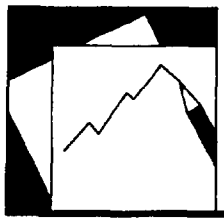

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Composition of Government Expenditure, Human Capital Accumulation, and Welfare

John M. Matovu

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Composition of Government Expenditure, Human Capital Accumulation, and Welfare

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Abstract

This paper uses a dynamic general equilibrium model calibrated to Ugandan data to examine the welfare effects of alternative scenarios of government expenditure and tax financing. Two expenditure types are considered: social spending that affects human capital, and infrastructure expenditures that affect productivity. The paper finds that social expenditures lead to higher economic growth depending on the form of financing; young generations benefit most from social spending financed by consumption taxes; agents do not substitute between human and physical capital as a result of changes in expenditure composition; and improving the productivity of fiscal expenditure is both growth and welfare enhancing.

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I. INTRODUCTION

This paper examines the effects of the composition of government expenditure on growth and economic welfare. There are several reasons for pursuing this line of inquiry. First, most developing countries are faced with difficult choices when undertaking fiscal reforms in the composition of government expenditure. Such choices include possible changes in public expenditures on social safety nets, health, education, firm subsidies and public infrastructure. The proper approach to making the right choice depends on the implications of each of these types of expenditures for long-term productivity, growth and welfare of agents. Second, while all available evidence suggests that investment in human capital is as important as physical capital accumulation, most dynamic studies have ignored the dynamic efficiency effects of the composition of government expenditure on human capital accumulation. In particular, there is the question as to whether agents substitute between physical and human capital under different policy environments.

Several studies have been undertaken to analyze the effects of the composition of government expenditure on growth and welfare.[2] Aschauer and Greenwood (1985) and Barro (1990) emphasize the distinction between public goods and services that enter into an agent's utility function and those that complement private sector production. The former, which they argue would include much of government consumption, are likely to have negative growth effects. This has been confirmed by Grier and Tullock (1987) who find that increased government consumption accompanied by high taxes reduces the returns on investments and the incentive to invest. In contrast, government investment expenditure, such as provision of infrastructure services, is thought to provide an enabling environment for growth. More recently, Devarajan et al. (1996) find that capital expenditures can potentially retard growth in developing countries. All these papers differ in specification, classifications of expenditures, methodologies used and to a large extent, the conclusions reached. Among the above studies, the paper by Turnovsky and Fisher (1995) is closest to the analysis in this paper.[3] However, they abstract from issues of human capital accumulation, uncertain future faced by agents, and types of taxes used to finance government expenditures.

In the tradition of Auerbach and Kotlikoff (1987), a dynamic general equilibrium model of overlapping generations of long-lived people is used in this paper. The model is extended in three ways: (1) differentiating the types of government expenditure which affect behavior of firms; (2) assuming that public spending on education and health has an effect on producing knowledge and human capital;[4] and, (3) assuming that agents are faced with uninsurable uncertainty in their life expectancy. The paper is also devoted to a more detailed investigation of the relative merits of different types of expenditures given alternative methods of tax financing. The three types of

[2]See Barro (1990), Aschauer (1988), Baxter and King (1993), Turnovsky and Fisher (1995), Devarajan, Swaroop and Zou (1996).

[3]Turnvosky and Fisher (1995) differentiate government expenditures which enhance the utility of consumers from those which directly affect the performance of firms.

[4]Auerbach and Kotlikoff (1987) assume that changes in government expenditure affect private choices only indirectly through changes in tax rates or debt issuing used to balance the government intertemporal budget constraint.

tax financing considered are: increasing lump sum taxes (LST); consumption taxes; and, income taxes. For each of the experiments on the composition of government expenditure, the tax rate used to finance the increase is determined endogenously. The analysis in this paper is important as it demonstrates that restricting the comparison to steady states, thereby ignoring welfare along the transitional paths, may in fact be misleading in terms of assessing the overall relative merits of the various policies.

The theoretical model developed in this paper is calibrated to data from Uganda. Social expenditures in Uganda have risen substantially, more than doubling in real per capita terms over the period 1990-98.[5] In addition, the share of health and education in total expenditure increased from 9 percent in 1992 to 21 percent in 1998. However, an increase in real per capita public resources devoted to social services may not necessarily result into welfare gains. The latter depends on the effectiveness and efficiency of spending. By calibrating the dynamic general equilibrium model to match the 1992 Ugandan demographic properties and key macroeconomic aggregates, the paper examines the effectiveness and efficiency of the social expenditures. The application of the model to Uganda is also motivated by the availability of household surveys to which comparisons of the simulated consumption, labor supply and assets profiles can be made.

Various alternatives to the composition of government expenditure are considered. First, the government may allocate a higher proportion of its expenditures on infrastructure, while keeping expenditure on other items, including health and education, unchanged. The second experiment is where the government increases its expenditure on health and education while keeping other expenditures unchanged. The third experiment is where government prioritizes its expenditures by increasing expenditures on health and education and reducing infrastructure expenditure by an equal amount, without changing its aggregate total expenditure. Lastly, the paper examines the implications of raising the productivity of both types of expenditures.

The key findings can be summarized as follows:

- Government expenditures on social services lead to higher capital accumulation and growth when they are tax financed. The impact is generally through the direct changes in the rate of return on capital for infrastructure expenditure, and the indirect positive effects of the improved human capital stock on marginal productivity.

- Agents do not substitute between human capital and physical assets as a result of changes in the composition of government expenditure. Instead, when government increases its expenditures on, for example, health and education, this reinforces the accumulation of physical assets and growth.

- All social expenditures are welfare enhancing especially when they are financed by a consumption tax. The higher positive effects of consumption taxes compared to the non-

[5]Measured in constant 1990/91 prices, per capita expenditures on education and health increased from U Sh 1,893 in 1992 to U Sh 4,909 in 1998.

distortionary LST can be attributed to the redistribution of consumption taxes from the old to young generations.

- Young generations benefit most from increases in social expenditures when they are financed by consumption taxes, while older generations benefit most from social expenditures financed by income taxes.

- Improving the productivity of either infrastructure or education/health expenditure is both growth and welfare enhancing.

The paper is organized as follows: Section II describes the model; Section III discusses the calibration procedures and parameters for the simulations; Section IV discusses the results; and, lastly is the conclusion.

