BALANCED BUDGET RULES AND AGGREGATE INSTABILITY: THE ROLE OF CONSUMPTION TAXES

Chryssi Giannitsarou *†

January 30, 2006

Abstract. It is known that, in the context of a real business cycle model with constant returns to scale and a balanced budget fiscal policy rule, steady state indeterminacy may arise as a result of endogenous labor income tax rates. In this paper, it is shown that when the government finances its expenditures via an endogenous consumption tax instead, there exists a unique steady state which is always saddle-path stable. As a result, combining income taxes with consumption taxes makes the ranges of indeterminacy shrink, thus reducing the possibility of aggregate instability. From a policy perspective, the results provide an additional argument in favor of (less distortionary) consumption taxes in place of capital taxes.

Keywords: Fiscal policy, consumption tax, balanced budget rules, indeterminacy.

JEL Classification: C62, E62

*I am grateful to Jang-Ting Guo, Andrew Scott, Joseph Zeira and two anonymous referees for their comments and suggestions on improving this paper. For various comments, I also thank seminar participants at the ECB, the University of Cambridge, the Hebrew University of Jerusalem, the University of Cyprus and the Athens University of Economics and Business. This project has been supported by the ESRC award RES-000-23-1152.

†University of Cambridge and CEPR. *Address for correspondence*: Faculty of Economics, Austin Robinson Building, Sidgwick Avenue, Cambridge, CB3 9DD, United Kingdom. *E-mail*: cg349@cam.ac.uk. *Web*: http://www.econ.cam.ac.uk/faculty/Giannitsarou/index.html

1. Introduction

Balanced budget fiscal policy is a recurrent theme of discussion and debate in many countries. For example, in 1997 a balanced budget constitutional amendment was proposed in the United States. Also, the Maastricht Treaty required that EMU countries had deficits below 3% of GDP in order to join the European Union, and the Growth and Stability Pact of the Amsterdam Treaty imposes penalties on countries that exceed this limit after joining. Economic theory proposes three main reasons for which a balanced budget rule may not be a wise fiscal policy. First, balanced budgets amplify the business cycle, create suboptimal volatility of tax rates and substantial welfare losses (e.g. see Barro (1979), Lucas and Stokey (1983), King, Plosser and Rebelo (1988), Greenwood and Huffman (1991)). Second, they create incentives for illegal and nontransparent economic activity (see Alesina and Perotti (1996)). Last, they may lead to indeterminacy, thus inducing belief driven aggregate instability and endogenous sunspot fluctuations. Schmitt-Grohé and Uribe (1997), were the first to point to this possibility and showed that indeterminate equilibria may arise for empirically plausible ranges of tax rates, in the context of a standard constant returns to scale neoclassical growth model, where the government's exogenous expenditures are financed solely by taxing labor and capital income.

The aim of this paper is to revisit the issue of aggregate instability, which may be caused by balanced budget fiscal policy rules, when government expenditures may be financed by consumption taxes as well. The main findings of the paper are that (i) consumption taxes alone do not induce indeterminacy, (ii) the possibility of endogenous aggregate instability caused by income taxes is reduced, if combined with a consumption tax rate that adjusts endogenously and that (iii) this possibility is further reduced if capital taxes are replaced by consumption taxes.

The analysis is done in the context of the standard neoclassical growth model augmented with a government, which has a constant stream of expenditures that may be financed by taxing income and/or consumption. It is first shown that, if the only source of government revenues is consumption taxes, any steady state is saddle-path stable and that indeterminacy is altogether impossible (the result is shown for a variety of preference specifications). This is because the consumption tax does not generate long-run distortions, as opposed to the case of financing government spending by a labor income tax, where long-run distortions imply a Laffer curve and the possibility of indeterminacy. In particular, if households expect the consumption tax rate to be above average, due to the intertemporal substitution effect, they expect to consume less in the future, but without changing their labor supply. Thus they will substitute away from future consumption by increasing current consumption. Since labor supply is not expected to change, there is no intertemporal negative wealth effect and no reduction in current consumption. Therefore, if consumption taxes are expected to increase, current consumption always increases, resulting in a decrease of the current consumption tax rate. In other words, expectations of higher consumption tax rates can never be fulfilled.

This finding is then used to explain how the government may be able to use taxes on consumption as a 'stabilizing' instrument, when these are combined with endogenous income taxes (as indeterminacy is less likely than if the only source of government revenue was income taxes alone). In particular, indeterminacy becomes less likely the higher the steady state level of the consumption tax rate is. This is in contrast to an alternative policy of combining endogenous income taxes decomposed into labor and capital taxes, where, for empirically plausible ranges, the higher the capital tax rate is, the wider the range of indeterminacy is.

The key policy implication of the present work is that endogenous fluctuations under a balanced budget rule can be avoided when income taxes are endogenous, as long as these are combined with endogenous consumption taxes. A second implication of the results is an additional argument in favor consumption taxes in place of capital taxes, since high capital taxes increase the possibility of indeterminacy when combined with endogenous labor taxes.

