes up this question and considers how the ability to accumulate human capital through both formal training and through on-the-job experience affects the dynamic behavior of the human capital stock.

Empirical evidence from micro data has consistently shown that work experience is an important determinant of an individual's human capital. In addition, the macro growth literature has recognized learning-by-doing as a legitimate means of human capital accumulation, however, the inherent tradeoff between accumulating human capital through working and accumulating it through schooling has not been well examined at an economy-wide level.[1] This paper acknowledges the micro evidence and uses a broad definition of human capital that includes both on-the-job learning as well as general education. One of the major insights gained by this approach is that a developing country's transition to its steady state level of human capital may not be characterized by a steadily rising human capital stock. In fact, a decrease in the human capital stock in the short-run may be an inevitable cost of attaining higher steady state income in the long-run.

The conclusion that a reduction in human capital that may occur as education begins to

[1]Following the seminal work of Arrow (1962), some important contributions on the macroeconomic impact of learning by doing include Lucas (1988), Young (1991, 1993), Stokey (1988) and Jovanovic and Nyarko (1996). Iyigun and Owen (1998, 1999) do consider a model in which individuals chose to accumulate one type of human capital at the expense of the other, but the focus of those papers is on the decision to engage in risky, entrepreneurial activities.

expand during the early phases of development is supported by the recent experiences of several developing countries that have witnessed large increases in enrollment rates but not corresponding increases in output. For example, Pritchett (1997) provides a summary of relevant stylized facts: In the years between 1960 and 1985, the educational attainment of the labor force in Sub-Saharan Africa grew at a faster rate than that in any other region. Yet growth of output was about half that of Latin America and about a quarter that of more rapidly growing regions.[2] Similarly, in other less developed countries as a whole, enrollment rates have increased significantly in the last thirty years while growth rates have been stagnating or even falling. In countries and regions that have recorded considerably high levels of educational attainment such as Sri Lanka, Costa Rica, Jamaica, the Philippines and parts of India, output levels have been significantly low for educational levels.

Work in the growth literature has provided mixed evidence in support of aggregate educational investment as a determinant of economic growth. On the one hand, following the work of Barro (1991) and Mankiw, Romer and Weil (1992), many have empirically demonstrated that human capital, even when defined only to include educational attainment, directly affects economic growth.[3] On the other hand, Benhabib and Spiegel (1994) and Barro and Sala-i-Martin (1995) find that changes in education levels of the labor force are not associated with changes in output in cross-country data as one might expect if human capital created by

[2]See Easterly and Levine (1997) for a detailed account of the economic performance of countries in Sub-Saharan Africa.

[3]However, even Barro (1991) implies that relatively large increases in enrollment rates are necessary to achieve significant increases in growth rates. The coefficients reported in Barro (1991) imply that an increase in secondary enrollment rates of 30 to 40 percentage points is necessary to achieve a 1 percentage point increase in the annual growth rate of per capita income.

schooling is a factor of production. Pritchett (1997) makes an even stronger point, showing that increases in educational capital due to improvements in the educational attainment of the labor force has a negative impact on the growth of output per worker. Finally, Easterly (1998) argues that human capital accumulation explains only a small part of the differing cross-country growth experiences.

Recent attempts to reconcile the micro evidence with this ambiguous evidence from macro data reveal that the positive relationship between schooling and growth may differ across countries and that it may not hold in the short run. Temple (1999) shows that the Benhabib and Spiegel results can be reversed if a smaller sample of countries is considered, finding that changes in education levels are positively associated with growth when outliers are trimmed from the sample, reducing it from 78 to 64 countries. Thus, for almost 20% of the sample, the expected positive correlation between education changes and income growth does not exist. In addition, he finds the coefficient on changes in education varies widely across samples, particularly when developing countries are included in the estimations, further suggesting that the relationship between growth and education is different in developing countries. Kreuger and Lindahl (2000) also confront the puzzling macroeconomic evidence and find some support for the idea that the relationship between changes in education and income growth varies across countries. They also qualify the Benhabib and Spiegel and Barro and Sala-i-Martin results by showing that when longer time spans are considered (10 to 20 years), there is a positive effect of changes in schooling across countries. While they attribute their inability to find a positive correlation when growth is measured over periods less than 10 years to a greater likelihood of measurement error, this finding is also consistent with the idea of this paper–changes in education may not always generate

immediate increases in human capital.[4]

