Endogenous Occupational Choice and Economic Development*

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Abstract

This paper constructs the three-period overlapping generations model in which the determination of occupational choice (unskilled labor or skilled labor) is endogenous. In this model, work in childhood and education investment is strategic complements and as a result, multiple equilibria may arise: one is the low income equilibrium in which there is child labor, the other is the high income equilibrium that there is no child labor. Which equilibrium is determined is affected by coordination policy. Friction of labor market prevents households from receiving education even if they receive education in no friction of labor market.

Keywords: Search; Matching; Overlapping generations model; Occupational Choice; Coordination failure.

JEL Classification: E24, E61, O11.

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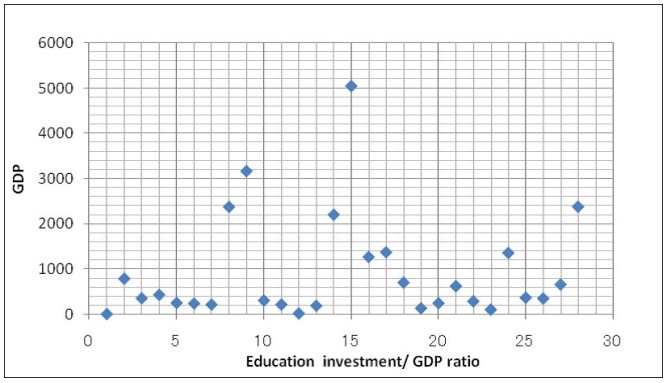

Figure 1 The Relationship between GDP and the ratio of educational investment

1 Introduction

Observing the developing countries, despite of the activity which intends to eliminate child labor, we notice that child labor remain. In fact, the International Labor Organization (ILO) estimates that 246 million of the world ' s children aged 5–17, or 16%, are child laborers, most living in developing countries. In the country such as Pakistan and Ghana in which child labor remain, some people go to school or others work in their childhood[1)]. As a result, there emerge two kinds of people, the educated and uneducated, or skilled and unskilled sector worker. This paper depicts such a situation and gives the reason why child labor remain and shows whether child labor is harmful for economic growth and welfare or not. According to the discussion in Edmonds (2005), as the income level increases, the ratio of child labor decreases.

There is a relationship that as the level of income is low, the school enrolment ratio also is low and as a result, the ratio of child labor increases. Fig.1 shows such a situation[2)]. Moreover, fig.2 shows the relationship in which as the level of income is low, the enrolment rate of school is also rate and the rate of children who are out of school is high. From these figures, we find that there is a possibility that these country fall into the vicious cycle in which people are poor because they cannot receive education and vice versa. In other words, these countries suffer from the interaction between poverty and unavailability of education. So, we find that it is inadequate only to prohibit child labor and it is also necessary to give opportunities to receive education to the children in such countries.

Let us discuss the relationship between the past studies and this paper. In what follows, we explain the issue of child labor and search model using and overlapping generations (OLG) model. Since the pioneering study; Basu and Van (1998), there are numerous studies as follows such as Doepke

[1)] Regarding the present state of child labor, see Ray (2000) or Bhalotra and Heady (2003), for instance.

[2)] Fig.1 and figre02.eps are based on the data of UNESCO Institute of Statistics. This can be derived at http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx.

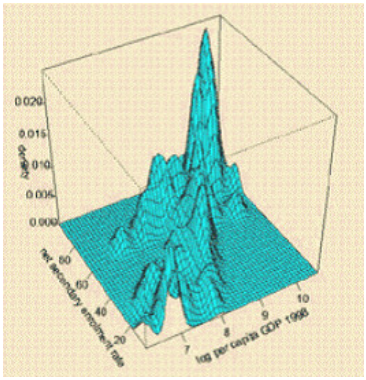

Figure 2　The Relationship between GDP and the ratio of out-of-school children

and Zilibotti (2005), Hazan and Berdugo (2002), Ranjan (2001), Baland and Robinson (2000), Dessy and Pallage (2005), Pallage and Zimmermann (2007), Contreras (2007), Strulik (2004) and so forth. Typically, these studies focus on the existence of child labor and investigate its effects on economic growth[3)]. However, what is common with these studies is that they assume the existence of child labor and do not show how child labor emerges. On the other hand, since the seminal paper, such as Diamond (1982) or Wright (1986) who show unemployment fluctuation, search model is indispensable tool for labor market analysis[4)]. For instance, Acemoglu (2001) shows the mechanism of engendering wage inequality. Including these studies, most studies focus on only the equilibrium. In the studies employed the search model, the amount of hiring and wage are determined by not firm's optimization but the restriction brought about by utility function, bargaining power and other factor. In this paper, we show that people work at both skilled and unskilled sector not only at equilibrium and at the process to the equilibrium, which means imperfect labor specialization (see Kim (1989).), and discusses the effect of educational policy for eliminating such a state. Regarding the studies which incorporate search model into an OLG model, there are some studies such as Galor and Lach (1990), Bean and Pissarides (1993), Horii and Sasaki (2006).Galor and Lach (1990) show the existence of unemployment equilibrium and Bean and Pissarides (1993) investigate the effect of unemployment on economic growth. Recently, Horii and Sasaki (2006) show the dual poverty trap (inter-generational and coordination trap), although they do not focus on child labor.

In those papers, our model is especially similar to that of Horii and Sasaki (2006) and Hazan and Berdugo (2002). The difference between this paper with Horii and Sasaki is that we investigate the dynamics of human and physical capital and shows more complex dynamics than Horii and Sasaki, whereas the difference with Hazan and Berdugo (2002) is that we show how the threshold emerges by

3) As a survey on child labor, see Basu (1999).

4) As a survey, see Rogerson, Shimer and Wright (2005) or Yashiv (2007).

introducing search activity, which is not introduced in Hazan and Berdugo. Moreover, this paper differs from other past study in some respects. Banerjee and Newman (1993) is close to our model in the respect that the model of occupational choice is employed. However, the probability that households determines which jobs they get is exogenous in their model, while, we endogenize such probability in our model by introducing search activity.

