

THE EFFECT OF EDUCATION POLICY ON TRADE AND GROWTH

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We analyze the effects of education policy in a model of overlapping generations with endogenous human capital formation and endogenous growth through learning by doing. First, we show how an economy's stock of human capital and growth rate are affected by active government intervention in education under autarky. It is demonstrated that active government support of education is desirable in terms of economic growth. Second, we investigate how the trade pattern is influenced by education policy in an open economy. It is argued that, after a comparison of the positive and negative effects of educational subsidies, the alteration of factor composition through the government subsidies could enhance economic growth by increasing the production and export of human capital intensive goods.

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I. INTRODUCTION

The purpose of this paper is to look into productive government expenditure in a dynamic general equilibrium model and to observe how different levels of education policy influence economic growth and trade pattern through the alteration of factor composition. Using a simple overlapping generations model, we illustrate the role of the government in tax and expenditure policy implementation to increase the stock of human capital in the economy.

Empirically, it has been shown that the stock of human capital is positively correlated with economic growth¹. Theoretically, the models of economic growth

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¹ Of the primary studies are Mankiw, Romer, and Weil (1990), Barro (1991), Benahib and

such as Romer (1986), Lucas (1988) etc. emphasize the investment in human capital as a significant factor contributing to economic growth. These models generate the persistent growth endogenously from the actions of individuals in the economy. However, to the extent that a vital component of human capital investment is formal schooling, they don't take into account the large involvement of public policy in human capital investment.

On the other hand, a lot of research has incorporated the public sector into the human capital formation in closed economies. Glomm and Ravikumar (1992) show that the long run growth is higher when education is privately purchased than when publicly funded, if there is bequest motivation between generations. Boldrin (1993) investigates a model of schooling under the various institutions such as private education, publicly provided education, publicly financed private education and a voucher system. Hamada (1974) studies how government expenditures on education affect economic equality in the framework of education-work choice in the presence of income tax. Benabou (1993) and De Bartolome (1990) examine how locational choice affects efficiency in models in which some aspect of education is local. Loury (1981), Perotti (1993), and Saint-Paul & Verdier (1993) investigate the political economy of state public education and some of its consequences for inequality and growth. Fernandez and Rogerson (1995) show that transfers of resources from lower to higher income groups are possible if individuals vote over the extent to which they subsidize education². Benabou (1996) examines how socioeconomic stratification and alternative systems of education finance affect inequality and growth. However, since most of these studies are focusing on one final good sector in production, they have some difficulty in addressing any issues related to the trade pattern in which the relative price is important.

Here, we explain the alteration of growth rate through education policy in a closed economy within two production sectors overlapping generations growth model. It is shown that active government support of education can exert a powerful influence on the average economic growth rates through the alteration of factor composition. Educational policy can display these effects because it influences private incentives for savings and human capital formation in the process of taxation and expenditure implementation. Higher tax imposition has the propensity to discourage human capital formation due to less available resources to support the group of students who choose to participate in the schooling process. However, if the government spends tax revenue to support education system, an individual agent has more incentive to take part in the schooling process due to cheaper education cost. We compare which effect is

Spiegel (1994), Barro and Lee (1994) and so forth.

² Fernandez & Rogerson (1996) compare the effects of different reforms on communities' composition and education expenditure and examines the political economy of local school finance.

dominant.

As for an open economy, even if one country has the same initial endowment as other countries, the trade pattern can be altered by educational policy. It is demonstrated that since each economy can have a diverse factor composition as a result of different education policy, the active government support for the schooling makes it possible to alter not only growth path but also comparative advantage in the economy.

Section II sets out the model. Section III analyzes how education policy affects human capital formation and growth rate in autarky. In section IV, we show that a small open economy can determine its comparative advantage through education policy. Section V investigates the trade pattern and growth rate in a two country world. Section VI presents our concluding remarks.

II. MODEL

Consider an overlapping generation economy in which individuals live for two periods and die at the end of the second one but economic activity extends over an infinite discrete time. In the second period of life, each individual gives birth to another so that the population remains constant over time. Each generation consists of a continuum of agents and cares about only his or her lifetime welfare. The model is two production sector dynamic general equilibrium one accompanied with the intertemporal optimization and endogenous human capital formation. High and low tech consumption goods are manufactured in two sectors that differ in their factor intensity but are operated under a perfectly competitive market structure.

In each time period t , a new generation enters the economy with the identical ability. Members of generation t face an occupational choice in the first period. Young agents must make a decision about whether to participate in the schooling as students, ST_t , or to work in the factory as unskilled workers, L_t . The schooling enables students to become the next period's stock of human capital-skilled labors- who will be employed either in the education institution as teachers or in high tech sector. Unskilled labors are hired in either of two production sectors.