II. MODEL

A. Consumers

The economy has overlapping generations of agents who live for a maximum of J periods, with ages denoted $j \in \otimes \equiv \{1, ..., J\}$.[6] The agents can die earlier than age J and the probability of survival from age j to $j+1$ at time t is given by α_{jt}, with $\alpha_{Jt} = 0$.[7] Let N_{jt} denote the number of people in the economy of age j during period t, the number of age j people alive at time t moves according to $N_{j+1,t+1} = \alpha_{jt} N_{jt}$. The probability that a person born at $t-j$ survives to age j is $\lambda_{jt} = \prod_{h=1}^{j} \alpha_{j-h,t-h}$. At time t, the newly born agents grows at a rate υ_t, so that $N_{0,t} = \prod_{h=1}^{t} \upsilon_h N_{0,0}$. Given $\eta_t = \Pi_{h=1}^{t} \upsilon_h$, the fraction of age j people at time t is given by:

$$f_{jt} = \frac{\lambda_{jt}\eta_t}{\sum_{j=0}^{J} \lambda_{jt}\eta_{t-j}} \tag{1}$$

General human capital can be described as an accumulated stock that enhances the productivity of individual labor efforts. Early investment in human capital combined with a rising profile of leisure over the life-cycle, produces predictions that agree with observed earnings profiles. New human capital can be produced through formal or informal on the job training, or as a by product of experience (learning by doing). The most general approach to modelling human capital is the "time allocation" approach. According to this paradigm, in each period an individual allocates time amongst leisure, work-effort and human capital investment effort. Total use of time is restricted to be less than or equal to 1. At each instant, an individual has a

[6]Individuals of age $j = 1$ refer to those who have just joined the labor force at the age of 20.
[7]The subsequent analysis assumes that the survival probabilities are constant over time. The paper abstracts from improvements of mortality rates over time given higher social expenditures.

certain stock of human capital, h_{jt}.[8] The stock of human capital is subject to depreciation, δ_h. Gross investment in human capital, W_{jt} depends on time allocated to accumulation of human capital q_{jt}, and on the size of human capital stock. The investment function used in the analysis is $W_{jt} = [\phi_1 g]^{\sigma_1} q_{jt}^{\theta_1} h_{jt}^{1-\theta_1}$ where g is total government expenditure and the condition $0 < \theta_1 < 1$ guarantee that the problem is concave in the control variable.[9] The productivity of public spending on health and education is an increasing function of the parameter σ_1. For $\sigma_1 = 0$, then public expenditure on health and education do not provide services that are required in the production of human capital. The stock of human capital evolves according to the following law of motion:

$$h_{j+1,t+1} = (1 - \delta_h) h_{j,t} + W_{jt} \tag{2}$$

In each period, individuals of all ages $j = (1, ...J)$ receive labor income of $w_{jt}(1 - l_{jt} - q_{jt})$ where w_{jt} is the wage index of individual at age j at time t, and l_{jt} is leisure by individual of age$-j$.[10] Aggregate wage payments at time t, w_t are distributed according to the efficiency levels of individuals (in this case captured by their human capital stocks). Thus, $w_{jt} = h_{jt} w_t$, where w_t is the real wage rate at time t. Given that τ_{yt} is the income tax rate during period t, the after tax income for all working age groups is given by:

$$y_{tj} = (1 - \tau_{yt}) w_t h_{jt} (1 - l_{jt} - q_{jt}) \text{ for } j = (1, ..., J) \tag{3}$$

In every period, agents receive capital income, $r_t a_{j-1,t-1}$, where a_{jt} is physical assets an agent with age j holds in period t, and r_t is the rate of return on capital.[11] Agents do not possess negative assets ($a_{jt} \geq 0$), and there is no altruistic bequest motive.[12] However, due to accidental deaths before maximum age limit J, accidental bequests are distributed to each individual as a lump-sum transfer, γ. Given that life uncertainty is not insurable in this economy, an agent starts accumulating assets while young for future consumption after retirement. Given the consumption tax τ_{ct}, LST τ_{lt}, and consumption c_{jt} by agent of age j, the budget constraints of an agent of age

[8]Estimation of relationships describing the accumulation of human capital is challenging, as it involves unobservable variables.

[9]This functional form is widely used in both the empirical literature and the literature on human capital accumulation. [See Uzawa (1985), Ben Porath (1967), Lucas (1988) and Ortigueira and Santos (1994)].

[10]Most authors model human capital as Harrod-neutral technological progress which augments work time in a multiplicative fashion. The simplest version of this idea was formulated by Ben-Porath (1967).

[11]The model abstracts from capital income taxation as it does not exist in Uganda.

[12]The assumption of agents not having any bequest motive could lead to an underestimation of the growth process. However, we use this framework as a starting point given that it has been widely studied in the literature. De Nardi, Imrohoroglu and Sargent (1997) incorporate a lifelong bequest motive in an overlapping generations model.

j, during period t, are written as follows:

$$a_{t1} = a_{t,J+1} = 0 \tag{4.1}$$

$$c_{tj} + a_{tj} = (1 + r_t)a_{t-1,j-1} + y_{tj} + \gamma_t - \tau_{ct}c_{tj} - \tau_{lt} \text{ for } (j = 1, ..., J) \tag{4.2}$$

The instantaneous utility function u is assumed to be strictly concave in private consumption and leisure. Given a discount factor β, consumers of age j maximize the following utility function subject to the budget constraint (4.1)-(4.3):

$$\max E_0 \sum_{j=1}^{J} \beta^{j-1} \lambda_j(t) u(c_{jt}, l_{jt}) \tag{5}$$

Assuming that consumers attach utility weight ρ_0 to leisure, and σ is the inverse of the elasticity of leisure with respect to wages, then momentary utility is assumed to be of a functional form,

$$u(c_{jt}, l_{jt}) = \ln(c_{jt}) + \frac{\rho_0 l_{jt}^{1-\sigma}}{1-\sigma} \tag{5.1}$$

The optimal consumption and time allocation profiles of individuals at different ages are derived. At this point, the problem is formulated by looking at its associated recursive structure via the value function:

$$v_{jt}(a_{jt}, h_{jt}) = \max_{c_{jt}, l_{jt}, a_{j+1,t+1}, h_{j+1,t+1}} u(c_{jt}, l_{jt}) + \beta \alpha_{j+1} v_{j+1,t+1}(a_{j+1,t+1}, h_{j+1,t+1}) \tag{6}$$

subject to:

$$(4.1 - 4.3) \text{ and } (3.0)$$

The agent solves a life-cycle optimization problem given the initial stocks of human capital and physical assets. Assuming interior solutions of the following value function, we obtain the following first order conditions:

$$u_{c_{jt}} = \beta \alpha_{j+1}(1 + \tau_c) \frac{\partial v_{j+1,t+1}}{\partial a_{j+1,t+1}} \tag{6.1}$$

$$u_{l_{jt}} = \beta \alpha_{j+1} h_{jt} w_t (1 - \tau_y) \frac{\partial v_{j+1,t+1}}{\partial a_{j+1,t+1}} \tag{6.2}$$

$$\frac{\partial v_{jt}}{\partial a_{jt}} = \beta(1+r_t)\alpha_{j+1}\frac{\partial v_{j+1,t+1}}{\partial a_{j+1,t+1}} \tag{6.3}$$

$$\frac{\partial v_{j+1,t+1}}{\partial a_{j+1,t+1}} = \beta\alpha_{j+1}\left[\frac{\theta_1 {q_{jt}}^{\theta_1-1}{h_{jt}}^{1-\theta_1}[\phi_1 g]^{\sigma_1}}{w_t h_{jt}(1-\tau_y)}\right]\frac{\partial v_{j+1,t+1}}{\partial h_{j+1,t+1}} \tag{6.4}$$

$$\begin{aligned}\frac{\partial v_{j,t}}{\partial h_{j,t}} &= \beta\alpha_{j+1}w_t(1-l_{jt}-q_{jt})(1-\tau_y)\frac{\partial v_{j+1,t+1}}{\partial a_{j+1,t+1}} \\ &+ \beta\alpha_{j+1}\left[(1-\theta_1){q_{jt}}^{\theta_1}{h_{jt}}^{-\theta_1}[\phi_1 g]^{\sigma_1}+1-\delta_h\right]\frac{\partial v_{j+1,t+1}}{\partial h_{j+1,t+1}}\end{aligned} \tag{6.5}$$

Equation (6.3) in the intertemporal arbitrage in returns on physical capital; (6.4) states that the marginal return to time invested in human capital investment equals its marginal cost; (6.5) implies that the marginal value of human capital is the return to current and future earnings. To find an analytical solution using the above first order conditions derived is impossible. Hence the analysis in the paper utilizes numerical methods given the convenience of solving the agents dynamic programming problem recursively.

