Distance to Frontier, Different Taxes and Selection

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Abstract

This paper examines the effects of taxation on the long run distance to the frontier of the economy as well as the welfare and growth rate. The technological progress of an economy is assumed to be obtained from both innovation and imitation. In this paper, both innovation and imitation improve the technology level of the economy. Innovation targets on local technology frontier, while imitation targets on global technology frontier. We show that higher capital income tax results in longer steady state distance to frontier while it increases steady-state welfare.

Keywords: E62; H20; O31; O38

JEL Classification Codes: Capital Income Tax; Growth; R&D; Welfare
1. Introduction

Distance to frontier is the technological proximity of an economy to the leading economy and can be measured by the ratio between the total factor productivity in the economy and that of the leading country. Many studies, such as Barro and Sala-i-Martin (1992), Mankiw et al. (1992), and Evans (1996), show that a large group of countries has been converging to parallel growth paths over the past 50 years. However, although the long-run growth rate converges, the long-run technology gap spreads. This hypothesis is the so-called the conditional convergence.

In the developing countries, shortening its long-run technological distance to the frontier countries is sometimes as important as the desire to promote economic growth. If so, careful consideration should be made before the implementation of any fiscal policy, since it might not be possible to “kill two birds with one stone.” Our main purpose in this paper is to analyze the effects of capital income tax and labor income tax on the developing countries’ long run technology distances to the frontier as well as on the welfare and growth rates of the economies.

It may not be apparent that shortening the technological distance to the frontier economy can be adopted by a government as a policy target. However, in reality, it is a crucial goal of a government in developing countries such as China to increase the technology level of the economy, and thus shorten the distance to the frontier economy. A piece of evidence is the catching-up strategy adopted by many countries. China took this strategy in the 1950s. During that time, the economic growth rate was not the primary goal of economic policy while catching up the leading counties was more critical. Technological progress in some specific area is still one of the key performance index and a criterion for promotion of Chinese government officials.

In this paper, we explore the optimal tax mix within a quality improvement model of growth framework. We assume that technology progression is obtained from two channels: technology adoption from the frontier economy which is often in forms of imitation; and purposeful innovation targeted at the local aggregate technology level. Both innovation and reproduction require two types of production inputs: physical capital and labor. The taxation choice of the government to finance a fixed amount of government expenditure then will have different effects on the innovation and imitation incentives, and thus, on the long run technology distance to frontier, welfare and growth rate of the economy. Therefore, the optimal strategy for the government requires balancing these three targets.

We show that capital income tax financing leads to higher steady-state welfare at the constant state. Steady-state welfare is determined by consumption, leisure, and growth rate. In the long run, growth rate converges to the frontier technology growth rate, which is independent of the economy itself. Thus, the negative growth rate effect of capital income tax is removed here. A higher capital income tax always leads to a lower incentive to accumulate; therefore the steady-state consumption is still higher. The ratio of capital input and labor input to the R&D sector keeps constant in steady state. To match a lower level of capital input to R&D, the required labor input is also lower. Thus, a higher capital income tax results in a higher leisure level. Both
higher consumption and higher leisure determine higher steady state welfare. Although higher capital income tax leads to higher welfare, it also results in a long distance to the technology frontier, i.e., a lower relative technology level. Higher capital income tax discourages accumulative input to R&D by reducing capital accumulation. It then results in the longer distance to the technology frontier in the long run.