For the lifetime, unskilled labors consume part of their first period wage income and save the remainder for their second period, since unskilled labors who take part in production in period t retire in $t+1$. In contrast, students who choose education in the first period do not receive an income during the schooling and borrow against their second period income as human capital so as to finance the first period consumption and education cost. A credit market functions as the regulation of savings and borrowings at an endogenous interest rate r_t .

Endogenous growth is fulfilled through learning-by-doing. That is, production

process in high tech sector generates knowledge capital and the productivity improvements by knowledge capital are accomplished as a result of inter industry spillover and diffusion effects.

The government is assumed to finance through a proportional wage income tax, τ_t , imposed to skilled and unskilled labors working in the economy. The interest income tax is ignored. The government provides part of education cost: some of the wages of skilled workers employed in the education institution are provided by government subsidy policy.

The production of both goods occurs within a period using constant returns to scale production technologies subject to an endogenous productivity progress. Producers choose the level of employment to maximize profits subject to technological constraints. The outputs of two production sectors are goods perished after one period respectively. However, two sectors differ in their factor intensity. High tech sector employs skilled labors more intensively than unskilled ones at all factor prices. Only unskilled labors are used for the production of low tech good.

$$Y_t = A_t (H_t^Y)^\alpha (L_t^Y)^{1-\alpha}$$

where $\frac{1}{2} < \alpha < 1$. (1)

$$X_t = A_t L_t^X \quad (2)$$

$$\Delta A_t = A_{t+1} - A_t = \delta Y_t, \quad \delta > 0. \quad (3)$$

Productivity in both sectors, A_t , knowledge capital as of time t , is predetermined but endogenous. Knowledge capital is accumulated as the by-product of high tech good production in every period. With complete spillovers within intra and inter sectors, each manufacturing firm in both sectors treats productivity, A_t , as given when making production and employment decisions.

All individuals, within as well as across generations, share the identical preferences over two perishable consumption goods. Given government tax and expenditure rules, individuals will maximize their lifetime utility subject to budget constraints. We set up the following intertemporal and time separable utility function

$$\text{Max } U = \ln \{ (C_t^X)^\eta \cdot (C_t^Y) \} + \beta \ln \{ (C_{t+1}^X)^\eta \cdot (C_{t+1}^Y) \}$$

where $0 < \beta < 1$. (4)

$$\begin{aligned} P_t \cdot {}_L C_t^X + {}_L C_t^Y &= w_t^L (1 - \tau_t) \cdot S_t, \quad P_{t+1} \cdot {}_L C_{t+1}^X + {}_L C_{t+1}^Y = (1 + r_t) \cdot S_t \\ \text{s. t. } P_t \cdot {}_H C_t^X + {}_H C_t^Y &= B_t - \Psi(1 - s_t) w_t^H, \\ P_{t+1} \cdot {}_H C_{t+1}^X + {}_H C_{t+1}^Y &= w_{t+1}^H (1 - \tau_{t+1}) - (1 + r_t) \cdot B_t \end{aligned} \quad (5)$$

where $\{\tau_t, s_t\}_{t=0}^{\infty}$ are a proportional wage income tax rate and an education subsidy rate by the government. In " C° ", superscript means a class of goods and subscript displays period in consumption. $\{S_t, B_t\}_{t=0}^{\infty}$ are saving and borrowing respectively which are chosen to maximize the intertemporal lifetime utility. " P_t " is the relative price of low tech good in terms of high one in period t . " β " represents a subjective time discount rate and " η " is the ratio of consumer expenditure on low tech good relative to that on high one. H and L denote the individual's lifetime career paths as a skilled and an unskilled labor.

$\Psi(1-s_t)w_t^H$ is the education cost per student charged by a young agent for its schooling.

When an individual participates in education in the first period to become a skilled labor, he or she should not only charge education cost but invest time for the schooling undertaken by the education institution which hires human capital as teachers. It is assumed that teacher-student ratio, Ψ , is constant & less than one half;

$$\frac{H_t^T}{ST_t} = \Psi \quad (6)$$

where H_t^T is the stock of skilled labors employed for education and ST_t is that of students who acquire formal education in period t . " Ψ " is a kind of the efficiency parameter of skilled labors employed in the education system.

For simplicity, each generation consists of a continuum of individuals of measure 1 in every period, $t \geq 0$. The labor constraints in each period t can be described by the following

$$1 = ST_t + L_t, \quad H_t = H_t^Y + H_t^T, \quad ST_{t-1} = H_t, \quad L_t = L_t^Y + L_t^X \quad (7)$$

In every period t , the supply of skilled labors H_t will be allocated between teachers in the education institution, H_t^T , and skilled workers in the production of high tech goods, H_t^Y . Under the equilibrium in this economy, the reward of skilled workers should be the same in both education and production sectors. Also, the total supply of skilled workers in the current period should be equal to the number of students who took part in the education during the previous one. The supply of unskilled workers should be divided between high tech good production, L_t^Y , and low one, L_t^X , under the full employment.

