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Effect of Comprehensive Income and Consumption Taxes on Human Capital, Economic Growth, and Income Distribution: Endogenous Economic Growth and Empirical Evidence

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Abstract

This research conducts a comparative study of the economic growth and income distribution effects of consumption and comprehensive income taxes by introducing them into an endogenous economic growth model with human capital formation. We obtained the following results. First, consumption tax does not directly suppress economic growth. Instead, it promotes physical capital accumulation, which causes favorable income distribution effects for capital income earners. Second, comprehensive income tax has the direct effects of suppressing economic growth, restraining physical capital accumulation, and increasing labor supply. Third, comprehensive income tax promotes human capital accumulation, which causes a more favorable income distribution for workers. Finally, by conducting an empirical study using international panel data, we show the growth effects of human capital and educational investment and the differentiated growth effects of income and consumption taxes.

Keywords: consumption tax; comprehensive income tax; endogenous economic growth; income distribution; human capital; policy

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1. Introduction

In many OECD member countries, consumption tax is levied as a major revenue source to finance current public expenditure and social security payments. In recent years, developing countries in Asia, notably China, and in Eastern Europe have increasingly relied on consumption tax to finance public investments in infrastructure, including education, to enhance per capita income and improve living standards. By contrast, in most advanced countries, human capital formation is expected to provide a basis for improved R&D and productivity for further economic growth.

In this regard, studies on the economic growth and income distribution effects of consumption tax have become common policy questions among diverse countries. This study investigates the economic growth and income distribution effects of comprehensive income and consumption taxes by using an endogenous economic growth model with private and public human capital formation and capital stock accumulation.

Using the theory of human capital formation, Uzawa (1965) and Lucas (1988) incorporate education and human capital into a model of economic growth and investigate the effect of human capital formation on economic growth. Romer (1986) and DeLong and Summers (1991) show that endogenous economic growth appears when capital investment has external effects and there is a phenomenon of increasing returns. Benhabib and Perli (1994), Greiner et al. (2005), and Acemoglu (2008) reveal that endogenous economic growth appears in a model with human capital as an engine of economic growth.[1]

Similarly, the empirical importance of growth effects from investment in education and human capital formation has been studied by many researchers, including Lucas (1988) and Mankiw et al. (1992). However, there has been long-lasting controversy over the growth effects of human capital. However, Lucas (1988), Mankiw et al. (1992), and Barro and Sala-i-Martin (1995) show a significant positive association between education and subsequent growth, while Islam (1995), Schoellman (2012), and Manuelli and Seshadri (2014) reveal only negative or insignificant effects on per capita income or labor productivity. Interestingly, Bils and Klenow (2000) show that growth has a stronger effect on education than education has on growth.[2]

Numerous studies in the field of taxation have investigated the effects of taxes on economic growth. Chamley (1986), Judd (1987), Hubbard (1997), and Bhattarai (2006) examined the economic effects of taxation based on the neoclassical economic growth model. Their main conclusion was that income tax inhibits capital accumulation and labor supply, which has a negative effect on economic growth, whereas consumption tax has a smaller distortion on the economy, and reforming the system from income tax to consumption tax has a positive effect on economic growth. In contrast, Barro (1990) and Alesina and Rodrik (1994), using endogenous economic growth models, analyzed the effects of income tax on economic growth and suggested that if tax revenues are used for productive public expenditure, income tax could potentially have a positive effect on economic growth.

Stokey and Rebelo (1995), Jones et al. (1997), and Hendricks (1999) analyzed the economic growth effects of income tax using endogenous growth models with human capital. They pointed out that labor income tax suppresses human capital formation and leads to negative economic growth effects. Yakita (2001) and Lin (2001), based on an endogenous economic growth overlapping generations model with human capital, show that although capital income tax has a welfare improvement effect, labor income tax increases capital stock and, hence, can reduce consumption and decrease the level of welfare. Moreover, Milesi-Ferretti and Roubini (1998) pointed out that while capital income tax and tax on human capital suppress the accumulation of human capital and have a negative effect on economic growth, the negative effect of consumption tax on human capital accumulation can be offset depending on the specification of leisure. Eriksson et al. (2022), using an endogenous economic growth model where human capital is invested in technological development, examined growth effects of tax and subsidy. They pointed out that a labor income tax hinders the accumulation of human capital and delays technological development, resulting in negative economic growth.

The results of empirical studies regarding the economic growth effects of tax vary depending on the model setup and the data used. Daniel and Jeffrey (2013) find that corporate income tax lowers the return of capital and hence suppresses economic growth. Feld and Herckemeyer (2008) show a negative relationship between corporate taxation and foreign direct investment (FDI), while Macek (2014) used OECD panel data to show the negative growth effects of corporate taxation and, conversely, the growth-promoting effects of VAT. Kate and Milionis (2019), Nguyen et al. (2021), and Sairmaly (2023) pointed out that the economic growth effect of income tax can be positive in developing countries,

while in developed countries it can be negative; moreover, the economic growth effect of consumption tax was noted to be positive.

Concurrently, a few studies have investigated the effects of income distribution caused by economic growth. Alesina and Rodrik (1994) investigate the relationship between capital taxation, economic growth, and income distribution using an endogenous economic growth model, in which government spending has a production effect. Sun and Nishigaki (2019) introduce comprehensive income and consumption taxes into Alesina and Rodrik's model and show that the economic growth effect of consumption tax is superior to that of comprehensive income tax and enhances economic welfare, as the former leads to a higher consumption stream growth rate. However, consumption tax also encourages inequitable capital holding due to this growth-enhancing effect.

In this study, we extend Greiner et al.'s (2005) endogenous growth model, which includes the accumulation of human capital; we introduce public education investment and income transfer financed by consumption tax and comprehensive income tax and investigate the economic growth and income distribution effects. We clarify the effect of consumption tax, relative to comprehensive income tax, on human capital formation from the relationship between economic growth and income distribution. Although many previous studies have investigated the effects of capital or labor income tax, we address comprehensive income tax, which has fewer research findings. Furthermore, as comprehensive income tax is said to be one of the least distorting taxes, it is interesting to compare it with consumption tax which has a similar nature. Moreover, we investigate the effects of public education investment on economic growth in comparison to income transfer, which may be considered a social insurance payment. Subsequently, we conduct an empirical analysis using world panel data to assess the theoretical results obtained in the endogenous growth analysis.

