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Education Development and Economic Growth:

An Investigation Using Simultaneous Equation Models

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Abstract

Interdependence between the growth of income (economic growth) and the growth of human capital stock, referred to as education development, is investigated using simultaneous equations models. The annual data of Lao villages, *K* district, for the years 1997/1998－2002/2003 are adopted for the investigation. Human capital stock is measured by the ratio of the number of workers who graduated from primary school and lower secondary school to the total labor force in each village (*school cluster/school grouping system*). We find a convergence of growth in both cases of income and human capital stock and interdependence between them by using the two-stage least squares method.

Key words: convergence, education development, economic growth, human capital, simultaneous equation models

Introduction

Most economists, in a certain sense, have always known that growth is very important. Considerable effort has recently been devoted to the empirical testing of hypotheses generated from long-run economic growth models. Much of the effort was motivated by the early contributions of Solow (1956, 1957). Yet, at the core of the discipline, the study of economic growth declined after the late 1960s. Then, after a lapse of two decades, in the late 1980s, there was renewed interest in this research that is evinced by Romer (1986), Lucas (1988), Barro (1991), and Mankiw et al. (1992). This new research began with models of the determination of long-run growth, which are now referred to as endogenous models. To sum up the major characteristics of those papers, an improvement in productivity, technological change, and R & D, including expansions in the variety and quality of products by human resource development through education development, research development, and vocational training produce a powerful and positive effect on economic growth; the lack of human resources is the chief factor that impedes economic growth[1]. Schultz (1963) was the first to address is this issue. The theory of education investment, which was first reported in Schulz's paper, stated that human resources, characterized by a high level of education, contributes to economic growth. In recent years, economists have paid attention to a reverse relation of cause and effect, namely, a high income level contributes to education development. To cite an example, Goetz and Hu (1996) analyze a cause-and-effect relationship between income growth and human capital growth (demand for education) using data from southern US counties for the period 1980－1990. A central theme in this work is the convergence of incomes over time, and widespread evidence exists that per capita incomes have converged, conditional on human capital stocks (educational attainment/education development), across states and countries in past decades.

In this paper, my concern is to stress the empirical implications of the theories and the relationship of these hypotheses to the data and evidence. This combination of theory and empirical work is the most exciting aspect of the ongoing research on economic growth. Thus, this paper employs two approaches whereby the research method is extended in two directions. The first direction involves an empirical investigation of the simultaneous relationship between economic growth and growth in educational attainment. Regions (villages or *school clusters*) with higher stocks of human capital experience faster income growth rates, but faster income growth also leads to higher rates of investment in human capital, if other things are equal. The second research direction is an examination of growth in educational attainment. Given an upper bound on human capital investment in a village or a school cluster, empirical convergence is expected. This pattern of convergence, which is parallel to that of incomes, has largely been ignored in the literature. However, it is closely related to income convergence. This paper, therefore, compounds two topics that have hitherto been analyzed separately — economic growth and

demand for education—using simultaneous equation models[2].

We use data from Lao villages, *K* district, for the years, 1997/98－2002/03[3]. By using data from a single country, data comparability and quality problems, as discussed by Summers and Heston (1991), are reduced. It should be added that education development in Laos is an important issue that should be addressed because in the long-run, education must be developed to maximize economic growth, eradicate poverty, and reduce inequality.

1. Quantitative completion of district data sets for empirical analysis

K district is located in the north of *V* province, 190

Table 1. School Group System in *K* district (1997/98)

SG No.	Number of villages	Number of constituent school members	Number of teachers	Number of students
01	5	3	22 (12)	746 (349)
02	5 [+1]	5	11 (0)	254 (106)
03	2 [+1]	2	10 (0)	334 (167)
04	4	4	12 (1)	291 (124)
05	1	1	6 (2)	98 (50)
06	3	3	7 (2)	224 (105)
07	3	3	6 (0)	206 (84)
08	4	3	21 (8)	488 (247)
09	3	3	8 (0)	149 (68)
10	2	2	7 (0)	183 (85)
11	5	5	17 (4)	424 (190)
12	2	2	8 (0)	254 (120)
13	4	4	7 (0)	203 (80)
14	6	6	11 (2)	285 (133)
15	1	1	6 (0)	129 (52)
16	5	5	9 (1)	259 (118)
Total	55 [+2]	52	168 (32)	4,527 (2,078)

Note 1: Female ( )
SG No.: School group number
Note 2: Statistically, there were two villages that did not belong to the school group in 1997/98. Nevertheless, the students actually attended school (SG No. 02 or SG No. 03).
(Source) *K* district education office.

