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EFFECTS OF TAXES AND PUBLIC GOODS ON ECONOMIC GROWTH IN ENDOGENOUS GROWTH MODELS

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ABSTRACT

For several decades the neoclassical growth theory dominated the growth literature. The engine of economic growth is the exogenously given rate of technical change in this theory. Empirical measure of this exogenous technical change is called Solow residual. For less developed countries the way to catch up industrially advanced countries is to hope realized Solow residuals be large enough. This is because, the rate of economic growth is policy invariant. This means that the neoclassical growth model has nothing to say about growth miracles of the so called Asian tigers. Furthermore, the neoclassical growth theory implies that per capita income levels should eventually convergence. Therefore, it fails to explain sustained differences in growth rates across countries. The failure of the neoclassical growth model led to the development of endogenous growth models. Endogenous growth models try to explain economic growth endogenously rather than assuming it is exogenously given. An important result we can draw from the endogenous growth models is that convergence in per capita income levels may not hold even in the long-run. However, this conclusion still does not explain the sustained difference in per capita income levels and growth rates. This study shows that economic growth is not policy invariant. Changes in tax rates and tax regimes have significant effects on the rate of economic growth. This means that a tax system that taxes investment less than others will have a favorable effect on the rate of economic growth. The effects of public goods and public investment on economic growth are also examined. The results obtained in this study shows that capital type public goods are important factors that determine the rate of economic growth. This is important because it clearly shows that public investment in infrastructure which has a significant positive externality can play an important role for many less developed countries to break the development traps. A most significant result of the study is related to the accumulation of human capital. Endogenous growth models seem to be more realistic if we take into account that a significant input to production in modern economies is human capital. Human capital has the most significant spillover effect which serves as an engine to economic growth. Therefore, government policies that creates significant incentives to human capital accumulation will help to break the poverty barriers many less developed countries face.

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1. Introduction

Recent developments in economic growth theory created much controversy among professional economists about the effects of government policies on economic growth rates. In the neoclassical growth model, government policies, particularly taxes, never mattered at all. Economists, based on the exogenous technical change assumption of the neoclassical growth model, were in deadlock: No one seemed to be sure of the answers to the question of what the government of a country with per capita real income level under one thousand and a growth rate under one percent can do. Is the destiny of the poor countries is to stay poor? Is the only relief to borrow from World Bank? Or, is there something that can create hope for these countries as well as others? These are serious questions about which the economists got excited since late 1980's with the introduction of endogenous growth models primarily in Romer (1986, 1989) and Lucas (1988), although some building blocks of these models date back to Arrow (1962) and Uzawa (1965).

Contrary to the neoclassical growth model, economic growth is not taken to be exogenously given in endogenous growth models. Engine of the growth is externality type knowledge spillover with constant returns in Romer (1986, 1989). In Lucas (1988), endogenous growth stems basically from constant returns to human capital accumulation, although the model incorporates knowledge spillover. Barro (1990) and Barro and Sala-i-Martin (1992) treat public goods as entering into the production function of the private sector and endogenous growth results in their model with the optimizing behavior of government. Endogenous growth models diverge greatly from the neoclassical model in terms of the policy actions of governments. In endogenous growth models, government is not a powerless entity in affecting growth rate of the economy. Tax and subsidy decisions of governments can have considerable effects on the rate of economic growth. Simulation studies of King and Rebelo (1990) showed that taxes can substantially affect the long-run growth rates and this can lead to "development traps" or to "growth miracles" particularly for small open economies with substantial capital mobility. Rebelo (1991) argues that heterogeneity of growth experiences can be explained by the cross country differences in government policies. Simulation exercises of Jones, Manuelli and Rossi (1993) showed that radical tax reforms have large effects on welfare and growth. In a simulation study, Trostel (1993) found substantial tax effects on human capital accumulation, hence, on the rate of economic growth.

One significant conclusion we can be drawn from the neoclassical model is that countries with the same exogenous rate of technical change should convergence in per capita income in the long-run. Differences in per capita income can only be explained by transitional dynamics. In the steady states,

countries should converge in per capita income. Differences in per capita income can only exist when the countries are off the steady states. On the contrary, in endogenous growth models, differences in per capita income levels may persist indefinitely independent of the transitional dynamics unless some severe restrictions are imposed on the model. As shown in section 2, cross country differences in growth rates may well be a mere consequence of economic policies of governments.

