Schooling, Risk Attitude and Growth

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ABSTRACT

This paper tries to provide a mechanism between risk attitude (or simple curvature of utility function) on schooling and the economic growth path. Schooling or education is used as an example of investment that may depend on the risk attitude of economic agents. The main findings are as follows: (i) an increasing rate of risk aversion implies a decreasing rate of growth; (ii) a constant rate of risk aversion means that there exists at least one steady state growth path; and (iii) a decreasing rate of risk aversion implies that there is an upper bound on the growth rate within one generation.

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Okullaşma, Risk Alma Eğilimi ve Büyüme

ÖZET

Bu makale tüketicilerin eğitim konusunda risk almasıyla ekonomik büyüme arasında olası bir bağlantının mekanizmasını vermeye çalışıyor. Okullaşma oranı ya da eğitim bir beşeri sermayayi oluşturan yatırımdır ve ekonomik ajanların risk alma konusundaki tutumlarına bağlıdır. Makalenin ana bulguları şunlardır: (i) risk almama oranı arttıkça büyüme oranı azalmaktadır; (ii) sabit bir risk alma oranı en az bir durağan denge yolu olduğu anlamına geliyor; (iii) azalan bir risk almama oranı bir jenerasyon içinde büyüme oranının bir üstten bir sınırı olacağını öngörür.

Anahtar Kelimeler: *büyüme, beşeri sermaye, yatırım ,risk alma.*

I. INTRODUCTION

The economic fluctuations of countries can be easily observed and various attempts have been made to explain the causes and processes underlying those observations. The neoclassical growth model, as developed by Ramsey (1928), Slow (1956) and others, generated a balanced growth path in which not only capital per capita is accumulated at the same rate as output or consumption per capita, but also the saving rate and the real interest rate are constant along the equilibrium growth path. The analyses were based on several assumptions, such as (i) identical rational individuals with optimizing behavior, (ii) a closed economy with competitive markets, (iii) an exogenously given production technology exhibiting diminishing returns to each factor (e.g., capital and labor), (iv) constant return to scale; and (v) exogenous population growth. In other word, exogenously given technology and population growth are the only driving forces that would lead to growth in the neoclassical growth model. As a result, a balanced equilibrium growth rate is characterized mechanically by the exogenous

variables without any specific description of technological progress or population change determined by the economic agents within the model.

However, in reality, there is much evidence undermining the neoclassical growth model. All economic growth paths cannot be explained by increases in the capital-labor ratio. Convergence of growth rates across countries, as predicted by neoclassical growth theory, has not been well supported in the face of several decades of empirical research (e.g., Barro, 1991; Barro and Sala-i-Martin, 1995; Lucas, 1990). Furthermore, endogenizing the source (or engine) of growth, such as technological progress (e.g., Arrow, 1962; Romer, 1986, 1990; and Lucas, 1988) and population growth and human capital accumulation (e.g., Becker et. al., 1990; and Rebelo, 1991), was attempted to explain the dynamic interaction between capital accumulation and economic growth, which is the central missing element of the neoclassical model. Particularly, the role of human capital and R&D (e.g., Aghion and Howitt, 1992) has been extensively explored and hence the assumption of constant returns of scale has been reconsidered.

A reformulation of the neoclassical growth model with increasing returns to scale through human capital accumulation has dynamic implications for growth theory. When an investment takes a place in an economy with increasing returns to scale, the marginal product of capital need not decline over time to the level of the discount rate. The reason is that the incentive to accumulate the capital may persist indefinitely, and thereby long-run economic growth can be sustained. Given the fact that technological progress and an effective labor force are the main factors in determining long-run economic growth, we should explain the determinants of an effective labor force and technology progress as a process of optimizing behavior of economic agents. Endogenous growth theory views economic growth as an endogenous phenomenon of those economic factors at work within a decentralized market system rather than the result of exogenous technology over which the market has no control. The factors that endogenize the growth can be formulated in various ways. For example, Grossman and Helpman (1991) established various factors, such as an expanding variety of intermediate goods, increasing quality of final product or decreasing production costs.

