# FISCAL POLICY, ELASTIC LABOR SUPPLY, AND ENDOGENOUS GROWTH*

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Endogenizing labor supply leads to fundamental changes in the equilibrium structure of the AK growth model. The balanced growth equilibrium can be described in terms of two tradeoff loci relating the equilibrium growth rate to the fraction of time devoted to leisure. The implications of endogenous labor supply for fiscal policy are analyzed. Three issues are addressed. First, the effects of various distortionary tax changes and government expenditure changes on the equilibrium growth-leisure (employment) tradeoff are analyzed. Second, optimal fiscal policy is characterized. Finally, the formal analysis is supplemented by numerical results, focusing particularly on the quantitative welfare implications.

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## 1. Introduction

Recent endogenous growth models have stressed the role of fiscal policy as a key determinant of long-run growth.[1] One limitation of these new models is that with few exceptions they treat labor supply as inelastic, thereby abstracting from the decision to allocate time between work and leisure. This treatment severely limits certain aspects of fiscal policy, implying for example, that both a consumption tax and a tax on labor income operate as non-distortionary lump sum taxes. Furthermore, it is familiar from intertemporal Ramsey-type models that the endogeneity of labor supply is essential for government consumption expenditure policy to have real effects on output and capital; see, for example, Turnovsky (1995). In a growth context, the well known Eaton (1981) result, showing how under debt financing the equilibrium growth rate is independent of the share of government (consumption) expenditure, is a manifestation of the same phenomenon.

This paper introduces an elastic labor supply into a simple AK investment-based growth model, using this model to analyze fiscal policy in the form of distortionary taxes and government expenditure changes. Under plausible conditions, the economy will always lie on its balanced growth path, just as it does in the standard one-sector AK model with fixed labor supply. However, endogenizing labor supply leads to fundamental changes in the economy's equilibrium structure, as well as to important implications for fiscal policy.

The balanced growth equilibrium for such an economy can be conveniently depicted in terms of two tradeoff loci relating the equilibrium balanced growth rate to the fraction of time devoted to leisure. The first locus describes the combinations of these two quantities that maintain consistency among rates of return; the second describes the combinations of these two quantities consistent with product market equilibrium. These relationships are highly nonlinear and an equilibrium may or may not exist in which both conditions are met simultaneously. This is in contrast to the basic one-sector AK model, in which the existence of a long-run balanced growth path is always assured.

The main focus of our analysis is to consider the consequences of endogenizing labor supply for fiscal policy. In contrast to the more familiar case of an inelastic labor supply, all fiscal

[1] See e.g. Barro (1990), Rebelo (1991), Jones, Manuelli, and Rossi (1993), Ireland (1994), and Turnovsky (1996).

variables, including taxes on capital income, labor income, and consumption, as well as both government expenditure on consumption and production, now influence the equilibrium growth rate. In addition, the benefits from government expenditure, both in consumption and in production, are important in the tradeoff loci that determine the existence (or lack thereof) of an equilibrium.[2]

Our analysis of fiscal policy focuses on three general issues. First, we conduct a number of comparative static exercises, analyzing the effects of distortionary tax changes and expenditure changes on the equilibrium growth-leisure (employment) tradeoff. These can be carried out by simple manipulation of the two equilibrium tradeoff loci. All tax rates reduce the labor supply and the growth rate. We also derive a ranking for the effects of government expenditure on the growth rate under different modes of tax financing. This ranking is in inverse order to the adverse effect of the particular tax on the incentives to accumulate capital.[3]

Second we characterize optimal fiscal policy. If government expenditures are set optimally, then capital should not be taxed; consumption and leisure should be taxed uniformly. If government expenditures are not at their optimal levels, then all three tax rates should be set so as to correct the distortions induced. In general, this enables the support of the first-best optimum.

Finally, the formal analysis is supplemented by some quantitative results. A benchmark economy is calibrated and the numerical effects of various types of policy shocks assessed. Two aspects to receive particular focus are: (i) the welfare of the representative agent as measured by his intertemporal utility, and (ii) the intertemporal government budget balance. Our numerical calculations suggest that reducing income taxes and introducing consumption taxes may yield numerically significant welfare gains, while at the same time having a favorable effect on the government's intertemporal balance. The optimal tax policies are also computed numerically.

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[2]Two recent papers to introduce leisure into an endogenous growth model include Benhabib and Perli (1994) and Ladrón-de-Guevara, Ortigueira, and Santos (1997). The focus of these papers is different from that presented here, in that they are concerned with issues of existence of equilibrium, showing how the endogeneity of labor may quite plausibly produce indeterminacy in the Lucas (1988) two-sector model. Brief discussions of the effects of taxation in models of endogenous labor supply are provided by Rebelo (1991) and Stokey and Rebelo (1995). None of these papers is concerned with our primary objective, which is to provide a comprehensive analysis of the impact of endogenous labor supply on the efficacy of fiscal policy in a growing economy.

[3]The experiments analyzed in the paper are illustrative. The model is amenable to the analysis of a range of policy issues, some of which are considered in an expanded version of this paper.

## 2. The Analytical Framework: Centrally Planned Economy

The economy consists of $N$ identical individuals, each of whom has an infinite planning horizon and possesses perfect foresight. Population remains fixed over time. We shall denote individual quantities by lower case letters, and aggregate quantities by corresponding upper case letters, so that $X = Nx$. We assume that the representative agent is endowed with a unit of time that can be allocated either to leisure, $l$, or to work, 1- $l$, $[0 < l < 1]$. Output of the individual firm, $y$, is determined by the Cobb-Douglas production function:

$$y = \alpha' G_p^{\beta}(1-l)^{\varphi} k^{1-\beta} \equiv \alpha'\left(G_p/k\right)^{\beta}(1-l)^{\varphi} k \quad 0 \le \beta \le 1,\ 0 < \varphi < 1,\ \varphi \le \beta \tag{1}$$

where $k$ denotes the individual's capital stock, assumed to be infinitely durable, and $G_p$ denotes the flow of services from government spending on the economy's infrastructure. We assume that these services are not subject to congestion so that $G_p$ is a pure public good. The individual firm faces positive, but diminishing, marginal physical products in all factors, non-increasing returns to scale in the private factors, capital and labor, but constant returns to scale in private capital and in government production expenditure.[4] We shall assume that government claims a fraction, $g_p$, of aggregate output, $Y$, for expenditure on infrastructure, in accordance with:

$$G_p = g_p Y \tag{2}$$

Thus combining (1) with (2), and $Y = Ny$, aggregate output in the economy is given by:

$$Y = \left(\alpha g_p^{\beta}\right)^{1/(1-\beta)}(1-l)^{\varphi/(1-\beta)} K \qquad \alpha \equiv \alpha' N^{\beta} \tag{3}$$

and is proportional to the aggregate capital stock, thereby leading to an equilibrium having ongoing, endogenously determined, growth. Thus the aggregate production function is an AK technology, in which the productivity of capital depends positively upon the fraction of time devoted to work and the share of productive government expenditure. We shall assume further that labor productivity is diminishing in the aggregate, leading to the additional constraint, $\varphi < 1-\beta$.

[4]It is well known that in order to assure ongoing growth the production function must be linearly homogeneous in the factors that are being accumulated (capital and government expenditure).

The representative agent's welfare is given by the intertemporal isoelastic utility function:

$$U = \int_0^\infty \frac{1}{\gamma}\left([C/N] l^\theta G_c^\eta\right)^\gamma e^{-\rho t} dt \tag{4}$$

$$\eta > 0,\ \theta > 0; \quad -\infty < \gamma \le 1; \quad 1 > \gamma(1+\eta); \quad 1 > \gamma(1+\eta+\theta)$$

where $C$ denotes total aggregate private consumption, $G_c$ denotes the consumption services of a government-provided consumption good, and the parameters $\theta$ and $\eta$ measure the impact of leisure and public consumption on the welfare of the private agent. We assume that both provide the agent with positive marginal utility.[5] The parameter $\gamma$ is related to the intertemporal elasticity of substitution, $s$ say, by $s = 1/(1-\gamma)$. The remaining constraints on the coefficients appearing in (4) are required to ensure that the utility function is concave in the quantities $C$, $l$, and $G_c$. These conditions imply other restrictions, such as $1 > \gamma(1+\theta)$, $1 > \gamma\theta$.