The government reaps internal revenues from a wage income tax levied on skilled and unskilled labors in every period. It does not issue interest-bearing bonds. Government budget constraint keeps balanced in every period: all of t -period revenue should be spent on t -period government program. Its flow budget constraint is

$$\tau_t(H_t \cdot w_t^H + L_t \cdot w_t^L) = s_t \cdot H_t^T \cdot w_t^H \quad (8).$$

It is assumed that the expenditure of government revenue is used to finance the part of the wages of skilled labors employed in the education institution as teachers. However, in order to emphasize and compare the negative tax effect and the positive subsidy effect in human capital formation, we analyze each effect separately at first and then investigate which effect is dominant in the balanced budget at the steady state.

III. AUTARKY

Since individuals enter the economy with the identical condition, they should enjoy the same lifetime utility regardless of the choice of two lifetime career paths “the first period unskilled labor and the second period retirement” & “the first period student and the second period skilled labor” respectively. So, we can derive

$$U_L = U_H \quad (9).$$

Given government policy $\{\tau_t, s_t\}_{t=0}^{\infty}$, a consumer maximizes his or her entire lifetime utility subject to the intertemporal budget constraints. From (4) & (5), we obtain the relationships between the relative price and the consumption ratio of high and low tech goods

$$P_t = \frac{\eta \cdot {}_j C_t^Y}{{}_j C_t^X}, \quad P_{t+1} = \frac{\eta \cdot {}_j C_{t+1}^Y}{{}_j C_{t+1}^X}, \quad j = H, L \quad (10).$$

From (9), (10) & the consumer budget constraints, we can derive saving and borrowing determined by the individual optimization.

$$\begin{aligned} S_t &= \theta w_t^L (1 - \tau_t) \\ B_t &= \theta \Psi w_t^H (1 - s_t) + \frac{\theta w_{t+1}^H (1 - \tau_{t+1})}{\beta(1 + r_t)} \\ &= \Psi w_t^H (1 - s_t) + \frac{\theta}{\beta} w_t^L (1 - \tau_t) \\ \text{where } \theta &= \frac{\beta}{1 + \beta}, \quad 0 < \theta < \frac{1}{2}. \end{aligned} \quad (11)$$

Form career arbitrage,

$$\frac{w_{t+1}^H (1 - \tau_{t+1})}{1 + r_t} = \Psi w_t^H (1 - s_t) + w_t^L (1 - \tau_t)$$

where θ can be regarded as the marginal rate of the savings out of disposable income. $w_t^L(1-\tau_t)$ is the disposable income of unskilled labor after a wage income tax. Since a skilled worker receives a wage in the second period of his life, his first period optimal borrowing reflects his future discounted labor income after a wage income tax. More patience results in less borrowing since more consumption is deferred into the second period. Higher education cost diminishes the first period consumption possibility and induces students to transfer more income from the second to the first period through increased borrowing. Career arbitrage means that two agents who choose the different career paths must have the same amount of expenditure in each period so as to have the same level of lifetime utility.

As for the credit market equilibrium, total savings by unskilled labors for the retirement period consumption should be equal to total borrowings by students who want to become human capital in the second period. Therefore,

$$(1 - H_{t+1}) \cdot S_t = H_{t+1} \cdot B_t \quad (12).$$

The credit market is cleared by an interest rate which depends on per capita supply and demand and the ratio of lenders to borrowers. From (11) & (12), a market interest rate can be obtained such as

$$(1 + r_t) = \frac{w_{t+1}^H(1 - \tau_{t+1})}{\beta \left[\frac{L_t}{ST_t} w_t^L(1 - \tau_t) - \Psi w_t^H(1 - s_t) \right]} \quad (13).$$

We can infer that the credit market clearing interest rate is contingent on the number of unskilled labors, that of students, wage income tax rate and government subsidy rate in the education institution. We can conjecture that the active government support of education brings down a market interest rate by the lower incentive for students to borrow the available fund.