The purpose of this paper is to show that government policies have significant effects on the rate of economic growth when economic growth is modeled as an endogenous phenomenon. In particular, I show that taxes are not neutral with respect to rate of economic growth and the rate and type of the tax matter. For instance, income taxes reduce the rate of economic growth while lump-sum taxes have no effect. A clear policy implication of this result is that changes in income tax rates and tax reforms will have significant effect on the rate of economic growth. I also show that productive services of governments or capital type public investment are important factors that determine the rate of economic growth. Furthermore, type of public goods combined with a special type of tax is a significant factor determining the rate of economic growth. This paper also shows that the rate of economic growth prevailing in market economies in the absence of government intervention falls short of the Pareto optimal growth rate. Therefore, government policies that pushes the rate of economic growth towards the Pareto optimal growth rate are indispensable policies for developing as well as developed countries. These results further brings an explanation for the sustained differences in growth rates across countries. As long as there are differences in the tax regimes and type of public goods provided by the governments there will be sustained differences in growth rates. These results are the most significant implications of the endogenous growth models and contrast sharply with the neoclassical growth model in which the rate of economic growth is invariant to the differences in government policies.

In section 2, I first present a modified version of Romer model and compare income and lump-sum taxes in terms of their effects on the per capita income growth rate when public goods enter directly into the utility function, i.e., all public goods are treated as consumption goods. Section 2 also shows that the results obtained from the Romer model cannot be obtained in a Lucas type endogenous growth model unless some additional assumptions are introduced. However, both the Romer and Lucas models imply that actual growth rate falls short of the Pareto optimal growth rate. Therefore, government intervention is necessary for the Pareto optimality. In section 3, I examine the Barro model in which public goods are treated as inputs to the private sector production. In 4, I compare and contrast the neoclassical and endogenous growth models. It is shown that convergence in per capita income across countries may not hold

because of tax effects even though one imposes restrictions on endogenous growth models to break down the differences with the neoclassical model in the absence of a government sector. Section 5 concludes the paper.

2. Tax Effects in Endogenous Growth Models

Arrow (1962) and Romer (1986, 1989) developed dynamic learning-by-doing models in which per capita production, y, depends on per capita capital, k, and also on the aggregate (in some versions average) stock of capital, K. The intuition in including aggregate capital stock as an input in the production function is that knowledge or ideas spillover from one producer to another. The effect of knowledge spillover on the growth rate can be captured by including the aggregate capital stock in firm's production function. A significant consequence of this type of model is that the competitive equilibrium growth rate falls short of the Pareto optimum growth rate unless producers are compensated for the spillover effect. In the Romer model, the imposition of an income tax leads to further divergence of the growth rate from the Pareto optimal solution.

I will assume that producers are identical, number of producers is equal to number of workers, full employment is satisfied, and population (number of workers or producers) is constant. Production function is assumed to be the following Cobb-Douglas form:

$$y = f(k, K) = k^{\alpha} K^{\theta}, \tag{2.1}$$

where K is given by

$$K = \sum_{i=1}^{N} k_i = Nk, \tag{2.2}$$

where N is the number of firms (workers). The per capita capital stock accumulates according to the following differential equation:

$$\dot{k} = k^{\alpha} K^{\theta} - c, \tag{2.3}$$

where c is per capita consumption. The momentary utility function is

$$u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma} \tag{2.4}$$

so that marginal utility has constant elasticity $-\sigma$. In this function σ^{-1} is the elasticity of substitution or the coefficient of risk aversion. Preferences over consumption streams are given by

$$\lim_{t\to\infty} e^{-\delta t}\lambda(t)k(t) = 0$$

should also be satisfied. I will assume that the transversality conditions are satisfied for all the optimal control problems that follow. I will also leave out the transition equations from the first order conditions.

Now define q_τ as the per capita income growth rate under income taxation. It is simple to show that q_τ also equals to per capita consumption growth rate. From (2.8) it follows that

$$\frac{\dot{\lambda}}{\lambda} = \sigma q_\tau. \tag{2.11}$$

Substituting (2.2) and (2.11) into (2.9) and assuming constant returns, i.e., $\alpha + \theta = 1$, yields

$$q_\tau = \sigma^{-1}\left((1-\tau)\alpha N^\theta - \delta\right). \tag{2.12}$$