The existing literature is oriented towards the importance of balanced budget rules in relation to the United States and this is perhaps the reason why consumption taxes are ignored (the consumption tax rates in the United States are estimated to be around 5 to 6 percent from 1965 to 1996; see Mendoza, Razin and Tesar (1994), updated estimates up to 1996 are available online from the authors). The results of the present paper are perhaps more relevant for European countries where consumption taxes are in general much higher than in the United States, but as it is demonstrated in section 4, indeterminacy can be avoided even for small levels of steady state consumption tax rates.[1] Moreover, the results presented here could be also be relevant for countries with low consumption taxes, if there are plans for cuts in capital income taxes.

The paper relates to the work of Guo and Harrison (2004), who study the model of Schmitt-Grohé and Uribe (1997) under the assumption that income taxes are held constant and that government expenditures are endogenous, in the absence of consumption taxes. They find that in this case, indeterminacy is impossible for all tax rates. Other related work includes Rudanko (2002), Evans and McGough (2005) and Duffy and Xiao (2005). In the context of the same model, these authors study whether sunspot equilibria that exist when the steady state is indeterminate may arise as outcomes of adaptive learning.

The rest of the paper is organized as follows. Section 2 presents the basic model, along with the equilibrium conditions and the steady state. In section 3, I show that there can never be indeterminacy, under the assumption that instantaneous utility is logarithmic in consumption and linear in hours worked, as in Hansen (1985); I then discuss the robustness of this result to other more general preference specifications. Section 4 discusses the policy implications of the results. Finally section 5 concludes.

2. The Model

In this section, I present a standard neoclassical growth model, where economy consists of a continuum of identical infinitively lived households, an infinitely lived firm and a government that finances its expenditures by levying taxes on consumption.

Before proceeding with the description of the model, it is worth pointing out that the result of Atkinson and Stiglitz (1980), i.e. that a labor tax is equivalent to a consumption tax, does

[1] For example, on average, the consumption tax rates in European Union countries vary from 10 to 35 %, while in the United States, the consumption tax rate has been around 5% for the last thirty years. The highest consumption tax rates in Europe are estimated for the Nordic countries. For example, the average consumption tax rate in Denmark in the period 1965-91 is approximately 35 percent (see Mendoza, Milesi-Ferretti and Asea, (1997)).

not hold in the framework to be studied. As explained in Renström (1999), this is because this result is not generally true in a dynamic setting with endogenous tax rates: it requires that the tax rates are constant and that the initial capital is taxable. Renström (1999) further shows that, although labor income tax is not generally equivalent to a consumption tax, when an appropriate capital income tax is introduced the equivalence holds. For the model studied here, the consumption tax is equivalent to an income tax with investment exemptions, as long as the income tax rate is less than 50%.

Households. The representative household is initially endowed with some capital, and receives income from renting out its capital and supplying labor. Income is used to finance consumption and to invest in additional capital. Consumption is taxed at a rate τ_{ct}. Letting c_t and n_t denote consumption and labor (hours worked) respectively, the households maximize discounted lifetime utility

$$\max \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho}\right)^t \left(\log c_t - A\frac{n_t^{1+\sigma}}{1+\sigma}\right), \quad \sigma \geq 0,\ A > 0 \tag{1}$$

$$\begin{aligned} \text{s.t.} \quad c_t + k_{t+1} &= w_t n_t + r_t k_t + (1-\delta)k_t - \tau_{ct} c_t, & (2) \\ & k_0 \text{ given} & (3) \end{aligned}$$

where r_t and w_t denote the rental price of capital and the wage rate respectively. Furthermore, the parameter $0 < \delta < 1$ denotes the depreciation rate of capital and $\rho > 0$ denotes the discount rate. The first order conditions associated with the household's problem are

$$\begin{aligned} \frac{c_{t+1}}{c_t} &= \frac{1}{1+\rho}\left[\frac{1+\tau_{ct}}{1+\tau_{c,t+1}}\left(1-\delta+r_{t+1}\right)\right], & (4) \\ A c_t n_t^{\sigma} &= \frac{1}{1+\tau_{ct}} w_t, & (5) \\ \lim_{t\to\infty}\left(\frac{1}{1+\rho}\right)^t \frac{k_{t+1}}{\left(1+\tau_{ct}\right)c_t} &= 0 & (6) \end{aligned}$$

The first expression is the Euler equation determining the intertemporal choice of the household, where the expression in the square bracket is the after tax gross interest rate. The second expression determines the intratemporal choice between consumption and labor, where the right hand side of the equation is the after tax wage rate. The last expression is the transversality condition.

