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Service Sector, Human Capital Accumulation And Exogenous Growth Model

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Abstract: The present paper analyses an external growth model in a two sector economy. The model is constructed with commodity and service sector, with the assumption that the income earned from commodity production is used for consumption and investment purposes. Investment is used here for physical capital accumulation, whereas the service good is totally consumed. The model is formed in such a manner that only skilled labours are employed in the service sector.

In this paper, we have shown that there exists a unique steady state growth path of human capital accumulation which is determined completely by external parameters. The growth rate of consumption is determined by the efficiency of technology parameter of commodity production function and commodity output elasticity of labour.

Key words: Service sector, Exogenous growth model, human capital accumulation, optimal growth path.

Introduction: In introductory part, we will write a short literature review on service sector and growth model. As the basis of increased prosperity of a nation is nothing but economic growth, the accumulation of human and physical capital, both, accelerates the rate of growth. Innovations lead to technical progress. It also plays a major role in economic growth. The accumulation of capital along with innovations raises productivity of inputs and thereby increases the potential level of output. The growth theory, developed in the 1950s and 1960s, showed that the main driving force for economic growth was accumulation of capital via. technical progress which was assumed to be exogenous. The seminal works of Solow (1956) and Swan (1956) formalised the neoclassical one sector growth model where steady-state growth equilibrium of the economy depends on aggregate capital labour ratio that is time invariant. Further, the rate of growth of output is equal to the sum of two exogenous factors: the rate of technological progress and growth rate of labour force. In the transitional phase the rate of growth varies inversely with the capital intensity of the economy leading to globally stable steady state equilibrium. In this model, the monetary and the fiscal policies can not affect rate of growth in long run.

A huge literature exists that modified the simple one sector Solow- Swan growth model and discussed different issues in the theory of economic growth. Studies by Uzawa (1961, 1963, 1965), Hahn (1965), Takayama (1963, 1965), Drandakis (1963), Inada (1963). Tobin(1965) introduces real balance effect in the savings function of the Solow (1956) model where the rate of savings was exogenously given. Cass (1965) and Koopmans (1965), following Ramsey (1928) model introduced household's inter temporal utility maximization behaviour in their model and endogenised the saving rate.

The decade following 1980's experienced the emergence of the endogenous growth theory that determines the growth rate of the economy endogenously. The pioneering literature on endogenous growth theory are mainly contributed by Lucas (1988), Romer (1986, 1990), Arrow (1962), Barro (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) etc. The present dissertation titled "Service sector, skill enhancement and Exogenous Growth" deals with the issues related to service sector in the endogenous growth model along with possible policy issues.

The seminal paper of Lucas (1988) is the first theoretical literature that deals with the role of human capital accumulation on endogenous growth. The growth rate of per capita income in the Lucas (1988) model depends on the rate of growth of human capital accumulation which is determined by the labour time allocation of the individuals to acquire skill. There is effect of human capital on aggregate productivity. Lucas (1988) determined the steady state equilibrium growth rate of a competitive economy and compared it to that of the command economy. It was observed that the economic agents cannot internalize the externality in the competitive economy but the social planner can do so in the planned economy.

Uzawa (1963) constructed a model considering a perishable consumption good sector. This particular feature of the good sector in Uzawa(1963) model is almost same with one of the characteristics of service good. But Uzawa (1963) model did not consider human capital accumulation and it was basically an exogenous growth model with zero rate of growth.

There are number of papers that deal with the issue of human capital in enhancing economic growth. Some of the important papers are mentioned here. The papers by Riley (2012), Mankiw et al.(1992), Fuente and Domenech (2000), Romer(1990), Pistorius (2004), Siggel (2000, 2001), Horwitz(2005), Funke and Strulik (2000), Bundell et al.(1999), Mincer (1995), Fuente and Cicoone (2002) basically deal with the issue of human capital that boosts up economic growth.

The present paper titled 'Service sector, skill enhancement and exogenous growth model' is divided in the following sub-sections :

Section 1 will discuss about the formation of the model. Section 2 will discuss about the growth paths of the economy in this exogenous growth model. Section 3 will deal with the derivation of optimal working hours for skill enhancement.