The most striking features of the growth rate given (2.12) can be stated as follows. First, this economy will grow at a constant rate q_τ, provided that $(1-\tau)\alpha N^\theta > \delta$, even if there is no exogenous technical change. This economy is capable of creating growth without any exogenous technical change. Second, growth rate of the economy depends on the preferences of the society. This is clear from the dependence of the growth rate q_τ on the parameters σ and δ. The dependence on the σ means that economies with thriftier consumers will grow faster than economies with less thriftier consumers. That is, an economy that saves more will grow faster. From the inverse dependence of the growth rate on the parameter σ, it can also be seen that risk averse societies will grow faster than risk taking societies. Third and last, the government intervention will affect the growth rate of the economy. For instance, higher tax rates inversely affects the growth rate in (2.12). It is simple to show that not only the taxes but almost all other government policies affect the growth rate of the economy in endogenous growth models.

As seen from (2.12) income tax reduces per capita income growth rate of the economy. This result contradicts the result of the neoclassical growth model in which income tax has no effect on the growth rate.

Under no tax or lump-sum tax assumption, solution to P1 would yield

$$\int_0^\infty u(c(t))e^{-\delta t}dt, \tag{2.5}$$

where δ is the discount rate. One can obtain convergence results from the endogenous growth models by imposing some restrictions. However, existence of a government sector breaks down the convergence in the endogenous growth models. Thus, I will explicitly introduce the government sector into the models I study to show the effects of government policies on the growth rate. Assume that output is taxed at rate τ and revenues are rebated to consumers, i.e., government provides only consumption services. Further, assume that the government budget is balanced. This can be stated as

$$g = \tau f(k, K), \tag{2.6}$$

where g is the per capita consumption services to individuals. Under these assumptions, consumers face a dynamic optimization problem for which the solution can be obtained using the optimal control theory. The dynamic optimization problem faced by consumers can be stated as follows:

$$\text{(P1)} \quad \max \int_0^\infty u(c(t)+g(t))e^{-\delta t}dt,$$
$$\text{s.t.} \quad \dot{k} = (1-\tau)k^{\alpha}K^{\theta} - c.$$

To solve P1, I set up the following current value Hamiltonian:

$$H = \frac{(c+g)^{1-\sigma}-1}{1-\sigma} + \lambda\left((1-\tau)k^{\alpha}K^{\theta} - c\right). \tag{2.7}$$

First order conditions for dynamic optimality are given by

$$\lambda = (c+g)^{-\sigma}, \tag{2.8}$$

$$-\frac{\dot{\lambda}}{\lambda} = (1-\tau)\alpha k^{\alpha-1}K^{\theta} - \delta, \tag{2.9}$$

$$\dot{k} = (1-\tau)k^{\alpha}K^{\theta} - \lambda^{-1/\sigma} + g. \tag{2.10}$$

Dynamic optimality also requires that the transversality condition

$$q_c = \sigma^{-1}\left(\alpha N^{\theta} - \delta\right). \tag{2.13}$$

Equation (2.13) shows that lump-sum tax is superior to income tax since it yields a higher growth rate. Under income tax the reduction in growth rate is $q_c - q_\tau = \sigma^{-1}\tau\alpha N^{\theta}$.

One point worth to mentioning is that the growth rate given by (2.13) is suboptimal even under no tax or a lump-sum tax. The reason for this suboptimality is that producers are not compensated for the externality (knowledge spillover) they create. Therefore, capital accumulation, hence growth rate, falls short of the one dictated by the Pareto optimality. Of course, as any other externality, this opens a room for government intervention. Government can provide the Pareto optimal growth rate

$$q_p = \sigma^{-1}\left(N^{\theta} - \delta\right) \tag{2.14}$$

by imposing a lump-sum tax and subsidizing the purchase of capital goods at rate $\left(1-\alpha N^{\theta}\right)$. This raises the growth rate by $q_p - q_c = \sigma^{-1}(1-\alpha)N^{\theta}$.

The Arrow-Romer model is not the only model that can create endogenous growth. Uzawa (1965) and Lucas (1988) introduced models that create endogenous growth through human capital accumulation. The engine of growth in the Uzawa-Lucas model is constant returns to human capital accumulation rather than constant returns to nonhuman capital accumulation. Therefore, education and policies that affect human capital accumulation are much more important in the Uzawa-Lucas model. However, it is possible to show that a simple income tax that are rebated back to consumers as consumption goods has no effect on the growth rate of the economy in the Uzawa-Lucas type endogenous growth models.