Firms. The representative firm produces output y_t, rents capital at a rate r_t and hires labor at a rate w_t, and maximizes profits in every period:

$$\begin{aligned} & \max\left(y_t - r_t k_t - w_t n_t\right) \\ \text{s.t.} \quad y_t &= F(k_t, n_t) \equiv k_t^{\alpha} n_t^{1-\alpha}, & (7) \end{aligned}$$

with $\alpha \in (0,1)$. Let F_k and F_n denote the first derivatives of the production function F with respect to capital and labor respectively. The first order conditions of the firm are

$$r_t = F_k(k_t, n_t), \tag{8}$$

$$w_t = F_n(k_t, n_t). \tag{9}$$

These simply equate the marginal products of the production inputs with their corresponding prices.

Government and fiscal policy. The government faces a exogenous stream of constant expenditures

$$g_t = G \tag{10}$$

that is financed by levying taxes on consumption. It maintains a balanced budget such that

$$g_t = \tau_{ct} c_t. \tag{11}$$

Competitive Equilibrium . Given an initial capital stock k_0, a competitive equilibrium for the economy is defined as a sequence of prices $\{r_t, w_t\}_{t=0}^{\infty}$, a sequence of allocations $\{c_t, k_{t+1}, n_t\}_{t=0}^{\infty}$, a government policy $\{\tau_{ct}\}_{t=0}^{\infty}$ and an exogenous sequence of government expenditures $\{g_t\}_{t=0}^{\infty}$ such that, when households maximize utility and firms maximize profits, subject to their constraints and taking prices and government policy as given, the chosen allocations are such that capital, labor and goods markets clear, and the government budget constraint is satisfied. The equilibrium conditions are given by the first order conditions from the household's maximization problem (2), (4), (5), (6), the capital and labor market clearing conditions (8) and (9), and the government's budget constraint and exogenous sequence of expenditures (11), (10). The goods market clearing condition is redundant according to Walras law.

Steady State. It is straightforward to demonstrate that there exists a unique steady state in this economy. To see this, first note that from (4) and (8) the steady state capital labor ratio is

$$\kappa = \frac{K}{N} = \left(\frac{\alpha}{\rho + \delta}\right)^{\frac{1}{1-\alpha}}, \tag{12}$$

where upper case letters denote the steady state levels of the variables, with the exception of the steady state consumption tax rate, which is denoted by τ_c. Note that the capital labor ratio is independent of the tax rate. Using (2), (8) and (11), steady state consumption becomes

$$C = \frac{1}{1 + \tau_c} \left(\kappa^{\alpha} - \delta\kappa\right) N \tag{13}$$

and from (5), the steady state of labor supply becomes

$$N = \left[\frac{(1-\alpha)\kappa^{\alpha}}{A\left(\kappa^{\alpha} - \delta\kappa\right)^{\eta}}\right]^{\frac{1}{1+\sigma}}. \tag{14}$$

Finally, from (11), (13) and (14)

$$G = \tau_c C = \varphi \frac{\tau_c}{1+\tau_c}, \tag{15}$$

where

$$\varphi = (\kappa^{\alpha} - \delta\kappa)^{\frac{\sigma}{1+\sigma}} \left[\frac{(1-\alpha)\kappa^{\alpha}}{A}\right]^{\frac{1}{1+\sigma}} > 0. \tag{16}$$

Since φ is positive and does not depend on the tax rate, G is strictly increasing in τ_c and therefore, the model has a unique steady state. Existence of unique steady state for this model, depends crucially on the fact that the steady state labor supply does not depend on the tax rate τ_c. This ensures that G is strictly increasing in τ_c, and therefore there can never be a Laffer curve.

3. Consumption Taxes and Saddle-Path Stability

It is straightforward to show analytically that in the model set forth in the previous section, there can never be indeterminacies. Let λ_t be the Lagrange multiplier from the household's maximization problem. The conditions describing the dynamics of the economy can be summarized by

$$\begin{aligned}
\lambda_t &= \frac{1}{1+\tau_{ct}} \frac{1}{c_t}, && (17)\\
\frac{\lambda_t}{\lambda_{t+1}} &= \frac{1}{1+\rho}\left[1-\delta+F_k(k_{t+1}, n_{t+1})\right], && (18)\\
An_t^{\sigma} &= \lambda_t F_n(k_t, n_t), && (19)\\
k_{t+1} &= F(k_t, n_t) + (1-\delta)k_t - c_t - G. && (20)
\end{aligned}$$

Log-linearizing the above conditions around the steady state, one can reduce the log-linear system of difference equations to

$$\begin{pmatrix} \hat{\lambda}_{t+1} \\ \hat{k}_{t+1} \end{pmatrix} = \begin{pmatrix} \frac{1+\rho}{1+\rho+\theta}\left[1+\sigma\left(\frac{\rho+\delta}{\alpha}\cdot\frac{1+\sigma}{\alpha+\sigma}-\delta\right)\right] & \sigma(1+\rho) \\ \frac{\rho+\delta}{\alpha}\cdot\frac{1+\sigma}{\alpha+\sigma}-\delta & 1+\rho+\theta \end{pmatrix} \begin{pmatrix} \hat{\lambda}_t \\ \hat{k}_t \end{pmatrix}, \tag{21}$$

where

$$\theta = \frac{(\rho+\delta)(1-\alpha)}{\alpha+\sigma}.$$

Note that the matrix that determines the local dynamics around the steady state does not depend on the tax rate. This is in contrast to the model of Schmitt-Grohé and Uribe (1997), where the dynamics, and thus whether there is indeterminacy or not, depends on the corresponding steady state of the labor tax. It is also easy to verify that the matrix of the dynamics satisfies always the conditions for saddle-path stability, given the parameter restrictions $0 < \alpha < 1$, $0 < \delta < 1$, $\sigma \geq 0$ and $\rho > 0$.

