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PUBLIC EDUCATION AND INTERGENERATIONAL ECONOMIC MOBILITY*

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This paper examines the role of public education in determining intergenerational economic mobility. It considers a model in which education is free and admission to schools is competitive. The results indicate that for mobility to increase during the process of development, the share of resources devoted to public education needs to be large enough to offset the relative advantage of having educated parents in academic attainment.

1. INTRODUCTION

Intergenerational economic mobility—the ease with which the relative economic status of families change over time—has been the focus of a number of theoretical and empirical studies. Some of these have explored the comparative effects on mobility of different education finance systems.[2] There are three important motivations for examining particularly the link between public education and economic mobility. First, education—even at the tertiary level—is predominantly government funded in most countries. Second, schooling is a determinant of individuals' socioeconomic classes. And third, centrally financed public education is often associated with equity. This paper explores the role public education plays in intergenerational economic mobility and identifies the conditions under which mobility and economic development are positively related. For mobility to rise during the process of development, the share of resources devoted to public education needs to be sufficiently large to offset the relative advantage of having educated parents in academic attainment.

In fact, empirical work in the economics and sociology literature reveals that economic development is positively associated with intergenerational mobility.

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[2] See, for example, Loury (1981), Glomm and Ravikumar (1992), Fernandez and Rogerson (1994), Benabou (1996a), Durlauf (1996), and Gradstein and Justman (1997).

Ganzeboom, Luijkx, and Treiman (1989) conducted a study covering 35 countries and concluded that international differences of intergenerational class mobility are significant and that, within countries, mobility has been increasing over time. Becker and Tomes (1986) reviewed a number of empirical studies for different countries that indicated a higher degree of intergenerational earnings mobility in developed countries than in less developed ones. Among those studies reviewed, Kelley, Robinson, and Klein (1981) provided evidence that fathers' education has a greater effect on sons' education in Bolivia than in the United States. They also showed that this effect declined over time in both countries.

Some recent theoretical work has—explicitly or implicitly—addressed how intergenerational economic mobility may be associated with the level of development and economic growth. For example, Banerjee and Newman (1993) demonstrated that initial inequality may have long-run effects on occupational choice and development. Galor and Zeira (1993) showed how large initial income inequality prevents upward intergenerational mobility and is associated with inequality of opportunity. Galor and Tsiddon (1997) argued that while major technological inventions enhance mobility, minor technological innovations lower it. And Owen and Weil (1998) found that economic growth may enhance mobility by relaxing the liquidity constraints that bind those individuals who otherwise find investment in education optimal.[3]

This paper focuses on intergenerational *earnings* and *class* mobility in studying the effects of public education on mobility.[4] In the model represented herein, parental education level affects the young in two ways: First, educated parents create a better learning environment at home, directly influencing the academic potential of their children. Second, the quantity of educational services depends positively on output, which in turn depends positively on the fraction of educated parents. Thus an increase in the fraction of educated parents in any period has potentially offsetting effects. First, by increasing total output, it expands the supply of educational services. Holding everything else constant, this 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 academic potential. Everything else constant, this would make admissions to school more competitive and would lower intergenerational economic mobility. Taking into account these two effects, increases in the supply of public education due to higher output enhance mobility if and only if the effect of having an educated parent on an individuals' potential is not large.

The remainder of this paper is organized as follows: Section 2 describes the technology of production, the supply of education, and the admissions process. Section 3 analyzes the evolution of the economy. Section 4 discusses intergenerational economic mobility. And Section 5 summarizes.

[3] For some other related studies, see Benabou (1996b), Durlauf (1996), and Torvik (1993).

[4] There are primarily three measures of intergenerational economic mobility: wealth mobility, quantified by the correlation between the wealth of parents and children; earnings mobility, measured by the correlation between the earnings of parents and children; and class mobility, quantified by the relative odds of being educated for children of educated parents compared with children of uneducated parents.

2. THE MODEL

The output of the economy is a single homogeneous good produced by a constant-returns-to-scale production function that uses efficiency units of labor as input. The goods can be used for consumption or for the provision of educational services. The output produced at time t, Y_t, is

$$Y_t = \alpha L_t \tag{1}$$

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

Educational services are provided by the government. In every period t, the government allocates a constant fraction of the total output to education.[5] The higher the fraction of educated workers, the higher is total output and the fraction of the next generation that can be educated.

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

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

where c ($c > 0$) denotes the cost of education per pupil and τ ($0 < \tau < 1$) 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).

