Human Capital, Poverty Trap, and Industrialization [*]

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Abstract

This paper is purposed to study the role of human capital in a two-sector economy consisting of a traditional sector and a modern sector, like Vietnam and other developing countries. By assuming that the modern sector requires some certain threshold level of human capital and the young can only borrow from their parents to invest on human capital because of the absence of a credit market for financing investment in human capital, we successfully construct an overlapping generations model in which there are a poverty trap in the traditional sector and a stable balanced growth path in the modern sector. This theoretical framework suggests important roles of public policies on human capital in reducing poverty and promoting the process of industrialization in developing countries. Empirical evidences, by using a cross-country database for developing countries and a cross-province database for the Vietnamese economy, also indicate that there are strongly positive relations between the levels of human capital and industrialization as well as an important role of public spending in education to the process of industrialization.

Keywords: Overlapping Generations, Human Capital, Poverty Trap, Industrialization.

JEL classification: D13, O14, O15, 018

I. Introduction

The developing and less-developed economies in the world nowadays have been diversified in economic development. However, they can be categorized into two main groups – the group of poor economies with relatively low levels of industrialization and the group of richer economies with relatively high levels of industrialization. Regarding to the poor group, the common feature of these economies is a highly dependent degree on agriculture in combination with a low level of investment in human capital, namely, education and health. There is a fact that many poor economies, most of them are located in Africa and Asia, have experienced no significant increases in per capita income, and fallen to catch up with other high growth developing and developed economies. [1] By contrast, the richer group has been largely industrialized and invested more in human capital. These economies have experienced relatively high economic growth rates with decreasing trends in the shares of the agricultural sector in total output. Some of them have enjoyed sustainable economic growth, such as Newly Industrial Countries (NICs) in the second haft of the last century. These facts might be important evidences in stylizing the central role of human capital to economic development, especially the process of industrialization, in developing and less developed countries.[2]

Studying the role of human capital to economic development is not a new subject for economists. In the 1960s, Schultz (1961) and Uzawa (1965), among others, already remarked the important role of investment in human capital to economic growth. Recently, the endogenous growth theory, notably Lucas (1988) and Romer (1986, 1990a, 1990b), has officially recognized human capital as an engine of economic growth. Endogenous growth models, developed by economists who study various issues of economic growth in the developed economies, focus on seeking mechanisms to avoid decreasing marginal returns to productive factors and how the balanced growth could be endogenized. However, the subject of economic development in the developing and less developed countries has some different features in comparison with that of developed countries. If the process of industrialization has been almost completed in the developed countries, the developing and less developed countries have still

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[1] According to the World Bank (2001a), in the year 1999 there are 50 countries experienced annually average growth rates in GDP per capita of less than one percent. There are also 56 countries with per capita GNP less than $US 800 and 30 countries with percentage of population living on less than $US one a day higher than 20 percent in the same year.

[2] Also see Lucas (1990, 1993).

been facing this task in different contexts and complicated socio-economic conditions. Therefore, the puzzle of how the accumulation of human capital affects economic development in general, and the process of industrialization in particular, in the developing and less developed world would still be an important issue to study.

Regarding to the subject of economic development, there is the well-known theory of development stages, which focuses on examining different trends in poverty, income distribution, industrialization, and economic development between rich and poor countries in the world economy, as well as in the same country at different stages of development (Lewis (1954), Kuznets (1955), Jorgenson (1961), Todaro (1969), Maddion (1982), Rostow (1978, 1991)). Developing these arguments, there are also studies focusing on the patterns of industrialization and economic development in the world economy (Johnson (1974, 1982, 1986), Diamandouros et. al.(1986), Haggard (1986)).[3] In recent years, there is also a trend in developing endogenous growth models to analyze different equilibrium paths of the economy (Aziadiaris and Drazen (1990), Braham et al. (1995), Zilibotii (1995)). However, these studies might still not be really relevant to recognize the important role of human capital to the process of industrialization, which is clearly evidenced in the developing and less-developed world.

This paper is purposed to illustrate explicitly the relation between human capital, poverty, and industrialization in a two-sector overlapping generations economy consisting of a traditional sector and a modern sector, like Vietnam and other developing and less developed economies. Based on the stylized facts of these economies, we assume that there is no credit market for financing investment in human capital (education) and the level of parents' income in the traditional sector is not enough to finance their children's optimum level of investment in human capital. As a result, the following generation's human capital cannot surpass some threshold level required by the modern sector. Therefore, they have to be engaged in the traditional sector with low levels of human capital and income. By contrast, in the modern sector, which requires the threshold level of human capital, a balanced long run growth path exists. The accumulation of human capital is recognized as the engine of economic growth in

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[3] There might be three patterns of industrialization and economic development in the world economies. The first one is the European Style closely concerning to centrally planned mechanism (in contrast to the Western Style characterizing by development of the free market mechanism). The second one is the Eastern Style concentrating export-promoting industrialization and the role of government policy, especially the industrial policy. The last one is the Latin American Style with the strategy of import-substitution. Also see Woo (1990), Krueger (1990), and World Bank (1993)).

this sector.

This theoretical framework is different from the conventional frameworks of dual economies and interrelations between traditional sector and the model sectors (such as Lewis (1954), Jorgenson (1961), and Martin (1999)) due to its two distinguished features - the threshold level of human capital required by the modern sector and the mechanism of financing investment in human capital. The model differs from Braham et al. (1995) because they could be used to explain different equilibriums in a multi-sector economy; it might also be distinguished from the threshold model of Aziadiaris and Drazen (1990) in the framework of the economy and the way of financing investment in education. The model developed in this paper might be plausible in explaining different trends and levels of industrialization and income distribution in the world economy, especially developing and less developed economies, as well as the roles of public policies on human capital in reducing poverty, promoting industrialization, and achieving sustainable long run growth.

The remaining of the paper is organized as follows. In the following section - section II, we construct the theoretical model, including the framework of the economy, steady state equilibriums, the mechanism of take-off from the traditional sector to the modern sector. Section III is for empirical analyses of the relation between human capital and industrialization for developing and less developed countries and provinces in Vietnam. Finally, section IV makes concluding remarks and suggests policy implications.

II.   The theoretical model

1. The framework of the economy

The economy consists of two sectors – the traditional sector and the modern sector. We assume that the modern sector requires some threshold level of human capital.[4] Although the wage rate (earning per unit of human capital) in this sector might be higher than that in the traditional sector, an individual working in the traditional sector may not enter into the modern sector because of her low level of human capital. She can only joint in the modern sector when

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[4] Technically, industries with relatively high levels of technologies would require certain levels of knowledge of laborers; only individuals who surpassed certain standard levels of human capital (or in other words, who are educated at certain levels, such as high school, technical schools, or tertiary education levels) can work in these industries.

her human capital level is equal to or higher than the threshold level required by the modern sector.

Now, we consider the behavior of a representative individual born at time t (called the generation-t individual). This representative individual lives for three distinct periods, namely, childhood (period 0), adulthood (period 1), and retirement (period 2). In period 0, she borrows from her parents to finance consumption and investment in human capital (education) in this period. At period 1, she works to earn wage based on her human capital level, repays debt (including principle and interest) to her parents, and decides how much to consume in this period and to save for the next period. In period 3, she retires and lives on what she earns from her saving in period 2 (principle plus interest). This assumption might be relevant to the economically intergenerational relations of households, especially in developing and less developed countries. The children live on the parents' income when young; and they, in turn, live on their children' income when old.[5]

The lifetime utility of the generation-t representative individual is assumed to have the following form,

$$U_t = U(c_{0,t}, c_{1,t}, c_{2,t}) = log(c_{0,t}) + \frac{1}{1+\theta} log(c_{1,t}) + \frac{1}{(1+\theta)^2} log(c_{2,t}), \qquad (1)$$

where:

$$c_{0,t} = b_t - e_t, \qquad (2.1)$$
$$c_{1,t} = w_t h_t - (1 + r_t) b_t - s_t, \qquad (2.2)$$
$$c_{2,t} = (1 + r_{t+1}) s_t, \qquad (2.3)$$

of which c_0, c_1, c_2 are the amounts of consumption at periods 0, 1, and 2, respectively; b is borrowing from her parents; e is investment in education; w is wage per unit of human capital; h is level of human capital; θ is the rate of time preference; s is saving; and r is the interest rate.[6]

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[5] Also see other studies of overlapping generation models, notably, Samuelson (1958).

