Non-Ricardian Consumers and Public Capital Externalities in Models of Fiscal Policy and Growth

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Abstract

Expanding research on the determinants of long run growth has shifted the focus of fiscal policy effect from that on short run growth to that on the long run steady state growth rate. This has been captured in models of endogenous growth broadly in two ways. One has been by extending the simple endogenous growth model with spill-overs from private investment to include the externality due to public spending on the supply side. The other has been by including deviations from Barro-Ricardian assumptions on the demand side. Consumers are assumed to face finite planning horizons, liquidity constraints, population growth and distortionary taxes. To analyse the impact of non-Ricardian assumptions and public capital externality we present a generalisation of the above models thus incorporating the various mechanisms by which fiscal policy can affect the long-run growth rate. We then analyse the impact of these assumptions on multipliers that indicate the effect of fiscal policy changes on the long run steady state rate of growth. The model is calibrated for India giving us a feel of the magnitudes involved.

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1. Introduction

Evidence on the consequences of small differences in the long run growth rate on living standards across countries highlighted the need for more research on the determinants of growth. The resurgence of growth theory in the last few years has shifted the focus of macroeconomics from short term business fluctuations to long term growth. For the study of the effects of fiscal policy, this implies an analysis of the impact of policy changes on the long term growth rate which was hitherto assumed to be exogenous. The impact of fiscal policy on long run growth has been incorporated in models with endogenous growth (Barro (1990), Alogoskoufis and van der Ploeg (1991), Buiter (1991), Futagami, Morita and Shibata (1993), Jappelli and Meana (1994) and Krichel and Levine (1995)). This effect has been captured broadly in two ways. One has been by extending the simple endogenous growth model with spill-overs from private investment to include the externality due to public spending on the supply side. The other has been by including deviations from Barro-Ricardian assumptions on the demand side.

The representative agent Barro-Ricardian model with infinite horizons predicts debt neutrality. If government financing policy does not affect aggregate consumption and investment, it has no effect on growth given government spending and its composition. But once an overlapping generations model with Yaari-Blanchard-Weil consumers is introduced, then even with exogenous growth, financing policy affects the levels of consumption, saving and investment. However, the growth rate, being determined by the rate of technical progress that is exogenously given, is not affected. But if the growth rate is determined by capital accumulation within the economy, financing policy would affect the rate of economic growth as well.

2. Models of Fiscal Policy and Growth

Barro (1990), for instance, incorporates externalities arising from public spending. He defines the production function to include the input of public services which raise the productivity of private capital. The government invests in both the material infrastructure like public highways, railways, telecommunications and the immaterial infrastructure like education and training, and health. He incorporates a public sector into an endogenous growth model where he assumes constant rather than diminishing returns to a broad concept of capital which encompasses both human and non-human capital. The role of public services as an input to private production creates a potentially positive linkage between government and growth. In other words, Barro assumes that even with a broad concept of private capital that includes physical capital, human capital and aspects of privately owned knowledge, production displays decreasing returns to private inputs if complementary infrastructure does not expand in a parallel manner. Constant returns apply to this broad measure of reproducible capital as long as the public service input changes in the same proportion as private capital. On the demand side Barro includes tax distortions in the form of a flat rate income tax. Externalities arising from the stock of public capital have been incorporated in Jappelli and Meana (1994). Futagami, Morita and Shibata (1993) also assume that externalities arise from the stock of public capital rather than the flow of public services. Their model also incorporates tax distortions on the demand side. The effect of finite horizons is incorporated in an endogenous growth model by Alogoskoufis and van der Ploeg (1990) who show that fiscal policy is not neutral when the probability of death is positive. Alogoskoufis and van der Ploeg (1991) and Buiter (1991) include the effect of both finite horizons and population growth in a model of endogenous growth and reach similar conclusions. Krichel and Levine (1995) extend the model to include liquidity constraints in addition to the other demand side non-Ricardian effects of finite horizons, population growth and distortionary taxes as well as public investment on the supply side.

To analyse the impact of non-Ricardian assumptions and public capital externality we present a generalisation of the above models. Our specification incorporates the various mechanisms by which fiscal policy can affect the long-run growth rate. In this model fiscal policy has both a supply side and a demand side effect on investment and growth. We then analyse the impact of these assumptions on multipliers that indicate the effect of fiscal policy changes on the long run steady state rate of growth. The model is calibrated for India giving us a feel of the magnitudes involved.

We capture non-Ricardian Blanchard-Weil effects due to finite horizons and population growth and include tax distortions and externalities due to public capital stock as in Krichel and Levine (1995) and Futagami, Morita and Shibata (1993). The structure of property rights is such that in equilibrium new generations are born with endowments whose value rises at the endogenous rate of growth. This way they have a claim to some share of the capital stock in existence when they are born as it is absorbed in their human capital (Buiter (1991)). This is ensured in the model by allowing workers to appropriate the returns created by an economy-wide production externality. Though in Barro (1990) the externality arises from the flow of public services we also include the effect of past government spending on education, health, infrastructure, etc. by assuming that the externality arises from the stock of public capital. Behaviour of consumers, producers and the government determine the output equilibrium conditions.

3. Non-Ricardian Consumers

Non-Ricardian effects are introduced in the aggregate consumption function by the inclusion of liquidity constraints following Hayashi (1982), finite horizons following Blanchard (1985) and population growth following Weil (1989). Any one of these factors leads to a deviation from Ricardian Equivalence. Time is discrete following Frenkel and Razin (1992).

3.1. Liquidity Constraints

The economy is assumed to comprise of two groups of consumers - the liquidity constrained consumers and the unconstrained consumers. The unconstrained consumers maximise utility subject to the intertemporal budget constraint. Their consumption expenditure can be more than or less than their current income. They have access to the credit market. Hence, they save or dissave. Assuming that a person is born with zero net wealth, they become owners of all the nation's financial and physical wealth. The component of wealth in the portfolio of an unconstrained consumer may be positive or negative.

Aggregate consumption is the sum of the consumption of the constrained and unconstrained consumers.

$$C_t = C_t^c + C_t^u \qquad (3.1)$$

where

C_t = Aggregate consumption

C_t^c = Consumption of constrained consumers

C_t^u = Consumption of unconstrained consumers

We assume that unconstrained consumers receive a proportion λ, of total post tax labour income, Ω_t. Constrained consumers thus receive a proportion $(1 - \lambda)$ of total post tax labour income. Since they consume their current income,

$$C_t^c = (1 - \lambda)\Omega_t \qquad (3.2)$$

If the value of λ is estimated to be unity, then one can conclude that all consumers are forward looking.

3.2. Finite Horizons

The group of unconstrained consumers consist of overlapping generations which, apart from age, are identical. To capture the "life-cycle" aspect and to deal with issues in which the change in behaviour over life are important, we would need to allow for differences in propensity to consume across agents. However, this makes aggregation difficult. To ease aggregation it is assumed, following Blanchard (1985), that agents face throughout their life, a constant instantaneous probability of death, p. Their expected life 1/p is constant throughout life. The aggregation problem is solved because though agents are of different ages and have different levels of wealth, they have the same horizon and the same propensity to consume. (1/p) the horizon index lies anywhere between zero and infinity. If we let p go to zero then we obtain the infinite horizon case as a limiting case.

As noted earlier, it is assumed that each agent is born with zero net wealth. Consumers leave neither assets, nor debt to their children. The model thus assumes the absence of a bequest motive. Because of uncertain life-time and the assumption that debt is not inherited by the borrower's children who would service it, it is assumed that each loan is associated with a direct surcharge on the loan which is an insurance premium. Perfect competition and the zero profit condition in the market for loanable funds would ensure that at the end of a period, after taking risk into account, each lender earns a return equal to the risk free return (1 + r). Since a proportion p of the population is expected to die in each period, only a proportion (1 - p) of the population is expected to survive. A competitive lender charges a rate of interest higher than r, the risk free rate of interest, because p per cent of the population is not going to be alive to repay the loan and pay the interest on it. The competitive lender thus charges (1 + r)/(1 - p) so that the safe return is (1 - p) [(1 + r)/ (1 - p)] = 1 + r. The effective cost of borrowing relevant for individual decision making is (1 + r) / (1 - p). To ease aggregation, we also ignore life-cycle aspects of labour income and assume that labour income is constant throughout the consumer's lifetime.

3.3. Consumption

The utility function is assumed to be of the constant elasticity of substitution type where the intertemporal elasticity of substitution is unity. A constant elasticity of substitution utility function may be written as

$$\begin{aligned} u(C_t) &= \frac{1}{1-\frac{1}{\sigma}} C_t^{1-\frac{1}{\sigma}} && \text{if } \frac{1}{\sigma} > 0, \frac{1}{\sigma} \neq 1 \\ &= \ln(C_t) && \text{if } \sigma = 1 \end{aligned}$$

The single period utility function of the consumer is thus logarithmic. σ is the intertemporal elasticity of substitution. Consider the unconstrained consumer born in period s. The unconstrained consumer's intertemporal utility function at time $t \geq s$, in the absence of any uncertainty apart from death is given by

$$U_{t,s} = \sum_{i=t}^{\infty} \left[\frac{1-p}{1+\delta} \right]^{i-t} \left[\gamma_1 \log C^u{}_{i,s} + \gamma_2 \log G^c_{i,s} \right] \tag{3.3}$$

where δ denotes the rate of time preference and $C_{i,s}$ and $G^c{}_{i,s}$ denote the consumption of private and public goods respectively over period (i, i + 1).