Individuals live for two periods in overlapping generations. There is no population growth, and in each time period a generation of size one is born. Individuals are identical in all aspects except for their innate mental ability and parental education level. Their innate abilities are unrelated to their parents' abilities and are drawn from a time-invariant uniform distribution with support $[\underline{a}, \bar{a}]$, where $\underline{a}$ and $\bar{a}$, respectively, denote the lower and upper bound of the support of the mental ability distribution. Innate mental ability is defined as all personal factors, except parental education, that affect an individual's academic productivity.[6]

In the first period of life, a member i of generation t invests time to get educated if he or she is admitted to a school. Admission to schools is competitive and based on individuals' academic potential. An individual's potential $p_{i,t}$ depends positively

[5] 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, the results will be unaffected. Iyigun and Levin (1998) consider a model in which the share of resources devoted to public higher education is endogenous and examine what role socioeconomic biases in admissions criteria play in the political economy of public higher education finance.

The assumption that government is the sole provider of educational services is also not critical in determining the results presented below. Rather, the important element is the provision of these services free of cost to individuals.

[6] 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.

on his or her innate mental ability $a_{i,t}$ and parental education level:

$$p_{i,t} = \begin{cases} \pi(a_{i,t}, 1) & \text{if i's parent is uneducated} \\ \pi(a_{i,t}, e) & \text{if i's parent is educated} \end{cases} \tag{3}$$

where e ($e \geq 1$), measures the effect of educated parents on individual i's potential $p_{i,t}$. The specification in equation (3) is consistent with most empirical formulations. For example, Coleman *et al.* (1966) find support for the importance of family backgrounds in educational attainment. And Fuchs and Reklis (1994) provide evidence that family characteristics influence math achievement of eight-grade students in the United States.

Let $\hat{p}_t$ denote the minimum potential necessary to be admitted to a school in period t. And let a_t^E and a_t^U denote the associated ability to gain admission to a school of children born to educated and uneducated parents, respectively. Given that $e > 1$ and that individuals' potential $p_{i,t}$ depends positively on their parental education level, equation (3) implies that children of uneducated parents must have more innate mental ability to qualify for admission than the children of educated parents. Specifically,

$$\hat{p}_t \equiv \pi\left(a_t^U, 1\right) = \pi\left(a_t^E, e\right) \Rightarrow a_t^U > a_t^E \quad \forall t \geq 0. \tag{4}$$

If individual i is not admitted to a school in the first period, he or she spends his or her time acquiring basic manual skills. An uneducated individual's labor input $l_{i,t+1}$ is equal to the raw labor income $\underline{l}$. In contrast, if individual i is admitted to a school in the first period, then his or her labor input equals $\bar{l}$, where $\bar{l} > \underline{l}$. Thus individual i's labor input in period $t+1$ is given by the following[7]:

$$l_{i,t+1} = \begin{cases} \underline{l} & \text{if } p_{i,t} < \hat{p}_t \\ \bar{l} & \text{if } p_{i,t} \geq \hat{p}_t \end{cases} \tag{5}$$

[7] A fixed return to education is assumed in this model in order to simplify the analysis by maintaining a one-dimensional state space. As a result, however, the return to education is independent of academic potential, and there needs to exist some efficiency motive for admitting individuals with highest academic potential to schools. This motivation may arise, for example, if acquiring $\bar{l} - \underline{l}$ units of efficiency labor requires individuals to spend some study effort in school. Provided that individuals' effort depends negatively on their academic potential and they receive disutility from the effort they spend in getting educated, optimal admissions policy would require those with highest potential to be admitted if the objective is to maximize intragenerational social welfare. Implicit in this analysis is, of course, the additional restriction that the amount of effort required to get educated is such that even an individual born to an uneducated parent with $\underline{a}$ innate ability prefers to become educated.

A more realistic version of the model could link individuals' labor income to their innate mental abilities and, perhaps, their parental education level. Or it could link negatively the cost of education per pupil to the average potential of those admitted to state schools. In both these cases, the output of the economy and the supply of educational services will be nonlinear functions of the average education level in the same period. Thus, unlike the simpler version discussed below, the dynamic evolution of the economy will be nonlinear as well. I have chosen the current specification because it simplifies the analysis without affecting the qualitative nature of the results.

In the second period, individual i uses the $l_{i,t+1}$ units of labor input he or she acquired in the first period and consumes all his or her income net of the fraction allocated to educational services (or alternatively, net of taxes).

3. THE EVOLUTION OF THE ECONOMY

The aggregate efficiency units of labor in period t (L_t) is an increasing function of the fraction of educated labor in the same period E_t. Namely,

$$(6) \qquad L_t = \underline{l} + \left(\bar{l} - \underline{l}\right)E_t \quad \text{and} \quad \frac{\partial L_t}{\partial E_t} = \left(\bar{l} - \underline{l}\right) > 0 \qquad \forall E_t \in [0,1]$$

Taken together with equation (2), equation (6) implies that the quantity of educational services available in any time period t (S_t) depends positively on the fraction of educated labor in the same period as well: $\forall E_t \in [0,1]$,

$$(7) \qquad S_t = \frac{\tau\alpha}{c}\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right] \quad \text{and} \quad \frac{\partial S_t}{\partial E_t} = \frac{\tau\alpha}{c}\frac{\partial L_t}{\partial E_t} = \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right) > 0$$

