ALTERNATIVE FORMS OF FINANCING GOVERNMENT EXPENDITURE: A STEADY STATE ANALYSIS

by

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ABSTRACT

This paper compares the relative merits of alternative methods of government expenditure financing. I consider the effect of three forms of financing namely: lump-sum tax, wage tax and tax on capital on agents with different preferences for leisure. While the different methods of financing are all ‘guilty’ of crowding-out private consumption, the different agents still ranked them differently in terms of long-run welfare. I show that lump-sum tax financing is preferable to both forms of distortionary tax financing. Also, all agents prefer wage tax to a tax on capital. This is because wage taxes lead to an initial reduction in welfare, due to the decline in the short-run consumption resulting from the higher short-run level of investment. However, the level of welfare rises over time as capital is accumulated, leading to more private consumption. The converse is also true when capital is taxed.
DEDICATION

To my sisters.
ACKNOWLEDGEMENTS

I have been indebted in the preparation of this project to my supervisors, Professor Andolfatto and Professor Mongrain for sharing their wealth of knowledge and experience so freely. I want to thank Professor Myers and Professor Kasa for their helpful suggestions. A special thank you to Professor Kennedy for his thoughtful commentary and practical advice.

I wish to thank my friends, colleagues for making my year in Vancouver immensely enjoyable. I would also like to thank my best friend for always being there.

Last but not least, I would like to thank my entire family for their unconditional support, both financially and emotionally throughout my degree.

I know I have forgotten to mention names here, of all those others who so kindly helped me get through to the end of this project. Please excuse my state of mind. I have not forgotten; it’s just that the names are not popping at this hour.
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1. INTRODUCTION

Any government wishing to increase its expenditures must decide how to raise the necessary revenue. Generally speaking, its options are to increase its stock of debt, raise various alternative specific tax rates, or do both. It is well understood in both the public finance and macroeconomic literature that different budgetary policies have different macroeconomic consequences. An immediate problem that arises is how to develop a criterion that assesses the relative merits of alternative forms of expenditure financing.

This paper is devoted to tackling the issue above. The framework adopted is a basic neoclassical model, in which the equilibrium emerges from the optimality conditions of the different agents in the economy. In comparing among the different modes of financing, I consider only overall utility evaluated over the agent’s entire planning period. For a more realistic approach, I abstract from the representative agent assumption. Rather, the economy is populated with agents who have different preferences for leisure. The long-run welfare effects were compared under three alternative modes of financing:

1. Lump-sum taxes;
2. Tax on labour income;
3. Tax on capital income;

Lump-sum financing is introduced primarily to serve as a benchmark. As one would expect, it dominates the two forms of distortionary tax financing in terms of
overall welfare, although in the short run it may lead to losses relative to these other modes of financing.

The current analysis abstracts from issues pertaining to government debt. Instead, the government maintains a balanced budget by continuously adjusting one of the three taxes to meet its current expenditures.

From the extensive literature, different authors have studied the welfare costs associated with various forms of taxation. Feldstein (1978) and Judd (1987) analyzed the effects on the excess burdens associated with exogenous changes in various tax rates, with the tax revenues typically being redistributed through lump-sum taxes. Chamley (1985) analyses the welfare gain of a shift from a tax on capital income to a tax on labor income. All these papers considered policies based on exogenous tax rates.

On the other hand, Turnovsky (1992) derives criteria for evaluating the impact of an increase in government expenditure on both the time path of instantaneous utility and overall welfare, under alternative forms of tax financing (i.e., lump sum, tax on labor and tax on capital). In this paper, the tax rates were endogenously determined to finance the given expenditures. The author used analytical methods and found that the lump sum financing dominates other forms of financing. However, comparisons between the two distortionary taxes depends upon the factors such as the supply of labor elasticity, elasticity of substitution in production and the relative extent to which the mode of tax financing will help correct for the distortion due to pre-existing wage taxes.