Our major conclusions are summarized as follows. (1) Consumption tax does not directly suppress economic growth but promotes physical capital accumulation, causing favorable income distribution for capital income earners. (2) Comprehensive income tax directly suppresses economic growth by restraining physical capital accumulation and decreasing labor supply. (3) It also promotes human capital accumulation, which causes a more favorable income distribution for workers and may promote the consumption of steady-growth equilibrium. (4) Our empirical analysis clarifies the growth effects of human capital and educational investment and the differentiated growth effects of comprehensive income and consumption taxes.

This study makes a novel contribution to the literature, being one of the few to investigate the economic growth effect of consumption tax and comprehensive income tax by using the endogenous economic growth model, with an explicit focus on human capital formation. To our knowledge, this is the first study to discuss the income distribution effects of comprehensive income and consumption taxes on steady-growth equilibrium with human capital. Additionally, it examines the empirical validity of the theoretical results obtained.

The remainder of this paper is organized as follows. Section 2 presents the basic model and its long-term equilibrium. In Section 3, we investigate the economic growth and income distribution effects of comprehensive income tax. Section 4 investigates the growth and income distribution effects of consumption tax. In Section 5, we conduct a global panel data analysis. Section 6 outlines and discusses this study's findings and conclusions.

2. Basic Model with Human Capital and Educational Investment Financed by Comprehensive Income and Consumption Taxes

In this section, we construct a model that introduces public education investment and income transfer funded by comprehensive income and consumption taxes into an endogenous economic growth model with human capital formation, based on Benhabib and Perli (1994) and Greiner et al. (2005). We consider a decentralized market economy consisting of representative households and enterprises.

The production section of this model is based on Benhabib and Perli (1994). Production is carried out in two sectors; the first uses labor, physical, and human capital stocks to produce integrated goods that can be used for consumption and investment in physical capital stocks. The second sector is the human capital stock production sector, which includes time, existing human capital stock, and public education investment. This human capital stock is defined as the technical level standardized for workers.

2.1. Composite Goods Production Sector

The production sector comprises many competitive firms. The production function of a representative firm is expressed by the following Cobb–Douglas production function.

$$Y = AK^{1-\alpha}(uhL)^{\alpha} \tag{1}$$

where the output Y depends on the labor input L, physical capital stock K, and human capital stock h. A is a constant parameter of technology and $(1-\alpha) \in (0,1)$ is the share of capital stock. u is the percentage of time input into labor, $u \in (0,1)$.

Since firms behave competitively, the following normal marginal productivity conditions are established regarding interest rates and wages (before comprehensive income tax).

$$w = \alpha AK^{1-\alpha}(uhL)^{\alpha-1} \tag{2}$$

$$r = (1-\alpha)AK^{-\alpha}(uhL)^{\alpha} \tag{3}$$

According to Equation (3), the interest rate in the market increases as human capital increases. Furthermore, according to Equation (2), labor wages decrease as human and physical capital increase.

2.2. Household Sector

According to Uzawa (1965) and Lucas (1988), capital stock and human capital stock investments are determined by maximizing expected utility. The benefits obtained from future consumption streams are shown by the following CES utility functions.

$$max \int_0^{\infty} L(t) \frac{c(t)^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt \tag{4}$$

where $\rho > 0$ is the constant discount rate and $\frac{1}{\sigma} > 0$ is the intertemporal consumption substitution rate; we assume that $\sigma \geq (1-\alpha)$.[3]

2.3. Government Behavior

In this section, we introduce a comprehensive income tax, τ $(0 \leq \tau \leq 1)$, and a consumption tax, τ_c $(0 \leq \tau_c < 1)$, on capital as well as labor income and on household consumption, respectively. The government uses a portion, β $(0 \leq \beta \leq 1)$, of revenue as educational expenditure and another, $(1-\beta)$, as income transfers. Therefore, in the case of $\beta = 1$, the government exclusively uses revenue for educational expenditure, and in the case of $\beta = 0$, income transfer is used. We consider the economic growth and income

distribution effects that bring about these taxes by considering both public education expenditure and income transfers. The government budget constraint can be given as

$$g = \tau Y + \tau_c c \tag{5}$$

In the following, we use the maximization problem of an individual's utility over infinite time to decide individual consumption, investment in physical capital stock, and input time for the formation of human capital. In addition, as it is assumed that individuals are homogeneous and the population growth rate is zero, the total labor supply is normalized to one ($L = 1$) without loss of generality.

2.4. Consumption and Investment into Physical Capital and Human Capital

The accumulation equation of human capital stock can be given as

$$\frac{\dot{h}}{h} = h\kappa(1-u) + \varepsilon\beta g \tag{6}$$

where $\kappa \geq 0$, $1 \geq \varepsilon > 0$ are constant coefficients. Equation (6) states that it depends on the human capital stock $h(t)$ at the time t and the input time $u(t)$ to education and government education investment, $g(t)$.

The budget constraint equation for households when the comprehensive income tax is considered can be expressed as follows:

$$\dot{K} + (1+\tau_c)c = (1-\tau)Y + (1-\beta)g \tag{7}$$

As mentioned, households determine their consumption, physical capital investment, and human capital investment by maximizing their utility obtained from a future consumption stream. Therefore, the utility maximization problem of representative households is shown to maximize the utility level obtained from consumption over an infinite lifetime, subject to the budget constraint (Equation (7)) and the accumulation of human capital (Equation (6)).

$$max \int_0^\infty \frac{c^{1-\sigma}-1}{1-\sigma} e^{-\rho t} dt \tag{8}$$

$$\dot{K} + (1+\tau_c)c = (1-\tau)Y + (1-\beta)g$$
$$\dot{h} = h\kappa(1-u) + \varepsilon\beta g$$
$$K(0) \geq 0, h(0) \geq 0$$