The evolution of this economy depends strictly on the evolution of the average level of education E_t. Since the supply of educational services in any given period t (S_t) determines the fraction of educated adults in the following period (i.e., $S_t = E_{t+1}$), the evolution of the average level of education $E_t, E_t \in [0,1]$, is governed by

$$(8) \qquad E_{t+1} = S_t = E_t\frac{\bar{a} - a_t^E}{\bar{a} - \underline{a}} + (1 - E_t)\frac{\bar{a} - a_t^U}{\bar{a} - \underline{a}}$$

where E_0 is given. The problem is to determine $\hat{p}_t$ and thereby to determine a_t^E and $a^U t$.

Using equations (6) and (7), we confirm that

$$(9) \qquad E_{t+1} = S_t = \frac{\tau\alpha}{c}\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right] > 0$$

and

$$(10) \qquad \frac{\partial E_{t+1}}{\partial E_t} = \frac{\partial S_t}{\partial E_t} = \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right) > 0$$

The evolution of the economy is characterized by equations (9) and (10), $\forall E_t \in [0,1]$, and by a unique steady-state equilibrium average education level $\overline{E}$ ($0 < \overline{E} \le 1$), where

$$(11) \qquad \overline{E} = \begin{cases} \dfrac{\tau\alpha\underline{l}}{c - \tau\alpha\left(\bar{l} - \underline{l}\right)} & \text{if } c > \tau\alpha\left(\bar{l} - \underline{l}\right) \\ 1 & \text{if } c \le \tau\alpha\left(\bar{l} - \underline{l}\right) \end{cases}$$

Note that if $\partial E_{t+1}/\partial E_t = (\tau\alpha/c)(\bar{l} - \underline{l}) \ge 1 - (\tau\alpha/c)\underline{l}$, then $\overline{E} = 1$. If $\partial E_{t+1}/\partial E_t = (\tau\alpha/c)(\bar{l} - \underline{l}) < 1 - (\tau\alpha/c)\underline{l}$, then $\overline{E} < 1$ (see figures 1 and 2). For simplicity, let us

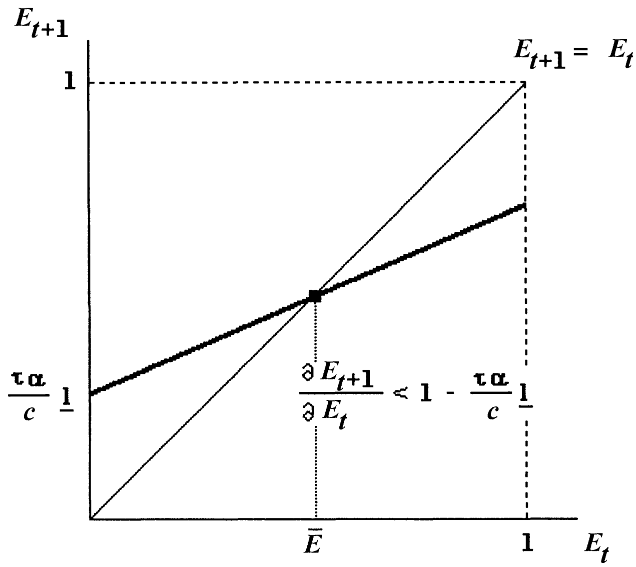

FIGURE 1

THE EVOLUTION OF THE AVERAGE EDUCATION LEVEL, E_t, WITH $\bar{E} < 1$

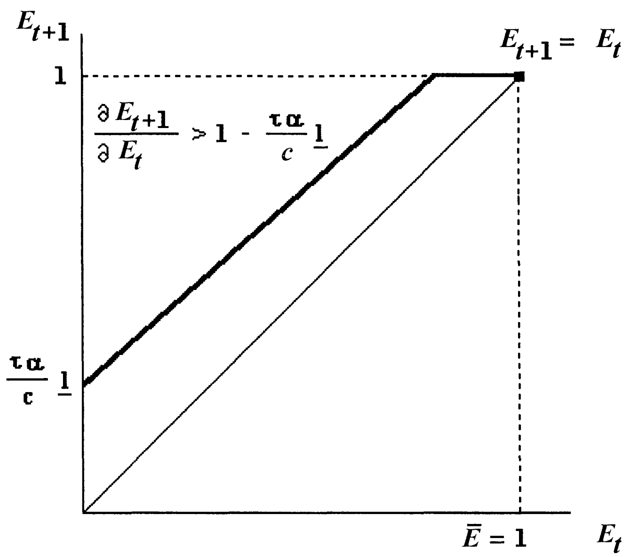

FIGURE 2

THE EVOLUTION OF THE AVERAGE EDUCATION LEVEL, E_t, WITH $\bar{E} \neq 1$

analyze further the case in which innate mental ability and the parental education level are perfect substitutes.[8] Then the academic potential of individual i is given by equation (3), which, by assumption, takes the following specific form

$$p_{i,t} = \begin{cases} a_{i,t} + 1 & \text{if i's parent is uneducated} \\ a_{i+t} + e & \text{if i's parent is educated} \end{cases} \tag{12}$$