The next section of the paper sets down the model. Section Three discusses the calibration in detail. Section Four goes on to describe the steady state behavior under the different budgetary policies. The final section presents the conclusions.
2. MODEL

2.1 Basics

The model considers resource allocations in an economy composed of infinitely lived households. At any point in time, households differ in terms of their preference for leisure. There is no uncertainty. Also, I assumed that households own all the factors of production and all shares in firms. Each household sells factor services to firms and buys the goods produced by firms, consuming some and accumulating the rest as capital. Firms own nothing; they simply hire capital and labor on a rental basis to produce output, sell output produced back to households, and return any profits that result to shareholders. Individuals have preferences defined over a sequence of consumption and leisure \((c_t, l - n_t)\) that are represented by the function:

\[
\sum_{t=0}^{\infty} \beta^t \left[ u(c_t) + \psi \nu (1 - n_t) \right]
\]  

(1)

where \(u\) and \(\nu\) are strictly increasing and concave, \(0 < \beta < 1\) is the discount factor and \(\psi\) is the heterogeneous leisure preference parameter.

Production of the composite good, \(Y_t\), is by means of a production function having the neoclassical properties of positive, but diminishing, marginal physical products and constant returns to scale:

\[
Y_t = f(K_t, N_t)
\]  

(2)
where \( K_t = \sum_{\psi} k_t(\psi)G(\psi) \), \( N_t = \sum_{\psi} n_t(\psi)G(\psi) \) and \( G(\psi) \) is the fraction of each type of individual \( \psi \).

Capital is assumed to depreciate at a constant rate \( 0 < \delta < 1 \), it is related to gross investment by:

\[
K_{t+1} = (1 - \delta)K_t + x_t
\]

where \( K_0 > 0 \) is given and \( x_t \) is the gross investment.

The other agent in the economy is the government, whose only source of revenue is taxation. It sets the tax rates on labor income, \( \tau^w_t \), capital income, \( \tau^k_t \), as well as lump-sum taxes, \( \tau^l_t \), so as to finance its level of expenditure, \( g_t \), in each period, according to:

\[
\tau^l_t + \tau^w_t w_t N_t + \tau^k_t r_t K_t = g_t
\]

### 2.3 Equilibrium

The choice problem for each household of each type \( \psi \) can be stated as follows.

Given \( \beta, k_0 > 0 \) and \( (\tau^w_t, \tau^k_t, \tau^l_t, g_t) \), choose \( \{c_t, n_t, l_t, x_t, k_{t+1} | t \geq 0\} \) to solve:

\[
\max_{k_{t+1}, n_t} \sum_{t=0}^{\infty} \beta^t [u(c_t) + \psi_n(1 - n_t)]
\]

subject to:

\[
(1 - \tau^w_t)w_t n_t + (1 - \tau^k_t)r_t k_t - \tau^l_t - c_t - x_t \geq 0;
\]

\[
k_{t+1} - (1 - \delta)k_t - x_t \geq 0;
\]

\[
1 - n_t - l_t \geq 0;
\]

\[
k_0 > 0;
\]
I restrict my attention to interior solutions. Hence, an optimal program satisfies the following restrictions:

\[(1 - \tau_i)w_i u'(c_i) - \psi v'(1 - n_i) = 0 ;\]

\[- u'(c_i) + \beta \left[ r_i (1 - \tau_i^k) + (1 - \delta) \right] u'(c_{i+1}) = 0 ;\]

where \( c_i = (1 - \tau_i^w) w_i n_i + k_i [(1 - \tau_i^k) r_i + (1 - \delta)] - k_{i+1} - \tau_i^l, \quad x_i = k_{i+1} - k_i, \)

\( r_i = f_K(K_i, N_i) \) and \( w_i = f_N(K_i, N_i) \).

The choice-problem essentially boils down to a choice of two sequences \( \{n_i, k_{i+1}\} \); abusing notation somewhat, let \( \{n_t(\psi), k_{i+1}(\psi) | t \geq 0\} \) denote a solution for type \( \psi \) faced with a particular tax regime.