This paper focuses on an endogenizing attempt based on the external effect of human capital accumulation, which generates increasing returns to scale in aggregate production. One way of formulating human capital as an endogenizing factor is to consider a production function that has the stock of social human capital as one of the production inputs (e.g., Lucas, 1988; and Romer, 1986). Human capital has many of the characteristics of public goods in the sense that once learned by one person, many people repeatedly use it at a very low cost without depreciation. The model considered here presents a growth model in which an investment in human capital (or schooling) is motivated by self-interest in the context of an overlapping generations model. The equilibrium growth path, measured in terms of the consumption for a given amount of human capital, is characterized by measuring the risk aversion of economic agents (or simple curvature of utility function). Leapfrogging phenomenon can be explained

by different attitudes toward risk and consequent decisions regarding schooling. The endogenous nature of human being's attitude is not directly addressed in the current work, so the endogenous interaction between the utility function and the changing economic environment is not considered. Schooling will be used as an example of investment that may depend on attitudes regarding risk.

The remainder of this paper is organized as follows. In Section II, a simple model is explored which provides the basic structure for subsequent modeling efforts and the concept of risk aversion used here is introduced. In Section III, a description of growth in terms of consumption for a given amount of human capital is provided. In Section IV, the equilibrium growth path is characterized in terms of risk aversion in decisions regarding schooling. Finally, some conclusions and implications are presented in Section V.

II. THE BASIC MODEL

The section provides a simple endogenous growth model that may explain leapfrogging or overtaking phenomena among countries, firms or individuals. The analyses are based on decision-making regarding accumulation of human capital in the framework of an overlapping generations model in which individuals live for only two periods. Thus, at any point in time, the economy is composed of two generations, the young and the old, and all individuals are assumed to have an additive time-separable utility function.

In period t, each individual allocates his or her time between schooling (s_t) as a kind of investment and work (w_t) for income. In other words, an individual born at period t has a time constraints $s_{1t} + w_{1t} \leq 1$ when he or she is young, assuming that each individual is endowed one unit of time in each period.[1] An individual born at t solves the following problem with a constant price level normalized to one.

$$\underset{c_{1t},c_{2t+1}}{\text{Max}} \quad U(c_{1t}) + (1+\theta)^{-1} U(c_{2t+1})$$

$$\text{subject to} \quad c_{1t} + \sigma s_{1t} + R_t c_{2t+1} \leq f(w_{1t})h_{1t} + R_t f(w_{2t+1})h_{2t+1}$$

(1)

$$h_{2t+1} = h_{1t} g(s_{1t})$$

(2)

$$h_{1t} = h_{2t} \ .$$

(3)

Here,

θ is the rate of time preference or the subjective discount rate, which is assumed to be nonnegative.

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[1] Throughout this paper, the subscripts 1 and 2 denote the young and the old, respectively.

c_{1t} and c_{2t+1} are the consumption of the young at period t and the old at period $t+1$, respectively.

w_{1t} and w_{2t+1} are the work of the young at period t and the old at period $t+1$, respectively.

h_{1t} and h_{2t+1} are the stock of human capital of the young at period t and the old at period $t+1$, respectively.

σ is the reciprocal of the coefficient of relative risk aversion or the intertemporal elasticity of substitution.[2]

s_{1t} is schooling (education) of the young in period t, which is assumed to be nonnegative.

R_t is a market interest factor $\left(R_t = \dfrac{1}{1+r} \right)$, which is carried from t into $t+1$.

Before analyzing the model, it is necessary to introduce a few formal assumptions. The first one is a tradition assumption concerning utility, accumulation of human capital and production function, as outlined below

Assumption 1. (i) utility function: $U'(\cdot) > 0$, $U''(\cdot) < 0$, $U'(0) = \infty$ and $U'(\infty) = 0$, (ii) production function: $f'(\cdot) > 0$, $f''(\cdot) < 0$, $f'(0) = \infty$ and $f'(\infty) = 0$ and (iii) accumulation of human capital: $g(0) = 0$, $g'(\cdot) > 0$, $g''(\cdot) < 0$, $g'(0) = \infty$ and $g'(\infty) = 0$.