B. Firms

Output is produced by a neoclassical production function exhibiting positive, but diminishing marginal physical productivity in all factors. Government investment expenditure on infrastructure is of a multiplicatively separable form in the production process which is given by $y_t = H(k_t, l_t)G(\phi_2 g)$ where k_t is capital stock, l_t is labor demanded by firms, and ϕ_2 is proportion of government expenditure spent on infrastructure. H_t is a Cobb-Douglas production function $H_t = \alpha_0(l_t)^{\alpha}(k_t)^{1-\alpha}$ where α is the labor share satisfying the condition $0 < \alpha < 1$ and α_0 is efficiency parameter of the firm. The total labor demanded by firms is a weighted value of the product of individual labor supply and human capital stock ($l_t = \sum_j f_{jt}h_{jt}(1-l_{jt}-q_{jt})$. The overall production is shifted upwards by a factor $G = (\phi_2 g)^{\sigma_2}$, where the parameter σ_2 measures the effectiveness of government expenditure in enhancing productivity. When $\sigma_2 = 0$, then public expenditure on infrastructure goods is not a required input in the production of the final good.

Aggregate capital stock is accumulated according to the following law of motion, $k_{t+1} = (1-\delta)k_t + i_t$, where i_t is total investment at time t. The firm pays a wage w_t and rate of return on capital given by r_t. The profit-maximizing behavior of firms gives rise to first order conditions which determine the net real return to capital and the real wage:

$$r_t = (1-\alpha)\alpha_0(\phi_2 g)^{\sigma_2}\left[\frac{k_t}{l_t}\right]^{-\alpha} - \delta \tag{7}$$

$$w_t = \alpha\alpha_0(\phi_2 g)^{\sigma_2}\left[\frac{k_t}{l_t}\right]^{1-\alpha} \tag{8}$$

C. Government

In order to sustain an equilibrium with steady growth, government expenditure is linked to the scale of the economy. An assumption that the resources allocated for total government expenditure gov_t are a fixed fraction ϕ of total output, of which various shares are allocated to health and education, infrastructure expenditures and other expenditures (Φ_t) is adopted. Total expenditure is given by:

$$gov_t = \phi_1 g + \phi_2 g + \Phi_t \tag{9}$$

The budget constraint of government is:[13]

$$gov_t = \tau_{yt} w_t \sum_j f_{jt} h_{jt}(1 - l_{jt} - q_{jt}) + \tau_{ct} \sum_j c_{jt} f_{it} + \tau_{lt} \tag{10}$$

D. Equilibrium

Definition 1. A competitive equilibrium is a set of stochastic processes for individual allocations, $\{a_{jt}, h_{jt}, c_{jt}, l_{jt}\}$, aggregate inputs, $\{k_t, l_t\}$, prices for the factors of production, $\{r_t, w_t\}$ such that: all allocations are feasible; all agents maximize (5) subject to (4.1)-(4.3), and; prices for the factors of production are equal to their marginal productivity.

Details on the proof of the existence of a competitive equilibrium can be found in Rios-Rull (1996). Although this standard definition of equilibrium is useful for proving existence and discussing optimality, it is not convenient for computational purposes. Defining a recursive competitive equilibrium, the analysis uses this construct that allows one to find equilibrium allocations without keeping track of the whole history of the economy. Allocations that satisfy the conditions of recursive equilibrium are also equilibria in a standard sense. Denoting the residual utility of an age-j individual by the value function $v(a_{jt}, h_{jt})$, the problem is set up under the assumption that each agent is a dynamic programmer as given by the definition below.

Definition 2. A recursive stochastic competitive equilibrium is a set of decision rules $\{a_{jt}, h_{jt}, c_{jt}, l_{jt}\}$ and corresponding value functions $v(a_{jt}, h_{jt})$, policy arrangements $\{\tau_y, \tau_c, \tau_l, \phi_1, \phi_2\}$, and factor prices $\{w_t, r_t\}$ such that the following conditions hold:

[13]Since the paper focuses on the incentive effects of tax financing of social expenditures, the model abstracts from government financing its expenditures by issuing debt.

(1) For each period t, factor markets clear:

$$k_t = \sum_j f_{jt} a_{jt} \tag{11}$$

$$l_t = \sum_j f_{jt} h_{jt} (1 - l_{jt} - q_{jt}) \tag{12}$$

(2) Factor prices are equal to marginal productivity in equations (9) and (10).

(3) Individual policy rules c_{jt}, h_{jt} and a_{jt} solve the dynamic maximization problem given as follows:

$$v_{jt}(a_{jt}, h_{jt}) = \max_{c_{jt}, l_{jt}, a_{j+1,t+1}, h_{j+1,t+1}} u(c_{jt}, l_{jt}) + \beta \alpha_{j+1} v_{j+1,t+1}(a_{j+1,t+1}, h_{j+1,t+1}) \tag{13}$$

subject to:

$$a_{j+1,t+1} = (1 - \delta) a_{j,t} + i_{j,t} \tag{14.1}$$

$$h_{j+1,t+1} = (1 - \delta_h) h_{j,t} + W_{jt} \tag{14.2}$$

(4) Goods market clears in each period t.

$$\sum_j f_{jt} \{c_{jt} + [a_{jt} - (1 - \delta) a_{j-1,t-1}]\} = Q_t \tag{15}$$

(5) Lump-sum distribution of bequests is determined by

$$\gamma_t = \sum_j f_{jt} (1 - \alpha_{j+1}) a_{jt} \tag{16}$$

Decisions of an agent are determined from the above recursive structure of the dynamic programming problem. An assumption that individuals after age J have a value function which is identically equal to zero, $v_{J+1} = 0$ is used. This condition is the starting point used in equation (13) to determine the maximizing values of assets, leisure and consumption for younger cohorts.

