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Service Sector And Optimal Taxation In An Endogenous Growth Model

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Abstract:
The paper entitled "Service sector and optimal taxation in an endogenous growth model" is formed in a command economy framework. In this model, the commodity output is produced with physical capital only, where the skilled labour is being used for producing the service good. Moreover, in this model, per capita government expenditure is used to create human capital. The model derives the optimal tax rate and steady-state growth path in an endogenous growth framework in a two-sector economy, when the service sector is being taxed only. This paper has done comparative static analysis on optimum service tax. The influence of population growth and the intensity of preference towards commodity consumption on service tax is analysed here.

KEY WORDS: taxation, government policy, endogenous growth, command economy, human capital accumulation.

Introduction: This paper is based on optimal tax policy, in the presence of service sector whose output is fully consumed. The development of endogenous growth theory enabled the policy makers to implement different fiscal policies in the growth model. There exists a huge literature that discusses the effects of various policies in endogenous growth models. The model is based on the assumption that the government spends tax revenue to finance accumulation of human capital.

The study by **Greiner A (2008)** tries to figure out the effects of fiscal policy in an endogenous growth model, giving special emphasis on human capital and heterogeneous agents.

Across the world, the human capital and education sector play a very important role in the development of any economy, a lot of works have been done on the theories of human capital accumulation in growth economics.

Hollanders and Weel (2003) have worked on the role of public expenditure on the human capital accumulation in a Lucas(1988) type growth model. The study by **Greiner (2006)** focuses on an endogenous growth model which is based on the assumption that human capital accumulation results from the investment of the public resources. The investment is financed by imposing income tax and from issuing government bonds.

Following **Heckman (1976) and Rosen (1976)**, the paper by **King and Rebelon (1990)** tries to find optimal accumulation of human capital and the effects of various taxation on optimal accumulation. The basic finding of the model is, the costs of welfare are higher for endogenous growth models than in neoclassical models with exogenously given technical progress.
There exists a huge number of papers that consider the role of government expenditure on public resources by the revenue earned through taxation in endogenous growth models. **Garcia-Castrillo and Sanso (2000) and Gomez (2003)** designed optimal fiscal policies in the **Lucas (1988)** model. The paper by **Gomez (2003)** also finds that the tax financed educational subsidy policy is optimal one. However, in the analysis of Gomez (2003), lump sum tax is never found to be optimal to finance the subsidy.

In the present paper, we assume that there exists a command economy where the service sector uses human capital as one and only input, which is accumulated through government expenditure on education sector. The physical output is used to produce commodity output only. Government expenditure is financed by tax revenue, which is earned through imposing tax on production sectors. In one of my papers, **written by me and my co-authors, Gupta et. al (2019) titled** "Optimal tax policy in an endogenous growth model with a consumable service good", we have derived steady-state growth paths. But , that paper finished out to leave a few comparative static analysis. In this paper, I have tried to figure out those undone derivations using the growth analysis. Therefore, the rest of the paper is organised as follows: In section 2, the basic general model is presented; In Section 3, optimal tax policy and steady-state growth paths are derived when service sector is being taxed only; In section 4, corresponding comparative static analysis is done under command economic regime.

2. The model:

Section 2 first describes the basic model and then shows the functioning of the economy under command economic regime.

The Households, Firms and Government:

A closed economy model is considered with two sectors namely, commodity sector and service sector. The total labour force is homogeneous as far as skill is concerned. The commodity and the factor markets are characterized by perfect competition. Identical rational agents inhabit the economy. Production technology is subject to constant returns to scale. Preferences over the consumption of different combinations of the commodity and service output are given by the following function where 'c' and 's' denote the flow of real per capita consumption of commodity and service output respectively.

$$u(c)=\int_0^{\infty}\frac{(c^{\alpha}s^{1-\alpha})^{1-\sigma}-1}{(1-\sigma)}e^{-\rho t}N(t)dt \qquad 1.$$

Here, we assume that the output of the commodity sector can be used for consumption or investment. The output of the service sector is fully consumed. Let α be the parameter that measures the intensity of preference towards commodity consumption and $(1-\alpha)$ measures the preference for service output consumption. The commodity output is a function of physical capital whereas the service product is produced with human capital only. Let ρ be the discount rate and σ, the elasticity of marginal utility and inverse of which is known as inter temporal elasticity of substitution. Let N represents the total labour force or working population.