Section 1: The model:

This section describes the basic model for the functioning of an economy under a command economic regime.

Households, Firms, and Government:

The service and commodity output production functions are as follows:
where 'y_c' and 'y_s' the flow of commodity output and service output respectively.
The commodity production function is $y_c = A_c N_1{}^{\eta} K^{1-\eta}$ 1.
And the service production function $y_s = A_s (N_2 uh)^{\beta}$ 2.
Let η and β be the commodity output elasticity of raw labour and service output elasticity of skilled labour abour respectively.
A_c measures the technological efficiency parameter for commodity production.
A_s measures the technological efficiency parameter for service production.
Following Lucas (1988) model , the accumulation of human capital is assumed to be proportional to the time allocated for education. Hence, human capital accumulation function is given by

$$\frac{\dot{h}}{h} = \delta(1-u) \qquad 3.$$

Here δbe the productivity parameter in the human capital accumulation function. It is

further assumed that skilled labor allocates 'u' fraction of time to produce commodity

output. Therefore the effective skilled work force in service production is $N_2 uh$.

It is assumed that the number of labor employed in commodity sector is N_1 and number of labour employed in service sector is N_2 respectively and N be the total labour force or working population such that

$$N = N_1 + N_2 \qquad 3a.$$

Population grows at a constant, exogenous rate and more over we assume that each segment of the population is growing at the same rate in the following way:

$$\frac{\dot{N}}{N} = \frac{\dot{N}_1}{N_1} = \frac{\dot{N}_2}{N_2} = \lambda \qquad 3b.$$

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

$$\dot{K} = y_c - Nc = y_c - (N_1 + N_2)c \qquad 4.$$

(4) can be written as

$$\dot{K} = A_c {N_1}^{\eta} K^{1-\eta} - (N_1 + N_2)c$$

It is also assumed that the service output is totally consumed

$$y_s = sN = s(N_1 + N_2) \qquad 5.$$

This paper considers a closed economy model with two sectors namely, commodity sector and service sector. The total labour force is heterogeneous with respect to skill level: skilled labour for service sector and unskilled labour or raw labour for commodity sector. The commodity and the factor markets are characterized by perfect competition. The economy is inhabited by identical rational agents. Production technology is subject to constant returns to scale. Preferences over consumption and service streams are given by the following function where 'c' and 's' denote flow of real per capita consumption of commodity and service respectively:

$$u(s,c) = \int_0^{\alpha} \{\frac{(c^{\alpha} s^{1-\alpha})^{1-\sigma} - 1}{(1-\sigma)}\} e^{-\rho t} (N_1 + N_2) dt \qquad 6.$$

Here α stands for the intensity of preference for commodity output and σdenotes the elasticity of marginal utility.

Section 2: Derivation of growth path

The objective of the economy is to maximize the value of utility defined by equation (6) subject to the constraints given by (3) and (4) in the above model.

The current value Hamiltonian can be written as,

$$H = \frac{(N_1+N_2)}{(1-\sigma)} [(c^{\alpha} s^{1-\alpha})^{1-\sigma} - 1] + \theta_1 [A_c {N_1}^{\eta} K^{1-\eta} - (N_1 + N_2)c] + \theta_2 [\delta h (1-u)]$$

7.

There are two decision variables u and c.

From (5), $y_s = s(N_1 + N_2)$

$$\text{Or, } s = \frac{A_s (N_2 u h)^{\beta}}{(N_1+N_2)} \qquad 9.$$

There are two decision variables u and c.

The first order conditions are

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

$$\text{Or, } \alpha c^{\alpha(1-\sigma)-1} s^{(1-\alpha)(1-\sigma)} = \theta_1 \qquad 8.$$

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

Or,

$$\frac{N}{N^{(1-\alpha)(1-\sigma)}}c^{\alpha(1-\sigma)}(A_s)^{(1-\alpha)(1-\sigma)}(N_2h)^{\beta(1-\alpha)(1-\sigma)}(1-\alpha)\beta u^{\beta(1-\alpha)(1-\sigma)-1}=\theta_2\delta h$$

10.