Wealth of an individual consists of two components: non-human wealth that includes physical and financial assets and human wealth which consists of the present value of the expected future stream of labour income. Real net financial and physical wealth at the end of period i is given by $V_{i,s}$. At this stage we omit taxation of non-labour income. The budget constraint of an individual may be defined as

$$V_{i,s} = [(1+r(1-\tau))/(1-p)]V_{i-1,s} + \Omega^u{}_{i,s} - C^u{}_{i,s} \tag{3.4}$$

where unconstrained consumers receive Ω_t^u which is a part of total post tax labour income, Ω_t, and r is the risk free real rate of interest. r is assumed to be constant. Rewriting (3.4) as,

$$V_{i-1,s} = \frac{1-p}{1+r(1-\tau)} \left(V_{i,s} + C^u{}_{i,s} - \Omega^u{}_{i,s} \right)$$

Solving forward in time and substituting we have

$$V_{i-1,s} = \frac{1-p}{1+r(1-\tau)} \left(C^u{}_{i,s} - \Omega^u{}_{i,s} \right) + \left(\frac{1-p}{1+r(1-\tau)} \right)^2 \left(C^u{}_{i+1,s} - \Omega^u{}_{i+1,s} \right) + .$$

Combining with the transversality condition that wealth does not grow at a rate faster than the rate of interest i.e. $\lim_{i \to \infty} \frac{V_{i+t,s}}{\left(1+r(1-\tau)\right)^{t+i}} = 0$, we arrive at the consolidated budget constraint over the individual's lifetime:

$$\sum_{t=0}^{\infty} \left[\frac{1-p}{1+r(1-\tau)} \right]^t C^u_{i+t,s} = \sum_{t=0}^{\infty} \left[\frac{1-p}{1+r(1-\tau)\_} \right]^t \Omega^u_{i+t,s} + \frac{1+r(1-\tau)}{1-p} V_{i-1,s} \qquad (3.5)$$

The consumer maximises utility defined by (3.3) subject to the intertemporal budget constraint (3.5). The resulting equation is :

$$C^u_{i+1,s}/C^u_{i,s} = (1+r(1-\tau))/(1+\delta) \qquad (3.6)$$

Combining (3.5) and (3.6) leads to

$$C^u_{i,s} = \mu\,[(1+r(1-\tau))/(1-p)V_{i-1,s} + H^u_{i,s})] \qquad (3.7)$$

where $\mu = (p + \delta)/(1 + \delta)$ and $H^u_{i,s}$ is human wealth of unconstrained consumers defined by

$$H^u_{i,s} = \sum_{t=0}^{\infty} \left(\frac{1-p}{1+r(1-\tau)} \right)^t \Omega^u_{i+t,s}$$

μ is interpreted as the marginal propensity to consume out of lifetime wealth. The amount an individual consumes out of an additional unit of lifetime wealth at any point of time depends on how he weighs present consumption relative to future consumption and upon his probability of being alive to consume it later. If the degree of impatience was infinitely high, the rate of time preference δ would be very high and μ would be nearly unity. In other words, he would consume every extra unit of wealth right away. The lower the degree of impatience, the more the individual would be prepared to wait to consume his wealth and the lower would be the value of the marginal propensity to consume out of lifetime wealth. If the rate of time preference was zero, the marginal propensity to consume out of lifetime wealth would be equal to p, the reciprocal of the life expectancy of the individual. In that case it can be shown that if the individual expected to live for n years he would smooth his consumption out such that he consumes an equal amount in each year. Since here the marginal propensity is equal to the average propensity he would consume 1/n amount of his wealth in each year.

In terms of the probability of survival, the higher is the probability of survival, the lower is the marginal propensity to consume out of lifetime wealth because of the need to spread consumption over a longer period.

3.4 Population Growth

We now look at the aggregate behaviour of unconstrained consumers to incorporate the effect of population growth. If $L_{t,s}$ is the size of the cohort born during the period [s,s + 1] who are still alive at the end of period t then $L_{t,s} = (1-p)^{t-s}L_{s,s}$. The unconstrained group can increase or decrease in size both due to natural birth and transfer to and from the constrained group. Let β be the 'birth rate' (assumed contant) that includes both birth and migration during a period such that $L_{t,t} = \beta(1-p)L_{t-1}$ where $L_{t,t}$ is the population born in period t and still alive in period t and L_t is the population size at the end of the period. If g = population growth (assumed constant), then $L_t = (1+g)^t L_0$. Hence we must have that

$$\begin{aligned} L_t &= (1+g)^t L_0 \\ &= \beta \sum_{s=-\infty}^{t} L_{t,s} = \beta L_0 \sum_{s=-\infty}^{t} (1+g)^{s-1}(1-p)^{t-s+1} \end{aligned} \tag{3.8}$$

Performing the summation leads to $1/(1+\beta) = (1-p) / (p + g)$ which determines the 'birth rate' β. For small p, g we have $\beta \cong p + g$.

Aggregate variables are defined as:

$$C^u{}_t = \sum_{s=-\infty}^{t} L_{t,s} C^u{}_{t,s} \tag{3.9}$$

$$H^u{}_t = \sum_{s=-\infty}^{t} L_{t,s} H^u{}_{t,s} \tag{3.10}$$

etc. Taking first differences of (3.10) we have

$$H^u{}_t - H^u{}_{t-1} = L_{t,t} H^u{}_{t,t} + \sum_{s=-\infty}^{t-1} \left[L_{t,s} H^u{}_{t,s} - L_{t-1,s} H^u{}_{t-1,s} \right] \tag{3.11}$$

The first term on the right hand side of (3.11) is equal to $\beta(1\text{-}p)L_{t-1}H^u{}_{t,t} = \beta[(1\text{-}p) / (1+g)]L_t H^u{}_{t,t}$. But $L_t H^u{}_{t,t} = H^u{}_t$ since human wealth of all age groups is equal according to our 'perpetual youth' or constant probability of death assumption. Using (3.7) human wealth of cohort s accumulates according to:

$$H^u{}_{i,s} = [(1+ r(1\text{-}\tau))/(1\text{-}p)]\ (H^u{}_{i-1,s} - \Omega^u{}_{i-1,s}) \tag{3.12}$$

Using (3.12) and the definition of aggregate human capital, the summation on the right hand side of (3.11) can be shown to be $(1+ r(1\text{-}\tau))(H^u{}_{t-1} - \Omega^u{}_{t-1})$.

Hence aggregate human wealth of the unconstrained group accumulates according to

$$[1\text{-}\beta\ (1\text{-}p)/(1+g)]H^u{}_t$$

$$= [(1\text{-}p)/(1+g)]H^u{}_t = (1+ r(1\text{-}\tau))(H^u{}_{t-1} - \Omega^u{}_{t-1}) + \varepsilon_t$$

$$\varepsilon_t \sim iid(O,\sigma^2{}_e) \tag{3.13}$$

ε_t represents the revisions in the expectation of human wealth that are made in period t. Under the assumption that expectations are rational, it is orthogonal to the set of information available to the household at t-1 and is serially uncorrelated. Aggregate human wealth of unconstrained consumers may be expressed as

$$H^{u}{}_{t} = \sum_{t=0}^{\infty}\left(\frac{1-p}{(1+r(1-\tau))(1+g)}\right)^{t}\Omega^{u}{}_{t} + \varepsilon_{t}$$

The presence of the growth rate of population in the expression for aggregate human wealth is indicative of the fact that the future expected labour income of those yet to join the unconstrained group is not owned by current households. Aggregate future labour income is discounted by the real rate of interest augmented by the probability of survival and the rate of growth of population.

V_t, total non-human wealth, is defined as the sum of physical and financial wealth. Ignoring consumer durables physical wealth is assumed to be the total private capital stock K_t. Financial wealth is assumed to consist of D_t, the government debt held by households. Since households constitute the private sector and own all the private capital stock, the sector as a whole does not have any other financial assets or liabilities in a closed economy apart from public debt. Individual household financial assets and liabilities in the private sector will balance out. We thus assume that the only financial wealth of the household sector as a whole is government debt. Thus

$V_t = D_t + K_t.$

If V_t is the sum of capital stock and financial assets in period t, we assume that the return earned on it is equal to r. If the net rate of return on capital stock was different from that on government debt then households would sell government debt and buy physical capital, assuming that no risks are involved in either. In equilibrium, therefore, the marginal rate of transformation which is the net return on capital is equal to the real risk free rate of interest.

Aggregating financial and physical wealth, the first term in the summation $L_{t,t}V_{t,t} = 0$ because the newly born consumers born in period [t, t+1] inherit no financial or physical wealth which can only start accumulating from t+1 onwards. Hence, corresponding to (3.13) we have

$$V_t = (1+ r(1-\tau))V_{t-1} + \Omega^u_t - C^u_t \quad (3.14)$$

where V_t is non-human wealth at the end of period t.

