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ECONOMIC DEVELOPMENT AND INTERGENERATIONAL ECONOMIC MOBILITY

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Abstract

This paper examines theoretically how economic growth affects intergenerational economic mobility. In the model developed in this paper, education is provided to the individuals free of cost, and admission to schools is competitive. The quantity of educational services available in any period depends on the total output of the economy in the same period. Individuals differ from each other in two respects. First, their innate mental abilities are determined by a stochastic process, and, second, their parents have different education levels. Individuals are admitted to schools based on their potential. An individual's potential is a function of her innate mental ability and her parent's education level.

In this model, economic growth increases intergenerational economic mobility if and only if the effect of having an educated parent on an individual's potential is not large. Moreover, if the effect of having an educated parent is not large, then there exists a unique steady state equilibrium and all economies will progress toward increased mobility. The model also shows that economic growth reduces the income difference between educated and uneducated labor if and only if the effect of having an educated parent on an individual's potential is not large. And, although population growth reduces intergenerational economic mobility, technological progress increases it.

ECONOMIC DEVELOPMENT AND INTERGENERATIONAL ECONOMIC MOBILITY

Murat F. Iyigun[1]

1. Introduction

Empirical work in the economics and sociology literature reveals that intergenerational economic mobility –the ease with which the relative economic status of families change over time– and the level of economic development are related. This paper develops a theory that provides an explanation for this observation. In doing so, it focuses on the effect of economic development on the supply of educational services and on admission to schools.

Both income inequality and intergenerational economic mobility are measures of economic equity. Income inequality –which is an intragenerational measure of income differences among individuals at a point in time– is an ex-post measure of economic equity. Intergenerational economic mobility is a measure of equality of opportunity and is an ex-ante measure of economic equity.

The relation between income inequality and economic growth has been a focus of research for several decades. Kuznets (1955) argues that income inequality increases in the early stages of development when per capita income is low and that it decreases at higher levels of economic development when per capita income is high. According to Kuznets, the main reason for this relation is the migration of workers from the low variance agricultural sector to the high income variance urban sector in the early stages of development.

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Following Kuznets, economists have mainly assumed that causation runs from economic growth to changes in the distribution of income. But in recent years, some researchers have studied causality in the reverse direction. Galor and Zeira (1988) show that, given the inability of individuals to collateralize human capital, the initial distribution of wealth effects aggregate output and investment both in the short and the long run. Aghion and Bolton (1991) construct a model in which the growth of the economy leads to a reduction in interest rates and a relaxation of the requirements for risky loans. Thus, as the economy grows, poor individuals find it easier to obtain loans to undertake productive ventures and the inequalities in income decline. Banerjee and Newman (1993) demonstrate that, because individuals cannot collateralize their investment in human capital, their choices of occupation and the distribution of initial wealth may lead to inequalities in the distribution of income that are consistent with Kuznets' hypothesis. In a related article, Torvik (1993) studies how the inability to collateralize human capital influences the allocation of talent between skilled and unskilled jobs. In his model, both bequest and ability are relevant in deciding whether or not to invest in education. The inability to collateralize human capital prevents the choice of education from being dependent on ability only and creates economic inefficiencies. Galor and Tsiddon (1994) demonstrate that in a model in which the average human capital creates positive externalities that induce individuals to get educated, only a small number of individuals invest in human capital when the average level of human capital is low. Therefore, income inequality widens in the early stages of development. However, increases in the average human capital level raise the incentive for everyone to invest in human capital, thus decreasing inequality in later stages of development.

Nonetheless, there is also convincing evidence that, although economic growth may reduce income inequality, there is persistence in the tails of the income distribution. Durlauf (1992, 1994), and Benabou (1993, 1994) develop theories that provide alternative explanations for why inequalities in income may be sustained in the long run. They emphasize the role neighborhood location on individuals' human capital investment decisions as the primary determinant of persistent income inequality.

Although, all of the work on economic growth and income inequality, mentioned above, has implications about intergenerational economic mobility, it does not fully explore the effects of economic growth on intergenerational economic mobility dynamics.

Earlier work on intergenerational economic mobility also ignored the relation between economic growth and mobility and examined the determinants of economic mobility in a static setup. For example, Becker and Tomes (1979, 1986) explore the effects of individuals' family specific endowments, such as genetically determined ability, race and other characteristics on their earnings. They demonstrate that if the degree of inheritability of family specific endowments and parents' propensity to invest in their offspring are both low, intergenerational earnings mobility is high. Loury (1981) examines the dynamics of the earnings distribution in a model in which the abilities of successive generations of individuals follow a stochastic process. In his model, the inability to collateralize human capital does not allow parents to borrow resources in order to invest in their offspring's human capital. Thus, parents' income constrains individuals' level of human capital and earnings which in turn causes a low degree of intergenerational economic mobility.

Owen and Weil (1994) explore the effects of economic growth on intergenerational economic mobility. Their primary focus is the liquidity constraints on individuals' educational decisions and the advantage of having wealthy parents, both of which result from the inability to collateralize human capital. They utilize a production function that treats educated and uneducated labor as complements and they show that economic growth can enhance intergenerational mobility.

Empirical work in the economics and sociology literature, indeed, reveals that intergenerational economic mobility and the level of economic development are related.

Ganzeboom, Luijkx and Treiman (1989) conduct a study covering thirty five countries and conclude that the international differences of intergenerational class mobility are significant and that intergenerational class mobility within countries has been increasing over time. Becker and Tomes (1986) review a number of empirical studies for different countries that indicate a higher degree of intergenerational earnings mobility in developed countries than in less developed countries. Among those studies reviewed, Kelley, Robinson and Klein (1981) provide evidence that fathers' education has a greater effect on sons' education in Bolivia than in the United States. They also show that this effect declined over time in both countries.

There are primarily three measures of intergenerational economic mobility: Wealth mobility, which is quantified by the correlation between the wealth of parents and children. Earnings mobility, which is quantified by the correlation between the earnings of parents and children. And, class mobility, which is measured by the relative odds of being educated for children of educated parents compared to children of uneducated parents. This paper, focuses on intergenerational earnings and class mobility in studying the effects of economic growth on economic mobility. It develops a theoretical framework in which the allocation of resources to education links intergenerational mobility and economic growth. One objective is to determine the conditions under which economic growth leads to a greater degree of intergenerational mobility. In other words, this paper attempts to explain the empirical findings that intergenerational economic mobility is higher in developed countries than in less developed countries and that intergenerational mobility within most countries has been increasing over time. Another objective is to evaluate the role of the family specific endowments on intergenerational economic mobility.