For further simplicity, assume that parameter specifications are such that highest-ability individuals born to uneducated parents have potential at least as large as lowest-ability individuals born to educated parents. That is, parameters satisfy $\underline{a} + e \leq \bar{a} + 1$. In determining how the threshold levels of innate mental ability for admission of children of educated and uneducated parents a_t^E and a_t^U evolve with changes in the fraction of educated parents E_t, there are three cases to consider.[9]

(I) If $\underline{a} < a_t^E$ and $a_t^U < \bar{a}$, then given equation (12), the threshold levels of innate mental ability to gain admission to a school of children of educated and uneducated parents a_T^E and a_t^U, respectively, satisfy

$$a_t^U + 1 = a_t^E + e = \hat{p}_t \tag{13}$$

Taken together, equations (7), (8), and (13) imply that the threshold innate mental ability for admission to a school of children of educated parents a_t^E is given by equation (14):

$$a_t^E = \bar{a} - (e-1)(1-E_t) - \frac{\tau\alpha}{c}\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right](\bar{a} - \underline{a}) \tag{14}$$

From equation (14), we derive

$$\frac{\partial a_t^E}{\partial E_t} = \frac{\partial a_t^U}{\partial E_t} = \frac{\partial \hat{p}_t}{\partial E_t} = e - 1 - \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right)(\bar{a} - \underline{a}) \tag{15}$$

Equation (15) implies that an increase in the fraction of educated workers at time t has two effects on the minimum innate mental ability necessary to get educated for the members generation $t+1$. First, it increases total output by $(\bar{l} - \underline{l})$ and the amount of educational services by $(\tau\alpha/c)(\bar{l} - \underline{l})$. Holding everything else constant, this would lower the minimum level of ability necessary to gain admission to school by $(\tau\alpha/c)(\bar{l} - \underline{l})(\bar{a} - \underline{a})$. Second, the increase in the fraction of educated workers at time t causes some members of the young generation to have greater potential due to the positive effect of educated parents on their children. Everything else constant, this would make admission to schools more competitive and would increase the minimum ability necessary to get educated by $e - 1$.

[8] The results derived in this section apply to cases in which innate mental ability and parental education level are complements as well (see Appendix Section A.1).

[9] At the outset we can dismiss two special cases that are not relevant to the dynamics: (1) a case in which $\bar{a} \leq a_t^E$, a_t^U cannot exist because the supply of education, as given by equation (7), is positive $\forall$ $E_t \geq 0$, and (2) a case in which $\underline{a} = a_t^E$ and $a_t^U = \bar{a}$ can only exist in the steady state because in that case $E_{t+1} = S_t = E_t$.

Taking into account these two effects, the innate ability necessary to get educated for the young generation decreases as the fraction of educated parents in period t (E_t) increases only if the effect on an individual's potential of having an educated parent e is sufficiently small. Then the increase in the amount of educational services is large enough to offset the effect of individuals with greater potential, and $\partial \hat{p}_t / \partial E_t$ is negative when case (I) applies. Alternatively, if the advantage of having an educated parent is sufficiently large, then $\partial \hat{p}_t / \partial E_t$ is positive, and the threshold potential to get educated $\hat{p}_t$ increases as the average education level at time t (E_t) increases.

(II) If $\underline{a} = a_t^E$ and $a_t^U < \bar{a}$, then resources allocated to educational services are relatively abundant that not only do all individuals with educated parents gain admission to schools but some born to uneducated parents also are admitted. In this case,

$$a_t^U = \bar{a} - \frac{\frac{\tau\alpha}{c}\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right] - E_t}{1 - E_t}(\bar{a} - \underline{a}) \tag{16}$$

From equation (16), we derive

$$\frac{\partial a_t^U}{\partial E_t} = \frac{\partial \hat{p}_t}{\partial E_t} = \frac{1 - \frac{\tau\alpha}{c}\bar{l}}{(1 - E_t)^2}(\bar{a} - \underline{a}) \tag{17}$$

Equation (17) shows that if the marginal effect of an increase in the fraction of educated parents on the supply of education $\partial S_t / \partial E_t = (\tau\alpha/c)(\bar{l} - \underline{l})$ is larger than $1 - (\tau\alpha/c)\underline{l}$ [which, in turn, implies that $(\tau\alpha/c)\bar{l} > 1$ and $\overline{E} = 1$], then admission becomes less competitive for children born to uneducated parents as the fraction of educated adults in the economy E_t increases. Note that case (II) can only arise when $E_{t+1} = S_t > E_t$.

