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ARTICLES

SOCIAL STRATIFICATION, CAPITAL–SKILL COMPLEMENTARITY, AND THE NONMONOTONIC EVOLUTION OF THE EDUCATION PREMIUM

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This paper presents a model that generates a nonmonotonic evolution of the return to education. The model highlights the role played by socioeconomic stratification in the joint determination of the supply of educated labor and the supply of physical capital. The recent theoretical literature attributes the increased education premium of the last decades to skill-biased technological progress. In contrast, our explanation is based on capital–skill complementarity and endogenous accumulation of physical and human capital in an environment characterized by credit constraints.

Keywords: Inequality, Growth, Human Capital, Capital–Skill Complementarity, Stratification

1. INTRODUCTION

This paper develops a theory of physical and human capital accumulation that offers an explanation for the nonmonotonic evolution of the skill premium observed in the United States and in several other western economies since the Industrial Revolution.[1] The theory focuses on the role of capital–skill complementarity and socioeconomic stratification, in an environment characterized by credit constraints, in generating these nonmonotonic patterns.

Most of the recent theoretical literature attributes the increased education premium of the last decades to skill-biased technological progress.[2] However, Krusell et al. (2000) show that changes in observed inputs alone can account for most

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of the variations in the skill premium over the past 30 years, without invoking technical change. They estimate a model in which the elasticity of substitution between physical capital (equipment) and unskilled labor is higher than that between capital and skilled labor. As follows from this specification, and consistent with their empirical findings, the accumulation of physical capital has a positive effect on the education premium while the accumulation of human capital affects the education premium negatively. Because of these contradicting effects, the education premium can either rise or fall when the supply of both skilled labor and physical capital increases.

We extend the analysis by Krusell et al. (2000) by embedding it in a theoretical framework where the supply of production factors evolves endogenously. In particular, we introduce the assumptions that physical capital and educated labor are complements in the production process, whereas uneducated labor and physical capital are substitutes,[3] into Galor and Zeira's (1993) model of wealth distribution and capital market imperfections.

Our explanation of the endogenous accumulation of physical and human capital highlights the role played by socioeconomic stratification in individuals' joint decisions regarding education and savings. We assume that individuals in different social groups differ in their access to education. Benabou (1996a,b) studies a variety of reasons for the stratification of access to education. Here, for simplicity, we focus on the case in which the economy is populated by groups of individuals who differ in their wealth; therefore, because of imperfections in capital markets, poorer individuals face higher costs of financing education.[4] These wealth differences change endogenously along the economy's growth path, due to the accumulation of wealth by dynasties that form the different strata, affecting investment decisions and the evolution of the return to education.[5]

The combination of the assumptions of capital–skill complementarity and social stratification enable an endogenous nonmonotonic evolution of the education premium. In early stages, only individuals from the rich stratum, for whom the cost of financing education is sufficiently low, purchase education. At this early phase, the increase in the supply of educated labor dominates the accumulation of physical capital and drives the education premium down. This process leads to a stage in which all of the individuals in the rich stratum acquire education, but the education premium is still not sufficiently high to encourage poorer individuals to acquire education. In this phase, the wealthy accumulate wealth by investing in physical capital. Therefore, the increase in the supply of physical capital is the dominant factor, positively affecting the demand for educated labor, negatively affecting the demand for uneducated labor and hence bringing about an increase in the education premium.[6] Eventually, the education premium becomes sufficiently high to induce the acquisition of education by individuals from poorer strata as well. When this stage is reached, the renewed growth in the supply of educated labor drives the education premium down again. Thus, we show that the stratification of access to education in the economy determines, for each period, whether the effect of an increased supply of educated labor will dominate the effect of increased demand

and drive the education premium down, or whether the demand effect will be the dominant force, driving the education premium up.

2. BASIC STRUCTURE OF THE MODEL

Consider a closed overlapping-generations economy, where economic activity extends over infinite discrete time. In every period, the economy produces a single homogeneous good that can be used for either consumption or investment. The good is produced using three production factors: physical capital, educated labor, and uneducated labor. The supply of the production factors is endogenously determined and the process of development is an outcome of the accumulation of physical and human capital.