2. Overview

In the model analyzed in this paper, education is public and is provided to the individuals by the government. In every period, the government allocates a constant fraction of total output to the provision of educational services. The higher is total output, the higher a fraction of the next generation the government educates.

Individuals live for two periods in overlapping generations. In the first period of life, if they are admitted to a state school, they invest time to get educated. Admission to state schools is competitive and is based on individuals' potentials. An individual's potential is a function of her mental ability and her parent's education level. All individuals who are not admitted to a school spend their time acquiring basic manual skills. In the second period, individuals supply labor inelastically and consume. Individuals who are uneducated earn a low income. Individuals who are educated earn higher incomes that are positively related to their potential.

In this model, the education level of parents affect the young generation in two ways: First, educated parents augment the labor input of their children directly by creating a better learning environment at home. Second, the quantity of educational services depends positively on total output which in turn depends positively on the fraction of educated people [2].

If the fraction of educated parents is low, then total output and the amount of educational services are low. In this case, only a small number of children who possess the highest potential levels are admitted to state schools. Most individuals born to uneducated parents remain uneducated. In contrast, children of educated parents benefit from having educated parents and a larger fraction of them gain admission to the few places in state schools. Therefore, when the fraction of educated parents and the amount

[2] In this regard, the model is similar to Galor and Tsiddon in which investments in human capital create both private (family specific) and social externalities on the decision of individuals to get educated.

of educational services provided are low, intergenerational class and earnings mobility are low.

An increase in the fraction of educated parents in any period has two effects: First, it increases total output and the amount of educational services provided. Holding everything else constant, this effect would make admissions to school less competitive and would increase intergenerational economic mobility. Second, an increase in the fraction of educated parents implies that some members of the young generation have greater potential. Everything else constant, this effect would make admissions to school more competitive and would lower intergenerational economic mobility. Taking into account these two effects, economic growth and intergenerational economic mobility will be positively related if and only if the effect of having an educated parent on an individual's potential is not large.

This study also has implications about how intergenerational economic mobility dynamics and the income differences between educated and uneducated labor are linked. The model shows that economic growth reduces the differences of income between educated and uneducated labor if and only if the effect of having educated parents on individuals' potential is not too large.

This paper is organized as follows: In the next section, the determination of output and the behavior of the government and individuals are explained. In section three, the evolution of the economy is discussed. First, the simpler case in which innate mental ability and the parental education level are perfect subsitutes is considered. Then, the results are generalized with a discussion of the case in which innate mental ability and the parental education level are complements. In section four, intergenerational economic mobility dynamics are explained. In section five, the implications of the model on income differences between educated and uneducated labor are presented. In section six, the effects of population growth and technological progress are considered. And in section seven, some concluding remarks are offerred.

3. The Model

The output of the economy is a single homogenous good produced by a constant returns to scale production function that uses efficiency units of labor as input. The good produced can be used for consumption or for educational services.

Given the above assumptions, output produced at time t, Y_t, is

$$Y_t = F(L_t) = \alpha L_t \tag{1}$$

where L_t is the quantity of efficiency units of labor input at time t and where α, $\alpha > 0$, is output per efficiency units of labor.

Educational services in this economy are provided by the government. In every period t, the government allocates a constant fraction of total output to educational services. The higher is the fraction of the population that is educated, the higher total output and the higher a fraction of the next generation the government educates. Note that the assumption that government is the sole provider of educational services is not critical in determining the results of this model. Rather, the important element is the provision of these services free of cost to individuals. Also, the allocation of a constant fraction of output to the provision of educational services is not essential. As long as increases in the stock of educated individuals among the older generation increase the amount of educational services available to the young generation, the main results will be unaffected.

Let S_t denote the amount of educational services provided in period t. Then,

$$S_t = \frac{\tau Y_t}{c} = \frac{\tau \alpha L_t}{c} \tag{2}$$

where τ, $1 > \tau > 0$ denotes the fraction of total output allocated to the provision of educational services (or, alternatively τ can be interpreted as the tax rate on wage income), and, where c, $c > 0$, denotes the cost of education per person.

Individuals live for two periods in overlapping generations. In each time period, a generation of size one is born. Thus, there is no population growth. Individuals are identical in all aspects except for their innate mental abilities and their parental level of education.

Individual's innate mental abilities are unrelated to their parents' abilities and are drawn from a time invariant uniform distribution

$$\int_{\underline{a}}^{\bar{a}} A'(a_i)da_i = 1 \tag{3}$$

where $A'(a_i)$ denotes the density function of innate mental abilities across individuals and where $\underline{a}$, $1 < \underline{a}$, and $\bar{a}$ denote the lower and upper bound of the support of the mental ability distribution, respectively. Innate mental ability is defined as all personal factors, except the parental education level, that affect individual's productive capacity that are not related to physical ability, and that are not within the individual's control. Note that the assumption of individuals' innate abilities being unrelated to that of their parents can be replaced by the assumption that abilities are transmitted from parents to offspring by a stochastic-linear (Markov) process. As Becker and Tomes (1979) demonstrate, a higher degree of inheritability of ability implies a lower intergenerational mobility. If a Markov process is assumed for the transmission of abilities from parents to offspring, the same result will hold in this model without affecting the remainder of the analysis.

In the first period of life, a member i of generation t invests time to get educated if she gains admission to a state school. Admissions to state schools are competitive and are based on individuals' potentials. An individual's potential, $p_{i,t}$, depends positively on her innate mental ability, $a_{i,t}$, and her parental education level. If individual i is not admitted to a state school, she spends her time acquiring basic manual skills. An uneducated individual's labor input, $l_{i,t+1}$, is equal to the fixed amount η that, for convenience, is assumed not to vary among individuals. If, individual i is admitted to a state school in the first period, her labor input, $l_{i,t+1}$, depends on her potential, $p_{i,t}$ as well as her fixed physical ability, η. Let $\hat{p}_t$ denote the minimum potential necessary to gain admission to a state school in period t. Then, the labor input of individual i who works in period $t+1$ is given by the following:

$$l_{i,t+1} = \begin{cases} \eta & \text{if} \quad p_{i,t} < \hat{p}_t \\ p_{i,t} + \eta & \text{if} \quad p_{i,t} \geq \hat{p}_t \end{cases} \tag{4}$$

where

$$p_{i,t} = \begin{cases} \pi(a_{i,t}\ ,\ 1) & \text{if i's parent is uneducated} \\ \pi(a_{i,t}\ ,\ e) & \text{if i's parent is educated} \end{cases} \tag{5}$$

where $\pi_1 > 0$, $\pi_2 > 0$ and where the parameter e, $1 < e$, measures the effect of educated parents on individual i's potential, $p_{i,t}$.