Corresponding to (3.7) the aggregate consumption function of unconstrained consumers is now

$$C^u_t = \mu((1+r(1-\tau))V_{t-1} + H_t) + u_t; \qquad u_t \sim \text{iid } (0,\sigma^2_u) \quad (3.15)$$

where the random error term u_t has been added to capture shocks to the consumer's utility function. (3.13), (3.14) and (3.15) present our model of aggregate consumption of unconstrained consumers.

Capital is assumed to earn a rate of return r_t in period t and depreciate at the rate π. Defining the consumption of unconstrained consumers as a function of W^u_t, the total wealth of unconstrained consumers at the beginning of period t and ignoring the error terms we have,

$$C^u_t = \mu W^u_t \quad (3.16)$$

where $$W^u_t = H^u_t + (1 + r_t(1 - \tau))V_{t-1} \quad (3.17)$$

Human wealth at the beginning of period t can be shown to be

$$H^u_t = \frac{(1+r_t(1-\tau))(1+g)}{1-p}\left[H^u_{t-1} - \Omega^u_{t-1}\right] \quad (3.18)$$

Labour income earned by unconstrained consumers is

$$\Omega_t^u = \lambda(Y_t - (r_t + \pi)K_t)(1 - \tau_t) \qquad (3.19)$$

Since aggregate consumption of unconstrained consumers depends on the value of lifetime wealth, the evolution of consumption depends on the evolution of wealth. We therefore turn to the evolution of aggregate wealth which is a combination of human and non-human wealth.

Using the (3.14), (3.16) and (3.17) we obtain

$$W_t^u = \frac{p+g}{1+g} H_t^u + [1 + r_t(1-\tau)] \frac{1-p}{1+\delta} W_{t-1}^u \qquad (3.20)$$

The value of wealth in period t is expressed in terms of its value in period t-1 and in terms of human wealth in period t. The evolution of aggregate wealth thus depends upon its composition. It reflects the asymmetry between human and non-human wealth. If the probability of death were zero and there was no population growth, we would have

$$W_t^u = \frac{[1 + r_t(1-\tau)]}{1+\delta} W_{t-1}^u \qquad (3.21)$$

The asymmetry thus disappears with the removal of uncertainty regarding the length of life and the evolution of wealth no longer depends on the magnitude of human wealth in the current period. It depends on its aggregate value rather than its composition.

From (3.16) and (3.20) it follows that

$$C_t^u = \left(\frac{p+\delta}{1+\delta}\right)\left(\frac{p+g}{1+g}\right) H_t^u + [1 + r_t(1-\tau)] \frac{1-p}{1+\delta} C_{t-1}^u \qquad (3.22)$$

If g=0 , p=0 , τ =0, and for a constant rate of interest, $C_t^u = \dfrac{1+r}{1+\delta} C_{t-1}^u$ which corresponds to the Euler equation in the representative agent model with infinite horizons. In addition if there are no liquidity constraints then aggregate consumption

$C_t = \dfrac{1+r}{1+\delta} C_{t-1}$. Non-Ricardian behaviour of aggregate consumption thus arises from four sources: finite horizons, population growth, distortionary taxes and liquidity constraints.

Using (3.16)), (3.17) and (3.20) we have

$$C_t^u = \left[1 + r_t(1-\tau)\right]\frac{1+g}{1+\delta} C_{t-1}^u - \left(\frac{p+\delta}{1+\delta}\right)\left(\frac{p+g}{1-p}\right)\left[1 + r_t(1-\tau)\right]V_{t-1} \qquad (3.23)$$

which describes the consumption behaviour of the unconstrained consumers in terms of lagged consumption and lagged non-human wealth. This may be referred to as the discrete time Yaari-Blanchard consumption function.[1]

4. Public Capital Externalities

The representative firm f produces homogeneous output with the following Cobb-Douglas constant returns to scale production function at time t

$$Y_{t,f} = F\left(K_{t,f}, J_{t,f}\right) = K^{\alpha}{}_{t,f}\, J^{1-\alpha}{}_{t,f} \qquad (4.1)$$

where $K_{t,f}$ is private physical capital and $J_{t,f}$ is labour input in efficiency units. Or,

$$J_{t,f} = \varepsilon_{t,i} L_{t,f} \qquad (4.2)$$

where $\varepsilon_{t,f}$ is a measure of the efficiency of raw labour input L_t. The crucial assumption that drives endogenous growth in this model is that this efficiency measure is a function of the economy-wide capital-labour ratio. Let K_t be aggregate private capital. In addition to the externality from private capital, the government affects labour efficiency by providing physical capital in the form of infrastructure which may be broadened to include education, health, etc., accumulated out of the economy's single output. This is captured by

$$\varepsilon_{t,f} = A_f \frac{\left(K_t^G\right)^{\gamma_1}\left(K_t\right)^{1-\gamma_1}}{L_t} \qquad (4.3)$$

where K^G_t is public capital and γ_1 is the contribution of public capital to the economy-wide efficiency of labour. This way workers inherit the benefits of past investment. Assuming identical firms that are constant in number, and aggregating, we arrive at the aggregate production function

$$Y_t = B\left(K_t\right)^{\gamma_2}\left(K^G{}_t\right)^{1-\gamma_2} \qquad (4.4)$$

where γ_2=1- (1-α)γ_1 and B depends on the constant number of firms in the economy.

It is assumed that the government does not produce. It buys output, including roads, dams, canals, hospitals, schools etc., from the private sector. This infrastructure is made available to the private sector without any user charges.

We assume that firm f ignores the externality in choosing capital stock. The marginal product of capital is $MP_K = \partial Y/\partial K = \alpha K^{\alpha-1} J^{1-\alpha} = \alpha Y/K$. The marginal cost of capital (including depreciation at a rate π)=$r_t+\pi$. Equating the private marginal product of capital to the cost of capital gives

$$\frac{K_t}{Y_t} = \frac{\alpha}{r_t + \pi} = K(r) \qquad (4.6)$$

Net private investment is then given by the addition to capital stock less the depreciation in period t

$$I_t = K_t - (1-\pi)K_{t-1} \qquad (4.7)$$

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[1] For small r, g, p, λ and δ this corresponds to the $\dot{C}$ = (r-δ)C - (p+g)(p+δ)V in continuous time.

5. The Government

The government provides an amount G^C_t of public consumption goods using the same technology as for the privately produced good, and purchases an amount G^I_t of the latter to invest in infrastructure. Total government expenditure is then $G_t = G^C_t + G^I_t$ which is financed by a combination of taxation (T_t) and borrowing (D_t) where D_t are single period bonds. (We ignore or rule out seigniorage). The government borrowing identity is given by

$$D_t = (1 + r_t)D_{t-1} + G_t - T_t \qquad (5.1)$$

and public sector capital accumulates according to

$$K^G_t = (1 - \pi)K^G_{t-1} + G^I_t \qquad (5.2)$$

assuming the same depreciation rate as in the private sector. Since the definition of capital is broad, public sector investment G^I_t is assumed to include public expenditure on health, education, etc. Since only profits net of depreciation are taxed at the rate τ total receipts are

$$T_t = \tau\,(Y_t - \pi K_t). \qquad (5.3)$$

6. The Steady State

We assume that the market always clears. Equilibrium in the output market gives

$$Y_t = C_t + I_t + G_t \qquad (6.1)$$

Thus, given the government choice of fiscal policy variables G^C_t, G^I_t and τ, the supply and demand sides of the economy are now fully determined.

We seek a balanced growth steady-state in which all stocks and flows are growing at the same endogenous rate n, the steady-state value of n_t. The debt/GDP ratio is assumed to be constant which is the strong solvency condition. It is assumed that r_t is constant at the rate r. If we express all macroeconomic stock and flow variables as ratios of GDP then in steady state balanced growth the ratios remain unchanged. We retain the same notation without the subscript t to denote these ratios to ease notational burden.

Consumption of constrained consumers who receive only labour income and consume their entire income is given by

$$C_t^c = \left(1-\lambda\right)(Y_t - (r+\pi)K_t)\left(1-\tau\right) \qquad (6.2)$$

We can substitute for the expression for non-labour income from (4.6) where $K_t(r+\pi) = \alpha Y_t$. Post-tax labour income of unconstrained consumers can be now defined in terms of total income. Consumption of constrained consumers defined as a ratio of GDP in the steady state is

$$\frac{C_t^c}{Y_t} = C^c = \left(1-\lambda\right)(1-\alpha)\left(1-\tau\right) \qquad (6.3)$$

We can now obtain the consumption of unconstrained consumers in the steady state from

$$(r(1-\tau)+g(1+r(1-\tau))-\delta-n(1+\delta))C^u=\{(p+g)(p+\delta)[1-r(1-t)]/(1-p)\}(D+K) \qquad (6.4)$$

The capital output ratio may be expressed as a ratio of GDP as

$$K(r) = \alpha /r+\pi \qquad (6.5)$$

Given that the rate of depreciation for public capital is the same as that for private capital we obtain public capital in the steady state as a ratio of GDP as

$$K^G = \frac{(1+n)G^I}{(n+\pi)} \qquad (6.6)$$

where G^I is the share of public investment in GDP.