Consumer optimization, career arbitrage and credit market clearing condition determine the level of investment in human capital and the stock of skilled labors allocated to the education system. From (6), (11) & (12), we can get

$$\begin{aligned} H_{t+1} &= ST_t = \frac{\theta w_t^L(1 - \tau_t)}{\Psi w_t^H(1 - s_t) + w_t^L(1 - \tau_t)} \\ &= \frac{\theta}{\Psi \frac{w_t^H(1 - s_t)}{w_t^L(1 - \tau_t)} + 1} \\ H_t^T &= \frac{\theta \Psi}{\Psi \frac{w_t^H(1 - s_t)}{w_t^L(1 - \tau_t)} + 1} \end{aligned} \quad (14).$$

From the first equation, the stock of students is positively influenced by saving (numerator) but negatively by the education cost and the opportunity cost (denominator). The stock of students and that of skilled labors allocated to education as teachers in period t depend positively on constant savings rate, since higher savings rate means more abundant resources for students' borrowing. The first expression implies that the higher wage of skilled labor in the current period will discourage the formation of human capital for the next one due to the increased education cost. It also means that higher wage income tax imposed on labors will have a negative impact on human capital formation. Since unskilled labors have less disposable income after the taxation, their savings will be diminished. It brings forth the result that the student group has more difficulty in borrowing the resources to support their consumption and education cost during the schooling. However, higher government subsidy in the education system diminishes the burden of students. Lower per capita education cost motivates more students to participate in education. The stock of teachers is also influenced by tax and subsidy rate in the same way with that of students, since more students require more skilled labors allocated to education. Here, the relative price is implicit in the relative wage, which transmits price effects only to affect incentives to provide a skilled labor - human capital. We can also obtain the equilibrium interest rate in the credit market such as $(1 + r_t) = \frac{w_{t+1}^H(1 - \tau_{t+1})}{\psi w_t^H(1 - s_t) + w_t^L(1 - \tau_t)}$ which means that the equilibrium interest rate is the ratio of benefit and cost in the investment for human capital. Higher tax rate has two offsetting effects on interest rate. It brings down the expected future income for the students and makes them hesitate the schooling participation. That decreased demand to the fund puts the downward pressure on interest rate. On the contrary, higher tax rate which diminishes the disposable income of unskilled labors brings less supply for the available resources for students. It causes the upward pressure on interest rate.

We choose the price of high tech good as the numeraire and set up such as $P_t^Y = 1$, $P_t = \frac{P_t^X}{P_t^Y}$. Since only relative prices are vital, the price of high tech good may be set to be equal to one in every period. From perfect competition & zero profit conditions, and duality principle, we can get

$$1 = \alpha^{-\alpha}(1 - \alpha)^{-(1-\alpha)} A_t^{-1} (w_t^H)^\alpha (w_t^L)^{1-\alpha}, \quad P_t = A_t^{-1} w_t^L \quad (15)$$

Using the equations of (15), the relationship between the relative price and the relative wage can be derived such as

$$P_t = \frac{P_t^X}{P_t^Y} = \chi \left(\frac{w_t^H}{w_t^L} \right)^{-\alpha}, \quad \text{where } \chi = \alpha^\alpha (1 - \alpha)^{(1-\alpha)} \quad (16)$$

We can be aware that the relative price is negatively dependent upon the relative wage of skilled labor in terms of unskilled labor out of the factor intensity in the production of high and low tech goods. From the combination of wages out of the value of marginal productivity of both factors in high tech sector, the relative wage can be written such as

$$\omega_t = \frac{w_t^H}{w_t^L} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{L_t^Y}{H_t^Y} \right) \quad (17).$$

This equation implies that the relative wage depends on the ratio of the stock of unskilled labor and that of skilled one which are employed in the production of high tech good. From the factor market equilibrium condition that unskilled labors should receive the same wage in both high and low tech sectors, we can derive

$$P_t = (1-\alpha) \left(\frac{H_t^Y}{L_t^Y} \right)^\alpha \quad (18).$$

From (18), we know that the relative price could be described by the factor ratio of skilled and unskilled labors hired in the production of high tech good. Utilizing (7), (17) & (18), we can express the relative wage and the relative price such as

$$\omega_t = \frac{w_t^H}{w_t^L} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{L_t^Y}{ST_{t-1} - \Psi ST_t} \right), \quad P_t = (1-\alpha) \left(\frac{ST_{t-1} - \Psi ST_t}{L_t^Y} \right)^\alpha \quad (19).$$

This shows that both the relative wage and price at period t can be described by the previous and current period stock of students and that of unskilled labors employed in high tech sector.

The productivity growth of this economy is achieved by the accumulation of knowledge capital through learning-by-doing in the production process of high tech good. From (1) and (3), the productivity growth rate can be written such as

$$\frac{\Delta A_t}{A_t} = \delta (H_t^Y)^\alpha (L_t^Y)^{1-\alpha} \quad (20).$$

This equation implies that economic growth is determined by the factor intensity of skilled labor and unskilled labor hired in high tech sector. In the partial equilibrium, growth rate depends positively on the stock of skilled and unskilled labors in high tech good production. However, in the general equilibrium with the full employment, productivity growth rate is decisively influenced by the stock of skilled labors in the economy. This will be straight-

forward in the steady state analysis.