The economic interpretation behind this result can be understood better once it is contrasted with outcomes in an economy where public spending is financed only by labor taxes, as in Schmitt-Grohé and Uribe (1997). For ease of exposition, I will refer to the present economy as the *consumption tax model* and the economy of Schmitt-Grohé and Uribe (1997) as the *labor* *tax model*. The steady state labor tax rate in the latter model is denoted by τ_n.

The common features between the two models is that in both cases, the steady state capital labor ratio is independent of the corresponding tax rates and that the steady state rental price for capital is the same as in the first best economy without taxation. The difference between the two models is that the steady state labor supply is decreasing in τ_n in the labor tax model, while it is independent of τ_c in the consumption tax model. In the former case, this implies a Laffer curve (i.e. two steady states), while in the latter case, the steady state production is unaffected by taxation. This last observation means that the consumption tax does not induce distortions: the households simply cut back on their private consumption in order to make resources available for public consumption.

To understand this last point better, consider the two possible effects induced by taxation. All types of taxation generate an (intratemporal) income effect: the reduction in income due to taxation makes households reduce their consumption and increase their labor supply to compensate for the loss of income. This effect does not imply distortions because it does not violate the condition for social efficiency (i.e. that the marginal rate of substitution between consumption and labor is equal to the marginal rate of transformation). Proportional taxes generate a further (intratemporal) substitution effect (since they make households substitute away from heavily taxed goods or activities), which causes reduction in both consumption and labor supply. In the labor tax model, this substitution effect dominates, resulting in labor supply being decreasing in τ_n, while in the consumption tax model, the substitution effect is completely offset by the income effect, implying that labor supply is independent of the tax rate τ_c.

Moving to the issue of indeterminacy, consider first the labor tax model. Suppose that the economy is in steady state. If households expect that the future labor tax rate will be above average, then, through the intratemporal substitution effect, they expect to work less in the future, thus the expected future return on capital is lower (due to diminishing returns). In turn, since households would want to invest less, this leads to lower current labor supply. Consequently, the government will have to raise current labor taxes in order to balance its budget. In particular, for some parametrizations, labor taxes will be increased by an amount that is higher than the expected increase and therefore such expectations can be fulfilled. Turning to the consumption tax model, if households expect that in the future the consumption tax rate will be above average, then they expect to consume less in the future, but do not expect to change their labor supply, since this is independent of the tax rate. Because of the intertemporal substitution effect, since households expect to substitute away from future consumption without changing their labor supply, they will increase current consumption. Since labor supply is not expected to change, there is no intertemporal negative wealth effect and thus there will never be a reduction in current consumption. Thus, the net effect implies that current consumption always increases, the current consumption tax rate will decrease (to balance the budget) and such expectations can never be fulfilled. In summary, the reason why a consumption tax does not imply multiplicity of steady states and equilibrium indeterminacy is that its net effect on the economy does not imply efficiency distortions.

Having showed that when a balanced budget is financed by consumption taxes, there can never be indeterminacies, it is interesting to examine the robustness of the result to other more general preference specifications. For this purpose, I consider the following variations of the model:

(a) *Non-separable utility* in consumption and leisure, with instantaneous utility function

$$\begin{aligned} u(c,l) &= \frac{\left(cl^{\phi}\right)^{1-\eta}}{1-\eta}, \text{ if } 0<\eta<1 \text{ or } \eta>1 \\ &= \log c + \phi \log l, \text{ if } \eta = 1, \end{aligned}$$

with the parameter restriction $\phi/(1+\phi) \leq \eta$, which ensures concavity of the utility function.

(b) *Multiplicative separable utility* in consumption and leisure, with instantaneous utility function

$$\begin{aligned} u(c,l) &= \frac{c^{1-\eta}}{1-\eta}\frac{l^{\phi}}{\phi}, \text{ if } 0<\eta<1 \text{ or } \eta>1 \\ &= \log c + \frac{l^{\phi}}{\phi}, \text{ if } \eta = 1, \end{aligned}$$

with the additional restriction $\frac{\eta(1-\phi)}{(1-\eta)\phi} \geq 1$, which ensures concavity of the utility function.

(c) *Additively separable utility* in consumption and hours worked

$$\begin{aligned} u(c,n) &= \frac{c^{1-\eta}}{1-\eta} - A\frac{n^{1+\sigma}}{1+\sigma}, \text{ if } 0<\eta<1 \text{ or } \eta>1 \\ &= \log c - A\frac{n^{1+\sigma}}{1+\sigma}, \text{ if } \eta = 1, \end{aligned}$$

with the parameter restrictions $A > 0$, $\sigma \geq 0$, which ensure concavity of the utility function.

