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PUBLIC EXPENDITURES, TAXATION AND WELFARE MEASUREMENT

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Abstract: this article addresses the welfare and macroeconomics effects of fiscal policy in a framework where government chooses tax rates and the distribution of revenues between consumption and investment. We construct and simulate a model where public consumption affects individuals' utility and public capital is an argument of the production function. The simulations suggest that by simply reallocating expenditures from consumption to investment, the government can increase the equilibrium levels of capital stock, hours worked, output and labor productivity. Furthermore, we show that the magnitude and direction of the long run impact of fiscal policy depends on the size of the elasticity of output to public capital. If this parameter is high enough, it may be the case that capital stock, within limits, increases with tax rates.

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1 Introduction

This paper investigates the impact of fiscal policy changes on economic variables using as framework a modified version of standard real business cycles models. In the economy we construct, government plays two distinct roles. On one hand, its consumption expenses have a public good quality as they affect individuals' utility. On the other hand, another type of public expenditure, investment, is part of the productive process of the economy and it affects the return on private factors. We modeled this last phenomenon by including the services from those expenses as a separate argument of the production function, following Barro (1990), among others. The government finances its operations taxing capital and labor. We do not allow bonds in this economy, so that government budget constraint is in equilibrium in every period.

In the model fiscal policy involves a decision of how much to tax, how to divide tax collection between capital tax and labor tax, and how to distribute the expenditures between consumption and investment. These decisions are not independent as the total revenue determines how much is available for consumption and investment.

We will first use the model to analyze how different compositions of public expenses and taxes affect the behavior of the economy. One such experiment, for instance, would investigate what happens with productivity, output and private factors of production when the share of investment on total public outlays increases while tax rates are kept constant.

We initially compare the long run properties of those alternatives policies and later we assess the transition path from one policy to another. In this process we will also compare the behavior of the economy assuming different intensities of output responses to public investment, using alternative estimations from Ferreira (1993) and Aschauer (1988). Part of our policy experiments in this section are similar to ones in Baxter and King (1993). However, they do not distinguish between capital and labor income.
taxation, they have lump sum transfers but not public goods and not all their simulations use productivity-augmented government purchases.

Our second purpose is to measure the welfare costs (or gains) of different fiscal policies. Again, we first measure how the steady state welfare is affected by alternative policies and then we take into account the transition path from the original steady state to the new one and the long run impact of such policy.

The paper is organized as follows. In the next section the model is presented and in the following one we discuss the solution method and the calibration procedures. Section four reports the outcome of the fiscal policy experiment for the steady state. Section 5.a discusses steady state welfare and section 5.b presents both the welfare and fiscal policy effects outside the steady state. Finally, in section 6 some concluding remarks are made.

2 The Model

In this economy individuals live forever and obtain utility from leisure, private consumption and also from government consumption. Government consumption is basically a public good which does not suffer from congestion. Preferences are given by:

\[
\sum_{t=0}^{\infty} \beta^t \left\{ \log(c_p + \mu c_g) + A \log l \right\} \\
0 < \beta < 1
\]

In the above expression \(c_p\) is private consumption, \(c_g\) public consumption and \(l\) is leisure. The parameter \(\mu\) can assume any value, but if it is one the consumer equally values public and private consumption. If \(\mu\) is zero the consumer do not care for public goods. Households maximize (1.1) subject to a sequence of budget constraints:

\[
c_p + i_t \leq w_t(1 - \tau_t)h_t + r_i(1 - \tau_t)k_t
\]

Households can divide their purchases between consumption goods and investment goods \((i_t)\). The funds available for this purchases include after tax capital income, where \(r_t\) is the rental rate of capital, \(k_t\) the stock of capital owned by the
household and $\tau_k$ is the tax rate on capital income and after tax labor, where $w_t$ is the wage rate, $h_t$ hours worked and $\tau_h$ is the tax rate on labor income. Total hours are normalized to one so that:

$$h_t + l_t = l$$

The law of motion of (private) capital is:

$$k_{t+1} = i_t + (1-\delta)k_t$$

In this economy the production function has constant returns to scale to private inputs and is subject to technology shocks. It also includes public investment ($K_g$) as separate argument. The technology is thus given by:

$$Y_t = \exp(z_t)K^\theta_gK^\theta_hH^{1-\theta}$$

Capital letters are used to represent per capita variables taken as given by the household, while small letters represent individual specific variables chosen by the household. In equilibrium those variables will be the same. The exogenous technology shock follows a law of motion given by

$$z_{t+1} = \rho z_t + \varepsilon_{t+1}, \quad 0 \leq \rho \leq 1$$

In the above expression $\varepsilon_t$ is an iid random variable with mean zero and variance $\sigma_{\varepsilon}^2$. It is assumed that all agents know $z_t$ in the beginning of period $t$.