Table 2. School Group System in *K* district (2002/03)

SG No.	Number of villages	Number of constituent school members	Number of teachers	Number of students
01	5	6	22 (12)	746 (349)
02	6	7	19 (0)	351 (106)
03	3	4	10 (0)	334 (167)
04	4	4	12 (1)	291 (124)
05	1	1	6 (2)	101 (70)
06	3	3	7 (2)	224 (105)
07	3	3	6 (0)	206 (84)
08	4	4	31 (8)	598 (247)
09	3	3	8 (0)	149 (68)
10	3	2	7 (0)	183 (85)
11	5	6	18 (5)	524 (290)
12	2	2	8 (0)	254 (120)
13	4	4	7 (0)	203 (80)
14	7	7	13 (3)	336 (133)
15	1	1	6 (0)	129 (52)
16	5	5	9 (1)	259 (118)
Total	59	62	189 (34)	4,888 (2,198)

Note 1: Female ( )
SG No.: School group number
Note 2: Each of the two villages (Table 1., Note 2) formally belonged to the school group (SG No. 02 and SG No. 03) in 2002/03, and as for the two emerging villages, one village was only divided into two. Thus, it is reasonable to say that the number of villages in 2002/03 (57 villages) was the same as in 1997/98.
(Source) *K* district education office.

km from the municipality; it spreads over 65 km in the north-south direction, 80 km in the west-east direction, within an approximate area of 4,700 km^2. Access to *K* district is via North No. Road 13. The district has about 4,000 households with a population of about 25,000, including 54.8% Low-land Lao, 43.7% Middle-land Lao, and 1.5% High-land Lao.

The primary school system in *K* district is the *school grouping system*. There is a complete primary school with several nearby incomplete primary schools existing in a *group school*. The administration depends on the center school (complete school) and *a group school* has only one director. Currently, there is no primary school, and 16 primary *group schools* exist in the district as public entities, including 16 complete primary schools and 36 incomplete schools, with a total student population of about 4,500. In some *group schools*, the subordinate (or satellite) incomplete schools are located far from the center (or mother) school, i.e., the nearest is 1 km and the furthest is 4 km in the central district areas, the nearest is 1 km and the furthest is 10 km in the main roadside areas, and the nearest is 2 km and the furthest is 12 km in the poor accessibility areas. Due to the difficulty of traveling to the school and the poor living conditions, a substantial number of children are not able to complete their education at the primary school level in rural areas such as *K* district.

In addition, the number of children who are not completing their primary school education is notably high owing to a lack of adequate school facilities, difficulty in traveling to school, and poverty. The district data illustrate that the number of students decreases in the higher grades and only one-third of the students completes the last grade of primary school. Moreover, the primary school buildings and facilities need to be improved qualitatively and quantitatively, taking into account the expected future growth of school-age children.

2. Consideration of human capital indicators

Not only the available data on physical capital but also the method of measuring human capital seems unreliable for developing countries, especially Laos[4]. Thus, an alternative to using the limited data that are available on physical capital per person, we assume that for given values of education, a higher level of initial real per capita income reflects a greater stock of physical capital per person.

Countries with abundant human capital have demonstrated that they can develop even if they have low reserves of natural resources. This paper also indicates how improving the quality of people as productive agents must be the central objective of development policies. Human capital is emphasized because the knowledge possessed by human beings is the basis for achieving an increase in total factor productivity. Land, labor, and physical capital may be subject to diminishing returns, but knowledge, or literature, is not. With regard to empirical analysis, however, it is very difficult to directly and accurately measure the quality and quantity of human capital. Hence, in many cases, we must make use of substitute variables in the exchange of human capital itself. We usually substitute education indicators for human capital from the viewpoint of a measuring rule. Part of the difficulty in choosing education indicators is that using flow education indicators — primary or secondary school enrollment ratio—is inappropriate (Barro, 1991). The greater part of the difficulty, however, is that making this selection properly entails not only conducting economic analysis, but also taking into account sociological, psychological, and political considerations.