Given the minimum potential necessary gain to admission to school, equation (5) implies that children of uneducated parents must have more innate mental ability to qualify for admission to school than the children of educated parents. Let a_t^E and a_t^U denote the minimum levels of innate mental ability to gain admission to a state school of children born to educated and uneducated parents, respectively. Then, given that $e > 1$ and that individuals' potential, $p_{i,t}$, depends positively on their parental education level,

$$\hat{p}_t = \pi(a_t^U\ ,\ 1) = \pi(a_t^E\ ,\ e), \quad \Rightarrow \quad a_t^U > a_t^E\ ;\ \ \forall t \geq 0 \tag{6}$$

In addition, the labor augmentation function specified in equations (4) and (5) implies that family backgrounds interact with individuals' innate mental abilities in determining their labor inputs . This specification is consistent with most empirical formulations. For example, 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 [3]. In addition, 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 the second period of life, individual i uses the $l_{i,t+1}$ units of labor input she acquired in the first period and consumes all of her income net of the fraction allocated to educational services (or, alternatively net of taxes).

Because education is provided by the government without a cost to individuals and because education increases the amount of efficiency units of labor input, individuals will want to get educated in the first period. However, admissions to state schools are competitive and are based on individuals' potentials. In addition, when the fraction of educated parents, E_t, in any given period t increases, the aggregate efficiency units of labor input in the same period, L_t, increases as well. Namely,

[3]In this context, we do not identify the various different ways in which the parental education level can affect an individual's performance in school. This effect may arise, for example, if parent's education level creates positive private externalities for the individual and induces her to spend more study effort (See Fan). Or, it may arise because educated parents can guide their offspring more successfully in their schoolwork compared to uneducated parents. A recent article states ".....students do considerably better in school when their parents view themselves as being in charge of their child's educational career.", *The New York Times*, "Success in School Called Family Effort", September 8, 1994, C1.

$$L_t = L(E_t) \qquad \text{and} \qquad L'(E_t) > 0 \qquad \forall E_t \epsilon [0,1] \tag{7}$$

Equations (2) and (7) imply that the quantity of educational services available in any time period t, S_t, depends positively on the fraction of educated parents in the same period: $\forall E_t \epsilon [0, 1]$,

$$\begin{gathered} S_t = \frac{\tau Y_t}{c} = \frac{\tau \alpha L(E_t)}{c} = S(E_t) \\ S'(E_t) = \frac{\tau \alpha L'(E_t)}{c} > 0 \end{gathered} \tag{8}$$

Moreover, we assume that the parameter values are such that the following conditions are satisfied:

$$S(0) = \underline{s} > 0 \quad \text{and} \quad 0 < S(1) = \overline{s} \leq 1 \tag{9}$$

4. The Evolution of the Economy

The evolution of this economy, and in particular, the evolution of the aggregate labor input, L_t, depends strictly on the evolution of the average level of education, E_t. Under all conditions, the evolution of the average level of education, E_t, $E_t \epsilon [0, 1]$, is governed by the autonomous first-order non-linear difference equation

$$E_{t+1} = S(E_t) = E_t \int_{a_t^E}^{\bar{a}} A'(a_i) da_i + (1 - E_t) \int_{a_t^U}^{\bar{a}} A'(a_i) da_i \tag{10}$$

$$= E_t \frac{\bar{a} - a_t^E}{\bar{a} - \underline{a}} + (1 - E_t) \frac{\bar{a} - a_t^U}{\bar{a} - \underline{a}}$$

where E_0 is given and where a_t^E and a_t^U satisfy equation (6). The problem is to determine $\hat{p}_t$, and, thereby to determine a_t^E and a_t^U.

4.1. The Case of Perfect Substitutes

If innate mental ability and the parental education level are perfect substitutes, the potential of individual i is given by equation (5) which, by assumption, takes the following specific form:

$$p_{i,t} = \begin{cases} a_{i,t} + 1 & \text{if i's parent is uneducated} \\ a_{i,t} + e & \text{if i's parent is educated} \end{cases} \tag{11}$$

Given equation (11), the threshold levels on innate mental ability to gain admission to a state school of children of educated and uneducated parents, a_t^E and a_t^U, respectively, satisfy the following:

$$a_t^U + 1 = a_t^E + e = \hat{p}_t \tag{12}$$

Taken together equations (10) and (12) imply that the threshold level of innate mental ability to gain admission to a school of children of educated parents, a_t^E, is given by equation (13):

$$a_t^E = \bar{a} - (\bar{a} - \underline{a})S(E_t) - (e - 1)(1 - E_t) \tag{13}$$

From (13), we derive (14) and (15): $\forall E_t \epsilon [0,1]$,

$$\frac{\partial a_t^E}{\partial E_t} = \frac{\partial a_t^U}{\partial E_t} = \frac{\partial \hat{p}_t}{\partial E_t} = -(\bar{a} - \underline{a})S'(E_t) + e - 1 \tag{14}$$

$$\frac{\partial^2 a_t^E}{\partial E_t^2} = -(\bar{a} - \underline{a})S''(E_t) \tag{15}$$

Equation (14) implies that an increase in the fraction of educated parents at time t has two effects on the minimum levels of innate mental ability necessary to get educated for the members of the following generation: First, it increases the total output, therefore, increases the amount of educational services as well. Holding everything else constant, this effect would lower the minimum level of ability necessary to gain admission to school in a given period. Second, the increase in the fraction of educated parents at time t implies that some members of the young generation have greater potential simply due to the positive effect of educated parents on individuals' potential. Everything else constant, this effect would make admission to schools more competitive and would increase the minimum level of ability necessary to get educated.