The aggregate production function can be expressed as a ratio of GDP as

$$\log B + \gamma_2 \log K + (1-\gamma_2)\log\frac{G^I}{(n+\pi)} = 0 \qquad (6.7)$$

In the steady state public and private capital grow at the same rate n and depreciate at the same rate π. Thus the ratio of public to private capital is constant and so production is linear in private capital.

In a steady state public debt grows at the rate n. Thus the government budget constraint may be expressed as

$$(1+n)D_t = (1+r)D_{t-1} + G_t - T_t \qquad (6.8)$$

Rearranging, we express the solvency condition in the steady state as

$$[(r-n)/(1+n)]D = T - G = [1-\pi K]\tau - G \qquad (6.9)$$

The market equilibrium in the steady state may be defined as ratios of GDP as

$$1 = C^c + C^u + I + G$$

$$C^u = 1-(1-\lambda)(1-\alpha)(1-\tau)-[(n+\pi)/(1+n)]K(r)-G \qquad (6.10)$$

7. Fiscal Policy and Long-Run Growth

This section studies the steady-state of the economy defined above. Given fiscal instruments, τ, G^C and G^I we have five equations in five endogenous variables r,C,D,K and growth n. We will focus on the effects of government debt D, the distortionary tax rate τ, and the mix of government spending as between consumption and investment. We characterise fiscal policy in terms of D and τ making total government spending endogenous. Let $G^I=\gamma G$ so that the third fiscal instrument is the proportion γ.

To compute an "order of magnitude feel" for their effects on long-run growth we derive multipliers for estimating the change in the rate of growth when there is a change in fiscal policy variables.

Substituting the value of consumption and eliminating G we arrive at the Yaari-Blanchard consumption relationship.

$$f(n,r,D,\tau)=((1+g)(r(1-\tau))+g-\delta-n(1+\delta))(1-[(n+\pi)/(1+n)]K(r)$$

$$+[(r-n)/(1+n)]D-\tau(1-\pi K(r)-(1-\lambda)(1-\tau)(1-\alpha)))$$

$$-\{(p+g)(p+\delta)[1+r(1-\tau)]/(1-p)\}(D+K(r))=0 \qquad (7.1)$$

The production function may be derived as

$$g(n,r,D,\tau,\gamma)=\gamma_2\log K(r)+(1-\gamma_2)(\log\gamma+\log(\tau(1-\pi K(r)-[(r-n)/(1+n)]D)+\log(1+n)-\log(n+\pi))$$

$$+\log B=0 \qquad (7.2)$$

The two relationships determine r and n given D,τ and γ.

The relationship $f(n,r,D,\tau)=0$ describes the locus of interest and growth rates consistent with Yaari-Blanchard consumption behaviour, output equilibrium, private sector investment and the government budget constraint. We term this locus the Yaari-

Blanchard (YB) curve. The relationship $g(n,r,D,\tau,\gamma)=0$ is the locus consistent with balanced growth and our linear technology, private sector investment and the government budget constraint. We call the relationship the linear technology (LT) curve.

Consider incremental changes in the exogenous fiscal variables dD, $d\tau$, $d\gamma$ and the corresponding incremental changes dn and dr along the YB and LT curves. Differentiating, these incremental changes satisfy

$$f_n dn+f_r\, dr +f_D dD +f_\tau d\tau =0$$

$$g_n dn +g_r dr +g_D dD+g_\tau d\tau + g_\gamma d\gamma=0$$

Hence keeping fiscal policy and income distribution fixed, the slope of the YB curve is given by

$$(\partial n/\partial r)_{f=0}=-f_r/ f_n$$

$$f_n=-(1+\delta)C-\phi(K+D)<0$$

From (7.1) $\phi C-\eta(D+K)=0$

since $C>0$, $K+D>0$,and $\eta=(p+g)(p+\delta)(1+r(1-\tau))/(1-p) >0$, so

$\phi=r(1-\tau)-\delta-n(1+\delta)>0$. Note that if $p+g=0$ then $\phi=0$. Also from (7.1) we have

$$f_r=\phi(D-[(n+\pi)/(1+n)](1-\tau))K'(r))+C(1+g)(1-\tau)-\{(p+\delta)(p+g)(1-\tau)/(1-p)\}(D+K(r))-\eta K'(r)>0$$

Since $fn < 0$ and $fr >0$ therefore $- fr/fn > 0$. In other words, $(\partial n/\partial r)_{f=0} > 0$ or the YB curve is upward sloping.

Turning to the LT curve when fiscal policy is given, its slope is given by

$$(\partial n/\partial r)_{g=0} =-g_r/ g_n$$

$g_n=(1-\gamma_2)[(1+r)D/(1+n)^2 G)-(1/(n+\pi))+1/(1+n)]$

$g_r=\gamma_2 \{K'(r)\}/\{K(r)\}-(1-\gamma_2)(D/G+\{\tau\pi K'(r)\}/G)$

Hence $g_n<0$ and $g_r<0$ if $D<G/n+\pi$ and $\tau\pi<GK(r)\gamma_2/(1-\gamma_2)$. For G=0.3 and $n+\pi<0.1$ the first of these conditions is satisfied if D<3 (i.e., a debt/GDP ratio less than 300%). We expect $\gamma_2>1/2$, $\tau<0.5$ and $\pi<0.1$ (on an annual basis). If G=0.3 again, the second condition is satisfied if K<6, not a stringent condition. From these considerations we deduce that, under very lax conditions, the LT curve is downward-sloping.

The remaining partial derivatives are

$f_D=\phi(r-n)/(1+n)-\eta$

$f_\tau=-r(1+g)C-\phi(1-\pi K+\lambda(1-\alpha))+\{(p+g)(p+\delta)/(1-p)\}r(D+K)$

$g_\tau=\{(1-\gamma_2)(1-\pi K)/G$

$g_D=-(1-\gamma_2)(r-n)G/(1+n)$

$g_\gamma=(1-\gamma_2)/\gamma$

From these results we can unambiguously sign $g_D<0$ and $g_\gamma>0$. We require $(1-\pi K(r))>0$ to obtain positive consumption which gives $f_\tau<0$ and $g_\tau>0$. Finally along f=0 we have that $f_D=\eta V/C(r-n)-\eta$. Hence $f_D<0$ if r-n < C/V which requires extraordinarily large capital/GDP and debt/GDP ratios to violate. To summarise we expect $f_r,g_\tau,g_\gamma>0$; $f_n,f_D,f_\tau,g_n,g_r,g_D<0$.

Keeping fiscal policy and income distribution fixed, the slope of the YB curve is given by $(\partial n/\partial r)_{f=0}=-f_r/f_n$. Since fn < 0 and fr >0 therefore - fr/fn > 0. In other words, $(\partial n/\partial r)_{f=0}>0$ or the YB curve is upward sloping. Turning to the LT curve when fiscal policy is given, its slope is given by $(\partial n/\partial r)_{g=0}=-g_r/g_n$ where we expect $g_n<0$ and g_r

< 0 and so, the LT curve is downward-sloping. In the case when public investment is irrelevant and γ_2=1 as in Romer(1986) we have K(r) = B and the LT curve is vertical. In an exogenous growth model the rate of growth is not affected by the rate of interest and the LT curve is horizontal.

We now look at the effect of fiscal variables on the YB and LT curves. To look at the effect of a change in the ratio of debt to GDP let $dr=d\tau=0$. We then have $f_n d_n + f_D dD=0$. Given $dn/dD=-f_D/f_n$, if $f_n, f_D < 0$, $dn/dD < 0$. Thus growth decreases as a result of the rise in debt everything else remaining constant. The YB curve shifts down.

Similarly, keeping r, τ and γ fixed, $dr=d\tau=d\gamma=0$, we have $g_n dn+g_D dD=0$ and so $dn/dD=-g_D/g_n$ .If $g_D, g_n < 0$ then $dn/dD<0$ and the LT curve shifts downwards when debt increases. The combined effect of an increase in debt is a reduction in long-run growth. We can derive the debt/GDP ratio multiplier

$[\partial N/\partial D]_{\tau,\gamma} = g_r f_D - g_D f_r / f_r g_n - g_r f_n$

where $f_r g_n - g_r f_n < 0$. From the expected signs of the partial derivatives we can expect $[\partial N/\partial D]$ to be negative. This implies that an increase in the steady state ratio of public debt to GDP reduces long-run growth given the ratio of government consumption to government spending and the tax ratio. This effect is not contrary to our expectations in a non-Ricardian world. Since public debt is considered net wealth in such a world, an increase in debt would raise consumption spending and reduce private savings available for investment. It should thus have a growth reducing effect if long-run growth depends on the level of investment.

Let us now look at the effect of a change in the tax rate. We assume that $dr=dD=0$. Now, $f_n dn+f_\tau d\tau=0$ or $dn/d\tau=-f_\tau/f_n$. If f_τ, $f_n < 0$ as expected, $dn/d\tau < 0$. In other words when the tax rate increases less is available for private sector saving and investment and when investment is lower, the growth rate is lower in an endogenous growth model. Hence the YB shifts down.