Government raises taxes on capital and labor incomes in order to finance its expenditures in consumption and investment. We rule out government bonds so that the budget constraint of the public sector is in equilibrium every period:

$$G_t = l_g_t + c_g_t = \tau_k r_t K_t + \tau_h w_l H_t$$

Taxes rates are fixed in this economy and we also assume that government follows a fixed and known rule to divide its expenditures between investment and consumption:

$$c_{g_t} = \alpha G_t$$

$$l_{g_t} = (1-\alpha) G_t$$

$$0 \leq \alpha \leq 1$$
In this setup a fiscal policy is represented by the two taxes rates and alpha, the proportion of total government expenditures allocated to consumption. The public capital law of motion is simply

\[ K_{g,t+1} = I_{g,t} + (1 - \delta_g) K_{g,t} \]

The firms' problem is to maximize profits, \( \pi = Y_t - w_t H_t - r_t K_t \), every period. From the first order conditions of this problem we obtain the following functions for the rental rate of capital and wage rate:

\[ w(K_t, H_t, z_t, K_{g,t}) = (1 - \theta) \exp(z_t) K_{g,t} \left( \frac{K_t}{H_t} \right)^\theta \]

\[ r(K_t, H_t, z_t, K_{g,t}) = \theta \exp(z_t) K_{g,t} \left( \frac{K_t}{H_t} \right)^{\theta - 1} \]

The households' dynamic problem can be cast as:

\[ V(k_t, K_t, K_{g,t}, z_t) = \max \{ U(c_t + \mu c_{g,t}, l - h_t) + \beta E V(k_{t+1}, K_{t+1}, K_{g,t+1}, z_{t+1}) \} \]

subject to

\[ c_t + i_t = w(K_t, H_t, z_t, K_{g,t})(1 - \tau_h) h_t + r(K_t, H_t, z_t, K_{g,t})(1 - \tau_k) k_t \]

\[ z_{t+1} = \rho z_t + \epsilon_{t+1}, \]

\[ k_{t+1} = i_t + (1 - \delta) k_t , \]

\[ K_{g,t+1} = I_{g,t} + (1 - \delta) K_{g,t} \]

\[ I_{g,t} = (1 - \alpha) G_t + (1 - \delta_g) K_{g,t} \]

\[ G_t = \tau_k r_t K_t + \tau_h w_t H_t \]

\[ L_t = I(K_t, K_{g,t}, z_t) \]

In the above problem \( V(\cdot) \) is the equilibrium maximized present value of the utility flow of a household which start at \( t \) with \( k_t \) and knows that the aggregate state is described by \( K_t, K_{g,t}, z_t \). In solving his problem the representative household takes into account that the wage rate and the rental rate are given functions of the aggregate state. Of course, the households take the evolution of \( K_t \) and \( K_{g,t} \) as given. In the last case, current public investment is a fixed proportion of total expenditures (or revenues) which
is also a function of the aggregate state, for given taxes rates and alpha. In addition, H and I are given functions of $K_t, K_{gt}, z_t$.

A **recursive competitive equilibrium** is a set of household decision rules, $i(k_t, K_t, K_{gt}, z_t)$, $h(k_t, K_t, K_{gt}, z_t)$, and $c(k_t, K_t, K_{gt}, z_t)$, a set of per capita decision rules $I(K_t, K_{gt}, z_t)$ and $H(K_t, K_{gt}, z_t)$, a set of pricing and public expenditure functions, $w(K_t, K_{gt}, z_t)$, $r(K_t, K_{gt}, z_t)$ and $G(K_t, K_{gt}, z_t)$ and a value function $V(k_t, K_t, K_{gt}, z_t)$ such that:

(i) households solve problem (1.12) taking as given $I$; $H$ and $G$.

(ii) $I(K_t, K_{gt}, z_t) = i(K_t, K_t, K_{gt}, z_t)$ and $H(K_t, K_{gt}, z_t) = h(K_t, K_t, K_{gt}, z_t)$

(iii) The market for final goods clear each period
\[ C(k_t, K_t, K_{gt}, z_t) + I(k_t, K_t, K_{gt}, z_t) + G(K_t, K_{gt}, z_t) = Y(K_t, K_{gt}, z_t) \]

3 Solution Method and Calibration Procedure

We solve the model using numerical methods. For the experiments of section four we simply used the first order conditions to find steady state expressions for private capital, hours worked and public capital in terms of technology, preferences and fiscal policy parameters. We used these expressions to perform policy experiments.

In section five we solve the model using numerical methods due to Kydland and Prescott (1982). However, given that the paper deals with a distortionary economy we cannot invoke the second welfare theorem and solve a planning problem. In this way we apply the recursive method described in Hansen and Prescott (1990) for distortionary economies.