2.1. Production of Final Output

Production occurs within a period according to a constant-returns-to-scale production technology. Consistent with conventional wisdom and recent empirical evidence, the production function is characterized by capital–skill complementarity as well as substitutability between capital and uneducated labor. The output produced at time t uses capital, K_t, uneducated labor, U_t, and educated labor, E_t, in the production process:

$$Y_t = A(K_t + U_t)^{\alpha} E_t^{1-\alpha} = E_t A k_t^{\alpha}, \tag{1}$$

where $k_t \equiv (K_t + U_t)/E_t$ and $\alpha \in (0, 1)$.

2.2. Factor Prices and Capital Markets

Producers operate in a perfectly competitive environment. Given the factor prices, producers determine the level of employment of capital, educated labor, and uneducated labor in order to maximize profits. Given the structure of the production technology and the competitiveness of markets, the wage of educated labor, w_t^e, the wage of uneducated labor, w_t^u, and the return to capital, R_t, at time t are

$$\begin{aligned} w_t^e &= (1-\alpha)Ak_t^{\alpha} \equiv w^e(k_t), \\ w_t^u &= \alpha A k_t^{\alpha-1} \equiv w^u(k_t), \\ R_t &= \alpha A k_t^{\alpha-1} \equiv R(k_t), \end{aligned} \tag{2}$$

where the derivatives have the following signs:

$$w_k^e > 0, \qquad w_k^u < 0, \qquad R_k < 0. \tag{3}$$

We assume that capital markets are imperfect. We model the imperfection by assuming that the interest rate for individual borrowers is higher than the interest rate for lenders, which is equal to the interest rate paid by firms. The difference between these interest rates is the real cost of keeping track of individual borrowers during their second period of life.[7] Furthermore, we assume that capital fully depreciates. Thus, during period t, the interest rate for lenders and for firms that borrow is: $R_{t+1} - 1$. We denote the interest rate for individuals who borrow during period t by $R^B_{t+1} - 1$, where

$$R_t^B = \delta R_t, \qquad \delta > 1. \tag{4}$$

2.3. Individuals

Our modeling of individuals' preferences and occupational choices, in an imperfect capital market environment, closely follows the framework of Galor and Zeira (1993). Individuals are identical in their preferences and their technologies of human capital formation within and across generations. They may differ, however, in their initial wealth, inherited from their parents. Thus, because of the imperfection of capital markets, their investment in human capital may differ. We assume that individuals live for two periods and have a single parent and a single child, that is, there is no population growth. When parents are in their second period of life, their children are in their first. In their first period of life, individuals who choose to become educated workers acquire an indivisible unit of education.[8] In their second period of life, individuals supply their unit-time endowment to the labor force. Individuals who acquired education work as educated workers and individuals who did not invest in human capital supply uneducated labor. We normalize the number of dynasties to unity and, therefore, $U_t + E_t = 1$ for all t.

Individuals' preferences are defined over second-period consumption and their bequests to their children.[9] The preferences of individual j born in period t are represented by the following utility function:

$$U\left(c^j_{t+1}, b^j_{t+1}\right) = (1-\beta)\log c^j_{t+1} + \beta \log b^j_{t+1}; \beta \in (0, 1), \tag{5}$$

where c^j_{t+1} is individual j's consumption in the second period of life and b^j_{t+1} is individual j's bequest in the second period of life. Hence, it follows from the individual's maximization problem that j's bequest to the offspring is

$$b^j_{t+1} = \beta y^j_{t+1}, \tag{6}$$

where y^j_{t+1} is individual j's wealth in the second period of life.

2.3.1. Occupational choice. Members of generation t face an occupational choice in the first period of their life. Since individuals derive utility only from second-period consumption and bequest, maximization of second-period wealth is necessary for utility maximization. Therefore, individuals choose to become educated workers if their second-period wealth as educated workers is higher than their second-period wealth as uneducated workers.

Unless they have acquired education in the first period of life, the individuals' second-period labor unit is of the uneducated type. Education can be acquired only in the first period of life and bears a fixed cost denoted by h.[10] Since individuals work only in their second period of life, their first-period wealth is the parental bequest. Those who inherit less than h have to borrow in order to acquire education.