(III) If $\underline{a} < a_t^E$ and $\bar{a} = a_t^U$, then the effect of having an educated parent is sufficiently large and resources allocated to the supply of educational services are relatively small that none of the individuals born to uneducated parents are admitted to schools. Using equation (8), we find that the threshold ability of children of educated parents required for admission to a school a_t^E is given by

$$a_t^E = \bar{a} - \frac{\tau\alpha}{c}\frac{\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right]}{E_t}(\bar{a} - \underline{a}) \tag{18}$$

From equation (18), we derive equation (19):

$$\frac{\partial a_t^E}{\partial E_t} = \frac{\partial \hat{p}_t}{\partial E_t} = \frac{1}{E_t^2}\frac{\tau\alpha}{c}\bar{l}(\bar{a} - \underline{a}) > 0 \tag{19}$$

or

$$\frac{1}{E_t^2} \cdot \frac{\tau\alpha}{c} \cdot \bar{l}(\bar{a} - \underline{a}) > 0$$

Thus, if $\underline{a} < a_t^E$ and $\bar{a} = a_t^U$, the threshold ability of children born to educated parents a_t^E is an increasing function of the fraction of educated parents in period t (E_t). Note that when case (III) applies $E_{t+1} = S_t < E_t$.

4. INTERGENERATIONAL CLASS AND EARNINGS MOBILITY

A commonly used measure of mobility is the odds ratio—the relative odds of being educated for children of uneducated parents compared with the children of educated parents.[10] Let M_t denote this ratio in period t.

$$M_t = \frac{\text{Prob}_t[\text{child is educated}|\text{parent is uneducated}]}{\text{Prob}_t[\text{child is educated}|\text{parent is educated}]} = \frac{\bar{a} - a_t^U}{\bar{a} - a_t^E} \tag{20}$$

Also let $\tilde{e}$ denote the value of e that sets $\partial \hat{p}_t / \partial E_t$, as given by equation (15), equal to zero:

$$\tilde{e} \equiv 1 + \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right)\left(\bar{a} - \underline{a}\right) \tag{21}$$

For the remainder of the analysis, consider $E_0 < \bar{E}$. Then, as the preceding section demonstrates, either case (I) or case (II) can apply.

If parameter specifications are such that

(i) $e < 1 + (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a}) < \tilde{e}$ and $E^* \equiv [e - 1 - (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a})]/[e - 1 - (\tau\alpha/c)(\bar{l} - \underline{l})(\bar{a} - \underline{a})] \leq E_0$, or

(ii) $1 + (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a}) < e < \tilde{e}$

then case (II) applies initially (see Appendix Section A.2). Under both (i) and (ii), $(\tau\alpha/c)\bar{l} > 1$. Thus $\partial a_t^U / \partial E_t < 0$ and $a_t^E = \underline{a}$, and intergenerational mobility increases monotonically during the transition to the steady state. In the early stages when the supply of public educational services is low, most individuals born to uneducated parents remain uneducated, and all children born to educated parents get educated. That is, the advantage of having educated parents in these early stages is high. Therefore, class mobility is low. As the economy approaches its steady state and the supply of public education expands, the minimum potential required for admission to schools decreases. This in turn allows a proportionately larger number of individuals born to uneducated parents to get educated. When either (i) or (ii) applies, increases in the supply of education in response to increases in the education fraction of the population are large enough that, over time, admission becomes less competitive for children of uneducated parents. Moreover, since

[10] While for the purposes of this paper I only consider the odds ratio, the results discussed below would remain unaffected if some other measure of mobility—such as the intergenerational correlation of educational attainment or socioeconomic status—is used instead. The reason is that in this simple setup where the distributions of educational attainment and economic status are bipolar, the correlations of individuals' traits with their parents' relevant characteristics will be positively associated with the conditional probabilities used in the odds ratio.

$\partial a_t^U / \partial E_t$ is negative throughout the transition, case (I)—the only other possible case when $E_0 < \bar{E}$—will not apply at any point.

If parameters satisfy either

(iii) $e < 1 + (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a}) < \tilde{e}$ and $E_0 < [e - 1 - (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a})]/[e - 1 - (\tau\alpha/c)(\bar{l} - \underline{l})(\bar{a} - \underline{a})] \equiv E^*$, or

(iv) $e < \tilde{e} < 1 + (1 - (\tau\alpha/c)\underline{l})(\bar{a} - \underline{a})$

then case (I) applies initially (see Appendix Section A.2). Under (iii) and (iv), $e < \tilde{e}$ still holds. Thus $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t < 0$ as given by equation (15), and intergenerational mobility increases throughout the transition to the steady state. Unlike under (i) and (ii), however, the initial supply of education is low enough that not all individuals born to educated parents are admitted to schools in the early stages. Nonetheless, as the economy evolves and the supply of public education expands, the advantage of having educated parents declines, and increases in the quantity of educational services reduce the minimum potential required for admission. This in turn allows a proportionately large number of individuals born to uneducated parents to get educated. Moreover, since under (iii) $(\tau\alpha/c)\underline{l} > 1$, further increases in the supply of education eventually lower the threshold ability of children born to educated parents to the lower support $\underline{a}$, and case (II) begins to apply during the remainder of the transition to the steady state, $\bar{E} = 1$. When parameters satisfy (iv), however, case (I) applies throughout the transition to $\bar{E} < 1$.