The second assumption is to make a condition that there is full externality of human capital over time, which implies $h_{1t+1} = h_{2t+1}$ at period $t+1$. That is,

Assumption 2. Human capital does not depreciate and there is no leisure in this model. At the end of period $t+1$, $h_{1t+1} = h_{2t+1}$.

In addition, labor supply is assumed to be constant across time to emphasize the external effect of human capital on economic growth. An additional assumption is discussed below.

Assumption 3. Population is assumed to be constant in each period, and is normalized to one. The old individuals spend the rest of their life working ($w_{2t+1} = 1$).

The above assumptions are, of course, designed to simplify the analysis. Therefore, economic growth in this model is attributed to accumulation of human capital, which is determined by the decision regarding schooling made by the

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[2] See the Chapter 6 of Blanchard and Fisher (1989) on an explicit justification for the interchangeable use between the intertemporal substitution and the measure of risk aversion.

young. On the other hand, the interest rate is determined by the credit market equilibrium, in which borrowing when young is equal to repayment when old, as shown below:

$$c_{1t} + \sigma s_{1t} - f(w_{1t})h_{1t} = f(w_{2t+1})h_{2t+1} - c_{2t+1}.$$

(4)

We will be looking for a steady state equilibrium growth path and making conjectures about the relationships between (i) the growth path and (ii) the risk attitude on schooling. In fact, this model does not consider any uncertainty.[3] If a consumer is highly risk averse, he or she must have a low intertemporal substitution as well. The curvature of the utility function measures how closely goods are intertemporally substitutable.

Assumption 1 ensures equalities on $w_{1t} = 1 - s_{1t}$ and on the constraint (1). Considering then $w_{2t+1} = 1$ (no schooling when old) and the constraint (2), the Lagrangian function is as follows;

$$\underset{c_{1t}, c_{2t+1}, s_{1t}, \lambda}{\text{Max}} \; L = U(c_{1t}) + (1+\theta)^{-1} U(c_{2t+1})$$
$$- \lambda \left[c_{1t} + \sigma s_{1t} + R_t c_{2t+1} - \{ f(1-s_{1t}) + R_t f(1)g(s_{1t}) \} h_{1t} \right]$$

The first order conditions (FOCs) are

$$L_{c_{1t}} = 0 = U'(c_{1t}) - \lambda$$

(5)

$$L_{c_{2t+1}} = 0 = (1+\theta)^{-1} U'(c_{2t+1}) - \lambda R_t$$

(6)

$$L_{s_{1t}} = 0 = \lambda \left[\sigma + \{ f'(1-s_{1t}) - R_t f(1)g'(s_{1t}) \} h_{1t} \right]$$

(7)

$$L_\lambda = 0 = c_{1t} + \sigma s_{1t} + R_t c_{2t+1} - \{ f(1-s_{1t}) + R_t f(1)g(s_{1t}) \} h_{1t}$$

(8)

For tractability, we substitute s_{1t} into zero, which may describe the mandatory education system and the young borrows for consumption but for schooling. The conditions on $U(\cdot)$ in Assumption 1 ensure a positive λ from (5). Manipulating (5) and (6) and assuming $\delta = 1/(1+\theta)$, we have

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[3] Optimal choice between consumption and saving under uncertainty was analyzed in Samuelson (1969) and Merton (1969). Further, Leland (1968) and Sandmo (1970) explicitly examined the effects of uncertainty on saving decisions.

$$\delta \frac{U'(c_{2t+1})}{U'(c_{1t})} = R_t .$$
(9)

Equation (9) is the condition of intertemporal consumption equilibrium.