We now examine individual j born in period t that inherits b_t^j. We define this individual's wealth in $t+1$ by $y_{t+1}^{e,j}$ if j chooses to invest in education, and by $y_{t+1}^{u,j}$ if j chooses not to. It follows from (2) and (4) that

$$y_{t+1}^{e,j} = \begin{cases} \left(b_t^j - h\right) R_{t+1} + w_{t+1}^e & \text{if} \quad b_t^j \geq h \\ \left(b_t^j - h\right) \delta R_{t+1} + w_{t+1}^e & \text{if} \quad b_t^j < h \end{cases} \equiv y^e\left(b_t^j, k_{t+1}\right), \tag{7}$$

which could be represented as

$$y^e\left(b_t^j, k_{t+1}\right) = \left[\left(b_t^j - h\right) + \min\left(0, b_t^j - h\right)(\delta - 1)\right] R_{t+1} + w_{t+1}^e, \tag{8}$$

where the term min(0, $b_t^j - h$) $(\delta - 1)R_{t+1}$, is the additional cost for borrowing caused by the capital market imperfection.

Similarly, individual j's wealth in $t+1$ if he chooses not to acquire education is

$$y_{t+1}^{u,j} = b_t^j R_{t+1} + w_{t+1}^u \equiv y^u\left(b_t^j, k_{t+1}\right). \tag{9}$$

Applying (7) and (9) in the condition $y_{t+1}^{e,j} \geq y_{t+1}^{u,j}$ for individual j to invest in human capital, we find that individual j will invest in human capital if

$$\frac{w_{t+1}^e - w_{t+1}^u}{R_{t+1}} \geq \left[\left(1 - \psi_t^j\right)\delta + \psi_t^j\right] h, \tag{10}$$

where $\psi_t^j \equiv \min[b_t^j / h, 1]$ is the share of self-financed investment and $1 - \psi_t^j$ is the share borrowed. The right-hand side of (10) presents the investment that includes the education cost, h, and a possible finance cost. The left-hand side presents the present value of the return on the investment.

We denote the period t education premium by P_t and define it by

$$P_{t+1} \equiv w_{t+1}^e - w_{t+1}^u. \tag{11}$$

From (3) it follows that the left-hand side of the condition for investment in education (10) is increasing in P_{t+1}. Based on that, we can define individual j's critical level of education premium, denoted by $\hat{P}_{t+1}^j$ as the level of the education premium, P_{t+1}, for which (10) holds as an equality: if $P_{t+1} > \hat{P}_{t+1}^j$, individual j invests in human capital, if $P_{t+1} < \hat{P}_{t+1}^j$, individual j does not invest, and if $P_{t+1} = \hat{P}_{t+1}^j$, individual j is indifferent whether to invest or not. Note that $\hat{P}_{t+1}^j$ is unique, positive, decreasing in b_t^j and increasing in h and δ. In addition, it follows from (10) that the exact values of b_t^j and δ are relevant for the investment decision only if $b_t^j < h$. The rationale behind these relations is that in the range $b_t^j < h$ the lower the bequest received by an individual, the stronger the liquidity constraints and the incentive, in the form of an education premium, required for investment.

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2.4. Stratification of the Economy

From (7) and (9) it follows that the second-period wealth of individual j born in period t is a function of the parental bequest, b_t^j, and prices in $t+1$. Since all individuals face the same prices, it follows that all individuals who inherit a bequest of the same size in period t will have the same wealth in period $t+1$. Therefore, by (6), these individuals' offspring will inherit identical bequests as well, implying that the economy is characterized by a composition of strata of dynasties, where dynasty wealth, which can evolve over time, is identical within each stratum.

Suppose that in period 0 the economy consists of two groups of adult individuals who differ only in their wealth. Members of group A are a fraction λ of all adult individuals in the society. Each member of group A is endowed with a wealth level y_0^A. Members of group B are a fraction $1-\lambda$ of all adult individuals in the society, each endowed with a wealth level y_0^B, where, $y_0^A > y_0^B$. In every period, therefore, a fraction λ of all adults are homogeneous members of group A, and a fraction $1-\lambda$ are homogeneous members of group B.

Since wealth, y_{t+1}^j, and therefore the bequest, b_{t+1}^j, are strictly increasing functions of the transfer received by the individual, b_t^j, it follows that $b_t^A > b_t^B$ and $y_t^A > y_t^B$ for all t and therefore $\hat{P}_{t+1}^A \leq \hat{P}_{t+1}^B$ for all t. Although initially the two groups are distinct, they may converge to one another. By (10), the critical values, $\hat{P}_{t+1}^A$ and $\hat{P}_{t+1}^B$, are equal if both b_t^A and b_t^B exceed h.