In contrast to mixed evidence from aggregate data, micro data has consistently shown that earnings and productivity increase with an individuals education.[5] The model in this paper is consistent with both the micro and macro evidence; it allows individuals' productivity to increase with their level of education but recognizes that the extent of the productivity increase will depend on the existing level of human capital. In this regard, the model is similar to some of the current work in the growth literature that incorporates a human capital externality. However, by acknowledging alternative methods of accumulating human capital, it differs significantly from the existing work in that it provides an explanation for why advocating increases in enrollment rates may be a policy that implicitly trades off current for future welfare. In fact, in countries in which the existing level of human capital is very low, the model identifies the possibility that increases in enrollment rates could actually *decrease* the economy's stock of human capital in the short to intermediate term.[6]

The model below considers a small open economy in an overlapping generations

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[4]Furthermore, when they try to control for measurement error in the longer term growth estimations using IV techniques, Krueger and Lindahl obtain statistically insignificant coefficients on the change in schooling.

[5]See, for example, Mincer (1993) for further discussion and evidence on this point.

[6]In a related paper, Fershtam, Murphy and Weiss (1996) also develop a model in which an increase in the number of educated workers can be associated with a decrease in the growth rate. In their model, a high social status of educated workers can result in an inefficient allocation of education as high-income, low-ability people "crowd out" low-income, high-ability people from growth-producing educated occupations.

Another related paper, Helpman and Rangel (1999), also models two types of human capital generated by experience and education. In this paper, however, experience is technology-specific and it is the switch to a new technology that can cause a decrease in output.

framework in which both physical capital and a labor input are factors of production. In the first period of life, individuals divide their time between working and going to school. Both activities increase an individuals second period human capital and, thus, increase the amount of the labor input the individual can supply in the second period. A high parental level of human capital influences the effectiveness of time spent in training more than it influences the effectiveness of accumulating human capital through the learning-by-doing that occurs on the job. As a result, when the previous generation has a low level of human capital, individuals may prefer to accumulate human capital through work experience and not through training. As the level of parental human capital rises, however, schooling becomes a more effective means of accumulating human capital and individuals choose more education over work in the first period. When loans for first period consumption are not available, the amount of time spent in school in the first period gradually increases with the parental stock of human capital. When individuals can borrow against second period income to finance first period consumption, however, they either spend all or none of their time in school.

This setup generates the possibility of multiple equilibria. When credit markets are perfect, there can be two stable steady states: a low human capital steady state in which individuals accumulate human capital only through work experience and a high human capital steady state in which individuals spend all of the first period in school. If there are credit market imperfections, individuals work part-time in the first period even in the high human capital steady state. Thus, the consideration of alternative means of human capital accumulation generates a human capital accumulation process at the macroeconomic level that exhibits threshold externalities similar to those discussed in Azariadis and Drazen (1990). However, because in this

paper the threshold effects are generated by an alternative human capital accumulation process, they are more severe--for some levels of human capital, small increases in education could actually decrease human capital.

These results are of interest to both policy makers and empirical researchers because they show how reasonable alternatives to the standard human capital framework in which education is the only means of accumulating human capital can have different implications for the dynamic behavior of the human capital stock, particularly for developing countries. Consistent with the available empirical evidence, the model in this paper shows how the relationship between increases in education and subsequent growth may differ in low and high income countries.

The conclusions described above are reached in the following three sections. Section 2 describes the basic elements of production and individual decision making, Section 3 considers the evolution of the human capital stock with and without liquidity constraints and Section 4 concludes.