This paper is related to several strands of literature. The first strand is the literature on the distance to frontier and global convergence. Technology transfer and cross-country convergence are one of the most studied topics in growth literature. Neoclassical literature pioneered by Solow (1956) usually explains convergence as a result of decreasing returns to capital (see, e.g., Barro and Sala-i-Martin, 1991; Mankiw et al., 1992). Endogenous growth literature, however, explains convergence from the view of international knowledge spillover (see, e.g., Aghion and Howitt, 1998; Aghion et al., 2005; Barro and Sala-i-Martin, 1997; Howitt, 2000; Howitt and Mayer, 2002). Barro and Sala-i-Martin (1997) explore the convergence implication of the endogenous growth model. In their model, the leading countries do innovation while the followers do an imitation. In the long run, the worldwide growth rate is determined by the leading economy. Our model is consistent with theirs, but with the difference that the followers do engage in both innovation and imitation activities. There is also an extensive literature on club convergence explaining the fact that the growth rates of a group of countries are converging to the same rate while others stagnate, such as in Aghion et al. (2005) and Howitt (2000). Our focus in this paper is on the group of countries that are converging, and we are to examine the technology distance to the frontier economy during the converging process.

Closely related to the convergence literature, several papers discuss the issue of technology distance to frontier. Acemoglu et al. (2006) analyze the possible non-convergence trap because of inappropriate institutions. Vandenbussche et al. (2006) examine the education policy given the distance to frontier showing that skilled labor has higher growth-enhancing the effect and thus higher education is more critical closer to edge. We follow the two papers’ shared assumption that technology improvement is obtained from both innovation and imitation. However, different from their models, the innovation and imitation inputs are capital and labor in our model. Moreover, the effects of fiscal policies on the long-run distance to frontier and social welfare are not examined in their models.

This paper also discusses the effects of taxation on welfare and current growth rates. As to the issue of optimal capital income tax, the conventional view advocates zero capital income tax (see, e.g., Atkinson and Stiglitz; 1976; Chamley, 1986; Judd, 1985; Ordover and Phelps, 1979). The central intuition is that the relative price of consumption in the future concerning consumption today goes to zero or infinity if capital income tax is favorable. Thus, favorable capital income tax is not optimal. Several later papers attempt to overturn the result. Chamley (2001) finds that capital income tax is not optimal when agents are credit constrained. Aghion et al. (2013) argue the result of Chamley (1986), and Judd (1985) no longer hold with endogenous growth models. Our finding in this paper also supports a positive capital income tax, as favorable capital income tax reduces the incentive to accumulate as well as leads to lower
labor income tax and therefore increases consumption and leisure. We attempt to propose a different approach in this theoretical literature.

This paper is organized as follows: Section 2 sets up the model. Section 3 analyzes the steady-state equilibrium; Section 4 discusses the effects of taxation on the distance to frontier and steady-state welfare; Section 5 concludes.

2. The Model

The basic model adopts the technology distance to the frontier framework developed by Acemoglu et al. (2006). Following is a detailed description of the economic environment in our model.

2.1. Productions

There are two types of production activities in the economy: final goods production and intermediate goods production. The productivity improvement occurs through two channels: innovations and technology adoption from the leading country. It is assumed that monopoly power exists in the intermediate goods sector, while the final good production is perfectly competitive.

2.1.1. Final Goods Production

A final goods producer uses a continuum of intermediate goods and a fixed factor as its inputs, subject to the following Cobb-Douglas production function:

\[ Y_t = F^{1-\alpha} \int_0^1 A_t^{\alpha} X_t^{\lambda} \, d\lambda, \quad A_t > 0, \quad 0 < \alpha < 1 \]  

(1)

Where the subscript t refers to time; \( A_t \) is a productivity parameter; \( \alpha \) measures the contribution of an intermediate good to the final goods production and inversely measures the intermediate monopolist’s market power; F is the quantity of the fixed factor; \( Y_t \) is the final output; and \( X_t \) is the flow of intermediate good i. For simplicity, we normalize the amount of the fixed factor to unity (F = 1). We also omit the time subscript t throughout the paper whenever there is no potential confusion caused. As a result, the final goods production function can be rewritten as

\[ Y = \int_0^1 A_t^{1-\alpha} X_t^{\lambda} \, d\lambda, \quad A_t > 0, \quad 0 < \alpha < 1 \]  

(2)