The commodity and service output production functions can be written as

$$y_c = AK \qquad 2.$$

$$y_s = B(Nh) \qquad 3.$$

Where y_c and y_s are commodity and service output. K is the aggregate physical capital. It is further assumed that the general skill level of a worker is 'h'. The effective skilled work force in commodity production is 'Nh'. A is a positive constant that reflects the level of technology. B is the index of knowledge available to the workforce.

The level of population is growing at an exponential rate in the following manner:

$$N(t) = N_0 e^{nt} \qquad 4.$$

Here, N_0 stands for the population size at initial time period. For simplicity the initial size of population is normalised, i.e., $N_0 = 1$. According to our assumption, government spends money on education to create human capital.

The human capital accumulation function can be written as

$$\dot{h} = \eta \frac{G}{N} \qquad 5.$$

Here η is the technology parameter of human capital accumulation whose value is always positive and G stands for government expenditure.

While considering the command economy, the objective of the economy is to maximize the value of utility defined by equation (1) subject to the constraint of physical capital and that of human capital.

3. The Command economy: When service sector is being taxed only

In this section, it is assumed that only the service sector is being taxed. The tax revenue is spent as government expenditure to build human capital. Let the tax rate be τ_s which is levied on per unit production of service output. Now the balanced budget equation can be written as

$$G = T = \tau_s y_s \qquad 6.$$

For this particular sector-specific model, the human capital accumulation function is follows as

$$\dot{h} = \eta \frac{G}{N} = \eta \tau_s Bh \qquad 7.$$

After deducting the taxable amount, the service output that is left as disposable service output, is totally consumed by the population. So the market clearing condition is derived as

$$s = (1 - \tau_s) Bh \qquad 8.$$

It is assumed that commodity output over aggregate consumption is accumulated as physical capital. The physical capital accumulation function is given by

$$\dot{K} = y_c - Nc \qquad 9.$$

The Command Economy allocates resources by solving a grand optimization problem **Dasgupta (1999).** The objective of the social planner is to maximize the value of utility defined by equation (1) subject to the constraints given by physical capital and human capital as stated in equation (9) and (7). The value of 's' which denotes per capita consumption of service output in our model, is substituted by equation (8) in the following Hamiltonian function.

The current value Hamiltonian as given in (10) is maximised with respect to the control variables c and τ_s where the state variables are K and h. Here, θ_1 and θ_2 are the shadow prices associated with $\dot{K}$ and $\dot{h}$ which stand for physical capital investment and human capital accumulation.

$$H = N(t)[\frac{[c^{\alpha}\{(1-\tau_s)Bh\}^{1-\alpha}]^{1-\sigma} - 1}{(1-\sigma)}] + \theta_1[AK - cN] + \theta_2 \eta \tau_s Bh \qquad 10.$$

From the first order conditions of the control variables and two co-state equations of state variables, the growth rates of per capita commodity output consumption, human capital accumulation and physical capital are solved (for detailed derivation see Appendix).

Steady-state growth paths when service sector is taxed only:

The growth rate of per capita commodity output is

$$\gamma_c = \frac{(1-\sigma)(1-\alpha)B\eta\tau_s + A - \rho}{\{1-\alpha(1-\sigma)\}} \qquad 11.$$

The growth rate of human capital accumulation is

$$\gamma_h = B\eta\tau_s \qquad 12.$$

Diving both sides of investment function by K in equation (9), the growth rate of physical capital accumulation is found

$$\frac{\dot{K}}{K} = A - c\frac{N}{K}$$

$$\text{Or, } \gamma_K = A - c\frac{N}{K} \qquad 13.$$

As γ_K is constant in steady-state $(\frac{cN}{K})$ is also constant in steady-state.

Therefore $(\frac{cN}{K}) =$ Constant.

Taking logarithm both sides of the above equation and differentiating with respect to time

$$\gamma_K = \gamma_c + n \qquad 14.$$

Thus, the growth rate of human capital accumulation, rate of growth of commodity consumption and that of physical capital are derived from equations (12), (11) and (14) respectively. Let k be the capital to skilled labour ratio or $k = \frac{K}{Nh}$.