To look at what happens to the LT curve, let dr=dD=dγ=0. We have $g_n dn+g_\tau d\tau=0$. So, $dn/d\tau=-g_\tau/g_n$. If $g_\tau>0$, $g_n<0$ then $dn/d\tau >0$. The LT curve shifts upwards when the tax rate increases. This is because more can be invested by the government while satisfying its intertemporal budget constraint. The total effect of the change in tax rate is not clearly in any one direction. We can derive the tax rate multiplier as

$[\partial N/\partial\tau]_{D,\gamma} = g_r f_\tau - g_\tau f_r / f_r g_n - g_r f_n.$

While the denominator is negative, the numerator can be either positive or negative. An increase in taxes thus has an ambiguous effect on growth. The reason for this is that as the tax rate increases, given the debt/GDP ratio, a higher government spending-GDP ratio consistent with the government budget constraint can be reached. Part of this additional spending goes on infrastructure which enhances growth. However, taxes are distortionary and, for a given real interest rate r, an increase in the tax rate reduces savings as a proportion of GDP which depresses private investment and hence growth.

Let us now look at the effect of the third fiscal policy variable γ. Since YB is not a function of γ, it does not shift due to a shift in γ. On the LT curve we assume that the tax rate and debt/GDP ratio remaining constant we will have $dn/d\gamma=-g_\gamma/g_n$. If $g_\gamma>0$ and $g_n<0$ then $dn/d\gamma >0$. The LT shifts upwards. An increase in the proportion of government spending on infrastructure raises the growth rate. We can show

$[\partial N/\partial\gamma]_{D,\tau} = - g_\gamma f_r / f_r g_n - g_r f_n \quad >0$

The result that an increase in the proportion of government spending on investment and development purposes raises growth is again in accord with the basic characteristics of the growth model presented here.

8. Calibration

Observed variables are those reported in the Economic Survey, Government of India and Yearbook of the International Financial Statistics published by the International Monetary Fund.

We assume that r, the implicit risk free real interest rate relevant for consumption decisions,is 14.0 per cent, the proportion of labour income received by unconstrained households is 70 per cent, the probability of death, p, is 0.02 and δ, the rate of time preference, is 0.032.[2]

A rate of growth of population over 1981-91 is reported to be 2.14 per cent. GDP grew at an average rate of approximately 4.5 per cent over this decade. Gross Domestic Private Investment as a percent of GDP for 1991-92 is reported to be 14.0 per cent. Consumption as a percent of GDP is calculated to be 64 per cent from the figures provided by the IMF. Government spending constitutes 22 per cent of GDP. The total outlay of the government - Central and State Governments and Union Territories is categorised as development and non-development expenditure. Non-development expenditure includes defence, tax collection charges, police, etc. To analyse the impact of government spending on productivity, we choose γ to be development expenditure as a proportion of total government expenditure. This includes public investment in infrastructure, education and health. Development spending as a proportion of total

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[2] Values of r, λ, δ and p as in Patnaik, I.,(1995) ' Consumption, Fiscal Policy and Endogenous Growth: The Case of India', Unpublished PhD thesis, University of Surrey, Guildford, U.K.

government expenditure has declined by about 10 per cent in the last decade and was 54.3 per cent in 1993-94.

π, the rate of depreciation, is chosen to be 5 per cent. Depreciation of physical capital through technological obsolescence as well as wear and tear may be expected to be roughly 10 per cent. Our concept of capital is broader and includes human as well as physical capital. Since we expect a much lower depreciation rate for human capital we choose the average depreciation rate for our broad concept of capital to be 5 per cent.

γ_1 is the contribution of public capital to the production externality i.e., it is the contribution of public capital to the economy-wide efficiency of labour. As γ_1 is neither estimated nor observed, it is imposed. Since we do not know its value, we impose different values of γ_1 and calibrate the model. To each level of γ_1 corresponds $1\text{-}\gamma_2 = \gamma_1 (1\text{-}\alpha)$, the elasticity of aggregate output to public capital stock. The value of α, the share of income accruing to private capital, was revealed to be approximately 29 per cent. So the higher is γ_1 the higher is the elasticity $1\text{-}\gamma_2$.Table 1 shows the values of the multipliers when the model is calibrated at different values of γ_1.

Table 1: The Multipliers for selected values of γ_1

γ_1	$\partial n/\partial \gamma$	$\partial n/\partial D$	$\partial n/\partial \tau$
0.2	0.03232	-0.00497	-0.0625
0.5	0.07678	-0.01202	0.06384
0.7	0.10404	-0.02174	0.14130
0.9	0.12960	-0.02772	0.21393

8.1. The Development Expenditure Multiplier

The development expenditure multiplier, ($\partial n/\partial \gamma$), measures the change in long run steady state growth rate corresponding to a change in the proportion of development expenditure in total government spending when the tax rate and the debt /GDP ratio are unchanged. For γ_1=0.2 a one per cent increase in the proportion of development expenditure in government spending leads to an increase in the long-run growth rate by 0.03 per cent. Similarly if γ_1 were 0.7 the rise in the long-run growth rate would be 0.1 per cent. A ten per cent reduction in the proportion of development expenditure then implies a 1 per cent decline in the long run growth rate. Any increase in the proportion of development expenditure to total government spending raises the long-term growth rate whatever the efficiency of the public sector. However, when γ_1 is higher, a reduction in the ratio of development expenditure to total government expenditure reduces growth to a larger extent. This can be seen in Figure 2. The higher is γ_1, the contribution of the public sector to raising the economy-wide efficiency of labour, the greater is the effect on long-term growth of a reduction in the proportion of development expenditure to total government spending.

8.2. The Tax Multiplier

While growth rates unambiguously increase as debt declines or as government spending on infrastructure increases, other things remaining the same, the change in growth brought about by a change in the tax rate is not so well defined. The tax multiplier, $(\partial n/\partial \tau)$, measures the change in long-run steady state growth due to a change in τ, the tax rate, when D and γ are unchanged. Given the government budget constraint a rise in the tax rate allows higher public spending and thus investment. When γ_1 is high, then a rise in the tax rate which reallocates resources to the public sector raises long-term growth rate. The tax multiplier is therefore positive. However, when γ_1 is low, higher taxes imply an increase in public investment at the cost of private saving which leads to a reduction in private investment. An increase in tax rate reduces long-run growth rate when the contribution of the public sector to the growth potential of the economy is relatively lower. Figure 3 shows how the value of the tax multiplier rises with an increase in γ_1. We see that the sign of the tax rate multiplier changes from negative to positive as γ_1 rises.

8.3. The Debt Multiplier

The debt multiplier, $(\partial n/\partial D)$, measures the change in long-run steady state growth due to a change in D, the debt/GDP ratio, when τ and γ are unchanged. Table 2 shows that if γ_1 were 0.2, a one per cent increase in the debt/GDP ratio leads to a reduction in the long run growth rate by 0.005 per cent. Or, a hundred per cent increase in the debt/GDP ratio would reduce growth rate by 0.5 per cent. At γ_1=0.7 a hundred per cent increase in D would reduce the growth rate by 2.17 per cent.

We observe in Figure 4 that the absolute value of the multiplier rises when γ_1 is higher and a rise in the debt ratio reduces long-term growth to a larger extent. If taxes remain unchanged, then a reduction in debt is achieved by reducing government spending. Since development expenditure constitutes nearly half of total government spending, the higher is γ_1, the larger will be the effect of a reduction in debt on long-term growth rate.

8.4. Non-Ricardian Effects

In this section we examine some of the implications that arise from the violation of Ricardian assumptions. We first look at the values the tax and debt multipliers would take on if the planning horizons of the unconstrained consumers were different. We next look at the effect of liquidity constraints.

8.4.1. Finite horizons

If the probability of death is higher, the effect of the shorter time horizon on the consumption of unconstrained consumers is revealed as larger non-Ricardian effects on growth rates. Figure 5 shows that the absolute value of the debt multiplier increases as the probability of death approaches unity. This accords well with our expectation that if consumers have shorter planning horizons then public debt is treated as net wealth and consumption rises crowding out private investment and reducing the rate of growth.

When p=0 the value of the multiplier is non-zero because of other non-Ricardian effects, namely distortionary taxes, population growth and liquidity constraints and the public capital externality.

Similarly the value of the tax multiplier would be higher if the probability of death were higher. Shorter time horizons represented by a higher value of p, other parameters remaining the same, imply small changes in the tax rate would have much larger effects on growth. Again the multiplier is non-zero when p=0 because of other non-Ricardian effects. This can be seen in Figure 6.

8.4.2. Liquidity constraints

We now examine the effect of liquidity constraints on the tax multiplier. As Figure 7 shows the value of the tax multiplier falls as we approach the Ricardian case (λ=1). This is because if a higher proportion of income is received by forward looking consumers then the effect of a change in the tax rate on consumption will be lower and the magnitude of crowding out is smaller. Hence the effect of a change in the tax rate on the growth rate is smaller.