The government must choose a tax policy in each regime to balance its budget at every date according to:

\[ g_i - \tau_i^w w_i N_i - \tau_i^k r_i K_i - \tau_i^l = 0; \]
2.3 Steady State

The economy converges to a steady state featuring constant labour supply \( n(\psi) \) and capital stock \( k(\psi) \) for each \( \psi \); these steady states values satisfy (for an interior solution):

\[
(1 - \tau^w) w u' (c^*(\psi)) - \psi v'(1 - n^*(\psi)) = 0 ; \\
-1 + \beta [(1 - \tau^k)r + (1 - \delta)] = 0 ; \\
g - \tau^w wn^* - \tau^k rK^* - \tau^l = 0 ;
\]  

(7a) (7b) (7c)

where \( c^*(\psi) = (1 - \tau^w) wn^*(\psi) + k^*(\psi) [(1 - \tau^k)r - \delta)] - \tau^l \), starred parameters denote the solution for each typed given a particular tax policy, \( K^* = \sum_\varphi k^*(\psi) G(\psi) \), \( N^* = \sum_\varphi n^*(\psi) G(\psi) \) and \( G(\psi) \) is the fraction of each type of individual \( \psi \).
3. CALIBRATION

I am primarily interested in examining how the model economy responds under the different tax regimes and how different agents in the economy respond in terms of labor choices and capital accumulation. Which type of agents are made better off under the different tax schemes and why? Which policy results in the highest output and social welfare? To answer these questions, I parameterize the model using numerical methods and steady state restrictions. I specified the preferences and technology as follows:

\[ u(c, l - n) = \ln(c) + \psi \ln(1 - n), \]
\[ \psi > 0 \]
\[ y = Ak^{1-\theta}n^\theta, \]
\[ 0 < \theta < 1 \]

To calibrate the model economy, the following assumptions were made:

- There are three different types of individuals in this environment, those with high, medium or low preferences for leisure, with 50% of the population taking on the medium value and the other 50% evenly divided across the two extreme values.
- Time period in the model corresponds to one year.
- Capital depreciates at 10% per year (i.e. \( \delta = 0.10 \)). With positive depreciation, individuals will in general devote some resources to replenishing their capital stock.
- Total time available to devote to work or leisure was normalized to one.
• The productivity parameter $A$ was solved from the equilibrium conditions of the model.

• Unequal relative importance of labour and capital in the production of output ($\theta = 0.65$).

• The discount factor ($\beta$) was chosen to be 0.96.

• Government expenditure ($g$) was chosen to be 20% of GDP in each period ($3.029$ in this case).

A social welfare function based on the weighted utilitarian criterion was employed:

$$SW(\tau_j) = \sum_{j=1}^{3} \lambda_i [u_i(c_i(\tau_j)) + \psi v_i(1 - n_i(\tau_j))]$$

where $\lambda_i$ is the share of each skill type and $j$ corresponds to the different tax regimes.

The parameter values used in the calibration are given in Table 1.
4. STEADY STATE ANALYSIS

In this section, I examine how the steady state of my model economy responds to the different three different tax regimes. I report values for the following variables: employment, consumption, capital stock, leisure, total utility and social welfare. It is important to note that only the steady state values are reported and compared in this analysis. However to fully understand the significance of the results, I also discuss the reaction of the agents as they converge to their respective steady states under the different tax regimes.

4.1 Consumption and Employment

Table 2 reports the results for consumption and labour supply under the different tax regimes. Employment for all the different agents is highest when the government expenditure is financed by lump-sum tax and lowest when government expenditure is financed by a tax on labour. These results are consistent with findings from similar literature (e.g. Turnvosky, 1992). The explanation being, with lump-sum tax financing, the capital-labour ratio determined by the marginal product condition (7b) remains fixed (since $\tau^k=0$). This implies that capital and labour will change in the same proportion. The higher government expenditure means higher lump-sum taxes and lower permanent income. This causes all agents to reduce their consumption of leisure, thus increasing the
supply of labour (i.e. pure income effect). Also, when government expenditure is financed with a wage tax, the long-run capital-labour ratio remains fixed, as it does with lump-sum tax financing. However, the different agents experience two opposing effects. The higher tax lowers permanent income thus increases labour supply (i.e. income effect). At the same time, the higher wage tax discourages labour supply since after tax wages are lower (i.e. substitution effect). From the results we see that the substitution effect and latter income effect dominates thus lowering long-run employment under this tax policy. On the other hand, when government expenditure is financed by a tax on capital, the lower permanent income resulting from the higher tax will raises the marginal utility of wealth, inducing more labour, as with lump-sum taxation. However, the higher tax on capital induced firms to substitute labour for capital. Based on the results, I conclude that the elasticity of substitution between labour and capital is insufficient (i.e. the substitution effect is small), because the level of long-run employment is lower under this regime than when the government finances its expenditure through lump-sum taxation.