III. WELFARE MEASURE

Given government policy rules $\Gamma_0 = \{\tau_y, \tau_c, \tau_l, \phi_1, \phi_2\}$, the value function of people in the baseline scenario corresponding to these policy rules is $v(\Gamma_0)$. When government adjusts its composition of government expenditure, and adjusts taxes to balance the budget continuously, the value function corresponding to the new policy rules would be $v(\Gamma_1)$. Our welfare measure is calculated as the additional amount of wealth (assets and labor income) to make an individual of age-j indifferent between the two policy rules. If ω_j is the additional resources required for an individual to be indifferent between policy rules Γ_0 and Γ_1, then our welfare measure is given by $\varsigma_j = \omega_j/Q_0$ where Q_0 is gross output under policy arrangement Γ_0.

IV. CALIBRATION AND PARAMETERS

The experiments reported in the next section share a common set of parameters and an initial steady state equilibrium. We choose all the parameters for both the consumers and producers so that our model economy mimics as closely as possible the main Uganda economic statistics:

(i) Factor shares: To construct the measure of the Ugandan economy capital share, we follow the methodology used by Cooley and Prescott (1995) by deriving this share from the national accounts. The exponent of capital in the production function is found to be 0.31.

(ii) Real rate of return: In this case a value of 6 percent is targeted. In an overlapping generations setting, economic theory does not impose any restriction on the size of the discount factor.[14] The value of the households' discount factor that implements the targeted rate of return is $\beta = 0.95$.[15]

(iii) Age-consumption profile: The choice of the efficiency parameters (σ_1, σ_2) of government expenditure are guided mainly by the objective to generate an empirically plausible age-consumption profile and capital-output ratio. The parameter σ_2 is fixed at 0.05 so that this produces capital-output ratio of 3 in the baseline. The parameter σ_1 is initially fixed at 0.5.

(iv) Age-leisure profile: The value of $\rho_0 = 0.6$ used in the baseline is guided by our objective of attaining the working hours profiles which are in the 1992 Uganda Integrated Household Survey. On average, agents allocate 0.45 of the total time to work effort.

(v) For the parameter θ_1, which is in the investment function of human capital, a value of 0.67 is used. Previous estimates of this parameter in the literature lie in the range of 0.5-0.8.[16]

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[14]See Deaton (1991) for a discussion of restrictions on the subjective discount factor in economies with infinitely lived agents.

[15]Recent empirical evidence on the value of β suggests that a subjective discount factor greater than unity is plausible Hurd (1989).

[16]See Hechman (1975).

(vi) Human capital depreciation rate (δ_h), is assumed to be 0.025. Driffill and Rosen (1983) use a value of 0.01; while Lord (1989) employs values of 0.08 and 0.12; some empirical studies report values as high as 0.10 for certain categories of labor, Rosen (1976).

(vii) The equilibrating baseline LST is obtained by iterating over the government budget constraint which has to be balanced in every period.

(viii) The baseline policy parameters for government expenditure (ϕ_1, ϕ_2) are derived from the functional expenditure allocations of 1992.

(ix) Data on adult mortality in sub-Saharan Africa is hard to find, largely reflecting the inadequacy of vital registration systems. The survival probabilities are derived from a study of the population dynamics of Africa which was done by United Nations Economic Commission for Africa (1984).

Table 1. Parameters

J	Maximum survival age limit	60
υ_t	Growth rate of working age population (labor force)	0.03
σ	Inverse of the elasticity of leisure with respect to wages	4.00
ρ_0	Utility weight attached on leisure	0.60
β	Discount factor	0.95
α	Share of labor in output	0.69
θ_1	Human capital investment parameter	0.67
δ_h	Depreciation of human capital	0.02
δ	Depreciation of physical capital	0.05
σ_1	Effectiveness of government expenditure on firms productivity	0.05
σ_2	Effectiveness of government expenditure on human capital formation	0.50
ϕ_1	Share of expenditure on health and education	0.30
ϕ_2	Share of expenditure on infrastructure	0.20
ϕ	Ratio of government expenditure to GDP	0.17

V. SIMULATIONS

Simulation 1 considers a scenario where the government increases its expenditures on infrastructure by 10 percent. In this case, expenditures on other items remain the same, and an increase in this item reflects an overall rise in government expenditure. The increase can be financed in three different ways: first, for the government to maintain its balanced budget constraint, it increases its LST during the time path of this increase. The second alternative is for the government to increase consumption taxes during the period of the expenditure increase. Thirdly, the government may raise its labor income taxes. Simulation 2 considers an increase of government expenditure on health and education, without reducing expenditures on other items. This experiment also uses similar financing mechanisms explained for simulation 1. Each of the financing schemes explained above affects generations differently in a life-cycle model. Simulation 3 is where the government prioritizes its expenditures by reducing expenditures on

infrastructure, and shifting resources towards education and health expenditures. In this scenario, no financing scheme is used. In simulations 4 and 5, analysis of the implications of increasing the productivity of public expenditure on health, education and infrastructure is undertaken. Lastly, the sensitivity of the results to choice of parameters β and σ is examined.

VI. RESULTS

The model described is well suited to studying the effects of the composition of government expenditure and financing alternatives on different generations. The analysis identifies the Pareto efficiency gains (losses) under the five scenarios illustrated above. Given that older generations have higher marginal propensities to consume than young generations, the financing mechanisms are of importance for equity purposes.

Table 2 reports the values of our simulated economy. The key statistics we aim to replicate are private consumption and investment output ratios. In 1992, the consumption and investment-output ratios were 83 and 16 percent, respectively. The simulated economy yields consumption and investment output ratios of 79 and 18 percent respectively.

Table 2. Base Case Steady State

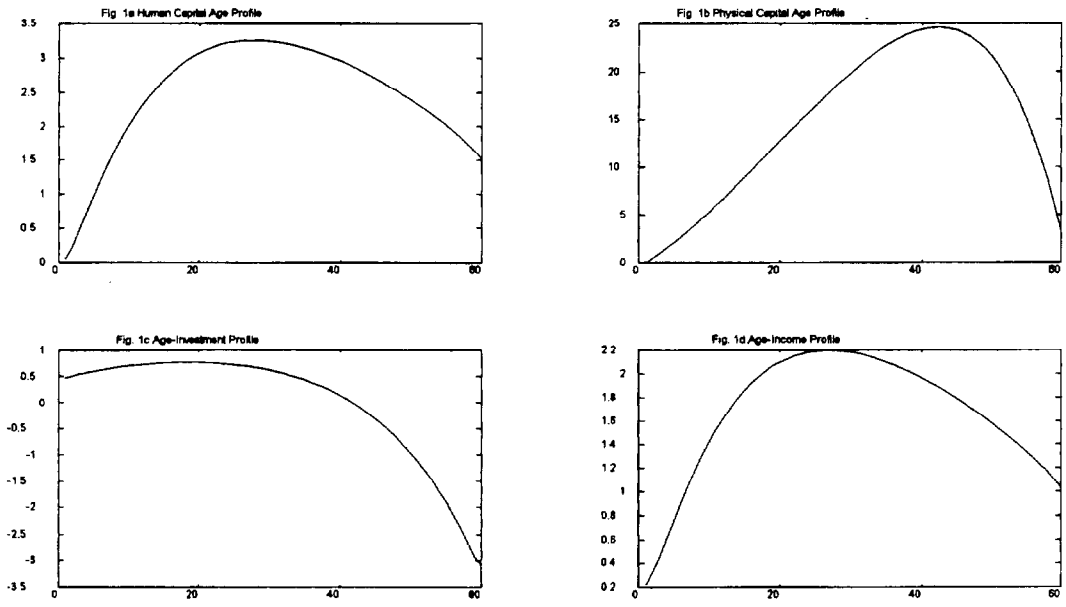
Variable	
Capital Stock (k)	7.2928
Labor demand (l)	1.4877
Wages (w)	1.1400
Rate of return on capital (r)	0.0676
Output (q)	2.4579
Consumption (c)	1.9417
Investment (i)	0.4517
Human capital stock (h)	2.2374
Capital output ratio (k/y)	2.9671
Consumption tax (τ_c)	0.1700
Income tax (τ_y)	0.2000
Lump-sum tax (τ_l)	0.0684