8.4.3. Distortionary Taxes

To examine the effect of distortionary taxes we assume that p=g=0 and λ=1 as in the Ricardian case. Now the deviation from Ricardian Equivalence is due only to distortionary taxes and the public capital externality. We re-estimate the multipliers at the mean value of $\gamma_1 = 0.5$. Table 3 shows us how these 'quasi-Ricardian' multipliers compare with the non-Ricardian case when there exist finite horizons, population growth, liquidity constraints and distortionary taxes. Since the development expenditure multiplier is determined on the supply side of the model we look at the tax and debt multipliers which would be affected by non-Ricardian effects on demand.

Table 3: The Multipliers for the Quasi Ricardian and Non-Ricardian Cases

Multiplier	Quasi Ricardian	Non-Ricardian
$\partial n/\partial D$	-0.0154	-0.0153
$\partial n/\partial \tau$	0.0599	0.0638

The tax and debt multipliers in the Quasi Ricardian case are only marginally lower than in the non-Ricardian case. Clearly the effect of finite horizons, population growth and liquidity constraints is not very large. We examine the relation between the tax rate and the long-run growth rate in Figure 8, 9, 10 and 11. We also look at the choice of the tax rate that maximises growth. This is considered to be the 'optimal' tax rate.

We first examine the relationship between the tax rate and the growth rate in Figure 8. γ_1 is assumed to be the mean level of 0.5. Figure 8 shows the optimal tax rate for different levels of γ, the ratio of development to total government spending. Given the level of γ at 0.54 growth rate can be raised by raising the tax rate to about 40 per cent. If γ were higher by 10 or 20 percentage points, growth rates achieved would be relatively higher at any tax rate.

As discussed earlier, the effect of distortionary taxes on the long-run growth rate depends on the contribution of public capital stock to the economy wide efficiency of labour. We see that the optimal tax rate is different at different values of γ_1. Figure 9 indicates that if γ_1 =0.25 the maximum growth rate is achieved when the tax rate is around 25 per cent. The higher is γ_1, the higher is the optimal tax rate. When γ_1 =0.75 the optimal tax rate is around 57 per cent.

Figure 10 shows growth rates at different levels of the tax rate corresponding to the debt /GDP ratio. γ_1 is assumed to be the mean level of 0.5. Again growth rate can be increased from its present level by raising the tax rate up to about 40 per cent. If the debt/GDP ratio is lower then growth rates are relatively higher for all τ.

Finally Figure 11 shows the optimal tax rate for different values of the liquidity parameter λ. It also shows that the effect on growth of changing the proportion of income received by unconstrained consumers. It can be seen that this effect is quite small. Increasing the proportion of income earned by the rich will not increase growth substantially even though they save and the poor don't. If all post-tax labour income was to be received by unconstrained consumers ($\lambda = 1$), the long run growth rate would be about 0.2 per cent higher. For the present value of the liquidity parameter of 70 per cent, the optimal tax rate is about 40 per cent. This is not significantly affected by the value of λ.

9. Some Examples

In this section we impose restrictions on the parameters p, g, λ, τ and γ_1 to evaluate the relative importance of the non-Ricardian effects for empirical analysis and obtain a range of specifications including the 'pure' Ricardian, and models similar to Alogoskoufis and van der Ploeg (1990) and Buiter (1991) among others. The endogenous growth character of the model is retained throughout by the assumption that there are externalities arising from private capital.

In the 'pure' Ricardian case we assume that there are no public capital externalities, no liquidity constraints, no population growth, horizons are infinite and taxes are non-distortionary. So $p = g = 1- \lambda = \tau = \gamma_1 = 0$.

The aggregate consumption function can be shown to be

$$C_t = \frac{1+r}{1+\delta} C_{t-1}$$

the consumption function of a representative agent. In the steady state expressing consumption as a ratio of GDP

$((1+n)(1+\delta)-(1+r))C = 0$

Since taxes are lump-sum, the government budget constraint is

$G=T-(r-n)/(1+n)D$

The market equilibrium condition is

$C = 1- ((n+\pi)/(1+n))K - G$

The 'Ricardian' equivalent of the 'Yaari-Blanchard' consumption function is

$f(n,r,D) = ((1+n)(1+\delta)-(1+r))(1- ((n+\pi)/(1+n))K - T+(r-n)/(1+n)D) = 0$

Assuming that $\gamma_1 = 0$ as in Romer (1986) i.e. public capital has no externalities then the LT curve becomes

$\log B + \log K(r) = 0$

The debt multiplier has been defined as

$[\partial N/\partial D]_{\tau,\gamma} = g_r f_D - g_D f_r / f_r g_n - g_r f_n$

In this case $g_D = 0$ and if $n=r- \delta$, f_D approaches zero and the debt multiplier approaches zero. The tax and development expenditure multipliers are also both zero. In other words, when consumers have infinite horizons, there are no liquidity constraints, no population growth, taxes are lump sum, public capital has no externalities and the growth rate is equal to the real interest rate minus the pure rate of time preference, fiscal policy is neutral.

In the Yaari-Blanchard case when only $p \neq 0$, and we assume that there are no liquidity constraints, population growth or externalities associated with public capital and $n = r - \delta$, non-Ricardian effects arise as the probability of death is positive. Due to finite horizons public debt is considered net wealth and this raises consumption and reduces saving which in turn reduces net investment and hence reduces the long run growth rate. The restrictions that $g = 0$, $\lambda = 1$, $\tau = 0$, $\gamma_1 = 0$ and $n = r - \delta$, reduce our model to the Alogoskoufis and van der Ploeg (1990) specification. As can be seen in Table 4 if $p = 0.02$ we find that when taxes are lump sum, the value of the debt multiplier is -0.0013. Thus a 100 percent decrease in the debt/GDP ratio leads to a 0.13 percent rise in the growth rate. Our result that in the presence of finite horizons, a change in the debt/GDP ratio affects the long-run growth rate, corresponds with their conclusions. When finite horizons and population growth are both included in the model as in Alogoskoufis and van der Ploeg (1991) and Buiter (1991) the debt multiplier becomes -0.0018. In other words, if in addition to finite horizons we include the population growth rate the absolute value of the debt multiplier rises by 0.0005. This suggests that the effect of Blanchard-Weil demographics are significant when taxes are lump sum and there arise no externalities due to public capital.

The model incorporates tax distortions in the form of a flat rate income tax imposed on all labour and non-labour income as in Barro (1990) and Futagami, Morita and Shibata (1993), Jappelli and Meana (1994) and Krichel and Levine (1995). When none of the other Ricardian assumptions are violated the debt multiplier is found to be non-zero at -0.001. The non-zero effects of government borrowing on long-run growth are entirely due to distortionary taxes. We can again look at how the multipliers would be affected if one or more of the other assumptions of the Ricardian theorem were violated as well.

When finite horizons and population growth are incorporated in the model with tax distortions the absolute value of the debt multiplier becomes higher. At p = 0.02, g = 0 the value of the debt multiplier is - 0.0027 and at p = 0.02, g = 0.02 it is -0.0030. In comparison with the lump sum tax case these values are nearly double indicating the importance of tax distortions. These results suggest that models like Alogoskoufis and van der Ploeg (1990, 1991) and Buiter (1991) while taking into account effects of finite horizons and population growth on the demand side, ignore more important demand side non-Ricardian effects due to distortionary taxes.

When the stock of public capital affects the economy-wide efficiency of labour, the effect of fiscal policy on the long-run growth rate is due not only to non-Ricardian demand side effects but due to the direct effect of public spending on infrastructure, education, health and other development expenditure which creates physical and human capital. We see that the multipliers are much larger in magnitude when the externality arising from public spending is taken into account. Our results are summarised in Tables 4, 5 and 6. At γ_1=0.5 the tax multiplier is now positive which indicates that higher taxes that finance development expenditure serve to raise growth, outweighing negative demand side effects.

Table 4: The Debt Multiplier[3]

Case	Distortion	Lump sum Taxes	Distortionary Taxes
Pure Ricardian	None	0	-0.001
Finite Horizons	p = 0.02	-0.0013	-0.0027
Finite Horizons and Population Growth	p = 0.02 g = 0.02	-0.0018	-0.0030
Public Capital Externality	$\gamma_1 = 0.5$	-0.0065	-0.0061
Finite Horizons and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02	-0.0074	-0.0074
Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02 g = 0.02	-0.0078	-0.0079
Liquidity Constraints, Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ $\lambda = 0.7$ p = 0.02 g = 0.02	-[4]	-0.0088

[3] We set r = 0.077 so that n = r- δ. All other parameters retain their previous values.
[4] In the case when we have lump sum taxes and liquidity constraints we need to determine the share of taxes paid by the two groups of consumers. Since there is no evidence for this we avoid imposing an arbitrary value and so do not calculate this multiplier.