In a closed economy, the domestic supplies of high and low tech goods should satisfy the domestic demands of both goods, respectively. After aggregating per capita consumption over all individuals, we can derive the first equality of equation (21) from (10). From the market clearing condition in goods market, we get the second equality of the following

$$P_t = \frac{\eta \cdot C_t^Y}{C_t^X} = \frac{\eta \cdot Y_t}{X_t} \quad (21).$$

From the high and low tech production functions (1) & (2), we get

$$\frac{Y_t}{X_t} = \left(\frac{H_t^Y}{L_t^Y} \right)^\alpha \left(\frac{L_t^Y}{L_t^X} \right) \quad (22).$$

From (18), (21), and (22), we are capable of deriving the equation about the division of unskilled labors allocated between high and low tech sectors

$$\frac{1-\alpha}{\eta} = \frac{L_t^Y}{L_t^X} \quad (23).$$

This implies that the relative ratio of unskilled labors employed in both high and low tech sectors depends on a factor intensity parameter in high tech good production and the expenditure share of low tech good in terms of high one in consumption. Higher implies that high tech good Y is produced in a more skilled labor intensive way and requires less unskilled labor relatively in the production process. Larger means that the consumer expenditure share on low tech good X is increased. It requires the more production of low tech good X in order to satisfy excess demand. From (7) & (23), we can derive

$$1 - ST_t = L_t^X + L_t^Y = \left(\frac{1+\eta-\alpha}{\eta} \right) L_t^X = \left(\frac{1+\eta-\alpha}{1-\alpha} \right) L_t^Y \quad (24).$$

From given fiscal policy, labor constraints, (19) and (24), the relative price & wage can be written such as

$$P_t = (1-\alpha) \left[\frac{ST_{t-1} - \Psi ST_t}{\left(\frac{1-\alpha}{1+\eta-\alpha} \right) (1-ST_t)} \right]^\alpha, \\ \omega_t = \frac{w_t^H}{w_t^L} = \left(\frac{\alpha}{1-\alpha} \right) \left[\frac{\left(\frac{1-\alpha}{1+\eta-\alpha} \right) (1-ST_t)}{ST_{t-1} - \Psi ST_t} \right] \quad (25)$$

We can conjecture that the relative price and the relative wage in period are

determined by the stock of students in period $t-1$ and t . From (14) and (25), we can get the following expression

$$ST_t = \frac{\theta}{\frac{(1-s_t)m(1-ST_t)}{(1-\tau_t)(ST_{t-1}-\Psi ST_t)} + 1}, \text{ where } m = \frac{\Psi\alpha}{1+\eta-\alpha}. \quad (26)$$

We are capable of interpreting that the stock of students is crucially influenced by wage income tax rate and government subsidy rate in education in period t .

It is assumed that " $\tau_t = \tau$ and $s_t = s$ " in every period. Defining the steady state level of students -human capital-, we can get $H^* = ST^* = ST_t = ST_{t-1}$. From factor constraints and (26), we can obtain the stock of human capital as well as that of unskilled labors at the steady state³

$$H^* = ST^* = \frac{\theta(1-\tau) - (1-s)n}{(1-\tau) - (1-s)n}, \quad L^* = 1 - ST^* = \frac{(1-\theta)(1-\tau)}{(1-\tau) - (1-s)n} \quad (27)$$

where $n = \frac{m}{1-\Psi} = \frac{\Psi\alpha}{(1-\Psi)(1+\eta-\alpha)}$.

It is required to have the following condition " $\theta > n$ " for the meaningful economy. Now, we can determine the relative price and the relative wage at the steady state. From (25), we acquire the following expressions about the relative price of low tech good in terms of high one and the relative wage of skilled labor in terms of unskilled one

$$P^* = (1-\alpha) \left[\frac{(1-\Psi)H^*}{\frac{1-\alpha}{1+\eta-\alpha}(1-H^*)} \right]^\alpha,$$

$$\omega^* = \left(\frac{w^H}{w^L} \right)^* = \left[\frac{\alpha}{(1-\Psi)(1+\eta-\alpha)} \right] \left[\frac{(1-H^*)}{H^*} \right] \quad (28)$$

From (28), as a result of Rybczynski effect, we can infer that the relative price depends positively on the stock of skilled labors, while the relative wage is negatively related with that of skilled labors -human capital- in the economy;

$$\frac{dP^*}{dH^*} > 0, \quad \frac{d\omega^*}{dH^*} < 0 \quad (29)$$

Since the increase of skilled labors makes unskilled ones scarce relatively in the economy, the relative wage of skilled labors in terms of unskilled ones is decreased. Therefore, the relative price of low tech good which uses only unskilled labor in production will be more expensive. Differentiating the stock of

³ The proof of the existence and stability of steady state is provided by Lim, G. (1998).

skilled and unskilled labors with regard to a wage income tax rate, we get

$$\frac{dH^*}{d\tau} = \frac{-(1-\theta)(1-s)n}{[(1-\tau)-(1-s)n]^2} < 0, \quad \frac{dL^*}{d\tau} = \frac{(1-\theta)(1-s)n}{[(1-\tau)-(1-s)n]^2} > 0 \quad (30)$$