[6] In the case of freely international capital mobilization (the opened economy), the interest rate is supposedly given.

In this economy, we assume that individuals cannot borrow from capital markets to finance investment in education. This is due to the less-developed conditions of financial markets as well as other obstacles and difficulties in the developing and less-developed countries. Only could they borrow from their parents to invest in education when young. It might be not only because of altruistic motivation or other reasons but also due to the assumption that their parents know about their child's ability in schooling, and then, the possibility to repay their loan, as recent studies of overlapping generation models suggest.[7]

The function of human capital accumulation takes the following form,

$$h_t = h(\,h_{t-1}, e_t\,) = \eta h_{t-1}^{\alpha} e_t^{1-\alpha} - \delta_h h_{t-1}, \; \delta_h, \alpha \in (0,1). \tag{3}$$

Of which η is a given parameter, and δ_h is the depreciation rate of human capital. This function of human capital accumulation is widely applied in the endogenous growth theory. The accumulation of human capital is not only dependent on the level of investment in education but also on the level of human capital of the previous generation. This is due to the externality of human capital, which could be perceived in both meanings of a micro aspect of within family externality (from parents to children) as well as a macro aspect that current stage of knowledge (the environment) would affect the efficiency of investment in education.[8]

For simplicity, we suppose that the economy consists of two representative individuals (households). One works in the traditional sector; and the other works in the modern sector. The modern sector requires a threshold level of human capital, $\bar{h}$. The level of human capital of the individual working in the traditional sector (sector A) is lower than this threshold level ($h^A < \bar{h}$). Meanwhile, the level of human capital of the individual working in the modern sector (sector B) is equal to or higher than this threshold level ($h^B > \bar{h}$). The growth rate of population is assumed to be zero.

Now, we consider optimization behaviors of the representative individual in each sector of the economy.

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[7] See Barham et al. (1995), Binh et al. (1995), Buiter and Kletzer (1995), and Owen (1999) for this argument.

[8] Also see Lucas (1988), Azariadis and Drazen (1990), among others.

<The traditional sector – Sector A>

In the traditional sector, the production function takes the following form,

$$y^A = F^A(h^A) = \lambda^A h^A, \quad h^A < \overline{h}, \qquad (4)$$

where λ^A is a given parameter representing the productivity of the traditional sector. [9] The generation-t individual maximizes the utility given by equation (1), subject to constraints (2.1), (2.2), and (2.3). It should be noted that we also need two other assumptions. One is that the representative individual can reach the threshold level of human capital if she is unconstrained in borrowing from her parents (she could invest in education as much as she wants), suppose that the level of human capital of the previous generation is high enough. The other is that her parents' saving is not sufficient to meet her demand for borrowing. Therefore, only two control variables, e and s, would be available for her.

The necessary conditions are as follows,

$$\frac{1}{b^A - e^A} = \frac{w^A h^{A\prime}}{(1+\theta)[w^A h^A - b^A(1+r_t) - s^A]}, \qquad (5)$$

$$\frac{1}{w^A h^A - b^A(1+r_t) - s^A} = \frac{1}{(1+\theta)s^A}, \qquad (6)$$

where $h^{A\prime} = \dfrac{\partial h^A}{\partial e^A}$.

Theses conditions mean that the representative individual would consume smoothly during her lifespan (the levels of marginal utility of consumption are equal in all three periods). The condition (5) also says that, in term of utility, the loss in scarifying one unit of consumption in period 0 to investment in education in that period would be equal to the gain from one unit of investment in education in the form of increasing in the wage in period 1.

The wage rate is paid at the marginal product of human capital. Then, from (4) we have,

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[9] Also see Jorgenson (1961), Robertson (1999), and Hazan and Berdugo (2002) for this type of production technology in the traditional sector.

$$w^A = \frac{\partial F^A}{\partial h^A} = \lambda^A. \tag{7}$$

Because the parents' saving is not sufficient to meet the representative individual's demand for borrowing, she borrows all of the saving of her parents. Hence, we have the following constraint,

$$b_t^A = s_{t-1}^A. \tag{8}$$

Then, replacing (7) and (8) into the necessary conditions (5) and (6), using the equation of human capital accumulation (3) we attain,

$$e_t^A * = e(\lambda^A, r_t, h_{t-1}^A, s_{t-1}^A), \tag{9}$$

$$s_t^A * = s(\lambda^A, r_t, h_{t-1}^A, s_{t-1}^A). \tag{10}$$

We can see that the optimal levels of investment in education and saving of the generation t individual would be dependent on the productivity parameter of the traditional sector, the interest rate, and the levels of human capital and the saving of the previous generation.

<The modern sector – Sector B>

In the modern sector, the production technology is a constant returns to scale function of physical capital, k, and human capital, h,

$$y^B = F^B(k^B, h^B) = \lambda^B(k^B)^\beta(h^B)^{1-\beta}, \ h^B \geq \overline{h}, \beta \in (0,1), \tag{11}$$

of which λ^B is a given parameter. Being different from the representative individual in the traditional sector, the representative individual in the modern sector is assumed to be unconstrained in borrowing when young because their parents' saving is large enough due to high levels of human capital and wage rate. Therefore, she has three control variables, b, e and s, when maximizing the utility given by equation (1), also subject to constraints (2.1), (2.2), and (2.3).

The necessary conditions are as follows,

$$\frac{1}{b_t^B - e_t^B} = \frac{w_t^B h_t^{B\prime}}{(1+\theta)[w_t^B h_t^B - b_t^B(1+r_t) - s_t^B]}, \quad (12)$$

$$\frac{1}{w_t^B h_t^B - b_t^B(1+r_t) - s_t^B} = \frac{1}{(1+\theta)s_t^B}, \quad (13)$$

$$\frac{1}{b_t^B - e_t^B} = \frac{1+r}{(1+\theta)[w_t^B h_t^B - b_t^B(1+r_t) - s_t^B]}. \quad (14)$$

where $h^{B\prime} = \dfrac{\partial h^B}{\partial e^B}$.

From the conditions (14) and (12), we attain *wh' = 1+r*. This equation means that the marginal product of human capital is equal to that of physical capital; or in other words, the individual would be indifferent in investing in physical capital or investing in education.

The wage rate and the rental rate are paid at the marginal products of human capital and physical capital, respectively. Then, from (11) we have

$$w^B = \frac{\partial F^B}{\partial h^B} = \lambda^B (1-\beta)\left(\frac{k^B}{h^B}\right)^{\beta}, \ r = \frac{\partial F^B}{\partial k^B} = \lambda^B \beta\left(\frac{k^B}{h^B}\right)^{\beta-1}. \quad (15)$$

Hence, the optimal values of control variables are as follows,

$$e_t^B* = e(w_t^B, h^B_{t-1}, r_t), \quad (16)$$

$$b_t^B* = b(w_t^B, h^B_{t-1}, r_t), \quad (17)$$

$$s_t^B* = s(w_t^B, h^B_{t-1}, r_t). \quad (18)$$

We also need the condition $b_t \leq s_{t-1}$.

From (16), (17), (18), the optimal levels of investment in education, borrowing, and saving of the generation t individual will be dependent on the wage rate, the interest rate, and the human capital's level of the previous generation. These levels are not directly affected by the level of saving of the previous generation because there is no constraint in borrowing for investment in education. According to equation (15), these optimal levels are only dependent on

the ratio of physical to human capital and the level of human capital of the previous generation.