Taking into account these two effects, the minimum level of mental ability necessary to get educated for the young generation decreases as the fraction of educated parents in period t, E_t, increases if only if the effect on an individual's potential of having an educated parent, e-1, is sufficiently small. In that case, the increase in the amount of educational services provided is large enough to offset the effect of individuals who have greater potential and $\frac{\partial \hat{p}_t}{\partial E_t}$ is negative $\forall E_t \epsilon [0,1]$. Alternatively, if the advantage of having an educated parent is sufficently large, then $\frac{\partial \hat{p}_t}{\partial E_t}$ is positive $\forall E_t \epsilon [0,1]$ and the threshold level of potential to get educated, $\hat{p}_t$, increases as the average level of education of the economy at time t, E_t, increases. In this case, the effect of the increase in the amount of educational services is smaller than the effect of individuals who have greater potential. Nevertheless, the rate at which the amount of educational services increases when the fraction of educated parents increases, $S''(E_t)$, has the same sign as $\frac{\partial \hat{p}_t}{\partial E_t}$ and is positively related to the potential of the marginal students that are admitted (which equals $\hat{p}_t$). Thus, $\frac{\partial^2 \hat{p}_t}{\partial E_t^2}$, as given by (15), always has the opposite sign of $\frac{\partial \hat{p}_t}{\partial E_t}$.

Finally, rearranging (13), (14) and (15), we derive

$$E_{t+1} = S(E_t) = \frac{\bar{a} - a_t^E - (e-1)(1-E_t)}{\bar{a} - \underline{a}} > 0, \tag{16}$$

$$\frac{\partial E_{t+1}}{\partial E_t} = S'(E_t) = \frac{1}{\bar{a} - \underline{a}} \left\{ e - 1 - \frac{\partial a_t^E}{\partial E_t} \right\} > 0 \tag{17}$$

and

$$\frac{\partial^2 E_{t+1}}{\partial E_t^2} = S''(E_t) = -\frac{1}{\bar{a} - \underline{a}} \frac{\partial^2 a_t^E}{\partial E_t^2} \tag{18}$$

Let $\tilde{e}(E_t)$ denote the value of e that sets $\frac{\partial \hat{p}_t}{\partial E_t}$ equal to zero:

$$\tilde{e}(E_t) \equiv 1 + (\bar{a} - \underline{a}) S'(E_t) \tag{19}$$

Proposition 1: *(a) If the effect of educated parents on their children's potential, e, is such that* $e < \tilde{e}(E_t) \quad \forall E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is negative* $\forall E_t \epsilon [0,1]$, *and the evolution of the economy is characterized by equations (16) and (17), with* $\frac{\partial^2 E_{t+1}}{\partial E_t^2} < 0$, $\forall E_t \epsilon [0,1]$, *and by a unique steady state equilibrium average education level,* $\bar{E}$, $0 < \bar{E} \leq 1$.
(b) If the effect of educated parents on their children's potential, e, is such that $e \geq \tilde{e}(E_t) \quad \forall E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is non-negative* $\forall E_t \epsilon [0,1]$, *and the evolution of the economy*

is characterized by equations (16) and (17), with $\frac{\partial^2 E_{t+1}}{\partial E_t^2} \geq 0$, $\forall E_t \epsilon [0,1]$, *and possibly by a multiple steady state equilibria.*

(c) Otherwise, if the effect of educated parents on their children's potential, e, is such that $e < \tilde{e}(E_t)$ *for some* $E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is non-positive* $\forall E_t \epsilon [0,1]$ *and the evolution of the economy is similar to that in case (a) with* $\frac{\partial^2 E_{t+1}}{\partial E_t} \leq 0$ $\forall E_t \epsilon [0,1]$.

Proof: Since $E_{t+1} = S(E_t)$ is a single valued continuous function such that $S(E_t) : S \rightarrow S, S \epsilon [0,1]$, it follows from Brouwer's Fixed Point Theorem that there exists an $\bar{E}$ such that $\bar{E} = S(\bar{E})$. If $e < \tilde{e}(E_t)$ $\forall E_t \epsilon [0,1]$, as in (a), then $\frac{\partial \hat{p}_t}{\partial E_t}$ is negative and $\frac{\partial^2 \hat{p}_t}{\partial E_t^2}$ is positive $\forall E_t \epsilon [0,1]$. Therefore, (18) is negative $\forall E_t \epsilon [0,1]$ and there exists a unique steady state equilibrium. If e is large enough that $e \geq \tilde{e}(E_t)$ $\forall E_t \epsilon [0,1]$, as in (b), then $\frac{\partial \hat{p}_t}{\partial E_t}$ is non-negative and $\frac{\partial^2 \hat{p}_t}{\partial E_t^2}$ is non-positive $\forall E_t \epsilon [0,1]$. In that case, (18) is positive $\forall \epsilon E_t [0,1]$ and multiplicity of the steady state level of education can occur if the marginal increase in the supply of educational services, $S'(E_t)$, is sufficiently small $\forall E_t \epsilon [0,1]$ (See Figures I and II). ||

[The implications of this proposition on intergenerational economic mobility is provided in Section 4.]

4.2. The Case of Complements

If innate mental ability and the parental education level are complements, then individual i's potential is given by equation (5) which, by assumption, takes the following form:

$$p_{i,t} = \begin{cases} a_{i,t} & \text{if i's parent is uneducated} \\ ea_{i,t} & \text{if i's parent is educated} \end{cases} \tag{20}$$

Equation (20) implies that the threshold levels of innate mental ability, a_t^E and a_t^U satisfy the following:

$$a_t^U = ea_t^E = \hat{p}_t \tag{21}$$

Using equations (10) and (21), we derive the threshold level of innate mental ability to gain admission to a school of individuals born to educated parents, a_t^E:

$$a_t^E = \frac{\bar{a} - (\bar{a} - \underline{a})S(E_t)}{E_t + e(1 - E_t)} \tag{22}$$