We start eliminating private consumption in the utility function using household budget constraint and the functions $w(\cdot)$ and $r(\cdot)$. We next find first order conditions for the household problem which are nonlinear. In order to obtain an analytical solution for this problem we form a linear quadratic approximation around the steady state. We first solve for the steady state by substituting for public consumption $\alpha(\tau_k r(\cdot) K + \tau_h w(\cdot) H)$
and then compute the linear-quadratic approximation. The final step is to solve this
dynamic programming problem iterating on the now quadratic Bellman's equation
imposing at each step that equilibrium condition (ii) holds. After convergence we obtain
equilibrium expressions for the aggregate labor and investment decisions rules in terms of
$z_t$, $K_{gt}$ and $K_t$, as $k_t = K_t$ in equilibrium.

We will use these expressions, along with the laws of motion of capital and
technology shock, the production function and expression (1.7) of government
expenditures to simulate the economy for different fiscal policies, in both the steady state
and outside the steady state. However, in order to use this methodology we have first
make the assumption that it is public investment, and not public capital, that enters in the
production function. We next have to transform variables by applying logarithms. The
reason for this transformation is that after substituting for $w_t$, $r_t$ and $h_t$ in the utility
function there is still one non-linear expression to be eliminated, which is

$$K_{gt+1} = lg_t = (1-\alpha)(\tau_k r_t K_t + \tau_h w_t H_t) + (1-\delta)K_{gt+1} = $$

$$(1-\alpha)(\tau_k \theta + \tau_h (1-\theta)) \exp(z_t) K_{gt} \theta H_t \mathcal{I}(1-\theta) + (1-\delta)K_{gt+1}$$

We cannot plug this expression into the utility function and the methodology
cannot be used for non-linear expressions. Our solution was to assume that $K_{gt+1} = lg_t$
and to apply logs to obtain,

$$\tilde{g}_{t+1} = \ln(1-\alpha)(\tau_k \theta + \tau_h (1-\theta)) + z_t + \phi \tilde{g}_t + \theta \tilde{K}_t + (1-\theta)\tilde{H}_t$$

In the above expression $\tilde{x}$ represents the logarithm of the variable $x$. We next
applied logs to all (steady state) variables and we plugged the investment equation
($i_t = k_{t+1} - (1-\delta)k_t$) in the utility function in order to be left only with (log) linear
expressions outside it. The functional values are not affected because inside the utility
function we used the exponential of $\tilde{x}$, whenever the variable "x" showed up.

The parameters values of this model follow closely the values used in most of the
recent RBC literature and are intended to match the ones observed in the US economy.
The labor share is assigned to be 70%, the average over the 48-85 period, and a
magnitude used, for instance, by Greenwood, Hercowitz and Krussel (1992) as well as Hansen and Prescott (1993). The depreciation rate for public and private capital is set at 0.02 per quarter, smaller than in Prescott (1986), but in line with Christiano (1988), Hansen and Prescott (1993) and Greenwood et al. We used 0.99 for the discount rate, a value used by almost every paper in the literature. It implies an interest rate of 6.5% a year. The parameters $\rho$ and $\sigma_e$ are set to be 0.95 and 0.0076, which we estimated for a production function with public expenditures as a separated argument. As in Cooley and Hansen (1992) $A$ is equal to 2 in the simulations. This value implies that the households allocate $2/3$ of their time to non-market activities.

We arbitrarily set $\mu$ to be equal to one, implying that consumers give the same weight to public and private consumption. We did that for three reasons. First, we do not know of any estimates of this parameter in the literature, so that any value would end up being arbitrary. Second, for the policy experiments we ran, changes in this parameter did not affect qualitatively the results but only their magnitude. Finally, smaller $\mu$ values strengthen the argument for investments relatively to public consumption. If $\mu$ is zero, the alternative to investments is "waste", which would make this problem trivial. Giving equal weight to public consumption and investment in consumer welfare, we emphasized the trade-off between the two types of public expenditure.

The remaining parameters, with the exception of $\phi$, are all policy parameters and will be changed according to the policy experiment performed. The base parameters, what will be called standard economy are the following. Alpha is set to be 0.88 since the average of infrastructure and equipment out of total government expenses is 0.12 for the 1972-1988 period. Labor and capital tax rates values follow Cooley and Hansen (1992): $\tau_k$ equal to 0.5 and $\tau_h$ equal to 0.23.

Finally we set $\phi$ equal to 0.09 which is the value estimated in Ferreira (1993) for US quarterly data. This value is well below previous estimates, particularly the
estimations in Aschauer (1989), so that we also used $\phi$ equal to 0.35 to compare the response of the economy to policy changes with this two different elasticities.

4 Long Run Analysis

Anticipated changes in fiscal policy have a significant influence on the steady state path of this economy. Figure one displays steady state levels of productivity as alpha, the proportion of consumption in total public expenditures, decreases (or $(1-\alpha)$, the proportion of investment in total expenses, increases).