The aim of our paper is to give an answer to the following question by investigating the effects of child labor on welfare using an OLG model.

1. Is child labor harmful for economic growth?
2. Why does child labor exist?
3. Is child labor a consequence of coordination failure?
4. How do we recover from the situation in which child labor remain?

The sketch of our model is as follows: First, households determines whether receiving education or work (child labor). In case of the latter, households can only work at unskilled sector over the course of their life, while households have to search jobs between the childhood and the adulthood. Because of that friction at skilled sector, some households who receive education cannot find a job at skilled sector. In that case, they work at unskilled sector. Therefore, households may avoid receiving education expecting such possibility. From another angle, a kind of "coordination failure" emerges. Intuitively, education investment and child labor are strategic substitute, which yields multiple equilibria. Our answer to the above question is as follows: The answer of first question is both 'Yes' and 'No'. Depending on the level of capital accumulation, the answer is alterable. The second and third answer is common. If education investment for children is not attractive for their parents, children are not received education, therefore, child labor exists in this economy. High education cost is one of the reasons that it is not attractive to give education investment. As other reason, if education brings about high labor income with low possibility, parents do not give education due to low expected income. This logic may be similar to that of Emerson and Knabb (2007).

The rest of this paper is organized as follows: In the section 2, we set up the model and investigate the dynamics of the model in the section 3 and investigate the policy effect in the section 4. The section 5 is the conclusion.

2 The Model

Our model is similar to that of Hazan and Berdugo (2002) expect for the the length of the households and the introduction of search activity. Consider a three-period OLG model in which the economy is composed of perfectly competitive firms, identical individuals, Time is discrete and denoted as $t = 0, 1, 2, \cdots, \infty$. A new generation is born in each period $t = 0, 1, 2, \cdots, \infty$ and individuals in each generation live for three periods: child (childhood), young (adulthood) and old period. There is no population growth. The size of each generation is normalized as $N > 0$. The economy consists of households and two kinds of firm. First, we explain firms' behavior.

2.1 Firms

Following Ranjan (1999), firms have two kinds of product sector: unskilled sector and skilled sector.

■Unskilled Sector We assume that unskilled sector needs only labor to produce final goods. The product function is assumed as follows:

$$Y_t^u = bL_t^u, \ \ b > 0, \tag{1}$$

where Y_t^u denotes final goods produced in unskilled sector and L_t^u denotes labor input in unskilled sector. B is constant.

■Skilled Sector On the one hand, we assume that skilled sector needs labor and physical capital to produce final goods. The product function is assumed as follows:

$$Y_t^s = AK_t^\theta L_t^s, \ \ (\theta \in (0,1)), \tag{2}$$

where Y_t^s denotes final goods produced in skilled sector and K_t, L_t^s denote aggregate physical capital stock and effective labor input in skilled sector, respectively. Assuming competitive market and considering profit maximization, the wage rate in unskilled sector w_t^u is shown as follows:

$$w_t^u = b \tag{3}$$

Let Π denote the revenue of the representative firm. Then, the representative firm's profit Π is shown as follows[5)]:

$$\Pi = Y_t^s - w_t^s N_t - cJ_t,$$

where w_t^s and c denotes the wage at skilled sector and search cost, respectively. J_t denotes the number of job. Creating job, it costs c per job. However, creating job gains the marginal profit $AK_t^\theta h_t - w_t^s h_t$ with certain probability.

[5)] See Bean and Pissarides (1993).

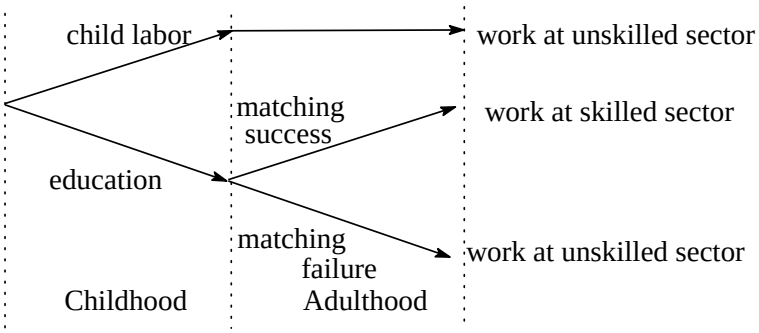

Figure 3　Structure of Decision Making

2.2 Households

In child period, children decide to receive education or supply labor as child labor. The young supply their labor to gain labor income and consume. The old only consume. If the young were not receive education in childhood, they can work in not skilled but unskilled sector. On the other hand, if the young were received education in their childhood, they can work in skilled sector under certain probability. Therefore, they can not always work in skilled sector even if they were received education. In this case, they have to work in unskilled sector.

There are two types of households; those who choose to work at primitive (unskilled) sector in childhood (child labor) and those who chose to receive education. In the former case, people work at unskilled sector in both childhood and adulthood. In the latter case, households born at t-th period receive education and determine the quality of human capital, and join the job market from the childhood to adulthood. Households give the labor supply based on the human capital.

When households are child, they (children) have to determine whether make their children work at unskilled sector (child labor) or receive education. Note that the determination depends on the return. In adulthood in case of education when they are children, there is a possibility that they can work at skilled sector when they are adult, while in case of working in their childhood, they have to work at unskilled sector.（They search jobs between child and young period and whether they can obtain jobs or not depends on matching.) When they are old, they consume their saving. Then, the game of this paper structures to the following two stage game. See fig. 3, which depicts the situation explained in the above.

1. Childhood: determine whether receive education or not
2. Adulthood: searching job in the job market when they are adult

■Determinants of Critical Value: Child Labor or Receiving Education?

