

Optimal Pre-Announced Tax Reform Revisited*

Mathias Trabandt[†]
Sveriges Riksbank

This Version: September 26, 2007

*I am grateful to Harald Uhlig for very valuable advice and suggestions. Further, I would like to thank Alexis Anagnostopoulos, Michael Burda, David Domeij, Andreas Haufler, Kenneth Judd, Dirk Krueger, Jesper Linde, Emanuel Mönch, Panu Poutvaara, Morten Ravn, Almuth Scholl, Christian Stoltenberg, Karl Walentin and Stanley Winer for very useful discussions and suggestions, Paul Klein for sending example GAUSS code of the numerical solution technique as well as seminar participants at Humboldt University Berlin, Sveriges Riksbank, 2006 CESifo Conference on Public Sector Economics, 2006 Southern Workshop in Macroeconomics, 2006 SED, 2006 German Workshop in Macroeconomics, 2006 DFG Network Quantitative Macroeconomics meeting, 2006 ESEM meeting and the 2006 Verein für Socialpolitik meeting. The author gratefully acknowledges financial support by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk" and by the RTN network MAPMU (contract HPRN-CT-2002-00237). Further, I am grateful to the EUI in Florence for its hospitality during a research stay where part of this paper was written. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of Sveriges Riksbank.

[†]Address: Mathias Trabandt, Sveriges Riksbank, Research Division, Brunkebergstorg 11, SE-103 37 Stockholm, Tel. +46-(0)-8-787-0438, email: mathias.trabandt@riksbank.se.

Abstract

Domeij and Klein (2005) have shown that the welfare gains of an optimal capital and labor income tax reform decline the longer the reform is pre-announced before its implementation. In other words, pre-announcement is costly in terms of welfare. I reexamine their claim by taking two additional features of government spending into account: public goods and public capital. In my baseline optimal reform, I show that valuable and productive government spending is likely to reduce the welfare costs of pre-announcement. Further, the baseline optimal pre-announced reform displays short-run confiscation and/or subsidy of capital and labor income. As a further contribution, I show that these short-run properties are not important for the welfare gains of pre-announced reforms with sufficiently long pre-announcement duration. In particular, a 4 years pre-announced suboptimal reform in which taxes move - without confiscation and subsidy - directly to their endogenous long-run values at the implementation date generates similar welfare gains as the 4 years pre-announced baseline optimal reform. The underlying tax structure of both reforms, however, appears to be very different.

Key words: pre-announced optimal tax reform, public goods, public capital, confiscation, subsidy, welfare

JEL Classification: E0, E6, H0

1 Introduction

Should fiscal policy pre-announce tax reforms before their implementation from a welfare point of view? This paper sheds new light on this issue. Domeij and Klein (2005) show that the welfare gains of an optimal capital and labor tax reform decline the longer the reform is pre-announced before its implementation. Hence, pre-announcement is costly in terms of welfare. The authors argue that the incentive effects of the future anticipated tax reform are dominated by the time delay effect and therefore fiscal policy should not pre-announce this type of tax reform.

In line with the classical optimal taxation literature, Domeij and Klein (2005) use a neoclassical growth model in which the fiscal authority collects distortionary taxes. The resulting tax revenues are rebated lump-sum to households or represent simply wasteful government spending. Is that an economically sensible description of the behavior of e.g. US fiscal policy? I believe it is not. Rather, I observe that fiscal policy uses tax revenues also to provide e.g. public goods and public capital. In this paper,

I describe public goods as non-productive but directly utility providing expenditures like government consumption while public capital describes productive government spending that is likely to affect private sector production through a public capital stock.

If these valuable and productive elements of government spending adjust endogenously in general equilibrium they are likely to affect the welfare consequences of pre-announced tax reforms. What are these welfare implications quantitatively? Does pre-announcement become more or less costly for a society in terms of welfare when taking public goods and public capital into account?

I attempt to answer this question by analyzing the welfare consequences of optimal pre-announced capital and labor tax reforms in a calibrated neoclassical growth model augmented with valuable and productive government spending.

My approach allows me to investigate an additional interesting issue. It turns out that the short- and long-run properties of the optimal tax system appear to be quantitatively very different. Put differently, the baseline optimal pre-announced tax reform displays short-run confiscation and/or subsidy of capital and labor income followed by a rather quick transition to the steady state of taxes. How important are the short-run properties of the optimal tax system for the resulting welfare gains of the pre-announced tax reform? In other words, is confiscation and/or subsidy quantitatively important for the resulting overall welfare gains of pre-announced tax reforms?

Therefore, the goal of this paper is twofold. First, I reexamine the claim of Domeij and Klein (2005) by taking two additional features of government spending explicitly into account: public goods and public capital. In other words, I examine the welfare consequences of utility providing government consumption and productive government capital in a pre-announced optimal tax reform. Second, I analyze how important the short-run properties of the optimal tax system - in other words con-

fiscation and/or subsidy of capital and labor income - are for the resulting overall welfare gains of the pre-announced tax reform.

My analysis employs a standard neoclassical growth model with distortionary taxation. The key ingredients of the model are endogenous government consumption that is part of a household utility function as well as productive government capital that enters the production function of firms, similar to Baxter and King (1993).

Suppose, the Ramsey planner is benevolent and is able to commit itself to the following type of tax reform. At time zero he credibly pre-announces an optimal capital and labor income tax reform that will be implemented at some future point in time. I study the transition to the Ramsey steady states as well as the welfare consequences of different pre-announcement horizons.

In my baseline optimal tax reform I find that valuable and productive government spending leads to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare gain reductions. More precisely, I find that the welfare gain of the baseline immediate optimal capital and labor income tax reform corresponds to a permanent increase of private consumption of 6.6 percent. By contrast, the welfare gain is 5 percent if the reform is pre-announced 4 years in advance. Hence, relative welfare gains fall by roughly 24 percent. By contrast, for a baseline optimal tax reform with fixed and non-valued government consumption and without public capital the welfare gains amount to 5.3 percent (immediate) and 3.4 percent (4 years pre-announced). This implies a relative reduction of welfare gains by roughly 36 percent similar to Domeij and Klein (2005). Hence, for my baseline reform, valuable and productive government spending - as employed in our model - leads to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare gain reductions.

These results depend of course on the valuation of government consumption by households as well as on the public capital share in private production. I show that

if either the valuation of government consumption or the public capital share are low or high then pre-announcement is less costly than in an economy without valuable and productive government spending. Interestingly, if both the valuation of government consumption and the public capital share are moderate then pre-announcement can be as costly as in an economy without these ingredients. A sensitivity analysis based on empirically reasonable parameter estimates reveals that for the overwhelming majority of parameter combinations pre-announcement is less costly than in an economy without valuable and productive government spending. Hence, I conclude that public goods and public capital are likely to reduce the welfare losses that are associated with pre-announcement.

Thus, my results show that the welfare costs of pre-announcing an optimal tax reform are likely to be smaller than previously thought. Interestingly, the reduction of welfare costs due to a more realistic description of the spending side of fiscal policy are not dramatic. Nevertheless, they are economically significant and therefore, the effects of valuable and productive government spending should be taken into account when benefits and costs of an optimal pre-announced tax reform are considered.

The second contribution of this paper focuses on the question whether short-run properties of the optimal pre-announced tax system are important for the resulting overall welfare gains. The baseline optimal tax reform displays short-run confiscation and/or subsidy of capital and labor income followed by a rather quick transition to the long-run values of taxes. How important is this short-run deviation from the long-run optimal taxes for the welfare consequences of the reform? In order to answer this question, we design a tax reform in which capital and labor income taxes move - without confiscation and subsidy - directly to their endogenous long-run values from the implementation date of the reform onwards. I argue that this pattern for the path of taxes is more in line with observed behavior of fiscal policy. Interestingly, I show that welfare gains for this “no confiscation/subsidy” tax reform

increase with the pre-announcement horizon as opposed to the decrease observed in the baseline optimal pre-announced tax reform.

In particular, I show that welfare gains for the “no confiscation/subsidy” tax reform increase substantially with the pre-announcement horizon. An immediate reform generates 3.5 percent higher permanent private consumption. By contrast, a 4 years pre-announced tax reform yields 4.7 percent higher permanent private consumption. Thus, I find that relative welfare gains increase by roughly 35 percent if the tax reform is pre-announced 4 years in advance.

Moreover, I show that the level of welfare gains is very different for the baseline optimal and the “no confiscation/subsidy” reform in case of immediate implementation. By contrast, the level of welfare gains becomes very similar for 4 years pre-announcement. Despite this, however, the underlying structure of taxes in both reforms appears still to be very different. For 4 years pre-announcement, the first freely chosen capital tax in the baseline optimal tax reform is still 178 percent. By contrast, the “no confiscation/subsidy” reform moves straight to zero percent capital taxes. The resulting loss of revenues in the “no confiscation/subsidy” reform is made up for by moving to moderately higher steady state labor taxes of 30 percent compared to 28 percent in the baseline optimal tax reform.

Therefore, my results indicate that confiscation and subsidy of capital and labor income are not important for the level of welfare gains that arise from an optimal tax reform which is sufficiently pre-announced in advance of its implementation. Finally, I show that my results prevail qualitatively even if the government has no access to government debt.

The paper is organized as follows. Section two presents the model. The results of the pre-announced tax reforms are discussed in section three. Section four reviews the related literature. Finally, section four concludes.

2 The Model

I use a standard neoclassical growth model similar to the one employed by Domeij and Klein (2005). However, with respect to utility providing government consumption and productive public capital I draw from the model in Baxter and King (1993).

2.1 Economic Environment

Time is discrete, $t = 0, 1, \dots, \infty$. The representative household maximizes the discounted sum of life-time utility subject to an intertemporal budget constraint and a capital flow equation. Formally,

$$\max_{c_t, n_t, k_t, x_t, b_t} \sum_{t=0}^{\infty} \beta^t u(c_t, n_t, g_t)$$

s.t.

$$\begin{aligned} (1 + \tau_t^c)c_t + x_t + q_t b_t &= (1 - \tau_t^n)w_t n_t + (1 - \tau_t^k)(d_t - \delta)k_{t-1} \\ &\quad + \delta k_{t-1} + b_{t-1} + s_t + \Pi_t \\ k_t &= (1 - \delta)k_{t-1} + x_t \end{aligned}$$

where c_t , n_t , k_t , x_t and b_t denote private consumption, hours worked, capital, investment and government bonds. q_t is the price that the household has to pay per government bond. The household takes government consumption g_t as given. Further, the household receives the wage w_t for supplying labor as well as dividends d_t for renting out capital to the firms. In addition, the household receives profits Π_t from the firms and lump-sum transfers s_t from the government. The household has to pay distortionary taxes on consumption, labor and capital income. By contrast to Domeij and Klein (2005), I add consumption taxes to the model since they reflect an important part of government tax revenue in US data, see e.g. Trabandt and Uhlig (2006).

The representative firm maximizes its period-by-period profits subject to a Cobb-Douglas production technology. Formally,

$$\max_{k_{t-1}, n_t} f_t(k_{t-1}, n_t, k_{t-1}^s) - d_t k_{t-1} - w_t n_t \quad (1)$$

s.t.

$$f_t(k_{t-1}, n_t, k_{t-1}^s) = k_{t-1}^{\theta_k} n_t^{\theta_n} (k_{t-1}^s)^{\theta_g} \quad (2)$$

where k_{t-1}^s denotes the public capital stock that is provided by the government. Note that equilibrium profits of the firm will be zero as long as $\theta_k + \theta_n = 1$ which I will impose when calibrating the model.

The government faces the following budget constraint,

$$g_t + s_t + b_{t-1} + x_t^s = \tau_t^c c_t + \tau_t^n w_t n_t + \tau_t^k (d_t - \delta) k_{t-1} + q_t b_t. \quad (3)$$

where x_t^s denotes government investment in the public capital stock. The latter has the following law of motion,

$$k_t^s = (1 - \delta_g) k_{t-1}^s + x_t^s. \quad (4)$$

At this point I would like to highlight the key differences to the model in Domeij and Klein (2005). First, government consumption g_t provides utility for the household and second, public capital k_{t-1}^s contributes to private production. A minor difference is the explicit introduction of consumption taxes for the reason given above.

2.2 Competitive Equilibrium

Given the economic environment, I am now ready to define a competitive equilibrium similar to Domeij and Klein (2005) and Ljungqvist and Sargent (2004).