2 The Model

2.1 Production

The output of the economy is a single homogenous good produced by a CRS production function that uses capital and labor as inputs. The output produced at time t, Y_t, is given by

$$Y_t = F(K_t, L_t) = L_t f(k_t); \quad k_t \equiv \frac{K_t}{L_t} \tag{1}$$

where K_t and L_t denote the quantities of physical capital and labor employed at time t. The production function $f:R_+ \rightarrow R_+$ satisfies the standard Inada conditions.

Production is carried out in a perfectly competitive environment, and both factors earn

their marginal products. Thus,

$$r_t = f'(k_t) \quad and \quad w_t = f(k_t) - f'(k_t)k_t \qquad \textbf{(2)}$$

where r_t and w_t denote the interest rate on physical capital and the wage rate paid to labor at time t.

The economy under consideration is open and small, and the world interest rate is constant at $\bar{r}$. Since the open economy permits perfect capital mobility, its interest rate is constant at $\bar{r}$, as well. Therefore, the ratio of physical capital to labor, k_t, and the wage rate paid to labor, w_t, are also constant.

$$r_t = \bar{r} = f'(k_t) \Rightarrow k_t = \bar{k} = f'^{-1}(\bar{r}) \qquad \textbf{(3)}$$

and,

$$w_t = f(\bar{k}) - f'(\bar{k})\bar{k} = \bar{w} \qquad \textbf{(4)}$$

2.2 Individuals

Individuals live for two periods in overlapping generations. The size of the population is normalized to one and there is no population growth. Individuals are endowed with one unit of time and with μ, $\mu > 0$, units of physical labor input in both periods. In the first period, they allocate their time and physical labor between work and education and they consume. In the second period, they supply all of their time and physical labor plus the human capital they accumulated in the first period to the labor market and consume. Thus, first period income is $x_t\mu\bar{w}$, and second period income is $(\mu + h_{t+1})\bar{w}$, where x_t is the fraction of time spent working in

the first period and h_{t+1} is the human capital supplied in the second period. Because there are no out-of-pocket expenses associated with formal training, getting an education affects first period resources only by reducing the amount of labor income.

Both work experience and formal training in the first period increase the amount of human capital supplied in the second period. In addition, the parent's level of human capital enhances the child's human capital accumulation. Specifically, an individual's second period human capital is given by

$$h_{t+1} = a h_t^b x_t + b h_t^a e_t \quad ; \quad 0 \le b < a < 1 \quad ; \quad a, b > 0 \qquad \textbf{(5)}$$

where h_t is the parental level of human capital, x_t is the time spent working, and e_t is the fraction of time spent in training. A key feature of the specification above is that the marginal product of time spent working or in school changes with the parental human capital. At low levels of parental human capital, working in the first period will provide for higher levels of human capital in the second period; but at higher levels of parental human capital, formal training results in higher human capital accumulation.[7] Define $\hat{h}$ as the threshold level of parental human capital, above which education is more productive in generating human capital of the child. Thus, $a\hat{h}^b = b\hat{h}^a$. Of course, in the context of this model, education can be interpreted broadly to

[7]Some of the studies mentioned in the introduction suggest that corruption and ethnic division are responsible for the poor results of increased education in some developing countries. These explanations would be consistent with Equation 5 if low levels of education and corruption or division are associated with each other. In particular, an uneducated population may provide an environment for corruption and division to fester, and, in turn, corruption and division may make schooling investments inefficient.

include not only traditional schooling but also other forms of formal training such as vocational training or apprenticeships. Thus, in our formulation, the human capital accumulated through work experience is exclusively a result of learning by doing.