This implies that the stock of skilled labors is negatively and that of unskilled ones is positively related with a wage income tax rate. These are the result of the fact that higher wage income rate decreases the disposable income for saving only to make it more difficult for students to finance the consumption and education cost during the schooling. After the differentiation of the stock of skilled and unskilled labors with regard to government education subsidy rate, the following can be obtained

$$\frac{dH^*}{ds} = \frac{(1-\theta)(1-\tau)n}{[(1-\tau)-(1-s)n]^2} > 0, \quad \frac{dL^*}{ds} = \frac{-(1-\theta)(1-\tau)n}{[(1-\tau)-(1-s)n]^2} < 0 \quad (30)'$$

In other words, the stock of human capital has the positive relation with subsidy rate, while that of unskilled labors is negatively related with it. These are owing to the fact that higher subsidy rate results in the less education cost only to motivate more students to take part in the schooling.

From (29), (30) & chain rule, we can get

$$\frac{dP^*}{d\tau} = \frac{\partial P^*}{\partial H^*} \frac{\partial H^*}{\partial \tau} < 0, \quad \frac{d\omega^*}{d\tau} = \frac{\partial \omega^*}{\partial H^*} \frac{\partial H^*}{\partial \tau} > 0 \quad (31)$$

These show how wage income tax rate influences the relative price and wage through the alteration of factor composition. We can interpret that the relative price is negatively influenced by a proportional wage income tax rate, while the relative wage is positively affected by it.

From (29) & (30)', the following results be obtained

$$\frac{dP^*}{ds} = \frac{\partial P^*}{\partial H^*} \frac{\partial H^*}{\partial s} > 0, \quad \frac{d\omega^*}{ds} = \frac{\partial \omega^*}{\partial H^*} \frac{\partial H^*}{\partial s} < 0 \quad (31)'$$

Since the government subsidy of education increases the stock of skilled labors but decreases that of unskilled ones, the relative price of low tech good X produced in a unskilled labor intensive way gets more expensive. The relative wage of skilled labor in terms of unskilled is decreased on account of the increased stock of skilled ones out of higher government subsidy rate in education. From (20), productivity growth rate at the steady state can be written such as

$$g = \frac{\Delta A_t}{A_t} = \delta[(1-\varphi)H^*]^\alpha \left[\left(\frac{1+\eta-\alpha}{1-\alpha} \right) (1-H^*) \right]^{1-\alpha} \quad (32)$$

Differentiating "g" with regard to H^* , we can derive the following relationship between productivity growth rate and the stock of human capital;

$$\frac{dg}{dH^*} > 0 \quad (33)$$

This makes it obvious that economic growth rate is positively related with the stock of human capital. From (30), (30)', & (33), we can get

$$\frac{dg}{d\tau} = \frac{\partial g}{\partial H^*} \frac{\partial H^*}{\partial \tau} < 0, \quad \frac{dg}{ds} = \frac{\partial g}{\partial H^*} \frac{\partial H^*}{\partial s} > 0 \quad (34)$$

Productivity growth rate is negatively related with the size of wage income tax levied on unskilled and skilled labors participating in economic activity, while it is positively influenced by government subsidy rate in the education system.

Proposition 1

In this autarky economy, when we don't take into account the balanced government budget constraints, growth rate and the stock of human capital have a negative relationship with wage income tax, while they have a positive relationship with education subsidy rate.

Now, we compare which effect is stronger for the determination of the stock of human capital and economic growth. Let's suppose that the current period tax revenue should be spent on the current subsidization of the government in education. Using the balanced budget constraint of the government (8), we are capable of deriving the relationship between proportional wage income tax rate and education subsidy rate at the steady state. From (8) & (28), we get

$$\frac{\tau}{s} = \frac{\alpha \Psi}{\alpha + (1 + \eta - \alpha)(1 - \Psi)}, \quad \tau = \ell s$$

where $\ell = \frac{\alpha \Psi}{\alpha + (1 + \eta - \alpha)(1 - \Psi)}, \quad 0 < \ell < 1$ (35)

It shows that the ratio of tax and subsidy rate is described by the technology parameter of high tech good production - α -, the expenditure share of low tech good in terms of high one - η -, and the efficiency parameter of the education institution - Ψ -. If we plug (35) into (27), we get

$$H^* = \frac{\theta(1-s\ell) - (1-s)n}{(1-s\ell) - (1-s)n}, \quad L^* = \frac{(1-\theta)(1-s\ell)}{(1-s\ell) - (1-s)n} \quad (27)'$$

Differentiating (27)' by the subsidy rate - s -, we get

$$\frac{dH^*}{ds} = \frac{n(1-\theta)(1-\ell)}{[(1-s\ell)-(1-s)n]^2} > 0 \quad \frac{dL^*}{ds} = \frac{-n(1-\theta)(1-\ell)}{[(1-s\ell)-(1-s)n]^2} < 0 \quad (36)$$

When the government keeps balanced budget in every period t and uses all of wage income tax revenue to subsidize the education system, the positive effect of subsidy dominates the negative effect of wage income tax only to promote the stock of skilled labors -human capital-. This result brings forth the following proposition.