In the simulated steady state base case, the LST is used to balance the government budget constraint. The base case income tax is set at 20 percent, while the consumption tax is set at 17 percent. By choosing a parameter value $\sigma_2 = 0.05$ the model produces a base case return on capital of 6 percent, and capital output ratio of 3.

Figure 1 shows the optimal life-cycle profiles of the selected variables for the reference case. The human capital stock accumulation process (on the job) starts when an individual joins the labor force, and it reaches its peak at age 50. The corresponding physical assets profile is given by Figure 1b. which increases during the prime years of the working cycle and starts declining

after age 60. The shapes of the simulated age-earnings and age-investment are not very different from what is found in cross section household surveys. Income rises with age and starts falling at about mid-working age. The investment profile remains positive in the early years and turns negative as agents decumulate their assets.

Figure 1. Human Capital, Physical Capital, Investment and Income Age Profiles



A. Aggregate Steady State Results

Infrastructure Expenditure

The standard result in public finance literature is that when government increases its total expenditures, this crowds out domestic savings, and depending on the international mobility of investments, it could crowd out domestic investment (capital formation) as well. However a distinction between the types of expenditures and how they are financed leads to different results. An increase in infrastructure expenditure affects the capital accumulation process through two different channels. The first channel is the "resource withdrawal" effect which is described above; the second channel reflects the direct impact of this expenditure has on marginal physical products of labor and capital. The dominant effect therefore determines how the capital accumulation process would be affected. Table 3 displays the impact of the structural changes in the composition of government expenditure on an economy in the initial steady state.

Table 3. Increasing Infrastructure, Health and Education Expenditure
(Percentage change)

Simulation	1			2		
Financing	τ_l	τ_c	τ_y	τ_l	τ_c	τ_y
k	1.8867	3.4653	0.6594	0.5875	2.2015	0.6612
l	0.1008	0.2221	0.0324	1.9023	2.0327	1.7976
w	2.7544	3.2309	2.3744	-0.3246	0.1589	-0.7062
r	1.0355	0.0201	1.6058	1.0355	0.0781	1.7518
y	2.8561	3.4645	2.3742	1.5745	2.1976	1.0825
c	0.4071	3.4695	-0.7917	-0.2177	2.2308	-3.1428
h	0.1698	0.2102	0.1431	1.8727	1.9139	1.8423
τ_c	0.0000	36.3548	0.0000	0.0000	24.9636	0.0000
τ_y	0.000	0.0000	18.1744	0.0000	0.0000	12.4576
τ_l	28.5088	0.0000	0.0000	19.8830	0.0000	0.0000

Comparing columns 1, 2 and 3 of simulation 1, it is found that the overall implications of increasing infrastructure expenditure depends largely on the type of tax financing. Some analytical models predict that an increase in infrastructure expenditure would have a contractionary effect on the long-term capital stock.[17] Taking into account the externality effects of this expenditure on the human capital accumulation process, we find the contrary under all forms of tax financing. First, with a LST which captures the direct effects of government expenditure, while isolating the incentive effects associated with consumption or income taxes, we find that expenditure increases on infrastructure is results into higher growth.[18] Relative to the base case, the capital stock under LST financing of infrastructure is 2 percent higher than the base case scenario. The equilibrium LST required for this increase in expenditure is 28.5 percent higher than the base case. An increase in infrastructure expenditure would unambiguously result into higher rates of return on capital during the shortrun. The increase in output realized in this experiment is partly due to the direct effects of government expenditure on infrastructure has on productivity, and the increase in the stock of human capital as a result. The indirect effects of increasing infrastructure expenditure on the human capital stock are small but positive. The increase in human capital stock despite the increase in the rate of return on physical capital shows that agents do not substitute assets under this policy environment.

Using a consumption tax to finance the expenditure would mitigate the loss in capital formation associated with increasing government expenditure. Increasing this type of expenditure directly increases the rate of return on capital, and thereby encouraging capital accumulation until the capital-labor ratio is restored to its original equilibrium level. Hence consumption tax financing of infrastructure expenditure leads to an increase in capital stock during the steady state of 3 percent and this is attained after a 36 percent increase of the consumption tax above its base case level. The capital deepening associated with increasing expenditure on infrastructure generates an increase of real wages of 3 percent higher than the base case. Due to the growth

[17] See Turnvosky and Fischer (1995).

[18] Without differentiating forms of government expenditure, Turnovsky (1991) finds that a LST financing of government expenditure raises the long-run capital stock unambigusly.

effects of this policy stance, overall consumption also increases by 4 percent. This is despite the fact that consumption taxes are higher which have a much wider impact on all age-cohorts since both the young and old generations are affected by this tax. The large steady state gains are mainly due to the fact that use of a consumption tax to finance infrastructure expenditures causes a systematic redistribution from older generations to young and unborn generations who accumulate assets.

Previous studies suggest that use of labor income taxes has a negative effect on human capital accumulation.[19] In this case, use of an income tax to finance expenditures on infrastructure leads to an expansion of the economy. By taxing income, this mainly affects the working age-individuals, while the older generations whose marginal propensities to consume are much higher would benefit from the improved social services without being taxed. The disposable income available to the working age cohorts would be reduced, and hence their consumption. The steady state of this policy stance is an increase in capital stock of 1.6 percent, while aggregate consumption is reduced by 0.8 percent. Real wages in the final steady state would be 2.4 percent higher than the base case value. The equilibrium income tax rate required to finance this expenditure increase is 18 percent above the base case level. Hence, while income tax financing could negatively affect the physical assets accumulation process of the young generation, the positive impact of infrastructure expenditure on marginal productivity dominates. It can also be seen that consumption tax financing of infrastructure expenditure stimulates the growth process much more than the income tax alternative. In contrast to the consumption tax financing of infrastructure expenditure, the steady state gains of income tax financing are much lower due to the fact that the young generations are affected most during their early life-cycle working years.

Health and Education Expenditure

The second experiment demonstrates the effects of increasing government expenditure on social services like health and education, while keeping other expenditures unchanged. This type of expenditure has two main channels through which it affects the capital accumulation process. First, is the "pure resource withdrawal" effect, where an increase in this expenditure crowds out domestic resources for accumulating more capital. The second effect, which is more indirect, is where changes in this expenditure leads to agents re-evaluating their decisions on accumulating more human capital. The key difference of this type of expenditure from infrastructure expenditure is that in the model it does not have a direct impact on prices of factors of production. The marginal productivity are only affected indirectly through changes in human capital stock held by individuals as they maximize their value functions.