FIGURE 1

Steady State Productivity Levels (Phi=0.09)

Steady state productivity increases continuously with $(1-\alpha)$. If this variable increases to 0.87 from 0.88, the average of the last years in the U.S., productivity will increase by 1.2 percent. Note also that most of the gains are obtained when investment
goes from zero to 20% of public expenses. It increases fifty seven percent in this interval while increasing only thirty one percent when the proportion of investment goes from twenty to ninety nine percent of total expenditures. This implies first that governments can use fiscal policy to affect labor productivity and also that at least as a policy to increase productivity governments do not need to dedicate politically unrealistic proportions of their budgets to investment as its returns rise more slowly as investment share gets larger.

It can be shown that the ratio of public investment to GNP also rises when alpha falls in this economy, as investment grows faster than output. So, for the long run at least, this results matches the empirical findings of Aschauer (1989), Morrison and Schwartz (1992) and Ferreira (1993) that changes in the proportion of public expenditures to GNP leads to changes in labor productivity in the same direction.

Figure II below plots the steady state levels of capital stock, hours and government investment against alpha levels.

FIGURE 2

Steady State Factors Levels (Phi=0.09)
Hours increase with \((1-\alpha)\) because the return to labor increases with public investment. Greater number of hours worked leads to higher income and investment and therefore higher capital. The return to capital also increases with public investment so that there is an additional force pushing investment and capital stock to higher steady state levels. However, a different behavior could be expected. Given \(G\), the reduction of \(\alpha\) causes a decrease in public consumption which leads to a decline in consumer's utility. This would induce an increase in private consumption to compensate for the loss of government consumption and, consequently, to a drop in private investment and capital stock. It turns out that this is never the case and the impact on private returns always dominates so that income, investment (public and private), consumption and government tax revenues and expenditures grow, for any \(\mu\) we used.

The impact of tax changes on the steady state path of the economy is highly influenced by the value of the parameter \(\phi\), the elasticity of output with respect to public expenditures. In the remaining of this section we compare two economies similar in every aspect but the coefficient \(\phi\). In one of them the value for this parameter is 0.09 which is the estimated value in Ferreira (1993). In the other we used a value close to the estimates of Aschauer (1989), \(\phi = 0.35\). The motivation for comparing the long run behavior of economies with such a difference in a relevant parameter is that we want to show that the fiscal policy recommendations, in addition to the economy behavior, will be rather different depending on the magnitude of \(\phi\). Furthermore, the estimated value from Aschauer (1989) is used because this article is widely cited in the empirical literature of productive public sector and it obtained results very distinct from the ones we obtained in our previous paper. The results here qualify in some ways the results in Aschauer (1989).

Figures 3 presents the steady state levels of income for different labor tax rates for the "standard" economy (\(\phi = 0.09\)) for \(\alpha\) equal to 0.88 (the average value for
the American economy), alpha equal to one half and equal to ten percent. Figure four displays income levels for the "Aschauer" economy (φ=0.35) when alpha is 0.88.

FIGURE 3

Steady State Income Levels (ϕ=0.09)

For the standard economy any increase in the labor tax rate, with alpha equal to 0.88, will reduce the output level in the steady state. Tax rates as low as 2% are sufficient to induce a drop in output in a fashion analogous to the case of a model without government investment in the production function. This is not the case for the "Aschauer" economy. Steady state income starts to fall only when τh is greater than 0.32. For values below this threshold, income level actually goes up with the labor tax rate. In this case, public investment is so productive that its impact on capital (and income) is strong enough to overcome the negative effect on returns due to higher taxes.
FIGURE 4
Steady State Income Levels (\( \phi=0.35, \alpha=0.88 \))

For alpha values well below 0.88, the behavior of these economies is somewhat harmonized but only up to a certain extent. The two upper curves in figure 3 display the steady state income levels in the standard economy when alpha is 0.5 and 0.1. For alpha equal to 0.1 (90% of government expenses goes to investment) steady state income grows with \( \tau_h \) for rates below 0.32 and for alpha equal to 0.5 it remains constant for rates below 0.08 and then it falls. However, for the "Aschauer" economy in the case of \( \alpha = 0.1 \) income grows with \( \tau_h \) for rates up to 0.62 and income rises with \( \tau_h \) for rates up to 0.42 when \( \alpha = 0.5 \). In other words: in an economy where output elasticity to public capital is around 0.35 a rise in the labor tax rate up to certain limits increase, not decrease, the income level in the steady state. For smaller elasticities (\( \phi = 0.09 \) in the present case) this is only the case when the proportion of investment out of total public expenditures is considerably higher than the actual ratio for the US. economy.
Figure five below tries to clarify these relationships. It shows the steady state levels of factors of production for the case where alpha is one half and phi is 0.35 (labor was excluded because it is too small compared with the others factors).