The important role that a parent's human capital plays in increasing the efficiency with which a child accumulates human capital can be justified in light of Coleman et al. (1966), Hanushek (1986) and Fuchs and Reklis (1994) which show that parent's education is important in determining the child's level of education. More specifically, Coleman et al. (1966) investigate the relative importance of family backgrounds in educational attainment and conclude that differences in backgrounds and characteristics of peers in school play a more important role than quality differences among schools. Hanushek (1986), in a survey of the literature on educational studies, remarks that general conceptual models depict the achievement of a given student as a function of the inputs of family, peers and teachers interacting with innate personal abilities. Fuchs and Reklis (1994) provide evidence that family and child characteristics, but not schools, influence math achievement of eighth-grade students in the U.S.

In addition to this evidence on parental roles in children's educational achievement in a developed country, other studies have emphasized the importance of learning-by-doing and the transmission of this knowledge to other family members in developing countries. Rosenzweig and Wolpin (1985) document the positive influence that older, more experienced, family members have on farm profitability in India, finding that the presence of an older family member increases bad-weather profits by 14% (compared to an 8.5% increase resulting from an additional year of schooling to the most educated individual in the household). Foster and Rosenzweig (1995) also show the importance of learning-by-doing in developing countries, finding that experience with

high-yielding seed varieties is essential for generating profits with their use.[8]

Since, in the first period, individuals allocate their time between education and work, it follows that

$$e_t + x_t \leq 1 \qquad \textbf{(6)}$$

Individuals receive utility from consumption in both periods, with the utility of an individual of generation t given by

$$U_t = U(c_t, c_{t+1}) \qquad \textbf{(7)}$$

where c_t and c_{t+1} denote the consumption of the individual in the first and second periods, and $U(c_t, c_{t+1})$ satisfies the usual conditions that ensure an interior solution.

Individuals maximize their utility subject to (6) and the following budget constraint:

$$(1 + \bar{r})c_t + c_{t+1} + (1 + \bar{r})\bar{w}\mu e_t \leq (2 + \bar{r})\bar{w}\mu + \bar{w}h_{t+1} \qquad \textbf{(8)}$$

3 The Evolution of the Economy

The optimal amount of time allocated to education, e_t, and to work, x_t, by the individual in the first period (and, therefore the evolution of the economy as a whole), will depend on whether there exists binding liquidity constraints on individuals' first period consumption choices. In what follows, I first analyze the evolution of a non-liquidity constrained economy in which individuals

[8]One of the results of this study of Indian households is that experienced farmers were able to earn profits while inexperienced farmers, both educated and uneducated, could not. Losses to inexperienced educated farmers were smaller than those to inexperienced and uneducated farmers, indicating that education did add to a farmer's human capital, but to a lesser degree than previous experience.

can borrow to finance consumption. Then, an economy in which individuals are liquidity constrained and cannot borrow to finance first period consumption is considered.

The evolution of this economy, and, in particular, the evolution of the stock of human capital, $\{h_t\}^{\infty}_{t=0}$ is governed by an autonomous, first-order difference equation. The evolution of the human capital stock, $\{h_t\}^{\infty}_{t=0}$, in turn determines the evolutions of the time allocated to education, $\{e_t\}^{\infty}_{t=0}$, and to work, $\{x_t\}^{\infty}_{t=0}$, and, therefore, the evolution of per-capita income, $\{y_t\}^{\infty}_{t=0}$.

3.1 The Case of No Liquidity Constraints

Let h* be the threshold level of parental human capital below which individuals do not choose any education in the first period. Then, given the assumptions outlined in (6), h* is strictly greater than ĥ since the opportunity cost of getting an education includes not only the foregone human capital accumulated through work experience but also the earnings associated with working. Since $\mu > 0$, at ĥ the opportunity cost of education is strictly greater than the opportunity cost of working. Thus, when there are no binding liquidity constraints on consumption in the first period, the optimal amount of time allocated to education by the individual, e_t, is given by the following:

$$e_t = \ddot{o}(h_t) = \begin{cases} 0 & \text{if } h_t \le h^* \\ 1 & \text{if } h_t > h^* \end{cases} \qquad \textbf{(9)}$$

where h^* is such that $ah^{*b} + m = bh^{*a}$.