Taking logarithm both sides of equation (9) and differentiating w.r.t time,

$\frac{\dot{A}_s}{A_s}+\beta\frac{\dot{N}_2}{N_2}+\beta\frac{\dot{u}}{u}+\beta\frac{\dot{h}}{h}-\frac{\dot{N}}{N}=\frac{\dot{s}}{s}$ 11.

Two transversality conditions are

$$lim\, e^{-\rho t}\,\theta_1(t)K(t)=lim\, e^{-\rho t}\,\theta_2(t)h(t)=0$$

The two equations of co-state variables

$\dot{\theta}_1=\rho\theta_1-\frac{dH}{dK}$ 12.

$\dot{\theta}_2=\rho\theta_2-\frac{dH}{dh}$ 13.

$$H=\frac{(N_1+N_2)}{(1-\sigma)}[(c^{\alpha}s^{1-\alpha})^{1-\sigma}-1]+\theta_1[A_c({N_1}^{\eta}K^{1-\eta})-(N_1+N_2)c]+\theta_2[\delta h(1-u)]$$

$\frac{dH}{dK}=\theta_1A_c(N_1)^{\eta}(1-\eta)K^{-\eta}$ 14.

$$H=\frac{(N_1+N_2)}{(1-\sigma)}[c^{\alpha(1-\sigma)}\{\frac{A_s}{(N_1+N_2)}(N_2uh)^{\beta}\}^{(1-\alpha)(1-\sigma)}-1]+\theta_1[A_c{N_1}^{\eta}K^{1-\eta}-(N_1+N_2)c]+\theta_2\delta(1-u)$$

$\frac{dH}{dh}=(N_1+N_2)c^{\alpha(1-\sigma)}(\frac{A_s}{N_1+N_2})^{(1-\alpha)(1-\sigma)}(N_2u)^{\beta(1-\alpha)(1-\sigma)}h^{\beta(1-\alpha)(1-\sigma)-1}\beta(1-\alpha)+\theta_2\delta(1-u)$

(15)

Putting the value of $\frac{dH}{dK}$ from (14) into (12)

$\dot{\theta}_1=\rho\theta_1-\theta_1A_c(N_1)^{\eta}(1-\eta)K^{-\eta}$ (16)

Putting the value of $\frac{dH}{dh}$ from (15) into (13)

$\dot{\theta}_2=\rho\theta_2-\frac{N}{N^{(1-\alpha)(1-\sigma)}}c^{\alpha(1-\sigma)}(A_s)^{(1-\sigma)(1-\alpha)}(N_2u)^{\beta(1-\alpha)(1-\sigma)}h^{\beta(1-\alpha)(1-\sigma)-1}\beta(1-\alpha)-\theta_2\delta(1-u)$

(17)

Rewriting equation (8)

$$\alpha c^{\alpha(1-\sigma)-1}s^{(1-\alpha)(1-\sigma)}=\theta_1$$

Taking logarithm both sides and differentiating w.r.t time,

$\{\alpha(1-\sigma)-1\}\frac{\dot{c}}{c}+(1-\alpha)(1-\sigma)\frac{\dot{s}}{s}=\frac{\dot{\theta}_1}{\theta_1}$ (18)

From equation (11)

$\mu_s+\beta\frac{\dot{N}_2}{N_2}+\beta\delta(1-u)-\frac{\dot{N}}{N}=\frac{\dot{s}}{s}$ (11)

or, $\mu_s+(\beta-1)\lambda+\beta\delta(1-u)-\frac{\dot{N}}{N}=\frac{\dot{s}}{s}$

Putting this value from (11) into (18)

$\{\alpha(1-\sigma)-1\}g+(1-\alpha)(1-\sigma)[\mu_s+\beta\delta(1-u)+\lambda(\beta-1)]=\frac{\dot{\theta}_1}{\theta_1}$ (19)

Here g is the growth rate of consumption

Rewriting equation (16),

$\frac{\dot{\theta}_1}{\theta_1}=\rho-A_c(N_1)^{\eta}(1-\eta)K^{-\eta}$ (21)

Substituting the above value into equation (20)

$$\rho-\frac{dy_c}{dK}=\{\alpha(1-\sigma)\}g+(1-\alpha)(1-\sigma)[\mu_s+\beta\delta(1-u)+(\beta-1)\lambda]$$

or, $\frac{dy_c}{dK}=\rho-\{\alpha(1-\sigma)\}g-(1-\alpha)(1-\sigma)[\mu_s+\beta\delta(1-u)+(\beta-1)\lambda]$

In the above equation u , g will grow at a constant rate in steady-state . So

$\frac{dy_c}{dK}$ will also grow at a constant rate in steady-state.