If the net income when individual receive education is larger than the income when individual do not receive education, then individual receive education. The wage rate per effective labor in skilled sector is w_t^s. If the individual that have human capital h_t, then the individual gain the labor income $w_t^s h_t$. The wage rate in unskilled sector is w_t^u. The uneducated individuals work in two periods (in childhood and adulthood), so the lifetime income is shown as $w_t^u + w_{t+1}^u = 2b$. For simplicity, we assume that the income brought about child labor is not added interest rate. On the other hand, educated individual can not work in childhood. He can gain $w_{t+1}^s h_{t+1}$ in the probability of q_{t+1} and w_{t+1}^u in the probability of $1-q_t$ respectively in young period. The condition that children can receive education is shown as follows.

Expected net income brought about education $\geq$ The income in the case of no education

In other words, households let their children receive education when the following equation holds.

$$e_t \leq q_{t+1} w_{t+1}^s h_{t+1} + (1-q_{t+1}) w_{t+1}^u - w_{t+1}^u - w_t^u. \tag{4}$$

This equation determines the threshold of this economy[6]. $(\tilde{k}, \tilde{h})$ is given (k,h) that equalizes the left and right side of above equation.

The utility function u_t is the following logarithmic function:

$$u_t = \beta \ln c_{1t} + (1-\beta) \ln c_{2t+1}. \tag{5}$$

where $\beta \in (0,1)$ is a parameter specifying the patience of agents, and c_{1t} and c_{2t+1} denote consumption in young and old period, respectively. We define s_{1t-1}, s_{2t} as the saving in childhood and young, respectively. Then, the budget constraints of parents in unskilled and skilled sector are shown as follows, respectively:

- The individuals who do not receive education

$$s_{1t-1} = w_{t-1}^u, \tag{6a}$$
$$c_{1t} + s_{2t} = s_{1t-1} + w_t^u, \tag{6b}$$
$$c_{2t+1} = (1+r_{t+1}) s_{2t}. \tag{6c}$$

- The skilled individuals who receive education

$$c_{1t} + s_{2t} = w_t^s h_t - e_t, \tag{7a}$$
$$c_{2t+1} = (1+r_{t+1}) s_{2t}. \tag{7b}$$

[6] See Azariadis and Drazen (1990).

- The unskilled individuals who receive education

$$c_{1t} + s_{2t} = w_t^u - e_t, \tag{8a}$$
$$c_{2t+1} = (1 + r_{t+1}) s_{2t}. \tag{8b}$$

where $e_t = \bar{e}$ if individuals pay education cost and $e_t = 0$ if individuals do not pay education cost. The equation of human capital accumulation is assumed as follows:

$$h_{t+1} = B e_t^{\alpha} h_t^{1-\alpha}. \text{ or } \Delta h_t = B e_t^{\alpha} h_t^{1-\alpha} - h_t \tag{9}$$

where E_t denotes the level of education and is assumed $E_t = \bar{f} + e_t$. $\bar{f}$ shows the education without school education.

Households decide the allocations of c_{1t} and c_{2t+1} to maximize their utility under the budget constraints((6a)–(6c), (7a),(7b), or (8a),(8b)). The optimal allocations are respectively as follows:

- The individuals who do not receive education

$$c_{1t} = \beta \left(w_{t-1}^u + w_t^u \right), \tag{10a}$$
$$c_{2t+1} = (1 + r_{t+1})(1 - \beta) \left(w_{t-1}^u + w_t^u \right). \tag{10b}$$

- The skilled individuals who receive education

$$c_{1t} = \beta \left(w_t^s h_t - \bar{e} \right) \tag{11a}$$
$$c_{2t+1} = (1 + r_{t+1})(1 - \beta) \left(w_t^s h_t - \bar{e} \right). \tag{11b}$$

- The unskilled individuals who receive education

$$c_{1t} = \beta \left(w_t^u - \bar{e} \right) \tag{12a}$$
$$c_{2t+1} = (1 + r_{t+1})(1 - \beta) \left(w_t^u - \bar{e} \right). \tag{12b}$$

■Search After receiving education, households go into the job market and aim to obtain the job by searching. In this paragraph, we explain that situation. We assume that search activity lasts only for single period and the cost to search job c is exogenous. As explained above, this model structures to the two-stage game and let us solve this model backward. Here, we explain the matching at the job market. Let M_t be the matching function as follows.

$$M_t = \bar{N}^{\phi} \bar{V}_t^{1-\phi}, \tag{13}$$

where $\bar{N}$ denotes the number of workers who search jobs (assumed to be constant) and $\bar{V}_t$ denotes the aggregate number of vacancy jobs. The probability for worker to match with jobs is $q \equiv \frac{M_t}{\bar{N}} = \left(\frac{\bar{N}}{\bar{V}_t} \right)^{\phi - 1}$. On the other hand, the probability for job to match worker is $p \equiv \frac{M_t}{\bar{V}_t} = \left(\frac{\bar{N}}{\bar{V}} \right)^{\phi}$.

Let J_t denote the pay off of the firm that can agree with workers. Considering free entry condition, the aggregate number of jobs $\bar{V}_t$ is determined so that expected revenue for a job is equivalent to the cost for creating a job, that is:

$$p(\theta_t)J_t = c. \tag{14}$$

Now in a general equilibrium, with a large number of identical firms, we have $V_t = \bar{V}_t$. Regarding skilled sector, we assume that the wage at the skilled sector is determined through bargaining between firms and workers. Outside option of the firm is shown as follows:[7)]

$$\Pi_{firm} = \text{payoff from agreement} - \underbrace{\text{payoff when there is no agreement}}_{=0} = J_t, \tag{15}$$

while outside option of the workers

$$\Pi_{worker} = \text{payoff from agreement} - \text{payoff when there is no agreement} = w_t^s h_t - w_t^u \tag{16}$$

When matching is established, the wage of skilled sector w_t^s is determines through Nash bargaining. Let $\phi \in (0,1)$ denote the bargaining power of workers.

$$\max_{w^s} \ (J_y)^{\varepsilon}(\Pi_v)^{1-\varepsilon},$$

that is,

$$w_t^s = \arg\max_{w_t^s} \left(w_t^s h_t - b\right)^{\varepsilon} J_t^{1-\varepsilon}$$

where $\varepsilon \in (0,1)$ denotes bargaining power of the worker. Also, w_t^s is determined by wage bargaining.