The first two preference specifications are consistent with balanced growth (see King, Plosser and Rebelo (1988)). The last specification is consistent with balanced growth only when $\eta = 1$, which the benchmark model already analyzed. I discuss each of these cases in turn.

For the case of non-separable utility, it can be shown that for all parameter values, there exists a unique steady state. This is because, once again, the steady state labor supply does not depend on the tax rate. However, the matrix describing the local dynamics around the steady state will in general depend on τ_c. Nevertheless, it can be shown that given the parameter restrictions, the steady state is never indeterminate. Because the relevant matrix is not elegant enough to examine the stability properties analytically, I have explored this numerically for the standard quarterly and yearly parametrizations for US. This was done by setting $N = 1/3$, and checking the stability properties for $0 \leq \tau \leq 1$, and $0 < \eta < 1$ or $\eta > 1$, by defining appropriate grids. The numerical investigation shows that the steady state is saddle-path stable for almost all combinations of τ and η, apart from a small minority of combinations, for which the steady state is unstable. These last cases occur for small η (below 0.7) and very high tax rates (above 80%), which are empirically implausible.

For the case of multiplicative separable utility, it can again be shown that there exists a unique steady state, because the steady state labor supply does not depend on the tax rate. Also, the matrix describing the local dynamics, depends on the tax rate. Doing a numerical experiment analogous to the case of non-separable utility, it can be shown that the steady state is always saddle-path stable, given the parameter restrictions.

Finally, for the case of additively separable utility, and whenever $\eta \neq 1$, the steady state labor supply depends on the tax rate, implying that in general G will not be a monotonic function function of the tax rate. Restricting attention to $0 < \tau < 1$, it can be shown that there is a Laffer curve whenever $0 < \eta < (1-\sigma)/2$. Since $\sigma \geq 0$, the implied values of η are small and thus empirically irrelevant, since usual estimates vary between 1 and 5. Nevertheless, it is straightforward to show that no steady state is ever indeterminate, for any $\eta \neq 1$ and $\sigma \geq 0$. Furthermore, it can be shown analytically that whenever $\eta \geq 1/2$, the unique steady state is saddle-path stable. It can also be confirmed numerically (as for the two other cases) that all steady states are saddle-path stable whenever $\eta < 1/2$.

In conclusion, the main result of the paper is robust to a variety of commonly used preference specifications. For all the cases, the intuition for this result follows from the fact that distortions induced due to consumption taxation (if any exist), are not strong enough to generate self-fulfilling prophecies, in the sense explained earlier.

4. Policy Implications

Next, I discuss the policy implications of introducing consumption taxes as a source of government revenues under balanced budget policy. The results produced in this section are based on the benchmark model with $\sigma = 0$, so that the model is in line with the model of indivisible labor of Hansen (1985) and the benchmark analysis of Schmitt-Grohé and Uribe (1997). The parameter A is set such that steady state labor is $N = 1/3$. Finally, the benchmark parametrization is in accordance with yearly US data, i.e. $\alpha = 0.3$, $\delta = 0.1$ and $\rho = 0.04$.

Having concluded that consumption taxes alone can never induce indeterminacy in this framework, it is easy to analyze the stability properties of steady states in economies where government spending may be financed by a combination of income and consumption taxes. The government's budget constraint now becomes

$$g_t = \tau_{yt} y_t + \tau_{ct} c_t. \tag{22}$$

This constraint allows for the possibility of endogenous government spending, but does not allow for income taxation after depreciation allowances. It can be verified numerically that if both income and consumption taxes are fixed and the government spending is endogenously determined, indeterminacies never arise. This is in accordance with the findings of Guo and Harrison (2004), who show that if capital and labor tax rates are held fixed and government spending is endogenous, agents' expectations about higher tax rates can never be fulfilled, since the government cannot alter the tax rates. If income taxes are fixed, while consumption taxes are endogenously determined, indeterminacy never arises either. This is because when an endogenous consumption tax rate is combined with a fixed income tax rate, income tax cannot be used as an instrument to balance the budget. On the other hand, when a fixed consumption tax is combined with an endogenous income tax, indeterminacy is possible. In this case, as the steady state consumption tax rate increases, the ranges of indeterminacy become overall smaller, although this reduction does not happen for empirically plausible income tax rates. This is because the government's only instrument for balancing its budget is the one generating indeterminacies in the first place. Finally, when both the consumption and income taxes are endogenous and proportional, higher consumption tax rates imply even smaller ranges of indeterminacy, since the government now has two instruments for balancing its budget. This is shown in figure 1, where, for example, if the consumption tax is 20%, the corresponding region of indeterminacy is $\tau_y \in [0.46, 0.67]$, as opposed to when the consumption tax is zero, with an indeterminacy region $\tau_y \in [0.43, 0.70]$.[2]