To solve this utility maximization problem, the current-value Hamiltonian is formulated as follows:

$$\begin{gathered} H(K,h,\theta,c,u,g) = \tfrac{1}{1-\sigma}\left(c^{1-\sigma}-1\right) + \theta_1[(1-\tau)Y + (1-\beta)g - (1+\tau_c)c] \\ +\theta_2[h\kappa(1-u) + \varepsilon\beta g] \end{gathered} \tag{9}$$

The first-order conditions of maximization are calculated and shown below (see Appendix A):

$$\frac{\partial H}{\partial c} = c^{-\sigma} - (1+\tau_c)\theta_1 = 0 \;\Leftrightarrow\; c^{-\sigma} = (1+\tau_c)\theta_1 \tag{10}$$

$$\frac{\partial H}{\partial u} = \theta_1(1-\tau)\alpha A K^{1-\alpha}(uh)^{\alpha-1}h - \theta_2 h(t)\kappa = 0 \tag{11}$$

$$-\dot{\theta}_1 = -\rho\theta_1 + \frac{\partial H}{\partial K} \iff \dot{\theta}_1 = \rho\theta_1 - \theta_1(1-\tau)(1-\alpha)AK^{-\alpha}(uh)^{\alpha} \tag{12}$$

$$-\dot{\theta}_2 = -\rho\theta_2 + \frac{\partial H}{\partial h} \iff \dot{\theta}_2 = \rho\theta_2 - \theta_1(1-\tau)\alpha A K^{1-\alpha}(uh)^{\alpha-1}u - \kappa(1-u)\theta_2 \tag{13}$$

In addition, the following are the two Transversality Conditions.

$$\lim_{t\to\infty} e^{-\rho t}\theta_1(t)K(t) = 0 \tag{14}$$

$$\lim_{t\to\infty} e^{-\rho t}\theta_2(t)h(t) = 0 \tag{15}$$

Equation (10) shows the consumption choice over time. Consumption tax raises the shadow price of consumption, and levying consumption tax may reduce consumption over time. However, per capita consumption only perceives the income effect according to the amount of comprehensive income tax collected.

Equation (11) shows the determination of the labor supply rate. Households face a wage rate decrease of $(1-\tau)$ owing to comprehensive income tax. In the long-run equilibrium, the substitution effect may cause the labor supply to decrease; conversely, the time spent on human capital formation increases. Thus, the taxation of comprehensive income reduces the opportunity cost of time spent on human capital and may promote human capital formation. However, consumption tax does not appear in Equation (11), which means that the tax has no direct effect on the determination of the labor rate. Still, consumption tax may promote capital accumulation through the substitution effect by raising the shadow price of consumption.

By calculating and rearranging Equations (10)–(13), we can summarize the dynamic behavior of the model using the following four equations:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}[(1-\tau)(1-\alpha)AK^{-\alpha}(uh)^{\alpha} - \rho] \tag{16}$$

$$\frac{\dot{K}}{K} = AK^{-\alpha}(uh)^{\alpha} - (1+\beta\tau_c)\frac{c}{K} - A\beta\tau K^{-\alpha}u^{\alpha}h^{\alpha} \tag{17}$$

$$\frac{\dot{h}}{h} = \kappa(1-u) + \varepsilon\beta\tau AK^{-\alpha}u^{\alpha}h^{\alpha-1} + \varepsilon\beta\tau_c\frac{c}{h} \tag{18}$$

$$\frac{\dot{u}}{u} = \frac{\alpha\kappa}{1-\alpha} + \kappa u - \frac{c}{K} + (1-\beta)\tau AK^{-\alpha}u^{\alpha}h^{\alpha} - \varepsilon\beta\tau AK^{1-\alpha}u^{\alpha}h^{\alpha-1} - \varepsilon\beta\tau_c\frac{c}{h} - (1+\beta\tau_c)\frac{c}{K} \tag{19}$$

From Equation (16), we see that comprehensive income tax has a direct and first-round effect of decreasing the growth rate of the economy $\{\frac{1}{\sigma}[(1-\tau)(1-\alpha)AK^{-\alpha}(uh)^{\alpha} - \rho]\}$ by reducing the marginal productivity of the physical capital stock. In contrast, it is not directly affected by consumption tax. Therefore, consumption tax does not affect economic growth.

Based on Equations (17) and (19), the interest rate for physical capital stock and the rate of labor supply are negatively influenced by comprehensive income tax. However, consumption tax may reduce capital accumulation through the income effect. Moreover, based on Equation (18), the introduction of public education promotes the accumulation of human capital stock. Regarding the labor supply rate, in Equation (19), the labor supply ratio u increases owing to the income effect; conversely, $(1-u)$ is decreased by these taxes. Therefore, the time spent on human capital is reduced, and the labor supply time increases. Consequently, the first-round effects of consumption tax are relatively advantageous to capital income earners and relatively disadvantageous to labor income earners. In the following section, we investigate how comprehensive income and consumption taxes affect the economy in a steady-growth equilibrium.

3. Growth and Income Distribution Effects of Comprehensive Income Tax

In this section, we consider the economic growth and income distribution effects of tax and educational investment policies. To clarify the analytical results, we concentrate on the case of comprehensive income tax finance of public expenditure by assuming that the consumption tax rate is zero ($\tau_c = 0$).

3.1. The Steady-Growth Equilibrium Path and Its Stability

We assume that steady-growth equilibrium (SGE) is a state in which per capita consumption, physical capital, and human capital grow at the same rate ($\frac{\dot{c}}{c} = \frac{\dot{K}}{K} = \frac{\dot{h}}{h} \equiv G$), but the labor supply ratio u remains constant. We set Equation (19) equal to zero ($\frac{\dot{u}}{u} = 0$).[4]

By setting $\tau_c = 0$ and introducing two new variables, $x \equiv h/K$ and $z \equiv c/K$, we can reduce the dimension of the system of differential equations from (16) to (19) into a system of two-dimensional simultaneous differential equations.