We assume that the government also claims a fraction, $g_c$, of output for consumption:

$$G_c = g_c Y \tag{5}$$

In this section, we consider the equilibrium generated in a centrally planned economy in which the planner chooses $K$, $C$, and $l$ to maximize the utility of the representative agent, subject to the aggregate resource constraint of the economy:

$$\dot{K} = (1 - g_c - g_p)Y - C \tag{6}$$

and the aggregate production function (3), and we assume $1 > g_p + g_c$.

We begin by assuming that the government shares of output used for production and consumption, $g_p, g_c$, respectively, are fixed arbitrarily, although Section 2.3 below will also consider the case where these are set optimally, along with the other decision variables.

[5]Note that the utility function (4) satisfies the functional form identified by Ladrón-de-Guevara, et al (1997) for which the introduction of leisure will be consistent with a balanced growth equilibrium.

## 2.1 Macroeconomic Equilibrium

The derivation of the macroeconomic equilibrium is outlined in the Appendix. There we indicate how it can be expressed as a first-order differential equation in the fraction of time devoted to leisure, $l$. Under weak conditions this equation is locally unstable, implying that the economy always lies on its balanced growth path.[6] Defining the quantity:

$$\Omega(l) \equiv \frac{\varphi}{\theta(1-\beta)}\left(\frac{l}{1-l}\right)$$

enables the equilibrium to be conveniently summarized by the five equations:

*intratemporal optimality*: $$\frac{1}{\Omega(l)}\left(\frac{C}{Y}\right) = \frac{\mu}{\lambda} \tag{7a}$$

*shadow value of output*: $$\frac{\mu}{\lambda} = 1 - g_p - g_c + \eta\frac{C}{Y} \tag{7b}$$

*Euler equation*: $$\psi = \frac{1}{1-\gamma(1+\eta)}\left\{\left(\frac{\mu}{\lambda}\right)\left(\frac{Y}{K}\right) - \rho\right\} \tag{7c}$$

*resource constraint*: $$\psi = \left[(1-g_p-g_c) - \left(\frac{C}{Y}\right)\right]\left(\frac{Y}{K}\right) \tag{7d}$$

*production function*: $$\left(\frac{Y}{K}\right) = \left(\alpha g_p^{\beta}\right)^{1/(1-\beta)}(1-l)^{\varphi/(1-\beta)} \tag{7e}$$

where $\lambda$ denotes the shadow value of capital, and $\mu$ is the shadow value of a marginal unit of output, $Y$. These five conditions jointly determine the equilibrium values (denoted by tildes) of: the fraction of time devoted to leisure, $\tilde{l}$, the consumption to output ratio, $\widetilde{(C/Y)}$, the output-capital ratio $\widetilde{(Y/K)}$, the relative value of output to capital, $\mu/\lambda$, and the balanced growth rate, $\tilde{\psi}$.[7]

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[6] Specifically we can show that if inequalities (8a) and (8b) (below) hold, so that a unique balanced growth path exists, then it is locally dynamically unstable. This local instability of the dynamic path depends in part upon our assumptions of a Cobb-Douglas production function and constant elasticity utility function, and justifies our focus on the balanced growth equilibrium in the present analysis. For more general production functions one cannot dismiss the possibility that the equation is stable, giving rise to potential problems of indeterminate equilibria; see Benhabib and Perli (1994), Benhabib and Farmer (1994), and Ladrón-de-Guevara, Ortigueira, and Santos (1997).

[7] The transversality condition $\lim_{t\to\infty}\lambda K e^{-\rho t} = 0$ also needs to be satisfied. Substituting the equilibrium values into this expression and evaluating, it can be verified to hold. The same applies in the decentralized economy discussed later.

To ensure a positive equilibrium consumption-output ratio requires:[8]

$$1 > \eta\Omega(l) \text{ or } l < l^* \equiv \Omega^{-1}(1/\eta) < 1 \tag{8a}$$

Thus in order for a feasible equilibrium consumption to exist, the fraction of time devoted to leisure cannot exceed the fraction $l^*$ defined in (8a). This condition describes a constraint imposed by balancing off two offsetting influences on the agent. The first is an incentive to decrease leisure $l$ and thus obtain higher output and derive greater government services (assuming $\eta > 0$). At the same time, more government consumption raises the utility of leisure, providing an incentive to reduce work and output. Henceforth we assume that (8a) holds; if $\eta = 0$ it certainly is met.

Equation (7a) describes the intratemporal optimality condition between consumption and leisure [see equations (A.1a), (A.1b)]. It asserts that the marginal rate of substitution between labor and therefore output, and consumption equals the relative price of output in terms of consumption (capital). Equation (7b) determines the relative price of output to capital. In the absence of government expenditure, $\mu/\lambda = 1$. Otherwise, the social value of a unit of output deviates from the social value of capital due to the claims of government on output and the value this has for the consumer. Specifically, with the size of government expenditure being tied to aggregate output, an increase in capital leading to an increase in output will divert resources away from private consumption, lowering the social return to capital, to the amount $1 - g_p - g_c$. But offsetting this, to the extent that the additional government expenditure either indirectly or directly augments private consumption, it yields utility benefits equal to $\eta C/Y$, making the overall relative value of output to capital as described in (7b).

Equation (7c) is the Euler equation which equates the social marginal return to capital to the rate of return on consumption. For the reduced form AK technology, the social marginal value of an extra unit of physical capital is given by $(\mu/\lambda)(\partial Y/\partial K) = (\mu/\lambda)(Y/K)$. This equation is essentially the usual equilibrium condition equating the (consumption) growth rate to the difference between the

[8]Solving (7a) and (7b) enables us to solve for $C/Y$ and $\mu/\lambda$ in the respective forms:

$$C/Y = (1 - g_p - g_c)\Omega(l)/[1 - \eta\Omega(l)]; \; \mu/\lambda = (1 - g_p - g_c)/[1 - \eta\Omega(l)]$$

return on capital and the discount rate, multiplied by the intertemporal elasticity of substitution.[9] Equation (7d) is the aggregate resource constraint, (6), per unit of capital, so that the left hand side is simply the equilibrium growth rate. Finally, (7e) restates the production function.

Substituting for the solution for $\mu/\lambda$ from footnote 8 and $(Y/K)$ from (7e) into (7c) yields the tradeoff between the equilibrium growth rate, $\psi$, and the long-run fraction of time devoted to leisure, $l$, that ensures the equality between the rate of return on consumption and the return on capital. This is illustrated by the solid line RR in Fig. 1, the formal expression for which is reported in the Appendix. From (A.2a) we observe that this tradeoff depends critically upon $\eta$, the utility benefits derived from government consumption. If $\eta = 0$ the slope is uniformly negative.[10] A higher fraction of time devoted to leisure will reduce the productivity of, and the return to, capital. For rates of return to remain in equilibrium, the return on consumption must fall correspondingly, and this requires the growth rate of the marginal utility of capital to rise, i.e. the balanced growth rate of the economy must decline. But if $\eta > 0$ an offsetting element is introduced. By lowering output, a larger $l$ reduces government spending, thereby reducing the utility gains from consumption. This increases the incentive to reduce private consumption, thus leaving more output for investment and increasing the equilibrium growth rate. Fig. 1.A illustrates how for small $l$ the slope depends upon whether $\eta \gtrless \theta$; as $l$ increases this latter effect dominates.