I modify the Uzawa-Lucas model to include income taxation and analyze the effects of income tax on the per capita income growth rate. Our model explicitly incorporates the government sector into the analysis. Production function in this model is

$$f\left(k,h,\bar{h}\right) = k^{\alpha}\left(uh\right)^{1-\alpha}\bar{h}^{\theta}, \tag{2.15}$$

where h is the per capita human capital, $\bar{h}$ is the average per capita human capital that captures the knowledge spillover, and u is the fraction of worker's nonleisure time that is devoted to the production of physical goods. Human capital accumulation is governed by

$$\dot{h} = \gamma(1-u)h, \tag{2.16}$$

where $(1-u)$ is the fraction of nonleisure time devoted to human capital accumulation and γ represents the effectiveness in human capital accumulation or learning. If we interpret h as education, then, γ represents the quality of schools. Assuming that output is taxed at rate τ and proceedings are rebated to consumers, the dynamic optimization problem can be stated as follows:

$$\max \int_0^\infty u(c(t)+g(t))e^{-\delta t}dt,$$

$$\text{(P2)} \qquad \text{s.t.} \quad \dot{k} = (1-\tau)k^\alpha (uh)^{1-\alpha}\bar{h}^\theta - c,$$

$$\dot{h} = \gamma(1-u)h.$$

I set up the following current value Hamiltonian for P2:

$$H = \frac{(c+g)^{1-\sigma}-1}{1-\sigma} + \lambda_1\left((1-\tau)k^\alpha (uh)^{1-\alpha}\bar{h}^\theta - c\right) + \lambda_2\gamma(1-u)h. \tag{2.17}$$

First order conditions are

$$(c+g)^{-\sigma} = \lambda_1, \tag{2.18}$$

$$-\frac{\dot{\lambda}_1}{\lambda_1} = (1-\tau)\alpha k^{\alpha-1}(uh)^{1-\alpha}\bar{h}^\theta - \delta, \tag{2.19}$$

$$-\frac{\dot{\lambda}_2}{\lambda_2} = (1-\tau)(1-\alpha)\frac{\lambda_1}{\lambda_2}k^\alpha u^{1-\alpha}h^{-\alpha}\bar{h}^\theta + \gamma(1-u) - \delta. \tag{2.20}$$

Combining (2.18) and (2.19) and using the equilibrium condition $h = \bar{h}$, I obtain

$$(1-\tau)\alpha k^{\alpha-1}u^{1-\alpha+\theta} = \delta + \sigma q_\tau. \tag{2.21}$$

Differentiating (2.21) with respect to time, using $\dot{h}/h = \gamma(1-u)$ from (2.16), and noting that $\dot{k}/k = \dot{c}/c$, I obtain

$$q_\tau = \left(1+(1-\alpha)^{-1}\theta\right)\lambda(1-u). \tag{2.22}$$

As it is clear from (2.22) income taxation does not have any effect on the per capita income growth rate. I would obtain (2.22) under no tax or lump-sum tax assumption. Therefore, income taxes and lump-sum taxes are identical in this model. Nevertheless, there is still a scope for government intervention resulting from the suboptimality of (2.22). Government can lead to the Pareto optimal growth rate by subsidizing the use of human capital input, and it does not make any difference whether this subsidy is financed by an income or lump-sum tax. Furthermore, neutrality of income taxation would certainly not hold, if I relax the assumption that the tax revenues are rebated to consumers as consumption goods and services. If one assumes that the tax revenues are used to subsidize education, then γ would depend on g and the growth rate would be higher than the growth rate obtained under competitive solution of the Uzawa-Lucas model.

3. Government Productive Services in Endogenous Growth Models

In section 2, I treated public goods as consumption goods that enter directly into the utility function. Recent studies on public goods, such as, Barro (1990) and Barro and Sala-i-Martin (1992), assumed that some public goods are public capital type and enter into the production function as productive services. This section treats public goods as productive services and incorporates them into the production function following Barro (1990).

I will assume that private capital is broadly defined in the sense that it encompasses human capital and nonhuman capital to simplify the model. In some cases, I will also assume that production function exhibits constant returns to scale to private capital. Models that follow are similar in nature to ones in Barro (1990) and Barro and Sala-i-Martin (1992). These type of endogenous growth models also show that per capita income across countries may not grow at the same rate due to the different tax policies. Therefore, convergence in per capita income level may not hold across countries.