$$\frac{\dot{x}}{x} = \kappa(1-u) + A\varepsilon\beta\tau u^{\alpha}x^{\alpha-1} - Ax^{\alpha}u^{\alpha} + z + A\beta\tau x^{\alpha}u^{\alpha} = 0 \tag{20}$$

$$\frac{\dot{z}}{z} = \frac{1}{\sigma}[(1-\tau)(1-\alpha)Ax^{\alpha}u^{\alpha} - \rho] - Ax^{\alpha}u^{\alpha} + z + A\beta\tau x^{\alpha}u^{\alpha} = 0 \tag{21}$$

$$\frac{\dot{u}}{u} = \frac{\alpha}{1-\alpha}\kappa + \kappa u - z + (1-\beta)Ax^{\alpha}u^{\alpha}\tau - \beta\varepsilon\tau Au^{\alpha}x^{\alpha-1} = 0 \tag{22}$$

Assuming that ($\frac{\dot{c}}{c} = \frac{\dot{K}}{K} = \frac{\dot{h}}{h} \equiv G$), ($\frac{\dot{x}}{x} = \frac{\dot{z}}{z} = 0$) is established in SGE. To clarify the results of the analysis, we assume that the initial tax rate of comprehensive income tax is zero.[5] Given this assumption, the SGE of this model is consistent with that of Benhabib and Perli (1994). The conditions for the existence and stability of the SGE of this model are also consistent with those of Benhabib and Perli (1994), and we therefore excluded them from a precise investigation.[6]

By completely differentiating Equations (20) to (22) with respect to the comprehensive income tax increase, we obtain the following system of equations:[7]

$$\begin{bmatrix} -\alpha\psi/x & 1 & -\kappa - \alpha\psi/u \\ \phi\alpha\psi/x & 1 & \phi\alpha\psi/u \\ 0 & -1 & \kappa \end{bmatrix} \begin{bmatrix} dx \\ dz \\ du \end{bmatrix} = -\psi \begin{bmatrix} \beta\left(1+\frac{\varepsilon}{x}\right) \\ \left(\beta - \frac{1-\alpha}{\sigma}\right) \\ (1-\beta) - \beta\frac{\varepsilon}{x} \end{bmatrix} d\tau \tag{23}$$

where $\phi \equiv \left(\frac{1-\alpha}{\sigma} - 1\right) \leq 0, \psi \equiv Ax^{\alpha}u^{\alpha} \geq 0$. The coefficient matrix of Equation (23) is obtained as

$$\begin{vmatrix} -\alpha\psi/x & 1 & -\kappa - \alpha\psi/u \\ \phi\alpha\psi/x & 1 & \phi\alpha\psi/u \\ 0 & -1 & \kappa \end{vmatrix} = -\kappa\frac{\alpha\psi}{x} < 0 \tag{24}$$

3.2. Economic Growth and Income Distribution Effect of Comprehensive Income Tax

We now analyze the economic effect of this tax by solving Equation (23) with respect to comprehensive income tax. First, regarding the change in the labor supply rate in the steady-growth equilibrium, the following result, $\frac{du}{d\tau} \geq 0$ for $\beta \geq 0$, is obtained.

$$\frac{du}{d\tau} = \frac{-\psi}{D}\beta\frac{\varepsilon}{x}\frac{\alpha\psi}{x} \geq 0, \tag{25}$$

where D is negative.

Therefore, if comprehensive income tax is levied, the labor supply ratio u will increase, and the time spent on human capital formation $(1-u)$ will decrease. Thus, the imposition of comprehensive income tax increases labor supply and, at the same time, prevents the formation of human capital stock. Thus, the provision of public education financed by total income tax has both negative and positive effects on the accumulation of human capital stock. Moreover, in the case of income transfer ($\beta = 0$), the labor supply remains unchanged, as the negative income effect caused by the tax is canceled by the transfer.

For the effects on the human capital–physical capital ratio, we have the following equation:

$$\frac{dx}{d\tau} = \frac{-\psi}{D}(\kappa u x - \varepsilon\alpha\psi\beta) \gtreqless 0 \quad \Longleftrightarrow \quad \kappa u x \gtreqless \varepsilon\alpha\psi\beta \tag{26}$$

Equation (26) suggests that the effects of comprehensive income tax on the human capital–physical capital ratio are not decided uniquely and may promote or hamper the accumulation of human capital. In the case of income transfer ($\beta = 0$), the human capital–physical capital ratio is enhanced by the negative income effect caused by tax.

For the effects on the consumption–physical capital ratio, we have the following equation.

$$\frac{dz}{d\tau} = \frac{-\psi}{D}\kappa\frac{\alpha\psi}{u}(1-\beta) \geq 0. \tag{27}$$

Equation (27) states that comprehensive income tax causes an increase in the equilibrium consumption–physical capital stock ratio when $(1-\beta) > 0$.

The growth effects of the tax on SGE can be calculated based on Equation (18) as follows.

$$\frac{dG}{d\tau} = -\kappa\frac{du}{d\tau} + \gamma\frac{\psi}{x} = -\beta\varepsilon\frac{\psi}{x} + \beta\varepsilon\frac{\psi}{x} = 0 \tag{28}$$

Equation (28) states that although the tax has first-round negative growth effects, the final growth effects remain zero.

The negative effects of human capital regarding the comprehensive income tax seem to be in line with the findings of Stokey and Rebelo (1995), Jones et al. (1997), and Hendricks (1999), as well as Milesi-Ferretti and Roubini (1998) concerning labor income tax. However, we found that if all the revenue from the comprehensive income tax is used for income transfers, the negative effects on human capital can be cancelled and human capital–physical capital ratio is enhanced. In addition, the negative impact of this tax on economic growth is also found to be suppressed.

Combining these considerations, we investigate the income distribution effect of comprehensive income tax. As all households in this model are homogenous; they earn the same combination of capital and labor income. Therefore, we compare the changes in capital and labor income. The burden of comprehensive income tax is proportional to labor income and capital income; comprehensive income tax promotes the accumulation of human capital when the government generates revenue from income transfer and creates favorable effects on wage income. In addition, because it also increases the equilibrium consumption–physical capital ratio, comprehensive income financed by income transfer improves lifetime utility/welfare.

4. Growth and Income Distribution Effects of Consumption Tax

In this section, we investigate the effects of consumption tax on economic growth and income distribution by considering public education expenditure and income transfer financed by consumption tax. We assume that comprehensive income tax is zero ($\tau = 0$).