![Steady State Factor Levels (phi=0.35, alpha=0.5)](image)

As $t_h$ increases, total tax collection and consequently public investment follows in the same direction. Everything else being the same, the return to capital and labor would rise with public investment. However, the higher taxes reduces the return to labor and it dominates the investment effect so that hours worked decreases, in the steady state, with $t_h$. Less hours would lead to lower income and investment and therefore to lower capital stock. For tax rates below some threshold (0.42 in this case) this force is weaker than the direct effect on capital return due to higher public investment, so that steady state capital
stock increases initially. With capital and public investment increasing with labor tax, income also rises, although hours worked are smaller. In the economy where $\phi$ is 0.09, the direct effect on returns is never strong enough (unless we assume unreasonable low alphas) to counteract the drop in hours, so that both capital and income steady state levels fall with the labor tax rate. The disincentive to work resulting from higher taxes outweighs the gain in returns induced by higher investments.

The behavior of these economies is even more distant when we look at the income responses to capital tax rates variations displayed in the figure below.

**FIGURE 6**

Steady State Income for Both Economies (alpha=0.88)

For the economy with the lower elasticity, steady state income always falls with increases in $t_k$, no matter what parameter value of alpha is used in the simulations (in the figure above it is 0.88). For the economy with $\phi = 0.35$, there will always exist an interval of tax rates, for almost any alpha, where the steady state income (and capital stock) will be larger with higher capital tax rates. When alpha equals 0.88, the U.S.
average, increases in \( t_k \) up to 0.22 lead to rises in the steady state income. In this case, government investment is so productive that its effect on capital returns is stronger than the tax effect. For the case when \( \phi \) is only 0.09, the tax effect always dominates, so that higher capital taxes always lead to decreases in the long run level of income.

In summary: increases in the proportion of investment out of total public expenses lead to higher steady state levels of capital, hours, income, labor productivity and attained utility. If the actual elasticity of output to public investment is closer to 0.35 then increases in both labor and capital tax rates lead, up to certain point, to increases in steady state capital and income, so that higher taxes could actually stimulate the economy. However, if that elasticity is closer to 0.09, higher taxes will always reduce the steady state level of the factors of production and output.

5 Welfare Comparisons

In this section we present two alternative estimates of the welfare costs of fiscal policies, while assuming different composition of government expenditure and different tax rates. Instead of comparing those allocations with a Pareto optimal allocation for this economy, we compared welfare variations between two (sometimes three) alternative policies. Basically we try to address the following question: what is the welfare loss (or gain) for society of going from a given fiscal policy to another? Except for the fiscal policy parameters (\( \alpha, \tau_h \) and \( t_k \)) all the parameters are the same as in the standard economy from the previous section.

5.a Steady State Welfare

The first welfare measure compares steady states and it is due to Cooley and Hansen (1989). It is based on the change in total consumption (private plus public) required to keep the consumer as well off under the new policy as under the original one.
The measure of welfare loss (or gain) associated with the new policy is obtained by solving for \( x \) in the following equation

\[
\bar{U} = \ln(C^*(1 + x)) + A \ln(1 - H^*). 
\]

In the above expression \( \bar{U} \) is steady state utility under the original policy, \( C^* \) and \( H^* \) are the total consumption and hours associated with the new policy. Total consumption is given by \( cp_t + \mu cg_t, \mu \) being equal to one. Welfare changes will be expressed either as a percent of steady state output (\( \Delta C/Y \)) or steady state consumption (\( \Delta C/C \)) where \( \Delta C ( = C^* \cdot x) \) is the total change in consumption required to restore an individual to the previous utility level.

For the steady state welfare changes four different groups of experiments are performed and they are displayed in table one below.

**TABLE I:**
Steady State Welfare

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Original Policy</th>
<th>New Policy</th>
<th>(\Delta C/C)</th>
<th>(\Delta C/Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\alpha)  (\tau_k)  (\tau_h)</td>
<td>(\alpha)  (\tau_k)  (\tau_h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>0.50          0.50   0.23</td>
<td>0.88         0.50  0.23</td>
<td>12.26</td>
<td>9.12</td>
</tr>
<tr>
<td>One.(b)</td>
<td>0.85          0.50   0.23</td>
<td>0.90         0.50  0.23</td>
<td>5.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Two</td>
<td>0.88          0.50   0.23</td>
<td>0.91         0.45  0.23</td>
<td>0.24</td>
<td>0.21</td>
</tr>
<tr>
<td>Three</td>
<td>0.88          0.50   0.23</td>
<td>0.76         0.45  0.23</td>
<td>-3.34</td>
<td>-2.97</td>
</tr>
<tr>
<td>Four</td>
<td>0.88          0.40   0.24</td>
<td>0.88         0.50  0.23</td>
<td>6.26</td>
<td>5.32</td>
</tr>
<tr>
<td>Four.(b)</td>
<td>0.88         0.50    0.23</td>
<td>0.88         0.45  0.23</td>
<td>-3.31</td>
<td>-2.80</td>
</tr>
</tbody>
</table>