And, using (22) we derive (23) and (24): $\forall E_t \epsilon [0, 1]$,

$$\frac{\partial a_t^E}{\partial E_t} = \frac{1}{e}\frac{\partial a_t^U}{\partial E_t}\frac{1}{e}\frac{\partial \hat{p}_t}{\partial E_t} = = \frac{1}{[E_t + e(1 - E_t)]^2}$$
$$\{(e-1)[\bar{a} - (\bar{a} - \underline{a})S(E_t)] - (\bar{a} - \underline{a})[E_t + e(1 - E_t)]S'(E_t)\} \tag{23}$$

$$\frac{\partial^2 a_t^E}{\partial E_t^2} = -\frac{(\bar{a} - \underline{a})S''(E_t)}{E_t + e(1 - E_t)} + \frac{2(e-1)}{[E_t + e(1 - E_t)]^3}$$
$$\{(e-1)[\bar{a} - (\bar{a} - \underline{a})S(E_t)] - (\bar{a} - \underline{a})[E_t + e(1 - E_t)]S'(E_t)\} \tag{24}$$

Equations (23) and (24) are the analogs of (14) and (15), respectively. Their interpretations are also similar to those of (14) and (15), as well. That is, for (23) to be negative and for (24) to be positive $\forall E_t \epsilon [0,1]$, the effect of having an educated parent, e, must be small. Conversely, for the threshold level of innate mental ability to get educated of children born to educated parents to be increasing in $E_t, \forall E_t \epsilon [0,1]$, the effect of having an educated parent, e, must be relatively large.

Rearranging (22), (23) and (24), we then derive the following: $\forall E_t \epsilon [0,1]$,

$$E_{t+1} = S(E_t) = \frac{\bar{a} - a_t^E[E_t + e(1-E_t)]}{\bar{a} - \underline{a}} > 0, \tag{25}$$

$$\frac{\partial E_{t+1}}{\partial E_t} = S'(E_t) = \frac{1}{\bar{a} - \underline{a}} \left\{ (e-1)a_t^E - [E_t + e(1-E_t)]\frac{\partial a_t^E}{\partial E_t} \right\} > 0 \tag{26}$$

and

$$\frac{\partial^2 E_{t+1}}{\partial E_t^2} = S''(E_t) = \frac{1}{\bar{a} - \underline{a}} \left\{ 2(e-1)\frac{\partial a_t^E}{\partial E_t} - [E_t + e(1-E_t)]\frac{\partial^2 a_t^E}{\partial E_t^2} \right\} \tag{27}$$

Equation (23) implies that the value of e that sets $\frac{\partial \hat{p}_t}{\partial E_t}$ equal to zero, $\tilde{e}(E_t)$, is given by the following:

$$\tilde{e}(E_t) \equiv \frac{\bar{a} + (\bar{a} - \underline{a})[S'(E_t)E_t - S(E_t)]}{\bar{a} - (\bar{a} - \underline{a})[S(E_t) + (1-E_t)S'(E_t)]} \tag{28}$$

Proposition 2: *(a) If the effect of educated parents on their children's potential, e, is such that* $e < \tilde{e}(E_t) \quad \forall E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is negative* $\forall E_t \epsilon [0,1]$, *and the evolution of the economy is characterized by equations (25) and (26), with* $\frac{\partial^2 E_{t+1}}{\partial E_t^2} < 0$, $\forall E_t \epsilon [0,1]$, *and by a unique steady state equilibrium average education level,* $\bar{E}$, $0 < \bar{E} \leq 1$.

(b) If the effect of educated parents on their children's potential, e, is such that $e \geq \tilde{e}(E_t)$ $\forall E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is non-negative* $\forall E_t \epsilon [0,1]$, *and the evolution of the economy is characterized by equations (25) and (26), with* $\frac{\partial^2 E_{t+1}}{\partial E_t^2} \geq 0$, $\forall E_t \epsilon [0,1]$, *and possibly by a multiple steady state equilibria.*

(c) Otherwise, if the effect of educated parents on their children's potential, e, is such that $e < \tilde{e}(E_t)$ *for some* $E_t \epsilon [0,1]$, *then* $\frac{\partial \hat{p}_t}{\partial E_t}$ *is non-positive* $\forall E_t \epsilon [0,1]$ *and the evolution of the economy is similar to that in case (a) with* $\frac{\partial^2 E_{t+1}}{\partial E_t} \leq 0$ $\forall E_t \epsilon [0,1]$.

Proof: Similar to the proof of Proposition 1. ||

5. Intergenerational Class and Earnings Mobility

In the above described economy, when the effect of educated parents on their children's potential is sufficiently small and when $E_0 < \bar{E}$, intergenerational economic mobility increases monotonically during the transition to the steady state, regardless of whether there exists complementarity between innate mental ability and the parental education level. In this case, most individuals born to uneducated parents remain uneducated and a proportionately larger number of children born to educated parents get educated during the early stages of development. In other words, the advantage of having educated parents during the early stages of development is high. Therefore, class mobility is low when the quantity of educational services is low. As the economy approaches its steady state, the advantage of having educated parents declines and increases in the quantity of educational services provided reduce the minimum level of potential to gain admission to schools. This, in turn, allows a proportionately larger number of individuals born to uneducated parents to get educated.

In contrast, when the effect of educated parents on their children's potential is sufficiently large and when $E_0 < \bar{E}$, intergenerational economic mobility decreases monotonically during the transition to the steady state. In this case, the effect of having educated parents is large enough that potentials are primarily determined by the educational level of individuals' parents. Moreover, increases in the amount of educational services are always offset by the effect of individuals who now have greater potential because their parents are educated and who make admission to state schools more competitive. Therefore, the threshold level of innate mental ability to gain admission to a school of children of both types of parents increase gradually and as the economy grows, individuals that are educated come proportionately more from educated households.