$$w_t^s = \arg\max (w_t^s h_t - w_t^u)^{\varepsilon} J_t^{1-\varepsilon}, \tag{17}$$

where $J_t = \left(AK_t^{\theta} h_t - w_t^s h_t\right)$. Then, we can obtain the wage through Nash bargaining w_t^s as follows:

$$w_t^s = \frac{\varepsilon AK_t^{\theta} h_t + (1-\varepsilon)b}{h_t}. \tag{18}$$

Similarly, we can obtain p_t as follows:

$$p_t(\theta) = \frac{c}{(1-\varepsilon)\left(AK_t^{\theta} h_t - b\right)}. \tag{19}$$

On the one hand, q_t which is the probability that worker meet a vacant job is shown as follows:

$$q_t = \left(\frac{1-\varepsilon}{c}\left(AK_t^{\theta} h_t - b\right)\right)^{\frac{1}{\phi}-1} \tag{20}$$

The increase in capital stock K_t, human capital h_t and unskilled labor wage rate $w^u = b$ increases the number of jobs. The decrease in vacancy cost c also increases the number of jobs. Then, the probability that workers meet vacancy jobs q_t increases, on the other hand, the probability that vacancy jobs meet workers p_t decreases.

[7)] Considering free entry condition, payoff when there is no agreement is zero.

2.3 Market Equilibrium

Finally, we formulate equilibrium conditions for each market.

- Capiltal market (Aggregate)

  Because the aggregate amount of capital equals to that of investment, the following equation holds.

  - The case that all generations's individuals do receive education:

$$\begin{aligned} K_{t+1} &= \bar{N}(w_t^u + (1-\beta)(w_t^u + w_{t-1}^u)), \\ &= \bar{N}B(3-2\beta). \end{aligned} \tag{21}$$

  - The case that all generations individuals receive education:

$$\begin{aligned} K_{t+1} &= \bar{N}(1-\beta)\left(q_t(w_t^s h_t - \bar{e}) + (1-q_t)(w_t^u - \bar{e})\right) \\ &= \bar{N}(1-\beta)\left(q_t w_t h_t + (1-q_t)b - \bar{e}\right). \end{aligned} \tag{22}$$

  - The case that individuals receive education but next generations individuals do not receive education:

$$\begin{aligned} K_{t+1} &= \bar{N}(1-\beta)\left(q_t(w_t^s h_t - \bar{e}) + (1-q_t)(w_t^u - \bar{e}) + w_t^u\right) \\ &= \bar{N}(1-\beta)\left(q_t w_t h_t + (1-q_t)b - \bar{e}\right). \end{aligned} \tag{23}$$

- Goods market

$$C_t + D_t + K_{t+1} + e_t\bar{N} = Y_t^s + Y_t^u,\ e_t = 0,\ \text{or}\ \bar{e}, \tag{24}$$

  where C_t and D_t are aggregate consumption of young and old generation, respectively.

- Labor market
  - unskilled sector:

    Note that labor supply in unskilled sector is those who do not receive education (child labor) and cannot obtain the jog at skilled sector.

$$L_t^u = L_t^{child} + L_t^{adult,noeducation} + (1-q_t)L^{adult,education} \tag{25a}$$

  - skilled sector:

    Note that labor supply in skilled sector is those who receive education and obtain the jog at skilled sector.

$$L_t^s = q_t L^{adult,education} \tag{25b}$$

the equilibrium conditions of capital market determines the dynamics of this economy.

3 Analysis

In this section, we investigate the dynamics of this economy[8)]

3.1 Dynamics

The Equilibrium in this model economy is determined by the capital K_t and human capita h_t. First, we consider the dynamics of human capital h_t.

■The Dynamics of Human Capital Taking eq. (9) into consideration, we can obtain $\Delta h_t \equiv h_{t+1} - h_t$ as follows:

$$\Delta h_t = B e_t^{\alpha} h_t^{1-\alpha} - h_t \tag{26}$$

Then, the locus of $\Delta h_t = 0$ is shown as follows:

$$h_t = B^{\frac{1}{\alpha}} E_t,\ E_t = \bar{f},\ or\ \bar{f} + \bar{e}. \tag{27}$$

■The Dynamics of Physical Capital If there is only unskilled sector in this model economy, Defining $\Delta K_t \equiv K_{t+1} - K_t$, the dynamics of physical capital

$$\Delta K_t = \bar{N} b \left(2 - \beta + (1-\beta)\right) - K_t. \tag{28}$$

The path of $\Delta K_t = 0$ is shown as follows:

$$K_t = \bar{N} b \underbrace{\left(2 - \beta + (1-\beta)\right)}_{3-2\beta}. \tag{29}$$

In this case, the dynamics of physical capital does not generate. On the other hand, there is not only unskilled sector but also skilled sector, the dynamics of physical capital is shown as follows.

$$\Delta K_t = \bar{N}(1-\beta)\left(q_t w_t^s h_t + (1-q_t) b - \bar{e}\right). \tag{30}$$

The locus of $\Delta K_t = 0$ is shown as follows:

$$K_t = \bar{N}(1-\beta)\left(q_t w_t^s h_t + (1-q_t) b - \bar{e}\right). \tag{31}$$

Considering eqs. (29), (18), and (19) the dynamics of K_t is determined, and the amount of K^* and h^* at the steady state are simultaneously determined by solving eqs. (20),(29),(31),(18), and (19). In the regime of only unskilled labor (no education), the capital stock K^* and human capital h^* in the steady state are shown as follows:

$$K^* = \bar{N} b (3 - 2\beta),$$
$$h^* = B^{\frac{1}{\alpha}} \bar{f}.$$

[8)] See also Galor (1992), Lin and Lin (2007), and Venditti (2005) for instance, which investigate the dynamics of the two-sector overlapping generations model.