4.1. SGE and the Stability of the Consumption Tax Finance Case

By setting $\tau = 0$ and introducing two new variables, $x \equiv h/K$ and $z \equiv c/K$, we can reduce the dimension of the system of differential equations from (16) to (19) into the system of two-dimensional simultaneous differential equations, as in the previous section. After rearranging, we obtain the following differential equations.

$$\frac{\dot{x}}{x} = \kappa(1-u) + \frac{\varepsilon\beta\tau_c}{x}z - Ax^{\alpha}u^{\alpha} + (1+\beta\tau_c)z = 0 \tag{29}$$

$$\frac{\dot{z}}{z} = \frac{1}{\sigma}[(1-\alpha)Ax^{\alpha}u^{\alpha} - \rho] - Ax^{\alpha}u^{\alpha} + (1+\beta\tau_c)z = 0 \tag{30}$$

$$\frac{\dot{u}}{u} = \frac{\alpha}{1-\alpha}\kappa + \kappa u - (1+\beta\tau_c)z - \beta\tau_c\frac{\varepsilon}{x}z = 0 \tag{31}$$

The Jacobi determinant of the system of Equations (29)–(31) is again negative. We also assume that the initial rate of the consumption tax is zero.

4.2. Effect of Consumption Tax on the Economy

By completely differentiating Equations (29) to (31) with respect to the increase in the consumption tax rate, we obtain the following equation.

$$\begin{bmatrix} -\alpha\psi/x & 1 & -\kappa - \alpha\psi/u \\ \phi\alpha\psi/x & 1 & \phi\alpha\psi/u \\ 0 & -1 & \kappa \end{bmatrix} \begin{bmatrix} dx \\ dz \\ du \end{bmatrix} = \beta z \begin{bmatrix} -\left(1+\frac{\varepsilon}{x}\right) \\ -1 \\ \left(1+\frac{\varepsilon}{x}\right) \end{bmatrix} d\tau_c \tag{32}$$

First, as the share of educational investment (β) appears on the right-hand side of Equation (32), all variables on the left-hand side remain unchanged in the case of income transfer ($\beta = 0$). Therefore, we can conclude that consumption tax with income transfer does not affect the equilibrium of SGE.

Next, we consider changes in the labor supply rate. From Equation (32), $du/d\tau_c$ can be calculated as follows.

$$\frac{du}{d\tau_c} = -\frac{\beta z}{D}\frac{\alpha\psi}{x}\frac{\varepsilon}{x} \geq 0, \tag{33}$$

Considering that the sign of D is negative, the labor supply rate will increase owing to an increase in consumption tax. By contrast, the time spent on human capital formation is reduced. Thus, an increase in consumption tax has a negative effect on the accumulation of human capital stock.

Regarding the effect on human capital and the physical capital ratio, the following result is obtained.

$$\frac{dx}{d\tau_c} = \frac{\beta z}{D}\frac{\alpha y}{u}\frac{\varepsilon}{x} \leq 0 \tag{34}$$

Therefore, the accumulation of physical capital exceeds the accumulation of human capital.

Finally, if we calculate the tax effect on consumption and capital stock ratio, we obtain the following equation:

$$\frac{dz}{d\tau_c} = \frac{\beta z}{D}\kappa\frac{\alpha\psi}{x} \leq 0. \tag{35}$$

Therefore, the consumption–physical capital ratio decreases, which means that consumption cannot cope with the accumulation of capital stock.

Using Equation (18), the change in the economic growth rate in the steady-growth path can be calculated as follows:

$$\frac{dG}{d\tau} = -\kappa\frac{du}{d\tau} + \gamma\frac{\psi}{y} = -\frac{\beta z}{D}\frac{\alpha\psi}{x}\frac{\varepsilon}{x}\kappa + \frac{\beta z\varepsilon}{x} = -\frac{\beta z\varepsilon}{x} + \frac{\beta z\varepsilon}{x} = 0 \tag{36}$$

There are not many preceding studies on the effects of consumption tax on human capital formation. Among them, Milesi-Ferretti and Roubini (1998) point out that the effects of a consumption tax depend on the specification of leisure and, especially, its effects can be offset in a 'home production' model. Our conclusion is that this becomes possible through government income transfers.

When we investigate the effects of income distribution, consumption tax is borne proportionally by labor income and capital income. However, since the accumulation of

physical capital is higher than that of human capital stock, in steady-growth equilibrium, consumption tax works more favorably for capital income.[8] However, since consumption is the physical capital ratio when SGE falls, consumption cannot cope with the accumulation of physical capital, which implies that the lifetime utility level in SGE does not increase despite the accumulation of physical capital stock.

5. Empirical Analysis Based on World Panel Data from 1972 to 2020

In this section, we detail how we conducted an empirical analysis to estimate the effects of income and consumption taxes on human capital formation and economic growth. Using the world panel data of OECD countries and developing countries from 1972 to 2020, we utilized the panel regression analysis method to obtain the economic growth effects of human capital accumulation and these taxes.

Our focus in this empirical study was to test the following hypotheses: 1. Human and physical capital promotes economic growth. 2. Growth effects differ between the tertiary and secondary education groups. 3. The effects of taxes on economic growth also differ between income and consumption.

5.1. Data and Analysis

The sources of the world panel data were the OECD and The World Bank Open Data. In particular, for developing countries, we used the latter because of data availability. Data were collected from 1972 to 2020.[9] Based on the theoretical basis of the previous chapter, taking the economic growth rate as the dependent variable, we used the secondary enrollment rate, tertiary enrollment rate, government expenditure on education, investment ratio of GDP, income tax ratio, and consumption tax ratio out of GDP from 1972 to 2020.[10] These variables and their notations, along with the theoretically expected signs, are summarized in Table 1.

Table 1. Selected variables.