By definition, an enrollment ratio is indicative of the current flow of school education and is not representative of the human capital indicator, for there is a time lag between entering primary or secondary school and being formulated as human capital in the labor market; furthermore, the dropout and repetition ratios are points to bear in mind carefully. Thus, there are many difficulties involved in using the enrollment ratio as a proxy for human capital stocks from the viewpoint of measuring the human capital stock accurately.

According to Barro and Lee (1993), the average number of years of schooling for the total labor force in each economy/region/community is regarded as a proxy for human capital stocks. In light of the example mentioned above, it is reasonable to suppose that the ratio of the numbers of workers who have junior college or higher degrees to the total labor force is the optimum proxy for human capital stocks.

This concept is adopted in this paper; however, there are some serious issues that have arisen such as the small number of workers who have high academic qualifications, as *K* district is behind the other districts of *V* province in terms of education development and few occupations demand advanced job training. Thus, we consider "the ratio of the number of workers who graduated from primary school to the total labor force in each school group" as a proxy for human capital stocks. The next paragraph describes the convergence of growth in both cases of income and human capital stock.

3. Convergence of the growth rate

We make observations at two points in time: 0 and *T*. The average growth rate of the per capita income for economy *i* over the interval from 0 to *T* is given in

Table 3. The initial level of educational attainment (human capital stock) and income per capita (1997/98), and rate of growth in educational attainment (human capital stock) and income per capita (2002/03)

	Income per capita		RNGP		RNGLS	
SG No.	1997/98	Rate of growth	1997/98	Rate of growth	1997/98	Rate of growth
01	3.98	2.99	10.73	5.38	3.33	6.83
02	4.88	1.81	29.93	4.80	2.18	9.32
03	3.11	3.03	20.22	4.15	5.20	5.66
04	2.87	4.13	41.99	3.95	4.86	6.05
05	4.39	1.98	29.11	3.44	1.53	5.51
06	2.71	3.25	30.25	3.76	3.90	4.67
07	4.92	1.75	18.34	4.91	3.77	3.97
08	2.23	4.28	30.67	4.82	8.44	3.03
09	4.11	3.51	27.99	4.06	1.24	6.70
10	3.76	3.46	40.33	4.28	3.22	5.99
11	2.18	3.57	11.98	5.49	2.11	6.69
12	3.37	3.44	32.91	3.99	1.05	5.95
13	3.77	2.90	31.63	4.10	4.48	4.09
14	2.90	3.55	17.33	3.97	1.88	6.13
15	3.60	3.74	48.28	2.81	4.79	3.94
16	2.86	3.03	36.72	4.06	3.59	5.21

Note: RNGP: The ratio of the numbers of workers who graduated from primary school to the total labor force in each SG
RNGLS: The ratio of the numbers of workers who graduated from lower secondary school to the total labor force in each SG
SG No.: School group number
(Source) LECS 2, LECS 3, and *K* district statistical center

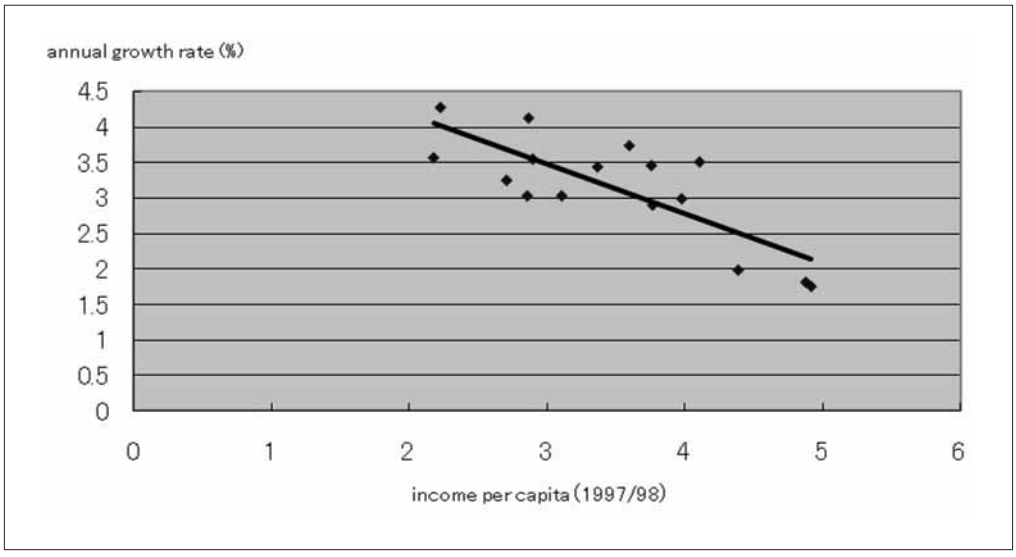

Fig. 1 Growth in real income per capita of group schools (1997/98−2002/03)

equation (1) below (Barro and Sala-i-Martin, 2004), where the subscript T denotes the year and the subscript i denotes the country or region.