For the rest of this section, and in order to make the results comparable with those of Schmitt-Grohé and Uribe (1997), I consider an alternative policy which taxes income after depreciation allowances, i.e.

$$g_t = \tau_{yt} \left(y_t - \delta k_t \right) + \tau_{ct} c_t$$

The basic insights from such an experiment are the same as the ones from the case when the government's constraint is given by (22), with the only difference being that whenever indeterminacy is possible, the corresponding regions are somewhat larger. This is because if the government taxes income after depreciation allowance, there is an incentive for the households to own more capital and supply less labor. This distorts the labor supply decisions more than when all income is taxed uniformly, thus making the possibility of indeterminacy larger. Figure 2 shows the region of indeterminacy when consumption and income taxes are endogenous and proportional.

The key point to keep from this analysis is that combining income taxation with consumption taxation *reduces* the possibility of indeterminacy. Therefore the main policy implication of the present analysis is that, if a government were to follow a balanced budget rule, the chances of aggregate instability may be reduced if government expenditures are financed more by consumption taxes and less by income taxes. Table 2 reports whether the steady state is determinate or not for the United States, the United Kingdom, Germany, Japan and Canada, by breaking the income tax rate into labor and capital tax rates. It is assumed that the labor tax rate is variable and endogenous, while the capital tax rate is fixed. Using the benchmark parameterization, the left hand side column reports the stability properties without taking into account the consumption taxes, while in the right hand side column, numbers are based on including the corresponding consumption tax rates (the estimated tax rates used are reported

[2] In all the graphs that follow, white areas show regions where the solution is indeterminate, the gray areas show regions where there is a unique saddle-point stable solution and black areas show regions where there are only explosive solutions. The indeterminacies were detected using the procedure described in Uhlig (1997). The procedure was implemented numerically in Matlab, by calculating relevant eigenvalues, for given ranges of steady state values of the tax rates which vary between 0.0001 and 0.9999, with grids of 1000 points.

in table 1).[3] As can be seen from this table, as long as the labor tax is not very high and as long as the consumption tax is endogenously determined, indeterminacy does not arise for the United States, the United Kingdom or Japan, despite the fact that, for example, τ_c is rather low for United States and Japan. On the other hand, if the consumption tax is ignored, then for all five countries the estimated tax rates fall in the areas of indeterminacy.

Another policy aspect of the present analysis is that it gives an additional argument in favor of consumption taxes in place of capital taxes.[4] To understand this, it is useful to replicate the results of Schmitt-Grohé and Uribe (1997) and Guo and Harrison (2004) in the absence of consumption taxes, when an income tax rate is broken into capital and labor tax rates, i.e. when the government's budget constraint is

$$g_t = \tau_{kt}(r_t - \delta)k_t + \tau_{nt}w_t n_t. \tag{23}$$

The areas of indeterminacy are shown in figure 3. There are four important conclusions deriving from the analysis of Schmitt-Grohé and Uribe (1997) and Guo and Harrison (2004). First, the crucial ingredient for indeterminacy is the presence of an *endogenous labor tax rate*. Second, combining an endogenous labor tax rate with an endogenous capital tax rate, in a sense 'absorbs' some of the indeterminacy. Third, for empirically plausible tax rates, if labor taxes are endogenous, as the capital tax rate increases (either as a steady state value of an endogenous τ_k or as being fixed), the range of indeterminacy with respect to labor taxes becomes larger, in particular, indeterminacy arises for increasingly smaller labor tax rates. Last, if all tax rates are held fixed and government spending is endogenous, then there is no indeterminacy.

The argument then relates to the third point: From figure 3, given a labor tax rate, non-zero capital taxes increase the possibility of indeterminacy (and thus the possibility of sunspot equilibria), while consumption taxes will in general decrease this possibility. Table 3 reports whether the steady state is determinate or not for the same countries and for the same type of policy rule as in table 2, when now capital taxes are substituted by consumption taxes. This is done by first calculating the implied G using the estimated tax rates reported in table 1 and then solving for the required steady state τ_c, when $\tau_k = 0$.[5] From the table, it can be seen that the solution for the parameterization of Canada becomes determinate once capital taxes are substituted by consumption taxes.

5. Summary and Conclusion

This paper revisits the issue of aggregate instability arising from self-fulfilling expectations under a balanced budget fiscal policy rule. The additional element that is taken into account is the fact that government expenditures may also be financed via consumption taxes. The

[3] The parameters used reflect US calibration, but the purpose of this table is to contrast the results with those of Schmitt-Grohé and Uribe (1997).

[4] The fact that capital taxation creates large distortions has been documented extensively in the literature. In terms of welfare, it has been shown that the loss associated with capital taxes is much larger than the loss associated with consumption taxes and this is still true even when the transition is taken into account (see Cooley and Hansen, 1992).