Profit maximization in the competitive final goods sector implies the following demand function for intermediate good i:

\[ P_i = \frac{\partial Y_t}{\partial X_i} = \alpha A_t^{1-\alpha} X_t^{\lambda-1}, \quad i \in [0, N] \]  

(3)

Where \( P_i \) is the price of intermediate good i in terms of the final good, the final good is used as the numeraire for all prices.
2.1.2. Intermediate Goods Production

Each intermediate producer \( i \) that has a patented technology and uses one unit of final good to produce one unit of an intermediate good. Given the interest rate \( r \) and the final good sector’s demand for intermediate goods given by (3), each intermediate good producer chooses the size of production that will maximize its profit:

\[
\Pi_i = P_i X_i - X_i = \alpha A_i^{1-\alpha} X_i^\alpha - X_i
\]

(4)

The solution to this maximization problem gives the demand function for \( X_i \), which in turn provide the profit \( \Pi_i \) of an intermediate goods producer, such that:

\[
\frac{2}{\alpha} X_i = A_i \alpha^{1-\alpha}
\]

(5)

and

\[
\frac{2}{\alpha} \Pi_i = \alpha (1 - \alpha) A_i \alpha^{1-\alpha}
\]

(6)

In a symmetric equilibrium, all firms have the same productivity. Then the value of \( X_i \) is independent of \( i \), and \( A_i \) is identical for all \( i \). We can denote \( X = X_i \), and rewrite \( Y \) as follows.

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\[
\Pi_i = P_i X_i - X_i = \alpha A_i^{1-\alpha} X_i^\alpha - X_i
\]

(7)

The solution to this maximization problem gives the demand function for \( X_i \), which in turn provide the profit \( \Pi_i \) of an intermediate goods producer, such that:

\[
X_i = A_i \left(\frac{2}{\alpha}\right)^{1-\alpha}
\]

(8)

And,

\[
\Pi_i = \alpha (1 - \alpha) A_i \left(\frac{2}{\alpha}\right)^{2-\alpha}
\]

(9)

In a symmetric equilibrium, all firms have the same productivity. Then the value of \( X_i \) is independent of \( i \), and \( A_i \) is identical for all \( i \). We can denote \( X = X_i \), and rewrite \( Y \) as

\[
Y = A^{1-\alpha} X^\alpha = A \alpha \left(\frac{2}{\alpha}\right)^{2-\alpha}
\]

(10)

As a result, the profit \( \Pi \) could be written as
\[ \Pi = \alpha(1 - \alpha)Y \]  
(11)

i.e., aggregate monopoly profit \( \Pi \) will be proportional to aggregate final output \( Y \). This result implies that any policy that expands aggregate final output will also raise the profit of intermediate production and thus stimulate innovation and economic growth.

2.2. Technology Improvement

Technology improvements of the intermediate products are obtained from two channels: (i) imitation activities aimed at adopting the world frontier technologies; (ii) innovation upon the local technological frontier. Both innovation and imitation use physical capital and labor as R&D inputs. In line with Acemoglu et al. (2006) and Vandenbussche et al. (2006), the dynamics of technology in sector the following equation can capture:

\[ A_i = \lambda \left\{ \left( \frac{K_{im}}{A} \right)^\beta l_{im}^{1-\beta} (\bar{A} - A) \right\}^\phi + z \left[ \left( \frac{K_{in}}{A} \right)^\beta l_{in}^{1-\beta} A \right]^{\frac{1}{\phi}} \]  
(12)

Where \( K_{im}, l_{im} \) are the capital and labor hired for innovation and \( K_{im}, l_{im} \) are those for limitation. \( \bar{A} \) is the world productivity frontier at time \( t \), and \( A \) is the aggregate technology in the local economy. \( \phi \) measures the elasticity of substitution between innovation and imitation in technology improvement and \( 0 < \phi < 1 \). When \( \phi = 1 \), innovation and imitation activities will be perfectly substitutable. However, usually one may think that innovation and imitation activities are complementary to some degree to facilitate technology progress. That is, innovation and imitation are not perfect substitutes. Besides, to avoid corner solution, we only consider the case when \( \phi < 1 \). \( \beta \) is the capital intensity in both sectors. \( \lambda \) and \( z \) are both constants scaling technological growth.