An increase of this expenditure by 10 percent financed by a LST leads to an overall increase in the capital stock of 0.6 percent, while the aggregate output increase by 1.6 percent. To the extent that the increase in this expenditure induces an instantaneous accumulation of capital coupled with higher efficient units of human capital stock, this leads to a decline in real wages. Correspondingly, when a consumption tax is used to finance the increase, agents respond by accumulating more assets in the short-run, while both output and consumption increase. Similarly,

[19] See King and Robelo (1990) and Trostel (1993).

with an income tax financing, this would lead to an increase of capital stock by 0.6 percent, and aggregate output would be 1 percent higher than the base case. On the contrary, consumption is much lower under income tax financing due to the lower growth effects this experiment has on the overall economy compared to the consumption tax and the reduction of the disposable income available to young agents.

Prioritization of Expenditures

The third experiment focuses on prioritization of expenditures. Expenditure on health and education is increased, while expenditure on infrastructure is reduced by an equivalent amount. In this case, the simulation does not require any form of tax financing. However, due to general equilibrium effects, the new (LST, consumption and income) tax rates will be different from the base case values. On average, prioritization of resources would lead to the capital stock increasing by 0.35, while aggregate output increases by 0.35 percent. The rate of return on capital is affected by two opposite effects: first is the negative effect of reducing infrastructure expenditure; second, is the positive effect arising from the human capital accumulation process, which results into higher efficiency units of labor being utilized in the production process.

Table 4. Prioritization of Expenditures
(Percentage change)

Simulation	3		
Financing	τ_l	τ_c	τ_y
k	0.3523	0.3434	0.3596
l	1.5812	1.5846	1.5786
w	-3.0088	-3.0014	3.0100
r	0.1841	0.0781	0.0487
y	0.3540	0.3444	0.3526
c	0.3569	0.3053	0.3466
h	1.4314	1.4281	1.4356
τ_c	0.0000	5.3427	0.0000
τ_y	0.0000	0.0000	9.0645
τ_l	11.4035	0.0000	0.0000

Given that the overall general equilibrium effects on the consumption tax increases it by only 5 percent, aggregate consumption increases by 0.3 percent due to the increased wealth of agents. Aggregate consumption is even higher when the income tax is used to balance the budget. The initial steady state is characterized by a decrease in real wages and an increase in the rate of return on capital due to increased physical and human capital accumulation.

Productivity of Social Expenditures

When resources are allocated to public infrastructure development, the quality and effectiveness of services provided matters. This effectiveness is captured by the parameter σ_2 in the model. By increasing the value of σ_2 from 0.05 to 0.06, the economy expands under all types of tax financing. Most importantly is the finding that increasing effectiveness of infrastructure expenditure also leads to a higher human capital stock. An increase in the parameter σ_1 implies greater productivity of public expenditure on health and education on the human capital accumulation process. In the fifth simulation, we increase this parameter from 0.5 to 0.6. This leads individuals to supply more units of efficient labor which increase the rate of return on physical capital. As a result, physical assets become attractive and this leads to an overall increase in stock of capital and growth. These three experiments also demonstrates how important the efficiency of public spending in the accumulation of both types of capital.

Table 5. Steady State Results
(Percentage change)

Simulation	4			5		
Financing	τ_l	τ_c	τ_y	τ_l	τ_c	τ_y
k	2.2017	2.1263	2.2726	1.6631	1.6063	1.7183
l	0.1479	0.1346	0.1481	1.4855	1.4808	1.4946
w	-2.0000	-1.9774	-2.0302	-0.1316	-0.1148	-0.1501
R	0.0387	0.0488	0.2726	0.1356	0.0098	0.0487
y	2.1522	2.1238	2.1815	1.6233	1.6031	1.6484
c	2.3367	2.1252	2.4203	1.7790	1.6203	1.8504
h	0.1296	0.1297	0.1342	1.3855	1.3907	1.3952
τ_c	0.0000	2.2298	0.0000	0.0000	11.3427	0.0000
τ_y	0.0000	0.0000	6.7862	0.0000	0.0000	9.0645
τ_l	2.7778	0.0000	0.0000	11.4035	0.0000	0.0000