$$(1/T)\cdot\log(Y_{iT}/Y_{i0}) = C - [(1-e^{-\beta T})/T]\cdot\log(Y_{i0}) + u_{i0,T}. \quad (1)$$

Y_{iT} and Y_{i0} represent the per capita real income of economy i at two points in time: 0 and T. $u_{i0,T}$ indicates the average of the error terms between 0 and T. Equation (1) constitutes a logarithmic relationship between the geometrical mean of the annual growth rate of income per capita and its initial level of income. The coefficient $[(1-e^{-\beta T})/T]$ approaches 0 as the interval increases and T approaches infinity, and the effect of the initial position on the average growth rate declines. It tends to β as the interval decreases and T approaches 0. This property corresponds to our concept of β convergence.

Based on this equation framework, we now use the data on per capita income and educational attainment for *K* district, *V* province, Laos to find the convergence of growth in both cases of income and human capital stock. Table 3 shows the growth rate of the average per capita income and the ratio of the number of workers

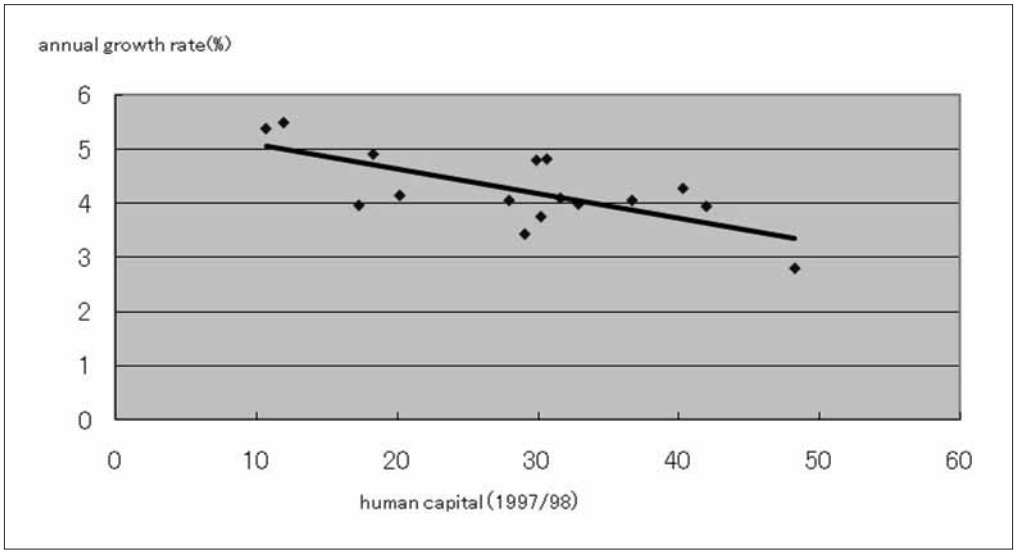

Fig. 2 Growth in human capital (ratio of the number of workers who graduated from primary school to the total labor force) (1997/98－2002/03)