The main thrust of the analysis is to explicitly solve the above equations for s_{1t}, c_{1t}, c_{2t+1} and R_t as a function of h_{1t}. After that, we will examine if the equilibrium growth rate, which is represented by ds_{1t}, is an increasing, decreasing or constant function of $\rho(c) = -\frac{cU''(c)}{U'(c)}$, which is the Arrow-Pratt measure of relative risk aversion.[4]

It would be convenient to specify functional forms to get s_{1t} explicitly. It must be noted that the subscripts cannot be eliminated using a steady state equilibrium since there will not be a steady state unless Constant Rate of Risk Aversion (CRRA) holds. The main interest is in the relation between the movement of ds_{1t} or dh_{2t+1} and the individual attitude, which implies the acceleration or deceleration of the growth rate stemming from the interaction between the external effect of the social human capital and the amount of investment in schooling. As long as education exhibits external effects and thus the path of s_{1t} plays an important role in the growth rate, the determining factor of education should be determined within the endogenous growth model. Given the amount of h_{2t+1}, the individual's attitude toward a decision on the amount of investment to schooling is crucial to the equilibrium growth path of the economy since an increasing, constant and decreasing growth rate implies and are implied by, a decreasing, constant and increasing relative risk aversion of $\rho(c)$.

III. DESCRIPTION OF GROWTH

This section describes the growth rate in terms of consumption for a given amount of human capital. The next section relates this growth rate to the measure of risk aversion expressed in the schooling decision. Rearranging the FOCs of (5) – (8) together with the budget constraint and the credit market equilibrium condition (4), and following Assumptions 1 and 3 ($w_{1t} = 1 - s_{1t}$ and $w_{2t+1} = 1$) gives,

$$f(1 - s_{1t})h_{1t} - c_{1t} - \sigma s_{1t} + f(1)h_{1t}g(s_{1t}) - c_{2t+1} = 0,$$
(10)

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[4] More precisely, it is equal to the elasticity of marginal utility with respect to consumption. See Arrow (1970) and Pratt (1964) on the measure of risk aversion.

$$c_{1t} + \sigma s_{1t} + R_t c_{2t+1} - f(1 - s_{1t})h_{1t} - R_t f(1)h_{1t}g(s_{1t}) = 0,$$
$$(11) \quad R_t U'(c_{1t}) - \delta U'(c_{2t+1}) = 0,$$
$$(12)$$
$$\sigma + [f'(1 - s_{1t}) - R_t f(1)g'(s_{1t})]h_{1t} = 0.$$
$$(13)$$

The above four equations determine s_{1t}, c_{1t}, c_{2t+1} and R_t as a function of h_{1t}: that is, the latter exogenous variable determines the former endogenous variables. Let us assume that $\sigma = 0$, which is analogous to the perfect free public education system. Then (10) – (13) transforms to the following equations (14) – (17).

$$f(1 - s_{1t})h_{1t} - c_{1t} + f(1)h_{1t}g(s_{1t}) - c_{2t+1} = 0,$$
$$(14)$$
$$c_{1t} + R_t c_{2t+1} - f(1 - s_{1t})h_{1t} - R_t f(1)h_{1t}g(s_{1t}) = 0,$$
$$(15)$$
$$R_t U'(c_{1t}) - \delta U'(c_{2t+1}) = 0,$$
$$(16)$$
$$[f'(1 - s_{1t}) - R_t f(1)g'(s_{1t})]h_{1t} = 0.$$
$$(17)$$

In order to describe the path of the equilibrium growth rate in terms of consumption for a given amount of human capital, we define two variables as $x_t = \dfrac{c_{1t}}{h_{1t}}$ and $y_t = \dfrac{c_{2t+1}}{h_{1t}}$. These denote the consumption per human capital of the individual, when he or she is young and old, respectively. The comparison of x_t and y_t enables us to describe the growth rate. Rearranging and dividing (14) and (15) by h_{1t}, we have

$$x_t = f(1 - s_{1t}) + f(1)g(s_{1t}) - y_t,$$
$$(18)$$
$$x_t = f(1 - s_{1t}) + R_t[f(1)g(s_{1t}) - y_t] = f(1 - s_{1t}) + \frac{f'(1 - s_{1t})}{f(1)g'(s_{1t})}[f(1)g(s_{1t}) - y_t]$$
$$(19)$$

The third term of (19) is derived using (17). Equations (18) and (19) determine x_t and y_t as a function of s_{1t}. Economic growth implies that

$x_t = \dfrac{c_{1t}}{h_{1t}} < y_t = \dfrac{c_{2t+1}}{h_{1t}}$, and (18) describes the production function. Equation