2. Steady-state equilibriums

\<Balanced growth equilibrium in the modern sector\>

In the modern sector, we have the following equations,

$$h_t^B = \eta(h_{t-1}^B)^\alpha (e_t^B)^{1-\alpha} - \delta_h h_{t-1}^B, \tag{3}$$

$$k_t^B = i_t^B + (1 - \delta_k) k_{t-1}^B, \tag{19}$$

$$s_{t-1}^{\ B} = b_t^B + i_t^B = c_{0,t}^B + e_t^B + i_t^B. \tag{20}$$

Equation (3) is the function of human capital accumulation, as presented above. Equation (19) is the equation of evolution of physical capital, of which $\delta_k \in (0,1)$ is the depreciation rate of physical capital. Equation (20) says that the saving of generation *t-1* individual is divided into two parts – one is to lend to their children (generation *t*), which consists of consumption and investment in education of their children; and the other is for investing in physical capital.

Remember that the production function is constant returns to scale, and the wage rate and rental rate of physical capital are paid at the marginal products of human capital and physical capital, respectively, from the first-order conditions (12), (13), and (14), and these above constraints (3), (19), and (20), we see that there exists a balanced growth equilibrium where,

$$\frac{\dot{k}^B}{k^B} = \frac{\dot{h}^B}{h^B} = \frac{\dot{y}^B}{y^B} = \frac{\dot{s}^B}{s^B} = \frac{\dot{b}^B}{b^B} = \frac{\dot{c}^B}{c^B} = \frac{\dot{e}^B}{e^B} = \frac{\dot{i}^B}{i^B} = \gamma. \tag{21}$$

The balanced growth rate (γ) and the ratio of physical capital to human capital (x) are determined in the following system of equations,

$$\gamma = \eta \left(\frac{1 + \lambda^B \beta x^{\beta-1}}{\lambda^B \eta (1-\alpha)(1-\beta) x^\beta} \right)^{\frac{\alpha-1}{\alpha}} - (1+\delta_h), \qquad (22)$$

$$[(1+\theta)^2 + (2+\theta)](1+r)(\gamma+\delta_k)x + \frac{(1+\theta)^2(1+\gamma)^2}{(1+r)}$$

$$+ [(1+r) - (2+\theta)](1+\gamma)(1+\delta_h+\gamma)^{\frac{1}{1-\alpha}} - w(1+\gamma) = 0. \qquad (23)$$

where $r = \lambda^B \beta x^{\beta-1}$, $w = \lambda^B(1-\beta)x^\beta$; and x is the ratio of physical capital to human capital at the balanced growth equilibrium. Because of the concavities of the utility function, production function and human capital accumulation function, this balanced growth equilibrium is stable (see the appendix 1).

<Poverty trap in the traditional sector>

From (5), (6), (7), and (8), we have

$$\lambda^A h^{A\prime} = \frac{(1+\theta)^2 [\lambda^A h^A - (1+r) s^A_{t-1}]}{(2+\theta)(s^A_{t-1} - e^A)}, \qquad (5\prime)$$

$$s^A = \frac{\lambda^A h^A - (1+r) s^A_{t-1}}{(2+\theta)}. \qquad (6\prime)$$

Now, we consider the evolution of the saving. From (6'), we attain,

$$\frac{\partial s^A_t}{\partial s^A_{t-1}} = \frac{1}{2+\theta} \left(\lambda^A h^{A\prime}_t \frac{\partial e_t}{\partial s_{t-1}} - (1+r) \right). \qquad (24)$$

Then, the saving evolution will be dependent on the sign of the parenthesis in (24). The first term reflects the gain from investment in education due to an increase of one unit of saving of the previous generation; meanwhile the second term represents the gain from using that increasing unit of saving for investing in physical capital through the capital market, such as buying shares in the modern sector. When the former is higher than the later, the saving would be increased; and vice versa, when the former is less than the later, the saving would be

decreased. From (5'), we also have,

$$\frac{\partial e_t^A}{\partial s_{t-1}^A} = \frac{(2+\theta)\lambda^A h_t^{A\prime}+(1+r)(1+\theta)^2}{[(2+\theta)+(1+r)(1+\theta)^2]\lambda^A h_t^{A\prime}-(2+\theta)(s_{t-1}^A - e_t^A)\lambda^A h_t^{A\prime\prime}}. \quad (25)$$

Because there is a credit constraint in borrowing for investment in human capital in the traditional sector, the marginal product of investment in human capital in the traditional sector is higher than the marginal product of investment in physical capital. In other words, investment in human capital in this sector is more productive than investment in physical capital (in the modern sector) because of an insufficient level of available financial source for investment in human capital in the traditional sector due to the low saving level of the previous generation. Therefore,

$$\lambda^A h_t^{A\prime} > 1+r.$$

In addition, $h_t^{A\prime\prime} < 0$, from (25) we attain,

$$1 > \frac{\partial e_t^A}{\partial s_{t-1}^A} > 0.$$

Intuitively, increases in the saving of the previous generation (parents) will make the investment in human capital of the present generation (children) increasing. However, it would be not the same amount because one proportion of the increased saving (and then, borrowing) would be consumed.

Looking at equation (24), we perceive that at some small level of investment in education, e, the sign of the right hand side would be positive. However, it will be negative when the level of investment in education is close to the optimal level that the individual wants to borrow when young, b^*, which makes $\lambda^A h_t^{A\prime} \rightarrow 1+r$. This is because of the concavity of the function of human capital accumulation (3).

Then we can describe the long run equilibriums of the economy as that in Figure 1. As showed in the figure, we see that the representative individual in the traditional sector will reach the point E after some finite periods, regardless the starting point in the saving curve. In

other words, she is to be engaged in a *poverty trap*. Meanwhile, the representative individual in the modern sector enjoys a long run growth.[10]

Figure 1: The equilibrium in the traditional sector (poverty trap)
and the balanced growth path in the modern sector.
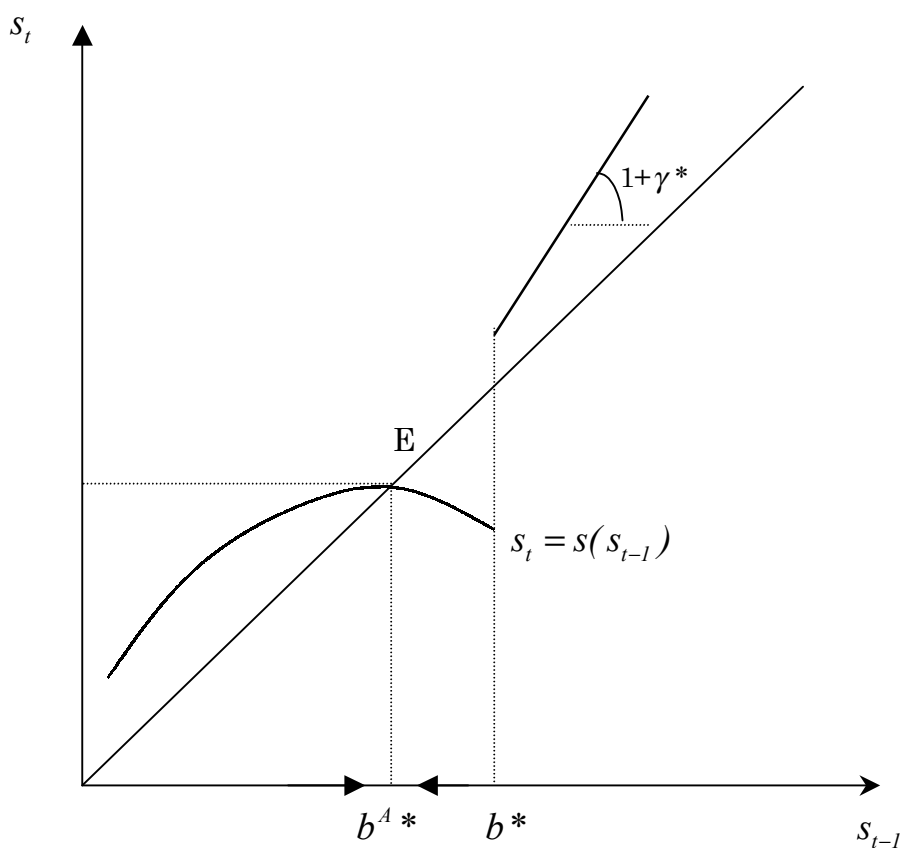
The equilibrium point E is characterized by following equations,