Variable Expectation	Unit	Notation	Theoretical Expectation
Consumption tax revenue to GDP	%	TAC	+/−
Income tax revenue to GDP	%	TAI	−
Enrollment in secondary education	%	EDS	+
Enrollment in tertiary education	%	EDT	+
Government expenditure on education	%	EDX	+
Rate of gross capital formation to GDP	%	INV	+
Per capita GDP	US$	PCGDP	(dependent)

From the perspective of data availability, we selected the 27 OECD countries for the panel of developed countries and the other 16 Asian and Eastern European countries for the panel of developing countries. The selected OECD (developed) countries were Australia, Austria, Belgium, Canada, Chile, Switzerland, Germany, Denmark, Spain, Estonia, Finland, the Republic of Korea, Poland, Turkey, the United States, New Zealand, Norway, Mexico, Sweden, the Czech Republic, the United Kingdom, Greece, Ireland, Iceland, the Netherlands, the Slovak Republic, and Slovenia. The 16 Asian and Eastern European countries were Croatia, China, Malaysia, Thailand, Vietnam, the Philippines, Romania, Singapore, Indonesia, Malta, Bulgaria, Cyprus, Cambodia, Lao PDR, Myanmar, and India.

Table 2 presents the descriptive statistics of the datasets of world countries, OECD countries, and developing countries.

Table 2. Descriptive statistics.

A. World Panel.					
	Samples	Mean	Maximum	Minimum	Standard Deviation
Taxes on goods	1960	5.961221	23.52799	0.002319	3.051891
Taxes on income	1897	5.147231	19.4667	0.011596	3.421709
Secondary education	2715	58.23775	163.9346	1.39655	31.63949
Tertiary education	2508	34.43576	148.5309	0.09459	27.9265
Education expenditure	1017	4.283386	13.4298	0.837147	1.385588
Capital formation	2813	23.62174	79.40187	0.915274	7.213019
Per capita GDP	2867	18,146.22	112,417.9	270.6577	18,522.1
B. OECD Panel.					
	Samples	Mean	Maximum	Minimum	Standard Deviation
Consumption tax	1294	6.324876	14.35865	0.236423	2.703474
Income tax	1237	6.01607	17.53824	0.947118	3.469334
Secondary education	1428	96.85138	163.9347	23.45034	21.50613
Tertiary education	1390	44.27265	148.5309	1.07454	25.16878
Education expenditure	759	4.351577	8.228977	1.557493	1.077623
Capital formation	1491	23.72639	54.6975	8.553732	4.565158
Per capita GDP	1143	28,739.35	112,417.9	2253.086	18,445.99
C. Developing Panel.					
	Samples	Mean	Maximum	Minimum	Standard Deviation
Consumption tax	666	5.254659	23.52799	0.002319	3.531246
Income tax	665	3.537592	19.4667	0.011596	2.668679
Secondary education	1285	61.77707	123.0334	1.39655	30.85274
Tertiary education	1118	22.20565	117.1008	0.09459	24.28112
Education expenditure	258	4.082776	13.4298	0.837147	2.027454
Capital formation	1322	23.50373	79.40108	0.915274	9.339035
Per capita GDP	1424	7411.743	91,434.54	270.6577	10,819.4

5.2. Estimation Model

Based on the theoretical basis of the previous chapter, taking the economic growth rate as the dependent variable, we utilized the secondary enrollment rate, tertiary enrollment rate, government expenditure on education, investment ratio of GDP, income tax ratio, and consumption ratio of government revenue from 1972 to 2019.

Model:

$$lnPCGDP_{it} = \alpha + \beta_1 TAC_{it} + \beta_2 TAI_{it} + \beta_3 EDS_{it} + \beta_4 EDT_{it} + \beta_5 EDX_{it} + \beta_6 INV_{it} + \mu_{it},\ i = 1.42; t = 1972.2020,$$

where $PCGDP_{it}$ represents per capita GDP; TAC_{it} indicates the proportion of tax revenue on consumption goods to GDP; TAI_{it} represents the proportion of income tax revenue to GDP; EDS_{it} refers to the enrollment rate for secondary education; EDT_{it} represents the enrollment rate for tertiary education; EDX_{it} represents the proportion of educational expenditure to GDP; INV_{it} represents the nominal investment rate in GDP; and μ_{it} refers to the error term of the t year of country i : $\mu_{it} = \sigma_{it} + \rho$. $i = 1, \ldots, N$ and t.

Here, we suppose the correspondence between the variables used in the econometric analysis and the variables that appeared in the theoretical model up to the previous section as follows. First, TAC approximates the consumption tax rate τ_c. TAI represents the ratio of total income tax revenue to GDP, assuming a comprehensive income tax, τ. However, the latter is a somewhat theoretical tax that taxes all income at the same tax rate, and there

are no countries that adopt this. Therefore, TAI approximates a comprehensive income tax. Next, EDS and EDT are used as proxy variables for human capital, h, as in many previous studies (for example, Mankiw et al., 1992). EDX is considered equivalent to $\varepsilon\beta g$ in the public expenditure on education in Equation (6). Finally, INV is the GDP ratio of investment expenditure and approximates $\dot{K}$ in Equation (17).

To set up the estimation model, we conducted an F-test and a Hausman test. The results of these tests are listed in Table 3. As the F test results showed individual effects in all datasets, we chose the fixed-effect model or the random-effect model according to the results of the Hausman test.

Table 3. Results of F test and Hausman test.

	F Test		Hausman Test		
Data Set	**F**	***p*-Value**	χ^2	***p*-Value**	**Model**
OECD Panel	457.48	$<22 \times 10^{-16}$	325.06	$<22 \times 10^{-16}$	Fixed effect
Developing Panel	211.04	$<22 \times 10^{-16}$	8.121	0.2294	Random effect
World Panel	460.43	$<22 \times 10^{-16}$	21.473	0.001508	Fixed effect

5.3. Panel Analysis Results

Before discussing the estimated results, we tested the hypotheses. First, when the government's investment in education increases, the accumulation of human capital increases, improving production and promoting economic growth. Therefore, the expected regression coefficient is positive. Second, physical capital accumulation also increases, so the expected regression coefficient is positive. Third, when consumption tax provides government investment in education, it drives the accumulation of human capital and promotes economic growth. Therefore, the expected regression coefficient is positive.

The results of the panel regression analysis are presented in Table 4.

Table 4. Estimated results.