Taking logarithm both sides of the expression $k = \frac{K}{Nh}$, and differentiating with respect to time we get, γ_k.

Now $\gamma_k = \gamma_K - n - \gamma_h$

$$\text{Or, } \gamma_K = \gamma_k + n + \gamma_h \qquad 14'.$$

Equating the value of γ_K from equation (14) and (14') we get

$$\gamma_c = \gamma_k + \gamma_h \qquad 14''.$$

From the Hamiltonian function using the first order conditions of the control variables and the co-state equations of state variables we get the following equation

$$\rho - B\eta = \alpha(1-\sigma)\gamma_c + \{(1-\alpha)(1-\sigma)-1\}\gamma_h + n \qquad 15.$$

Substituting the expressions of γ_c, γ_h into the above equation we get

$$\rho - B\eta = \alpha(1-\sigma)\frac{\{(1-\sigma)(1-\alpha)B\eta\tau_s - \rho + A\}}{\{1-\alpha(1-\sigma)\}} + \{(1-\alpha)(1-\sigma)-1\}B\eta\tau_s + n \qquad 16.$$

From this equation we can solve the value of optimal tax rate while only the service output is being taxed under command economic regime.

The value of optimal tax rate is

$$\tau_s = \frac{A\alpha(1-\sigma) + \{1-\alpha(1-\sigma)\}(n+B\eta) - \rho}{B\eta\sigma} \qquad 17.$$

Substituting the value of optimal service tax in the growth paths, we can solve the optimal growth rate of the economy. The detail derivation has been done in appendix.

SECTION 4: COMPARATIVE STATIC ANALYSIS:

We have done two comparative static analysis on optimal service tax:

Differentiating service tax, with respect to intensity of preference towards commodity consumption, we get

$$\frac{\partial \tau_s}{\partial \alpha} = \frac{-(1-A)(1-\sigma)}{B\eta\sigma}$$

If σ <1 , which means when the elasticity of marginal utility, the inverse of which is known as inter temporal elasticity of substitution is less than 1, the tax on service commodity will be negatively related to the intensity of preference towards commodity consumption, i.e $\frac{\partial \tau_s}{\partial \alpha}$<0 and vice versa.

Proposition 1: When σ <1, $\frac{\partial \tau_s}{\partial \alpha}$< 0 ; the elasticity of marginal utility is less than 1, the tax on service commodity will be inversely related to the intensity of preference towards commodity consumption.

The logic behind such result is quite obvious. If individuals derive more utility from commodity consumption than service consumption it is advised to decrease tax on service output to encourage consumption of service.

Differentiating with respect to population growth,

$$\frac{\partial \tau_s}{\partial n} = \frac{\{1-\alpha(1-\sigma)\}}{B\eta\sigma}$$

If $\alpha < \frac{1}{(1-\sigma)}$, which means when the intensity of preference towards commodity consumption **is sufficiently low,** the tax on service commodity will be positively related to the growth rate of population.

Proposition 2: When $\alpha < \frac{1}{(1-\sigma)}$, $\frac{\partial \tau_s}{\partial n} > 0$**;** the tax on service commodity will be positively related to the growth rate of population.

The logic behind the result is, when population rises, the necessity for human capital accumulation also rises. For the required investment, the service tax has to be raised.

CONCLUSION:

This paper constructs a two-sector endogenous growth model under a command economic regime in order to discover the optimal tax policy. Commodity output is produced with only physical capital, whereas skilled labour is the only input used to produce service output. One tax regime is considered. In this regime, the service sector is taxed only. We first consider the benchmark model where the tax revenue is invested to create human capital through government expenditure. Steady-state growth paths are studied under a command economic regime. The optimal tax rate and steady-state growth path are derived.

Only when the service sector is taxed, along the steady-state balanced growth path the optimal service tax is found to be positive. This paper offers an alternative theory of optimal policy in a simplified model where human capital is used only in final services while physical capital is only used as an input to produce final commodities. This paper has done comparative static analysis on optimum service tax. The influence of population growth and the intensity of preference towards commodity consumption on service tax is analysed here.