(19) relates the growth to the production function and the human capital accumulation function. Further, combining (9) and (13), we get

$$\frac{U'(c_{2t+1})}{U'(c_{1t})} = \frac{f'(1-s_{1t})}{\delta f(1)g'(s_{1t})} = \frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}.$$

(20)

The choice variable of schooling s_{1t}, which determines the stock of human capital, and the market interest rate R_t, which connects the individual decision on schooling to the credit market equilibrium, can be related to the equilibrium growth rate through the utility function. Therefore, the utility function will determine the economic growth path through the choice of schooling since (18) – (20) are reduced by eliminating R_t. Equation (20) relates the utility function with (18) and (19) so that the growth path can be related to the individual's attitude on schooling in this model.

IV. CHARACTERIZATION OF THE GROWTH PATH IN TERMS OF RISK AVERSION

This section characterizes the equilibrium growth path in terms of the measure of risk aversion through the schooling decision. Equation (20) in the previous section determines the relationship between s_{1t} and h_{1t} by utility function so that utility function plays a key role in explaining the growth path. Taking the total differentiation of (20) and using the Arrow-Pratt measure of relative risk aversion, $\rho(c) = -\dfrac{cU''(c)}{U'(c)}$ yields:

$$\left[-\frac{f''(1-s_{1t})}{\delta f(1)g'(s_{1t})} - \frac{f'(1-s_{1t})g''(s_{1t})}{\delta f(1)g'(s_{1t})^2} \right] ds_{1t} =$$

$$\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})} \left[\{\rho(x_t h_{1t}) - \rho(y_t h_{1t})\} \frac{dh_{1t}}{h_{1t}} + \left\{ \rho(x_t h_{1t}) \frac{dx_t}{x_t} - \rho(y_t h_{1t}) \frac{dy_t}{y_t} \right\} \right].$$

(21)

Since education is nonnegative, the inside of the brace in the Left Hand Side (LHS) is always positive under Assumption 1 (e.g., $f' > 0$, $f'' < 0$, $g' > 0$ and $g'' < 0$). The first brace of the Right Hand Side (RHS) depends on CRRA (=

0), IRRA (< 0) and DRRA[5] (> 0). In the second brace of the RHS in (21), definitive relationships derived from the growth rate and the measure of risk aversion can be revealed in terms of the direction of the growth rate. Therefore, the question boils down to the sign in the whole RHS in (21) making use of the measure of risk aversion. In short, we can observe the relationship between the schooling and the measure of risk attitude from (21). It is worthwhile to note that $dh_{1t} \geq 0$ implies that the worst (or minimum) education is just not adding any human capital to the existing level. In other words, no depreciation in human capital is assumed. The formal propositions concerning the risk attitude on schooling and growth are as follows.

Proposition 1. IRRA implies a decreasing rate of growth.

Proof. Assume that $ds_{1t} \geq 0$ and IRRA. Then $\rho(x_t h_{1t}) < \rho(y_t h_{1t})$ and hence it must be the case that $\rho(x_t h_{1t}) \dfrac{dx_t}{x_t} - \rho(y_t h_{1t}) \dfrac{dy_t}{y_t} > 0$. It requires that $\dfrac{dx_t}{x_t} > \dfrac{dy_t}{y_t}$. Since $x_t = \dfrac{c_{1t}}{h_{1t}}$ and $y_t = \dfrac{c_{2t+1}}{h_{1t}}$, we can translate into $\dfrac{dx_t}{x_t} = \dfrac{dc_{1t}}{c_{1t}} - \dfrac{dh_{1t}}{h_{1t}}$ and $\dfrac{dy_t}{y_t} = \dfrac{dc_{2t+1}}{c_{2t+1}} - \dfrac{dh_{1t}}{h_{1t}}$. Therefore, $\dfrac{dx_t}{x_t} > \dfrac{dy_t}{y_t}$ implies $\dfrac{dc_{1t}}{c_{1t}} > \dfrac{dc_{2t+1}}{c_{2t+1}}$, which in turn implies a decreasing rate of proportional growth for the economy in terms of consumption for a given level of human capital.
Q.E.D.