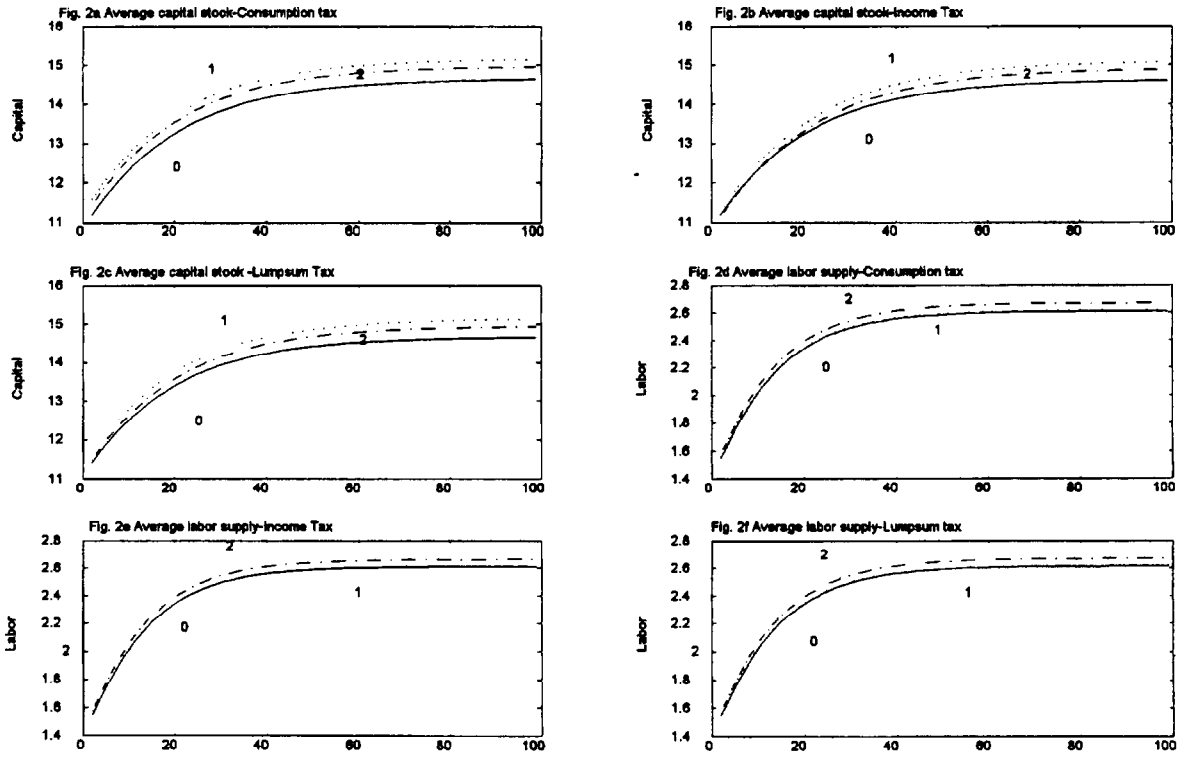
B. Transition Path

Figures 2-3 show the time path of the major economic variables before the economy attains its new final steady state. These effects arise from changes in the real rate of return on assets; incentive effects arising from the different financing schemes of government expenditure; and, the demographic changes which prompt individuals to save while they are young, and decumulate their assets as they grow older. The profile labelled "0" refers to the base case steady state, "1" is increasing infrastructure expenditure, "2" is increasing health and education expenditure, "3" is where infrastructure expenditure is reduced while health and education expenditures are increased by equal amounts, "41 and 42" is where the productivity parameter σ_1 is increased under the consumption or income tax regime, "51 and 52" is where the productivity parameter σ_2 is increased with either consumption or income taxes being used to balance the budget.

Use of a consumption tax to finance the social expenditures above leads to higher accumulation of capital. The cases of increasing government expenditure on infrastructure or education and health under a consumption tax financing are reported in Figure 2a which shows that during the transition, the capital stock for either type of expenditure described above is consistently higher than the baseline scenario. Figure 2b shows that an increase in infrastructure expenditures financed by an income tax leads to a higher dynamic path of capital stock, while for health expenditures, the capital stock path is slightly higher than the baseline scenario. It is also shown that the capital accumulation under health and education expenditures mainly occurs in later years of the transition, while in the shortrun the path does not diverge significantly from the baseline.

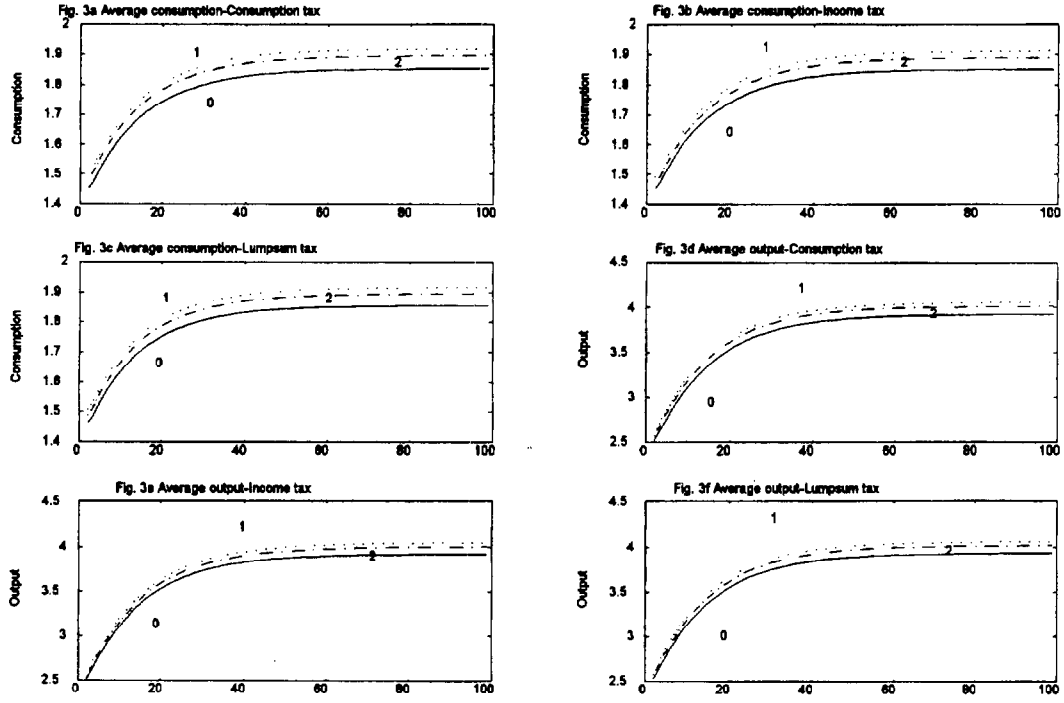
The accumulation of capital mainly works through the response of agents towards their decisions on time allocated for human capital accumulation and labor supply. When labor supply increases compared to the baseline, this leads to an increase in the rate of return on capital, and induces the capital accumulation process.

Figure 2. Aggregate Capital Stock and Labor Supply



The capital stock path followed after an increase in infrastructure expenditure is above the health and education expenditure path. The increase in both types of expenditures is clearly induced by increased supply of efficient units of human capital as shown in Figure 2d. We note from Figures 2d-f that an increase in health and education expenditure has a higher impact on increasing labor supply compared to infrastructure expenditure. For the case of health and education expenditures, the agents response to the availability of health and education services mitigates the negative impact of the resource withdrawal mechanism. This is supported by Figure 2d-f where the labor supply response under health and education expenditure is above all the other simulations.

Figure 3. Aggregate Consumption and Output



Due to the growth effects of the two types of expenditure, the resources available to agents for spending are much higher and aggregate output after these reforms is also much higher than the baseline.

C. Welfare Results

Although the long-run welfare effects are important, much of the concern about welfare effects of structural changes in government expenditure centers on the immediate impact on generations alive during the period when changes are implemented. However, welfare implications in the long-run are particularly important depending on the type of financing used to implement the structural changes. In particular we are interested in the question of whether there is a trade-off between short-run and long-run welfare gains from changes in the composition of government expenditure under different financing mechanisms. For instance, while financing expenditures

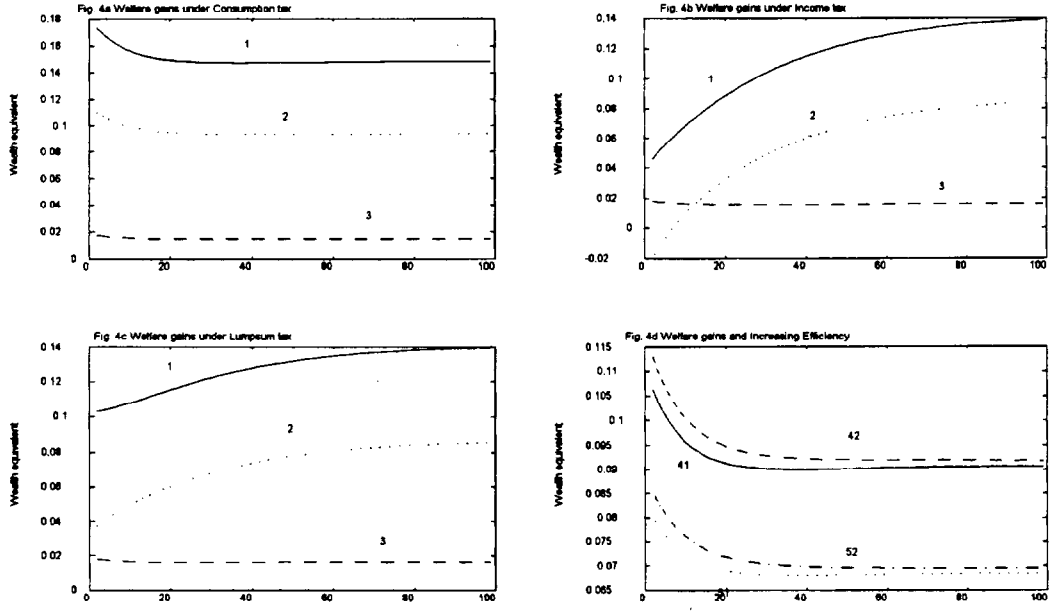
using income taxes mainly affects the younger generations, consumption taxes are much more broader and affect all age-cohorts.