In sum, if the effect of educated parents on their children's potential is such that $e < \tilde{e}$, class mobility increases during the transition to the steady state. And $\forall E_t \in [0, \bar{E}]$, either case (I) applies with $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t < 0$ or case (II) applies with $\partial a_t^U / \partial E_t \leq 0$ and $\partial a_t^E / \partial E_t = 0$. Thus, $\forall T > 0$,

$$M_0 = \frac{\bar{a} - a_0^U}{\bar{a} - a_0^E} \leq M_t = \frac{\bar{a} - a_T^U}{\bar{a} - a_T^E} \tag{22}$$

In contrast, if $\tilde{e} < e$, then case (I) applies throughout the transition to the steady state, and the effect of educated parents on their children's potential e is large enough that intergenerational economic mobility decreases monotonically during the transition. Under this scenario, the effect of having educated parents is sufficiently large that potentials are determined primarily by parental education. Moreover, the effect on mobility of increases in the amount of educational services is always offset by the effect of a larger group of individuals who are born to educated parents. Therefore, the threshold ability of children born to educated and uneducated parents required for admission increases gradually. As the economy grows, individuals who are educated come proportionately more from educated households. Note that if case (I) applies initially and the effect of educated parents on their children's potential e is sufficiently large that $e > \tilde{e}$, case (II) cannot apply at any point during the transition. The reason is that $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t > 0$ when $e > \tilde{e}$. That is—together with the fact that case (III) applies only when $E_{t+1} < E_t$— guarantees that if initially case (I) applies with $e > \tilde{e}$, an interior solution with $(\tau\alpha/c)\bar{l} < 1$ and $\bar{E} < 1$ exists.

TABLE 1
PARAMETER CONFIGURATIONS AND MOBILITY DYNAMICS

	$\frac{\tau\alpha}{c}\bar{l} < 1$	$\frac{\tau\alpha}{c}\bar{l} \geq 1$
$e < \tilde{e}$	$0 < \bar{E} < 1$ and $\forall T > 0, M_0 \leq M_t$	$\bar{E} = 1$ and $\forall T > 0, M_0 \leq M_t$
$e > \tilde{e}$	$0 < \bar{E} < 1$ and $\forall T > 0, M_0 > M_t$	N.A.

NOTE: N.A.: not applicable.

In sum, if the effect of educated parents on their children's potential is such that $e > \tilde{e}$, class mobility decreases monotonically during the transition to the steady state. Under this scenario, $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t > 0, \forall E_t \in [0, \bar{E}]$. Therefore, $\forall T > 0$,

$$M_0 \neq \frac{\bar{a} - a_0^U}{\bar{a} - a_0^E} > M_T = \frac{\bar{a} - a_T^U}{\bar{a} - a_T^E} \tag{23}$$

Table 1 summarizes the dynamics of intergenerational class mobility under different parameter specifications.

Finally, two straightforward implications of the model should be noted: First, the effect of an increase in the fraction of resources allocated to public education τ is unambiguously higher mobility regardless of the effect of educated parents on their children. The reason is that an increase in τ immediately lowers a_t^U and a_t^E by identical amounts, and given that $a_t^U \geq a_t^E$, mobility increases. As equation (21) indicates, an increase in τ also raises $\tilde{e}$, making it more likely that mobility will increase during the transition to the steady state. Nonetheless, economic development will be associated with greater intergenerational mobility if and only if the increase in τ is large enough to make $\tilde{e}$ larger than e. That is, the fraction of resources allocated to public education needs to be sufficiently large to offset the effect educated parents have on their children. If the increase in τ is not large enough to make $\tilde{e}$ larger than e, following an instantaneous increase, mobility will continue to decline during the transition to the steady-state.

Second, a decrease in the cost of education per pupil c is analogous to an increase in the tax rate τ. Therefore, its effect on mobility is identical to that of an increase in τ.

5. SUMMARY

This paper presents a channel through which public education affects intergenerational economic mobility. The primary motivation for exploring this link arises from three facts: (1) education is predominantly government funded in developing countries as well as most developed countries, (2) schooling is a primary determinant of individuals' earnings as well as their socioeconomic classes, and (3) public provision of educational services is commonly considered as a way of limiting—if not reducing—economic inequities.