Since $\hat{P}_{t+1}^j$ is decreasing in b_t^j, it follows that the allocation of education among the economic strata is positively correlated with wealth. In particular, if $b_t^A > b_t^B$ and $h > b_t^B$, then the following two results hold: First, if an individual from group B acquires education, then all individuals in group A acquire education; second, if an individual from group A does not acquire education, then no individuals in group B acquire education.

Based on the definition of the critical education premium, the curve denoted by E^s in Figure 1 presents the supply of educated labor and the curve denoted by E^D presents the demand for educated labor in period $t+1$. As the economy grows, the demand curve shifts up due to the accumulation of physical capital, and the supply curve shifts down due to the relaxation of liquidity constraints as a result of the decline in the return to physical capital and the accumulation of wealth by dynasties in the economy. In periods in which demand and supply cross at the horizontal part of the supply curve, the education premium falls since the swings in demand merely provoke matching increases in the supplied quantity of E_{t+1}. Likewise, in periods in which these curves cross at the vertical part of the supply curve, the education premium increases. This exemplifies the role of the stratification of the economy in determining which of the effects—demand or supply—will dominate the dynamics of the education premium in each period.

In our model, the stratification of the economy arises merely from wealth heterogeneity. However, as Figure 1 shows, what is actually crucial for our results is

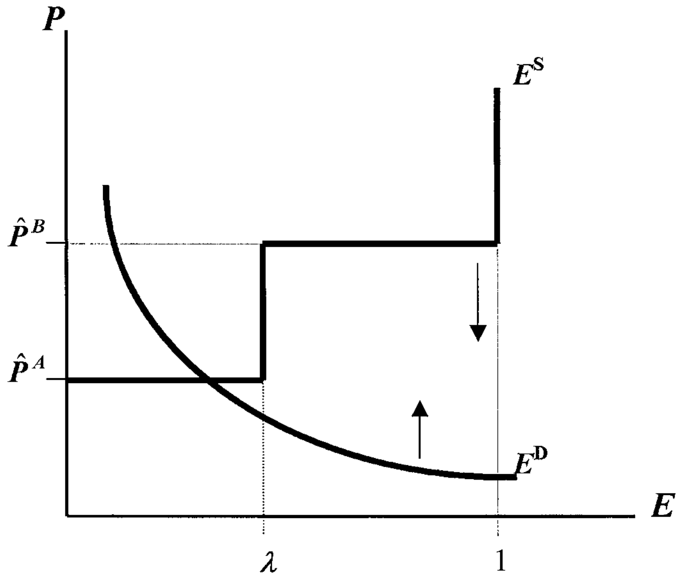

Figure 1. Demand and supply in the market for educated labor.

stratification of the critical education premium, $\hat{P}^j_{t+1}$. This stratification can also arise from heterogeneity in the costs of education, h, or in the interest requirements by lenders as captured by δ.

Figure 1 also makes clear that the main results of this paper are not restricted to the simplified discrete case analyzed in this section. Consider a case in which the joint distribution of y, h, and δ is smooth but leads to a distribution of $\hat{P}^j_{t+1}$ that has peaks in it. In that case, the supply curve will be smooth, in contrast to the one in Figure 1, but it can be sufficiently elastic in certain intervals and sufficiently inelastic in others to make changes in dominance across time between the demand and supply effects on the education premium.

2.5. Equilibrium and the Dynamical System

In this section we show that the distribution of bequests in period t, b^A_t and b^B_t, uniquely determines the equilibrium levels of human and physical capital in period $t+1$, E_{t+1}, and K_{t+1}, and therefore uniquely determines period $t+1$ prices. Moreover, since prices in $t+1$ and the bequest b^j_t uniquely determine the bequest to the next generation, the initial bequest distribution (as determined by the initial wealth distribution) uniquely determines the evolution of the economy.

In each period, the economy's equilibrium is determined by the constraint on capital formation, the equality between savings and investments, and by individuals' occupational choices. Because of full depreciation of physical and human capital,

$$S_t = K_{t+1} + hE_{t+1}, \tag{12}$$

where S_t denotes aggregate saving in period t.