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[10] The gaps of income between two sectors would be widened, as experienced in many developing and less developed countries where governments did not pursue relevant policy measures of enhancing investment in human capital, along with other policies for economic development.

$$\frac{\partial s_t^A}{\partial s_{t-1}^A} = 0; \quad s_t^A * = s_{t-1}^A * = s^A * = b^A *;$$

$$h_{t-1}^A * = h_t^A * = h^A *; \quad e^A * = \left(\frac{1+\delta}{\eta}\right)^{1/(1+\alpha)} h^A *;$$

$$h^A * = \frac{\lambda^A \eta (1-\alpha) \left(\dfrac{\eta}{1+\delta}\right)^{\alpha/(1+\alpha)} - \dfrac{(\lambda^A + \theta r)(1+\theta)}{(3+\theta+r)}}{\delta \lambda^A}. \qquad (26)$$

We also should note that $b*$ in Figure 1 is level when this individual can borrow as much as she wants, and,

$$lim_{b \to b*}(h^A *) = \bar{h}.$$

That means she would attain the threshold requirement of human capital to join in the modern sector.

3. The mechanism of "take-off" from the traditional sector to the modern sector

Now, supposing that the government pursues some policy measures (or, there are some gifts from the heaven), which make the representative individual in the traditional sector unconstrained in borrowing when young.[11] When the individual in the traditional sector becomes unconstrained, she will borrow the optimal level of $b*$, invest in education as much as she wants. Consequently, the level of human capital of the representative individual in the traditional sector would reach the threshold level $\bar{h}$ after some certain periods. Hence, she would enjoy "take-off" to work in the modern sector and earn higher wage.

We suppose that the "take off" happens at the beginning of period t, in the modern sector the level of physical capital is k_t at the beginning of that period; meanwhile the level of human capital is $h_t + \bar{h}$. The ratio of physical capital to human capital is less than its equilibrium level. The wage rate and the rental rate are separately paid at the marginal products of human capital and physical capital; then, looking at the production function (11), because of increasing in human capital, the wage rate of human capital will decrease; and the rental rate of physical

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[11] These measures might be public credit programs, schemes of taxes and subsidies, or policies of publicly providing education services (also see the following section).

capital will increase in comparison with the equilibrium level. Physical capital becomes relatively expensive in comparison with human capital. Decreasing in the wage rate and increasing in the interest rate will make the investment in human capital (education) relatively less productive than the investment in physical capital. Hence, in relative terms some investment will be transferred into investment in physical capital. This makes the ratio of physical capital to human capital increasing and approaching the equilibrium level after some finite generations.[12]

The evolution of the ratio of physical capital to human capital can be described as in the following figure.

Figure 2: the process of take-off and the evolution of the ratio of physical to human capital
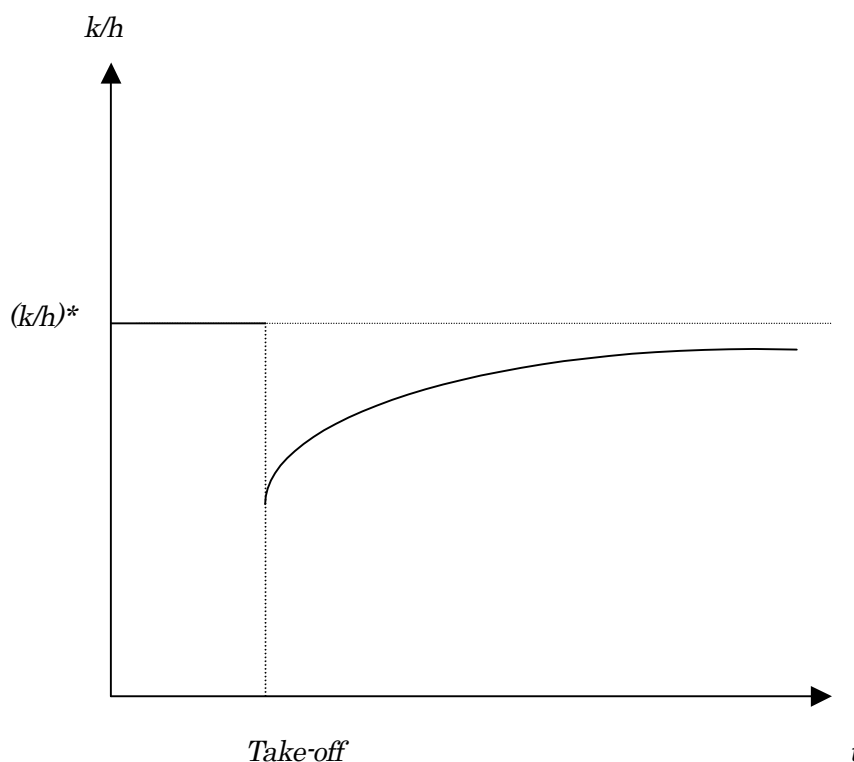
It should be noted that the model developed here could be expanded into a multi-sector growth model, or used to illustrate the situation of multi-stage of economic development. Suppose that there are a number of thresholds of human capital required by different

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[12] For the case of a small opened economy and there is a free mobilization of capital between countries, the level of physical capital will be automatically adjusted to match up with the level of human capital to ensure the optimal ratio between them, as regarded above.

industries with their specified levels of technologies of production in the whole economy. To join in the industries with higher level of technologies, there is a need of a process of accumulating human capital. Therefore, there might exist a multi-stage of economic development in the economy with the important role of human capital as an engine of economic growth.

4. The role of public policies

The roles of public policies on human capital in reducing poverty and promoting industrialization as well as attaining sustainable long run economic growth can also be explicitly explained. Following the theoretical framework developed in this paper, human capital is regarded as one of the main engines of economic growth of the economy. This suggests that when the poor is not able to finance their children investment in education, the government should take some relevant measures to enhance their level of investment in education to bring them out of the poverty trap. These measures might be public credit programs for educating poor children, public policies on income redistribution through taxes and subsidies and other wages and income redistribution programs, and policies of publicly providing educational services. These policy programs of enhancing investment in human capital would be relevant for developing and less developed countries to pursue the goals of reducing poverty and inequality, promoting industrialization, and achieving sustainable economic growth.[13]

<Education-financing credit schemes>

Providing education loans for poor people is an important measure to help them to escape from the poverty trap. There might be two feasible schemes - government (public) credit funds for schooling or government guaranteed mechanisms for financing education. For theses policy programs, there are also some problems concerning the implementation process, such as how to recognize individuals' abilities in schooling and reduce adverse selections. Because of being highly dependent on the development of financial markets and other necessary conditions, these measures might be popularity applied in many developed countries under different forms of public funds for education loans; however, they are usually not widely used in the developing and less-developed countries. These measures are especially difficult for developing and less

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[13] One of the most important issues should be noted is that all of feasible policy measures are only effective if they provide a sufficient resource for the poor to attain the threshold level of human capital required by the modern sector.

developed countries to apply because of their less developed financial systems, weak fiscal capacities, and other difficult socio- economic conditions.[14]

<Redistribution policies – Taxes and subsidies>

Redistribution policies, such as imposing taxes and making transfer payments, are also very important for the purpose of enhancing investment in human capital, especially for the poor. The tax system, especially taxes on labor and capital income, would have significant effects on investment in education and the balanced growth paths or equilibrium situations of the economy. Similarly, the policy of subsidizing investment in education would also stimulate the accumulation process of human capital. It could be possible to introduce these policies' variables, such as rates of taxes and subsidies, into the model and analyze the effects of these policies, although the optimal levels of these policy variables would be dependent on the policy objective function of the government. However, it should be noted that it is usually difficult to estimate effects of these policy measures, besides, there is also a problem of gaps between policy objectives and practices in the developing and less developed world.[15]

<Publicly providing education services>

The most popular solution to enhance the level of investment in education might be the policy of publicly providing education services. This policy seems to be less efficient in developed countries where capital markets have been developed and households' income is also high enough to finance their children's investment in education. However, it would be necessary and inevitable for developing and less developed countries where there are relatively high shares of less-educated population, who are so poor that they could not finance their children' investment in schooling at some relatively sufficient levels. This is also an important content of policy programs recommended by international financial institutions, such as IMF and WB, to developing countries in order to improve poverty and inequality and to promote economic growth.[16]

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[14] Also see Al-Yousif (2002) for empirical evidences of the relation between financial development and economic growth.