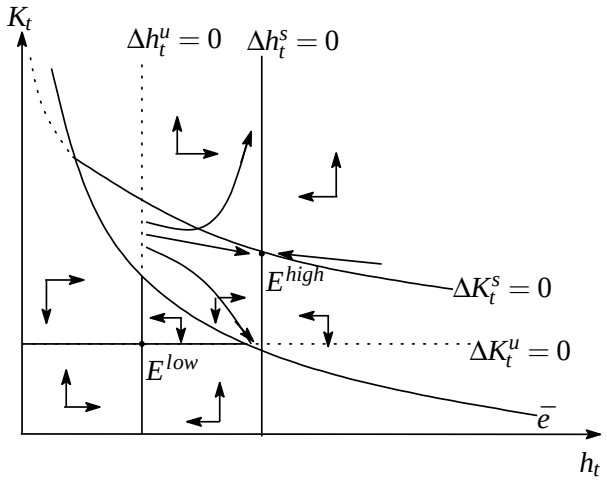

Figure 4 Regime 1: Two Equilibria

On the other hand, in the regime of both skilled labor and unskilled one, the capital stock K^* and human capital h^* in the steady state are shown as follows:

$$K^* = \bar{N}(1-\beta)\left(\left(\frac{1-\varepsilon}{c}\right)^{\frac{1}{\phi}-1}\varepsilon\left(AK^{*\theta}h^* - b\right)^{\frac{1}{\phi}} + b - \bar{e}\right),$$
$$h^* = B^{\frac{1}{\alpha}}(\bar{f}+\bar{e}).$$

The phase diagram under each regime can be depicted as fig.2-7.Line of $\bar{e}$ shows the border whether parents give their children education investment or not, and the following condition is held, parents give their children education investment:

$$K_t^{\theta} h_t > \frac{1}{A}\left(\left(\frac{\bar{e}+b}{\left(\frac{1-\varepsilon}{c}\right)^{\frac{1}{\phi}-1}\varepsilon}\right)^{\phi} + b\right). \tag{32}$$

3.1.1 The Case of $\phi < \theta$

case 1: (Two Equilibria) Depending on the initial value, both the equilibrium with low income (bad equilibrium) and the equilibrium with high income (good equilibrium) are plausible as in fig.4.

case 2: (Two Equilibria) Similar to Case 1, both the equilibrium with low income (bad equilibrium) and the equilibrium with high income (good equilibrium) are plausible as in fig.5.

case 3: (One Equilibrium) There is only the equilibrium with low income (bad equilibrium) is stable as in fig.6. Note that the intersection of eq. (4) and $\Delta h^u = 0$ is located below the intersection of $\Delta h^u = 0$ (h^u denotes h in $e = 0$) and $\Delta K^u = 0$ (K^u denotes K in $e = 0$).

$\Delta h_t^u = 0$ and $\Delta K_t^u = 0$ denote (24) and (28) in $E_t = \bar{f}$, respectively. $\Delta h_t^s = 0$ and ΔK_t^s denote (25) and (30) in $E_t = \bar{f} + \bar{e}$, respectively.

In $\phi < \theta$, it is brought about the two equilibria: one for the equilibria: one for the equilibrium with

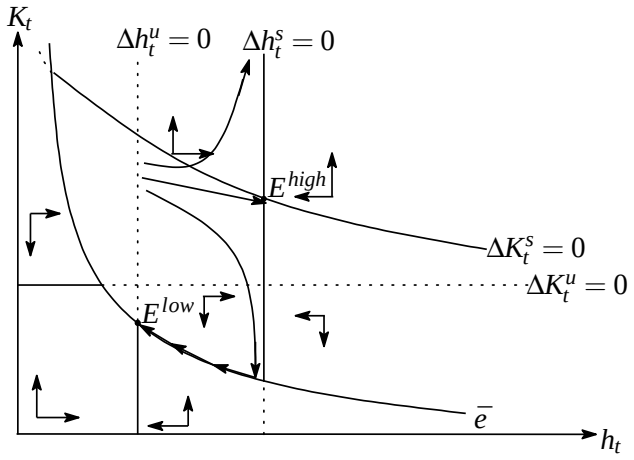

Figure 5 Regime 2: One Equilibrium

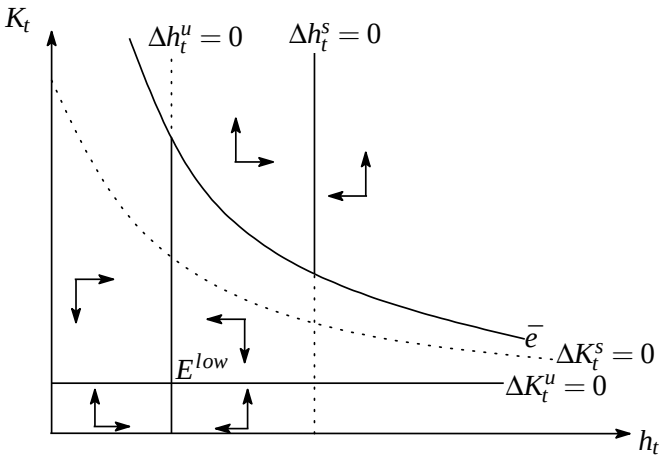

Figure 6 Regime 3: One Equilibrium

low income and the other for the equilibrium with high income. The equilibrium with low income is stable one, on the other hand, the equilibrium with high income is unstable. Therefore, even if the initial capital stock and human capital (K_0, h_0) are above the line of $\bar{e}$, an economy may converges the equilibrium with low income. On the other hand, giving the other initial condition, income growth continues.

3.1.2 The case of $\phi \geq \theta$

case 4: (Two Equilibriua) Depending on the initial value, both the equilibrium with low income (bad equilibrium) and the equilibrium with high income (good equilibrium) are plausible as in fig.7.

case 5: (One Equilibria) Despite of the initial value, the only equilibrium with high income (good equilibrium) is plausible as in fig.8 Note that the intersection of eq. (4) and $\Delta h^u = 0$ is located above the intersection of $\Delta h^s = 0$ and $\Delta K^s = 0$.