Savings are accrued by individuals in their first period of life. In the absence of first-period consumption, individuals save the bequest that they receive from their parents. Therefore, the aggregate savings in the economy is

$$S_t = \lambda b_t^A + (1-\lambda)b_t^B, \tag{13}$$

and from (12) and (13),

$$K_{t+1} + hE_{t+1} = \lambda b_t^A + (1-\lambda)b_t^B. \tag{14}$$

Given the structure of the production technology (1), human capital is an essential factor of production, whereas physical capital can perfectly substitute for uneducated labor. Therefore, we restrict the analysis to parameter values for which $K_{t+1} \geq 0$ in the model's equilibrium. This implies that $E_{t+1} \leq S_t/h$.

The *KK* line in Figure 2 describes the capital formation equation (14), which presents K_{t+1} as a decreasing linear function of E_{t+1}. Based on Figure 1, the *EE* line in Figure 2 shows E_{t+1} as a function of K_{t+1} for given b_t^A and b_t^B.[11] As Figure 2 shows, the equilibrium values of K_{t+1} and E_{t+1} are unique functions of b_t^A and b_t^B since one equation presents a positive relationship between K_{t+1} and E_{t+1}, while the other presents a strictly negative relationship.

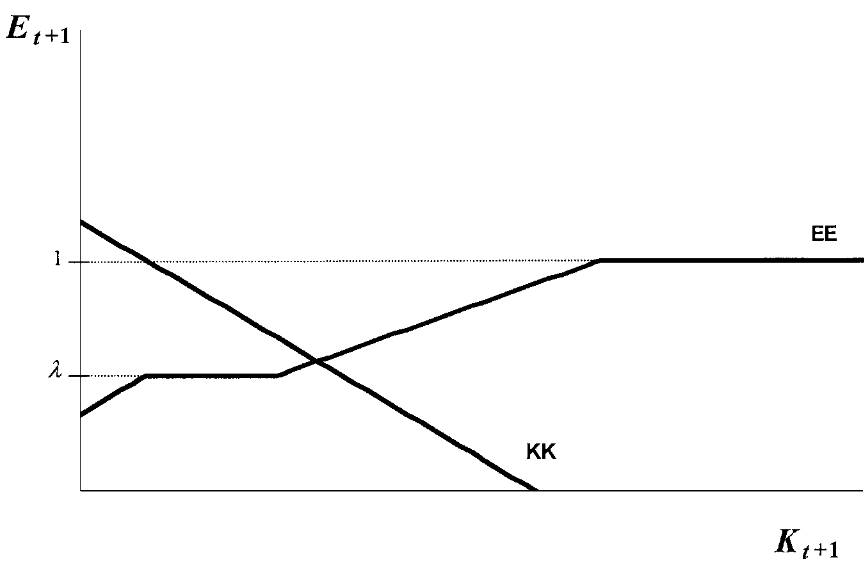

FIGURE 2. Equilibrium in the model.

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Thus, since b_t^A and b_t^B determine K_{t+1} and E_{t+1}, which in turn determine b_{t+1}^A and b_{t+1}^B, the economy can be characterized by a dynamic system of the form:

$$\begin{aligned} b_{t+1}^A &= \phi^A\left(b_t^A, b_t^B\right), \\ b_{t+1}^A &= \phi^B\left(b_t^A, b_t^B\right). \end{aligned} \tag{15}$$

3. APPLICATIONS

In this section we present simulations of some possible patterns for the economy's evolution. We focus on the dynamics of output, Y_t, education, E_t, physical capital, K_t, and the skill premium. For some parameters, the economy follows a path in which Y_t, E_t, and K_t monotonically increase while the skill premium monotonically declines.[12] This decline indicates that the effect of the increase in the supply for skilled labor dominates the effect of the increase in demand.