A possible interpretation of Proposition 1 is that one is less willing to sacrifice current consumption for future consumption under IRRA. In other words, the increasing rate of risk aversion implies that the wealthier you become, the less education you obtain to secure present consumption. Accordingly, lower investment combined with slower growth would happen since there is less external effect of education generated in this economy. Proposition 1 can be reinterpreted as the following Corollary 1.

Corollary 1. An increasing rate of growth implies NON-IRRA.
Proof. Suppose an economy grows at an increasing rate, then the LHS of (21) is always positive. The first brace in the RHS of (21) is always negative with the property of IRRA ($\rho(x_t h_{1t}) < \rho(y_t h_{1t})$). In addition, an increasing rate of

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[5] IRRA and DRRA are the abbreviations of "Increasing Rate of Risk Aversion" and "Decreasing Rate of Risk Aversion," respectively.

proportional growth implies that $\dfrac{dx_t}{x_t} < \dfrac{dy_t}{y_t}$ and hence the second brace is always negative since $\rho(x_t h_{1t}) < \rho(y_t h_{1t})$. Therefore, the RHS in (21) is always negative, which is a contradiction. **Q.E.D.**

Corollary 1 is a simple restatement of Proposition 1. Now, analysis proceeds in the cases of CRRA and DRRA, and their effects on growth.

Proposition 2. CRRA implies that there exists at least one steady state growth path.

Proof. CRRA implies that $\rho(x_t h_{1t}) = \rho(y_t h_{1t})$, which is non-zero under the assumption on the utility function (Assumption 1). Suppose that $\rho(y_t h_{1t})\left\{\dfrac{dy_t}{y_t} + \dfrac{dh_{1t}}{h_{1t}}\right\} \neq \rho(x_t h_{1t})\left\{\dfrac{dx_t}{x_t} + \dfrac{dh_{1t}}{h_{1t}}\right\}$, which means non-steady state growth (i.e. $\dfrac{dx_t}{x_t} \neq \dfrac{dy_t}{y_t}$). We can define S as one steady state growth path such that $ds_{1t} = 0$ in S, and hence the LHS in (21) equals to zero. Given $\rho(x_t h_{1t}) = \rho(y_t h_{1t})$ and $\dfrac{dx_t}{x_t} \neq \dfrac{dy_t}{y_t}$, both $\rho(x_t h_{1t})$ and $\rho(y_t h_{1t})$ should be zero,

which is a contradiction. **Q.E.D.**

CRRA may imply the nullification of the external effect of education on economic growth, because each agent takes account of the externality stemming from the education in the previous period. A certain level of human capital, however, can sustain the economic growth by itself without additional investment in education ($ds = 0$). With the self-growing effect of human capital, the economy displays a constant rate of growth, i.e., $\dfrac{dx_t}{x_t} = \dfrac{dy_t}{y_t}$. In the endogenous growth model, human capital has an important implication in the divergence of the economic growth rate across countries. Proposition 2 implies that the steady state growth path determined by education decision can differ across countries. Moreover, it does not necessary converge to a common growth path as long as the attitudes on schooling in each country are different. The reverse case of Proposition 2 is provided in the following Corollary 2.

Corollary 2. Steady state growth path implies CRRA.

Proof. The LHS in (21) is always zero in the steady state equilibrium path since $ds_{1t} = 0$. The second brace of RHS in (21) is also zero since both

$\dfrac{dx_t}{x_t}$ and $\dfrac{dy_t}{y_t}$ are zero. Then the first brace of RHS of

$\{\rho(x_t h_{1t}) - \rho(y_t h_{1t})\}\dfrac{dh_{1t}}{h_{1t}}$ must be zero. Therefore, $\rho(x_t h_{1t}) = \rho(y_t h_{1t})$ since

$\dfrac{dh_{1t}}{h_{1t}} > 0$. **Q.E.D**.

Corollary 2 says that increasing or decreasing risk aversion leads to a decrease or an increase in the growth rate so that there does not exist a steady state growth path. Another interpretation of Corollary 2 is that increasing or decreasing intertemporal substitutability results in a decrease or an increase in the growth rate. Only constant substitutability can give rise to a steady state growth path. According to Corollary 2, the different growth path or paths of the economy reflect individuals' attitudes about an uncertain future. Finally, the relationship between DRRA and economic growth is expressed in the following proposition.