Table 5: The Tax Multiplier

Case	Distortion	Distortionary Taxes
Pure Ricardian	None	-0.0478
Finite Horizons	p = 0.02	-0.0481
Finite Horizons and Population Growth	p = 0.02 g = 0.02	-0.0764
Public Capital Externality	$\gamma_1 = 0.5$	0.1267
Finite Horizons and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02	0.1305
Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02 g = 0.02	0.1168
Liquidity Constraints, Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ $\lambda = 0.7$ p = 0.02 g = 0.02	0.1196

Table 6:The Development expenditure Multiplier

Case	Distortion	Lump sum Taxes	Distortionary Taxes
Pure Ricardian	None	0	0
Finite Horizons	p = 0.02	0	0
Finite Horizons and Population Growth	p = 0.02 g = 0.02	0	0
Public Capital Externality	$\gamma_1 = 0.5$	0.0850	0.0710
Finite Horizons and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02	0.0858	0.0726
Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ p = 0.02 g = 0.02	0.0874	0.0754
Liquidity Constraints, Finite Horizons, Population Growth and Public Capital Externality	$\gamma_1 = 0.5$ $\lambda = 0.7$ p = 0.02 g = 0.02		0.0765

When we include only the externality due to public capital then the value of the debt multiplier is -0.0065, while if we include all the non-Ricardian demand side effects due to finite horizons, population growth, tax distortions and liquidity constraints it is -0.0088. This means that the effect of a ten per cent reduction in growth rate would raise the long run growth rate in the first case by 0.065 per cent and in the second by 0.088 per cent. By ignoring non-Ricardian demand side effects, though they have been found to exist, the anticipated change in the long run growth rate would not be very different. From the current level of 4.5 per cent it is anticipated to rise to 4.5088, when demand side effects are included and 4.5065 when they are ignored. Even in the case of development expenditure and the tax rate, there is only a marginal change in the value of the multiplier when these effects are ignored.

10. Conclusions

The strongest effect on growth arises from public capital externalities, and in their absence from tax distortions. Our results thus appear to suggest that in an endogenous growth model which takes into account supply side effects caused by externalities arising from development expenditure, ignoring non-Ricardian effects on the demand side would not significantly affect the results. Ignoring Blanchard-Weil demographics may on the one hand lead to loss of generality and perhaps reduce the accuracy of our results, but more may be gained from the analytical simplicity achieved by making Ricardian assumptions on the demand side. These results arise primarily because a change in development expenditure or spending directly changes total investment in addition to influencing private investment by making it more productive. It thus has a greater impact on the long run growth rate compared to the effect of a change on government's financing policy which affects investment only indirectly. Non-Ricardian assumptions imply that the government's decision to raise debt at the expense of taxes raises net wealth and consequently raises consumption demand which raises real rates of interest and hence lowers private investment. Demand side effects on growth, though present, are quite small.

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The Yaari-Blanchard and Linear Technology Curves :

Effect of a rise in the Debt/GDP ratio

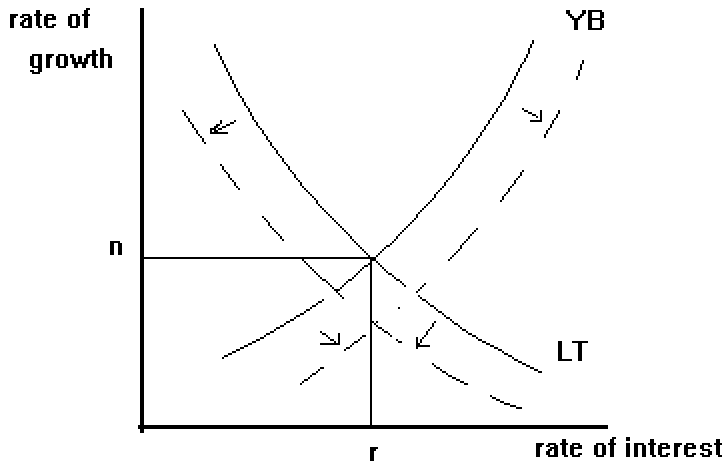


Figure 1

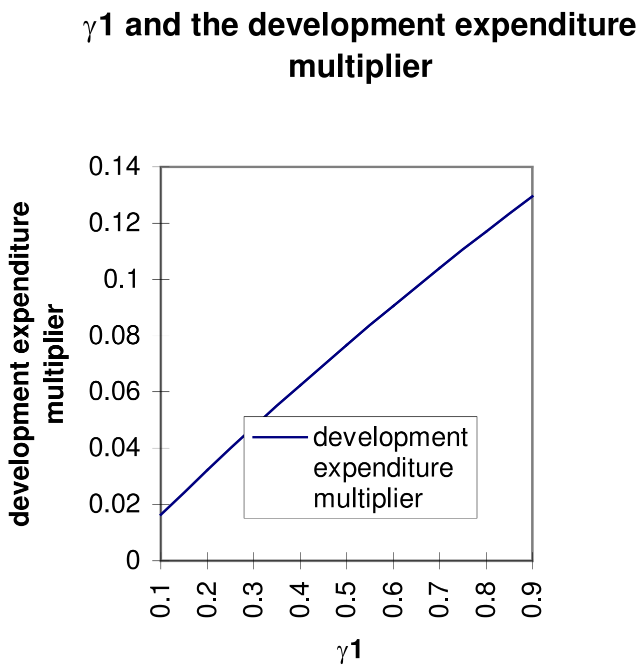

γ1 and the development expenditure multiplier
development expenditure multiplier
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
γ1
development expenditure multiplier

Figure 2

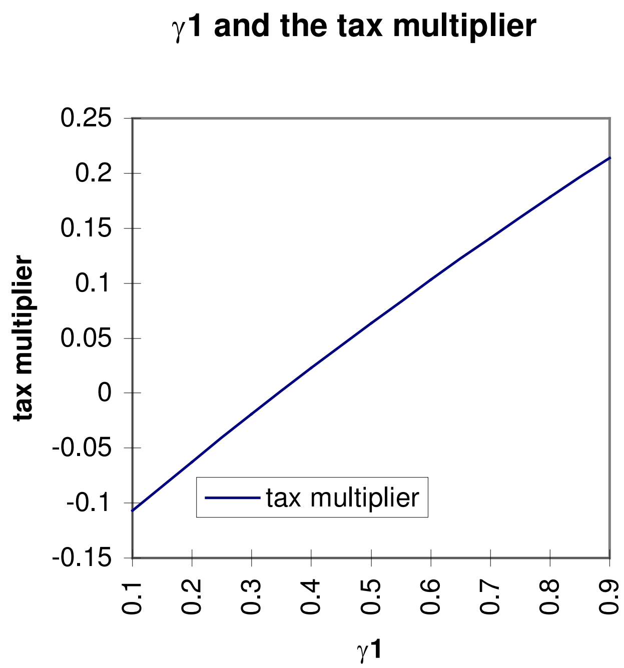

γ1 and the tax multiplier
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
tax multiplier
tax multiplier
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
γ1

Figure 3

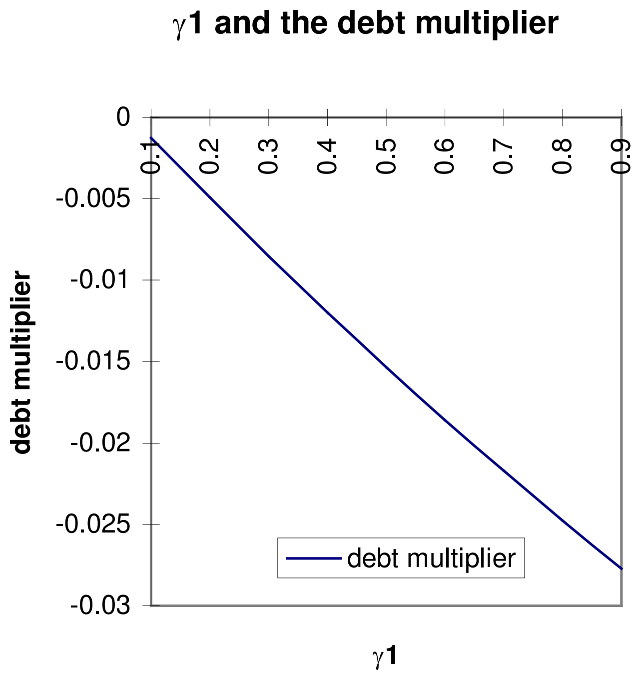
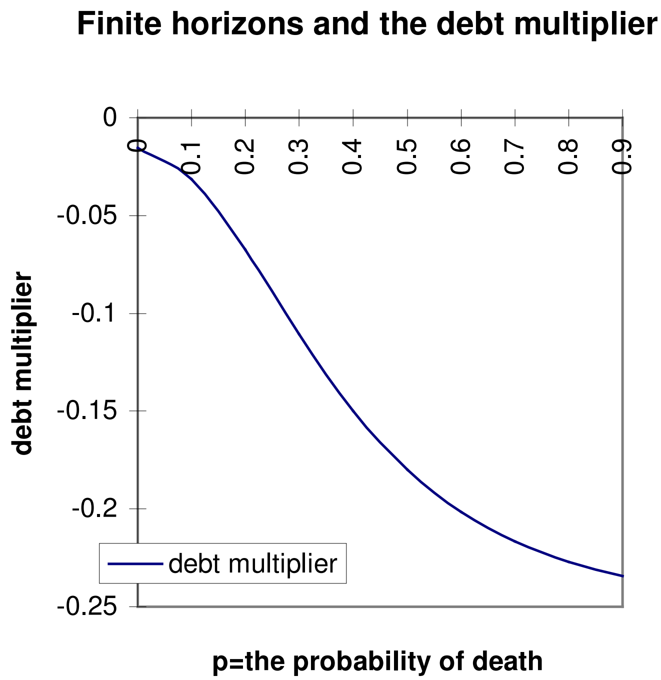
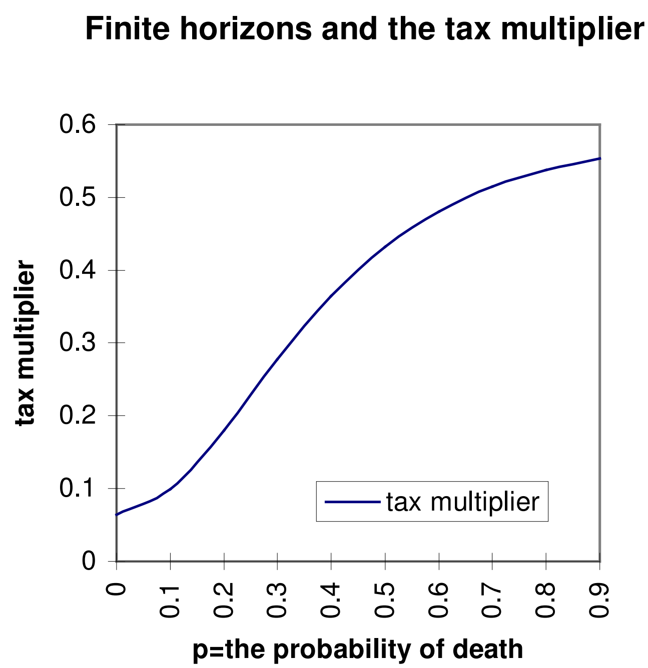