[15] Also see Lucas (1988), Heckman et al. (1998), and Song (2002)

III.   Empirical Analyses

Based on the theoretical arguments, in this section we make quantitative analyses of the relation between human capital and industrialization in the developing and less developed world by using a cross-country database and in Vietnam by using a cross-province database. First, we examine the situation of investment in human capital and industrialization in the developing and less developed countries and in provinces of Vietnam. Then, based on theoretical arguments, we use an econometric model to analyze these relations. [17]

1. The situation of investment in human capital and industrialization in the developing and less developed countries and Vietnam.

As discussed above, the levels and trends of industrialization in the world economy nowadays are highly biased. In two main groups of the developing and less-developed world, the poor group, consisting of agriculture-based economies mostly located in Africa and Asia, is characterized by the situation of low levels of human capital and experienced low growth rates. Meanwhile, the richer group has relatively high levels of industrialization, invests more resources in human capital (education), and enjoys relatively high growth rates. Newly Industrial Countries (NICs) in Asia are brightened examples for successfully achieving sustainable economic growth with appropriate policy programs, especially public policies of enhancing investment in education. These evidences prove the important role of the public policies, specifically policies on human capital, to economic development, specifically the process of industrialization.

Looking overall, we can see that although developed- and newly industrial countries enjoy sustainable growth, many poor economies have been still engaged in poverty with no significant increases in per capita income during a long period. They seem to lose their way to catch up with other high growth developing and developed countries. As regarded above, the common feature of these economies is a highly dependent degree on agriculture accompanied with a low level of investment in human capital (education and health).[18] This suggests a

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positive relation between the levels of investment in human capital and industrialization. The relation of human capital and industrialization in the developing and less developed countries could be seen in the following figure (Figure 3).

Figure 3: The relation between public spending on education and
the agricultural share in developing and less developed countries
(98 countries in the appendix 2)
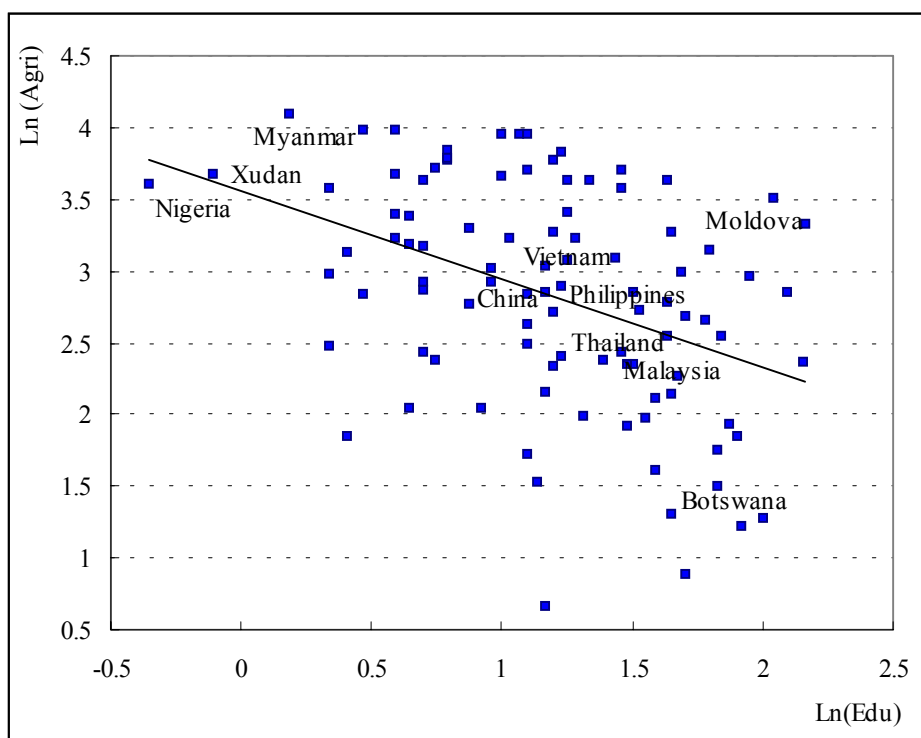
In this figure, we use the ratio of public spending on education to GDP (or GNP in some cases) as a proxy for investment in human capital. Looking at the figure, we see that the higher the level of public spending on education, the lower the level of agricultural share in total output; or in other world, the higher the level of industrialization would be. Generally, in relative terms, poor countries in Africa (Sudan, Nigeria) are less industrialized and invest less in human capital; meanwhile, other developing countries in South East Asia (Thailand,

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spending on primary education of less than 1.7 percent GNP; One-tenth of these countries spent less than 0.7 percent GNP. Meanwhile, the average level of spending on education is around 5 percent GNP for developed countries in the period 1980-97. If including all levels of education, in 1997 the developed countries spent 28 times as much per pupil as that spent by the less developed countries. An estimated 250 million children between the ages of five and fourteen in developing countries are child workers with approximately 50 percent of these children working full-time. Also see OECD (1998).

Malaysia, Philippine, China) are relatively higher industrialized and invest more in human capital. These countries have been also growing very fast with significant decreases in the share of agricultural in total output since recent decades.

The relation between the levels of investment in human capital and industrialization might exist not only in the developing countries but also in the economic regions in each country. As the above theoretical framework suggests, the level of human capital is the necessary conditions for industrialization - the process of taking off from the traditional sector, namely the agricultural sector, to the modern sector, namely the industrial sector, in a narrow meaning. Because there are usually differences in the levels of human capital between economic regions in the same country, especially between rural and urban areas, it would be expected that there are also biased in the level of industrialization between these economic regions. For the Vietnamese economy, there are likely evidences of the relation between public spending on education and industrialization, similarly to the case of developing and less developed countries presented above, as presented in the following figure (Figure 4).

Figure 4: The relation between public spending on education and the agricultural share in the Vietnam's 61 provinces and central cities
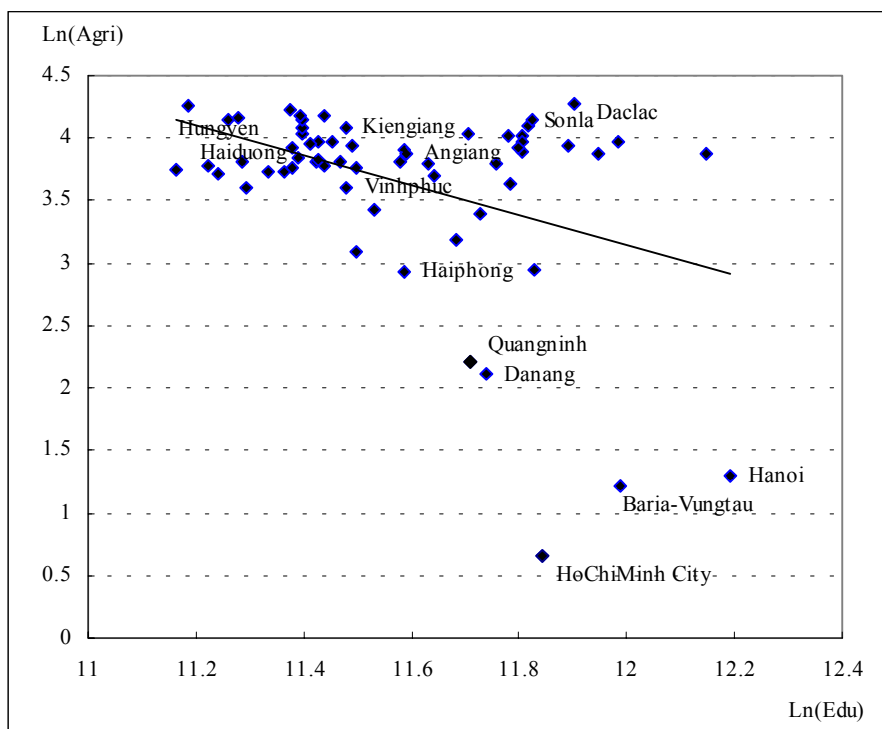
(Data source: UNDP, 2001)

Looking at the figure, we also recognize that in Vietnam highly agriculture-based provinces are obviously those have relatively low levels of human capital, which is represented by the level of public spending in education. If replacing the variable of public spending on education by the variable of the unskilled labor share, we also see a positive relation between the percentage of unskilled labor in the total labor force and the agricultural share in total output.