Nonmonotonic skill premium dynamics are also possible, as demonstrated by Figure 3.[13] The figure shows the dynamics that accompany the economy's monotonic increase of output over time. In the first periods, the number of educated individuals is smaller than the number of individuals in the richer stratum; that is, $E_t < \lambda$, which means that only individuals from the richer stratum purchase education. In those periods, the increase in E_t leads to a decrease in the wage gap. Then, when $E_t = \lambda$, i.e., when all of the individuals from the rich stratum purchase education, E_t temporarily stops increasing and the wage gap begins to widen since K_t continues to grow. During these periods, the individuals in the poor stratum still do not purchase education since they have heavier liquidity constraints than the rich. The wage gap continues to widen until it provides a strong enough incentive for individuals in the poor stratum to purchase education. When this liquidity barrier is overcome, the output growth is once again accompanied by a decreasing wage gap due to an increasing supply of educated labor. In this example, the economy converges to a steady state in which individuals in group B are credit-constrained, that is, $\lim_{t\to\infty} b_t^B < h$. Therefore, as depicted in Figure 3, wealth inequality, as captured by the wealth Gini coefficient, persists. This persistence of wealth inequality stems from our use of the Galor and Zeira (1993) framework, in the modeling of individuals.

4. STRATIFICATION AND CYCLES

In this section we show that when the economy's stratification is extended beyond the case of two strata, the wage-gap dynamics may be characterized by profound cyclical behavior. To enhance the role of economic stratification, we use the following utility function:

$$U_t^j = (1-\beta)\log c_{t+1}^j + \beta\log\left(a + b_{t+1}^j\right);\ \beta \in (0,1), a \geq 0, \tag{16}$$

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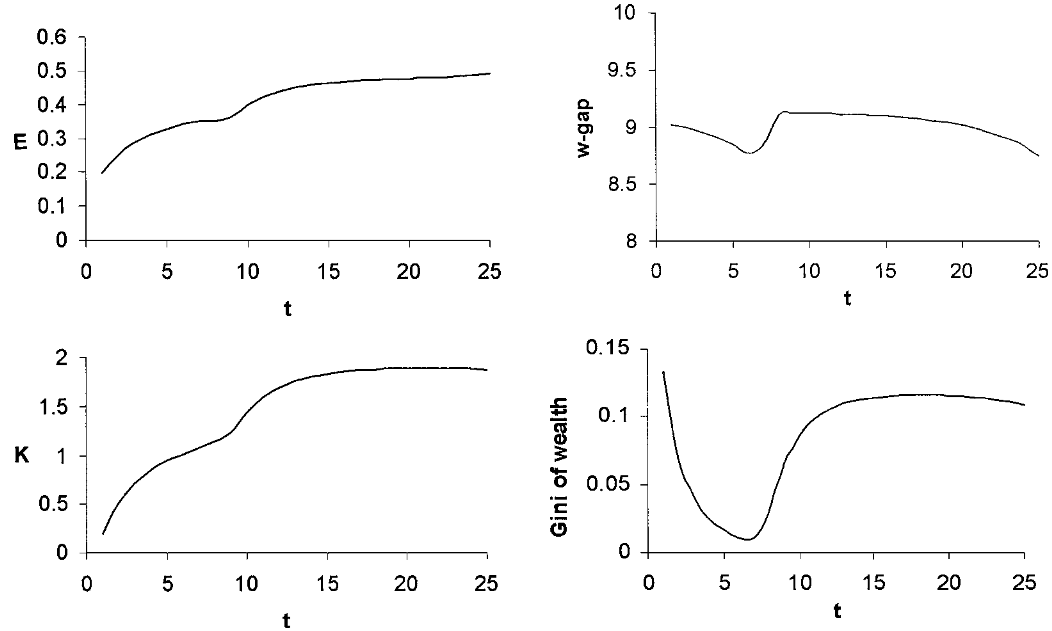

FIGURE 3. E, K, the wage gap, and the wealth Gini coefficient along the dynamic path that starts at $b^A = 1.98$ and $b^B = 0$, given $A = 10$, $\beta = 0.3$, $\alpha = 0.5$, $h = 2.5$, $\delta = 4$, $\lambda^A = 0.35$, and $\lambda^B = 0.65$.

which is a generalization of the utility function used thus far. Under this utility function, the bequest function is

$$b_t^j = b\left(y_t^j\right) = \begin{cases} \beta\left(y_t^j - \bar{a}\right) & \text{if} \quad y_t^j > \bar{a} \\ 0 & \text{if} \quad y_t^j \leq \bar{a}, \end{cases} \tag{17}$$

where $\bar{a} \equiv a(1-\beta)/\beta$. Thus, the share of bequests is an increasing function of income.