Definition: A competitive equilibrium consists of prices $\{w_t, d_t, q_t\}_{t=0}^{\infty}$, quantities $\{c_t, n_t, k_t, x_t\}_{t=0}^{\infty}$, profits $\{\Pi_t\}_{t=0}^{\infty}$ and fiscal policy $\{\tau_t^c, \tau_t^n, \tau_t^k, s_t, g_t, b_t, k_t^s, x_t^s\}_{t=0}^{\infty}$ such that (1) given prices, fiscal policy and profits, the household solves its maximization problem, (2) given prices and fiscal policy, the firm solves its maximization problem, (3) the aggregate resource constraint $c_t + g_t + x_t + x_t^s = f(k_{t-1}, n_t, k_{t-1}^s)$ holds, (4) the government sets fiscal policy such that the government budget constraint is satisfied, (5) bond prices q_t are determined by the no-arbitrage condition $\frac{1}{q_t} = R_{t+1} = 1 + (1 - \tau_{t+1}^k)(d_{t+1} - \delta)$ and (6) profits are zero in all periods, i.e. $\{\Pi_t = 0\}_{t=0}^{\infty}$.

2.3 Calibration and Parameterization

I calibrate and parameterize the steady state of the competitive equilibrium to US data from 1975 to 2005. Time is taken to be annual. In principle, there are two ways to proceed.

First, estimate the model and use the estimation results to calibrate and parameterize the model. This, however, turns out to be a thorny issue. Similar to Domeij and Klein (2005), I have chosen a deterministic model. Hence, in order to estimate it with e.g. recent Bayesian model estimation procedures, I would need to put the economy into a stochastic environment with many shocks or by mechanically integrating measurement errors. Further, I use a small-scale model without any nominal or real rigidities. Estimating the model would potentially deliver biased or non-identified parameter estimates since Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2003), Mankiw and Reis (2006) and others have shown that additional features such as sticky prices, sticky wages, sticky information, investment and capacity utilization costs, limited participation etc. are important ingredients for a model in order to explain macroeconomic time series behavior. These features, however, would complicate the model considerably and simultaneously fog up the key issues this paper attempts to address. Finally, in order to estimate the model, I would need to specify fiscal policy rules, e.g. how taxes or transfers adjust to changes in debt or other

types of government expenditures in the competitive equilibrium. I believe, that the particular choice of fiscal policy rules as well as their dynamic lead/lag pattern has important effects for the resulting parameter estimates of the model. Due to these reasons, I do not estimate the model. However, addressing these issues thoroughly would be a useful next step on the research agenda and would certainly justify a separate piece of research.

Instead, and in line with Domeij and Klein (2005), I calibrate the competitive equilibrium steady state to historical averages of data respectively parameterize the model using standard parameter values used in the literature. Later on, I perform a sensitivity analysis with respect to key parameters of the model. In particular, I set $\bar{\tau}^c = 0.057$, $\bar{\tau}^n = 0.235$ and $\bar{\tau}^k = 0.514$ as in Jonsson and Klein (2006). Further, I set \bar{g} and \bar{b} such that $\bar{g}/\bar{y} = 0.162$ and $\bar{b}/\bar{y} = 0.509$ as in the data. Moreover, I fix \bar{k} and \bar{k}^g such that $\bar{k}/\bar{y} = 2.6$ and $\bar{k}^g/\bar{y} = 0.6$ correspond to the data as reported by Lansing (1998).

Comparable to Klein, Krusell, and Rios-Rull (2004) I specify preferences of the household as follows:

$$u(c_t, n_t, g_t) = \frac{(c_t^\alpha (1 - n_t)^{1-\alpha} g_t^{\alpha\chi})^{1-\sigma} - 1}{1 - \sigma}. \quad (5)$$

I set $\alpha = 0.323$ to match $\bar{n} = 0.25$ which corresponds to the estimate of McGrattan and Rogerson (2004). Moreover, I set $\sigma = 1$ which implies a unit intertemporal elasticity of substitution with respect to private consumption which is in line with e.g. Domeij and Klein (2005).

The parameter χ pins down the marginal rate of substitution between private and government consumption. Formally, $MRS_{\bar{g}, \bar{c}}^{model} = \frac{u_{\bar{g}}}{u_{\bar{c}}} = \chi \frac{\bar{c}}{\bar{g}}$. I set $\chi = 0.2443$ to obtain a marginal rate of substitution that is equal to 1. This choice is within the estimated

two standard deviations range of the implied $MRS_{g,c}^{data} \in [0.86, 1.73]$ in Amano and Wirjanto (1998).¹

I set the depreciation rates $\delta = 0.0542$ and $\delta_g = 0.0567$ in order to match private and public investment to GDP ratios in the data i.e. $\bar{x}/\bar{y} = 0.141$ and $\bar{x}^g/\bar{y} = 0.034$.

Moreover, I fix $\theta_k = 0.36$ and $\theta_n = 0.64$ which is in line with e.g. Gomme and Rupert (2005) and Domeij and Klein (2005). Finally, I set $\theta_g = \bar{x}^g/\bar{y} = 0.034$ as in Baxter and King (1993).² Tables 1 and 2 summarize my calibration and parameterization.

3 Optimal Pre-Announced Tax Reforms

In this section, I set up and analyze the optimal baseline as well as the “no confiscation/subsidy” pre-announced capital and labor income tax reforms. For both reforms, I also consider the cases when the government has no access to choose government debt optimally.

3.1 Modeling Pre-Announcement

Similar to Domeij and Klein (2005), I assume that the Ramsey planner is benevolent and has access to a commitment technology. The Ramsey planner credibly announces in period $t = 0$ that from period T onwards there will be an optimal capital and labor income tax reform. For the periods from $t = 0, \dots, T - 1$ the government keeps the capital and labor income tax at the competitive equilibrium steady states. I

¹From Amano and Wirjanto (1998) I can back out the implied marginal rate of substitution which is given by $MRS_{g,c}^{data} = \exp(\mu) \left(\frac{\bar{c}}{\bar{g}}\right)^\alpha$. The estimated two standard deviations ranges for the parameters are $\alpha \in [0.494, 0.778]$ and $\exp(\mu) \in [0.431, 0.571]$. From the data I obtain $\frac{\bar{c}}{\bar{g}} = 4.06$. These estimates result in the range for the $MRS_{g,c}^{data}$ given in the text.

²Note that this implies, as in Baxter and King (1993), that I have constant returns to scale for private capital and hours worked while I have increasing returns to scale for private capital, hours worked and public capital. I have also examined the consequences of imposing constant returns to scale for all three factors. However, my conclusions later on with respect to the welfare implications appear to be robust to this modification.

can translate this into the following pre-announcement constraints for the Ramsey planner,³

$$\tau_t^k = \bar{\tau}^k \quad \text{and} \quad \tau_t^n = \bar{\tau}^n \quad \forall t = 0, \dots, T-1.$$

In order to obtain a non-trivial Ramsey problem in case of an immediate reform ($T = 0$), I follow Domeij and Klein (2005) and fix the initial capital tax to its competitive equilibrium steady state, i.e. $\tau_0^k = \bar{\tau}^k$ for $T = 0$.⁴

3.2 Baseline Ramsey Reform

It is convenient for the formulation of the baseline Ramsey problem that the government budget constraint can be rewritten as follows,⁵

$$\sum_{t=0}^{\infty} \beta^t \frac{U_c(t)}{1 + \tau_t^c} [Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g] = \frac{U_c(0)}{1 + \tau_0^c} b_{-1} \quad (6)$$

where tax revenues are given by

$$Rev_t = \tau_t^c c_t + \tau_t^n f_{n,t} n_t + \tau_t^k (f_{k,t} - \delta) k_{t-1}. \quad (7)$$

As Domeij and Klein (2005), I assume that the Ramsey planner takes government transfers $\{s_t\}_{t=0}^{\infty}$ as a given stream of expenditures. In terms of taxes, I assume that the Ramsey planner in my model chooses optimal labor and capital income taxes $\{\tau_t^n, \tau_t^k\}_{t=0}^{\infty}$ as in Domeij and Klein (2005) but takes consumption taxes $\{\tau_t^c\}_{t=0}^{\infty}$ as

³In line with Domeij and Klein (2005) I assume that only capital and labor income taxes are fixed throughout the pre-announcement horizon. All other endogenous variables which the Ramsey planner chooses in the next subsection are free to adjust already in the pre-announcement period.

⁴If the government would be free to choose τ_0^k in case of an immediate reform ($T = 0$) it would confiscate initial capital k_{-1} through an initial capital tax levy that is high enough to finance all future government expenditures while simultaneously achieving zero future capital and labor income taxes. Ljungqvist and Sargent (2004) note on a standard immediate tax reform "To make the Ramsey problem interesting, I always impose a restriction on τ_0^k ". In the literature there exist at least two approaches. Either fix τ_0^k to a small or historical value as in Sargent and Ljungqvist or Domeij and Klein (2005) or impose an upper bound for τ_0^k as in Chamley (1986) or Jones, Manuelli, and Rossi (1993). I examine the latter case in one of the subsequent sections.

⁵I obtain this by repeated substitution of government bonds in consecutive government budget constraints. Further, I impose the transversality condition $\lim_{t \rightarrow \infty} \prod_{i=0}^t q_i b_t = 0$ and make use of the equilibrium relationship $\beta^t \frac{U_c(t)}{U_c(0)} \frac{1 + \tau_0^c}{1 + \tau_t^c} = \prod_{i=0}^{t-1} q_i$ which can be derived from the Euler equation for bonds.

given.⁶ Similar to Ljungqvist and Sargent (2004), I am now ready to define the Ramsey problem.

Definition: Given the pre-announcement horizon T , initial capital and government debt k_{-1}, b_{-1} as well as consumption taxes and transfers $\{\tau_t^c, s_t\}_{t=0}^\infty$, the Ramsey problem is to choose a competitive equilibrium that maximizes $\sum_{t=0}^\infty \beta^t u(c_t, n_t, g_t)$.

In other words, the Ramsey planner maximizes household utility subject to the competitive equilibrium conditions and pre-announcement constraints.⁷ Formally,

$$\begin{aligned}
& \max \sum_{t=0}^{\infty} \beta^t \left[u(c_t, n_t, g_t) + \phi \frac{U_c(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) \right. \\
& - \mu_t (U_n(t)(1 + \tau_t^c) + U_c(t)(1 - \tau_t^n)f_{n,t}) \\
& - \gamma_t (c_t + g_t + k_t + k_t^g - f_t(k_{t-1}, n_t, k_{t-1}^g) - (1 - \delta)k_{t-1} - (1 - \delta_g)k_{t-1}^g) \\
& - \omega_t (Rev_t - \tau_t^c c_t - \tau_t^n f_{n,t} n_t - \tau_t^k (f_{k,t} - \delta)k_{t-1}) \\
& \left. - \eta_t \left(\beta \frac{U_c(t+1)}{1 + \tau_{t+1}^c} \left((1 - \tau_{t+1}^k)(f_{k,t+1} - \delta) + 1 \right) - \frac{U_c(t)}{1 + \tau_t^c} \right) \right] - \phi \frac{U_c(0)}{1 + \tau_0^c} b_{-1} \\
& - \sum_{t=0}^{T-1} \beta^t \nu_t (\tau_t^k - \bar{\tau}^k) - \sum_{t=0}^{T-1} \beta^t \kappa_t (\tau_t^n - \bar{\tau}^n).
\end{aligned}$$

⁶As pointed out earlier, I have introduced consumption taxes since they are an important part of government tax revenue in US data (see e.g. Trabandt and Uhlig (2006)) and thus helps me to realistically calibrate the model. However, choosing capital, labor and consumption taxes simultaneously would imply non-unique solutions since labor and consumption taxes affect the labor supply decision of the household in the same way. That is, a high labor tax and a low consumption tax are equivalent to a low labor tax and high consumption tax. Hence, I leave the consumption tax at its competitive equilibrium steady state value and solve for the optimal labor and capital income taxes as in Domeij and Klein (2005).

⁷An alternative way to set up the Ramsey problem would be to apply the so-called primal approach, i.e. using an implementability condition. However, for my particular Ramsey problem I find the subsequent approach which is also described by Ljungqvist and Sargent (2004) more suitable.

Given the pre-announcement horizon T , the Ramsey planner solves for the sequences $\{c_t, n_t, k_t, g_t, k_t^g, Rev_t, \tau_t^n\}_{t=0}^\infty, \{\tau_t^k \mid \tau_0^k = \bar{\tau}^k\}_{t=1}^\infty$ if $T = 0$ and $\{c_t, n_t, k_t, g_t, k_t^g, Rev_t, \tau_t^n\}_{t=0}^\infty, \{\tau_t^k\}_{t=0}^\infty$ if $T \geq 1$. I assume that the Ramsey planner takes k_{-1}, b_{-1}, τ_t^c and s_t at their competitive equilibrium steady states as given.

Finally, note that the multiplier η_t on the Euler equation constraint becomes a state variable. As discussed in Marcat and Marimon (1998), optimal policy decisions in period t then depend on η_{t-1} with $\eta_{-1} = 0$.