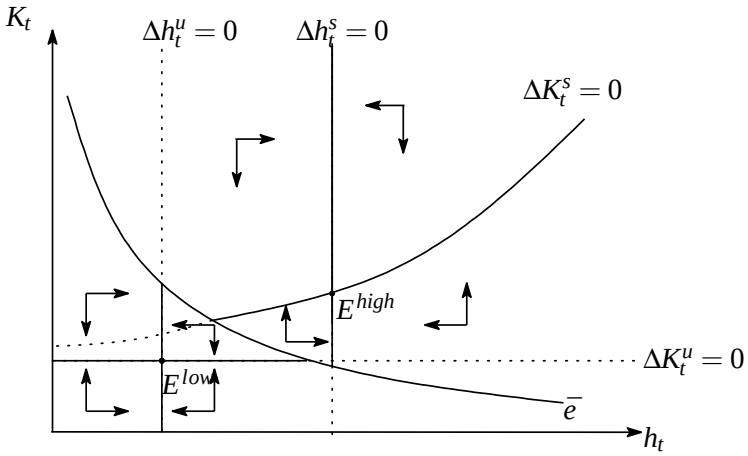

Figure 7 Regime 4: Two Equilibria

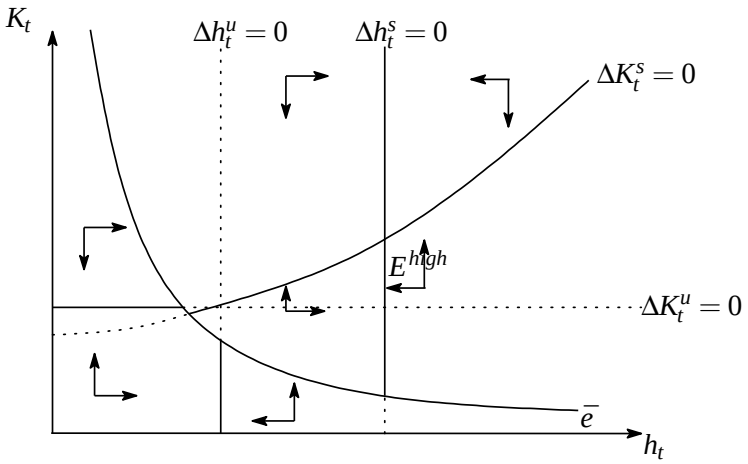

Figure 8 Regime 5: Two Equilibria

case 6: (One equilibrium) Despite of the initial value, the only equilibrium with low income (bad equilibrium) is plausible as in fig.9)

In $\phi \geq \theta$, it is also brought about two equilibria: one for the equilibrium with low income and the other for the equilibrium with high income. However, both equilibria are stable. To summarize, we can state as,

Proposition 1

1. *Under each regime, the equilibrium with low income is stable. However, the equilibrium with high income is stable if* $\phi \geq \theta$
2. *Depending on the initial value, which equilibrium the economy reaches determines.*

The accumulation od capital stock K_t has two effects in this economy. Increase in K_t pulls up the wage rate of skilled worker. Simultaneously, change of K_t changes matching probability. If capital

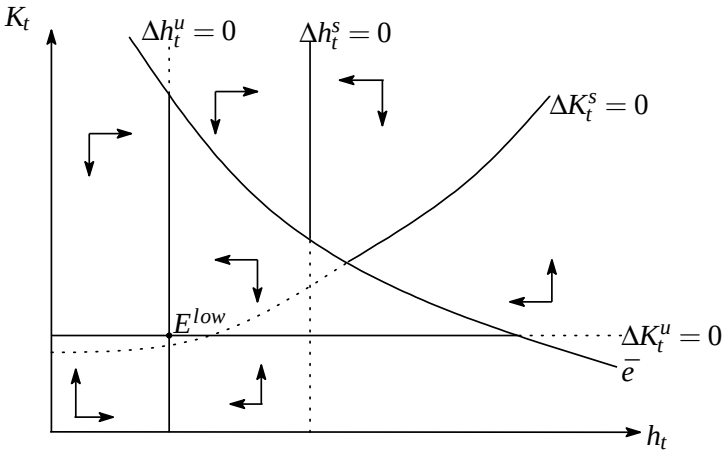

Figure 9 Regime 6: One Equilibrium

stock K_t increases, the probability that workers meet vacant jobs increases. Therefore, if $\phi < \theta$, the latter effect is large. In this case, it is possible to continue to increase (or decrease) the capital stock. On the other hand, $\phi > \theta$, the latter effect that skilled worker increase by increase in matching probability is small, the equilibrium with high income is stable.

In this model, there is an uncertainty of labor market (whole educated person can not work as skilled worker). Therefore, if expected income when each individual receive education is low because of low probability of matching, the equilibrium with high income may vanish even if skilled wage rate is high. Then, ε is low, that is the profit share of skilled workers is low, the probability of matching increases, parents give education investment for children even if the skilled wage income is not high.

3.2 Evolution of Worker's Distribution

As times passes, how does the worker's distribution evolve? We then focus the dynamics of $\frac{L_t^s}{L_t^s + L_t^u}$.

$$\frac{L_t^s}{L_t^s + L_t^u} \equiv g(K_t, h_t) = \left(\frac{(1-\varepsilon)}{c} \left(A K_t^{\theta} h_t - b \right) \right)^{\frac{1}{\phi} - 1}. \tag{33}$$

We then investigate the dynamics of $g(K_t, h_t)$. Due to $\frac{\partial g_t}{\partial K_t} > 0$, $\frac{\partial g_t}{h_t}$ and $\frac{\partial g_t}{\partial \varepsilon}$, we reach to the following proposition.