Let the production function be given by

$$y = f(z, g, \ldots), \tag{3.1}$$

where y is the per capita output, z is the private capital in broad concept, and g is the public services (public capital). Now, I can define the optimization problem as

$$\text{(P3)} \qquad \max \int_0^\infty u(c(t))e^{-\delta t}dt,$$

$$\text{s.t.} \quad \dot{z} = f(z, g, \ldots) - c.$$

Current value Hamiltonian for P3 is

$$H = \frac{c^{1-\sigma} - 1}{1-\sigma} + \lambda\left(f\left(z, g, \ldots\right) - c\right), \tag{3.2}$$

and FOC's are

$$c^{-\sigma} = \lambda, \tag{3.3}$$

$$-\frac{\dot{\lambda}}{\lambda} = f_z - \delta. \tag{3.4}$$

From (3.3) I obtain

$$q_c = \frac{\dot{c}}{c} = \sigma^{-1}\frac{\dot{\lambda}}{\lambda}. \tag{3.5}$$

Combining (3.4) and (3.5), I get

$$q_c = \sigma^{-1}\left(f_z - \delta\right). \tag{3.6}$$

Note that positive growth implies $f_z > \delta$. To see that solve (3.5) for $c(t)$, which is

$$c(t) = c(0)e^{\sigma^{-1}(f_z - \delta)t}. \tag{3.7}$$

Then consumption growth is positive if $f_z > \delta$. I also require that utility is bounded, i.e., integral in P3 should be convergent. Substituting (3.7) into this integral, I get

$$\int (1-\sigma)^{-1}\left(c(0)^{1-\sigma} e^{\left(\left(\sigma^{-1}-1\right)(f_z-\delta)-\delta\right)t} - e^{-\delta t}\right)dt.$$

This integral is convergent if $\delta > (1-\sigma)f_z$. Therefore, I will assume that the following condition holds

$$f_z > \delta > (1-\sigma)f_z. \tag{3.8}$$

I will define a general form production function which will simplify the discussions in the following sections. I consider the following general form:

$$f(z,g,Z) = z\left(gN^{1+\eta-\phi}Z^{-\psi}\right)^{\alpha}, \tag{3.9}$$

where N is total number of firms (which is assumed to be equal to the total number of workers or population), and Z is the aggregate private capital stock defined as

$$Z = \sum_{i=1}^{N} z_i = Nz. \tag{3.10}$$

Barro (1990) and Barro and Sala-i-Martin (1992) examine the effects of taxes when tax revenues are used to finance publicly provided private goods, pure public goods, or public goods subject to congestion. I will now examine these three cases in the context of the above model.

3.1. Publicly Provided Private Goods

When the goods provided by the government are publicly provided private goods, then, I have $\phi = \eta = \psi = 1$. Therefore, production function becomes

$$f(z,g) = z^{1-\alpha}g^{\alpha}. \tag{3.11}$$

I assume that government runs a balanced budget and levies a proportional tax on private output at the rate $\tau = g/f$. Return to private capital can be obtained from (3.11), which is

$$f_z = (1-\tau)(1-\alpha)\left(\frac{g}{f}\right)^{\alpha/(1-\alpha)}. \tag{3.12}$$

As government provides one unit of g it reduces private resources by one unit. Hence, a natural efficiency condition proposed by Barro (1990) for the size of government is

$$f_g = \alpha f g^{-1} = 1. \tag{3.13}$$

Then, from (3.13) I have

$$g/f = \alpha. \tag{3.14}$$

Therefore, $g/f = \alpha = \tau$. Substituting (3.12) and (3.14) into (3.5), I obtain

$$q_\tau = \sigma^{-1}\left((1-\tau)(1-\alpha)\alpha^{\alpha/(1-\alpha)} - \delta\right). \tag{3.15}$$

If government were to levy a lump-sum tax, then the term $(1-\tau)$ would be absent from equation (3.15). Therefore, growth rate given by (3.15) is less than the Pareto optimal growth rate. One way to obtain the Pareto optimal solution is to impose a lump-sum tax, which can be a consumption tax in this model since there is no leisure choice in the model. Alternatively, subsidizing the private purchases of capital goods at rate τ would result in the Pareto optimal growth.