Therefore, we can see that similar to the case of developing countries there is also a positive relation between human capital and industrialization in Vietnam, as theoretically illustrated. Generally, the higher the level of investment in human capital represented by the level of public spending on education, the lower the level of the agricultural share would be. In other words, countries have relatively high levels of investment in human capital are also those being more industrialized. Now, we will make more technically analyses of the relation by using an econometric model.

2. The econometric model

To make empirical analyses of the relation between human capital and industrialization, we use the following econometric model,

$$Ln(\,Agri\,) = a + \sum \beta_i Ln(H_i) + \gamma Ln(GDP) + ... + \varepsilon.$$

where *Agri* is the share of agriculture in total output; *Hi* is the human capital related variable (public spending on education, the share of unskilled labor, the illiteracy rate, the enrolment ratios, or other human capita related variables); *GDP* is the gross domestic product per capita; and ε is the residual term. We can also add other explained variables. These explained variables would be varied in different databases because of the availability of concerning data.

3. Empirical results

<For provinces of Vietnam>

It is usually difficult to make quantitative analyses on the Vietnamese economy because of shortages of necessary database. However, we are fortunate to access the database of the survey in the year 2000 made by the Vietnamese government with technical assistances from the Donor Group led by United Nations Development Programs (UNDP). This survey is

purposed to make the first Human Development Report of Vietnam, which was eventually published in 2001. Regarding to explained variables concerning human capital, we have data on the ratio of unskilled labor (*Unskilled*), public spending on education (*Edu*), the gross enrollment rate of primary, secondary and high school (*Enroll*), the enrolment rate of high school (*HighSchool*). We also have the enrollment rate of tertiary education; however, the enrolment rate of tertiary education would be less meaning because most of students would work at the industrial and services centers (cities) after graduation. Data on the share of agriculture in total output in 1999 is abstracted from GSO (2001b). Besides, we use data on public investment in statistical yearbooks as a proxy for public infrastructures (*Ig*), which is expected to have a positive effect on the process of industrialization.

The estimated results are presented in Table 1. In equation I, we use three explained variables, including the ratio of unskilled labor (Unskilled), the gross enrollment rate of primary, secondary and high school (Enroll), and GDP per capita (GDP). It could be easy to see that all of these variables significantly affect the share of agriculture in total output with the effect of unskilled labor positive and the effects of gross enrollment rate and GDP per capital negative. In equation II, we replace the variable of the gross enrolment ratio by the variable of the enrolment ratio of high school. This variable also presents a negative impact on the agricultural share with a significantly statistical meaning. Between the variables of the gross enrolment ratio and the enrolment ratio of high school, there might be a statistical correlation. However, we also could see that the variable of the high school enrollment rate has a stronger effect on the share of agriculture in total output.

In equation III, we introduce a new variable of public investment and a dummy variable representing cities. All of these variables have negative effects on the share of agriculture in total output, as theoretically expected. Specifically, keeping effects of other factors unchanged, one percent increasing in the ratio of unskilled labor has an effect of 2.15 percent increasing in the share of agriculture in total output. Meanwhile, one percentage increasing in the high school enrolment rate makes the agricultural share reduced by 0.28 percent. Similarly, an increase of one percent in GDP per capita would have a negative effect of 0.41 percent in the share of the agricultural sector. On the other hand, an increase of one percent in the public investment, which is a proxy of public infrastructures, would have a negative effect of 0.15 percent in the agricultural share. The dummy variable representing cities has also a strong negative effect on the share of agriculture.

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Table 1: Empirical results for provinces of Vietnam

Equation	I	II	III	IV	V	VI	VII
Constant	-9.07	-11.42	-0.21	28.38	22.6	13.94	4.19
	(-2.24**)	(-3.45)	(-0.06)	(9.75)	(9.41)	(6.73)	(0.98)
Ln(Unskilled)	4.82	4.71	2.15				1.74
	(7.54***)	(7.36)	(2.96***)				(2.28**)
Ln(Edu)				-0.85	-0.92	-0.38	-0.25
				(-3.91***)	(-4.47***)	(-2.37**)	(-1.52*)
Ln(Enroll)	-0.84			-1.68			
	(-2.31**)			(-4.49)			
Ln(HighSchool)		-0.26	-0.28		-0.57	-0.36	-0.30
		(-2.59***)	(-3.24)		(-5.38)	(-4.31***)	(-3.49***)
Ln(GDP)	-0.66	-0.64	-0.41	-0.85	-0.81	-0.4	-0.42
	(-7.58)	(-7.53)	(-4.81)	(-8.34)	(-8.21)	(-4.62)	(-5.02)
Ln(Ig)			-0.15			-0.13	-0.12
			(-3.22)			(-1.87**)	(-1.90**)
Dum(City)			-0.95			-1.23	-0.94
			(-4.39)			(-6.99)	(-4.41)
Adjusted R-Squared	0.803	0.807	0.869	0.689	0.721	0.862	0.872
Number of observations	61	61	61	61	61	61	61

(Note: Dum(City) is the dummy variable representing cities and industrial centers including Hanoi, Hai Phong, Ho Chi Minh City, Da Nang, Quang Ninh, Baria-Vungtau; t- values are in the parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%).

Equations IV, V, VI are similar to equations I, II, and III, respectively; of which we replace the explained variable *Unskill* (the share of unskilled labor) by the variable *Edu* (per capita public spending on education). The results indicate that there is a strongly negative relation between public spending on education and the agricultural share. Looking at equation VI, keeping other factors' effects unchanged, an increase of one percent in public spending on education would reduce the share of agriculture in total output by 0.38 percent. All of other explained variables

also have significantly negative effects on the agricultural share.[19]

Overall, these empirical results show strongly statistical relations between human capital and industrialization. The higher the level of human capital, the lower the level of the agricultural share, or in other words, the higher the level of industrialization would be. These results strongly confirm the theoretical arguments. As the theoretical model suggests, investment in education would be one of the main engines of promoting industrialization as well as economic growth.

<For the developing and less developed economies>

For developing countries, because of limits in data sources, we choose a database consisting of the ratios of public spending on education to GDP and to GNI (*Edu/GDP* and *Edu/GNI*), the rate of adult illiteracy (*Illiteracy*), the enrolment ratio of tertiary education (*Tertiary*), and GNI per capita in PPP (*GNI*) from the World Bank's World Development Indicator (2001). Then, we use these variables to explain the share of agriculture in total output, which represents the level of industrialization. The empirical results are presented in Table 2.

In equation I, we use two explained variables - the ratio of public spending on education to GDP and gross national income, in term of per capita. Both of these variables have negative effects on the agricultural share at significantly statistical meanings. If other factors' effects are unchanged, one percent increasing in the ratio of public spending on human capital to GDP would have a negative effect of 0.24 percent on the share of agriculture in total output. The level of gross national income per capita even has a strongly negative impact of 0.66 percent on the agricultural share for one percent increasing in this variable. This is because the richer would have more resources to invest in education, besides the public spending.