Firm \( i \) will then choose \( K_{im}, l_{im} \) and \( K_{im}, l_{im} \) to maximize the discounted value of the firm:

\[ V_t = \int_t^\infty G_s \exp \left( - \int_t^s r_{d\tau} \right) ds \]  
(13)

where

\[ G_s = \Pi_t - r(K_{im} + K_{in}) - w(l_{in} + l_{im}) = \alpha(1 - \alpha)A^{2\alpha} \frac{\alpha}{\alpha + 1} - r(K_{im} + K_{in}) - w(l_{in} + l_{im}) \]  
(14)

Here, \( r \) is the interest rate, and \( w \) is the wage rate. The firm maximizes the value of the firm (equation (13)) subject to the dynamics of technology progress (equation (12)). The current value Hamiltonian function for the problem is as follows:

\[ H = \alpha(1 - \alpha)A^{2\alpha} \frac{\alpha}{\alpha + 1} - r(K_{im} + K_{in}) - w(l_{in} + l_{im}) + \mu \lambda \left( \left( \frac{K_{im}}{A} \right)^\beta l_{im}^{1-\beta} (\bar{A} - A) \right)^{\phi} + 
\begin{align*}
&z \left[ \left( \frac{K_{in}}{A} \right)^\beta l_{in}^{1-\beta} A \right]^{\frac{1}{\phi}} \]  
(15)
Where $\mu$ is the co-state variable. The first order conditions for firm $i$ are:

$$M \mu \beta K_{im}^{\phi-1} l_{im}^{(1-\beta)\phi} \frac{(\bar{A} - A)\phi}{\lambda} = r$$  (16)

$$M \mu (1 - \beta) K_{im}^{\phi-1} l_{im}^{(1-\beta)\phi} A^{(1-\beta)\phi} = w$$  (17)

$$M \mu \beta z K_{im}^{\phi-1} l_{im}^{(1-\beta)\phi} A^{(1-\beta)\phi} = r$$  (18)

$$M \mu \beta z (1 - \beta) K_{im}^{\phi-1} l_{im}^{(1-\beta)\phi} A^{(1-\beta)\phi} = w$$  (19)

$$\alpha (1 - \alpha) \alpha^{\frac{2\alpha}{1-\alpha}} = r \mu - \dot{\mu}$$  (20)

with transverse condition:

$$\lim_{t \to \infty} e^{-rt} \mu_t A_t = 0$$  (21)

where

$$M = \left[\left(\frac{K_{im}}{A}\right)^{\beta} l_{im}^{1-\beta} (\bar{A} - A)\phi + z\left[\left(\frac{K_{im}}{A}\right)^{\beta} l_{im}^{1-\beta} A\right]^{1-\phi}\right]^{\frac{1-\phi}{\phi}}.$$ Equations (16) (respectively (17), (18), (19)) equalizes the marginal benefit and marginal cost of capital input in imitation (respectively, labor input in imitation, capital input in innovation, labor input in innovation). Equation (20) is the optimal dynamic condition for the technology level.

2.3. Households

The model economy is populated by a continuum of infinitely-lived identical households with measure one. The household has the utility function:

$$U = \int_0^\infty [\ln C + \epsilon \ln (L - l)] \exp (-\rho t) \, dt$$  (22)

Where $C$ is per capital consumption and $\rho$ is the constant rate of time preference. $L$ is the total labor supply which is allocated into either imitation or innovation. $s$ is the weight of leisure in the utility function. The typical household has a budget constraint:

$$C + \dot{K} = r K (1 - \tau_K) + W L (1 - \tau_l) + P_F + \chi$$  (23)