Similarly, substituting $C/Y$ from footnote 8 and $(Y/K)$ into (7d) leads to a tradeoff between the equilibrium growth rate and the fraction of time devoted to leisure that ensures product market equilibrium is maintained. This is illustrated by the solid line PP, the formal expression for which is given in equation (A.2b), and the slope of which is unambiguously negative. Intuitively, a higher fraction of time devoted to leisure reduces the productivity of capital. It also increases the consumption-output ratio, thus having a net negative effect on the rate of growth of capital in the economy. As $l$ increases, employment declines, the marginal product of labor increases, and this tradeoff along the PP locus becomes steeper.

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[9]This deviates from the usual expression due to the presence of government consumption. The same modification applies with inelastic labor supply; see Turnovsky (1996).
[10]We should also point out that Fig, 1 pertains to the case where $\eta > 0$. The case where $\eta = 0$ is qualitatively the same as for the decentralized economy illustrated by the broken line RR in Fig. 1.

The tradeoff relationships PP and RR are both nonlinear and impose restrictions on the parameters in order for a balanced growth equilibrium to exist. By virtue of (8a) these curves are defined only in the range $0 \le l \le l^* \le 1$. From equations (A.2a) and (A.2b) we can show that a unique balanced growth equilibrium [denoted by the point Q or Q'] will exist if and only if

$$\gamma < \frac{\rho}{(1 - g_c - g_p)\left(\alpha g_p^{\beta}\right)^{1/(1-\beta)}(1+\eta)} \tag{8b}$$

Given the empirical evidence suggesting that $\gamma < 0$, (8b) will plausibly be met.[11] But since a large $\gamma$ means a low rate of return on consumption, if $\gamma$ were sufficiently large to violate (8b), then for any positive combination of employment and growth consistent with goods market equilibrium, the rate of return on investment would dominate that on consumption. In that case, the RR would lie everywhere above the PP curve so that no equilibrium point of intersection would exist.

It is further seen from Figs 1 [and can be formally shown] that a unique equilibrium is associated with an intersection point at which the PP curve is always more negatively sloped than the RR curve. In other words, in the neighborhood of the equilibrium point the tradeoff between growth and leisure necessary to maintain product market equilibrium is steeper than that required to maintain portfolio balance equilibrium.

## 2.2 Expenditure Increases

With the economy always being on a balanced growth path, the effects of government policy on the equilibrium are obtained by taking the differentials of (7). Routine calculations yield the qualitative responses:

$$\frac{\partial \tilde{\psi}}{\partial g_c} < 0; \quad \frac{\partial \tilde{l}}{\partial g_c} > 0 \tag{9a}$$

An increase in the share of government consumption, $g_c$, reduces the growth rate and increases leisure. The former response is standard in models with fixed employment; see Turnovsky (1996).

[11]For example, Hall (1988) estimates the intertemporal elasticity of substitution in consumption $s = 1/(1-\gamma)$ to be around 0.1. These results obtained for the United States are confirmed in a more recent study by Patterson and Pesaran (1992) who also obtain slightly higher estimates (0.4) for the United Kingdom.

The increase in resources claimed by the central planner for nonproductive purposes reduces the amount available for investment, and the growth rate declines. Now this is exacerbated by a second effect, namely the fact that the increase in government consumption expenditure enhances the utility of leisure, inducing a decline in work effort and further reducing output and growth.

The qualitative effects of government production expenditure on $\tilde{\psi}$ and $\tilde{l}$ are:

$$sgn\left(\frac{\partial\tilde{\psi}}{\partial g_p}\right) = sgn\left[\beta(1-g_c)-g_p\right]; \quad sgn\left(\frac{\partial\tilde{l}}{\partial g_p}\right) = sgn\left[g_p-\beta(1-g_c)\right] \tag{9b}$$

There are now two offsetting effects. First, the resource claim by the government, $-g_p$, takes away from resources from investment and is growth-reducing, as is government consumption expenditure. At the same time, the fact that $g_p$ is productive enhances output growth, to the extent that the additional output is not claimed by the government for consumption.[12] This is reflected by the term $\beta(1-g_c)$. Thus both equations (9a) and (9b) highlight the tradeoff between leisure and growth.

## 2.3 Optimal Government Expenditure

Suppose now that the planner chooses his expenditure shares, $g_c, g_p$, optimally in conjunction with $C$, $l$ $Y$, and $K$. Maximizing the Hamiltonian expression in the Appendix with respect to $g_c$, $g_p$, the following optimality conditions in addition to (A.1a) - (A.1d) apply (where ^ denotes optimum):

$$\hat{g}_c = \eta\frac{C}{Y} \tag{10a}$$

$$\hat{g}_p = \frac{\beta}{1-\beta}\frac{\mu}{\lambda} \tag{10b}$$

Equations (10a) equates the marginal utility of the public consumption good to that of private consumption; $\partial U/\partial G_c = \partial U/\partial C$. Equation (10b) equates the value of the marginal productivity of public expenditure, $\mu\partial Y/\partial g_p$, to the marginal value of the consumption foregone, $\lambda Y$.

Combining (10) with (7b) leads to the following relationship:

[12]This result is identical to that obtained in the standard AK model. The only difference is that these models typically introduce only one form of government expenditure at a time; see e.g. Barro (1990), Turnovsky (1996).

$$\hat{g}_p = \beta\left[1 + \hat{g}_c - g_c\right] \tag{11}$$

The optimal share of government productive expenditure depends upon the share of government consumption expenditure relative to its optimum. At the overall optimum, $g_c = \hat{g}_c$, $\hat{g}_p = \beta$; if $g_c < \hat{g}_c$, then $\hat{g}_p > \beta$, and vice versa. Corresponding to the first-best optimal government expenditure policy, the relative price of output to capital, $\widehat{(\mu/\lambda)} = 1 - \beta$, and the overall first-best consumption-output ratio $\widehat{(C/Y)} = (1-\beta)\Omega(\hat{l})$; see (7a) and (7b).

Comparing (11) with (9b) we see that the growth maximizing level of government production expenditure coincides with the welfare maximizing expenditure if and only if $\hat{g}_c = 0$. Otherwise, the growth maximizing level of expenditure will fall short of what is required to maximize welfare, by an amount that depends upon the optimal consumption needs.[13]

## 3. Decentralized Economy

The individual agent in a decentralized market economy purchases consumption out of the after-tax income generated by labor and his holdings of capital. His objective is to maximize:

$$\int_0^\infty \frac{1}{\gamma}\left(cl^\theta G_c^\eta\right)^\gamma e^{-\rho t} dt \tag{4'}$$

subject to the individual accumulation equation:

$$\dot{k} = (1-\tau_w)w(1-l) + (1-\tau_k)r_k k - (1+\tau_c)c - T/N \tag{12}$$

where: $r_k$ = return to capital, $w$ = real wage rate, $\tau_w$ = tax on wage income, $\tau_k$ = tax on capital income, $\tau_c$ = consumption tax, $T/N$ = agent's share of lump-sum taxes. As before, $k$ refers to the individual agent's holdings of capital, and now $c$ denotes individual consumption level.[14]

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[13]This is the same as in the standard AK model. The fact that the growth maximizing fraction of government expenditure coincides with the welfare maximizing fraction in the Barro (1990) model is a consequence of the absence of government consumption expenditure from that analysis.

[14]We could easily add government bonds, but as in the fixed employment economy, they play no real role.