Appendix A.1 summarizes the first order optimality conditions for the Ramsey problem. I follow Domeij and Klein (2005) regarding the solution technique. Appendix A.2 explains in detail how I solve the model.

3.2.1 Baseline Results

Table 3 provides a comparison of the data, the competitive equilibrium steady state as well as the Ramsey steady states. Consider the column “Baseline” for the moment. The Ramsey planner chooses a zero capital income tax in steady state which is in line with the classical optimal taxation literature. Further, the Ramsey planner chooses a higher private capital to output ratio but a lower public capital to output ratio. It turns out that the public capital stock is lower in the Ramsey compared to the competitive equilibrium steady state.⁸ Note that the private and public capital to output ratios are independent of the pre-announcement horizon. This is because the Ramsey planner always chooses a zero steady state capital income tax. Hence, the real return on capital is not distorted in the steady state Ramsey equilibrium at any pre-announcement horizon and thereby the optimal capital to output ratio is unaffected by the pre-announcement horizon.

⁸This is due to the public capital share $\theta_g = 0.034$. If I assume, e.g. $\theta_g = 0.05$, the Ramsey planner chooses a higher public capital stock than in the competitive equilibrium steady state. I examine the implications of this in the sensitivity analysis.

By contrast, the Ramsey steady state labor income tax rate is higher than in the competitive equilibrium steady state. Furthermore, it increases with the pre-announcement horizon. Front-loading of government debt decreases with pre-announcement and lower receipts must be financed by higher labor income taxes. Finally, private and government consumption increase in the Ramsey steady state but output increases by more so that the private and government consumption to output ratios decrease relative to the competitive equilibrium steady state.

Figure 1 shows the transition of the key variables in response to the baseline optimal tax reform. In line with Domeij and Klein (2005) I observe that the initially chosen capital income tax, the consumption boom and the front-loading of government debt reduces with the pre-announcement horizon. However, the Ramsey planner also chooses government consumption and public capital in my model. The figure reveals that government consumption is reduced initially before it smoothly converges towards a higher level than in the competitive equilibrium steady state. Interestingly, the transition path of government consumption is smooth throughout all pre-announcement horizons and thus, the government contributes to smooth out household utility.

On the other hand, the government chooses to reduce the public capital stock initially before it converges upwards towards a lower steady state than in the competitive equilibrium steady state. Hence, the existing competitive equilibrium steady state public capital stock is inefficiently high and its reduction enhances efficiency since distortionary labor taxes do not need to increase as much as with maintaining a high public capital stock. The initial fall of public capital serves the following purpose. The government uses these resources to reduce the amount of outstanding debt and thereby the interest payments. Note that this occurs almost irrespective of the chosen pre-announcement period. Since the household accumulates less government debt it uses free resources to invest in the private capital stock which partly makes up for the lower public capital stock.

Figure 4 shows the welfare effects of the optimal pre-announced tax reform for different pre-announcement horizons. I measure welfare in permanent private consumption equivalents. See appendix A.3 for the details of these calculations. According to the solid blue line in the upper panel of the figure the welfare gain of an immediate optimal tax reform corresponds to a permanent increase of private consumption of 6.6 percent. By contrast, the welfare gain is 5 percent if the reform was pre-announced 4 years in advance. Hence, pre-announcement leads to relative welfare gain reductions of 24 percent in this baseline reform.

By contrast, as shown in figure 5, for a baseline optimal tax reform with fixed and non-valued government consumption and without public capital the welfare gains amount to 5.3 percent (immediate) and 3.4 percent (4 years pre-announced). This implies a relative reduction of welfare gains by roughly 36 percent similar to Domeij and Klein (2005). Hence, for my baseline reform, valuable and productive government spending - as employed in our model - leads to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare gain reductions.

The higher absolute welfare gain in my baseline reform is due to the efficiently chosen levels of government consumption and public capital which lead to less distortions and hence higher welfare. The lower relative reduction of welfare gains can be explained by two facts. First, the higher absolute level of welfare gains reduces the relative costs of pre-announcement. Second, the government chooses smooth paths for government consumption and public capital irrespective of the pre-announcement horizon and hence smoothes out the welfare effects. Thus, for my baseline reform valuable and productive government spending leads to higher absolute welfare gains and makes pre-announcement less costly in relative terms.

Hence, my results show that the welfare costs of pre-announcing an optimal tax reform are likely to be smaller than previously thought. Interestingly, the reduction of welfare costs due to a more realistic description of the spending side of fiscal policy are not dramatic. Nevertheless, they are economically significant and there-

fore, the effects of valuable and productive government spending should be taken into account when benefits and costs of an optimal pre-announced tax reform are considered.

3.2.2 Sensitivity

My results depend of course on the valuation of government consumption by households χ as well as on the public capital share in private production θ_g . For illustrative purposes, we experiment with the following alternative values: $\theta_g \in \{0.005; 0.1\}$ and $\chi \in \{0.15; 0.35\}$. I choose these particular values since each combination of these values represents the cases that either government consumption or public capital converges to a higher and/or lower Ramsey steady state compared to the competitive equilibrium steady state. Figure 5 shows that if either the valuation of government consumption or the public capital share are low then pre-announcement is even less costly than in my baseline optimal reform. Interestingly, if both the valuation of government consumption and the public capital share are set to higher values then pre-announcement can be almost as costly as in an economy without these ingredients.

In order to investigate this issue more thoroughly and to ensure further robustness of my results, I proceed as follows. I construct many random parameter combinations (θ_g, χ) by drawing both parameters from the following uniform distributions: $\theta_g \sim U[0.00001, 0.2]$ and $\chi \sim U[0.00001, 0.6]$.⁹ I draw 329 parameter sets and solve the baseline model for the following pre-announcement horizons $T \in \{0, 2, 4\}$.¹⁰ The case of $\theta_g = 0.00001$ resembles a non-productive government capital stock which is similar to the standard Cobb-Douglas production function as in e.g. Cooley and Prescott (1995). By contrast, $\theta_g = 0.2$ corresponds to a comparably high

⁹I have chosen lower bounds of 0.00001 since the solution algorithm has difficulties to find solutions if the lower bound is strictly zero.

¹⁰It takes roughly one hour to solve the model for a given parameter combination and a given pre-announcement horizon. Hence, total time for this analysis is 329 hours times 3 pre-announcement horizons which amounts to roughly 5.5 weeks of total computation time. Thus, generating additional draws respectively incorporating further pre-announcement horizons is extremely computationally burdensome.

public capital share relative to my baseline specification. However, this value is still only half as large as the estimate in Aschauer (1989). To that end, we keep the upper bound $\theta_g = 0.2$ since my solution algorithm appears to be sensitive to higher values of θ_g .¹¹ Nevertheless, we consider the uniformly distributed interval $[0.00001, 0.2]$ for θ_g as still reasonably large for a useful sensitivity analysis. The uniformly distributed interval for χ implies marginal rates of substitutions between private and government consumption in the competitive equilibrium steady state of $MRS_{g,c}^{Model} \in (0.00004, 2.45)$ which captures considerably more than the two standard deviations range $MRS_{g,c}^{data} \in (0.86, 1.73)$ of the empirical estimate reported in Amano and Wirjanto (1998).

The upper left panel of figure 6 shows the random parameter combinations for θ_g and χ . The upper right panel shows the resulting welfare gains for each random parameter combination. In addition, I add the results of our baseline parameterization (bold black solid line) as well as the results of the model with non-valued and fixed government consumption and no productive public capital (bold black dashed line) similar to Domeij and Klein (2005). In order to facilitate comparison with respect to the welfare losses of pre-announcement, we normalize all welfare gains such that they equal 100 for $T = 0$. The figure shows that it is possible that 4 years pre-announcement is almost costless in terms of relative welfare gain reductions. On the other hand, it is also possible that 4 years pre-announcement is as costly as in the model that features non-valued and fixed government consumption and no productive public capital, i.e. 36 percent relative welfare gain reduction. However, the overwhelming majority of cases is located somewhere in between these two extremes. In particular, the mean of the relative welfare gain reduction for 4 years pre-announcement is 20 percent. Moreover, our baseline parameterization generates a relative welfare gain reduction of 4 years pre-announcement of 24 percent which is located well within if not slightly on the upper end of possible relative welfare gain reductions.

¹¹In particular, values $\theta_g \gg 0.2$ imply that the Ramsey steady state of public capital is very far away from its competitive equilibrium steady state level. In these cases, the solution algorithm appears to have difficulties to calculate stable transition paths to the Ramsey steady state.

The question that arises is which parameter combinations are responsible for these results? The lower two panels of figure 6 examine the relative welfare gain reductions that are due from moving from $T = 0$ (immediate reform) to $T = 4$ (4 years pre-announced reform) for all random parameter combinations and from different angles. It appears that my baseline parameter combination ($\theta_g = 0.034, \chi = 0.2443$) generates a relative welfare gain reduction of roughly 24 percent whereas the parameter combination ($\theta_g = 0.071, \chi = 0.325$) generates the maximum reduction of 36 percent. For the latter, both, government consumption and public capital converge to Ramsey steady states that are higher than their competitive equilibrium counterparts. For this parameter combination, it turns out that the additional transitional costs are as large as the additional steady state gains that arise from valuable and productive government spending. In other words, the relative welfare gains are as large as for the non-valued and constant government consumption and no public capital model similar to Domeij and Klein (2005). For the overwhelming majority of alternative parameter combinations, that is higher or lower values of θ_g and χ , the transitional costs are lower than the steady state gains which results in higher relative welfare gains throughout all pre-announcement horizons.

To sum up, using empirically reasonable parameter intervals, it turns out that for the overwhelming majority of cases pre-announcement is less costly than in an economy without valuable and productive government spending. From this, I conclude that public goods and public capital are likely to reduce the welfare losses that are associated with pre-announcement.

3.3 Baseline Ramsey Reform With Upper Bound On Capital Taxes

The baseline optimal tax reform is characterized by initial capital income taxes much higher than 100 percent. That is, capital income is confiscated entirely and moreover, the household pays to rent out capital to the firms. By contrast, Chamley (1986) and

Jones, Manuelli, and Rossi (1993) analyze optimal immediate tax reforms with an upper bound on capital taxes - say 100 percent. As a further extension to Domeij and Klein (2005), I analyze the effects of imposing an upper bound of 100 percent on capital taxes in my baseline optimal pre-announced tax reform. In this case, the Ramsey planner faces the following additional constraint for the Ramsey problem in section 3.2:

$$\tau_t^k \leq 1 \quad \forall t = 0, \dots, \infty. \quad (8)$$

3.3.1 Baseline Results With Upper Bound On Capital Taxes

The column “Baseline (τ^k bound)” in table 3 shows the steady state characteristics of this reform. The upper bound on capital taxes prevents the government from accumulating an asset position as large as before. The loss in revenues is made up for by higher labor income taxes. Figure 2 shows the transition of variables for this reform. In case of immediate implementation ($T=0$) capital taxes hit the upper bound for 5 periods before turning to zero fairly quickly afterwards. The relatively prolonged period of 100 percent capital income taxes leads to a long lasting consumption boom as opposed to the short lived consumption boom in the baseline reform. It turns out that the longer the reform is pre-announced the smaller is the amount of periods in which the capital tax hits the upper bound. The case of $T=6$ is the first time when the first freely chosen capital tax is below 100 percent.

The upper panel of figure 4 shows the welfare gains of this reform. Again, an immediate reform generates the highest welfare gains which are now 5.9 percent. However, the welfare gains are lower by roughly 0.7 percent compared to the baseline optimal tax reform without upper bounds. In case the reform is pre-announced 4 years in advance welfare gains fall to 5 percent. Hence, relative welfare gains decline by roughly 15 percent. However, one has to be careful by comparing this figure to Domeij and Klein (2005) since they did not consider the case of an upper bound for capital taxes. If anything, in my case it leads to a further reduction of the welfare losses due to pre-announcement. Finally, note that as the pre-announcement horizon

becomes sufficiently large, welfare gains coincide with the baseline optimal reform since the upper bound constraint is not binding anymore.