Table 6. Welfare in the Initial Steady State

Simulation	τ_l	τ_c	τ_y
1	0.0864	0.1583	0.0305
2	0.0382	0.1122	0.0031
3	0.0013	0.0800	0.0361
4	0.1019	0.0969	0.1039
5	0.0852	0.0817	0.0871

First we compare the aggregate welfare changes in the initial steady state given in Table 6 above. Welfare gains are much more higher under the consumption tax financing followed by the LST financing for infrastructure expenditure. Similarly, agents benefit most from health and education expenditures when they are financed by the consumption tax. By increasing the efficiency parameters of public expenditure, this leads to short-term welfare gains under both the consumption and income tax financing alternatives.

Figure 4. Transition Welfare Changes



The key question in this paper is to establish which generations benefit (lose) after an expenditure policy change. Figure 4 above shows that the consequences for the distribution of cohort welfare differ markedly under different expenditure policy reforms. Increasing all social expenditure under all forms of financing results into higher welfare gains. However, the figure also shows that the efficiency gains by different generations are dependent on the form of financing. For instance, consumption tax financing of social expenditures leads to a downward trend overtime, which implies that the current generations benefit most from the expenditure

reform. On the contrary, when increases in social expenditures are financed using income taxes, we get a rising trend, which implies that the future generations benefit most. The downward trend of the consumption tax financing is due to its redistributive nature across generations. The welfare gains attained by prioritizing expenditures are very small. Lastly, improving the productive efficiency of social expenditures is welfare enhancing both in the shortrun and longrun.

D. Sensitivity Analysis (β, σ)

This subsection summarizes the results of the sensitivity analysis along two dimensions: first, we decrease the discount factor, and; second, we increase the inverse of the elasticity of leisure and compare the steady state results to the base case. The results show that with a much lower discount factor, the incentive for agents to defer consumption in favor of accumulating higher physical and human capital would be much higher. Therefore, the initial steady state would be characterized by a reduction in consumption of 5 percent, and this would lead to a higher capital stock of 20 percent compared to the base case as individuals accumulate more assets. On the other hand, increasing the inverse elasticity of leisure leads to a reverse process which is described above, where agents accumulate less assets especially during their early years.

Table 7. Sensitivity Analysis in Steady State

Financing (τ_l)	β	σ
k	19.7591	-2.8673
w	6.0606	-0.2368
R	-1.6580	0.1479
y	7.0558	-2.7991
h	0.4246	-0.1743
c	-5.5546	2.1554

We derive two conclusions from the following sensitivity analysis in reference to our social expenditure experiments. First, using a lower discount rate reinforces the growth effects of increasing social expenditures under consumption tax financing. Second, increasing the coefficient of risk aversion reinforces the decumulation process.

VII. Concluding Remarks

In this paper a dynamic general equilibrium model is used to examine the welfare benefits associated with alternative compositions of government expenditure and tax financing. The set up consists of 60-period lived individuals facing mortality risk. In the absence of insurance markets to safeguard against uncertainty in life expectancy, individuals save through private asset holdings in order to insure against future old-age consumption.

Two types of government expenditures are considered: first, expenditures on health and education which directly affect the human capital accumulation process; second, expenditures on infrastructure which affect the productivity of firms. It is found that expenditures on infrastructure or health and education lead to a higher level of growth, with the precise impact depending on the form of tax financing. For example, the use of broad consumption taxes to finance these expenditures leads to higher growth and welfare gains as income taxes result in lower savings and investment. Current generations benefit most from social expenditures when they are financed by consumption taxes. Human and physical capital are not substitutable under all the policy environments investigated. Therefore, agents are not induced to substitute human capital for physical capital when the former is subsidized by government. Lastly, improving the efficiency of infrastructure expenditures is both growth and welfare enhancing under consumption and income tax financing.

Several extensions of the analysis conducted in the paper would be useful. By creating an artificial economy with different heterogeneous agents, which mimics the distributional patterns found in a typical household survey, questions of dynamic redistribution of wealth and income mobility could be explored under different policy alternatives. Also, the efficiency and equity trade-offs of narrow and broad targeting of expenditures could be analyzed.

APPENDIX I

Numerical Algorithm

Steady state

The methods used to find the steady state of the model are well explained by Rios-Rull (1999) for stochastic models and Auerbach and Kotlikoff (1989) for deterministic models.[20]

Step 1: Guess the aggregate capital stock (k^0), labor demand (l^0), and bequests (γ^0).

Step 2: Given $k^0$and l^0, compute for the factor prices (r, w).

Step 3. Given r, w and initial human capital stock h_0, find the human capital stock profile by using non-linear first order condition 6.5 after substituting in (6.1-6.4).

Step 4: Given r, w and the human capital profile h_j, find the assets profile using the second order difference equation given by (6.3). Solve this equation to obtain the assets profile a_j subject to the conditions $a_1 = a_{J+1} = 0$, and $v_{J+1} = 0$.

Step 5: Obtain the new value of the capital stock k^1 as a summation of assets a_j.

Step 6: Compute the aggregate labor input $l^1 = \sum_j f_j h_j (1 - l_j - q_j)$.

Step 7: Compute aggregate left-over assets due to accidental death $\gamma^1 = \sum_j f_j (1-\alpha_{j+1}) a_j$.

Step 8. If $k^1 = k^0$, $l^1 = l^0$ and $\gamma^1 = \gamma^0$, then go to step 9. If not, upgrade the guess for k^0 , l^0 and $\gamma^0$and go to step 2.

Step 9. Stop.

Transition

The non-linear Gauss-Seidal algorithm is used to solve for the transition path. Then we follow the following steps:

Step 1: Guess a sequence of prices $\{r_t^0, w_t^0\}_{t=2}^T$.

Step 2: Given prices $\{r_t^0, w_t^0\}_{t=2}^T$, solve for the dynamic path of physical and human capital using first order conditions (16.3 and 16.5), subject to the terminal value ($v_{Jt} = 0$) and $a_{1t} = a_{J+1,t} = 0$.

Step 3: Aggregate assets and human capital stocks to calculate new factor prices $\{r_t^1, w_t^1\}_{t=2}^T$.

Step 4: If $\{r_t^0, w_t^0\}_{t=2}^T = \{r_t^1, w_t^1\}_{t=2}^T$ then stop: else revise factor prices and go to step 2.

[20]The computer code used to solve this problem is available on request.

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