[5] The implied consumption taxes are 10.87% for the US, 22.06% for the UK, 19.12% for Germany, 11.93% for Japan and 17.33% for Canada.

analysis shows that consumption taxes alone do not induce indeterminacy and that with such an additional source of government revenue, the possibility of indeterminacy is reduced, as long as the consumption tax rate is allowed to adjust endogenously. Furthermore, an interesting by-product of the analysis is a new argument in favor of taxing consumption rather than capital, since in the presence of endogenous labor taxation, capital taxes increase the possibility of indeterminacy, while consumption taxes decrease this possibility.

References

[1] Alesina, A. and R. Perotti, 1996. "Fiscal Discipline and the Budget Process". *American Economic Review*, Papers and Proceedings, 86, 401 - 407.

[2] Atkinson, A. B. and J. E. Stiglitz (1980), "Lectures on Public Economics", *McGraw-Hill*.

[3] Barro, R., 1979. "On the Determination of Public Debt". *Journal of Political Economy*, 87, 940 - 971.

[4] Cooley, T. F. and G. Hansen, 1992. "Tax Distortions in a Neoclassical Monetary Economy", *Journal of Economic Theory*, 58, 290 - 316.

[5] Duffy, J. and W. Xiao, 2005. "Instability of Sunspot Equilibria in Real Business Cycle Models Under Adaptive Learning", mimeograph.

[6] Evans, G. and McGough, 2005. "Indeterminacy and the Stability Puzzle in Non-Convex Economies", *Contributions to Macroeconomics*, 5, No. 1, Article 8.

[7] Greenwood, J. and G. W. Huffman, 1991. "Tax Analysis in a Real Business Cycle Model", *Journal of Monetary Economics*, 27, 167 - 1990.

[8] Guo, J.-T. and S. Harrison, 2004. "Balanced-Budget Rules and Macroeconomic (In)stability", *Journal of Economic Theory*, 119, 357 - 363.

[9] Hansen, G. 1985. "Indivisible Labor and the Business Cycle", *Journal of Monetary Economics*, 16, 309 - 341.

[10] King, R. G., C. I. Plosser and S. Rebelo, 1988. "Production, Growth and Business Cycles I: The Basic Neoclassical Growth Model". *Journal of Monetary Economics*, 21, 195 - 232.

[11] Lucas, R. and N. Stokey, 1983. "Optimal Fiscal and Monetary Policy in an Economy Without Capital", *Journal of Monetary Economics*, 12, 55 - 94.

[12] Mendoza, E. G., G. M. Milesi-Ferretti and P. Asea, 1997. "On the Effectiveness of Tax Policy in Altering Long-Run Growth: Harberger's Superneutrality Conjecture", *Journal of Public Economics*, 66, 99 - 126.

[13] Mendoza, E. G., A. Razin and L. L. Tesar, 1994. "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption", *Journal Monetary Economics*, 34 (3), 297 - 323.

[14] Renström, T., 1999. "Endogenous taxation in a dynamic economy". PhD Thesis, University of Oxford.

[15] Rudanko, L., 2002. "On the Implications of a Balanced Budget Rule - An Adaptive Learning Perspective", Research Report 93:2002, University of Helsinki.

[16] Schmitt-Grohé, S. and M. Uribe, 1997. "Balanced-Budget Rules, Distortionary Taxes, and Aggregate Instability", *Journal of Political Economy*, 105, 976 - 1000.

[17] Uhlig, H., 1999. "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily", in Computational Methods for the Study of Dynamic Economies, ed. R. Marimon and A. Scott, *Oxford University Press.*

Tax rates[a]	τ_c	τ_n	τ_k
US	0.0546	0.2773	0.3962
UK	0.1524	0.24406	0.4717
Germany	0.1639	0.4238	0.2391
Japan	0.0600	0.2743	0.4261
Canada	0.1036	0.3263	0.5066

[a]The tax rates estimates used are for 1996 (updated estimates from Mendoza, Razin and Tesar, (1994); available online from the authors).

Table 1: Estimated tax rates, 1996

	$\tau_c = 0$	$\tau_c \neq 0$
US	indeterminate	determinate
UK	indeterminate	determinate
Germany	indeterminate	indeterminate
Japan	indeterminate	determinate
Canada	indeterminate	indeterminate

Table 2: Stability properties

	$\tau_c = 0$, $\tau_k \neq 0$	$\tau_c \neq 0$, $\tau_k = 0$
US	indeterminate	determinate
UK	indeterminate	determinate
Germany	indeterminate	indeterminate
Japan	indeterminate	determinate
Canada	indeterminate	determinate