3.4 “No confiscation/subsidy” Tax Reform

In this section, I focus on the question whether short-run properties of the optimal pre-announced tax system are important for the resulting overall welfare gains. More precisely, as we have seen in the previous sections, the baseline optimal tax reform displays short-run confiscation and/or subsidy of capital and labor income followed by a rather quick transition to the long-run values of taxes. How important is this short-run deviation from the long-run taxes for the welfare consequences of the reform? Put differently, how much of the welfare gains are attributable to the initial confiscation and/or subsidy of capital and labor income and how much of the welfare gains are due to the long-run constant tax rates? In order to answer this question, I design a tax reform in which capital and labor income taxes move - without confiscation and subsidy - directly to their endogenous long-run values from the implementation date of the reform onwards. I call this reform “no confiscation/subsidy” tax reform.¹²

This type of reform shares one dimension of one of the experiments in Chari, Christiano, and Kehoe (1994), Domeij and Klein (2005) and Dominguez (2006a). These authors analyze the case when the government imposes a constant zero capital income tax over time in case of an immediate reform. They show that welfare declines compared to the case when the government confiscates capital through a high initial capital income tax. In particular, Chari, Christiano, and Kehoe (1994) report that 80 percent while Domeij and Klein (2005) report that 45 percent of the welfare gains are due to the initial confiscation of capital income. However, these papers consider the

¹²Note that for short pre-announcement horizons confiscation of capital income occurs. As in Domeij and Klein (2005), for very long pre-announcement horizons the initial capital income tax is negative and hence a subsidy occurs. Finally, for immediate reforms, labor income taxes are initially negative which is also a subsidy. The label “no confiscation/subsidy” is chosen since the reform avoids all these confiscation and subsidy pattern.

confiscation effects of this policy for an immediate reform only.¹³ Hence, my analysis extends the existing literature in two dimensions. First, I analyze the importance of confiscation and subsidy for the welfare properties of a pre-announced tax reform. In addition, I consider the case that the government moves capital *and* labor taxes to their endogenous long-run values at the implementation date of the tax reform.

The policy that capital and labor taxes move directly to their endogenous long-run values in this alternative reform can be translated into the following additional constraints for the Ramsey planners problem in section 3.2,

$$\tau_t^k = \bar{\tau}_{n-cs}^k \quad \text{and} \quad \tau_t^n = \bar{\tau}_{n-cs}^n \quad \forall t = T, \dots, \infty \quad (9)$$

where $\bar{\tau}_{n-cs}^k$ and $\bar{\tau}_{n-cs}^n$ denote the endogenously determined long-run steady state values of capital and labor income taxes that correspond to the “no confiscation/subsidy” reform.¹⁴

3.4.1 Results “No confiscation/subsidy” Tax Reform

The column “no confiscation/subsidy” in table 3 shows the steady states of the pre-announced tax reform with impact tax transitions. As for the baseline reform, the optimal steady state capital income tax is zero and hence, I obtain the same private and government capital to output ratios. Since the government cannot confiscate capital through a high initial capital tax I observe less front-loading with respect to government debt. In particular, for $T = 0$ the government can only attain a roughly zero debt to output ratio and in order to cover expenditures a higher steady state labor income tax is needed. By contrast, for $T = 4$ the government accumulates sur-

¹³Dominguez (2006a) assumes a one period implementation lag. However, she does not discuss welfare implications in the presence of the zero capital income tax policy.

¹⁴These additional constraints for the Ramsey planner can be motivated alternatively by imposing time-invariant taxes. E.g. for capital taxes I impose that $\tau_t^k = \tau_{t+1}^k = \tau_{t+2}^k = \tau_{t+3}^k = \dots = \tau_\infty^k$. However, at $t = \infty$ we are at the “no confiscation/subsidy” steady state and hence $\tau_\infty^k = \bar{\tau}_{n-cs}^k$. Thus, I can write $\tau_t^k = \tau_{t+1}^k = \tau_{t+2}^k = \tau_{t+3}^k = \dots = \bar{\tau}_{n-cs}^k$ or alternatively $\tau_t^k = \bar{\tau}_{n-cs}^k \quad \forall t = 0, \dots, \infty$. Finally, in the presence of T pre-announcement periods I obtain the above constraint $\tau_t^k = \bar{\tau}_{n-cs}^k \quad \forall t = T, \dots, \infty$. The case of labor taxes follows accordingly.

pluses and reaches a negative debt position that generates interest revenues. Hence, the steady state labor income tax is lower than for $T = 0$. Note that this is exactly the opposite effect compared to the baseline optimal reform. Now, pre-announcement leads to less distortions in steady state for this type of tax reform. The private and government consumption to output ratios change only very little. Finally, labor supply and output in steady state increase with pre-announcement as opposed to the baseline optimal reform.

Figure 3 shows the transition of variables for the “no confiscation/subsidy” tax reform. Interestingly, the government prefers again a smooth pattern of government consumption and public capital even for different pre - announcement horizons. By contrast again, the transition of government debt depends much more on the pre-announcement length. The government accumulates only a net asset position if the pre-announcement horizon is sufficiently large. There is no initial consumption boom since there is no longer any initial confiscation of capital. An immediate reform moves the capital income tax to zero in the initial period which induces a large increase in the real return on capital. In order to expand the private capital stock the individual reduces consumption by a relatively large amount. By contrast, if the reform is pre-announced consumption declines by less since in anticipation of the reform, the capital stock increases smoothly over time in the pre-announcement periods.

Figure 4 depicts the welfare effects of pre-announcement for the “no confiscation/subsidy” tax reform. The solid red line with squares shows that the welfare gains from pre-announcement increase with the pre-announcement horizon. The upper panel shows that an immediate reform implies 3.5 percent higher permanent private consumption whereas a 4 years pre-announced reform delivers

4.7 percent higher permanent private consumption.¹⁵ Hence, relative welfare gains increase by roughly 35 percent.

This is due to the following reason. In case of an immediate reform, the government is not able to initially choose very high capital taxes and negative labor taxes. The absence of the capital confiscation implies that the government cannot accumulate a net-asset position in steady state and hence a higher steady state labor income tax is needed to generate enough tax revenues to balance the government budget. Hence, higher distortions imply low welfare gains. Consider the case of pre-announcement. Now, the government can accumulate a net-asset position because tax revenues rise in the pre-announcement period due to higher labor supply and capital accumulation. A steady state net-asset position implies lower steady state labor income taxes and therefore lower distortions. This in turn results in larger welfare gains for the pre-announced tax reform.¹⁶

Moreover, notice that there are rather large differences between the level of welfare gains of the optimal baseline and the “no confiscation/subsidy” tax reform in case of an immediate implementation. These differences become very small if the reforms are pre-announced 4 years in advance. However, and more importantly, although the level of welfare gains appear to be rather similar in both reforms the structure of taxes is rather different. For 4 years pre-announcement, the first freely chosen capital tax in the baseline optimal tax reform is still 178 percent. By contrast, the “no confiscation/subsidy” reform moves straight to zero percent capital taxes. The resulting loss of revenues in the “no confiscation/subsidy” reform is made up for by

¹⁵Note that my results for the immediate reform are in line with the existing literature. As pointed my earlier, Chari, Christiano, and Kehoe (1994) find that 80 percent of the welfare gains of an immediate optimal reform are due to confiscation of capital income. Domeij and Klein (2005) report that 45 percent of the welfare gains are due to high initial capital taxes. I find that removing confiscation and subsidy of capital and labor taxes reduces the welfare gains from 6.6 percent to 3.5 percent and hence by 53 percent in an immediate reform. However, the literature does only examine these effects for immediate reforms while I take a further step ahead by analyzing how pre-announcement affects these results.

¹⁶Technically, pre-announcement reduces the immediate tax transition constraints and hence the government has more degrees of freedom. However, for very long pre-announcement periods, the gains from pre-announcement may be out-weighted by the delay effect since households discount the future.

moderately higher steady state labor taxes of 30 percent compared to 28 percent in the baseline optimal tax reform.

To sum up, I have analyzed a tax reform in which the government moves taxes - without confiscation and subsidy - directly to their endogenous long-run values. For this reform, I observe that the welfare gains - though the absolute level is lower compared to the baseline optimal reform - increase with the pre-announcement horizon. Further, I show that the level of welfare gains is very similar to those of an optimal 4 years pre-announced reform. Hence, my analysis indicates that confiscation and subsidy of capital and labor income are not important for the level of welfare gains that arise from an optimal tax reform which is sufficiently pre-announced in advance of its implementation.

3.5 Pre-Announced Tax Reforms With Fixed Debt

In the previous sections, we have seen that the transition path of public capital and government consumption is smooth despite different pre-announcement periods. By contrast, the pattern of government debt changed a lot with the pre-announcement horizon. Moreover, in many of the cases that I have considered the government accumulates a net asset position. Although this is a standard result in the optimal taxation literature with immediate implementation it is not a typical observation in the data. A natural question to ask is therefore: what happens to the results if we assume that the government has no access to government debt? That is, the government leaves the existing stock of government debt untouched at its competitive equilibrium steady state. In order to capture this variation formally, I impose

$$b_t = \bar{b} \quad \forall t = 0, \dots, \infty. \quad (10)$$

Technically, the intertemporal government budget constraint in section 3.2 is replaced by its period-by-period version. In addition, I impose the constant debt requirement

as well as the no-arbitrage condition which results in the following period-by-period government budget constraint for the Ramsey planner,

$$g_t + s_t + k_t^g = \tau_t^c c_t + \tau_t^n w_t n_t + \tau_t^k \left(\theta_k \frac{y_t}{k_{t-1}} - \delta \right) k_{t-1} + (1 - \delta_g) k_{t-1}^g + \left((1 + (1 - \tau_{t+1}^k) \left(\theta_k \frac{y_{t+1}}{k_t} - \delta \right))^{-1} - 1 \right) \bar{b}. \quad (11)$$

I study the effects of the fixed debt assumption for the baseline as well as for the “no confiscation/subsidy” tax reform.

3.5.1 Results Fixed Debt Reforms

Consider the column “Baseline/No conf-subsidy (Fixed Debt)” in table 3 now. Both reforms result in the same steady state since debt is not available as a policy instrument for the government. For the same reason, the steady states of the variables do not depend on the pre-announcement horizon anymore. Again, the optimal steady state capital income tax is zero which delivers the same private and public capital to output ratios as before. The absence of government debt as an instrument for the government implies that labor taxes are higher compared to the previous reforms. The debt to output ratio falls because output rises. Note however, that the increase of output is the lowest for all reforms.

Figures 7 and 8 show the transition of variables in response to the tax reforms.¹⁷ And indeed, if government debt is fixed, the transition pathes of public capital and government consumption are not as smooth as before and depend much more on the pre-announcement horizon. Under fixed debt, the Ramsey planner allocates the revenues from immediate or pre-announced taxation between government consumption

¹⁷I do not report results when an upper bound on capital taxes is imposed. The upper bound only binds for $T = 0$ and then only for two periods. The changes in allocations are only minimal. Further, the changes in welfare gains are almost indistinguishable for $T = 0$ and identical to the baseline reform with fixed debt for $T \geq 1$. These results make sense since the $\tau_0^k = \bar{\tau}^k$ constraint for $T = 0$ is replaced by the constraint $\tau_0^k \leq 1$ which is active for two periods only. Hence, the allocations and welfare gains are rather similar to the baseline reform with fixed debt and due to this I do not report them here.

and public capital which in turn affects the transition of e.g. private consumption, hours and private capital.

Figure 9 shows the welfare effects for the baseline (dashed-dotted) as well as “no confiscation/subsidy” (dashed-dotted/squares) tax reform under the fixed government debt requirement. Two things are noticeable. First, both curves are below the ones that allow for variable debt. If the government has no access to government debt this reduces the set of its instruments and hence the benefits of an optimal reform will be lower. Second, the “no confiscation/subsidy” tax reform with fixed debt also generates increases of welfare gains in the presence of pre-announcement. However, longer pre-announcement horizons are needed to obtain almost the same welfare gains as in the baseline reform with fixed debt. Nevertheless, my result that pre-announcement increases welfare gains in case of the “no confiscation/subsidy” tax reform prevails qualitatively even if the government has no access to government debt.

4 Discussion of Related Literature

Optimal taxation in a standard neoclassical growth model using a normative approach proposed by Ramsey (1927) is studied by many authors, see e.g. Chamley (1986), Judd (1985a), Lucas (1990), Chari, Christiano, and Kehoe (1994), Atkeson, Chari, and Kehoe (1999), Chari and Kehoe (1999) and Erosa and Gervais (2001). Typical results of this literature are the optimal zero steady state capital income tax as well as sizable welfare gains from the tax reform. However, common to this literature is that it analyzes optimal taxation with immediate implementation only and therefore abstracts from pre-announcement effects.

By contrast, Domeij and Klein (2005) investigate an optimal pre-announced labor and capital income tax reform in a standard neoclassical growth model. The authors show that the welfare gains of an optimal capital and labor tax reform de-

cline the longer the reform is pre-announced before its implementation. Hence, pre-announcement is costly in terms of welfare. Domeij and Klein (2005) argue that the incentive effects of the future anticipated tax reform are dominated by the time delay effect and therefore fiscal policy should not pre-announce this type of tax reform. In line with the classical optimal taxation literature, Domeij and Klein (2005) use a neoclassical growth model in which the fiscal authority collects distortionary taxes. However, Domeij and Klein (2005) assume that government consumption is constant and not valued by households and there does not exist a variable and productive government capital stock. By contrast, I examine the importance of valuable and productive government spending for the resulting welfare gains of pre-announced tax reforms.