The analysis for the case of three strata (denoted A, B, C, and assuming $y_0^A > y_0^B > y_0^C$) is similar to the one performed in the previous sections for the case of two strata. Figure 4 shows the evolution of the economy, demonstrating a cyclical pattern of the skill premium.[14]

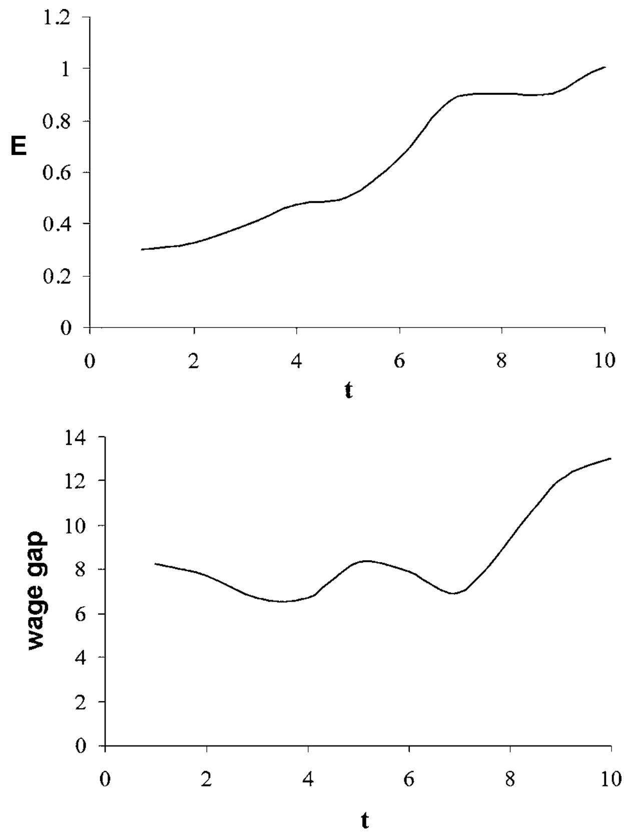

Figure 4. E and the wage gap along the dynamic path that starts at $b^A = 2$, $b^B = 1$, and $b^C = 0$, given $A = 10$, $\alpha = 0.5$, $h = 2.5$, $\beta = 0.5$, $\delta = 3$, $\lambda^A = 0.5$, $\lambda^B = 0.4$, and $\lambda^C = 0.1$.

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5. CONCLUDING REMARKS

In this paper we present a general equilibrium model, in which growth stems from physical and human capital accumulation, where skilled labor and physical capital are complementary factors in the production process, and unskilled labor and physical capital are substitutes. We show that the combination of imperfections in the capital markets and socioeconomic stratification can generate nonmonotonic skill premium dynamics.

In the model, the economy's social groups differ in their initial wealth. Because of capital market imperfections, the differences in wealth induce differences in the decisions regarding the purchase of education. Wealth differences can be replaced by stratification based on other variables, such as access to capital markets, differences in the direct cost of education, geographic location, or social barriers. As long as different strata differ in their access to education, the qualitative results of the theory should hold.

The cost of education in our model should not be viewed merely as the college tuition. For example, the social spillover discussed in several recent articles, for example, Benabou (1996a,b), may force the family to move to an appropriate neighborhood, at a large cost, in order to make higher education feasible for the offspring. Moreover, even in the absence of tuition, credit-constrained individuals may avoid higher education due to the consumption cost associated with forgone income during the time spent in school.

We take the simplifying assumption that there is only one level of education. Given the strong empirical evidence that returns to education are highest at the lowest levels of education, this assumption makes our model relevant mostly to the analysis of the decision to purchase higher levels of education.[15]

Note that in contrast to Galor and Zeira (1993) and the related literature that focuses on poverty traps and multiple equilibria, the indivisibility of the investment in human capital is not designed to generate persistence of poverty.[16] Its role here is to amplify the impact of credit constraints on investment in human capital, by denying it completely from social groups that are not sufficiently wealthy at a given point in time. Alternatively, preventing investment in education from the poor can be a result of a convex bequest function, as demonstrated by Moav (2002). If, however, the assumption of indivisibility would be partly relaxed, then the model could generate empirical predictions regarding the effect of the return to education on the level of investment in education by the different strata of the economy. In particular, both the less educated (high school dropouts, for instance) and the more educated (individuals with more than 12 years of schooling, for instance) would have a stronger incentive to graduate from high school and college, respectively. This response would introduce an additional mechanism that would offset the increase in the return to education in periods of growth in which the accumulation of physical capital is the main engine of growth.