The production function remains as specified in (3), while equilibrium wage rate and return to capital satisfy the marginal product conditions:[15]

$$w = \frac{\partial y}{\partial(1-l)} = \varphi \frac{y}{(1-l)} \qquad r_k = \frac{\partial y}{\partial k} = (1-\beta)\frac{y}{k} \tag{13}$$

The government continues to tie expenditure levels to aggregate output as in (2) and (5). In the absence of debt, tax revenues and government expenditures must satisfy a balanced budget:

$$\tau_w N w(1-l) + \tau_k r_k K + \tau_c C + T = (g_c + g_p)Y \tag{14}$$

Summing (12) over the *N* individuals and combining with (14) leads to the resource constraint (6).[16]

Carrying out the optimization for the consumer and aggregating over the *N* identical representative agents leads to the macroeconomic equilibrium. Again under plausible conditions (that now involve tax rates) the system always lies on its balanced growth path, which we now represent as follows:

*intratemporal optimality*: $$\frac{(1-\beta)}{\Omega(l)}\left(\frac{C}{Y}\right) = \frac{1-\tau_w}{1+\tau_c} \tag{7a'}$$

*Euler equation*: $$\psi = \frac{1}{1-\gamma(1+\eta)}\left\{(1-\tau_k)(1-\beta)\left(\frac{Y}{K}\right) - \rho\right\} \tag{7c'}$$

*resource constraint*: $$\psi = \left[(1-g_p-g_c) - \left(\frac{C}{Y}\right)\right]\left(\frac{Y}{K}\right) \tag{7d}$$

*production function*: $$\left(\frac{Y}{K}\right) = \left(\alpha g_p^{\beta}\right)^{1/(1-\beta)}(1-l)^{\varphi/(1-\beta)} \tag{7e}$$

and which now determine $\tilde{l}$, $(\widetilde{C/Y})$, $(\widetilde{Y/K})$, and $\tilde{\psi}$. The parallels between (7a'), (7c') and (7a), (7c) are clear. The main difference is that in the decentralized economy the agent takes the size of

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[15]Aggregating the individual production functions (1), aggregate output is determined by

$$Y = Ny = \alpha' G_p^{\beta}[N(1-l)]^{\varphi} K^{1-\beta} N^{\beta-\varphi} = \alpha' G_p^{\beta} L^{\varphi} K^{1-\beta} N^{\beta-\varphi}$$

where $L \equiv N(1-l)$ = aggregate supply of labor. The equilibrium real wage and the return on capital are determined by:

$$w = \partial Y/\partial L = \varphi Y/L = \varphi y/(1-l); \;\; r = \partial Y/\partial K = (1-\beta)Y/K = (1-\beta)y/k .$$

[16]Note that equation (12) ignores the residual income attributable to the fixed factor, land say, associated with the non-increasing returns to scale in private capital and labor. Strictly speaking this needs to be taken into account in deriving the aggregate resource constraint (6) in the decentralized economy.

government as independent of his decisions and responds to tax incentives. The fact that a higher tax on consumption reduces the consumption-income ratio is straightforward and familiar from models having inelastic labor supply. But in addition, a higher tax on labor income, for given leisure, *l*, also reduces the consumption-output ratio. This is because for given output, a higher wage tax reduces the income available for private consumption. The relevant return now for the Euler equation is the net private after-tax rate of return on capital. Equations (7d) and (7e) remain unchanged.

Substituting for $(Y/K)$ from (7e) into (7c') this equation describes the tradeoff locus, RR, between the equilibrium growth rate and leisure that ensures the equality between the after-tax rate of return on capital and the return on consumption. This is illustrated by the broken line in Fig. 1. In contrast to that of the centrally planned economy this locus is unambiguously negative. This is because the agent ignores the effect through government consumption expenditure. Similarly, substituting (C/Y) from (7a') and $(Y/K)$ into (7c) leads to the tradeoff locus, PP, between the equilibrium growth rate and leisure that ensures product market equilibrium is maintained. In this case a higher fraction of time devoted to leisure reduces the output-capital ratio. As in the centrally planned economy this is negatively sloped, although it is now defined for $0 < l < 1$.[17]

## 4. Fiscal Shocks in Decentralized Economy

The qualitative effects of simple changes in the fiscal instruments on the macroeconomic equilibrium are readily obtained by considering shifts in the RR and PP curves. Others, involving composite changes require more formal analysis.

### 4.1 Increase in Distortionary Tax Rates

An increase in any of the tax rates, $\tau_k, \tau_w, \tau_c$ has the same qualitative effects, decreasing the fraction of time devoted to work and reducing the equilibrium growth rate:

$$\frac{\partial \tilde{\psi}}{\partial \tau_i} < 0; \quad \frac{\partial \tilde{l}}{\partial \tau_i} > 0; \quad i = k, w, c \tag{15a}$$

[17]The formal expressions for the RR and PP loci in this case are given in equations (A.4a,b) of the Appendix.

These responses are illustrated in Fig. 2. An increase in the tax on capital, $\tau_k$, with revenues rebated in lump sum fashion, leads to a downward rotation in the RR locus, to RR'. Starting from the initial equilibrium at E, given the fraction of time devoted to leisure, this leads to an immediate reduction in the growth rate, as measured by the move from E to A. This reduces the return on consumption, causing a substitution of leisure for labor, and reducing the rate of return on capital to that of consumption.[18] This decrease in employment reduces output leading to a further reduction in the growth rate. The ultimate shift in equilibrium is thus represented by a move from E to B along the (original) PP locus. An increase in the tax on wage income or on consumption leads to an upward rotation in the PP locus, to PP'. Given leisure, this leads to an immediate reduction in the consumption-output ratio, and a corresponding rise in the growth rate of output, from E to F. This raises the return on consumption, causing agents to increase consumption and leisure over work. This causes a reduction in output and the growth rate, leading to a reduction in the return to capital and in consumption. The eventual shift in equilibrium is thus represented by a move from E to D along the (original) RR locus.

### 4.2 Increase in Rates of Government Expenditure

An increase in either government consumption expenditure or in government production expenditure, financed by lump sum taxation, can be shown to raise the growth rate and employment, both effects being larger for the latter shock:

$$\frac{\partial\tilde{\psi}}{\partial g_p} > \frac{\partial\tilde{\psi}}{\partial g_c} > 0; \quad \frac{\partial\tilde{l}}{\partial g_p} < \frac{\partial\tilde{l}}{\partial g_c} < 0 \tag{15b}$$

An increase in government consumption expenditure is qualitatively directly opposite to an increase in either $\tau_c$ or $\tau_w$. It is represented by a downward shift in the PP curve. Suppose the initial equilibrium is at D. This leads to an immediate reduction in the growth rate of capital, measured by DG. This reduces the rate of return on consumption and induces the agent to substitute away from

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[18]The rate of return on consumption equals $\rho - \dot{\lambda}/\lambda$, which varies positively with the growth rate, $\psi$.

consumption toward labor, leading to less leisure and more growth. The new equilibrium is represented by a move from D to E along RR. Given that the PP locus is steeper than the RR locus, the ultimate increase in the growth rate exceeds the immediate reduction represented by the downward shift in the PP curve. This effect also operates in the case of an increase in government production expenditure. The latter however includes an additional effect, due to the fact that the additional expenditure enhances the productivity of labor, thereby inducing further incentives to work and further increasing the growth rate.

The expansionary effect of the increase in the fraction of output devoted to government consumption expenditure contrasts with the well known result due to Eaton (1981) that a debt-financed (or lump-sum financed) increase in government consumption expenditure simply crowds out private consumption leaving the growth rate unaffected. In the present case, the higher taxes and the associated reduction in wealth, raises the marginal utility of wealth, inducing workers to devote a larger fraction of their time to work, thereby increasing the long-run growth rate.