Aiyagari (1995) examines optimal capital income taxation in an economy with incomplete insurance markets and borrowing constraints. He shows that in such an environment the optimal capital income tax rate is positive in the short- and long-run. Due to uninsurable, idiosyncratic risk, individuals accumulate too much capital because of precautionary savings motives. A positive capital income tax reduces the capital stock to its optimal level. By contrast, the present paper assumes homogeneous agents that face no borrowing constraints as in Domeij and Klein (2005) and therefore, the optimal long-run capital income tax will be zero in my model.

Lansing (1998) studies optimal fiscal policy in a business cycle model that features utility providing public consumption and public capital. He employs a stochastic model in order to analyze optimal fiscal policy responses to technology and preference shocks. Lansing (1998) analyzes approximated local dynamics but does not consider transitional dynamics of the underlying optimal tax reform. Cassou and Lansing (2006) study the effects of tax reforms with useful public expenditures in an endogenous growth model. In their model, public expenditures contribute to human capital formation as well provide utility. The authors compare the effects of optimal tax reforms with sub-optimal revenue-neutral tax reforms. However, both papers

assume that fiscal policies are implemented immediately and do not consider effects from pre-announcement.

Baxter and King (1993) were one of the first authors who analyzed the effects of fiscal policy in a neoclassical growth model with productive government capital and utility providing government consumption. McGrattan (1994) analyzes the macroeconomic effects of distortionary taxation in a neoclassical growth model in which household utility depends on government spending. Further, Christiano and Eichenbaum (1992) assume that government consumption affects household utility and show that this has important consequences for aggregate labor market fluctuations. However, these papers make no reference to pre-announcement.

Judd (1985b) shows in a representative agent model that anticipated future investment tax credits may depress current investment. Further, he shows that an immediate income tax cut that is financed by future cuts in government expenditures also depresses current investment. Judd (1987b,a) analyzes the welfare costs of unanticipated and anticipated tax changes. He finds that delay increases the excess burden of capital taxation while it reduces the excess burden for wage taxation. Further, an investment tax credit at a future point in time always dominates a capital income tax cut at that time. However, these papers do not analyze optimally chosen tax rates in the presence of delay. Further, Judd abstracts from valuable and productive government spending.

The present paper analyzes the short-run slopes of the US and EU-15 Laffer curves for immediate and pre-announced labor and capital tax cuts. It is shown that the short-run dynamics can be very different depending on the timing of tax cuts. House and Shapiro (2006) investigate the aggregate effects of the timing of tax rate changes in a case study for the 2001 and 2003 US tax law changes. They find that economic growth increased by 0.9 percent once the 2003 law eliminated the pre-announcement structure of the 2001 law. However, these two contributions do not derive optimal tax reforms nor they consider welfare issues. House and Shapiro

(2006), however, conjecture in footnote 1 that “Because it is often optimal to tax the initial capital stock heavily, the optimal tax rate on capital income should be phased-in”. In terms of welfare, Domeij and Klein (2005) as well as this paper show that the baseline optimal tax reform with immediate implementation (no phase-in) generates the highest gains. Hence, the optimal baseline tax reform should not be phased-in. However, my “no confiscation/subsidy” reform shows indeed that optimal tax rates should be implemented with pre-announcement (or should be phased-in) since for this type of reform welfare gains increase with pre-announcement.

Recently, Klein, Krusell, and Rios-Rull (2004) study the optimal choice of utility providing government expenditures when the government cannot commit to future policies. By contrast, the present paper assumes that the government can commit to future government expenditures. In addition, the paper by Klein, Krusell, and Rios-Rull (2004) considers immediately implemented reforms only.

Hassler, Krusell, Storesletten, and Zilibotti (2004) analyze the optimal timing of capital income taxes when capital depreciation is not constant. The authors find that under commitment the optimal time pattern of capital taxes is oscillating whereas optimal capital taxes are smooth without commitment. However, although the paper considers a one period implementation lag of optimal capital taxes, pre-announcement of more periods is not considered. In addition, the paper abstracts from utility providing government consumption as well as from productive government capital.

Dominguez (2006a) analyzes the time-inconsistency of optimal capital income taxes in an economy without full commitment. She studies optimal capital and labor income taxation in a neoclassical growth model with debt restructuring and an institutional delay of capital tax changes of one year. Referring to the terminology that is used in the present paper, the institutional delay can also be interpreted as a one year pre-announcement of a capital tax change. Dominguez (2006a) finds that debt restructuring together with the institutional delay enforces commitment of the government to the optimal tax reform. Put differently, without full commitment, debt

restructuring and institutional delay can improve welfare. The author concludes that the time-inconsistency problem of optimal capital taxes is not as severe as previously thought since decision making in democratic societies is characterized by institutional delays. However, my paper abstracts from debt restructuring policies and assumes that the Ramsey planner can commit to future policies.

Klein and Rios-Rull (2003) examine optimal fiscal policy when the government has no access to commitment. The authors study the properties of Markov perfect equilibria in an economy with a one period implementation lag for capital taxes but without government debt. Klein and Rios-Rull (2003) show that optimal time-consistent capital taxes are different from zero. Benhabib and Rustichini (1997) explore optimal capital taxes in an environment without commitment, without government debt and without implementation lags. They find that capital taxes are likely to be different from zero in the long-run. Phelan and Stacchetti (2001) analyze the set of sustainable equilibria in an economy without commitment and without government debt and report that optimal capital taxes may be different from zero in the steady state. Recently, Dominguez (2006b) has shown that these results are sensitive to whether the government has access to government debt. In particular, as soon as the government can issue debt and smooth taxes over time, it appears that optimal long-run capital taxes are zero.

Eichengreen (1990) analyzes confiscation of capital income in theory and practice. Using a highly stylized theoretical model, he argues that a capital levy which is subject to an institutional delay induces capital owners to move their assets abroad. Due to the capital flight the capital levy as such is likely to be abolished at the date of implementation. Eichengreen (1990) examines historical cross-country evidence with respect to capital levies and concludes that capital flight in conjunction with institutional delays are the reasons for unsuccessful capital levies in practice. By contrast, the present paper examines pre-announced capital levies in a closed economy. In line with Domeij and Klein (2005), we find that the size of the optimal initial capital levy decreases with the pre-announcement horizon. Capital cannot move abroad in

our model as it is the case in Eichengreen (1990). However, I observe nevertheless a similar effect. In my model, individuals decide to accumulate less capital if they expect a levy in the future which in turn induces the Ramsey planner to choose a lower levy. In addition, and more importantly, my “no confiscation/subsidy” reform shows that capital levies as such are not important for the resulting welfare gains of an optimal pre-announced reform.

My “no confiscation/subsidy” reform shares one dimension of one of the reform experiments in Chari, Christiano, and Kehoe (1994), Domeij and Klein (2005) and Dominguez (2006a). These authors analyze the case when the government imposes a constant zero capital income tax over time in case of an immediate reform.¹⁸ I depart from this work in two dimensions. First, we analyze the effects of pre-announcement for the resulting welfare gains of this type of tax reform. Second, I analyze the effects when the government moves capital and labor taxes to their endogenous long-run values at the implementation date of the reform.

This paper employs the normative approach proposed by Ramsey (1927) in order to determine optimal fiscal policy. The Ramsey planner is assumed to be able to choose linear distortionary taxes optimally but cannot choose lump-sum taxes. Moreover, most of the literature assumes that there is no heterogeneity across individuals. The Ramsey literature arrives at the result that savings decisions shall not be distorted in the long-run and hence capital income taxes are zero in the steady state. By contrast, Mirrlees (1971) proposed an alternative approach. He explores a model in which agents have private information about their stochastic individual skills. The Mirrlees approach aims at designing a tax system that provides insurance for skill risk on the one hand and incentives for more production of high skilled agents on the other hand. The resulting optimal tax schedule is non-linear in the sense that there are no distortions for high skilled agents but distortionary taxes for low skilled agents. Insurance is then provided via lump-sum redistribution.

¹⁸Dominguez (2006a) assumes a one period implementation lag. However, she does not discuss welfare implications in the presence of the zero capital income tax policy.

Recently, the New Dynamic Public Finance literature puts the Mirrlees approach into a dynamic context. Golosov, Tsyvinski, and Werning (2006) as well as Kocherlakota (2006) provide excellent and comprehensive surveys that summarize the growing body of work of that literature. Outstanding papers by Albanesi and Sleet (2006), Golosov, Kocherlakota, and Tsyvinsky (2003) as well as Golosov and Tsyvinski (2006) have shown that it is optimal to distort the savings decisions of individuals if skills change stochastically over time. Kocherlakota (2005) shows that in an environment with idiosyncratic and aggregate shocks the expected individual wealth tax rate is zero. More importantly, he shows that the government never collects net revenues from wealth taxes. In other words, the dynamic Mirrlees approach in Kocherlakota (2005) generates an optimal aggregate capital income tax rate that is zero in all periods. Interestingly, this result is similar to the long-run zero aggregate capital income tax result suggested by the Ramsey approach.

However, I am not aware of work that has been done in the New Dynamic Public Finance literature which examines the effects of pre-announcement respectively the effects of valuable and productive government spending. Examining these features within this literature would certainly be a useful next step on the research agenda. To that end, however, I rely on the Ramsey approach in since it is particularly useful for my question. First, the paper represents an extension to the work of Domeij and Klein (2005) who themselves apply the Ramsey approach in their analysis. Hence, in order to facilitate comparison, I also choose the Ramsey approach. Second, I aim to assess the importance of short-run confiscation and subsidy of capital and labor income in the presence of pre-announcement in the Ramsey approach.

In the present paper, the benevolent Ramsey planner undertakes an optimal pre-announced tax reform in which he also chooses optimal levels of valuable and productive government spending. Hence, the Ramsey planner determines the optimal size of the government in my economy given preferences and technology. By contrast, Krusell and Rios-Rull (1999) explore a model with heterogeneous agents in which majority voting determines policies. The political economy paradigm enables

the authors to analyze how different policy selection procedures and collective choice mechanisms affect taxes and the size of the government. As a result, their political economy model predicts e.g. a size of transfers that is consistent with US data. For further prominent contributions on political economy implications for economic policies, see e.g. Alesina and Rodik (1994), Persson and Tabellini (1994), Krusell and Rios-Rull (1996), Krusell, Quadrini, and Rios-Rull (1996, 1997), Hassler, Krusell, Storesletten, and Zilibotti (2005) and Hassler, Storesletten, and Zilibotti (2003, 2006). However, political economy considerations are beyond the scope of this paper. Instead, I regard my work as an extension to Domeij and Klein (2005) by examining the welfare effects of pre-announced tax reforms when the Ramsey planner chooses optimal levels of valuable and productive government spending that are consistent with preferences and technology. I believe, that reexamining my work from a political economy perspective might be an interesting next step. However, I leave this issue to future research.

To sum up, the contribution of the present paper to the literature is twofold. First, I reexamine Domeij and Klein (2005) by taking two additional features of government spending explicitly into account: public goods and public capital. In other words, I examine the welfare consequences of utility providing government consumption and productive government capital in a pre-announced optimal tax reform. Second, I analyze how important the short-run properties of the optimal tax system - in other words confiscation and/or subsidy of capital and labor income - are for the resulting overall welfare gains of the pre-announced tax reform.

5 Conclusion

This paper has analyzed the following question: should fiscal policy pre-announce tax reforms before their implementation from a welfare point of view? Domeij and Klein (2005) show that the welfare gains of an optimal capital and labor tax reform decline the longer the reform is pre-announced before its implementation. Hence,

pre-announcement is costly in terms of welfare. I have reexamined the claim of Domeij and Klein (2005) by taking two additional features of government spending explicitly into account: public goods and public capital.

In my baseline optimal tax reform I find that valuable and productive government spending leads to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare gain reductions due to pre-announcement. More precisely, a 4 years pre-announced reform reduces relative welfare gains compared to an immediate reform by roughly 24 percent in the presence of valuable and productive government spending. By contrast, the relative loss is roughly 36 percent in an economy without valuable and productive government spending. In addition, a sensitivity analysis based on empirically reasonable parameter estimates reveals that for the overwhelming majority of parameter combinations pre-announcement is less costly than in an economy without valuable and productive government spending. Hence, I conclude that public goods and public capital are likely to reduce the welfare losses that are associated with pre-announcement.

Thus, my results show that the welfare costs of pre-announcing an optimal tax reform are likely to be smaller than previously thought. Interestingly, the reduction of welfare costs due to a more realistic description of the spending side of fiscal policy are not dramatic. Nevertheless, they are economically significant and therefore, the effects of valuable and productive government spending should be taken into account when benefits and costs of an optimal pre-announced tax reform are considered.