In equation II, we replace the variable of the ratio of public spending on education to GDP by the variable of the ratio of public spending on education to GNI. This new variable has a stronger impact because the income base might be more suitable. Equations III and IV examine the effects of the enrolment rate of tertiary education and the adult illiteracy rate on

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[19] In equation VII, we add the explained variable of Unskilled, because of the possibility of existing a correlation between the variables of the ratio of unskilled labor and public spending on education, the t-values of all variables decrease. However, as theoretically expected, the variable of the ratio of unskilled labor has a positive effect on the share of agriculture in GDP; meanwhile the effects of all of remaining

the share of agriculture in GDP. Both variables prove strong effects on the agricultural share. The former has a negative impact; meanwhile the later has a positive impact, as theoretically suggested. In equation V, we consider the effects of the ratio of public spending on education to GDP and the enrolment rate of tertiary education. The results show that both of these variables have strong negative impacts on the agriculture share.

Table 2: Empirical results for developing countries

Equation	I	II	III	IV	V	VI	VII
Constant	8.23	8.02	3.64	1.94	4.04	3.26	3.3
	(16.19)	(13.97)	(16.80)	(6.70)	(15.58)	(5.04)	(5.04)
Ln(Edu/GDP)	-0.24				-0.41	-0.42	
	(-2.12**)				(-2.11**)	(-2.29**)	
Ln(Edu/GNI)		-0.32					-0.43
		(-2.51***)					(-2.16**)
Ln(Tertiary)			-0.39		-0.43	-0.27	-0.26
			(-4.41***)		(-4.52)	(-2.21**)	(-2.11**)
Ln(Illiteracy)				0.26		0.14	0.15
				(3.18***)		(1.29*)	(1.36*)
Ln(GNI)	-0.66	-0.61					
	(-9.66)	(-8.01)					
Dum	0.37	0.33			0.63	0.86	0.84
	(2.66***)	(2.29**)			(3.11***)	(3.46***)	(3.34***)
Adjusted R Squared	0.578	0.531	0.269	0.148	0.394	0.432	0.429
No. of observations	89	82	51	51	56	51	51

(Note: Dum is the dummy variable for transitional economies; t-values are in the parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%)

In equation VI, we add the variable of the adult illiteracy rate, and see that the impact of this variable is also positive, as expected. In equation VII, we replace the variable of the ratio of

variables are negative.

public spending on education to GDP by the variable of the ratio of public spending on education to GNI. This change also does not affect the signs of the coefficients of explained variables, although there is a little change in the magnitudes and significant meaning of these variables.

Therefore, similarly to the case of the Vietnamese economy, these empirical evidences also suggest that there are strongly positive relations between human capital related variables and the level of industrialization in the developing world, as the theoretical framework indicates.

IV.   Concluding remarks and policy implications

This paper has studied the relation between human capital, poverty, and industrialization in a two-sector economy like Vietnam and the developing and less-developed economies. In the theoretical framework, the modern sector requires some threshold level of human capital; when an individual has the level of human capital lower than this threshold level, she could not joint the modern sector, and therefore, has to stay in the traditional sector with the low level of productivity. With the assumption that there is no credit market for financing education and low levels of the households' income in the traditional sector, we have successfully constructed an economic growth model with a poverty trap in the traditional sector and a balanced long run growth in the modern sector. In the traditional sector, human capital cannot surpass the threshold level required by the modern sector because the parents' income is not enough to finance the children's optimum level of investment in education. Then, they are engaged in the traditional sector with low levels of human capital and income; or in other words, they fall into a poverty trap. On the other hand, a balanced long run growth path exists in the modern sector. The accumulation of human capital is recognized as an engine of economic growth of the economy. Therefore, the model developed in this paper has contributed a theoretical approach for the subject of industrialization in the developing and less-developed world with the emphasis on the role of human capital.

We have also made empirical analyses on the relation between levels of human capital and industrialization by using a cross-section database for developing countries and a cross-province database for the Vietnamese economy. The empirical results indicate that there are strongly positive relations between the levels of human capital and industrialization. Specifically, for the case of developing countries, the ratio of public spending on education to GDP or GNI, the enrollment rate of tertiary education, and the literacy have strongly negative

effects on the agricultural share. For the case of Vietnam, the ratio of unskilled labor has strongly positive effects on the agricultural share; meanwhile, public spending on education, the enrolment rates, and public investment have significantly negative effects. These evidences show that where investment on human capital is emphasized, the level of industrialization would be high, as the theoretical model suggests.

These theoretical and empirical evidences might be reasonable in explaining biased trends and different levels of industrialization, economic development, and income distribution in the world economy, especially developing and less developed economies. Human capital is regarded as one of the main factors to determine the face of the economy, specifically the situations of poverty and industrialization. It is also well adapted to the history of economic development in the world and to the current situation of developing and less developed economies. At the early stage of development, the inequality in income distribution between the modern sector and the traditional sector increases because the traditional sector would falls to a poverty trap, meanwhile the modern sector enjoys a balanced growth. The roles of public policies on human capital in reducing poverty, promoting industrialization, and maintaining sustainable economic growth could be explicitly explained. Accordingly, when the poor is not able to finance their children education at some sufficient levels, the government should take relevant measures to enhance their level of investment in education to bring them out of the poverty trap. These measures might be credit programs, taxes and subsidies, or publicly providing education services, especially for educating poor children.

For the case of the Vietnamese economy, the government might be right when promulgating the strategy of developing a knowledge economy along with the strategy of industrialization and modernization. However, the main policy headache is how to implement these strategies reasonably and effectively under the current socio-economic conditions of Vietnam. Based on the theoretical and empirical evidences in this paper, there might be following important policy implications. The first one is that not only physical capital is inevitable for industrialization; human capital is also a necessary condition of industrialization. A projected figure of only 3.7 percent (or 4.3% in the second scenario) of total capital resources would be poured into the field of education and training in the five-year master plan of investment 2001-05 is obviously not satisfied the task of considering human capital as a necessary condition of promoting

industrialization as well as reducing poverty.[20]

The second one concerns the definition of industrialization. We should perceive that industrialization does not have only a narrow meaning of a process of transferring other economic sectors into the industrial sector but also a wide meaning that includes the process of industrializing and modernizing within each economic sector. For the case of Vietnam, this is especially important because the currently unbalanced situations of economic and labor structures. The strategy of industrialization and modernization should be focused on this point, emphasizing the process of industrializing and modernizing the traditional sector, namely, the agricultural sector. One of the effective and feasible measures to implement the strategy is the policy of enhancing investment on human capital, especially education, especially for the poor in the rural areas.

Finally, another important implication is that there is necessary to designate and to implement a comprehensive program of education reforms; otherwise, Vietnam might be failed to achieve the policy targets of promoting industrialization and reducing poverty and inequality, and impossible to catch up with other countries in the region. Regarding to the education programs, the government need to push up all education levels, from basic education (primary and secondary levels) to higher education (high schools, technical schools, university levels) and vocational schools and on-the-job training. Both aspects of quality and quantity of the education system are needed to be seriously considered. To catch up with international levels of education, the government also need to create frameworks and to push up international integration and co-operations. Of course, the long-term objectives of the education reforms should be higher education and technical training in order to develop an industrialized and modernized economy; however, under the current condition of relatively less-developed education system in Vietnam, the government has still to develop basic education (primary- and secondary schools) and other types of complementary education.

Regarding to the financing resources for education and training, the government should enhance government spending on education, along with pushing up a policy framework of diversifying and encouraging other financing sources for education. The level of government spending on education should be increased to reach a level of 4.5-5 percent GDP – the same level of other South-East Asian countries; in addition, the easy and feasible policy frameworks

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[20] See "The Comprehensive Poverty Reduction and Growth Strategy (CPRGS)", Government of Vietnam (2002)

for private education funds, trust funds and donation funds for education, as well as ODA projects for education, especially for higher education levels, should be urgently designated and widely implemented to simultaneously enhance the level and the efficiency of investment in education of the whole society.