### 4.3 Alternative Modes of Government Expenditure

Different modes of government finance have different effects on the performance of the economy. In general, the effects of a distortionary tax-financed increase in government expenditure on the equilibrium growth rate are given by:

$$\left(\frac{d\tilde{\psi}}{dg_i}\right)_{\tau_j} = \left(\frac{\partial\tilde{\psi}}{\partial g_i}\right)_T + \frac{\partial\tilde{\psi}}{\partial\tau_j}\frac{\partial\tau_j}{\partial g_i}; \;\; i = c,p, \;\; j = k,w,c \tag{16a}$$

where changes in expenditures and tax rates are subject to the government budget constraint:

$$\tau_w\varphi + \tau_k(1-\beta) + \tau_c(C/Y) + (T/Y) = g_c + g_p \tag{16b}$$

For simplicity, we shall assume that the changes are from an initial equilibrium in which $T = \tau_c = 0$, implying that $\partial\tau_w/\partial g_j = 1/\varphi;\ \partial\tau_k/\partial g_j = 1/(1-\beta);\ \partial\tau_c/\partial g_j = 1/(C/Y)$. Under weak conditions, the effects of lump-sum tax, consumption tax, wage income tax, and capital income tax financing of the two types of expenditure on the equilibrium growth rate can be ranked as follows:

$$\left(\frac{d\tilde{\psi}}{dg_i}\right)_T > \left(\frac{d\tilde{\psi}}{dg_i}\right)_{\tau_c} > \left(\frac{d\tilde{\psi}}{dg_i}\right)_{\tau_w} > \left(\frac{d\tilde{\psi}}{dg_i}\right)_{\tau_k} \qquad (17)$$

Sufficient conditions to ensure that this ranking holds: (i) $\tau_k \geq \tau_w$, (ii) the equilibrium growth rate $\tilde{\psi} \geq 0$, and (iii) the equilibrium fraction of time devoted to leisure, $\tilde{l} \geq \theta/(1+\theta)$. These conditions are met in the numerical simulations performed in Section 6. Intuitively, the ranking reflects the relative adverse effect of the particular tax on the incentives to accumulate capital.

## 5. Optimal Fiscal Policy

We now address the question of optimal fiscal policy and consider the extent to which the policy maker in the decentralized economy is able to set expenditure and tax rates so that the equilibrium in that economy, described by (7a'), (7c'), (7d) and (7e), replicates the first-best outcome obtained by the central planner, (7a) - (7e).

To characterize the optimal policy in the decentralized economy, it is useful to recall the first-best optimal government expenditure shares:

$$\hat{g}_c = \eta \widehat{(C/Y)} = \eta(1-\beta)\Omega(\hat{l});\ \hat{g}_p = \beta \qquad (18)$$

With this notation, we see that (7c') will coincide with (7c), so that the growth rate in the decentralized economy will coincide with that in the centrally planned economy, if and only if:

$$1-\tau_k = \frac{\widehat{(\mu/\lambda)}}{(1-\beta)} = \frac{1-g_p-g_c}{(1-\beta)[1-\eta\Omega(\hat{l})]} = \frac{1-g_p-g_c}{1-\hat{g}_p-\hat{g}_c} \qquad (19a)$$

Likewise, the intratemporal optimality condition (7a') will coincide with (7a), so that the consumption leisure margins in the two economies will coincide, if and only if

$$\frac{1-\tau_w}{1+\tau_c} = \frac{\widehat{(\mu/\lambda)}}{(1-\beta)} = \frac{(1-g_p-g_c)}{1-\hat{g}_p-\hat{g}_c} \qquad (19b)$$

Thus (19a) implies that the equality of the growth rates will be accomplished provided the optimal tax on capital is determined to equate the private marginal after-tax rate of return on capital, $(1-\tau_k)(1-\beta)(Y/K)$ to the social rate of return, $(\mu/\lambda)(Y/K)$. The magnitude of the optimal tax on capital depends upon the deviation in the *aggregate* share of government expenditure from its optimum.[19] If this aggregate exceeds the optimum, the costs of the resources utilized by the government exceed the benefits and it has a net adverse effect on the social return to capital. The private agent, however, fails to recognize this and overinvests relative to the optimum. This is corrected by imposing a positive tax on private capital income. If government expenditure is below its optimum the benefits exceed the costs and capital needs to be subsidized.

When government expenditure is set optimally, $[g_c = \hat{g}_c,\ g_p = \hat{g}_p]$, (19a) and (19b) reduce to

$$\hat{\tau}_k = 0; \qquad \hat{\tau}_w = -\hat{\tau}_c \tag{19'}$$

That is, capital income should remain untaxed, while the tax on labor income must be equal and opposite to that on consumption. Interpreting the tax on wage income as a negative tax on leisure, (19') says that in the absence of any externality, the optimal tax structure requires that the two utility-enhancing goods, consumption and leisure, be taxed uniformly. This result can be viewed as an intertemporal application of the Ramsey principle of optimal taxation; see Deaton (1981), Lucas and Stokey (1983). If the utility function is multiplicatively separable in $c$ and $l$, as we are assuming here, then the uniform taxation of leisure and consumption is optimal.

The first best optimal integrated fiscal policy is characterized by (18) and (19'). The optimal tax rates and expenditure shares must also be consistent with the government budget constraint (14). Setting $\hat{\tau}_k = 0, \hat{\tau}_c = -\hat{\tau}_w$ and evaluating (13), (7a) at the optimum, yields: $N\hat{w} = \varphi\hat{Y}/(1-\hat{l})$; $\hat{C} = (1-\beta)\Omega(\hat{l})\hat{Y}$ so that (14) may be expressed as:

$$\hat{\tau}_w\left(\varphi - (1-\beta)\Omega(\hat{l})\right)\hat{Y} + T = (\hat{g}_c + \hat{g}_p)\hat{Y} \tag{14'}$$

Any combination of $\hat{\tau}_w$ and $T$ consistent with this equation can sustain the first best optimum. This can be feasibly achieved without lump-sum taxation, ($T$ = 0), if and only if $\varphi < (1-\beta)\Omega(\hat{l})$. A

[19] It is of interest to note that the *composition* of government expenditure is irrelevant to the optimal tax structure.

sufficient condition for this to be met that both the simulations support and any plausible economy will satisfy is that the optimal consumption-output ratio, $(\hat{C/Y})$, exceeds the optimal government production expenditure-output ratio, $\hat{g}_p = \beta$. In this case, the first best optimum can be attained by subsidizing the labor-leisure choice and applying an exactly offsetting tax to consumption:[20]

$$\hat{\tau}_w = -\hat{\tau}_c = \frac{\eta(1-\beta)\Omega(\hat{l}) + \beta}{\varphi - (1-\beta)\Omega(\hat{l})} < 0 \qquad (21)$$

## 6. Some Numerical Results

Further insights into the effects of fiscal policy can be obtained by carrying out numerical analysis of the model. We begin by characterizing a benchmark economy, by calibrating the model using the following parameters representative of the U.S. economy:

| | |
|---|---|
| *Production parameters*: | $\alpha = 0.16$, $\beta = 0.08$, $\varphi = 0.08$ |
| *Preference parameters:* | $s = 1/(1-\gamma) = 0.5$, i.e. $\gamma = -1$, $\rho = 0.04$, $\theta = 0.3$, $\eta = 0.3$ |
| *Fiscal parameters:* | $g_c = 0.14$, $g_p = 0.08$, $\tau_w = 0.28$, $\tau_k = 0.28$, $\tau_c = 0$ |

Being a one-sector A-K technology, capital should be interpreted broadly as an amalgam of physical and human capital, with the fraction of human capital being around 2/3. The tax on capital, $\tau_k$, should therefore be interpreted as being a broad general income tax, rather than as a narrow tax on physical capital. Thus $\tau_w$ is the tax on the labor-leisure choice. Our benchmark setting $\tau_w = 0.28$ reflects the average marginal personal income tax rate in the US. Given the complex nature of capital income taxes, part of which may be taxed at a lower rate than wages, and part of which at a higher rate, we have chosen the common rate $\tau_k = 0.28$ as the benchmark. The benchmark assumes a zero consumption tax.

The equality, $\varphi = \beta = 0.08$, in the production function implies that government production expenditure is purely "labor-augmenting", with $g_p$ being set at its optimum.[21] The corresponding

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[20]In the implausible case where $\beta > (\hat{C/Y})$, (21) implies that labor income should be taxed and consumption subsidized at more than 100%. Obviously this is infeasible and lumpsum taxation would be required to sustain the optimum.