Consumption on the other hand, is highest for all the different agents under lump sum financing and lowest when the tax is on capital. With lump-sum and wage tax, agents experience temporary reductions in private consumption resulting from increases in the short-run level of investment. However, consumption increases over time as capital accumulation increases. The converse is also true when the government finances its expenditure with a capital tax.
4.2 Capital Accumulation

Table 2 also reports the results for capital stock accumulation under the different
tax regimes. As one would expect, financing with a tax on capital has the least
expansionary effect on long-run capital accumulation. From the previous section, we
know that the capital-labour ratio remains fixed under the lump-sum and wage tax
regimes. This implies that the increase in long-run employment under both forms of
government financing increases capital accumulation. On the other hand, when the
government finances its expenditure with a tax on capital, increase in long-run
employment leads to a reduction long-run capital stock as firms substitute between the
two factors of production.

4.3 Long-run Utility and Social Welfare

Table 3 reports the results for long-run utility for each type of agents under the
different tax regimes. The three different policies all have direct crowding-out effects.
As government increases its expenditure, it directly takes away resources from the private
sector thus reduces private consumption by the same proportion. However, the three
different agents still rank the regimes differently. It is immediately clear that economic
welfare is highest when the government finances its expenditure through lump sum taxes.
Also, all the agents prefer the government financing its expenditure by taxing labour
rather than capital. This is because, under lump-sum and wage tax, short run welfare
losses are incurred as the increase in government expenditure induces an instantaneous
accumulation in capital, and therefore less consumption. Over time, as capital is accumulated, the higher level of output permits higher consumption; which is welfare improving in the long-run. A capital tax on the other hand, is welfare improving in the short run as a reduction in the capital stock results in higher consumption, but this is also associated with long-term welfare losses.

Table 4 reports the results of social welfare under the different regimes. Social welfare rankings are consistent with the above results. In the long-run, the representative agent prefers lump-sum tax financing and prefers a wage tax over a tax on capital.
5. CONCLUSION AND RECOMMENDATIONS

I examined the relative merits from a welfare point of view of the alternative ways to finance a given increase in government expenditure. The intertemporal optimizing framework adopted here assesses gains (or losses) in terms of utility associated the eventual steady state. Based on the results, I found that for most agents, lump-sum tax financing dominates either form of distortionary tax financing in terms of overall welfare. Also, in terms of overall welfare, agents prefer a wage tax to a tax on capital. This is because a wage tax is more likely to be consistent with a stable growth path, since in the long-run, a tax on capital has an adverse effect on the level of the capital stock thereby inhibiting growth and long-run consumption. Also in terms of social welfare, the ranking is as follows:

\[ SW_{\text{lump-sum}} > SW_{\text{wagetax}} > SW_{\text{capitaltax}} \]

An example of a policy prescription to combat the adverse effects of a capital tax may be for the government to offer firms some form of subsidy (lump-sum). This will helpful in reducing the negative long-run effects, as firms will no longer have an incentive to substitute a huge proportion of capital for labor.

Turnvosky (1992) argued that examining steady state utility alone is misleading since it implies an ordering based on the response of the long-run capital stock. This is because it ignores welfare along the transition path, for example, the fact that a tax on capital has a more adverse effect on the long-run capital stock than does a wage tax.
means that, during transition it is associated with a higher rate of decline in the capital stock, which permits a higher short-run rate of consumption, thus any short-run relative gains in utility from this are offset later on by longer term losses resulting from the larger decline in the long-run capital stock. To that end, comparing welfare along the transition paths for the different agents would be an interesting extension of the paper to examine rankings differences in the short-run and their eventual long-run states.

Also, another possible extension will be to compare monetary policy (i.e. government financing through bonds or printing money) and the alternative tax policies. It will be interesting to see how the different regimes rank in terms of overall welfare along the transition path and at steady-state. Optimal method(s) of financing government expenditure can also be considered in an extended version of this paper.