	OECD Countries	**Developing Countries**	**World Panel**
Dependent Variable	**Per Capita GDP In Natural Logs**		
Model Selected	**Fixed Effect**	**Random Effect**	**Fixed Effect**
Intercept		7.2596324 ***	
		(47.599)	
TAC	−0.00510720	0.0329024 ***	0.00716544
	(−1.0608)	(3.2419)	(1.5730)
TAI	−0.01058862 **	−0.0138970 *	0.00489932
	(−2.2196)	(−1.8140)	(1.2606)
EDS	0.00886426 ***	0.0072617 ***	0.00840414 ***
	(27.2395)	(6.0168)	(25.2410)
EDT	0.00683272 ***	0.0109892 ***	0.00699732 ***
	(13.2647)	(7.8785)	(13.9697)
EDX	−0.08486062 ***	0.0014581	−0.04465921 ***
	(−11.9914)	(0.1314)	(−7.8889)
INV	0.01023358 ***	0.0013655	0.00828691 ***
	(7.2122)	(0.6206)	(0.6206)
Total Sum of Squares	28.53	12.356	33.579
Residual Sum of Squares	6.2106	1.6896	8.9526
R-Squared	0.78231	0.86393	0.7338
Adjusted R-Squared	0.76785	0.85856	0.71244
F statistic	342.6	387.949	326.877

Note: *, **, and *** represent the significance level at 10%, 5%, and 1%. The values in parentheses under the estimated coefficients indicate t-values for the OECD panel and world panel and z-values for the developing country panel.

For OECD countries, in Table 4, taxes on income have a significant negative effect on economic growth. However, both secondary and tertiary education promote economic growth and show that education and human capital play a certain role in economic growth. Additionally, the coefficient of capital formation is significantly positive. This coefficient shows the theoretically predicted results. On the contrary, government expenditure on education has a negative effect on economic growth, while the coefficient for consumption tax is not significant.[11]

We compared these estimates with those of previous studies. First, the growth effects of human capital are significantly positive here, but Macek (2014) did not show significant results for OECD data, although the estimation period was not the same. In addition, Macek showed significantly negative coefficients for income tax and government spending, and our results are consistent with those of Macek. However, Macek showed a significantly positive result for sales tax.

For developing countries, consumption tax has a significant positive effect on economic growth, whereas income tax has a negative effect on economic growth. In addition, both secondary and tertiary education show a significant positive effect on economic growth, implying that human capital in developing countries also has a significant growth effect. This conclusion is in line with that of Cinnirella and Streb (2017) and Keji (2021). However, no significant results were obtained for education spending or capital formation.

In the case of world countries, both secondary and tertiary education have a positive effect on economic growth, which proves the significance of the growth-promoting effect of human capital in the world panel data. While the coefficient of government spending on education is negative and significant, no significant results are obtained for the two tax variables in this case.

The above results are summarized in Table 5.

Table 5. Summary of the panel regression analysis results.

	OECD Countries	Developing Countries	World Panel
TAG		+	
TAI	−	−	
EDS	+	+	+
EDT	+	+	+
EDX	−		−
INV	+		+

Note: + indicates positive growth effect, while − signifies that it is negative.

6. Conclusions

This study investigated the growth and income distribution effects of consumption and comprehensive income taxes, using an endogenous economic growth model that incorporates the accumulation of human capital.

We obtained eight main findings, described below. (1) The imposition of comprehensive income tax increases labor supply and prevents the formation of human capital stock. The provision of public education financed by comprehensive income tax has both negative and positive effects on human capital stock accumulation. (2) The effects of comprehensive income tax on the human capital–physical capital ratio are not determined uniquely, and the human capital/physical capital ratio may promote or hamper the accumulation of human capital. However, the tax increases the consumption–physical capital stock ratio when the government uses its revenue as income transfer at the same time. (3) The imposition of consumption tax increases labor supply, and thus, time spent on human capital formation is reduced, and an increase in consumption tax has a negative effect on the accumulation

of human capital stock. (4) Consumption tax hampers consumption and promotes the accumulation of physical capital; consequently, the consumption–physical capital ratio decreases, and consumption cannot cope with the accumulation of capital stock, which causes a decline in lifetime utility. (5) Regarding income distribution, the burden of comprehensive income tax is proportional to labor income and capital income. Comprehensive income tax promotes the accumulation of human capital when the government uses revenue for income transfer and creates favorable effects on wage income. In addition, since comprehensive income tax also increases the equilibrium consumption–physical capital ratio at the same time, income transfer financed by comprehensive income tax improves lifetime utility/welfare. (6) Consumption tax is borne proportionally by labor income and capital income. However, since it promotes the accumulation of physical capital, it works more favorably for capital income in steady-growth equilibrium. However, as the consumption–physical capital ratio in SGE falls, the utility level in SGE does not increase despite physical capital stock accumulation.

In econometric analysis, panel regression was performed using the OECD, developing country, and world panel data. Using per capita GDP as the explanatory variable, regression analysis was performed using secondary education and tertiary enrollment rates as human capital, income tax as tax-related data, and consumption tax, public education expenditure, and capital formation as the other explanatory variables. (7) Consequently, significantly positive coefficients were obtained for these two enrollment rates in all datasets, confirming the growth effect of human capital in all cases. (8) For public education spending, the coefficient was significantly negative in the OECD and world panel data, which means this expenditure is used for purposes other than achieving growth, such as income redistribution through equal educational opportunities. As for the explanatory variables related to taxes, (9) income tax is significantly negative in OECD and developing countries, and consumption tax is positive in developing countries. These results suggest that the growth effect varies considerably between taxes.

In future research, if the economic effects of comprehensive income tax and consumption tax are examined, assuming individuals with different human capital levels, research on tax income distribution will show further development. Furthermore, introducing progressive or regressive taxes into the framework of our model is an interesting challenge and is likely to lead to many unpredictable outcomes. Finally, in the empirical analysis, interesting conclusions can be drawn by explicitly examining the income distribution effects of human capital and taxes.