The first simulation assumes a hypothetical economy with half of public expenditures going to investments. \(\tau_k\) equal to 0.5 and \(\tau_h\) equal to 0.23. The welfare cost
are considerable when alpha moves up to the average for the US economy, which is 0.88, while keeping the tax rates constant. It is 12.26 when measured as a proportion of steady state consumption (Δ C/C) and 9.12 when measured as a proportion of steady state output, still a significant value. From the previous section it is easy to understand the reasons for this fact. As the share of public investment out of total expenses falls, private investment, capital stock, hours worked and, consequently, output and consumption fall. With a smaller steady state output, tax collection also drops, so that not only private consumption but also total consumption steady state levels end up being smaller, despite the fact that the share of public consumption went up.

Even when values closer to the American experience are used the welfare costs are substantial. From the beginning of the seventies to the end of the eighties expenditures in structures and equipment of the general government went from 14.3% to 10.8% of public expenses. In this case, the welfare costs of changing alpha from 0.85 to 0.9 (simulation 1.b) is 4.2 percent of GNP or 5 percent of consumption, when measured as ΔC/Y or ΔC/C, respectively. In other words: the slowdown of public investment in the seventies and eighties implies a sizable long run welfare loss. At current levels 4.2 percent of GNP amounts to approximately US $230 billion.

These results above maybe the most important lesson of this whole section: there is much to be gained by simply reallocating public expenses, without change the tax structure, from non productive consumption to investments in infrastructure and equipment. This is true even when it is taken into account that public consumption may affect individuals' well being.

Next, two stylized policy experiments are analyzed. In the first one (simulation 2) capital tax rate is reduced from the base value and, at the same time, the share of public consumption is increased. We call it, quite inaccurately it is true, a “Republican style” policy, as we can think of it, together with the capital tax reduction, as transfer of government money from investment infrastructure to defense projects, a public good.
The parameter $\tau_k$ goes from 0.5 to 0.45 and the parameter alpha goes from 0.88 to 0.91, which is slightly higher from where it stood in 1989. In this case the gains from the smaller taxes are canceled by the smaller investment share. There is a small welfare loss of 0.21 when measured as a proportion of GNP or 0.24 as a proportion of consumption. As a matter of fact $\tau_k$ has to fall below 0.44 for there to be any welfare gains if $\alpha$ goes from 88 to 91.

When keeping the share of investment constant at the base value the gains from the reduction of capital tax rate from 0.5 to 0.45 (simulation 4.b) are considerable, 3.3% of steady state consumption or 2.8% of steady state output. As in the standard real business cycle model, tax reduction is welfare improving, the difference here is that there is limit for tax reduction. Beyond this limit welfare falls because the excessive decline in public investment induced by the lower tax negatively affects output and consumption. For instance, if the base policy is modified to one with a zero capital tax rate and labor tax close to zero. (there is no equilibrium with both tax rates being exactly zero) the welfare cost as a percent change of output is 321.4!

The other stylized policy (simulation 3) approximates president Clinton's declared plans: more investment in infrastructure and higher taxes. The Clinton style policy we simulate consists of an increase of 10 percent in the capital tax rate (from 0.50 to 0.55) and a twice as large public investment share (from 12% to 24% of G). The final result was a welfare gain of 2.97 when measured by $\Delta C/Y$ and 3.44 when measured by $\Delta C/C$. Similar to the previous policy, there are two forces canceling out each other and part of the gains from the higher investment share is lost because of the increased taxes. If $\alpha$ alone changed, the welfare gains as proportion of GNP is 6.2%, more than twice the gains from the Clinton styled policy.

The last experiment follows more directly the lines of Cooley and Hansen (1989) as we modified the mix of tax rates while keeping tax revenue, and alpha, constant. We start with a policy which has $\tau_k = 0.4$ and $\tau_l = 0.24$, and change it to the standard values.
\( \tau_k = 0.5 \) and \( \tau_h = 0.23 \). The welfare cost of this policy is 6.29 percent of steady state consumption and 5.32 percent of steady state output. The effect of the higher capital tax necessary to keep revenues constant in the face of smaller labor tax is strong enough to depress investment and income, and consequently private consumption, although public consumption remained the same. As a curiosity note, the values of the welfare costs for this tax changes are roughly comparable to the costs of modifying \( \alpha \) from 0.80 to 0.88.

To sum up the steady state experiments, the simulations indicate that the reduction of public investment vis a vis public consumption observed in the American economy in the last two decades brought about a sizable welfare loss. Furthermore, policy proposals of increased investment financed by higher taxes (the Clinton style experiment) or reduced capital taxation accompanied by smaller investments (the Republican style policy) need a precise fine tuning in order to avoid that the gains from the change of one policy instrument be lost with the modification of some other instrument.

The question we should ask is if those results carry on when we work outside the steady state and take into account the transition paths. We try to answer this question in the next subsection.