The second contribution of this paper focuses on the question whether short-run properties of the optimal pre-announced tax system are important for the resulting overall welfare gains. The baseline optimal tax reform is characterized by initial confiscation and/or subsidy of capital and labor income via taxation followed by a rather quick transition to the long-run values of taxes. In order to evaluate the importance of this short-run confiscation and/or subsidy for the resulting welfare

gains, I design a tax reform in which capital and labor income taxes move - without confiscation and subsidy - directly to their endogenous long-run values from the implementation date of the reform onwards.

Interestingly, I show that welfare gains for this “no confiscation/subsidy” tax reform increase with the pre-announcement horizon as opposed to the decrease observed in the baseline optimal pre-announced reform. In particular, I find that relative welfare gains increase by roughly 35 percent if the tax reform is pre-announced 4 years in advance. Moreover, I show that the level of welfare gains is very different for the baseline optimal and the “no confiscation/subsidy” reform in case of immediate implementation. By contrast, the level of welfare gains becomes very similar for 4 years pre-announcement. Despite this, however, the underlying structure of taxes in both reforms appears still to be very different. For 4 years pre-announcement, the first freely chosen capital tax in the baseline optimal tax reform is still 178 percent. By contrast, the “no confiscation/subsidy” reform moves straight to zero percent capital taxes. The resulting loss of revenues in the “no confiscation/subsidy” reform is made up for by moving to moderately higher steady state labor taxes of 30 percent compared to 28 percent in the baseline optimal tax reform.

Therefore, my results indicate that confiscation and subsidy of capital and labor income are not important for the level of welfare gains that arise from an optimal tax reform which is sufficiently pre-announced in advance of its implementation. Finally, I show that my results prevail qualitatively even if the government has no access to government debt.

References

AIYAGARI, S. R. (1995): “Optimal Capital Income Taxation With Incomplete Markets, Borrowing Constraints, And Constant Discounting,” *Journal Of Political Economy*, 103(6), 1158–1175.

- ALBANESI, S., AND C. SLEET (2006): "Dynamic Optimal Taxation With Private Information," *Review Of Economic Studies*, 73(1), 1–30.
- ALESINA, A., AND D. RODIK (1994): "Distributive Politics And Economic Growth," *Quarterly Journal Of Economics*, 109(2), 465–490.
- AMANO, R. A., AND T. S. WIRJANTO (1998): "Government Expenditures And The Permanent Income Model," *Review Of Economic Dynamics*, 1, 719–730.
- ASCHAUER, D. A. (1989): "Is Public Expenditure Productive?," *Journal Of Monetary Economics*, 23, 177–200.
- ATKESON, A., V. V. CHARI, AND P. J. KEHOE (1999): "Taxing Capital Income: A Bad Idea," *Federal Reserve Bank Of Minneapolis Quarterly Review*, 23(3), 3–17.
- BAXTER, M., AND R. G. KING (1993): "Fiscal Policy In General Equilibrium," *American Economic Review*, 82(3), 315–334.
- BENHABIB, J., AND A. RUSTICHINI (1997): "Optimal Taxes Without Commitment," *Journal Of Economic Theory*, 77.
- CASSOU, S. P., AND K. J. LANSING (2006): "Tax Reform With Useful Public Expenditures," *Journal Of Public Economic Theory*, 8(4), 631–676.
- CHAMLEY, C. (1986): "Optimal Taxation Of Capital Income In General Equilibrium With Infinite Lives," *Econometrica*, 54(3), 607–622.
- CHARI, V. V., L. J. CHRISTIANO, AND P. J. KEHOE (1994): "Optimal Fiscal Policy In A Business Cycle Model," *Journal Of Political Economy*, 102(4), 617–652.
- CHARI, V. V., AND P. J. KEHOE (1999): "Optimal Fiscal And Monetary Policy," *J.B. Taylor And M.Woodford, Eds., Handbook Of Macroeconomics, Amsterdam: North-Holland*, 1, 1671–745.
- CHRISTIANO, L. J., AND M. EICHENBAUM (1992): "Current Real-Business-Cycle Theories And Aggregate Labor-Market Fluctuations," *American Economic Review*, 82, 430–50.

- CHRISTIANO, L. J., M. EICHENBAUM, AND C. EVANS (2005): "Nominal Rigidities And The Dynamic Effects Of A Shock To Monetary Policy," *Journal Of Political Economy*, 113(1), 1–45.
- COOLEY, T. F., AND E. PRESCOTT (1995): "Economic Growth And Business Cycles," *Frontiers Of Business Cycle Research (Ed. Thomas F. Cooley)*, Princeton University Press, pp. 1–38.
- DOMEIJ, D., AND P. KLEIN (2005): "Pre-Announced Optimal Tax Reform," *Macroeconomic Dynamics*, 9(2), 150–169.
- DOMINGUEZ, B. (2006a): "On The Time-Inconsistency Of Optimal Capital Taxes," *Forthcoming Journal Of Monetary Economics*.
- (2006b): "Public Debt And Optimal Taxes Without Commitment," *Forthcoming Journal Of Economic Theory*.
- EICHENGREEN, B. (1990): "The Capital Levy In Theory And Practice," *R. Dornbusch And M. Draghi, Eds., Public Debt Management: Theory And History*, Cambridge University Press, pp. 191–220.
- EROSA, A., AND M. GERVAIS (2001): "Optimal Taxation In Infinitely-Lived Agent And Overlapping Generations Models: A Review," *Economic Quarterly, Federal Reserve Bank Of Richmond*, 87(2).
- GOLOSOV, M., N. KOCHERLAKOTA, AND A. TSYVINSKY (2003): "Optimal Indirect And Capital Taxation," *Review Of Economic Studies*, 70(3), 569–588.
- GOLOSOV, M., AND A. TSYVINSKI (2006): "Designing Optimal Disability Insurance: A Case For Asset Testing," *Journal Of Political Economy*, 114(2), 257–269.
- GOLOSOV, M., A. TSYVINSKI, AND I. WERNING (2006): "New Dynamic Public Finance: A Users Guide," *NBER Macroeconomic Annual*.
- GOMME, P., AND P. RUPERT (2005): "Theory, Measurement And Calibration Of Macroeconomic Models," Federal Reserve Bank Of Cleveland, Working Paper.

- HASSLER, J., P. KRUSELL, K. STORESLETTEN, AND F. ZILIBOTTI (2004): "On The Optimal Timing Of Capital Taxes," Manuscript.
- (2005): "The Dynamics Of Government," *Journal Of Monetary Economics*, 52(7), 1331–1358.
- HASSLER, J., K. STORESLETTEN, AND F. ZILIBOTTI (2003): "Dynamic Political Choice In Macroeconomics," *Journal Of The European Economic Association*, 1(2-3), 543–552.
- (2006): "Democratic Public Good Provision," *Forthcoming Journal Of Economic Theory*.
- HOUSE, C. L., AND M. D. SHAPIRO (2006): "Phased-In Tax Cuts And Economic Activity," *Forthcoming American Economic Review*.
- JONES, L. E., R. E. MANUELLI, AND P. E. ROSSI (1993): "Optimal Taxation In Models Of Endogenous Growth," *Journal Of Political Economy*, 101(3), 485–517.
- JONSSON, M., AND P. KLEIN (2006): "Accounting For The Relationship Between Money And Interest Rates," *Macroeconomic Dynamics*, 10(4), 545–571.
- JUDD, K. L. (1985a): "Redistributive Taxation In A Simple Perfect Foresight Model," *Journal Of Public Economics*, 28, 59–83.
- (1985b): "Short-Run Analysis Of Fiscal Policy In A Simple Perfect Foresight Model," *Journal Of Political Economy*, 93(2), 298–319.
- (1987a): "A Dynamic Theory Of Factor Taxation," *American Economic Review Papers And Proceedings*, 77(2), 42–48.
- (1987b): "The Welfare Cost Of Factor Taxation In A Perfect-Foresight Model," *Journal Of Political Economy*, 95(4), 675–709.
- KLEIN, P., P. KRUSELL, AND J. V. RIOS-RULL (2004): "Time-Consistent Public Expenditures," Manuscript.
- KLEIN, P., AND J. V. RIOS-RULL (2003): "Time-Consistent Optimal Fiscal Policy," *International Economic Review*, 44(4), 1217–1245.

- KOCHERLAKOTA, N. (2005): "Zero Expected Wealth Taxes: A Mirrlees Approach To Dynamic Optimal Taxation," *Econometrica*, 73(5), 1587–1621.
- (2006): "Advances In Dynamic Optimal Taxation," *Advances In Economics And Econometrics: Theory And Applications, Ninth World Congress, I*, 269–299.
- KRUSELL, P., V. QUADRINI, AND J. V. RIOS-RULL (1996): "Are Consumption Taxes Really Better Than Income Taxes?," *Journal Of Monetary Economics*, 37, 475–504.
- (1997): "Politico-Economic Equilibrium And Economic Growth," *Journal Of Economic Dynamics And Control*, 21, 243–272.
- KRUSELL, P., AND J. V. RIOS-RULL (1996): "Vested Interests In A Positive Theory Of Stagnation And Growth," *Review Of Economic Studies*, 63(2), 301–329.
- (1999): "On the Size of US Government: Political Economy in the Neoclassical Growth Model," *American Economic Review*, 43, 699–735.
- LANSING, K. (1998): "Optimal Fiscal Policy In A Business Cycle Model With Public Capital," *The Canadian Journal Of Economics*, 31(2), 337–364.
- LJUNGQVIST, L., AND T. J. SARGENT (2004): *Recursive Macroeconomic Theory*. MIT Press, 2nd edn.
- LUCAS, R. E. (1990): "Supply-Side Economics: An Analytical Review," *Oxford Economic Papers, New Series*, 42(2), 239–316.
- MANKIW, G. N., AND R. REIS (2006): "Sticky Information In General Equilibrium," *Forthcoming Journal Of The European Economic Association*.
- MARCET, A., AND R. MARIMON (1998): "Recursive Contracts," Manuscript.
- MCGRATTAN, E. R. (1994): "The Macroeconomic Effects Of Distortionary Taxation," *Journal Of Monetary Economics*, 33(3), 573–601.
- MCGRATTAN, E. R., AND R. ROGERSON (2004): "Changes In Hours Worked, 1950-2000," *Quarterly Review, Federal Reserve Bank Of Minneapolis*.

- MIRRELES, J. A. (1971): “An Exploration In The Theory Of Optimum Income Taxation,” *Review Of Economic Studies*, 38(2), 175–208.
- PERSSON, T., AND G. TABELLINI (1994): “Is Inequality Harmful For Growth?,” *American Economic Review*, 84(3), 600–621.
- PHELAN, C., AND E. STACCHETTI (2001): “Sequential Equilibria In A Ramsey Tax Model,” *Econometrica*, 69, 1491–1518.
- RAMSEY, F. P. (1927): “A Contribution To The Theory Of Taxation,” *The Economic Journal*, 37, 47–61.
- SMETS, F., AND R. WOUTERS (2003): “An Estimated Dynamic Stochastic General Equilibrium Model Of The Euro Area,” *Journal Of The European Economic Association*, 1(5), 1123–1175.
- TRABANDT, M., AND H. UHLIG (2006): “How Far Are We From The Slippery Slope? The Laffer Curve Revisited,” *Humboldt University SFB 649 Discussion Paper*, (2006-23).