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Appendix: When tax is levied on service good:

$$u(c,s)=\int\frac{(c^{\alpha}s^{1-\alpha})^{1-\sigma}-1}{(1-\sigma)}e^{-\rho t}N(t)dt \qquad (A.1)$$

$$y_c = AK \qquad (A.2)$$

$$y_s = B(hN) \qquad (A.3)$$

$$\dot{h}=\eta\frac{G}{N} \qquad (A.4)$$

$$G = T = \tau_s y_s \qquad (A.5)$$

$$(1-\tau)y_s = sN \qquad (A.6)$$

$$N(t)=e^{nt} \qquad (A.7)$$

$$\dot{K} = (1-\tau_s)y_c - cN \quad (A.8)$$

Using equation (A.3) into (A.5)

$$G = T = \tau_s y_s \quad (A.9)$$

Using equation (A.4) into (A.5)

$$\dot{h} = \eta \frac{\tau_s B(hN)}{N} = \eta \tau B h \quad (A.10)$$

Or, $\gamma_h = \eta \tau B$

Substituting the value of y_s into the market clearing equation (A.6) we have

$$(1-\tau_s)B(hN) = sN$$

Or, $s = (1-\tau_s)Bh$ (A.11)

The current value Hamiltonian can be formulated as

$$H = N(t)\{\frac{(c^{\alpha}s^{1-\alpha})^{1-\sigma}-1}{(1-\sigma)}\} + \theta_1[y_c - cN] + \theta_2 B\tau_s h\eta \quad (A.12)$$

Substituting the value of s into the Hamiltonian function

$$H = N(t)\{\frac{(c^{\alpha}\{(1-\tau_s)Bh)^{1-\alpha}]^{1-\sigma}-1}{(1-\sigma)}\} + \theta_1[y_c - cN] + \theta_2 B\tau_s h\eta \quad (A.13)$$

Control variables are c, τ_s. State variables are K, h.

The first order conditions are

$$\frac{dH}{dc} = 0$$

Or, $\alpha c^{\alpha(1-\sigma)-1}(1-\tau_s)^{(1-\alpha)(1-\sigma)}B^{(1-\alpha)(1-\sigma)}h^{(1-\alpha)(1-\sigma)} = \theta_1$ (A.14)

Taking logarithm both sides and differentiating with respect to time we get

$$\frac{\dot{\theta}_1}{\theta_1} = \{\alpha(1-\sigma)-1\}\gamma_c + (1-\sigma)(1-\alpha)\gamma_h - (1-\alpha)(1-\sigma)\frac{\dot{\tau}_s}{\tau_s}(\frac{\tau_s}{1-\tau_s}) \quad (A.15)$$

As τ_s is constant at steady-state, equation (A.15) is written as

$$\frac{\dot{\theta}_1}{\theta_1} = \{\alpha(1-\sigma)-1\}\gamma_c + (1-\sigma)(1-\alpha)B\eta\tau_s \qquad \text{(A.16)}$$

The co-state equation of the state variable K is

$$\dot{\theta}_1 = \rho\theta_1 - \frac{dH}{dK} \qquad \text{(A.17)}$$

Now, $\frac{dH}{dK} = \theta_1 A$

Substituting this value into equation (A.17)

$$\dot{\theta}_1 = \theta_1(\rho - A)$$

Or, $\frac{\dot{\theta}_1}{\theta_1} = (\rho - A)$ (A.18)

Equating the expressions of $\frac{\dot{\theta}_1}{\theta_1}$ from equations (A.16) and (A.18) we get

$$\rho - A = -\{1-\alpha(1-\sigma)\}\gamma_c + (1-\sigma)(1-\alpha)B\eta\tau_s$$

Or, $\gamma_c = \frac{(1-\sigma)(1-\alpha)B\eta\tau_s + A - \rho}{\{1-\alpha(1-\sigma)\}}$ (A.19)