When there are not liquidity constraints, in the first period, individuals devote all of their

time to either work or to education, with the choice depending on the relative marginal returns of each activity. Specifically, individuals borrow to finance first period consumption and allocate all of their time in the first period to getting educated when their parental human capital stock is sufficiently high. Otherwise, at low levels of the parental human capital stock, individuals choose to spend all of their time at work in the first period.

Noting that $e_t + x_t = 1$, we can describe the time path of the human capital stock by combining equations (5) and (9):

$$h_{t+1} = \phi(h_t) = ah_t^{\alpha}[1-\theta(h_t)] + bh_t^{\beta}\theta(h_t) = \begin{cases} ah_t^{\alpha} & \text{if } h_t \le h^* \\ bh_t^{\beta} & \text{if } h_t > h^* \end{cases} \quad \textbf{(10)}$$

where the initial stock of human capital, h_0, is historically given.

Along the dynamic path, h_t evolves monotonically. Namely,

$$\frac{\partial h_{t+1}}{\partial h_t} = \phi'(h_t) = \begin{cases} \dfrac{\alpha a}{h_t^{1-\alpha}} \ge 0 & \text{if } h_t < h^* \\ \dfrac{\beta b}{h_t^{1-\beta}} > 0 & \text{if } h_t > h^* \end{cases} \quad \textbf{(11)}$$

$$\frac{\partial^2 h_{t+1}}{\partial h_t^2} = \phi''(h_t) = \begin{cases} \dfrac{a\alpha(\alpha-1)}{h_t^{2-\alpha}} \le 0 & \text{if } h_t < h^* \\ \dfrac{b\beta(\beta-1)}{h_t^{2-\beta}} \le 0 & \text{if } h_t > h^* \end{cases} \quad \textbf{(12)}$$

$$\lim_{h_t \to \infty} \phi'(h_t) = 0 \quad \textbf{(13)}$$

A steady-state equilibrium is a stationary stock of human capital, $\bar{h}$, such that

$$\bar{h} = \phi(\bar{h}) \qquad \textbf{(14)}$$

Once the human capital stock reaches its steady-state, $\bar{h}$, the amount of time that individuals allocate to education, time allocated to work, and per capita income reach their steady-state levels, respectively denoted by $\bar{e}, \bar{x}, \bar{y}$, as well. Because $\lim_{h\to 0} \frac{ab}{h_t^{1-b}} > 1$, we know a non-trivial steady state exists. Figure 1 shows three possibilities for $\phi(h_t)$. In figure 1A, there is a unique non-trivial steady state in which individuals choose no education, in 1B there is a unique non-trivial steady state in which individuals do not choose to work in the first period, and in 1C, there are two steady states, one in which there is no work and one in which there is no education in the first period. Standard assumptions about utility will generate examples in which all three cases are possible.[9]

3.2 The Case of Liquidity Constraints

When there are liquidity constraints, individuals cannot borrow to finance their consumption in the first period of their lives. As a result, individuals' first period consumption cannot exceed their first period income. Thus, to ensure positive consumption in both periods, they will always choose to allocate some portion of their time to work in the first period.

The optimal amount of time allocated to education by the individual, e_t, when there are

[9]For example, if one considers logarithmic utility (e.g., $U=\ln(c_t) + \ddot{a}\ln(c_{t+1})$; $0 \le \ddot{a} \le 1$), depending on parameter values, all 3 cases are possible.

binding liquidity constraints on consumption, is given by the following:

$$e_t = \ddot{o}(h_t) = \begin{cases} 0 & \text{if } h_t \le h^* \\ e(h_t) > 0 & \text{if } h_t > h^* \end{cases} \qquad \textbf{(15)}$$