Proposition 3. DRRA implies that there is an upper bound on growth rate.

Proof. Suppose that the economy grows at a positive rate. Then DRRA implies both (i) $\rho(x_t h_{1t}) > \rho(y_t h_{1t})$ and (ii) $\rho(x_t h_{1t})\dfrac{dx_t}{x_t} > \rho(y_t h_{1t})\dfrac{dy_t}{y_t}$ in

(21). It simple puts an upper bound on $\dfrac{dy_t}{y_t}$ relative to $\dfrac{dx_t}{x_t}$ depending on the degree of DRR **Q.E.D.**

A possible interpretation of Proposition 3 is that no matter how ambitious and patient it is, an economy has a certain limitation in terms of the maximum growth rate within one generation. This interpretation may give us a caution when we study the convergence or divergence of economic growth across countries. We can observe a non-linear economic growth pattern in reality: namely, some developing countries such as Newly Industrialized Countries (NICs: Hong Kong, Korea, Singapore and Taiwan) caught up with leading countries in the developing country group, but those NICs are still behind compared to the countries in the developed country group. Proposition 3 partially explains such a non-linear growth pattern. In any case, we need sufficient time series data to make any judgment on the "catching-up" or "leapfrogging" phenomenon as long as we stick to the Proposition 3.

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V. CONCLUDING REMARKS

The analysis of this paper has focused on the mechanism between risk attitude on schooling and the economic growth path in an overlapping generations model. The curvature of utility is used to represent the degrees of risk attitude. Decision-making regarding schooling is considered as an example of investment by economic agents. It is established that the economic growth path depends on the measure of risk aversion through the schooling decision. Increasing or a decreasing risk aversion leads to a decrease or an increase in the growth rate so that there is no existence of a steady state growth path. However, a constant rate of risk aversion implies that there exists at least one steady state growth path. The results have a policy implication. Since the level of economic agents' risk attitudes may influence the effectiveness of policy, policy makers should consider this aspect of risk attitude.

There are a number of issues for future research. This paper assumes that each individual makes the decision on schooling to maximize his or her lifetime welfare. In other words, the engine of growth is self-interest of each individual in each generation. Hence, it is worthwhile to introduce "altruism" as a driving force of the economic growth. The "dynastic utility function" combined with the risk attitude will be an interesting topic for future study. In addition, the results of this model are based on the certainty on investment. Incorporating uncertainty regarding investment will complete the analysis of this paper. The reason is that not all people can succeed in investments such as additional schooling. As presented in Tssidon (1992), a low growth-trap exists due to a moral hazard problem, which is derived from only investment in the low level of education.

Appendix: Derivation of (21)

Taking the total differentiation of (20) yields:

$$\left[-\frac{f''(1-s_{1t})}{\delta f(1)g'(s_{1t})}-\frac{f'(1-s_{1t})g''(s_{1t})}{\delta f(1)g'(s_{1t})^2}\right]ds_{1t}$$

$$=\frac{U''(y_t h_{1t})}{U'(x_t h_{1t})}\left[h_{1t}dy_t + y_t dh_{1t}\right]-\frac{U'(y_t h_{1t})U''(x_t h_{1t})}{U'(x_t h_{1t})^2}\left[h_{1t}dx_t + x_t dh_{1t}\right]$$

$$=$$

$$\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}\left[\frac{U''(y_t h_{1t})}{U'(y_t h_{1t})}\{h_{1t}dy_t + y_t dh_{1t}\}\right]-\frac{U'(y_t h_{1t})U''(x_t h_{1t})}{U'(x_t h_{1t})^2}\left[h_{1t}dx_t + x_t dh_{1t}\right]$$

$$=$$

$$\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}\left[\frac{U''(y_t h_{1t})\cdot y_t h_{1t}}{U'(y_t h_{1t})}\left\{\frac{dy_t}{y_t}+\frac{dh_{1t}}{h_{1t}}\right\}\right]-\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}\left[\frac{U''(x_t h_{1t})\cdot x_t h_{1t}}{U'(x_t h_{1t})}\right]\left\{\frac{dx_t}{x_t}+\frac{dh_{1t}}{h_{1t}}\right\}$$