[21]This implies $1-\beta = 0.92$ so that the share of output going to physical capital is around 0.3.

equality, $\theta = \eta = 0.3$, in the preference function implies that government consumption expenditure is purely "leisure-augmenting". This implies that the optimal ratio of government consumption to private consumption is 0.3. Government expenditure parameters have been chosen so that the total fraction of net national production devoted to government expenditure on goods and services equals 0.22, the historical average in the United States. The breakdown between $g_c = 0.14$ and $g_p = 0.08$ is arbitrary, but plausible. Government investment expenditure is less than 0.08 and our choice of $g_p = 0.08$ is motivated by the fact that a substantial fraction of government consumption expenditure, such as public health services, impact as much on productivity as they do on utility.

These parameters lead to the following plausible benchmark equilibrium, reported in the first row of Table 1: fraction of time allocated to leisure: $l = 0.77$;[22] consumption-output ratio: $c/y = 0.65$; growth rate: $\psi = 1.41\%$; net rate of return on capital: $r_k(1-\tau_k) = 7.25$.

Two other measures of economic performance are summarized in Table 1. Economic welfare is the optimized utility of the representative agent, which evaluates to:

$$W = \int_0^\infty \frac{1}{\gamma}(cl^\theta G_c^\eta)^\gamma e^{-\rho t}dt = \frac{1}{\gamma}\frac{c^\gamma l^{\theta\gamma} g_c^{\eta\gamma} \left(Y/\tilde{K}\right)^{\eta\gamma} K_0^{\gamma(1+\eta)}}{\rho - \gamma(1+\eta)\psi} \tag{22}$$

The welfare gains reported in the final column are calculated as a percentage equivalent variation in the stock of capital necessary to maintain the level of $W$ in response to the policy change. Defining the primary deficit to be $T(t) = [g_c + g_p + \nu - \tau_w\beta - \tau_k(1-\beta)]Y - \tau_c C$, the quantity

$$V = \int_0^\infty \frac{T(t)}{K_0} e^{-r_k(1-\tau_k)t}dt \tag{23}$$

measures the present discounted value of the lump-sum taxes necessary to continuously balance the budget, normalized by the initial stock of capital. This depends upon government transfers, $\nu$, which are taken to be 0.12, close to the long-run historical average for the United States. The quantity $V$ is thus a measure of the intertemporal imbalance of the fiscal deficit. Evaluating (23) along the balanced growth path yields:

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[22]The fraction of total hours in the year devoted to work is around 2000/8760 =0.23, i.e. leisure = 0.77.

$$V = \frac{[g_c + g_p + \nu - \tau_w \beta - \tau_k (1-\beta)]\left(\tilde{Y/K}\right) - \tau_c \left(\tilde{C/K}\right)}{(1-\tau_k)(1-\beta)\left(\tilde{Y/K}\right) - \psi} \tag{24}$$

In the benchmark case, V = 0.118 and implies an overall intertemporal fiscal deficit equal to nearly 12% of the initial capital stock. Much of this due to the assumed size of transfers of 12% of current income. In their absence, (24) implies an intertemporal fiscal surplus; in that case tax revenues exceed government expenditures on goods and services by around 6% of current income.[23]

### 6.1 Uncompensated Fiscal Changes

Rows 2-7 in Table 1A describe various policy shocks from the benchmark, meaning that these shocks lead to changes in the intertemporal fiscal imbalance. Row 2 describes an increase in $\tau_k$ to 0.40. This has almost no direct effect on the consumption-leisure margin, and therefore on the fraction of time devoted to work. It has a significant adverse effect on the after-tax return to capital, inducing agents to devote a higher fraction of output to consumption, leading to a substantial reduction the growth rate and to a 4.4% reduction in welfare. The government's intertemporal fiscal imbalance now moves into surplus, and indeed zero balance can be achieved by a smaller increase in $\tau_k$ to around 0.35. Row 3 describes a comparable increase in $\tau_w$. The effects are qualitatively similar, but smaller, with the exception of leisure which is the factor upon which the tax rate impacts directly. The generally modest numerical impact of the wage tax throughout the simulations is due to the fact that $\tau_w$ pertains only to the labor/leisure component of labor income.

Row 4 describes a uniform reduction in income taxes to 20%. This shifts the consumption-work tradeoff in favor of the latter, thus raising the fraction of time devoted to work, and with it the productivity of capital. Consequently, the equilibrium growth rate increases and private welfare improves. However, the lower tax revenues cause the intertemporal fiscal balance to deteriorate significantly. Row 5 introduces a 10% consumption tax to the benchmark economy. This eliminates the intertemporal fiscal balance, with only small adverse impacts on the growth rate and on welfare.

[23]This accords approximately with recent data on surplus of government account on goods and services.

Rows 6 and 7 contrast a 50% cut in government production expenditure with a 50% cut in government consumption expenditure. Both have comparable effects on work effort and on the consumption-income ratio. Not surprisingly, the former has a more adverse effect on the growth rate, but the latter has the more adverse effect on welfare.

## 6.2 Revenue-Neutral Fiscal Changes

Recent discussions of fiscal policy focus on revenue neutral policy changes. Part B of Table 1 considers cases where a change in the tax rate is accompanied by some other accommodating change determined so that the current government deficit, *T*, remains unchanged. In the first row income tax rates are reduced to 20% which requires the introduction of a consumption tax of 13% to maintain the current deficit unchanged. The small rise in the after-tax return to capital together with the rise in the growth rate leads to small decline in the intertemporal fiscal imbalance, *V*. There is also a modest welfare increase of around 2%. If the current deficit is balanced through a reduction in current government consumption, $g_c$ must be reduced from 0.14 to 0.06. This has precisely the same impact on the equilibrium growth rate and on the intertemporal fiscal imbalance, but causes an 11% reduction in welfare. If the accommodation takes place through a reduction in government production expenditure, $g_p$ needs to be almost entirely eliminated to 0.01. It leads to a reduction in the growth rate, an increase in the fiscal imbalance and to a welfare loss of 14%. Cutting productive government expenditure is an unsatisfactory way to balance the current budget.

The final policy change eliminates the income tax and maintains the current government deficit by replacing it with a 52% consumption tax. This has a very positive effect on the growth rate, leading to both a substantial welfare gain and to a reasonable reduction in the fiscal imbalance. Taken in conjunction with the first of these revenue-neutral fiscal changes, this suggests that a move toward a consumption tax is desirable from both a welfare and intertemporal fiscal standpoint.[24]

[24]We have also considered an unbalanced change, closer to that proposed in policy circles, namely replacing the current income tax with a consumption tax, of 25%. While this leads to a doubling of the growth rate and a welfare gain of over 6%, it is, however, accompanied by a dramatic deterioration in the government's intertemporal fiscal imbalance to 0.30.

### 6.3 Optimal Taxation

Table 1.C presents numerical results for various optimal polices, using the benchmark structural parameters. Row 1 presents the overall first-best global optimum that corresponds to that derived analytically in Section 5.[25] For these parameters the global optimum is one in which 34% time is devoted to production, the consumption to income ratio is 0.52 and the growth rate is 2.8%. This implies a greater proportion of effort toward work and production than in the decentralized benchmark economy in Table 1.A. In order to induce the shift from the benchmark to the first-best optimum, the tax on capital income should be eliminated. Labor (in the labor-leisure choice) should be subsidized by 54%, and this should be exactly offset by an equal consumption tax. Government production expenditure should remain at 0.08 (equal to $\beta$) while government consumption expenditure should be increased slightly to 0.16. The welfare gain in carrying out these policies and moving from the benchmark to the first best optimum is quite sizable, being around 4.9%.

Various second-best expenditure policies are discussed in the remainder of the table. Row 4 describes the case where the total size of the government is optimal (0.24), but the composition between consumption expenditure and production expenditure is incorrect, being exactly reversed. This non-optimal composition of the government sector has relatively little effect on $l$ or on $c/y$. The switch from government consumption to government production stimulates the growth rate to over 3%. The 50% reduction in government consumption has a direct welfare cost of around 14%, though this is offset by the benefits from the higher growth rate leading to a net welfare loss of 7.6%.