Note that the amount of time allocated to education, e_t, is a non-decreasing function of the parental human capital stock, and the amount of time allocated to work in the first period, x_t, is a non-increasing function of the parental human capital stock. Thus, $\ddot{o}'(h_t) = 0$ when $h < h^*$, and $\ddot{o}'(h_t) > 0$ when $h_t > h^*$. Combining equations (5) and (15) gives a description of the dynamic behavior of the human capital stock when there are liquidity constraints:

$$h_{t+1} = \o(h_t) = ah_t^{\hat{a}}[1-\ddot{o}(h_t)] + bh_t^{\acute{a}}\ddot{o}(h_t) = \begin{cases} ah_t^{\hat{a}} & \text{if } h_t \le h^* \\ ah_t^{\hat{a}}[1-e(h_t)] + bh_t^{\acute{a}}e(h_t) & \text{if } h_t > h^* \end{cases} \qquad \textbf{(16)}$$

Moreover,

$$\lim_{h_t \to \infty} e(h_t) < 1 \qquad \textbf{(17)}$$

As in the case of no liquidity constraints examined above, h_t evolves monotonically along the dynamic path. Specifically,

$$\frac{\partial h_{t+1}}{\partial h_t} = \o'(h_t) = \begin{cases} \dfrac{a\hat{a}}{h_t^{1-\hat{a}}} \ge 0 & \text{if } h_t < h^* \\ \dfrac{b\acute{a}}{h_t^{1-\acute{a}}}e(h_t) + \dfrac{a\hat{a}}{h_t^{1-\hat{a}}}[1-e(h_t)] + e'(h_t)[bh_t^{\acute{a}} - ah_t^{\hat{a}}] > 0 & \text{if } h_t > h^* \end{cases} \qquad \textbf{(18)}$$

where the sign of ø"(h_t) when $h_t > h^*$ is indeterminate.

As in the liquidity constrained case, $\lim_{h\to 0} \frac{ab}{h_t^{1-b}} > 1$, and a non-trivial steady state

$$\frac{\partial^2 h_{t+1}}{\partial h_t^2} = ø''(h_t) = \begin{cases} \frac{aâ(â-1)}{h_t^{2-â}} \le 0 \quad if\ h_t < h^* \\ \frac{bá(á-1)}{h_t^{2-á}} e(h_t) + \frac{aâ(â-1)}{h_t^{2-â}}[1-e(h_t)] + 2e'(h_t)[\frac{bá}{h_t^{1-á}} - \frac{aâ}{h_t^{1-â}}] \\ + e''(h_t)[bh_t^{á} - ah_t^{â}] \qquad if\ h_t > h^* \end{cases} \tag{19}$$

exists. When there are liquidity constraints, however, ø(h_t) is a continuous function of the human capital stock, h_t. Figure 2 shows three possibilities for the ø(h_t) function in the liquidity constrained case. Figure 2A generates a unique steady state with no education, 2B generates a unique steady state in which individuals both work and go to school and 2C shows the case in which multiple equilibria exist. At $\bar{h}_1$ there is no education and at $\bar{h}_2$, there is both work and education in the first period.[10]

3.3 Policy Implications

The model discussed above highlights three policy implications of considering alternative means of human capital accumulation. First, similar increases in enrollment rates will not have equivalent effects on human capital in countries in different stages of development. In fact, when

[10]As in the non-liquidity constrained case, logarithmic utility generates an example which, depending on parameter values, all three cases are possible.

the level of human capital in the economy is sufficiently low ($h_t < \hat{h}$) increasing school enrollments will actually decrease the economy's stock of human capital in the short run. This point is illustrated in Figure 3 which shows the time path of human capital for three different initial levels of human capital under the assumption that a policy is devised so that the amount of time spent in school is set equal to the level that would be chosen in the high-income steady state. Thus, the presence of alternative methods of human capital accumulation can help explain the observation that many developing countries that have recently experienced increases in enrollment rates have not experienced a corresponding increase in per capita income.