Proposition 2

Under the above tax and expenditure policy,

1 active government support in the education system promotes the level of human capital and growth rate in the economy.

2 the economy with active support in education has the cheaper relative price of high tech good and the lower relative wage of human capital.

IV. SMALL OPEN ECONOMY

Now, we investigate the effects of education policy in a small open economy. The preceding framework developed in a closed economy may be applied to a small open one. We adopt the usual international trade theorist's interpretation of a small open economy as being one that does not influence larger economic environment in which it operates. The key implication of this definition is that the small country confronts perfectly elastic demand in the world goods market and trades at exogenously given terms of trade. It is also assumed that only goods are mobile. That is, in credit market, domestic borrowings are financed only through domestic savings. So as to focus on education policy issues in an open economy, we abstract from the international diffusion of knowledge capital and migration. We exclude the possibility of complete specialization in the production of high tech good Y : it is assumed that both goods are produced.

Given the relative price " P^{world} " in the world goods market, the relative wage can be obtained by substituting " P^{world} " in (16). We get the following relationship between the given relative world price of low tech good and the relative wage of skilled labor in terms of unskilled in a small open economy:

$$P^{world} = \chi \cdot \left(\frac{w^H}{w^L} \right)^{-\alpha} = \chi \cdot (\omega^{world})^{-\alpha} \quad (37)$$

It displays that the given world relative price fixes the relative wage in domestic factor markets. Since P^{world} can be described by the relative wage with a given technology parameter α in the production of high tech good Y , the

relative wage of a small open economy should be equalized to that of the world in the trading equilibrium. Note that the absolute wages of skilled and unskilled labors can be different according to each economy's level of productivity. From (17) & (18), we can be aware that the ratio of unskilled and skilled labors employed in the production of high tech good Y is fixed;

$$\omega^{world} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{L^Y}{H^Y} \right), \quad P^{world} = (1-\alpha) \left(\frac{H^Y}{L^Y} \right)^\alpha \quad (38)$$

Using these descriptions, we can conjecture that factor composition in the economy will determine the product quantities of both goods with productivity. In a small open economy, the domestic supplies of low and high tech goods do not have to be equal to the domestic demands of both goods respectively. So domestic goods market clearing condition does not hold in the trading equilibrium any longer. It is assumed that the individuals in the world share the same preference and that their utility function is homothetic in the consumption of low and high tech good. In a small open economy as in a closed one, career arbitrage, domestic credit market clearing and consumer optimization give us the stock of students. From (14) & (37), we can get

$$H_{t+1} = ST_t = \frac{\theta}{\Psi \omega^{world} \frac{(1-s_t)}{(1-\tau_t)} + 1} \quad (39)$$

Given the world relative price and hence the relative wage, the stock of students have a negative relationship with the size of wage income tax levied on two types of workers and a positive one with government subsidy rate. According to the domestic credit constraint, the interaction of domestic saving and borrowing determines the stock of each factor with education policy.

Now, we analyze policy implications at the steady state in a small open economy. It is assumed that " $\tau_t = \tau$, $s_t = s$ " in every period. In this small open economy, from (39), the steady state level of human capital can be derived such as

$$H^* = ST^* = \frac{\theta}{\Psi \left(\frac{\chi}{P^{world}} \right)^\alpha \frac{(1-s)}{(1-\tau)} + 1}, \quad \text{where } P^{world} = \chi (\omega^{world})^{-\alpha} \quad (40)$$

We can get the result that the stock of human capital in this small open economy is positively influenced by the given world relative price and subsidy rate, but negatively by the size of wage income tax at the steady state. Since the higher world relative price of low tech good X causes the relative wage of skilled labor to be lower Stolper-Samuelson effect-, the education cost gets cheaper for students who want to become skilled labors in the second period of

life. Higher subsidy rate brings the bigger stock of human capital because of the fact that cheaper education cost enables more students to participate in the schooling process. Since the credit market is constrained domestically, higher wage income tax rate brings about less disposable income and hence the diminished saving of unskilled labors. That makes it more difficult for students to borrow the resources for the consumption and education cost during the schooling. Consequently, it brings forth less skilled labor in the economy. The above causalities can be written such as

$$\frac{dH^*}{dP^{world}} > 0, \frac{dH^*}{d\tau} < 0, \frac{dH^*}{ds} > 0 \quad (41)$$