A commonly used measure of class mobility is the odds ratio which is defined as the relative odds of being educated for children of uneducated parents compared to the children of educated parents. Let M_t denote the odds ratio in period t. Then,

$$M_t = \frac{Prob_t[child \;\; is \;\; educated | parent \;\; is \;\; uneducated]}{Prob_t[child \;\; is \;\; educated | parent \;\; is \;\; educated]} = \frac{\int_{a_t^U}^{\bar{a}} A'(a_i) da_i}{\int_{a_t^E}^{\bar{a}} A'(a_i) da_i} = \frac{\bar{a} - a_t^U}{\bar{a} - a_t^E} \tag{29}$$

Proposition 3: *When* $E_0 < \bar{E}$;

(i) If the effect of educated parents on their children's potential is such that $e < \tilde{e}(E_t)$ $\forall E_t \epsilon [0,1]$, *then class mobility increases monotonically during the transition to the steady state.*

(ii) If the effect of educated parents on their children's potential is such that $e > \tilde{e}(E_t)$ $\forall E_t \epsilon [0,1]$, *then class mobility decreases monotonically during the transition to the steady state.*

Proof: (i) In the case of perfect substitutes, if (i) applies, then $\frac{\partial a_t^U}{\partial E_t} = \frac{\partial a_t^E}{\partial E_t} < 0, \forall E_t \epsilon [0,1]$. In the case of complements, if (i) applies, then $\frac{\partial a_t^U}{\partial E_t} < \frac{\partial a_t^E}{\partial E_t} < 0, \;\; \forall E_t \epsilon [0,1]$. Thus, together with equations (12) or (21) (whichever is relevant), this implies that, $\forall T > 0$,

$$M_0 = \frac{\bar{a} - a_0^U}{\bar{a} - a_0^E} \quad < \quad M_T = \frac{\bar{a} - a_T^U}{\bar{a} - a_T^E} \tag{30}$$

(ii) Otherwise, in the case of perfect substitutes, if (ii) applies, then $\frac{\partial a_t^U}{\partial E_t} = \frac{\partial a_t^E}{\partial E_t} > 0$, $\forall E_t \epsilon [0,1]$. In the case of complements, if (ii) applies, then $\frac{\partial a_t^U}{\partial E_t} > \frac{\partial a_t^E}{\partial E_t} > 0$, $\forall \epsilon [0,1]$. Together with equation (12) or (21) (whichever is relevant), this implies that, $\forall T > 0$,

$$M_0 = \frac{\bar{a} - a_0^U}{\bar{a} - a_0^E} \quad > \quad M_T = \frac{\bar{a} - a_T^U}{\bar{a} - a_T^E} \tag{31}$$

||

In this economy, intergenerational earnings and class mobility are positively related. Economic mobility of families is related inversely to the extent to which parental characteristics rather than personal ones determine an individual's income. When the effect of educated parents on their children's potential is small and when the fraction of educated parents, E_t, is low, class mobility is also low. In this case, the education level of parents is a primary determinant of individuals' earnings as well as their economic classes. Thus, during these periods, most individuals born to low income, uneducated parents remain uneducated and they earn low wages. In contrast, a larger fraction of children born to high income, educated parents remain educated and they earn high wages. As the fraction of educated parents, E_t, increases and approaches its steady state level, $\bar{E}$, intergenerational class mobility increases and there exists proportionately more high income, educated individuals born to uneducated, low income parents when the fraction of educated parents, E_t, is high. Moreover, when the fraction of educated parents is high, most of the variation in incomes of educated individuals are attributed to differences in personal innate abilities since the relative importance of parental educational backgrounds is lower. Therefore, intergenerational earnings mobility increases as class mobility and the fraction of educated parents, E_t, increases.

When the effect of educated parents is sufficiently large, then as the economy develops and intergenerational class mobility declines, so does earnings mobility.

6. Income (Wage) Differences

The relation between economic growth and income differences between educated and uneducated labor has been explored by a variety of empirical investigations. Some studies, such as Psacharopoulos(1985) and Williamson(1985), have found evidence that economic growth leads to a reduction in the income differences between educated and uneducated labor. The model presented here shows that economic growth reduces the difference between the income of educated and uneducated labor if and only if the effect of having educated parents on individuals' potential is not large.

In this model, the effect of educated parents on their children's potential is small, then as the economy approaches its steady state and as more individuals become educated, the income differences between educated and uneducated labor decrease. In this case, while the average income of uneducated labor remains constant, the average income of educated labor continually declines. The main reason for this decline is that as the fraction of educated parents, E_t, increases, the amount of educational services increases which causes individuals with lower potentials to acquire education. Otherwise, if the effect of educated parents on their children's potential is large, the income differences increase as the economy grows.

Proposition 4: *When* $E_0 < \bar{E}$*;*

(i) If the effect of educated parents on their children's potential, e, is such that $e < \tilde{e}(E_t)$ $\forall E_t[0,1]$, then income differences between educated and uneducated labor decline monotonically during the transition to the steady state.

(ii) If the effect of educated parents on their children's potential, e, is such that $e > \tilde{e}(E_t)$ $\forall E_t[0,1]$, then income differences increase monotonically during the transition to the steady state.

Proof: Let $\bar{I}_t^E$ and $\bar{I}_t^U$ respectively denote the average income of educated and uneducated labor at time t. And, let $P_t'(.)$ denote the probability density function of individuals' potentials, $p_{i,t}$. Then, the ratio of the average incomes of educated and uneducated labor, R_t, is given by

$$R_t = \frac{\bar{I}_t^E}{\bar{I}_t^U} = \frac{1}{[1 - P_t(\hat{p}_t)]\eta} \int_{\hat{p}_t}^{\infty} l_{i,t+1} P_t'(p_{i,t}) dp_{i,t} \tag{32}$$

where

$$\frac{\partial R_t}{\partial E_t} = \frac{P_t(p_{i,t}) \frac{\partial \hat{p}_t}{\partial E_t}}{[1 - P_t(\hat{p}_t)]\eta} \left\{ \frac{\int_{\hat{p}_t}^{\infty} l_{i,t+1} P_t'(p_{i,t}) dp_{i,t}}{1 - P_t(\hat{p}_t)} - [\hat{p}_t + \eta] \right\} \tag{33}$$

Note that the first term in the parenthesis in equation (33) is the average income of educated labor and that the second term is the income of the educated individual with the lowest potential. Thus, if (i) holds then $\frac{\partial \hat{p}_t}{\partial E_t} < 0$ and (33) is negative $\forall E_t \epsilon [0,1]$. If (ii) holds, then $\frac{\partial \hat{p}_t}{\partial E_t} > 0$ and (33) is positive $\forall E_t \epsilon [0,1]$. ||

7. Population Growth and Technological Progress

In this section, we incorporate into the model the effects of population growth and technological change. Not surprisingly, the results show that while population growth reduces intergenerational economic mobility, technological progress increases it.