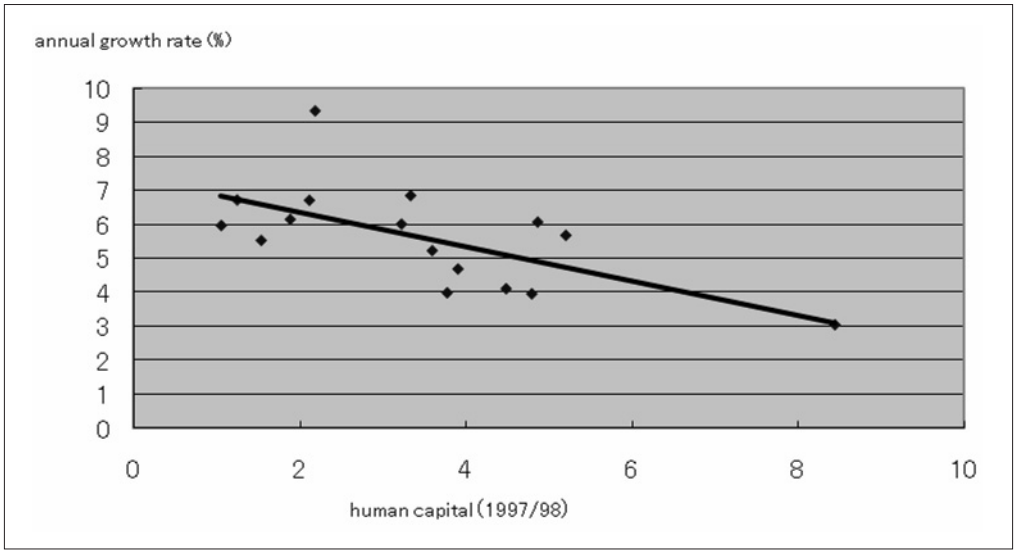

Fig. 3 Growth in human capital (ratio of the number of workers who graduated from lower secondary school to the total labor force) (1997/98－2002/03)

—used as a proxy for human capital stocks—who graduated from primary and lower secondary schools to the total labor force in each school group and the growth rate of that rate from 1997/98 to 2002/03.

In equation (1), ordinary least squares (OLS) estimates using data from Table 3 shows that the growth rate of per capita income depends negatively on the initial level of income and that the same is true of the relationship between the growth rate and the initial level of human capital stock.

Fig 1 illustrates that the growth rate of the school group's per capita income for 1997/98－2002/03, shown on the vertical axis, is negatively related to the per capita income in 1997/98, shown on the horizontal axis. The same negative relationship regarding human capital stock also appears in Figs. 2 and 3.

4. Construction of a growth model

We use an empirical framework that uses two kinds of variables of real per capita growth: the initial levels of state variables such as the stock of physical capital and the stock of human capital in the form of educational attainment, and control or environmental variables[5].

Since an established theoretical framework for specifying regional economic growth models does not exist, variable selection is essentially an empirical issue that is

conditioned by the units chosen for the analysis. In this paper, the specification of a functional form and selection of explanatory variables are guided by previous studies. A general economic growth model can be developed on the lines of Barro and Sala-i-Martin (2004). We can write the function for a country's per capita income growth rate as

$$Dy = F(Y_0, H_0, S_0, \cdots). \tag{2}$$

In estimation (2), Dy is the per capita income growth, Y_0 is the initial per capita income, H_0 is the initial human capital stock (based on measures of educational attainment), and S_0 is a set of control and environmental influences (which comprises an array of control and environmental influences)[6]. In most previous studies, functional form F is assumed to be linear (Levine and Renelt, 1992). On the basis of Barro (1991, 1993), Lee and Lee (1995), and Goetz and Hu (1996), the determinants of income growth are specified empirically as

$$Dy = a_0 + a_1 Y_0 + a_2 H_0 + a_3 Dh + \Gamma S_0 + u_T. \tag{3}$$

Dh is an evaluation of the independent effects of the initial human capital stock, a and Γ are the parameters to be estimated, and u_T is a random disturbance. In particular, Γ is a coefficient matrix that is a group of S_0. As is evident from the second paragraph, we use educational attainment as a proxy for human capital stocks; H_0 is measured as the percentage of the population that graduated from primary school. Since growth in human capital has been identified as one of the most important contributors to economic growth, Dh is included as a regressor. This allows us to evaluate the independent effects of initial human capital stocks and growth in human capital on income growth.

Growth in human capital has been modeled as a function of output and initial human capital stocks (e.g., Mankiw et al., 1992 and Jones, 1995). In the same manner, using a similar functional form as in (3), the determinants of human capital growth (the ratio of the number of workers who graduated from primary school to the total labor force in each school group) are specified empirically as

$$Dh = b_0 + b_1 Y_0 + b_2 H_0 + b_3 Dy + \theta Q_0 + v_T, \tag{4}$$

where Q is a set of control and environmental variables that affect human capital growth , b and θ are the parameters to be estimated, and v_T is a random disturbance.