Appendix 1: Balanced growth equilibrium in the modern sector

In the modern sector we have

$$y = F(k,h) = \lambda(k)^{\beta}(h)^{1-\beta}, \ h \geq \overline{h}, \tag{A1}$$

$$h_t = \eta(h_{t-1})^{\alpha}(e_t)^{1-\alpha} - \delta_h h_{t-1}, \tag{A2}$$

$$k_t = i_t + (1-\delta_k)k_{t-1}, \tag{A3}$$

$$s_{t-1} = b_t + i_t = c_{0,t} + e_t + i_t. \tag{A4}$$

$$\frac{1}{b_t - e_t} = \frac{w_t h_t{}'}{(1+\theta)[w_t h_t - b_t(1+r_t) - s_t]}, \tag{A5}$$

$$\frac{1}{w_t h_t - b_t(1+r_t) - s_t} = \frac{1}{(1+\theta)s_t}, \tag{A6}$$

$$w_t h_t{}' = 1 + r_t. \tag{A7}$$

Then,

$$\frac{\dot{k}}{k} = \frac{k_t - k_{t-1}}{k_{t-1}} = \frac{i_t}{k_{t-1}} - \delta_k, \tag{A8}$$

$$\frac{\dot{h}}{h} = \frac{h_t - h_{t-1}}{h_{t-1}} = \eta\left(\frac{e_t}{h_{t-1}}\right)^{1-\alpha} - (1+\delta_h), \tag{A9}$$

$$1 + \lambda\beta\left(\frac{k_t}{h_t}\right)^{\beta-1} = \lambda\eta(1-\alpha)(1-\beta)\left(\frac{k_t}{h_t}\right)^{\beta}\left(\frac{e_t}{h_{t-1}}\right)^{-\alpha}. \tag{A10}$$

Equation (A10) is obtained from calculating marginal products of productive factors h and k in the production function (A1) and marginal output of investment in human capital in the function of human capital accumulation (A2), and then replacing the results into equation (A7).

Based on the concavities of the utility function (1), the function of human capital accumulation (A2), and the production function (A1), these above conditions of optimally allocation of resources between consumption and investment in human capital and physical capital constitute the balanced growth equilibrium of the modern sector. The modern sector in this economy is similar to the one-sector endogenous growth models with human capital (Also see Lucas (1988), Jones and Manuelli (1990), Barro and Sala-I-Martin (1995) for similar cases.)

Now, we characterize the balanced growth equilibrium. At the equilibrium point, the growth rates of all variables are equal to γ ,

$$\frac{\dot{k}}{k} = \frac{\dot{h}}{h} = \frac{\dot{y}}{y} = \frac{\dot{s}}{s} = \frac{\dot{b}}{b} = \frac{\dot{c}}{c} = \frac{\dot{e}}{e} = \frac{\dot{i}}{i} = \gamma .$$

Let $\dfrac{k_t}{h_t} = x$, from (A2), (A3), we have,

$$\frac{i_t}{e_t} = \frac{(\gamma + \delta_k)x}{\left(\dfrac{1 + \delta_h + \gamma}{\eta} \right)^{\frac{1}{1-\alpha}}} , \tag{A11}$$

$$\frac{e_t}{h_{t-1}} = \left(\frac{1 + \lambda \beta x^{\beta - 1}}{\lambda \eta (1 - \alpha)(1 - \beta)x^{\beta}} \right)^{\frac{-1}{\alpha}} = \left(\frac{1 + \delta_h + \gamma}{\eta} \right)^{\frac{1}{1-\alpha}} . \tag{A12}$$

From (A5)-(A7) and the constraint (A4) we also attain,

$$\frac{c_{0t}}{s_{t-1}} = \frac{c_{0t}}{s_t} \frac{s_t}{s_{t-1}} = \frac{b_t - e_t}{s_t} \frac{s_t}{s_{t-1}} = \frac{(1 + \theta)^2 (1 + \gamma)}{(1 + r)} , \tag{A13}$$

$$\frac{c_{0t}}{e_t} = \frac{(1 + \theta)^2 \left(\dfrac{w(1 + \gamma)}{(1 + r) \dfrac{e_t}{h_{t-1}}} - 1 \right)}{[(1 + \theta)^2 + (2 + \theta)]} , \tag{A14}$$

$$\frac{e_t}{s_{t-1}} = \frac{c_{0t}}{s_{t-1}} \frac{e_t}{c_{0t}} = \frac{c_{0t}}{s_{t-1}} \cdot \frac{1}{c_{0t}/e_t} , \tag{A15}$$

$$\frac{i_t}{s_{t-1}} = \frac{s_{t-1} - c_{0t} - e_t}{s_{t-1}} = 1 - \frac{c_{0t}}{s_{t-1}} \left(1 + \frac{1}{c_{0t}/e_t} \right) \tag{A16}$$

From (A11)-(A16), we derive,

$$\gamma = \eta \left(\frac{1 + \lambda\beta x^{\beta-1}}{\lambda\eta(1-\alpha)(1-\beta)x^{\beta}} \right)^{\frac{\alpha-1}{\alpha}} - (1 + \delta_h). \qquad (A17)$$

$$[(1+\theta)^2 + (2+\theta)](1+r)(\gamma + \delta_k)x + \frac{(1+\theta)^2(1+\gamma)^2}{(1+r)}$$

$$+ [(1+r) - (2+\theta)](1+\gamma)(1+\delta_h+\gamma)^{\frac{1}{1-\alpha}} - w(1+\gamma) = 0. \qquad (A18)$$

In (A17) and (A18), $r = \lambda\beta x^{\beta-1}, w = \lambda(1-\beta)x^{\beta}$. This system of equations determines the values of the balanced growth rate, γ, and the ratio of physical capital to human capital, x, at the balanced growth equilibrium.

Appendix 2: Developing and less developed countries in Figure 4

No.	Name	No.	Name	No.	Name
1	Albania	34	Ethiopia	67	Nepal
2	Algeria	35	Gabon	68	Niger
3	Angola	36	Gambia, The	69	Nigeria
4	Argentina	37	Georgia	70	Pakistan
5	Armenia	38	Ghana	71	Panama
6	Azerbaijan	39	Guatemala	72	Paraguay
7	Bangladesh	40	Guinea	73	Peru
8	Belarus	41	Honduras	74	Philippines
9	Benin	42	India	75	Romania
10	Bolivia	43	Indonesia	76	Russian Federation
11	Botswana	44	Iran, Islamic Rep.	77	Rwanda
12	Brazil	45	Jamaica	78	Senegal
13	Bulgaria	46	Jordan	79	Slovenia
14	Burkina Faso	47	Kazakhstan	80	South Africa
15	Burundi	48	Kenya	81	Sri Lanka
16	Cambodia	49	Kyrgyz Republic	82	Sudan
17	Cameroon	50	Lao PDR	83	Syrian Arab Republic
18	C. Africa Republic	51	Latvia	84	Tajikistan
19	Chad	52	Lebanon	85	Tanzania
20	Chile	53	Lesotho	86	Thailand
21	China	54	Lithuania	87	Togo
22	Colombia	55	Macedonia, FYR	88	Trinidad and Tobago
23	Congo, Rep.	56	Madagascar	89	Tunisia
24	Costa Rica	57	Malawi	90	Uganda
25	Cote d'Ivoire	58	Malaysia	91	Ukraine
26	Croatia	59	Mali	92	Uruguay
27	Cuba	60	Mauritania	93	Uzbekistan
28	Dominican Republic	61	Mauritius	94	Venezuela, RB
29	Ecuador	62	Moldova	95	Vietnam
30	Egypt, Arab Rep.	63	Morocco	96	Yemen, Rep.
31	El Salvador	64	Mozambique	97	Zambia
32	Eritrea	65	Myanmar	98	Zimbabwe
33	Estonia	66	Namibia		

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