Rows 2 and 3 enable us to see how the welfare losses from the non-optimal composition of government are due to $g_p$ being too large and $g_c$ being too small. In the case where $g_p = g_c = 0.16$, output and the overall size of government is too large, and capital income must be taxed at around 11% in accordance with (19a). The higher tax on capital reduces its net rate of return. To reduce output, the subsidy to labor must be reduced as is the required tax on consumption, though be less. The growth rate declines relative to the first best optimum and welfare declines by around 3.9%. The consequence of $g_c$ being correspondingly too small requires a subsidy to capital income, thus

[25]We have carried out extensive sensitivity analysis of the first-best optimal policy.

raising the net return to capital. Output needs to be enhanced and this requires a larger subsidy to labor. The growth rate is increased, though the reduced government consumption benefits are welfare reducing. On balance, we see that the overall reduction in welfare between Row 1 and 4 is due marginally more the result of $g_c$ being too small rather than $g_p$ being too large.

## 7. Conclusions

Most endogenous growth models assume that labor is supplied inelastically. This assumption is not only unrealistic, but it has strong, yet misleading, policy implications. In this paper we have introduced an elastic labor supply determined by the consumption-leisure tradeoff of agents. Our formulation is a tractable one, enabling the steady-state equilibrium in such an economy to be characterized by a pair of tradeoff loci between the fraction of time devoted to leisure (work) and the growth rate that ensure: (i) equality among rates of return, and (ii) equilibrium in the output market. In principle, an elastic labor supply raises potential problems of non-existence of an equilibrium balanced growth rate and time devoted to leisure consistent with these objectives simultaneously being met. In practice, however, under plausible conditions, strongly supported by our simulations, a unique balanced growth path exists, with the economy always being in such an equilibrium state.

The endogeneity of labor supply has important consequences for fiscal policy. It causes both the consumption and labor income tax to have adverse effects on the growth rate, as does the tax on capital, though they are smaller in magnitude. A lump-sum tax financed increase in government consumption expenditure in the decentralized economy now has a positive effect on the growth rate. This is due to its adverse wealth effect, the resulting increase in the marginal utility of wealth, and the substitution this induces toward work and away from leisure and consumption. This positive effect on the growth rate in the decentralized economy contrasts with the negative effect in the centrally planned economy. This is because the central planner is in effect financing his expenditure by using a distortionary income tax, the contractionary effects of which more than offset the expansionary effects of the expenditure. The endogeneity of labor also plays a role in determining the relative effects of different modes of expenditure financing on the equilibrium growth rate.

The optimal tax structure in the decentralized economy has been characterized. In general, the optimal distortionary tax rates will depend upon the chosen aggregate level of government expenditures relative to the optimum. These rates are set in response to externalities that these expenditures generate in: (i) financial markets, and (ii) the consumption-leisure choice. If government expenditure shares are chosen optimally the first externality vanishes. In that case, the optimal tax rate on capital income is zero and leisure and consumption should be taxed uniformly, in accordance with established principles of public finance.

Finally, the formal analysis has been supplemented with a series of simulations. Beginning with a benchmark economy, the numerical effects of various policy shocks have been considered, with particular attention being devoted to assessing the effects of these policies on the intertemporal welfare of the representative agent and on the government's intertemporal fiscal imbalance. The numerical calculations suggest that reducing income taxes and introducing consumption taxes may yield numerically significant welfare gains, while at the same time having a favorable effect on the government's intertemporal balance. Moreover, the welfare losses of the benchmark economy not being at its first-best optimum appear to be quite sizable, being of the order of nearly 5%.

**Table 1**

**Fiscal Shocks**

**A. Uncompensated Changes**

| | $\tau_k$ | $\tau_w$ | $\tau_c$ | $g_p$ | $g_c$ | $l$ | $c/y$ | $r_k(1-\tau_k)$ | $\Psi$ | V | Welf. gain |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bench mark** | **0.28** | **0.28** | **0** | **0.08** | **0.14** | **0.77** | **0.65** | **7.25%** | **1.41%** | **0.113** | |
| higher $\tau_k$ | 0.40 | 0.28 | 0 | 0.08 | 0.14 | 0.78 | 0.70 | 6.01% | 0.88% | -0.107 | -4.44% |
| higher $\tau_w$ | 0.28 | 0.40 | 0 | 0.08 | 0.14 | 0.80 | 0.65 | 7.16% | 1.37% | 0.094 | -0.76% |
| lower $\tau_k$ , $\tau_w$ | 0.20 | 0.20 | 0 | 0.08 | 0.14 | 0.74 | 0.62 | 8.14% | 1.80% | 0.244 | 2.40% |
| introd $\tau_c$ | 0.28 | 0.28 | 0.10 | 0.08 | 0.14 | 0.79 | 0.65 | 7.20% | 1.39% | -0.010 | -0.41% |
| lower $g_p$ | 0.28 | 0.28 | 0 | 0.04 | 0.14 | 0.79 | 0.70 | 6.79% | 1.21% | 0.037 | -3.94% |
| lower $g_c$ | 0.28 | 0.28 | 0 | 0.08 | 0.07 | 0.79 | 0.72 | 7.20% | 1.39% | -0.019 | -8.96% |

**B. Compensated Changes**

| | $\tau_k$ | $\tau_w$ | $\tau_c$ | $g_p$ | $g_c$ | $l$ | $c/y$ | $r_k(1-\tau_k)$ | $\Psi$ | V | Welf. gain |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\tau_c$ accom. | 0.20 | 0.20 | 0.13 | 0.08 | 0.14 | 0.77 | 0.62 | 8.07% | 1.77% | 0.104 | 2.04% |
| $g_c$ accom. | 0.20 | 0.20 | 0 | 0.08 | 0.06 | 0.77 | 0.70 | 8.07% | 1.77% | 0.104 | -8.58% |
| $g_p$ accom. | 0.20 | 0.20 | 0 | 0.01 | 0.14 | 0.77 | 0.72 | 6.79% | 1.21% | 0.118 | -14.1% |
| elim. income taxes | 0 | 0 | 0.52 | 0.08 | 0.14 | 0.75 | 0.54 | 10.1% | 2.67% | 0.098 | 4.33% |

NB The percentage welfare gains or losses in Parts A and B of this table are relative to the **Benchmark** economy.

## C. Optimal Taxation

| | $\tau_k$ | $\tau_w$ | $\tau_c$ | $g_p$ | $g_c$ | $l$ | $c/y$ | $r_k(1-\tau_k)$ | $\psi$ | Welf. gain |
|---|---|---|---|---|---|---|---|---|---|---|
| **Global optim.** | **0** | **-0.54** | **0.54** | **0.08** | **0.16** | **0.66** | **0.52** | **10.4%** | **2.79%** | **4.88%** |
| $g_p$ too large | 0.11 | -0.32 | 0.48 | 0.16 | 0.16 | 0.67 | 0.48 | 9.81% | 2.52% | -3.87% |
| $g_c$ too small | -0.12 | -0.81 | 0.62 | 0.08 | 0.08 | 0.65 | 0.54 | 11.7% | 3.36% | -4.67% |
| $g_p + g_c$ opt | 0 | -0.56 | 0.56 | 0.16 | 0.08 | 0.65 | 0.51 | 11.1% | 3.09% | -7.60% |

NB The percentage welfare gain in the Row 1 in Part C of this table is relative to the **Benchmark** economy.
The percentage welfare losses in Rows 2-7 are measured relative to the **Global optimum** reported in Row 1.