Consider the following alterations in the above described model: First, let N_t denote the population of the economy in period t and assume that it grows at the rate n, $0 < n$, in every period t. Then,

$$N_{t+1} = (1+n)N_t \tag{34}$$

Second, assume that output per efficiency units, ϕ, is a positive function of the fraction of educated parents, E_t. Namely,

$$\alpha_t = \alpha(E_t) \qquad \text{and} \qquad \alpha'(E_t) > 0 \qquad \forall E_t \epsilon [0,1] \tag{35}$$

Therefore, output produced at time t, Y_t, is given by (36)

$$Y_t = \alpha_t N_t L_t = \alpha(E_t) N_t L(E_t) \tag{36}$$

and, the quantity of educational services available in period t, S_t, is given by (37)

$$S_t = \tau \alpha_t N_t L_t = N_t S(E_t) \tag{37}$$

where

$$S'(E_t) = \tau[\alpha'(E_t)L(E_t) + \alpha(E_t)L'(E_t)] > 0 \tag{38}$$

Note that equations (8) and (38) imply that increases in the fraction of educated parents has a greater effect on the quantity of educational services provided per person because of technological progress.

Taken together, equations (10), (34) and (37), then imply that

$$E_{t+1} = S(E_t) = \frac{N_{t+1}}{N_t} \left[E_t \int_{a_t^E}^{\bar{a}} A'(a_i) da_i + (1 - E_t) \int_{a_t^U}^{\bar{a}} A'(a_i) da_i \right]$$
$$= (1 + n) \left[E_t \frac{\bar{a} - a_t^E}{\bar{a} - \underline{a}} + (1 - E_t) \frac{\bar{a} - a_t^U}{\bar{a} - \underline{a}} \right] \tag{39}$$

To keep the analysis simple, consider the case of perfect substitutes in which the potential of individual i, $p_{i,t}$, is given by equation (11). Then, (12) and (39) imply that

$$a_t^E = \bar{a} - \frac{\bar{a} - \underline{a}}{1 + n} S(E_t) - (e - 1)(1 - E_t) \tag{40}$$

From (40), we derive (41):

$$\frac{\partial a_t^E}{\partial E_t} = \frac{\partial a_t^U}{\partial E_t} = \frac{\partial \hat{p}_t}{\partial E_t} = -\frac{\bar{a} - \underline{a}}{1 + n} S'(E_t) + e - 1$$
$$= -\frac{\bar{a} - \underline{a}}{1 + n} \{\tau[\alpha'(E_t)L(E_t) + \alpha(E_t)L'(E_t)]\} + e - 1 \tag{41}$$

Equation (41) implies that population growth dilutes the positive effect on intergenerational economic mobility of an increase in the fraction of educated parents, E_t. That is, economic growth increases the quantity of educational services provided but population growth increases the number of qualified individuals. Nonetheless, equation (41) also implies that technological progress strengthens the positive effect on intergenerational economic mobility of an increase in the fraction of educated parents, E_t, because total output and the quantity of educational services provided in any period t increases.

Proposition 5: *For any set of parameter values, population growth reduces and technological progress increases intergenerational economic mobility.*
Proof: Follows directly from a comparison of equations (14) and (41). ||

8. Summary

This paper develops a theoretical framework in which economic growth determines intergenerational economic mobility. In the model developed above, educated individuals' academic performance as well as their labor input depend on their innate mental ability and their parental education level. Educational services in this economy are provided by the government and admissions to state schools which depend on individuals' academic potentials, are competitive.

In this economy, the education level of parents affect the young generation in two ways: first, educated parents augment the labor input of their children directly by creating a better learning environment at home. Thus, educated parents create positive private externalities for their children. Second, educated parents raise the fraction of educated individuals in the economy. Since the amount of educational services provided in a given period depends positively on aggregate output which in turn depends positively on the fraction of educated parents in the same period, educated parents also create positive social externalities in education for the young.

The results of this study can be summarized as follows: First, economic growth raises intergenerational mobility if only if the relative effect of having an educated parent on individuals' potential is not large. Second, the study demonstrates that when the relative effect of having an educated parent is low, there exists a unique steady state equilibrium, otherwise, multiple steady state equilibria may exist. The results also show that intergenerational economic mobility dynamics affect the income difference between educated and uneducated labor. If economic growth increases intergenerational economic mobility, which can occur if and only if the effect of having an educated parent on an individual's potential is not large, then educated and uneducated labor income differences decline. Otherwise, economic growth reduces intergenerational economic mobility and the income differences between educated and uneducated labor increase.

The model presented above examines the effect of economic growth on intergenerational economic mobility. However, in doing so, it abstracts from the role of liquidity constraints that has already been studied in the literature and, instead, emphasizes the effects of family specific endowments on intergenerational economic mobility. The paper shows that these family specific endowments not only determine intergenerational mobility in the short run, as Becker and Tomes demonstrate, but also that they affect mobility in the long run.

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Figure I: The evolution of the fraction of educated parents ($e < \tilde{e}(E_t)$ for all $E_t \in [0,1]$)