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Appendix A

By substituting the budget constraint equations of the individual and government into the utility maximization conditional Equations (10) to (13), the change in consumption over time can be expressed as follows:

$$-\sigma\frac{\dot{c}}{c} = \frac{\dot{\theta_1}}{\theta_1} \tag{A1}$$

Next, the following equation is obtained by arranging Equation (11).

$$\frac{\dot{\theta_1}}{\theta_1} = \rho - (1-\alpha)AK^{-\alpha}(uh)^{\alpha}(1-\tau) \tag{A2}$$

By integrating Equations (A1) and (A2), the differential equation for the growth rate of consumption is obtained as follows:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}[(1-\tau)(1-\alpha)Ak^{-\alpha}(uL)^{\alpha}h^{\alpha} - \rho] \tag{A3}$$

Next, the differential equation of capital accumulation is obtained from Equation (7).

$$\frac{\dot{K}}{K} = AK^{-\alpha}(uh)^{\alpha} - \frac{c}{K} - \beta\tau K^{-\alpha}u^{\alpha}h^{\alpha}A \tag{A4}$$

Similarly, by substituting the government budget constraint equation into Equation (6) and rearranging it, we obtain the differential equation for human capital stock:

$$\frac{\dot{h}}{h} = \kappa(1-u) + \varepsilon\beta\tau AK^{-\alpha}u^{\alpha}h^{\alpha-1} \tag{A5}$$

Finally, the following equation is obtained by changing Equation (13).

$$\theta_1[\alpha Ak^{1-\alpha}u^{\alpha-1}\,h^{\alpha-1}](1-\tau) = \theta_2\kappa h \tag{A6}$$

By substituting Equation (2) into Equation (13) and rearranging it, the following equation is obtained.

$$\frac{\dot{\theta_2}}{\theta_2} = \rho - \kappa \tag{A7}$$

By differentiating Equation (A4) with respect to time, we obtain a new expression:

$$(1-\alpha)\frac{\dot{u}}{u} = \frac{\dot{\theta}_1}{\theta_1} + (1-\alpha)\frac{\dot{K}}{K} - \frac{\dot{\theta}_2}{\theta_2} - (1-\alpha)\,\frac{\dot{h}}{h} \tag{A8}$$

Substituting (A2), (A4), (A5) and (A7) into Equation (A8) yields the following equation:

$$\frac{\dot{u}}{u} = \frac{\alpha\kappa}{1-\alpha} + \kappa u - \frac{c}{K} + (1-\beta)\tau AK^{-\alpha}u^{\alpha}h^{\alpha} - \varepsilon\beta\tau AK^{1-\alpha}u^{\alpha}h^{\alpha-1} \tag{A9}$$

Appendix B

By substituting the budget constraint equations of the individual and the government into the utility maximization conditional Equations (36) to (39), the change in consumption over time can be expressed as follows:

$$-\sigma\frac{\dot{c}}{c} = \frac{\dot{\theta_1}}{\theta_1} \tag{A10}$$

Next, the following equation is obtained by arranging Equation (38).

$$\frac{\dot{\theta_1}}{\theta_1} = \rho - (1-\alpha)AK^{-\alpha}(uh)^{\alpha} \tag{A11}$$

By integrating Equations (A1) and (A2), the differential equation for the growth rate of consumption is obtained as follows:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}[(1-\alpha)AK^{-\alpha}u^{\alpha}h^{\alpha} - \rho] \tag{A12}$$

Next, the differential equation of capital accumulation is obtained from Equation (33).

$$\frac{\dot{K}}{K} = Ak^{-\alpha}(uh)^{\alpha} - (1+\tau_c)\frac{c}{K} + (1-\beta)\tau_c\frac{c}{K} \tag{A13}$$

Similarly, by substituting the government budget constraint equation into Equation (30) and rearranging it, we obtain the differential equation for human capital stock:

$$\frac{\dot{h}}{h} = \kappa(1-u) + \varepsilon\beta\tau_c\frac{c}{h} \tag{A14}$$

Finally, the following equation is obtained by changing Equation (38).

$$\theta_1[\alpha Ak^{1-\alpha}u^{\alpha-1}\,h^{\alpha-1}] = \theta_2\kappa \tag{A15}$$

By substituting Equation (2) into Equation (39) and rearranging it, the following equation is obtained.

$$\frac{\dot{\theta}_2}{\theta_2} = \rho - \kappa\alpha AK^{1-\alpha}u^{\alpha}\,h^{\alpha-1}\Big/\alpha AK^{1-\alpha}u^{\alpha-1}\,h^{\alpha-1} - \kappa(1-u) = \rho - \kappa \tag{A16}$$

By differentiating the expression in (A4) with respect to time, we obtain a new expression:

$$(1-\alpha)\frac{\dot{u}}{u} = \frac{\dot{\theta}_1}{\theta_1} + (1-\alpha)\frac{\dot{K}}{K} - \frac{\dot{\theta}_2}{\theta_2} - (1-\alpha)\,\frac{\dot{h}}{h} \tag{A17}$$

Substituting (A11), (A13), (A14) and (A16) into Equation (A17) yields the following equation:

$$\frac{\dot{u}}{u} = \frac{\alpha\kappa}{1-\alpha} + \kappa u - \varepsilon\beta\tau_c\frac{c}{h} - (1+\beta\tau_c)\frac{c}{K} \tag{A18}$$

Notes

1 See, for example, Krueger and Lindahl (2001) for a survey of the field.

2 Lucas (2015) avers that something like a consensus emerged on human capital playing a modest role in determining productivity levels and growth rate, based on the misinterpretation of evidence or misuse of related data. He also showed a labor productivity gap by schooling years based on U.S. data.

3 σ is usually estimated as larger than one; see Greiner et al. (2005).

4 See Greiner et al. (2005).

5 Although this assumption is restrictive, it is one of the common premises in dynamic tax analysis; see Yakita (2001).

6 See p. 123 of Benhabib and Perli (1994) for the reference.

7 See Appendix B for the precise calculation procedure.

8 Sun and Nishigaki (2019) show that the flat burden to both labor income and capital income earners occurs only in the steady state.

9 The dataset is available upon request.

10 Due to the availability of the compensation of employees and operating surplus data, we use GDP to standardize the tax revenue and education expenditure.

11 The result may suggest that government expenditure may have counter-cyclical fluctuations for economic stimuli and that educational expenditures could also fluctuate, influenced by these policies. Additionally, educational expenditure is used for purposes other than growth policy, such as income redistribution through equal educational opportunities.

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