In general, predictions of my basic neoclassical model are in line with existing literature. Also, the results provide an interesting insight from a welfare perspective on the consequences of the various tax policies. These provide beneficial policy implications for improving standard of living of all the different citizens in the long-run.
## APPENDICES

### Table 1

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$\delta$</th>
<th>$\theta$</th>
<th>$\text{tfp}=A$</th>
<th>$\phi_1$</th>
<th>$\phi_2$</th>
<th>$\phi_3$</th>
<th>$g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.96</td>
<td>0.10</td>
<td>0.65</td>
<td>7.97</td>
<td>1.55</td>
<td>1.90</td>
<td>2.31</td>
<td>3.03</td>
</tr>
</tbody>
</table>

### Table 2

Employment, Consumption, Capital Stock and Tax rates.

<table>
<thead>
<tr>
<th></th>
<th>Employment</th>
<th>Consumption</th>
<th>Capital Stock</th>
<th>Tax rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.4226</td>
<td>9.5865</td>
<td>41.3956</td>
<td>3.0292</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3000</td>
<td>4.2279</td>
<td>2.4705</td>
<td>0.3000</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.3379</td>
<td>6.3767</td>
<td>33.0874</td>
<td>0.3979</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.3826</td>
<td>8.3925</td>
<td>37.4778</td>
<td>3.0292</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3000</td>
<td>4.2279</td>
<td>2.4705</td>
<td>0.3000</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.2946</td>
<td>5.5613</td>
<td>28.8566</td>
<td>0.3979</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.3455</td>
<td>7.2843</td>
<td>33.8416</td>
<td>3.0292</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3000</td>
<td>4.2279</td>
<td>2.4705</td>
<td>0.3000</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.2548</td>
<td>4.8100</td>
<td>24.9586</td>
<td>0.3979</td>
</tr>
</tbody>
</table>
### Table 3

<table>
<thead>
<tr>
<th>Total Utility</th>
<th>Total Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.6114</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3857</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.5267</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.5268</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3324</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.4578</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
</tr>
<tr>
<td>Lump-sum</td>
<td>0.4361</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.2674</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.3864</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Social Welfare</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lump-sum</td>
<td>0.5253</td>
</tr>
<tr>
<td>Tax on capital</td>
<td>0.3295</td>
</tr>
<tr>
<td>Wage tax</td>
<td>0.4572</td>
</tr>
</tbody>
</table>
SOURCE CODE

/* Model Calibration */

gbar = 1.0;
rho = 0.5;
sigma = 0.01;
beta = 0.96; /* discount factor */

/* stdg = sigma/(1-rho^2)*sqrt(0.5); This is the (ergodic) percent standard deviation in g. */

length = 100; /* Length of time period */

eta = 1; /* calibrated to labor supply elasticity */

theta = 0.65; /* calibrated to labor's share */
nstar = 0.30; /* calibrated to data on hours */
gyratio = 0.20; /* ratio of government purchases to GDP -- calibrated from data */
talk = 0; /* tax on capital */
taow = 0; /* tax on labor */
delta = 0.10; /* depreciation rate */

kstar = (1-theta)/(1/beta - 1 + delta); /* Steady State level of capital */

ystar = 1; /* output equals 1 in the steady state */

tfp = 1/(kstar*(1-theta)*nstar*theta); /* Calculation from assignment 5 */

A = gbar/(gyratio*kstar*(1-theta)*nstar*theta);

rent = (1-theta)*tfp*kstar*(theta-nstar*theta); /* return on capital */
wage = theta*tfp*kstar*(theta-nstar*(theta-1)); /* return to labor */

/* We can use this restriction to solve for the psi that calibrates the model to the average level of employment; ie. */

/* temp = (theta*A*kstar*(theta-nstar*(theta-1)) - wage); */

/* psistar = temp / (A*kstar*(1-theta)*nstar*theta*(1-gyratio)*(1-nstar)^(-1)); */

psistar = (theta*kstar*(1-theta)*nstar*(theta-1))/(kstar*(1-theta)*nstar*theta*(1-gyratio)*(1-nstar)^(-eta));

gexp = 3.0292; /* government expenditure selected */

N = 3;
knew = ones(N,1);
nnew = ones(N,1);
tao = ones(1,1);
connew = ones(N,1);
altcon = ones(N,1);