Of course, in the model of this paper, individuals would never choose this suboptimal level of education because they have full information about the value of education to them and have no altruistic motives. Suboptimal individual decisions may be apparent in the data because individuals do not have perfect information about the value of education given their circumstances. It seems quite plausible that individuals and policy makers do not have this information, particularly since the relationship between education and long-run growth is still being debated among economists. It would also be the case that even with perfect information, altruistic individuals might still chose a short-run sacrifice for a long-run gain.

A second policy implication is that policies that seek to ease liquidity constraints may hasten growth in some but not all developing economies. As demonstrated in the model, removal of liquidity constraints only increases the human capital accumulation of those who have parental levels of human capital greater than h*. Thus, educational loans may be an effective policy in a more advanced developing economy, but may be ineffective among the impoverished.

Finally, economies that have been successful in attracting jobs with a relatively high

learning content, may find that they have sacrificed long-run growth for short-run gain. If work experience is fairly effective in increasing future earnings, the incentive to attend school decreases (i.e., h* increases). In fact, the value of work experience must take on an intermediate value in order for the economy to achieve the high income steady state. When the value of work experience is too low, the economy cannot accumulate enough human capital to make education worthwhile; and when the value of work experience is too high, individuals choose not to accumulate human capital through education.

Unfortunately, this section cannot be concluded with one overriding recommendation appropriate for all countries. Considering alternative means of human capital accumulation shows how policies that are effective in one country may not be effective in another. However, the model does help to identify the circumstances under which certain policies will be appropriate and offers an explanation as to why increases in education do not always translate into increases in per capita income.

4 Conclusion

This paper focuses on how the ability to accumulate human capital through both formal training and through on-the-job experience affects the dynamic behavior of the human capital stock and allows several conclusions, some of which have important policy implications. First, the relationship between increases in schooling and growth of income differs across countries; and, in some cases, an increase in schooling can generate a decrease in human capital. Second, the effectiveness of a policy that removes liquidity constraints will also vary across countries and will be successful only in economies that already have accumulated a minimum level of human capital.

An alternative way of viewing the results here is that they also justify models which employ a fixed cost of schooling (e.g., as in Galor and Zeira (1993)), particularly for developing countries. In the model of this paper, when the human capital level of the economy is low, only large increases in education can generate additional human capital, creating a de facto minimum investment in schooling before it becomes productive.

Overall, this paper has demonstrated the importance of incorporating alternatives to education in the human capital accumulation process. Reasonable alternatives to the standard macroeconomic human capital accumulation process generate different dynamic behavior and different policy prescriptions. This area remains a fruitful one for further research.