Thus, equation system (3) and (4) can be rewritten as

$$\Phi G = \Lambda I + R, \tag{5}$$

where

$$\Phi = \begin{pmatrix} 1 & -a_3 \\ -b_3 & 1 \end{pmatrix},\ G = \begin{pmatrix} Dy \\ Dh \end{pmatrix},\ \Lambda = \begin{pmatrix} a_1 & a_2 \\ b_1 & b_2 \end{pmatrix},$$
$$I = \begin{pmatrix} Y_0 \\ H_0 \end{pmatrix},$$

and

$$R = \begin{pmatrix} a_0 + \Gamma S_0 + u_T \\ b_0 + \theta Q_0 + v_T \end{pmatrix}.$$

The reduced form of the system is

$$G = \Phi^{-1}\Lambda I + \Phi^{-1} R, \tag{6}$$

and the reduced-form effects of the initial levels of income and educational attainment are

$$\Phi^{-1}\Lambda I = [1/(1-a_3 b_3)] \begin{pmatrix} a_1 + a_3 b_1 & a_2 + a_3 b_2 \\ b_1 + a_1 b_3 & b_2 + a_2 b_3 \end{pmatrix} \begin{pmatrix} Y_0 \\ H_0 \end{pmatrix}. \tag{7}$$

These parameters catch two effects of each variable. For illustrative purposes, we consider the effects of initial income on income growth. One is the direct effect of Y_0 on Dy, represented by a_1, which indicates the speed of income convergence. Another effect is that of Y_0 through Dh on Dy, represented by $a_3 b_1$, which catches the contribution of educational growth to income growth and the effect of initial income on educational growth, to the extent that $a_1 < 0$ and $a_3 b_1 > 0$. These two effects are in opposite directions and the conventional reduced-form estimation yields only a net effect. The effects of Y_0 on Dh, H_0 on Dh, and H_0 on Dy can be analyzed in a similar manner. Moreover, the whole coefficient, $(a_1 + a_3 b_1)/(1 - a_3 b_3)$, is the net effect on Y_0.

5. Empirical results

As we have seen, in order to select variables in S_0 in (3) and Q_0 in (4), we draw on recent studies, most of which are based on surveys of individuals.

The choice of regressors in S_0 varies in the literature within the context of the study and data limitations. On the basis of previous studies, the following regressors are included here. *The rate of urban areas* (*RU*: in order to consider the effect of the industrial sector)[7] and *the rate of accessible roads in the rainy season* (*RRR*) capture the effects of urbanization in an area[8]. *The rate of households with piped water or a protected well* (*RDW*) is an indicator variable with value 1 if the government intends to invest in rural areas as a proxy for local public investment. In addition, *the number of hotels* (*NGET*: the so-called *guest house*) has a tremendous effect on local commercial activity. It is expected that these indicators have an impact on income growth, in other words, economic growth. Finally, higher local taxation measured by a tax capacity index at the

Table 4. Basic statistics

	Mean	Std.	Min	Max
Dy	3.52	0.39	1.29	4.99
Dh	4.51	0.31	2.01	6.47
Y	3.62	2.32	1.94	5.22
Hp	29.95	25.21	10.12	53.68
RU	28.377	25.311	15.870	33.579
RDW	65.923	45.978	25.611	74.698
RRR	28.182	9.4521	0.0436	40.922
NGET	1.765	1.613	0	5
PTAX	5.987	13.879	0.478	54.960
POP	21.984	24.004	17.235	34.477
ROH	74.389	10.730	60.729	82.656
FAMSZ	3.71	0.402	3.31	6.84
UNEMP	4.270	1.373	0.592	8.198
DRGR	0.241	0.225	0.152	0.853
LEB	57.83	1.263	35.6	72.8
WAGE	1.935	0.278	1.731	3.976

province level (*PTAX*) is expected to affect individual or small firms and to deter industries from establishing themselves in *K* district, *V* province and, therefore, stifle economic growth.

In order to select variables in Q_0, we again draw on recent studies, most of which are based on surveys of individuals. Using LECS data[9], for example, Kakwani et al. (2002) maintain that gender, number of siblings, parents' education, family income, and area of residence influence the probability of entering and leaving primary school. On the basis of same data, we also confirm a new finding that age, household head's occupation, and house ownership affect primary school entry decisions. Furthermore, using the data of a panel study on income dynamics, we determine that, in addition to the variables found to be important by other economists, unemployment rates, average wage rates, and city size also influence primary school completion.