Proposition 2

1. *An increase in physical capital K_t or human capital h_t increases skilled labor.*
2. *An increase in bargaining power of firms increases skilled labor.*

The intuition of the Proposition 2.2 means that the bargaining power of the workers increases, the ratio of skilled worker decreases. The reason is intuitive. The increase in the share of worker decreases

firm's profit. Therefore, this effect makes firm's incentive of employing skilled worker decrease. The increase in K_t and h_t increases the ratio of skilled worker. The increase in K_t and h_t increases firm's profit, so the firm increases skilled labor.

Incidentally, in steady state, $q_t = q_{t+1} = q_t$ is shown as follows:

$$\frac{L^s}{N} = g(K^*, h^*) = q^* = \left(\frac{1-\varepsilon}{c} \left(AK^{*\theta} h^* - b \right) \right)^{\frac{1}{\phi}-1}. \tag{34}$$

In the steady state, an increase in the bargaining power of skilled worker ε does not always increase the share of skilled labor. Increase in ε increases the wage rate of skilled labor. On the other hand, increase in ε decreases the share of skilled labor in the short run. These two effects determines the change of K_t, this change affects q^* indirectly. Therefore, $\frac{\partial q^*}{\partial \varepsilon}$ is ambiguous.

4 Education Policy

Depending on initial conditions, it is determined whether an economy converges to the equilibrium with high income or that with low income. Moreover, in some parameter condition, the equilibrium with high income is vanished, therefore, an economy converges to the equilibrium with low income even if any initial conditions are givens. Then, the government should set the education policy. We consider two education policies: one for public education policy and the other for education subsidy policy. Public education policy is that education cost is financed by taxation. On the other hand, education subsidy policy is to decrease the burden of household's education.

4.1 Public Education Policy

Considering wage income taxation, the equilibrium condition in public education policy is shown as follows:

$$\Delta K_t = \bar{N}(1-\beta)(1-\tau)\left(q_t w_t^s h_t + (1-q_t)b\right), \tag{35}$$

$$\Delta h_t = B\left(\bar{f} + \bar{e}\right)^{\alpha} h^{1-\alpha} - h_t, \tag{36}$$

$$\bar{e} = \tau\left(q_t w_t^s h_t + (1-q_t)b\right). \tag{37}$$

With public education policy, the equilibrium with high income E^{high} is brought about as shown by Fig. even if the capital stock decreases.

4.2 Education Subsidy Policy

The equilibrium condition in education subsidy policy is shown as follows:

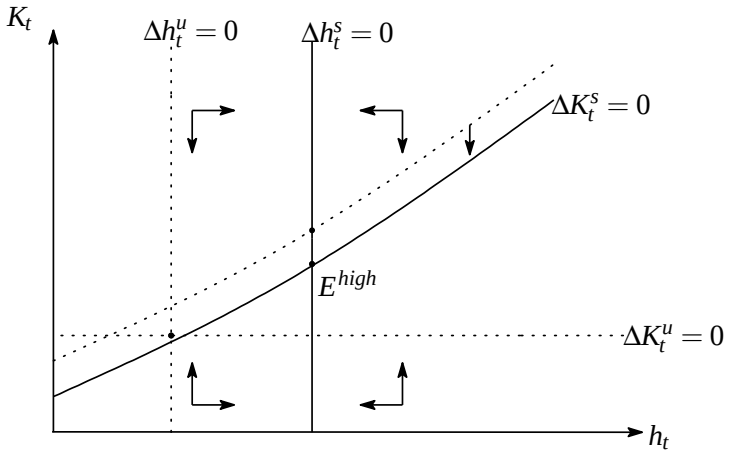

Figure 10　Public Education Policy

■The case that individuals do not receive education

$$\Delta K_t = \bar{N}(1-\tau)b(3-2\beta), \tag{38}$$
$$\Delta h_t = B\left(\bar{f}+\bar{g}\right)^{\alpha} h^{1-\alpha} - h_t, \tag{39}$$
$$\bar{g} = 3b\tau, \tag{40}$$

where $\bar{g}$ denotes the amount of education subsidy, $\bar{e} > \bar{g}$. If $\bar{e} = \bar{g}$, this shows public education policy. On the other hand, in the case that individuals receive education,

■The case that individuals receive education

$$\Delta K_t = \bar{N}(1-\beta)(1-\tau)(q_t w_t^s h_t + (1-q_t)b - (\bar{e}-\bar{g}), \tag{41}$$
$$\Delta h_t = B\left(\bar{f}+\bar{e}\right)^{\alpha} h^{1-\alpha} - h_t, \tag{42}$$
$$\bar{g} = \tau\left(q_t w_t^s h_t + (1-q_t)b\right). \tag{43}$$

With education subsidy policy, the equilibrium with high income is brought about as shown by Fig 11. Even if the capital stock decreases and there is no equilibrium with high income without education subsidy policy.

This results shows which policies the government sets. Depending on initial condition, an economy does not converges to the equilibrium with high income even if the education subsidy is occurred. In this case, the government sets the public education policy, therefore an economy can converges to the equilibrium with high income.

5　Concluding Remarks

This paper constructs the three-period overlapping generations model in which the determination of occupational choice is endogenous. We show that work in childhood and education investment is