Finally, a more realistic modeling of the production of human capital would involve an indexation of the cost of education to the wage rate of skilled workers.

This modification, however, would demand sacrificing simplicity. Moreover, it would have no qualitative impact on the results since the basic structure of the model, in which individuals differ only in their means of financing education, while the cost of education is identical across all individuals, is unchanged. Nevertheless, this modification can generate an interesting quantitative impact on the magnitude of changes in the education premium, and the duration of the stages of increasing or decreasing premium. A high wage of skilled workers, due to a relatively low supply of skilled workers, can further limit the access of individuals to skilled occupations, potentially increasing both the duration of periods in which the skill premium increases and the magnitude of the increase. In contrast, when the supply of skilled workers is relatively high, their wage, and therefore the cost of education, is low, further easing the access to skilled occupations, and increasing the duration of periods in which the skill premium declines and the magnitude of this decline.

NOTES

1. See Katz et al. (1995), Autor et al. (1998), and Goldin and Katz (2000).

2. See, among others, Galor and Tsiddon (1997), Acemoglu (1998), Caselli (1999), Galor and Moay (2000), Hassler and Rodriguez Mora (2000), Eicher and Garcia-Penalosa (2001), Gould (2001), and Gould (2002).

3. In addition to Krusell et al. (2000), empirical support for the structure of the production function is presented by Griliches (1969), Katz and Murphy (1992), Krueger (1993), Baldwin and Cain (1997), and Goldin and Katz (1998).

4. Our analysis of investment in human capital under capital market imperfections follows earlier studies by Loury (1981) and Becker and Tomes (1986), who focus on the impact of market imperfections on intergenerational mobility. Maoz and Moav (1999) extend this line of research by incorporating endogenously determined wage premium, and thereby offer an explanation for the observed relationship between income inequality, mobility, and economic growth. Here, however, in contrast to the existing literature, we offer an explanation for the nonmonotonic evolution of the education premium.

5. Stokey (1996), comparing growth in a closed economy with open regimes, makes the same assumptions regarding the properties of the production function as in our model. However, because of perfect capital markets and the absence of social stratification, her model does not generate nonmonotonic wage inequality dynamics.

6. This outline is consistent with the evidence provided by Gottschalk (1997) that much of the increase between 1979 and 1994 in the college premium in the United States stems from a 20% decline in the real wage of high school graduates. Also see Katz and Murphy (1992), Juhn et al. (1993), and Autor et al. (1998).

7. We take Galor and Zeira's (1993) result of a linear cost without repeating the detailed explanation.

8. We discuss the role of the indivisibility in the concluding remarks.

9. For evidence supporting this form of altruism, see Altonji et al. (1997) and Wilhelm (1996).

10. As will become apparent, the fixed cost of education is a simplifying assumption. An alternative assumption, discussed in the concluding remarks, of indexing this cost to the skilled wage, does not have a qualitative effect on the model's results.

11. In Figure 2, the parameter values ensure that $b_t^B < h$.

12. The example is based upon the following parameter values: $A = 10$, $\alpha = 0.5$, $\beta = 0.3$, $\delta = 3$, $h = 2.5$, $\lambda = 0.5$, $b_0^A = 2$, $b_0^B = 0$.

13. This example is based on the parameter values: $A = 10$, $\alpha = 0.5$, $\beta = 0.3$, $\delta = 4$, $h = 2.6$, $\lambda = 0.35$, $b_0^A = 1.98$, $b_0^B = 0$.

14. This example is based on the parameter values: $A = 10$, $\alpha = 0.5$, $h = 2.5$, $\beta = 0.5$, $a = 2.7$, $\delta = 3$, $\lambda^A = 0.5$, $\lambda^B = 0.4$, $\lambda^C = 0.1$, $y_0^A = 2$, $y_0^B = 1$, $y_0^C = 0$.

15. For such evidence on the return to education, see Psacharopoulos and Patrinos (2002).

16. However, note that the nonconvexity of the investment technology is a crucial assumption for the persistence of wealth inequality that could emerge in the model under some parameters.

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