Definitely, at the aggregated level of counties, the effects of variables such as gender are difficult to detect. Thus, as some socioeconomic factors affect human capital growth, we limit our choice of regressors to *the unemployment rate* (*UNEMP*)[10], with an expected negative sign, according to Cohn and Hughes (1994); *the rate of home ownership* (*ROH*); *family size* (*FAMSZ*), according to Kakwani et al. (2002); *life expectancy at birth* (*LEB*); *population density* (*POP*); *mean wage rate* (*MWAGE*); and *drug addiction rate* (*DRGR*), for example, users of heroin, opium, and amphetamine-based stimulants[11], for which we expect a negative sign for human capital growth.

Two stage least squares (2 SLS) estimates using data from all 57 villages (16 *group schools*)[12] in *K* district, *V* province, Laos are reported in Tables 4 and 5, along with descriptive statistics for the variables[13].

The regression results on primary education (human capital) show that each equation is statistically significant from the viewpoint of the adjusted coefficients of determination and the absolute value of the *F*-statistics. Regarding the estimated coefficient on the explanatory variables, the estimated coefficient of initial human capital stock (H_0) in the economic growth equation (*Dy*) is statistically significant at the 5% significance level, but the estimated coefficient of initial per capita income (Y_0) in the education attainment equation (*Dh*) is not significant. On the other hand, each of the statistically significant variables in both the 2 SLS equations has the expected signs. In addition, the estimated coefficient on the explanatory variable (*Dy*, *Dh*) is positive and statistically significant[14]. This indicates interdependence between the growth of income and the growth of human capital stock.

With regard to the dual effects of initial income levels on economic growth by simultaneous analysis, the parameters of Eq.(7) in Table 5 highlight the relationship between income growth and educational growth. We see from Table.6 that the absolute value of the direct effect (−0.1099) regarding income growth rate is larger than that of the indirect effect (0.1060), and that the absolute value of the direct effect (−0.2031) regarding human capital stock, is likewise larger than that of the indirect effect (0.1499); moreover, since the sign turns out to be negative, the growth rate slows down if each of the initial levels is high.

As the estimated effect of initial human capital stock on the income growth rate is 0.0152 and that of initial income on human capital stock growth rate is 0.2123, we conclude that their direct effects, which are positive, are larger than their indirect effects; that is to say, each effect of the initial levels hastens another's growth rate and vice versa.

Additionally, as the estimated effect of initial income on the human capital stock growth rate (0.2123) is larger than the estimated effect of initial human capital stock on the income growth rate (0.0152), it is reasonable to think that in light of the interdependence between *education development* and *economic development*, economic growth strongly affects the percentage of the population that graduates from primary school in each village (as a proxy for human capital stocks)[15]. In other words, the development of primary education has come about through the development of *K* district's local economy.

6. Conclusions

Our main findings are as follows. First, with regard to the growth rate of the school groups' per capita income, school clusters with higher initial income levels exhibit slower economic growth, which is indicative of

Table 5. Regression results for the determinants of income [Dy] and educational attainment [Dh] growth

	OLS		2 SLS	
	Dy	Dh	Dy	Dh
Y_0	−0.663***	0.0482	−0.1099***	0.2321***
	(−7.94)	(1.220)	(−7.511)	(3.583)
H_0	0.0390**	−0.189***	0.0973***	−0.2031***
	(1.799)	(−6.720)	(2.773)	(−5.89)
RU	0.00085		−0.00342	
	(0.661)		(−0.312)	
RDW	0.0104**		0.00911*	
	(1.976)		(1.776)	
RRR	0.0390*		0.00609*	
	(1.875)		(1.894)	
NGET	0.00491		0.00327**	
	(1.299)		(1.992)	
PTAX	−0.00814		−0.011	
	(−0.994)		(−0.427)	
POP		0.000102		−0.00056
		(0.733)		(−0.638)
ROH		0.0405***		0.0433***
		(3.082)		(2.992)
FAMSZ		−0.577		−0.633**
		(−1.032)		(−2.095)
UNEMP		−0.115**		0.0143
		(−1.883)		(0.466)
DRGR		−1.252		−4.131**
		(−0.591)		(−2.005)
LEB		0.1779		0.183***
		(1.132)		(2.376)
MWAGE		0.582		−0.190
		(0.443)		(−0.320)
Dh			0.457***	
			(2.772)	
Dy				1.541***
				(2.570)
F	40.651	20.885	35.900	20.533
Adj. R^2	0.793	0.753	0.844	0.838

Notes: ( ) = t-statistics; significance levels: * = 10%, ** = 5%, *** = 1%

Table 6. Effects of the initial levels of income and educational attainment on income and educational growth

	Direct effect		Indirect effect		Net effect	
	Y_0	H_0	Y_0	H_0	Y_0	H_0
Dy	−0.1099	0.0973	0.1060	−0.0928	−0.0131	0.0152
Dh	0.2321	−0.2031	−0.1693	0.1499	0.2123	−0.1787

(Source) Based on Table 5.