5.b Welfare Changes and Transition Paths

The second welfare measure takes into account the transition from one policy to the other. Using methods due to Cooley and Hansen (1992), we construct for this model economy the transition path from one steady state to another after a change in fiscal regime. We obtain \( K, Kg \) and \( H \) for the entire path and with them we construct \( C_p, Gg \) and \( C \). The welfare cost is calculated solving a equation like (5.1) for all the transition periods where \( C^* \) and \( H^* \) are substituted for the total consumption and hours for the period in question. The welfare measure we use is the present value of \( x \cdot C_i \) over all periods of simulation as a percentage of the present value of income. Note that "x" above.
like in the previous case, is the proportional change in total consumption required to keep consumers as well off in the new policy as in the original one.

In the present method we first use a nonlinear equation solver to find the equilibrium capital level, hours and public investment in the transition path. The initial conditions are the steady state values of the original policy. At every period we solve for the first order conditions and law of motion of public investment (given by equations 1.7 and 1.8):

\begin{align}
(5.2) & \quad \frac{C_{t+1}}{C_t} = \beta \left( r_t \left( 1 - \tau_k \right) + (1 - \delta) \right) = 0 \\
(5.3) & \quad w_t (\cdot^{-1})^t \left( 1 - \tau_h \right) (1 - H_t) - A C_t = 0 \\
(5.4) & \quad K_{g_{t+1}} = (1 - \alpha) (\cdot^{-1})^t \left( \tau_k \cdot^{-1} K_t + \tau_h w_t H_t \right)
\end{align}

To solve the above system, we first substitute the expressions for \( w, r, \psi \) and \( c \) in order to obtain a system in terms only of \( K, H \) and \( Kg \). The fiscal parameters are the ones for the new policy. This procedure is used from time zero to a given period \( T \) when the economy is close enough to the new steady state. From this period on the equilibrium decision rules obtained as explained in section three are used to simulate the economy for the remaining periods. In the present simulation \( T \) is 100 and the total number of periods is 2000.

In addition to welfare comparisons we will also use the equilibrium transition path for policy analysis. One of the main objections to the kind of policy comparisons of section four is that they are only stationary results and thus we cannot discuss the path from one steady state to another. This path, however, can have a long convergence period, implying that the full effect of a new fiscal policy would be felt many years or even decades later. It can also happen that variables can go for a large number of periods in the opposite direction of the final steady state. In the last case, a policy that, for instance, increased the income level in the long run via smaller alphas but "gets there" from below because of higher taxes, may happen to be on the whole an undesirable policy because of the costs along the path to achieve the higher output level.

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Table two presents the results of four groups of simulations reproducing most of the policies changes that were analyzed in the previous section. The welfare measure used is the present value of the consumption change over the simulation as a percentage of the present value of output, so that it roughly corresponds to \( \Delta C / Y \) from section 5.a.

**TABLE II: Welfare in The Transition Path**

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Original Policy</th>
<th>New Policy</th>
<th>Welfare Cost</th>
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<tr>
<td></td>
<td>( \alpha )</td>
<td>( \tau_k )</td>
<td>( \tau_h )</td>
</tr>
<tr>
<td>One</td>
<td>0.50</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>One.b</td>
<td>0.85</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>Two</td>
<td>0.88</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>Two.b</td>
<td>0.85</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>Three</td>
<td>0.88</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>Four</td>
<td>0.88</td>
<td>0.40</td>
<td>0.24</td>
</tr>
<tr>
<td>Four.b</td>
<td>0.88</td>
<td>0.40</td>
<td>0.23</td>
</tr>
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The first policy changes alpha from 0.5 to 0.88 while keeping all other parameters constant. The welfare cost in this case is 2.16, and when the change in alpha is from 0.85 to 0.9, modeling recent American experience (simulation one.b), it is 1.14% of present value of output. Those values are considerable lower than the welfare costs of the corresponding steady state policy. In both cases the reason is that consumption and utility approaches the new steady state from above. This is clear from figure seven below that measures the percentage change in the variable in question from the original steady state. Utility rises initially and up to the fifteenth period is larger than the previous one. The reason is that government consumption (not displayed in the graph) rises initially due to the increase in alpha, and it countervails the fall in private consumption. Later, with the continuous reduction in output and tax collection public consumption ends up
also falling, but never below the original steady state level. Note also the continuous drop on labor productivity.

Figure 7

Transition Path (Policy 1)

Simulation two reproduces the Republican style policy of the previous section: the share of public consumption increases from 0.88 to 0.91 and capital tax decreases from 0.5 to 0.45. In this case, the total welfare cost is 0.23, almost the same as in the steady state simulations. For this policy, steady state income did not change much, it went from 0.2611 to 0.2602 (less than 0.4%), while private consumption actually increased from 0.1539 to 0.1546. The drop in welfare is due, for the steady state case, to the fact that public consumption falls more than private consumption so that total consumption decreases\(^1\). The welfare cost is higher in the present case as compared to

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\(^1\) Note that if \(\mu\) was set to be smaller than one so that individuals did not value public consumption at the same weight than private consumption, the final outcome of the present simulation might well be an increase and not reduction of welfare.
the steady state because income and consumption first fall and then converge to the new steady state from below.