Table 3: Susbstituting capital for consumption taxes

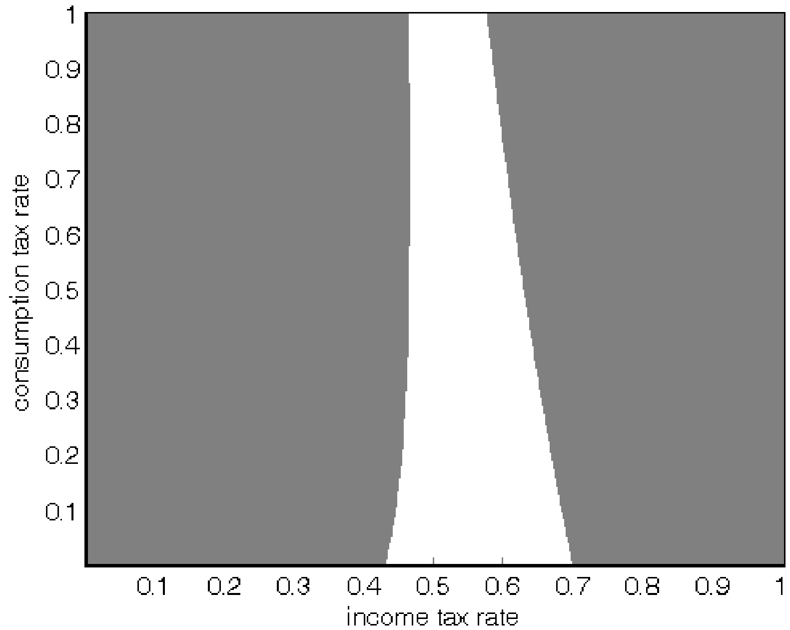

Figure 1: Endogenous consumption and income taxes, no depreciation allowances. The white area shows indeterminacy.

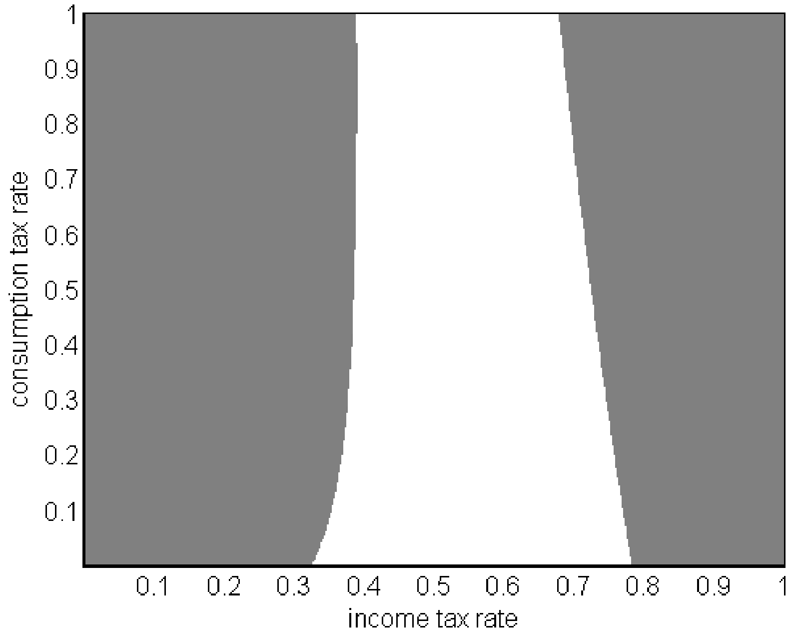

Figure 2: Endogenous income tax and endogenous consumption tax, with depreciation allowances. White regions show indeterminacy.

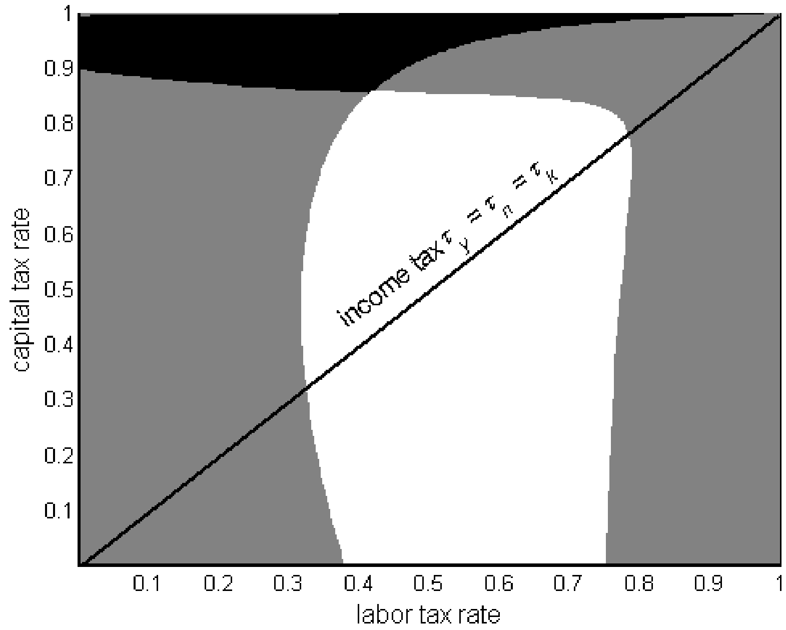

Figure 3: Indeterminacies with endogenous income tax rates, broken into capital and labor tax rates. White areas show indeterminacy and black areas show unstable steady states.