The results show that increases in the availability of public education that result from higher output need not raise intergenerational economic mobility. Whether public finance of education reduces economic inequities over time—as measured by higher intergenerational class and earnings mobility—depends on the degree of inheritability of family specific characteristics. Specifically, for mobility to rise during the process of economic development, the share of resources devoted to public education needs to be large enough to offset the relative advantage of having educated parents in academic attainment.

APPENDIX

A.1. *The Case of Complements.* If innate ability and parental education are complements, then individual i's potential is given by equation (3), which, by assumption, takes the following form:

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

As in the case of perfect substitutes, there are three cases to consider. Nonetheless, since the evolution of the economy is still characterized by equations (9) and (10), the analyses of cases (II) and (III) remain unchanged.

(I) If $\underline{a} < a_t^E$ and $a_t^U < \bar{a}$, then equation (A.1) implies that the threshold levels of innate mental ability a_t^E and a_t^U satisfy the following:

$$a_t^U = ea_t^E = \hat{p}_t \tag{A.2}$$

Using equations (7), (8), and (A.2), we derive the threshold innate mental ability to gain admission to a school of individuals born to educated parents a_t^E:

$$a_t^E = \frac{\bar{a} - \dfrac{\tau\alpha}{c}(\bar{a} - \underline{a})\left[\underline{l} + \left(\bar{l} - \underline{l}\right)E_t\right]}{E_t + e(1 - E_t)} \tag{A.3}$$

And using equation (A.3), we derive equation (A.4), $\forall E_t \in [0,1]$:

$$\frac{\partial a_t^E}{\partial E_t} = \frac{1}{e}\frac{\partial a_t^U}{\partial E_t} = \frac{1}{e}\frac{\partial \hat{p}_t}{\partial E_t} = \frac{(e-1)\bar{a} - \dfrac{\tau\alpha}{c}(\bar{a} - \underline{a})\left(e\bar{l} - \underline{l}\right)}{\left[E_t + e(1 - E_t)\right]^2} \tag{A.4}$$

Equation (A.4) is the analog of equation (15). Its interpretation is also similar to that of equation (15). That is, for equation (A.4) to be negative, $\forall E_t \in [0,1]$, 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, $\forall E_t \in [0,1]$, the effect of having an educated parent e must be relatively large.

The rest of the analysis goes through as in the case of perfect substitutes.

A.2. *Determination of Parameter Specifications Consistent with Cases (I) and (II).* Using equations (7), (8), (13), and (14), we can determine the conditions under which corner solutions to the determination of a_t^E and a_t^U apply. Given that, by assumption, parameters are restricted to satisfy $\underline{a} + e \leq \bar{a} + 1$, we need to check conditions under which $a_t^E = \underline{a}$ and $a_t^U = \bar{a}$.

For $a_t^E = \underline{a}$,

$$\text{(A.5)} \qquad E_t = \frac{e - 1 - \left(1 - \frac{\tau\alpha}{c}\underline{l}\right)(\bar{a} - \underline{a})}{e - 1 - \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right)(\bar{a} - \underline{a})} \equiv E^*$$

and for $a_t^U = \bar{a}$,

$$\text{(A.6)} \qquad E_t = \frac{\frac{\tau\alpha}{c}\underline{l}(\bar{a} - \underline{a})}{e - 1 - \frac{\tau\alpha}{c}\left(\bar{l} - \underline{l}\right)(\bar{a} - \underline{a})} \equiv E^{**}$$

If $(\tau\alpha/c)\bar{l} > 1$, then $1 + [1 - (\tau\alpha/c)\underline{l}](\bar{a} - \underline{a}) < \tilde{e}$ and $\bar{E} = 1$. Thus, if—as specified in (i)—$e < 1 + [1 - (\tau\alpha/c)\underline{l}](\bar{a} - \underline{a}) < \tilde{e}$, both the numerator and the denominator of the rhs of equation (A.5) are negative, and $0 < E^* < 1$. Moreover, given that $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t < 0$ holds globally when $e < \tilde{e}$, it also holds at the margin when $a_t^E = \underline{a}$. As a result, $a_t^E \geq \underline{a}$ when $E_t \leq E^*$, and $a_t^U < \bar{a}$ $\forall E_t \in (0,1)$. Hence, if (i) holds, then $a_t^E = \underline{a}$ and $a_t^U < \bar{a}$, and case (II) applies. Otherwise, if—as specified in (iii)—$e < 1 + [1 - (\tau\alpha/c)\underline{l}](\bar{a} - \underline{a}) < \tilde{e}$ but $E_0 < E^*$, then $\underline{a} < a_t^E$, $a_t^U < \bar{a}$, and case (I) applies. If the effect of educated parents on their children is larger and (ii) holds, then E^* in equation (A.5) is larger than 1. Therefore, $\underline{a} < a_t^E$, $a_t^U < \bar{a}$, and case (I) applies.