To emphasize the drawbacks of these kind of conflicting measures (higher alpha and lower capital tax) and the necessity of fine tuning the parameters change, Simulation two.b exacerbates the parameter change. Alpha now goes from 0.85 to 0.9 and \( \tau_k \) goes from 0.5 to 0.4. Figure 8 below displays percentage change of selected variables with respect to the original steady state. Although utility and total consumption increase in the steady state there is a welfare loss of 0.04 in terms of present value of GNP when the transition path and long run effect are taken into account. Immediately after the policy change, private consumption, total consumption and attained utility, fall from the original steady state by 9%, 6.1% and 6.4%, respectively. The convergence is not only from below but its pace is very slow in this case, taking private consumption 20 quarters to finally surpass the old steady state level. All the long run gains from the smaller capital tax are canceled out by the temporary drop in consumption and utility due to the reduction in alpha.
As expected, tax changes by themselves bring sizable welfare effects. In Simulation four. b only capital tax is modified. It rises from 0.4 to 0.5 and the welfare cost is 1.03. However, when we keep steady state revenue constant, by decreasing the labor tax from 0.24 to 0.23 (Simulation four), the welfare cost is now only 0.133. This is well below the welfare cost from comparable steady state exercise, which was 5.32. As in Simulations one and one. b the reason is that the series converge from above to the new steady state. The basic point, however, is that although the new tax mix induces a long run increase in output, keeping revenue constant, welfare did not improve but declined. Government size (total taxes in this model) must decline for welfare to increase, or capital taxes must decrease and labor taxes increase.

Simulation 3 is what we called a Clinton style policy in the last section: public investment share goes from 12% to 24% and capital tax rate goes from 0.5 to 0.45. The effect over economic series of this policy are displayed in figure IX below.
The first thing that catches our attention is the fast convergence as opposed to Simulation three.b. In less than four quarters most of the series are very close to the new steady state. Also, given the relative magnitude of the change in parameters, hours, after an initial reduction, as well as consumption, labor productivity (not displayed in the graph) and attained utility all increase. We could expect that if the change in alpha was smaller and/or the increase in τₖ larger, the opposite could happen, as higher tax rates induce reduction in these variables. As a matter of fact, capital stock falls with this policy change as expected. Nonetheless, output increases as the effect of higher hours and public investment dominates. Finally, the welfare gain of the present policy change is 0.89, as both consumption and utility rise, but it is smaller than the gain from the comparable policy for the steady state.
6 Conclusion

This paper addressed the welfare and macroeconomic effects of fiscal policy in a modified real business cycle framework where government not only chooses the tax rates but also the distribution of revenues between consumption and investment. The model is set such that public consumption affects individuals' utility and public capital is part of the productivity process as a separate argument of the production function.

The policy simulations suggest that the larger the proportion of investments out of total public expenditures, the larger the equilibrium level of capital stock, hours worked and output. It also increases labor productivity indicating that part of the slowdown of productivity growth in the seventies and eighties can be explained by the slowdown in the public investment observed in this period. We showed that when investment goes from 12% to 13% of public expenditures, labor productivity increases by 1.2%. In addition, reallocating expenditures to investment also induces higher attained utility levels: the increase in output leads to higher private consumption and also public consumption, as the larger tax revenues counteract the effect of the decrease in the proportion of public consumption in total government expenditures. Note that this results imply that simply by shifting public expenditures to investment, keeping tax rates constant, governments can reduce its budget deficit because it leads to an expansion in tax revenues.

The effect of tax changes depends on the magnitude of the elasticity of output with respect to public expenses. For values large enough, increases in both the capital and labor tax rates can actually lead to increases in the capital stock and output. The effect on returns due to higher public investment (boosted by the enlarged tax revenues) overcomes the reduction on returns due to the larger tax rates. For smaller elasticities, the distortionary effect dominates, and the usual neoclassical result of higher tax leading to smaller output and capital stock prevails.
The welfare exercises point to the fact that there is much to be gaining only by increasing the share of investment in total public expenditures. However, recent policy proposals that add tax increases to this need a careful fine tuning, otherwise what is gained by higher proportional investment is lost because of the increase in taxation. Another result indicates that government can be tempted to increase consumption while cutting tax because of short run welfare gains. Governments are short lived and although the long run outcome, in present value, represents a welfare loss the political benefits of 4 or 8 years of increased consumption could well decide in favor of this kind of policy. One of our next goals is to study more deeply this type of trade off in environments were policies are endogenous.
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