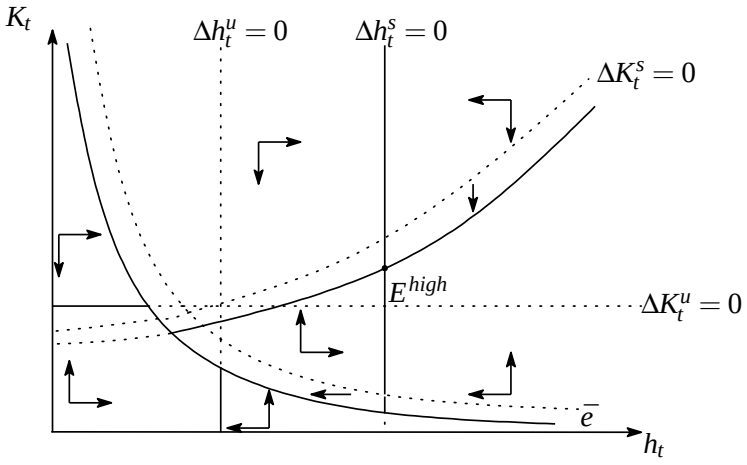

Figure 11 Education Subsidy Policy

strategic complements and as a result, multiple equilibria may arise: one is the low income equilibrium that there is child labor, the other is the high income equilibrium that there is no child labor. Whether the economy converges to low income equilibrium and high income equilibrium depends on initial conditions. This result corresponds to the current situation in which in some countries, there remain child labor and low ratio of school enrolment, whereas there exits no child labor and high ratio of school enrolment in other countries. We then show because of friction in labor market, households do not receive education. On the other hand, even if there is friction in labor market, there is a possibility that the economy which falls into the low income equilibrium reaches the higher income equilibrium by constructing scheme of public education. The second result may help the low-income countries reduce child labor and escape the coordination failure.

Appendix A

A.1 Derivation of Wage at Skilled Sector

We solve

$$w_t^s = \arg\max_{w_t^s} (w_t^s h_t - w_t^u)^{\varepsilon} \{(1-\theta)Ak^{\theta} - w_t^s h_t\}^{1-\varepsilon}.$$

The first order condition for the problem is

$$\frac{d \ln w_t^s}{d w_t^s} = \varepsilon \frac{h_t}{w_t^s h_t - b} - (1-\varepsilon) \frac{h_t}{AK_t^{\theta} h_t - w_t^s h_t} = 0.$$

Therefore, wage rate of skilled labor is given by $w_t^s = \frac{\varepsilon A K_t^{\theta} h_t + (1-\varepsilon) b}{h_t}$.

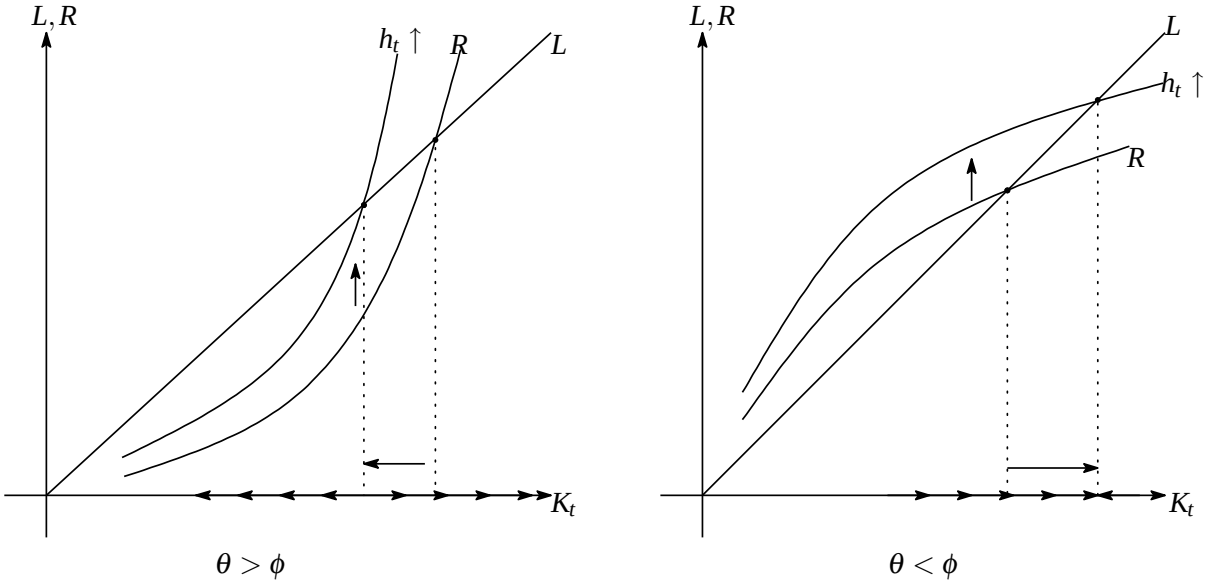

Figure 12 Determination of Phase

A.2 The Phase Diagram in the Economy with Both Unskilled Labor and Skilled One

ΔK_t is shown as follows:

$$\Delta K_t = \bar{N}(1-\beta)\left(\left(\frac{1-\varepsilon}{c}\right)^{\frac{1}{\phi}-1}\varepsilon\left(AK_t^{\theta}h_t - b\right)^{\frac{1}{\phi}} + b - \bar{e}\right) - K_t. \tag{44}$$

Defining $L \equiv \bar{N}(1-\beta)\left(\left(\frac{1-\varepsilon}{c}\right)^{\frac{1}{\phi}-1}\varepsilon\left(AK_t^{\theta}h_t - b\right)^{\frac{1}{\phi}} + b - \bar{e}\right)$ and $R \equiv K_t$,

$$\frac{\partial L}{\partial K_t} = \frac{L_1}{A}\theta K_t^{\theta-1}h_t\phi\left(AK_t^{\theta}h_t - b\right)^{\frac{1}{\phi}-1} > 0, \tag{45}$$

where $L_1 \equiv \bar{N}(1-\beta)\varepsilon\left(\frac{1-\varepsilon}{c}\right)^{\frac{1}{\phi}-1}$. $\frac{\partial^2 L}{\partial K_t^2}$ is shown as follows:

$$\frac{\partial^2 L}{\partial K_t^2} = \frac{L_1 A\theta K_t^{\theta-2}h_t}{\phi^2}\left(AK_t^{\theta}h_t - b\right)^{\frac{1}{\phi}-2}\left(AK_t^{\theta}h_t(\theta-\phi) + \phi(1-\theta)b\right).$$

If $\theta > \phi$, $\frac{\partial^2 L}{\partial K_t^2} > 0$. Then, Case 1-3 are given as the figure shows. On the other hand, if $\theta < \phi$ and K_t or h_t is in certain level, $\frac{\partial^2 L}{\partial K_t^2} < 0$. Then, Case 4-6 are given as the figure shows.

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