Where $K$ is capital stock; $P_F$ is the return to the fixed factor; $\chi$ is the dividends from R&D activities and intermediate productions; $\tau_K$ and $\tau_l$ are the taxes for capital income and labor income, respectively. The typical household chooses consumption $C$, the labor supply $l$ to maximize its lifetime utility, subject to the budget constraint. The current-value Lagrange function for this optimization problem is:

$$L_{DE} = \ln C + \epsilon \ln (L - l) + \sigma \left[ r K (1 - \tau_K) + W L (1 - \tau_l) - C + P_F + \chi \right]$$  (24)
Where $\sigma$ is the co-state variable associated with Equation (20). The first-order conditions for this optimization problem are (23) together with the following terms:

$$\frac{1}{c} = \sigma$$  \hspace{1cm} (25)

$$\epsilon L^{-1} = \sigma w_l(1 - \tau_l)$$ \hspace{1cm} (26)

$$\sigma r(1 - \tau_k) = -\sigma + \rho \sigma$$ \hspace{1cm} (27)

Equation (25) (respectively, (26)) equalizes the private marginal benefit and cost of consumption (respectively, labor supply). Equation (27) is the optimal dynamic conditions for capital accumulation.

2.4. Government Budget

Assuming that the government’s budget is balanced at each point in time, we have:

$$G = rK\tau_K + Wl\tau_L$$ \hspace{1cm} (28)

Where the left-hand side is the total government expenditure, while the right-hand side is the total revenue from capital income and labor income, we assume that the government expenditure is a fixed fraction $g_0$ of the final output, i.e., $G_t = g_0 Y_t$, with $0 < g_0 < 1$.

The resource constraint of the economy is then:

$$Y = C + \dot{K} + G + X$$ \hspace{1cm} (29)

where output is allocated into consumption, investment, government expenditure and intermediate good production.

3. Decentralized Steady-State Equilibrium

In this section, we use the first-order conditions for consumer’s optimization problem and the first-order conditions for (final good, intermediate good, and innovation) firms’ profit maximization problems to derive a system of equations that describes the steady-state equilibrium of the decentralized economy.

In the steady state, the labor supply ($l = l_m + l_n$) and interest rate ($r$) is constant, and all of the other variables (consumption $C$, physical capital stock $K$ and final output $Y$) grow at the same constant rate. To describe the steady state, we define $q = Q/A$ to obtain a stationary model ($Q$ could be consumption $C$, physical capital stock $K_m$ and $K_n$ and final output $Y$). Moreover, define $\omega = w/A$. Then in the steady state, $k_m, k_n, k, c, y, \omega$ are all constant.
We assume the growth rate of the technology frontier is $g^*$. In steady state, the growth rate of the decentralized equilibrium should converge to $g^*$ as well. We can see this from equation (12). Since all the firms are symmetric, we have $A_i = A$. Thus, we can rewrite equation (12) as:

$$\frac{\dot{A}}{A} = \lambda \{k_m \beta \phi l_m (1-\beta)\phi (\bar{A}/A - 1)\phi + z k_n \beta \phi l_n (1-\beta)\phi \}^{\frac{1}{\phi}}$$

(30)

This result is similar to Vandenbussche et al. (2006). The difference is that here the R&D inputs are labor and physical capital instead of skilled and unskilled labor. $A$ grows at a constant rate $g$, we have $\frac{\dot{A}}{A} = g$. Furthermore, because $k_m$, $k_n$, $l_m$ and $l_n$ are all constant in steady state, $\frac{\dot{A}}{A}$ must be constant as well. Thus, we have $\frac{\dot{A}}{A} = \frac{\dot{A}}{A} = g^*$. It is straightforward that the relative productivity of the local economy to the leading country $\alpha$ is also constant in steady state. Clearly, $\alpha$ measures the technology distance to the frontier economy. A closer to 1 means the technology is closer to the frontier.