Benchmark parameters: $\gamma = -1$, $\beta = 0.08$, $\theta = 0.3$, $\eta = 0.3$, $\rho = 0.04$, $\alpha = 0.18$. $v = 0.12$

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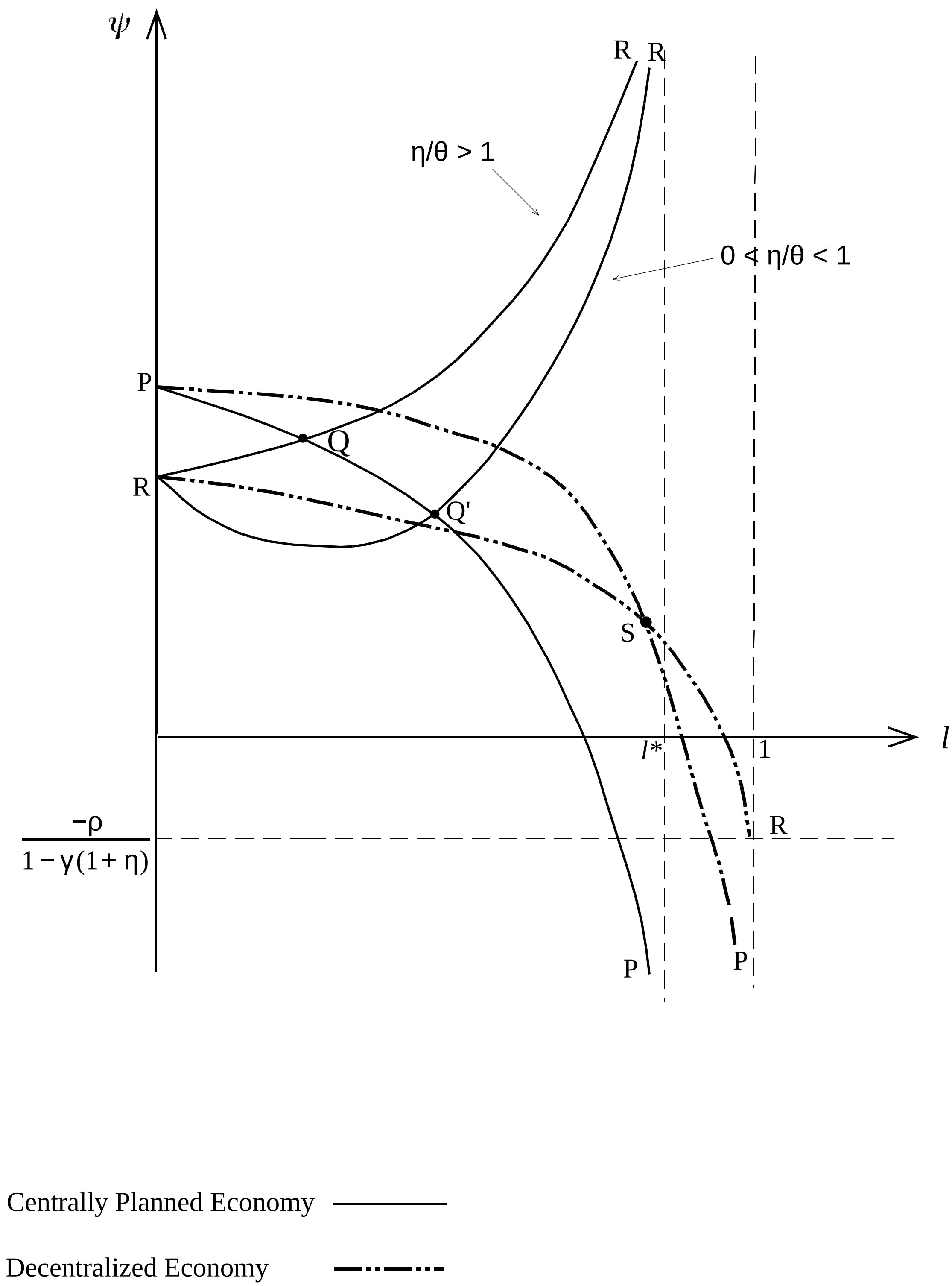


Fig 1 : Growth-Leisure Tradeoff

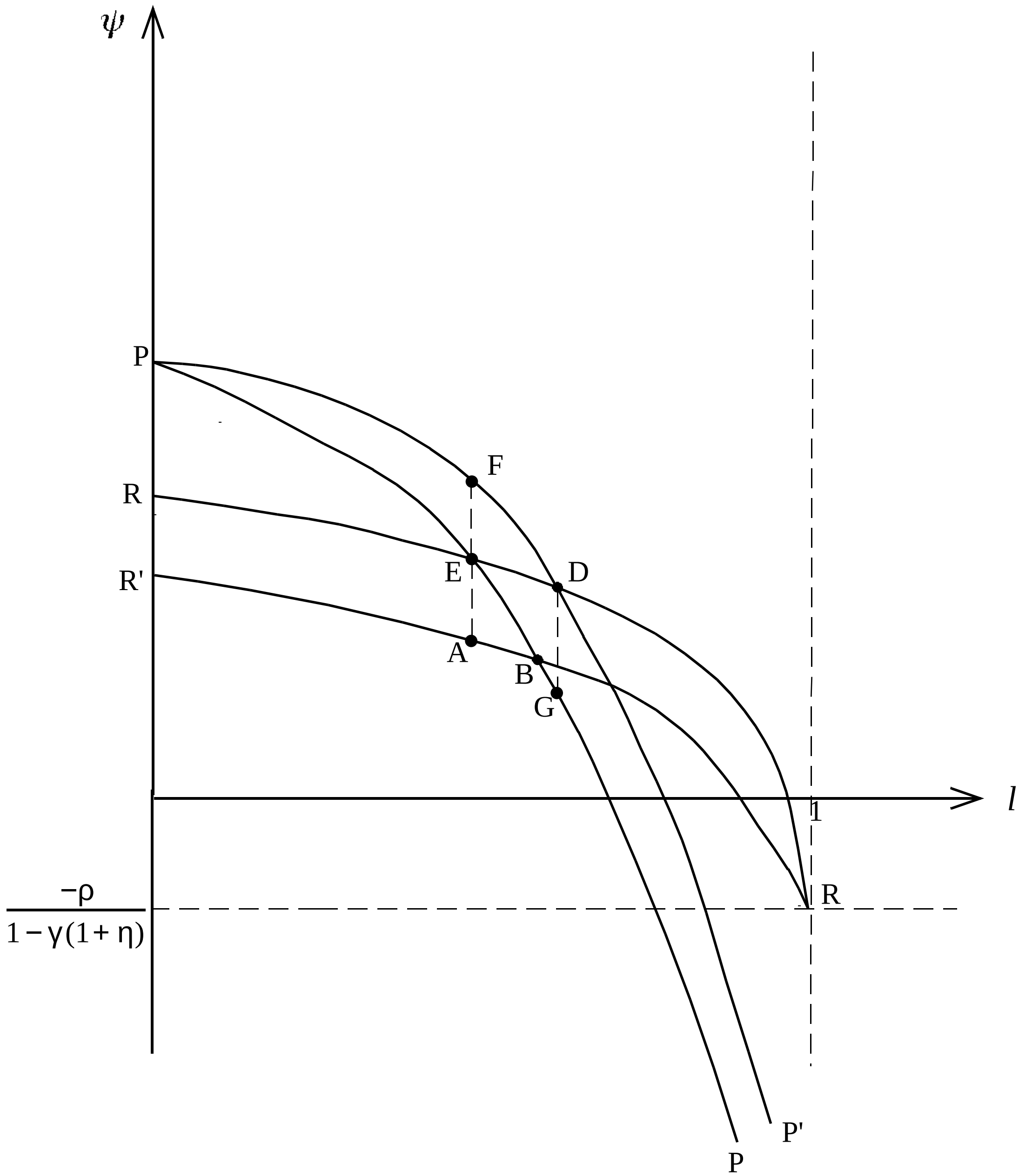


Fig 2 : Fiscal Shocks in Decentralized Economy