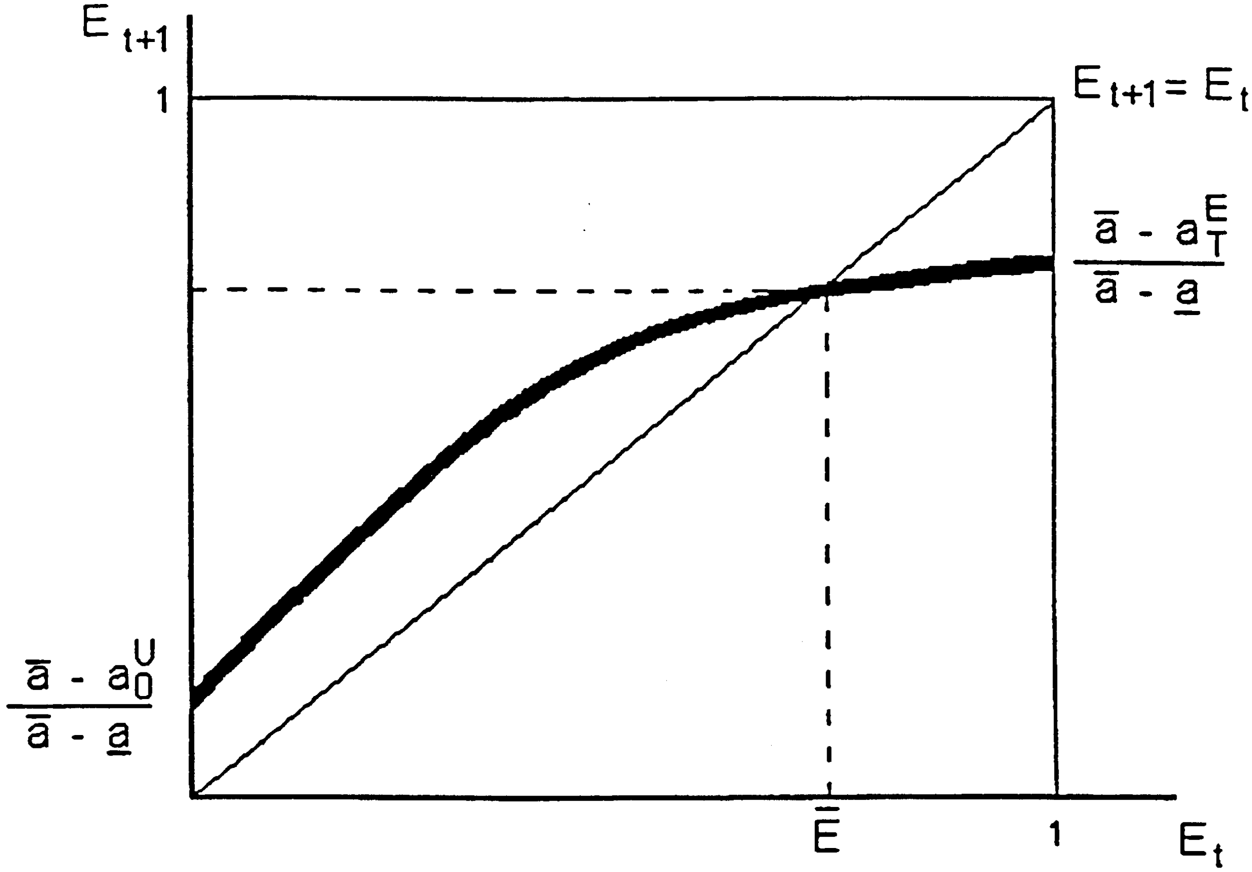
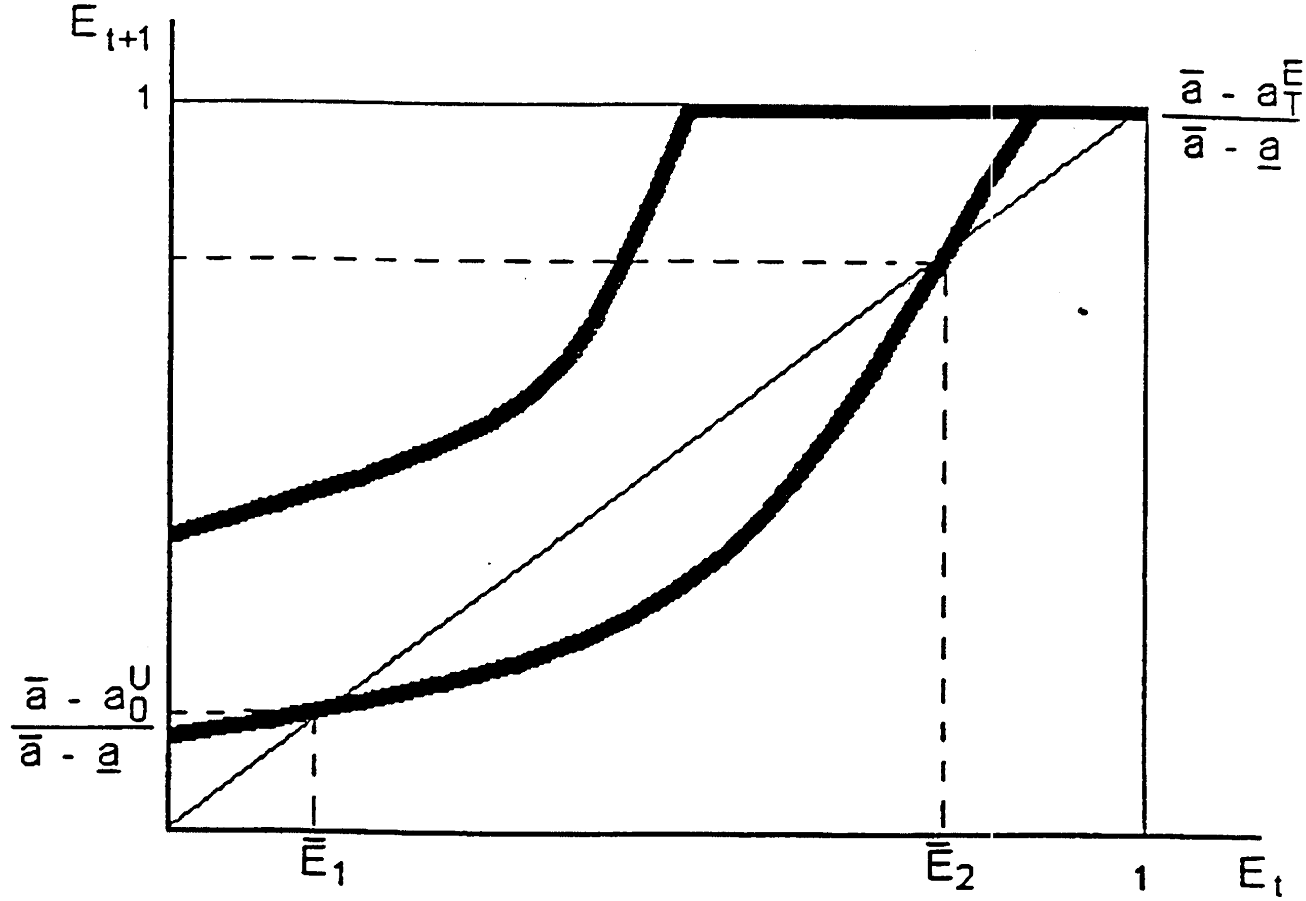


Figure II: The evolution of the fraction of educated parents
($e > \tilde{e}(E_t)$ for all $E_t \in [0,1]$)



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