From Eq. (25) and Eq. (27), we have:

$$r = \frac{g^* + \rho}{1 - \tau_k}$$

(31)

From Equation (20), we have

$$\mu = (1 - \alpha)^{\frac{1+\alpha}{1-\alpha}}/r$$

(32)

Dividing Equations (16) and (17) and also Equations (18) and (19), we have

$$\frac{l_m}{k_m} = \frac{l_n}{k_n} = \frac{(1-\beta)r}{\beta w}$$

(33)

Combining Equations (16), (18) and (33) into Equation (12) yields:

$$\beta g^*(1 - \alpha)^{\frac{1+\alpha}{1-\alpha}}r^{-2} = k + k_n$$

(34)

In the intermediate goods sector, we have already shown that:

$$x = \alpha^{\frac{2}{1-\alpha}}$$

(35)

and

$$y = \alpha^{\frac{2\alpha}{1-\alpha}}$$

(36)

Equations (22) and (23) yield,

$$c = \frac{w(1-\tau_l)(1-l_m-l_n)}{\varepsilon}$$

(37)
Transforming the aggregate resource constraint to \((1 - g_0)y = c + (k_m + k_n)g^* + x\), and plugging Equations (36), (37), and (33), we have

\[
(1 - g_0 - \alpha^2)\frac{2\alpha}{\alpha + \alpha - \alpha} - \frac{w(1 - \tau)\beta L}{\alpha} = (k_m + k_n)[g - \frac{(1 - \tau_1)(1 - \beta)r}{\beta \epsilon}]
\]  

(38)

Re-writing the above equation and plugging into Equation (34), we have

\[
w = \frac{(1 - g_0 - \alpha^2)\alpha^{1 - \alpha} - \beta g^{-2}(1 - \alpha)\alpha^{1 - \alpha}r^{-2} \epsilon}{(1 - \tau)\beta L} + (1 - \tau)\alpha^{1 - \alpha}r^{-2} \Delta
\]  

(39)

To get the equilibrium of \(\alpha\), we plug Equation (33) into Equations (16) and (18)

\[
k_n = \phi_1 w^{\frac{-\phi(1 - \beta)}{(1 - \phi)}}
\]

(40)

\[
k_m = \phi_2 w^{\frac{-\phi(1 - \beta)}{(1 - \phi)}} \left( \frac{1}{\alpha} - 1 \right)^{\frac{(1 - \phi)}{(1 - \phi)}}
\]

(41)

\[
\phi_1 = \frac{\alpha}{\lambda} \left[ (1 - \alpha)\alpha^{1 - \alpha} \lambda \beta (1 - \beta) \phi r (1 - \beta)^{1 - \phi} \right]^{\frac{1}{\phi}}
\]

and

\[
\phi_2 = \frac{\alpha}{\lambda} \left[ (1 - \alpha)\alpha^{1 - \alpha} \lambda \beta (1 - \beta) \phi r (1 - \beta)^{1 - \phi} \right]^{\frac{1}{\phi}}
\]

Plugging the above two equations into (31), we have

\[
(1/\alpha - 1)^{\frac{(1 - \phi)}{(1 - \phi)}} = \frac{\beta g^{*2}(1 - \alpha)\alpha^{1 - \alpha}w^{\frac{(1 - \phi)}{(1 - \phi)}}}{\phi_2 r^2} = \frac{1}{z^{1 - \phi}}
\]

(42)

The distance to frontier is determined by the capital income tax and labor income tax as well as other parameters.


The government chooses the combination of a capital income tax rate \(\tau_1\) or a labor income tax \(\tau_2\) (or mixed policies) to finance the government spending, which is a constant fraction of the final output. There are three main concerns of the government while deciding its policy choice: enhancing economic growth, promoting social welfare, and moreover, shortening the technology distance to frontier. The effects of the tax rates on the three targets may be different. Thus, the government faces trade-off to balance the three objectives.