Table 1: Calibration of the Competitive Equilibrium Steady State

Variable	Value	Description	Restriction
$\bar{\tau}^n$	0.235	Labor tax rate	Data
$\bar{\tau}^k$	0.514	Capital tax rate	Data
$\bar{\tau}^c$	0.057	Consumption tax rate	Data
\bar{g}/\bar{y}	0.162	Government consumption to output ratio	Data
\bar{b}/\bar{y}	0.509	Government debt to output ratio	Data
\bar{k}/\bar{y}	2.6	Private capital to output ratio	Data
\bar{k}^s/\bar{y}	0.6	Public capital to output ratio	Data

Table 2: Parameterizing the Competitive Equilibrium Steady State

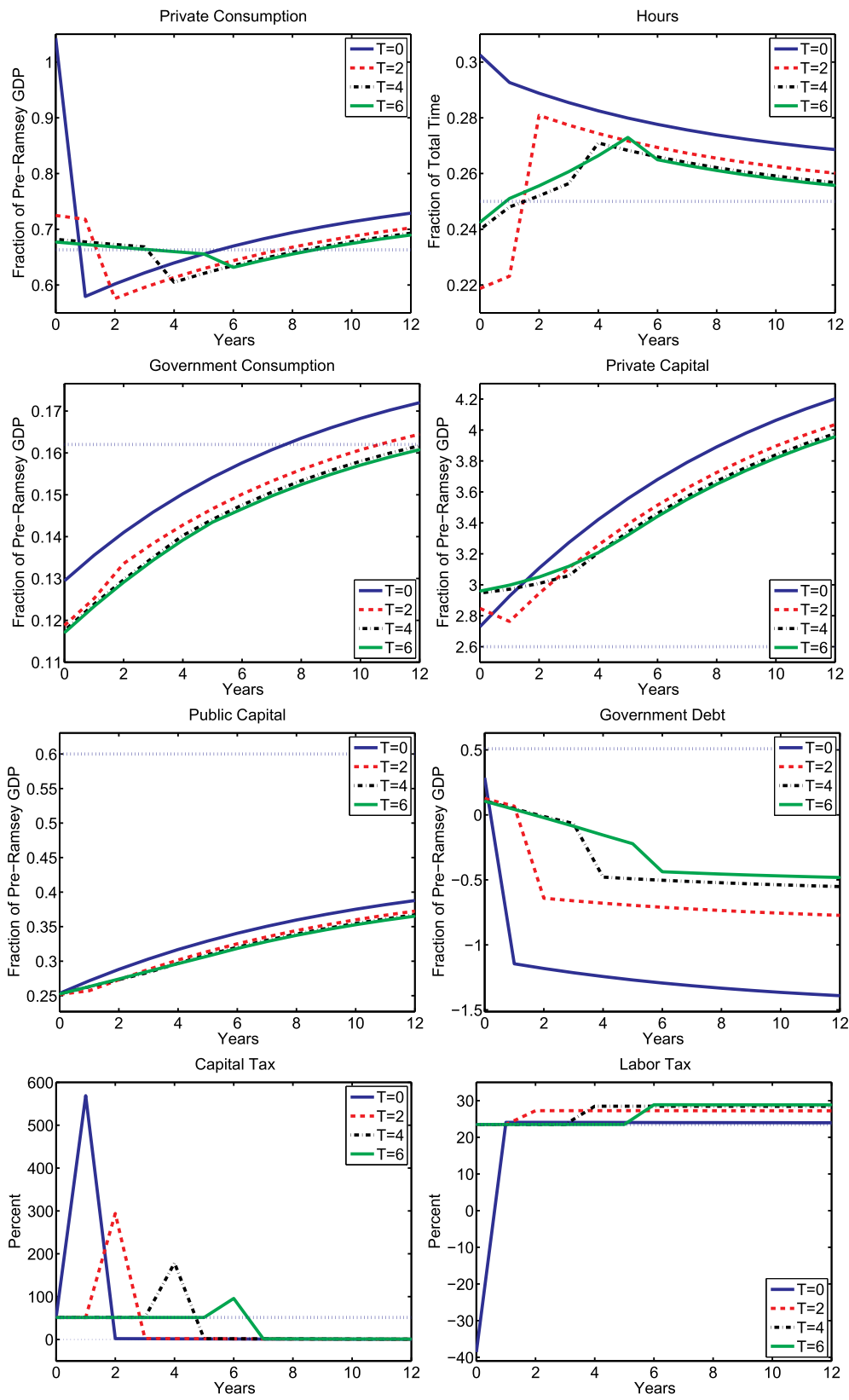
Variable	Value	Description	Restriction
α	0.323	Priv. consumption weight in utility	$\bar{n} = 0.25$
χ	0.2443	Det. weight of gov. cons. in utility	$\frac{u_{\bar{g}}}{u_{\bar{c}}} = 1$
σ	1.00	Det. intertemp. elast. of subst.	$-\frac{u_{\bar{c}}}{u_{\bar{c}\bar{c}}} = 1$
θ_k	0.36	Private capital share on production	Data
θ_n	0.64	Labor share on production	Data
θ_g	0.034	Public capital share on production	Data
δ	0.0542	Depreciation rate of private capital	Data
δ_g	0.0567	Depreciation rate of public capital	Data

Table 3: Data, Competitive Equilibrium and Ramsey Reform Steady States

Variable	Data	Comp. Equilib.	Tax Reforms			
			Baseline	Baseline (τ^k Bound)	No confiscation/ subsidy	Baseline/No conf-subsidy (Fixed Debt)
$\bar{\tau}^k$	0.514	0.514	0.00	0.00	0.00	0.00
\bar{k}/\bar{y}	2.60	2.60	3.783	3.783	3.783	3.783
\bar{k}^s/\bar{y}	0.60	0.60	0.348	0.348	0.348	0.348
$\bar{\tau}^n$	0.235	0.235	$T = 0$	$T = 4$	$T = 0$	$T = 4$
\bar{b}/\bar{y}	0.509	0.509	0.239	0.284	0.318	0.301
\bar{c}/\bar{y}	0.675	0.663	-1.185	-0.503	0.004	-0.248
\bar{g}/\bar{y}	0.162	0.162	0.627	0.628	0.629	0.629
			0.148	0.147	0.146	0.147
\bar{n}	0.25	0.25	0.260	0.248	0.239	0.243
\bar{y}	-	0.397	0.500	0.476	0.457	0.467

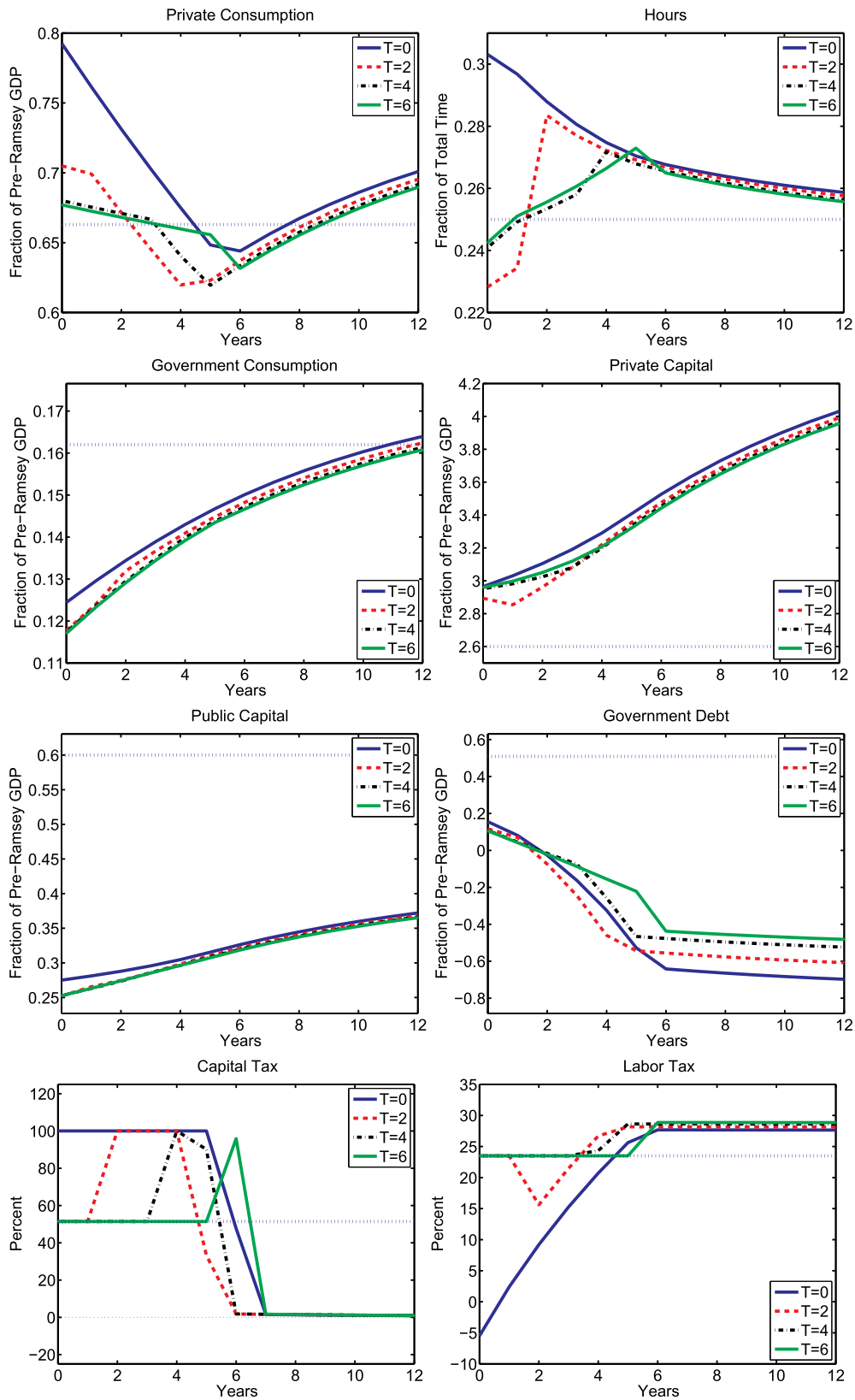
Notes: The table provides a comparison of the data, the competitive equilibrium steady state and the tax reform steady states. "Baseline" refers to the optimal capital and labor income tax reform. "Baseline (τ^k Bound)" means the optimal baseline reform with an upper bound on capital taxes. "No confiscation/subsidy" is the reform when the government moves taxes - without confiscation and subsidy - to their endogenous long-run values from the implementation date onwards. The last column shows the steady states for the reforms with fixed government debt. T denotes the pre-announcement horizon.

Figure 1: Baseline Tax Reform



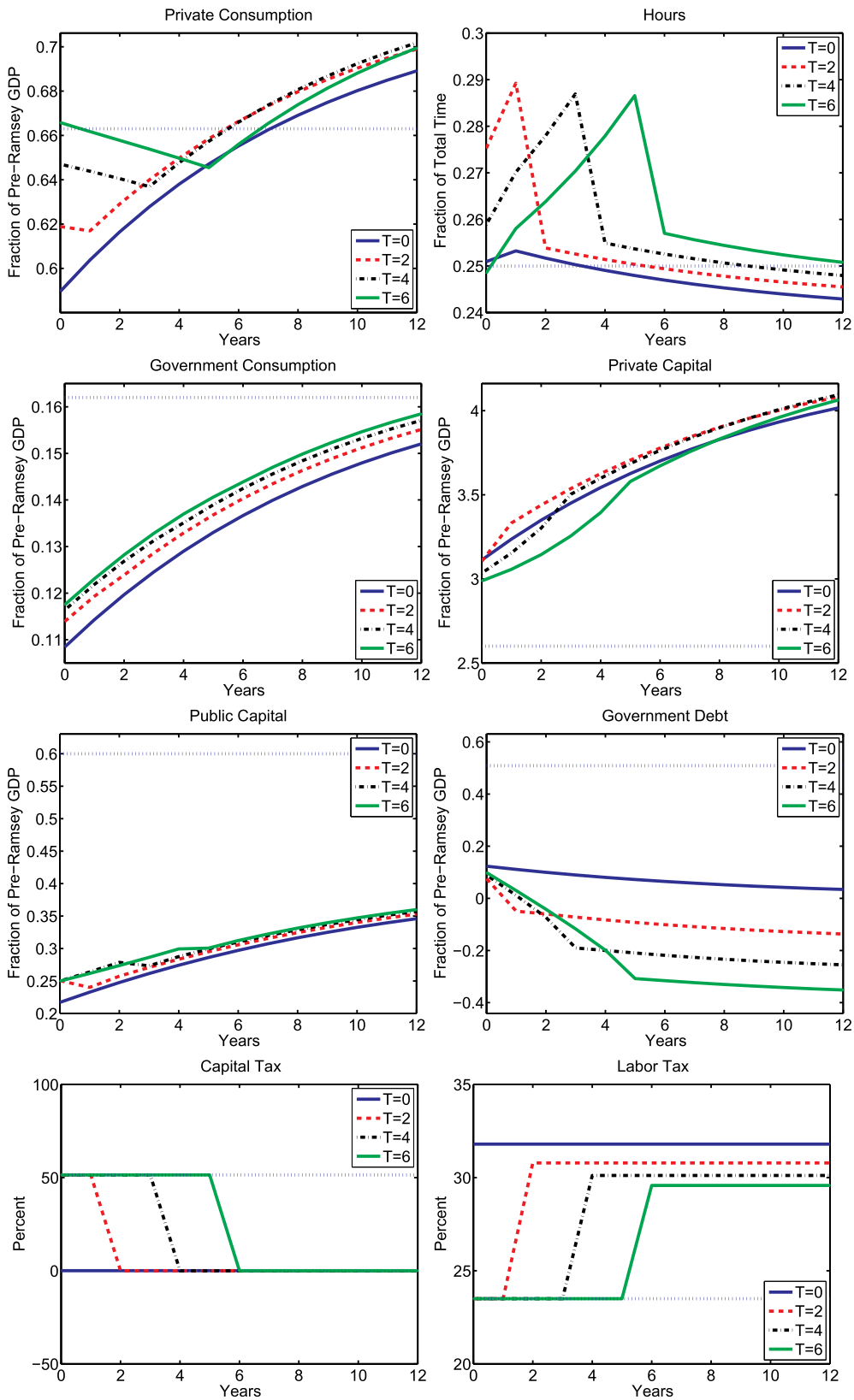
Notes: Baseline tax reform for different pre-announcement periods. (horizontal line: competitive equilibrium steady state).