From the production function, $\frac{y_c}{K}=A_cN_1{}^{\eta}K^{-\eta}=\frac{1}{(1-\eta)}.\frac{dy_c}{dK}$ (22)

It is obvious from the above equation that,

$\frac{y_c}{K}$ will also grow at a constant rate in steady-state $y_c=Nc+\dot{K}$

as $\frac{y_c}{K}$ is growing at a constant rate in steady-state

$$y_c=Nc+\dot{K}$$

or, $\frac{y_c}{K}=\frac{Nc}{K}+\frac{\dot{K}}{K}$

$\frac{y_c}{K}$ and $\frac{\dot{K}}{K}$ will grow at a constant rate in steady-state. So, $\frac{Nc}{K}$ must be growing constant in steady-state.

$\frac{Nc}{K}$=constant

Taking logarithm both sides and differentiating with respect to time,

$$\frac{d(\log N)}{dt}+\frac{d(\log c)}{dt}-\frac{d(\log K)}{dt}=0$$

or, $\frac{\dot{N}}{N}+\frac{\dot{c}}{c}=\frac{\dot{K}}{K}$

or, $\lambda+g=k$ (say) (23)

Here λ is the rate of growth of population and g is the growth rate of consumption.

From the production function,

$$\frac{y_c}{K} = A_c {N_1}^{\eta} K^{-\eta}$$

As, $\frac{y_c}{K}$ is growing at a constant rate in steady-state, taking logarithm both sides and differentiating w.r.t time we get

$$\frac{\dot{A}_c}{A_c} + \eta \frac{\dot{N}_1}{N_1} + (-\eta) \frac{\dot{K}}{K} = 0$$

Or, $\mu_c + \eta\lambda + (-\eta)(\lambda + g) = 0$ (24)

Rewriting equation (10), $\frac{dH}{du} = 0$

$$\frac{N}{N^{(1-\alpha)(1-\sigma)}} c^{\alpha(1-\sigma)} (A_s)^{(1-\alpha)(1-\sigma)} (N_2 h)^{\beta(1-\alpha)(1-\sigma)} (1-\alpha)\beta u^{\beta(1-\alpha)(1-\sigma)-1} = \theta_2 \delta h$$

Or, $N^{1-(1-\alpha)(1-\sigma)} c^{\alpha(1-\sigma)} (A_s)^{(1-\alpha)(1-\sigma)} (N_2 h)^{\beta(1-\alpha)(1-\sigma)} (1-\alpha)\beta u^{\beta(1-\alpha)(1-\sigma)-1} = \theta_2 \delta h$ (25)

Taking logarithm both sides and differentiating w.r.t time,

$$\{1-(1-\alpha)(1-\sigma)\}\frac{\dot{N}}{N} + \alpha(1-\sigma)\frac{\dot{c}}{c} + (1-\alpha)(1-\sigma)\frac{\dot{A}_s}{A_s} + \beta(1-\alpha)(1-\sigma)\frac{\dot{N}_2}{N_2} + \beta(1-\alpha)(1-\sigma)\frac{\dot{h}}{h} + \{\beta(1-\alpha)(1-\sigma)-1\}\frac{\dot{u}}{u} = \frac{\dot{\theta}_2}{\theta_2} + \frac{\dot{h}}{h}$$

Or,

$$[1+(1-\alpha)(1-\sigma)(\beta-1)]\lambda + \alpha(1-\sigma)g + (1-\alpha)(1-\sigma)\mu_s + [\beta(1-\alpha)(1-\sigma)-1][\sigma(1-u)] = \frac{\dot{\theta}_2}{\theta_2} \quad (26)$$