The policy choice must ensure the decentralized equilibrium condition, Equation (42), and government budget constraint, Equation (28), are satisfied. From Equation (34), we have:

\[
k_m + k_n = \frac{\beta g^{*2}(1 - \alpha)\alpha^{1 - \alpha}w^{\phi(1 - \beta)}}{\phi_2 r^2} \frac{(1 - \tau_1)^{(1 - \beta)r}}{(g^* + \rho)^2}
\]

(43)
It indicates that an increase in capital income tax will decrease the capital level in a country. From Equations (33) and (28), we have

\[ g_0y = r(k_m + k_n)\tau_k + w(l_m + l_n)\tau_l = r(k_m + k_n)(\tau_k + \tau_l) \]  

(44)

From the above equation, we can derive

\[ \frac{g_0^{\frac{2a}{1-\sigma}}(g^*+\rho)}{\beta g^*(1-\sigma)\alpha^{1-\sigma}} = (1 - \tau_k)(\tau_k + \tau_l) \]  

(45)

Rewrite the above equation, we get

\[ \tau_l = \frac{g_0^{\frac{2a}{1-\sigma}}(g^*+\rho)}{\beta g^*(1-\sigma)\alpha^{1-\sigma}(1-\tau_k)} - \tau_k \]  

(46)

4.1. Single Tax Financing

If the government only has access to capital income tax, to finance the required expenditure, the corresponding tax rate \( \tau_{kg} \) should satisfy:

\[ (1 - \tau_{kg})\tau_{kg} = \frac{g_0^{\frac{2a}{1-\sigma}}(g^*+\rho)}{\beta g^*(1-\sigma)\alpha^{1-\sigma}} \]  

(47)

However, if the government only has access to labor income tax, to finance the required expenditure, the corresponding tax rate \( \tau_{lg} \) should satisfy:

\[ \tau_{lg} = \frac{g_0^{\frac{2a}{1-\sigma}}(g^*+\rho)}{\beta g^*(1-\sigma)\alpha^{1-\sigma}} \]  

(48)

In this section, we consider the welfare effects and growth effects of taxations. The social welfare is measured by the lifetime utility of the representative household. Here, we only consider steady state welfare. That is to say; we assume the economy starts from a steady-state. In the following section where we discuss the transitional dynamics, we will present the result for welfare with the transitional path which we call total welfare. The steady-state welfare is then:

\[ \Gamma = \max \int_0^\infty e^{-\rho t}[lnC + \epsilon \ln(L - l)]dt = \frac{1}{\rho} [lnC + \epsilon \ln(L - l)] + \frac{g}{\rho^2} \]  

(49)

Proposition 1: With the access to only one tax instrument, to finance the required expenditure which is a fixed share \( g_0 \) of the final output, the required capital income tax rate \( \tau_{kg} \) is higher than the necessary labor income tax rate \( \tau_{lg} \).

Proof: Apparent, from Equations (47) and (48). Q.E.D. From Equations (39), and (37), we have:
\[
c = \alpha^{2a}(1 - g_0 - \alpha^2)\frac{g^2(1-a)\alpha^{1+\alpha}(1-\tau_k)^2}{(g + \rho)^2} \\
l_m + l_n = \frac{g^*(1-\beta)(1-a)\alpha^{1+\alpha}}{\epsilon(g^*+\rho)}\left\{\frac{2a^{2\alpha}(1-g_0-\alpha^2)}{(1-\tau_k)(1-\tau_l)} + \frac{(1-\beta)(1-a)\alpha^{1+\alpha}g}{\epsilon(g + \rho)} - \frac{g^2(1-a)\alpha^{1+\alpha}(1-\tau_k)}{(g + \rho)^2(1-\tau_l)}\right\}^{-1} \tag{51}
\]

**Proposition 2:** With access to only one tax instrument, the steady state welfare under capital income tax financing is greater than that under labor income tax financing.

**Proof.** From Equations (47) and (48) as well as \(\tau_k > \tau_l\), it is easy to get the consumption level is higher under capital income tax, while the total labor supply is lower under capital income tax which implies a higher leisure level. Thus, according to the steady-state welfare equation \(\Gamma = \frac{1}{\rho}[\ln c + \epsilon \ln (L-1)] + \frac{g}{\rho^2}\), the welfare is higher under capital income tax.