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leis = ones(N,1);
outp = ones(N,1);
psi = ones(N,1);
wage = ones(N,1);
rent = ones(N,1);
welfare = ones(N,1);
SWelfare = ones(1,1);
/*Skill differences */
psi[1] = psistar*exp(-0.2);
psi[2] = psistar;
psi[3] = psistar*exp(0.2);
xO = kstar^kstar*nstar*nstar*nstar*nstar;
    output=0;
    {x,f,g,h} = NLSYS(&focl,x0);
knew[1]=x[1];
knew[2]=x[2];
knew[3]=x[3];
nnew[1]=x[4];
nnew[2]=x[5];
nnew[3]=x[6];
tao=x[7];
totcap=0.25*knew[1] + 0.50*knew[2] + 0.25*knew[3];
totlab=0.25*nnew[1] + 0.25*nnew[2] + 0.25*nnew[3];
totout=tfp*totcap*(1-theta)*totlab*(theta);
rrent=(1-theta)*tfp*(totlab/totcap)*(theta); /*RENT */
rwage=(theta)*tfp*(totcap/totlab)*(1-theta); /*WAGE*/
/* CONSUMPTION UNDER LUMP SUM */
/* CONSUMPTION UNDER WAGE TAX */
altcon[1]=(1-tao)*rwage*nnew[1] + knew[1]*(rent-delta);
/* CONSUMPTION UNDER CAPITAL TAX */
altcon[1]=rwage*nnew[1] + knew[1]*((1-tao)*rent-delta);
leis[1]=1-nnew[1];
leis[3]=1-nnew[3];
welfare[1]=log(altcon[1])+psi[1]*log(leis[1]);
SWelfare=(0.25*welfare[1])+(0.50*welfare[2])+(0.25*welfare[3]);

"employment" nnew;
"capital stock" knew;
"tax rate" tao;
"Consumption" altcon;
"Leisure" leis;
"Welfare" welfare;
"Social Welfare" SWelfare;
"wage" wage;
"rent" rent;
"psi" psi;
"A" A;
"tfp" tfp;
"total output" totout;

end;

proc foc1(x);
local fn1,fn2,fn3,fn4,fn5,fn6,fn7,c4,c5,c6,c7,c8,c9,c10,c11;
c4=(1-theta)*tfp*((x[4]/x[1])^theta);
c5=(1-theta)*tfp*((x[5]/x[2])^theta);
c6=(1-theta)*tfp*((x[6]/x[3])^theta);
c7=0.25*x[1]+0.50*x[2]+0.25*x[3]; /* K*/
c8=0.25*x[4]+0.50*x[5]+0.25*x[6]; /*N*/
c10=(1-theta)*tfp*(c8/c7)^theta; /*RENT*/
c11=(1-theta)*tfp*(c7/c8)^theta; /*WAGE*/

/* CONDITION UNDER LUMPSUM AND WAGE TAX */
fn1=-1+beta*(c4+(1-delta));
fn2=-1+beta*(c5+(1-delta));
fn3=-1+beta*(c6+(1-delta));

/* LUMP SUM */
fn4=c11*(1-x[4])-psi[1]*(c11*x[4]+x[1]*(c10-delta)-x[7]);
fn5=c11*(1-x[5])-psi[2]*(c11*x[5]+x[2]*(c10-delta)-x[7]);
fn6=c11*(1-x[6])-psi[3]*(c11*x[6]+x[3]*(c10-delta)-x[7]);
/* WAGE TAX */

/* CONDITION UNDER CAPITAL TAX */
fn1 = -1 + beta * ((1-x[7]) * c4 + (1-delta));
fn2 = -1 + beta * ((1-x[7]) * c5 + (1-delta));
fn3 = -1 + beta * ((1-x[7]) * c6 + (1-delta));

/* GOVERNMENT BUDGET CONSTRAINTS */
fn7 = gexp - x[7]; /* lump-sum */
fn7 = gexp - (0.25) * (x[7] * c11 * x[4]) + (0.50) * (x[7] * c11 * x[5]) + (0.25) * (x[7] * c10 * x[6]); /* wage tax */
fn7 = gexp - (0.25) * (x[7] * c10 * x[1]) + (0.50) * (x[7] * c10 * x[2]) + (0.25) * (x[7] * c10 * x[3]); /* capital tax */
retp (fn1|fn2|fn3|fn4|fn5|fn6|fn7);
endp;
REFERENCE LIST