$$=\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}\left[-\rho(y_t h_{1t})\left\{\frac{dy_t}{y_t}+\frac{dh_{1t}}{h_{1t}}\right\}+\rho(x_t h_{1t})\left\{\frac{dx_t}{x_t}+\frac{dh_{1t}}{h_{1t}}\right\}\right] \quad \text{since}$$

$$\rho(c)=-\frac{cU''(c)}{U'(c)}.$$

Therefore, we obtain

$$\left[-\frac{f''(1-s_{1t})}{\delta f(1)g'(s_{1t})}-\frac{f'(1-s_{1t})g''(s_{1t})}{\delta f(1)g'(s_{1t})^2}\right]ds_{1t}=$$

$$\frac{U'(y_t h_{1t})}{U'(x_t h_{1t})}\left[\{\rho(x_t h_{1t})-\rho(y_t h_{1t})\}\frac{dh_{1t}}{h_{1t}}+\left\{\rho(x_t h_{1t})\frac{dx_t}{x_t}-\rho(y_t h_{1t})\frac{dy_t}{y_t}\right\}\right].$$

REFERENCES

AGHION, P. and P. HOWITT, (1992), "A Model of Growth through Creative Destruction," *Econometrica*, vol. 60, no. 2, 323-351.

ARROW, K. J. (1970), *Essays in the theory of Risk Bearing*, Chicago: Markham.

_____. (1962), "The Economic Implications of Learning by Doing," *Review of Economic Studies*, vol. 29, 155-173.

BARRO, R. J. (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, vol. 106, no. 2, 407-433.

_____ and X. Sala-i-Martin, (1995), *Economic Growth*, McGraw-Hill, Inc.

BLANCHARD, O. and S. FISHER, (1989), *Lectures on Macroeconomics*, Cambridge, MA: MIT Press.

Becker, G. S., K. M. Murphy, and R. Tamura, (1990), "Human Capital, Fertility, and Economic Growth," *Journal of Political Economy*, vol. 98, no. 5, pt. II, S12-S37.

GROSSMAN, G. M. and E. HELPMAN, (1991), *Innovation and growth in the Global Economy*, Cambridge, MA: MIT Press.

LELAND, H. (1968), "Saving and Uncertainty: The Precautionary Demand for Saving," *Quarterly Journal of Economics*, vol. 82, 465-473.

LUCAS, R. E. Jr. (1990), "Why Doesn't Capital Flow from Rich to Poor Countries?" *American Economic Review*, vol. 80, 92-96.

_____. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics*, vol. 22, no. 1, 3-42.

MERTON, R. C. (1969), "Lifetime Portfolio Selection under Uncertainty: The Continuous Time Case," *Review of Economics and Statistics*, vol. 51, 247-257.

PRATT, J. (1964), "Risk Aversion in the Small and in the Large," *Econometrica*, vol. 32, 122-136.

RAMSEY, F. (1928), "A Mathematical Theory of Saving," *Economic Journal*, vol. 38, 543-559.

REBELO, S. (1991), "Long-Run Policy Analysis and Long-Run Growth," *Journal of Political Economy*, vol. 93, no. 3, 500-521.

ROMER, P. M. (1986), "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, vol. 94, no. 5, 1002-1037.

_____. (1990), "Endogenous Technological Change," *Journal of Political Economy*, vol. 98, no. 5, pt. II, S71-S102.

SAMUELSON, P. A. (1969), "Lifetime Portfolio Selection by Dynamic Stochastic Programming," *Review of Economics and Statistics*, vol. 51, 239-246.

SANDMO, A. (1970), "The Effect of Uncertainty on Saving Decision," *Review of Economic Studies*, vol. 37, 353-360.

SOLOW, R. M. (1956), "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, vol. 70, no. 1, 65-94.

TSSIDON, D. (1992), "A Moral Hazard to Growth," *International Economic Review*, vol. 33, no. 2, 299-321.