3.2. Pure Public Goods

In this section, public goods are treated as Samuelson goods: non-rival and non-excludable public goods. In this case, I set $\eta = \psi = 1$ and $\phi = 0$, which gives the following production function:

$$f(z,g) = z^{1-\alpha}(gN)^{\alpha}. \tag{3.16}$$

Again, assuming a proportional tax, $g/f = \tau$, equation (3.12) is replaced by

$$f_z = (1-\tau)(1-\alpha)\left(\frac{gN}{f}\right)^{\alpha/(1-\alpha)}. \tag{3.17}$$

Equation (3.14) still holds, then growth rate becomes

$$q_\tau = \sigma^{-1}\left((1-\tau)(1-\alpha)(\alpha N)^{\alpha/(1-\alpha)} - \delta\right). \tag{3.18}$$

Under the Pareto optimality, equation (3.18) would not contain $(1-\tau)$. As in the previous case, the Pareto optimal growth rate can be obtained either by switching to lump-sum taxes or subsidizing the private purchases of capital.

Henceforth, I showed that lump-sum tax is Pareto superior to income tax since the former yields the same growth rate as the one dictated by the Pareto optimality.

3.3. Public Goods Subject to Congestion

In this section, I allow for the congestion of the public goods and services. In this case, public goods are rival but not excludable. For a given level of aggregate public services, $G = Ng$, the quantity and/or quality of public services available to a single producer will be less (either in quantity or quality, or both), if other producers raise their usage levels. Usage levels of producers are represented by the aggregate private capital, Z. To obtain a production function with the congestion of public services I set $\phi = \eta = 0$ and $\psi = 1$. This yields

$$f(z,g,Z) = z\left(gNZ^{-1}\right)^{\alpha}. \tag{3.19}$$

Again, I assume that government levies a proportional tax $g/f = \tau$, on the output. From (3.12), private return to capital is given by

$$f_z = (1-\tau)\left(\frac{g}{f}\right)^{\alpha/(1-\alpha)}. \tag{3.20}$$

Noting that the condition for the optimal government size still holds, I obtain the following growth rate:

$$q_\tau = \sigma^{-1}\left((1-\tau)\alpha^{\alpha/(1-\alpha)} - \delta\right). \tag{3.21}$$

I should point out that the growth rate given in (3.21) is equal to the Pareto optimal growth rate. The Pareto optimal solution with production function (3.19) would replace τ by α in equation (3.21). Note that, $\alpha = \tau = g/f$, then the growth rate in (3.21) is the Pareto optimal growth rate.

We see that the income tax leads to the Pareto optimal solution when the public services are subject to congestion. Using a lump-sum tax would yield a growth rate higher than the one dictated by the Pareto optimality. In this last case, lump-sum tax is not superior to income tax, because income tax works as a user fee and prevents excessive use of public goods when there is congestion.

4. A Comparison of Endogenous Growth Models with the Neoclassical Growth Model

In this section, I will compare the implications of the endogenous growth models studied in previous sections with the implications of the neoclassical growth model of Ramsey (1928), Solow (1956), Swan (1964), Cass (1965), and Koopmans (1965). Without going into details, implications of the neoclassical growth theory can be derived from the following model:

$$\text{(P4)} \qquad \max \int_0^\infty u\big(c(t)+g(t)\big)e^{-\delta t}\,dt,$$
$$\text{s.t.} \quad \dot{k} = (1-\tau)Ak^{\alpha} - c.$$

where exogenously given rate of technical change, $\dot{A}/A$, is ω. The current value Hamiltonian associated with this problem is

$$H = \frac{(c+g)^{1-\sigma}-1}{1-\sigma} + \lambda\big((1-\tau)Ak^{\alpha} - c\big). \tag{4.1}$$

First order conditions for the dynamic optimality are given by

$$\lambda = (c+g)^{-\sigma}, \tag{4.2}$$

$$-\frac{\dot{\lambda}}{\lambda} = (1-\tau)\alpha Ak^{\alpha-1} - \delta, \tag{4.3}$$

$$\dot{k} = (1-\tau)Ak^{\alpha} - \lambda^{-1/\sigma} + g. \tag{4.4}$$

Proceeding as in the previous sections, growth rate is given by

$$q_\tau = (1-\alpha)^{-1}\omega. \tag{4.5}$$

It is easy to show that even if there is no tax on the output, growth rate would be $\omega/(1-\alpha)$, hence, income tax has no effect on the steady state growth rate in the neoclassical model.

It should be clear from the preceding result that there is a substantial difference between the endogenous growth models I have examined and the neoclassical growth model in terms of their responsiveness to income tax. Basically, the neoclassical growth model and the Uzawa-Lucas model are steady state invariant to income tax. Although the income tax reduces growth rate off the steady states, there will be no effect once the economy is on the steady state growth path. In contrast, in the Barro and Romer models, income tax will have a permanent effect on the growth rate.