In a small open economy, productivity growth rate is

$$g = \frac{\Delta A_t}{A_t} = \delta (H^Y)^\alpha (L^Y)^{1-\alpha} \quad (42)$$

The growth rate in knowledge capital will be determined by the factor quantities of skilled and unskilled labors employed in the domestic production of high tech good. Unlike autarky, in a small open economy, we cannot use the domestic goods market clearing condition in order to get the allocation share of unskilled labors between high and low tech good production. However, we can utilize the given world relative price in this small open economy. Using the factor constraints and (37) & (38), we can get

$$g = \frac{\Delta A_t}{A_t} = \delta \left(\frac{1-\alpha}{P^{world}} \right)^{\frac{1-\alpha}{\alpha}} (1-\Psi) H^* \quad (43)$$

As in autarky, it is obvious that productivity growth rate has a positive relationship with the stock of skilled labors in a small open economy. That is,

$$\frac{dg}{dH^*} > 0 \quad (44)$$

From the chain rule and (41) & (44), the following relationships between growth rate and government tax-subsidy policy can be written such as

$$\frac{dg}{d\tau} = \frac{\partial g}{\partial H^*} \frac{\partial H^*}{\partial \tau} < 0, \frac{dg}{ds} = \frac{\partial g}{\partial H^*} \frac{\partial H^*}{\partial s} > 0 \quad (45)$$

So, we can have the following results in a small open economy like in autarky.

Proposition 3

In a small open economy, growth rate and the stock of human capital have a negative relationship with wage income tax, while they have a positive relationship with government subsidy rate in education.

We investigate which effect is dominant to influence the stock of human CO examine the case in which all of the wage income tax revenue is used to subsidize education and that government budget constraint keeps balanced at every period. From the balanced budget constraint (8), we can get the following at the steady state

$$\frac{\tau}{s} = \frac{\psi \cdot H^*}{H^* + \frac{(1-H^*)}{\omega_{world}}} \quad (46)$$

Using the education sector condition $0 < \psi < \frac{1}{2}$, we can get the following result

$$0 < \frac{\tau}{s} < 1 \Rightarrow 0 < \frac{1-s}{1-\tau} < 1 \quad (47)$$

Utilizing this relationship, from (40) & (44), we know that the active government subsidization of education out of wage income tax promotes the stock of human capital and productivity growth in a small open economy. In other words, the positive effect of government subsidization for the schooling dominates the negative effect of wage income taxation in saving action. As a result, factor composition will be transformed favorably for high tech good production and productivity growth in this small open economy.

Proposition 4

In a small open economy, under the above tax and subsidization policy,

1 active government support for education brings the more abundant stock of human capital and higher growth rate.

2 active government support for education enables this small open country to produce more high tech goods and thus to export them.

V. TWO LARGE COUNTRIES

From the properties of the model in section II, it is straightforward to proceed to the full general equilibrium analysis of a two-country world economy and the endogenous determination of the relative commodity prices. We can establish how different levels of education policy between two countries affect comparative advantage in each country. Two countries are identical in every respect such as individual tastes and initial endowment except for the extent of

government education policy. Under free trade, the relative wages of two countries will be equalized as long as two countries are producing both low and high tech good respectively. The country with more active government support in education will have more human capital and higher growth rate, even if that country imposes higher wage income tax on unskilled and skilled workers in order to support the education institution for students who will be skilled labors in the future. Here it is assumed that knowledge capital does not spill over between countries and that domestic borrowings should be financed only from domestic savings as in a small open economy. Before trade, the education policy oriented country has lower price in high tech sector as well as higher growth rate. As a result, this country has comparative advantage in high tech sector after free trade. On the contrary, the less education policy oriented country has less human capital, lower growth rate and comparative advantage in low tech sector.

Proposition 5

Even if two countries have the same initial condition such as endowment and tastes, the country with an active government support for education has more abundant human capital and comparative advantage in high tech good.

VI. CONCLUSION

The government can play several roles in determining a country's growth potential and its comparative advantage. In this paper, we investigated how the extent of education policy can determine national factor endowment, economic growth and trade pattern. Unlike the existing literature, we examined both the positive and negative effects in the process of taxation and expenditure implementation to finance education policy and then compared which effect is dominant. Even if each economy has the same initial conditions, it has been shown that growth rate and comparative advantage can be different as a result of the degree of investment in education policy, which alters factor composition. In autarky, an economy with active government support for education has the larger stock of skilled labors -human capital- and higher growth rate. In a small open economy which faces the given world price, we have established that the economy can enhance growth rate and its export of high tech goods through the promotion of the stock of human capital by an active government education policy. In the two country world, we have also examined how each country's growth rate and trade pattern are determined by its education policy.

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