The first order condition for the tax rate is

$$\frac{dH}{d\tau_s} = 0$$

Or, $N(t)c^{\alpha(1-\sigma)}B^{(1-\alpha)(1-\sigma)}h^{(1-\alpha)(1-\sigma)}(1-\alpha)(1-\tau_s)^{(1-\alpha)(1-\sigma)-1} = \theta_2 Bh\eta$ (A.20)Taking logarithm both sides and differentiating with respect to time

$$\{(1-\alpha)(1-\sigma)-1\}\gamma_h + \alpha(1-\sigma)\gamma_c + n = \frac{\dot{\theta}_2}{\theta_2} \qquad \text{(A.21)}$$

The other co-state equation is

$$\dot{\theta}_2 = \rho\theta_2 - \frac{dH}{dh} \qquad \text{(A.22)}$$

The first order condition for the tax rate is

$$\frac{dH}{dh} = N(t)c^{\alpha(1-\sigma)}(1-\tau_s)^{(1-\alpha)(1-\sigma)}B^{(1-\alpha)(1-\sigma)}(1-\alpha)h^{(1-\alpha)(1-\sigma)-1} + \theta_2 B\tau_s\eta$$

Or, $\frac{\dot{\theta}_2}{\theta_2} = \rho - B\eta(1-\tau_s) - B\tau_s\eta = \rho - B\eta$ (A.23)

Equating the expressions of $\frac{\dot{\theta}_2}{\theta_2}$ from (A.21) and (A.23) we get

$$\{(1-\alpha)(1-\sigma)-1\}\gamma_h + \alpha(1-\sigma)\gamma_c + n = \rho - B\eta \quad \text{(A.24)}$$

Substituting the value of γ_h and γ_c

Or, $\{(1-\alpha)(1-\sigma)-1\}\eta\tau_s B + \alpha(1-\sigma)[\frac{(1-\sigma)(1-\alpha)B\eta\tau_s - \rho + A}{\{1-\alpha(1-\sigma)\}}] + n = \rho - B\eta$

Solving τ in terms of parameters.

$$\tau_s = \frac{\{1-\alpha(1-\sigma)\}(n+B\eta) + A\alpha(1-\sigma) - \rho}{B\eta\sigma}$$

Now $\gamma_h = \eta\tau_s B$

Substituting the value of τ_s in growth equation of human capital we get

$$\gamma_h = \frac{\{1-\alpha(1-\sigma)\}(n+B\eta) + A\alpha(1-\sigma) - \rho]}{B\eta\sigma}\eta B$$

Or, $\gamma_h = \frac{\alpha(1-\sigma)[A-n-B\eta] + (n+B\eta-\rho)}{\sigma}$

Substituting the value of τ_s into γ_c expression we get

$$\gamma_c = \frac{(1-\sigma)(1-\alpha)B\eta[\frac{\{1-\alpha(1-\sigma)\}(n+B\eta) + A\alpha(1-\sigma) - \rho}{B\eta\sigma}] + A - \rho}{\{1-\alpha(1-\sigma)\}}$$

Or, $\sigma\{1-\alpha(1-\sigma)\}\gamma_c = [(1-\alpha)(1-\sigma)(n+B\eta) - \rho]\{1-\alpha(1-\sigma)\} + A[\sigma + \alpha(1-\alpha)(1-\sigma)^2]$

Or, $\gamma_c = \frac{[(1-\alpha)(1-\sigma)(n+B\eta) - \rho]}{\sigma} + A\frac{[\sigma + \alpha(1-\alpha)(1-\sigma)^2]}{\sigma\{1-\alpha(1-\sigma)\}}$

Differentiating τ_s with respect to α

$$\frac{\partial \tau_s}{\partial \alpha} = \frac{-(1-A)(1-\sigma)}{B\eta\sigma}$$

Differentiating τ_s with respect to n

$$\frac{\partial \tau_s}{\partial n} = \frac{\{1-\alpha(1-\sigma)\}}{B\eta\sigma}$$

$$\frac{\partial \tau_s}{\partial n} > 0, \quad \text{if } \{1-\alpha(1-\sigma)\} > 0$$

Now $\{1-\alpha(1-\sigma)\} > 0$

Or, $1 > \alpha(1-\sigma)$

Or, $\alpha(1-\sigma) < 1$

Or, $\alpha < \frac{1}{(1-\sigma)}$

If $\alpha < \frac{1}{(1-\sigma)}$, $\frac{\partial \tau_s}{\partial n} > 0$