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Figure 1A

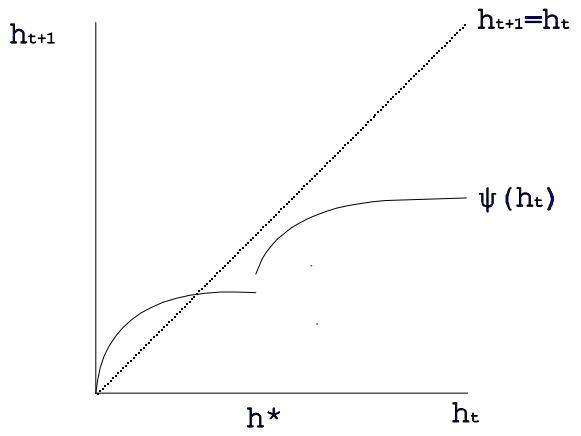


Figure 1B

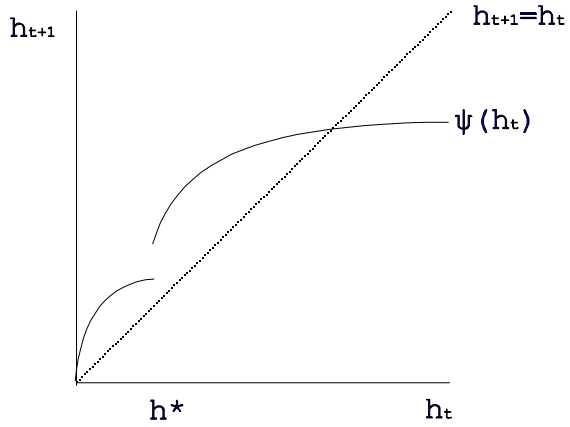


Figure 1C

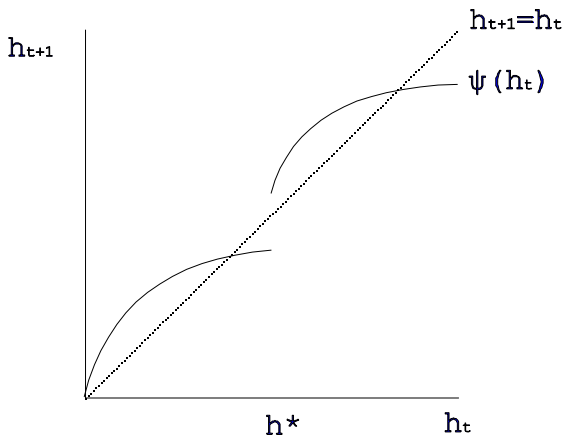
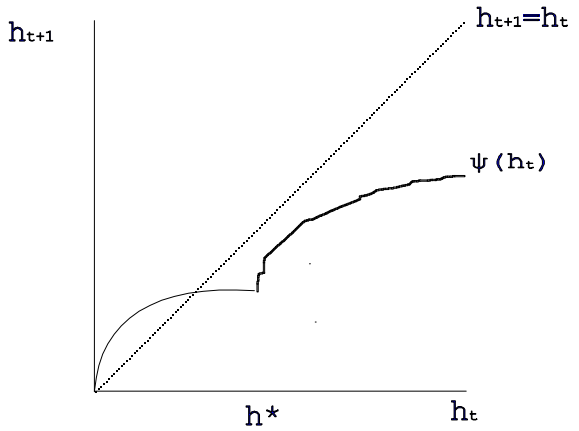


Figure 2A



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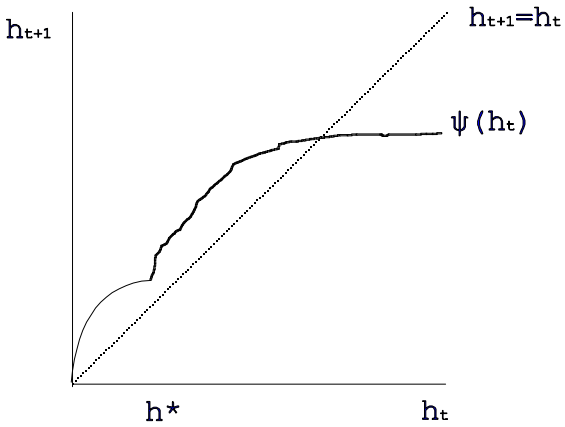

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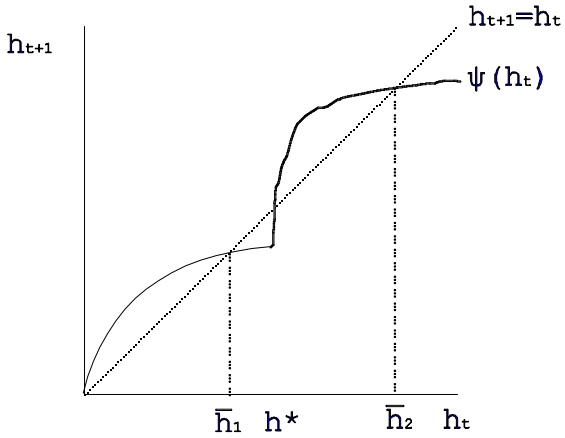

Figure 3