γ1 and the debt multiplier
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
debt multiplier
debt multiplier
γ1

Figure 4



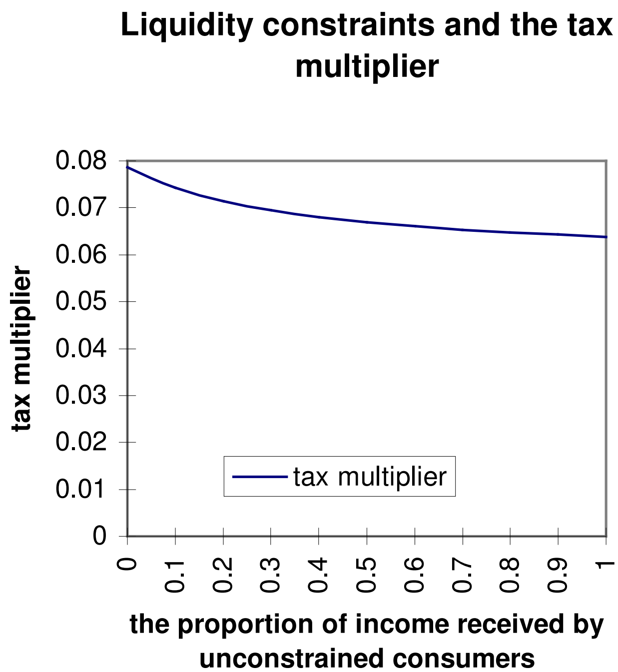
Finite horizons and the debt multiplier
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
debt multiplier
debt multiplier
p=the probability of death

Figure 5



Finite horizons and the tax multiplier
tax multiplier
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
p=the probability of death
tax multiplier

Figure 6



Liquidity constraints and the tax multiplier
tax multiplier
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
tax multiplier
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
the proportion of income received by unconstrained consumers

Figure 7

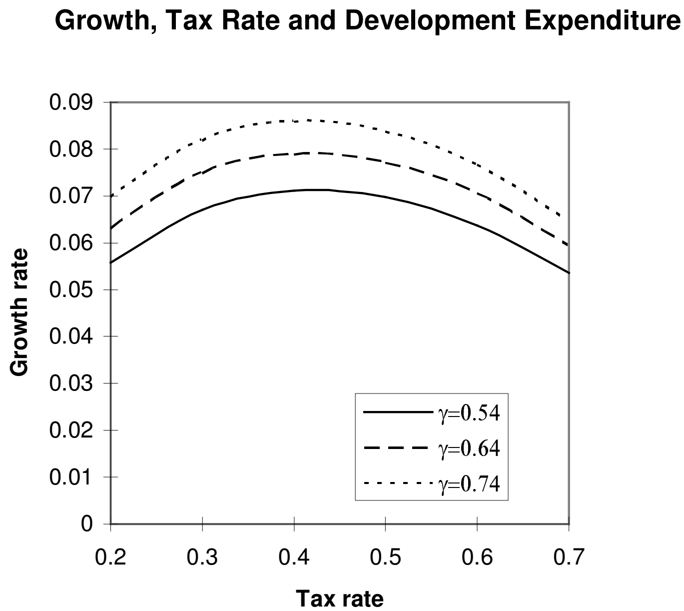


Figure 8

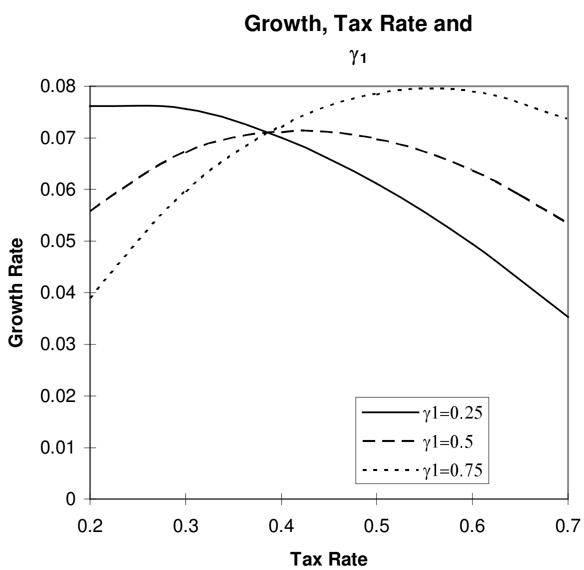


Figure 9

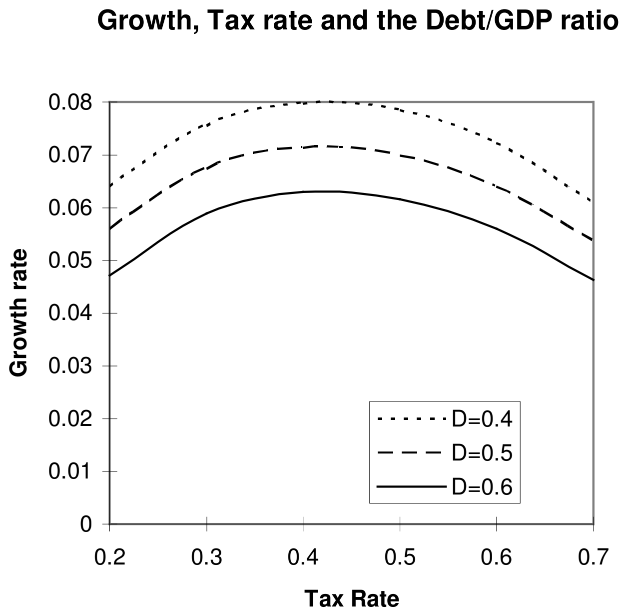

Growth, Tax rate and the Debt/GDP ratio
Growth rate
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.2
0.3
0.4
0.5
0.6
0.7
Tax Rate
D=0.4
D=0.5
D=0.6

Figure 10

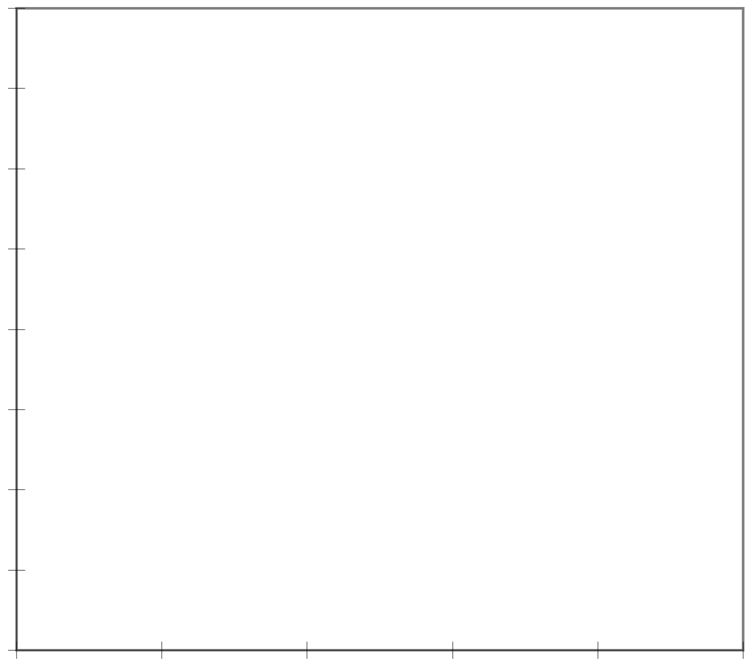


Figure 11