β convergence, for a year. We still see this convergence pattern in human capital stocks (using the ratio of the number of workers who graduated from primary and lower secondary schools to the total labor force in each school group as a proxy). Second, as hypothesized, the coefficient estimates a_3 and b_3 are both statistically significant and positive, confirming that a simultaneous relationship exists between income and educational growth over time. Third, although in most previous studies, the coefficient of initial income was estimated using single equations such as reduced-form models, we find that a simultaneous analysis captures dual effects:

the direct effect and the indirect effect. In this case, we observe that each direct effect somewhat dominates the indirect effects, namely, if the initial levels of income and human capital are high, the speed of the growth rate is reduced, and the effect of the initial income levels hastens the growth of human capital stocks and the effect of the initial level of educational attainment on income growth. Finally, we find that as the estimated effect of initial income on the human capital stock growth rate is larger than the estimated effect of initial human capital stock on the income growth rate, the contributions of economic growth to human capital growth are stronger than those in the reverse direction.

Notes

1 Hayami (1995) shows a correlation between GNP per capita and human resources (the average enrollment ratio of primary and secondary schools, the average life expectancy) for a broad panel of countries in 1990.

2 See Goetz and Hu (1996) for the use of simultaneous equation models.

3 See Takita (2008) for specific data on Laos (Lao P.D.R.). We employed the Lao Expenditure and Consumption Survey (LECS). LECS has been carried out three times so far: LECS 1 in 1992/93, LECS 2 in 1997/98, and LECS 3 in 2002/03. Each survey used the following samples—LECS 1: 17 prefectures, 2937 households; LECS 2: 18 prefectures, 8,882 households; LECS 3: 18 prefectures, 8,092 households.

4 Barro and Lee (2001) state that the data depend on arbitrary assumptions about depreciation and rely on inaccurate measures of benchmark stocks and investment flows.

5 As an alternative to the limited data that are available on physical capital, we assume that for the given values of schooling, a higher level of initial real per capita income reflects a greater stock of physical capital per person.

6 These variables would include preferences for saving and fertility, government policies with respect to spending and market distortions, and so on. Barro and Sala-i-Martin (2004), for instance, consider a measure of international openness, the ratio of government consumption to GDP, a subjective indicator of the maintenance of the rule of law, a subjective indicator of democracy (electoral rights), the log of the total fertility rate, the rate of real gross domestic investment to real GDP, and the inflation rate as control and environmental variables. In neoclassical growth models, a change in a control or environmental variable affects the steady-state level of output per effective worker, but not the long-term per capita growth rate. The long-run or steady-state growth rate is given by the rate of exogenous technological progress. In contrast, in endogenous growth models, variables that affect R & D intensity also influence long-term growth.

7 In consideration of increasing the number of immigrants from mountainous areas to K district, this variable is chosen.

8 For a detailed argument, see Kakwani et al. (2002).

9 This refers to the Lao Expenditure and Consumption Survey conducted by the National Statistics Center.

10 *K* district is now under a money economy.

11 The Lao government has placed particular emphasis on the problems that are closely connected to poverty, such as the spread of HIV/AIDS/STDs and poppy production.

12 In consideration of the number of samples, we use the data of all the villages, which were acquired from the district statistical center and the concerned organizations of the district. See Table 1 and Table 2.

13 In OLS estimates, an estimated equation is denoted by $a_3 = b_3 = 0$. In addition, in 2 SLS estimates, the theoretical values obtained from the equation, which include Dy and Dh as endogenous variables, are considered as explanatory variables.

14 Most of the explanatory variables except for those above are not entirely satisfactory. Moreover, the signs and the direction of the tests of significance are not what we expected. However, with regard to S_0 and Q_0, the same is also found in previous studies. The selection of variables is an issue that needs to be addressed as a future inquiry.

15 This is in comparison to the reverse case that describes the effect of the percentage of the population that graduated from primary school in each village on the economic growth.

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