One of the most important differences between the endogenous growth models and the neoclassical model is that thriftiness and risk aversion has no effect on the steady state growth rate in the neoclassical model. This can be seen from the absence of the parameters δ and σ in (4.5). Therefore, in the

neoclassical growth model, a country that saves more will be richer but will not grow faster than a country that saves less. On the other hand, in the endogenous growth models, a country that saves more grows faster indefinitely.

Another consequential implication is that history does not matter in the neoclassical model, i.e., with the same technology and preferences, every country will converge in per capita income level independent of which country starts off first. In the endogenous growth models, this consequence is turned on its head.

A well established result from the transitional dynamics of the neoclassical growth model states that per capita income growth rate is inversely related to the initial level of per capita income. Therefore, poor economies grow faster than rich economies. Combining this result with the identical technology and preferences, I obtain an important consequence: Economies or countries will converge in per capita income independent of the initial level of per capita income or per capita capital stock.

There is nothing inherent in the endogenous growth models to result in convergence in per capita income levels unless one assumes identical technologies, preferences and tax regimes with the same tax rates across countries. Convergence, in the endogenous growth models, will break down due to differences in government policies. Particularly, policies hat create incentives for savings and accumulation of human capital will play a very significant role in explaining the growth rate differences across countries. Another point worth to mentioning is that the same technology assumption together with the exogenously given rate of technical change results in convergence in per capita income growth rate independent of the preferences in the neoclassical growth model. This should be clear from the dependence of growth rate defined in (4.5) only on the parameters α and ω.

In the endogenous growth models, convergence in per capita income levels does not hold in general either because of the same reasons which breaks down convergence in the neoclassical model, mainly technological differences across countries, or differences in initial per capita income or capital stock across economies, which does not matter in the neoclassical growth model. Furthermore, in the Romer and Barro models, convergence in per capita income levels breaks down because of the variations in tax rates, which has no effect in the Uzawa-Lucas and neoclassical models. Convergence in per capita income growth rates does not hold in all endogenous growth models due to differences in technology and preferences. Additionally in the Romer and Barro models convergence in the per capita income growth does not hold, because of the tax differences and initial values of the per capita income or the per capita capital stock with the exception that these initial values do not affect the growth rates when public goods are pure or congestion type in the Barro model.

Conclusion

Many economists did not find the neoclassical growth model satisfactory for several decades, because this model is not capable of explaining sustained differences in per capita income levels and per capita income growth rates. Given the exogenous technical change assumption, the neoclassical growth model implies that less developed countries should grow faster than the developed countries. Therefore, less developed countries should eventually catch up the developed countries in terms of per capita income level. However, this convergence proposition does not hold even for the most industrially advanced countries. There are sustained differences in per capita income levels as well as growth rates even among the most industrially advanced countries.

The implications of the neoclassical growth model may be consistent with the history of some fast growing Asian countries. The so called Asian tigers do actually have a growth rate well above the growth rate of industrially advanced countries. Unfortunately, the neoclassical growth model does not have much to say about growth miracles of these Asian countries. The fast growth in these countries is an endogenous phenomenon rather than the result of exogenously given technical change which the neoclassical growth model presumes. Economists should have a different story to explain the growth histories of these countries.

Endogenous growth models take a different approach and relax the assumption of exogenously given rate of technical change. These models assume that growth is an endogenous phenomenon. Realistic models of growth should be able to explain this phenomenon. One approach to model the growth as an endogenous phenomenon is to assume constant returns to capital. The intuition behind this assumption is knowledge or technology spillover. A new technology spillovers from firm to firm creating a positive externality. Thus the level of aggregate capital may be thought as representing the size of knowledge spillover and enters into the production function as a separate input. The models constructed under this constant returns assumption creates economic growth without any exogenous technical change.

A very disappointing result of the neoclassical growth model is the policy invariance of the economic growth rate. An economist who takes the neoclassical growth theory granted has no policy recommendation to less developed countries. However, this study shows that policy invariance property of the neoclassical growth model does not generalize to the endogenous growth models. First conclusion we draw from the endogenous growth models is that income tax has a direct affect on the economic growth rate. Second, it is shown that there is scope for government intervention in market economies, because the growth rate that

results in market economies is not Pareto optimal. Government intervention is essential to obtain the Pareto optimal growth rate. Third, this study also shows that government productive services and type of taxes imposed have a direct effect on the rate of economic growth. These results help to explain sustained differences in growth rates among less developed as well as developed countries.