### 4.2. Mixed Taxes Financing

Combining Equations (28) and (33), fixing the value of \(g_0\), we assign different values to \(\tau_k\) and \(\tau_l\) on the country’s steady state welfare and technology distance to frontier. The analytical results are hard to obtain in this case. Thus, we exploit the numerical results in the following.

#### 4.2.1. Benchmark Model

In this numerical example, we choose an exogenous worldwide growth rate \(g^* = 0.03\). The population in the economy is assumed to be 1, and each household is endowed with one unit of time. The discount factor \(\varphi = 0.02\) is consistent with the literature. The leisure elasticity in utility \(s = 0.08\) ensures a labor supply of 0.6583. We assume that the capital intensity in the inputs to productivity improvement is \(\beta = 0.4\). The share of a fixed factor in the final product is chosen as \(1-\alpha = 0.3\). \(\varphi\) measures the substitutability between innovation and imitation in generating technology growth. We choose \(\varphi = 0.3\), \(\lambda = 0.02\) and \(z = 1\) to generate a steady state technology distance \(a = 0.6573\).

#### 4.2.2. Introducing Fiscal Policy

The government collects revenue from capital income tax and labor income tax to finance government spending. Assume that the share of government spending in final output is \(g_0 = 0.01\). Next, we will compare the welfare effects and technology improving effects of the two taxes. Firstly, we assume government expenditure is financed only by capital income tax.

We get the following result which is consistent with Proposition 2:

**Result 1:** In terms of technology distance, labor income tax is superior to capital income tax. However, capital income tax is superior to labor income tax in terms of welfare.

Next, we use both capital income tax and labor income tax to finance government spending and report the findings in Table 1. Figure (1) and Figure (2) show the effects of tax changes on
technology distance and welfare.

The results can be summarized as follows:

Result 2: With a constant share of government spending, relative technology level decreases in capital income tax, while social welfare increases in capital income tax.

<table>
<thead>
<tr>
<th>Table 1. Comparison of Single Tax Financing</th>
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<tbody>
<tr>
<td>Technology distance</td>
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<tr>
<td>Capital income tax financing</td>
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<tr>
<td>Labor income tax financing</td>
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</tbody>
</table>

Since the growth rate of the local economy converges to the growth rate of the leading country, the steady state welfare is determined by steady-state consumption and labor supply. With higher capital income tax, there will be a lower incentive to accumulate capital. Therefore, the steady-state capital decreases in \( \tau_k \). Consumption then increases. On the other hand, higher capital income tax means lower labor income tax. Lower labor income tax then leads to lower wage rate and thus lower labor supply. Together, higher capital income tax leads to higher welfare. This result is different from literature because the growth rate effect of capital income tax is eliminated in the steady state.

With higher capital income tax, there is a lower incentive to accumulate which results in a lower steady-state capital stock for R&D input. Moreover, a smaller labor income tax leads to lower labor supply. Both of the inputs to technology improvement are decreasing in \( \tau_k \). Thus, the steady state relative technology level is reducing in \( \tau_k \). That is to say, the higher the capital income tax, the further the steady state distance to the frontier economy.
5. Conclusion

In this paper, we assume that the technological progress of an economy comes from both innovation and imitation. By introducing fiscal policy, we examine the growth effects and welfare effects of taxation mix. Moreover, we analyze the impact of taxation on the long-run technology distance to the frontier economy. We find that higher capital income tax results in longer steady state distance to frontier while it increases steady-state welfare. The policy implication for government is then to balance not only between growth rate and social well-being, but also to balance the long-run distance to frontier and social well-being. Higher capital income tax increases social welfare but reduces the short run economic growth and long-run relative technology level of the economy. Low capital income tax in many developing countries may not be because of the short sightedness of the governments. It can also be because the governments care more about the long run distance to frontier.

References