Now consider $(\tau\alpha/c)\bar{l} < 1$, which implies that $\bar{E} < 1$. If—as in (iv)—$e < \tilde{e}$, E^{**} as given by equation (A.6) is negative, and $a_t^U < \bar{a}$, $\forall E_t \in [0, \bar{E}]$. Moreover, since $e < \tilde{e} < 1 + [1 - (\tau\alpha/c)\underline{l}](\bar{a} - \underline{a})$, E^*, as given by equation (A.5), is greater than 1. Thus $\underline{a} < a_t^E$, $a_t^U < \bar{a}$, and case (I) applies when (iv) holds.

Finally, if the effect of having educated parents on their childrens' potential is large enough that $e > \tilde{e}$, then $\partial a_t^E / \partial E_t = \partial a_t^U / \partial E_t > 0$ holds at the margin when $a_t^U = \bar{a}$. Given the assumption that $\underline{a} + e \leq \bar{a} + 1$, $\bar{E} < E^{**}$. Thus, when $e > \tilde{e}$, $\underline{a} < a_t^E$, $a_t^U < \bar{a}$, and case (I) applies.

REFERENCES

BANERJEE, A.V. AND A.F. NEWMAN, "Occupational Choice and the Process of Development," *Journal of Political Economy* 101 (2) (1993), 274–298.

BECKER, G.S. AND N. TOMES, "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility," *Journal of Political Economy* 87 (6) (1979), 1153–1189.

——— AND ———, "Human Capital and the Rise and Fall of Families," *Journal of Labor Economics* 4 (1986), S1–S39.

BENABOU, R., "Heterogeneity, Stratification and Growth: Macroeconomic Implications of Community Structure and School Finance," *American Economic Review* 86 (3) (1996a), 584–609.

———, "Equity and Efficiency in Human Capital Investment: The Local Connection," *Review of Economic Studies* 63 (1996b), 237–264.

COLEMAN, J.S., E.Q. CAMPBELL, C.J. HOBSON, J. MCPARTLAND, A.M. MOOD, F.D. WEINFELD, AND R.L, YORK, *Equality of Educational Opportunity* (Washington: U.S. G.P.O., 1966).

DURLAUF, S.N., "A Theory of Persistent Income Inequality," *Journal of Economic Growth* 1 (1996), 75–93.

FERNANDEZ, R. AND R. ROGERSON, "Public Education and Income Distribution: A Quantitative Evaluation of Education Finance Reform," NBER Working Paper No. 4883, October 1994.

——— AND ———, "Income Distribution, Communities, and the Quality of Public Education," *The Quarterly Journal of Economics* 111 (1) (1996), 135–164.

FUCHS, V. AND D. REKLIS, "Mathematical Achievement in Eight Grade: Interstate and Racial Differences," NBER Working Paper No. 4784, 1994.

GALOR, O. AND D. TSIDDON, "Technological Progress, Mobility and Economic Growth," *American Economic Review* 87 (3) (1997), 363–382.

GALOR, O. AND J. ZEIRA, "Income Distribution and Macroeconomics," *Review of Economic Studies* 60 (1993), 35–52.

GANZEBOOM, H.B.G., R. LUIJKX, AND D.J. TREIMAN, "Intergenerational Class Mobility in Comparative Perspective," *Research in Social Stratification and Mobility* 8 (1989), 3–84.

GLOMM, G. AND B. RAVIKUMAR, "Public versus Private Investment in Human Capital: Endogenous Growth and Income Inequality," *Journal of Political Economy* 100 (4) (1992), 818–834.

GRADSTEIN, M. AND M. JUSTMAN, "Democratic Choice of an Education System: Implications for Growth and Income Distribution," *Journal of Economic Growth* 2 (1997), 169–183.

IYIGUN, M.F. AND A.T. LEVIN, "Macroeconomic Implications of Competitive College Admissions," mimeo, Board of Governors of the Federal Reserve System, 1998.

KELLEY, J., R.V. ROBINSON, AND H.S. KLEIN, "A Theory of Social Mobility with Data on Status Attainment in a Peasant Society," *Research in Social Stratification and Mobility* 1 (1981), 27–66.

LOURY, G.C., "Intergenerational Transfers and the Distribution of Earnings," *Econometrica* 49 (4) (1981), 843–867.

OWEN, A.L. AND D.N. WEIL, "Intergenerational Earnings Mobility, Inequality and Growth," *Journal of Monetary Economics* 41 (1) (1998), 71–104.

TIEBOUT, C., "A Pure Theory of Local Expenditures," *Journal of Political Economy* 64 (1956), 416–424.

TORVIK, R., "Talent, Growth and Income Distribution," *Scandinavian Journal of Economics* 95 (4) (1993), 581–596.