The results obtained in this study has significant policy implications for the governments of less developed countries. First, thriftiness and risk awareness matter. Therefore, a thriftier society saves more and grows faster. Thus, policies targeted to increase saving rate will improve the growth rate. Second, tax regime and income tax rates have a direct effect on the rate of economic growth. Tax reforms that reduce capital taxes and taxes that are particularly affecting human capital accumulation will also raise the rate of economic growth. Third, contrary to many claims in the literature large public capital may be desirable and will in general affect the economic growth positively. Therefore, policies that lead to higher public investment may be an important policy tool. Fourth and last, endogenous growth models point out to an important source of economic growth that is human capital. Therefore, policies that lead to a rise in human capital accumulation may help to break the poverty barrier faced by many less developed countries.

ÖZET

Neoklasik büyüme teorisi çok uzun bir zamandır iktisadi büyüme konusundaki literatüre hakim olmuştur. Be teoride dışsal olarak veri teknolojik değişme büyümenin lokomotifi rolünü görmektedir. Bu dışsal teknolojik değişmenin ampirik ölçümüne Solow artık değeri denmektedir. Neoklasik büyüme teorisinin sonuçlarına göre azgelişmiş ülkelerin gelişmiş ülkeleri yakalayabilmek için Solow artık değerinin yeterince yüksek gerçekleşmesini ümit etmekten başka yapabilecekleri fazla bir şey yoktur. Bunun sebebi, bu teoriye göre iktisat politikasının ekonomik büyüme hızını değiştirmekte etkinsiz olmasıdır. Bu neoklasik büyüme teorisinin Asya kaplanları olarak bilinen ülkelerin gerçekleştirdiği büyüme mucizesi hakkında söyleyecek hiçbir şeyinin olmaması demektir. Daha da önemlisi, neoklasik büyüme teorisi nihai olarak kişi başına gelir seviyelerinin eşitlenmesini öngörmektedir. Böylece, bu teori süregiden ülkelerarası kişi başına gelir ve büyüme hızı farklılıklarını açıklamakta başarısız kalmaktadır. Neoklasik büyüme teorisinin bu başarısızlığı, içsel büyüme modellerinin geliştirilmesine neden olmuştur. İçsel büyüme modelleri ekonomik büyüme hızını dışsal olarak veri almak yerine onu içsel olarak modellemektedir. İçsel büyüme modellerinden elde edilen çok önemli bir sonuç uzun dönemde dahi kişi başına gelir seviyelerinin eşitlenmeyebileceğidir. Ancak, bu sonuç süregiden kişi başına gelir ve büyüme hızı farklılıklarını açıklamakta yetersizdir. Bu çalışma ekonomik büyüme hızının ekonomik politika değişikliklerine karşı

duyarsız olmadığını göstermektedir. Vergi sistemi ve vergi oranlarındaki değişmelerin ekonomik büyüme hızı üzerinde önemli bir etkiye sahip olduğu gösterilmiştir. Buna göre, yatırımı daha düşük oranlarda vergileyen bir vergi sistemi ekonomik büyüme hızını olumlu yönde etkileyecektir. Kamu mallarının ve kamu yatırımlarının ekonomik büyüme hızı üzerindeki etkileri de incelenmiştir. Elde edilen sonuçlar göstermektedir ki sermaye türündeki kamu malları ve bu tür kamu mallarına yapılan kamu yatırımları ekonomik büyüme hızını belirleyen çok önemli faktörlerdir. Bu çok önemli bir sonuçtur, çünkü az gelişmiş ülkelerin özellikle altyapı yatırımlarını artırmak suretiyle düşmüş oldukları geri kalmışlık tuzağından kurtulabileceklerini göstermektedir. Bu çalışmanın en önemli sonuçlarından birisi beşeri sermaye birikimi ile ilgilidir. İçsel büyüme modelleri beşeri sermayenin üretimde önemli bir girdi olduğu modern ekonomiler için daha gerçekçi bulunmaktadır. Beşeri sermaye yarattığı çok önemli pozitif dışsal ekonomiler sebebiyle ekonomik büyümede lokomotif rolü görmektedir. Beşeri sermaye birikimini teşvik eden politikalar birçok az gelişmiş ülkenin yoksulluk çemberini kırmasında çok önemli bir rol oynayabilir.

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