From equation (17)

$$\frac{\dot{\theta}_2}{\theta_2} = \rho - [N^{1-(1-\alpha)(1-\sigma)} c^{\alpha(1-\sigma)} (A_s)^{(1-\sigma)(1-\alpha)} (N_2 u)^{\beta(1-\alpha)(1-\sigma)} h^{\beta(1-\alpha)(1-\sigma)-1} \beta(1-\alpha)]\frac{1}{\theta_2} - \delta(1-u) \quad (27)$$

Putting the value of θ_2 from (25) into (27)

$$\frac{\dot{\theta}_2}{\theta_2} = \rho - \delta \quad (28)$$

Equating the value of $\frac{\dot{\theta}_2}{\theta_2}$ from (26) and (28)

$$[1-(1-\alpha)(1-\sigma)(\beta-1)]\lambda + \alpha(1-\sigma)g + (1-\alpha)(1-\sigma)\mu_s + [\beta(1-\alpha)(1-\sigma)-1][\delta(1-u)] = (\rho-\delta) \quad (29)$$

From equation (24)

$\mu_c + \eta\lambda - \eta(\lambda + g) = 0$

Or, $g = \frac{\mu_c}{\eta}$

Or, $\frac{\dot{c}}{c} = \frac{\mu_c}{\eta}$

This is the growth rate of the economy.

Thus, the growth rate of the economy is derived here, by using Hamiltonian technique of dynamic optimization.

The growth rate in this model is determined exogenously. Here, the growth rate of the economy is positively influenced by the growth rate of technological progress in commodity sector and negatively affected by commodity output elasticity of raw labour. Commodity output elasticity is the relative responsiveness of commodity output to labour.

Proposition 1: In a command economy, human capital and commodity output have a positive, unique steady-state growth rate.

Proposition 2: The growth rate of technological progress in necessary for the growth
of the economy.

Proposition 3: The growth rate of economy is inversely related with the commodity
output elasticity of labour which implies unskilled labour participation in commodity sector creates retarding influence on growth rate in this exogeneous model.

Section 3:

The number of hours, devoted by labours to acquire skill in commodity sector is derived in the following section:

Substituting the value of g into equation (29) we get

$$(\rho - \delta) = [1 + (1-\alpha)(1-\sigma)(\beta - 1)\lambda] + \alpha(1-\sigma)\frac{\mu_c}{\eta} + (1-\alpha)(1-\sigma)\mu_s + [\beta(1-\alpha)(1-\sigma) - 1]\delta$$
$$-\delta u[\beta(1-\alpha)(1-\sigma) - 1]$$

Or, $u = \frac{[1+(1-\alpha)(1-\sigma)(\beta-1)\lambda]+\alpha(1-\sigma)\frac{\mu_c}{\eta}+(1-\alpha)(1-\sigma)\mu_s+[\beta(1-\alpha)(1-\sigma)-1]\delta}{\delta[\beta(1-\alpha)(1-\sigma)-1]}$

This is the expression of the number of hours that is dedicated for human capital accumulation.

Proposition 4: The number of hours devoted for skill enhancement for commodity sector is positively related to the growth rate of technological progress for both the sectors and is negatively related to the commodity output elasticity of labour. When the relative responsiveness of commodity production to raw labour is low, the number of hours dedicated for skill accumulation increases. It is quite obvious that, as unskilled labours create a retarding influence on growth, the urge for skill generation will be increased maintain a positive growth path.

Therefore, the factors that determine the number of hours which is dedicated to form human capital is derived in the above section. We can make comparative static analysis on the other parameters also.

CONCLUSION:

This paper constructs a two-sector exogenous growth model in a closed economy. Commodity output is produced with only physical capital, whereas skilled labour is the only input used to produce service output. Steady-state growth paths are studied.

This paper simply studies the growth path of human capital accumulation as well as the economy where human capital is used only in services while physical capital is only used as an input to produce final commodities. This paper also finds the factors which will help a labour to decide how many hours to devote for skill development.

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