Figure 2: Baseline Tax Reform with Upper Bound on Capital Taxes



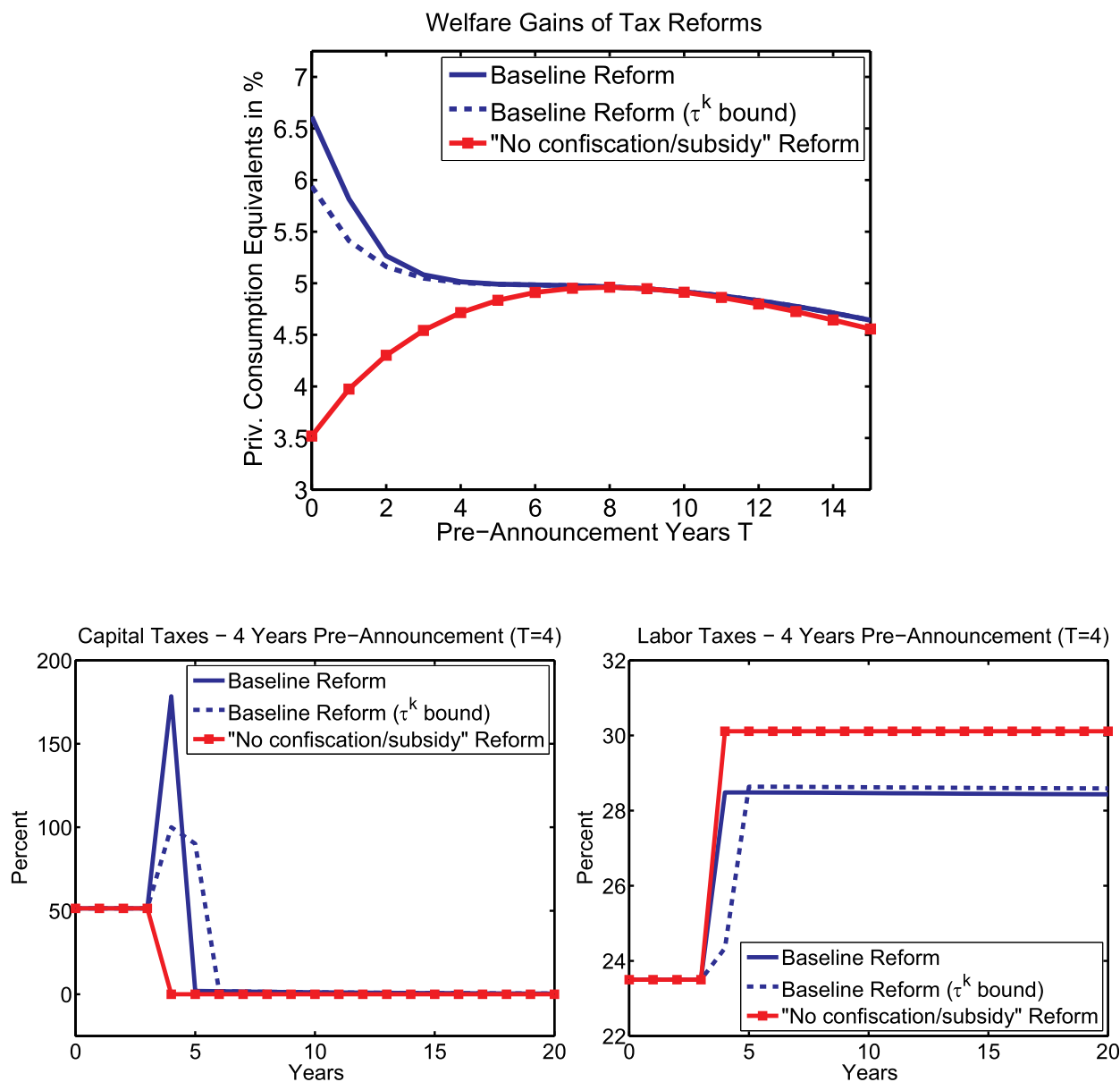
Notes: Baseline tax reform with upper bound on capital taxes for different pre-announcement periods. (horizontal line: competitive equilibrium steady state).

Figure 3: “No confiscation/subsidy” Tax Reform



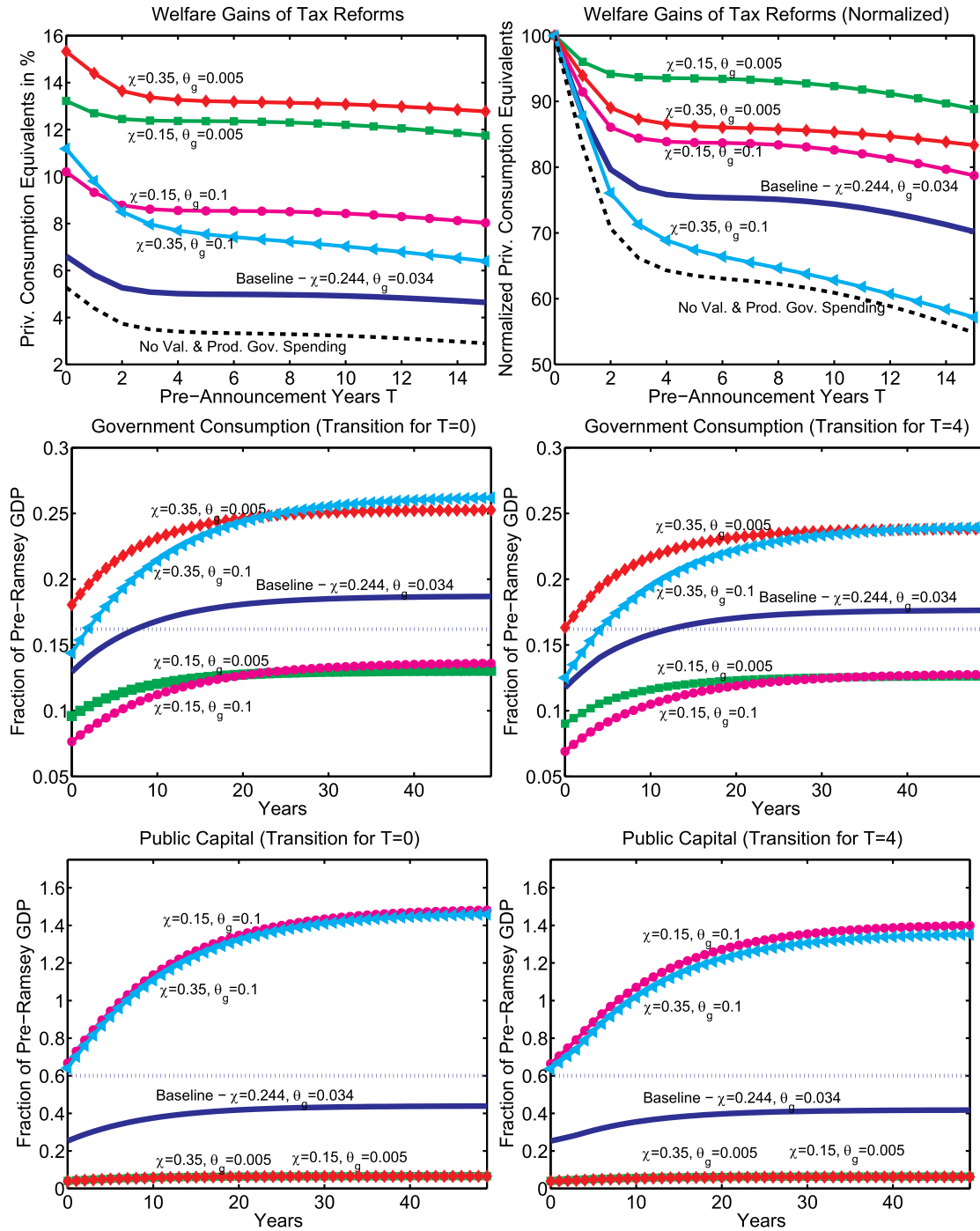
Notes: “No confiscation/subsidy” tax reform for different pre-announcement periods. (horizontal line: competitive equilibrium steady state).

Figure 4: Welfare Gains and Taxes of Baseline and “no confiscation/subsidy” Tax Reforms



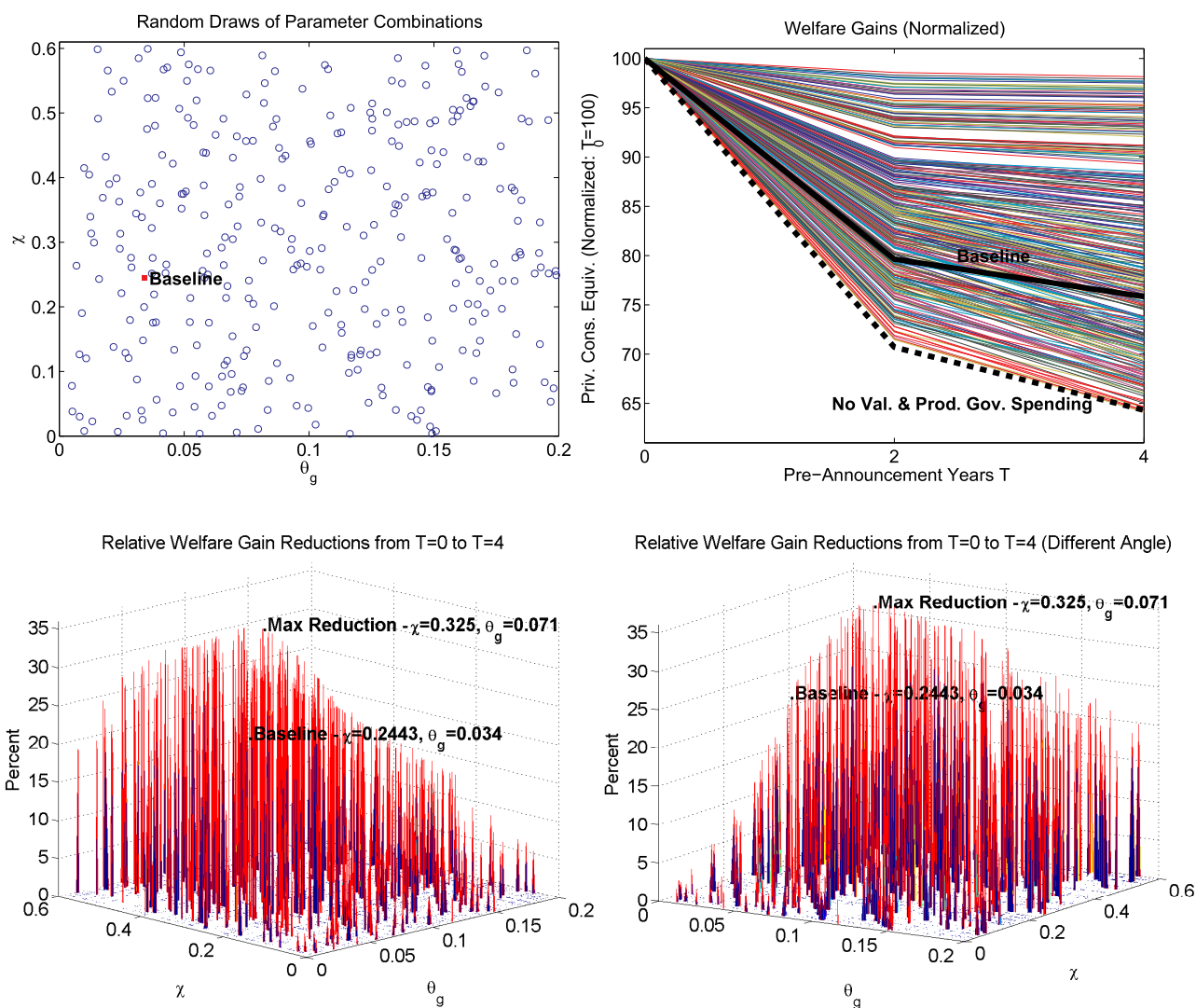
Notes: The upper panel plots welfare gains measured in permanent increases of private consumption for the baseline tax reform, the baseline tax reform with an upper bound on capital taxes as well as for the “no confiscation/subsidy” tax reform. In the latter reform, the government moves taxes - without confiscation and subsidy - directly to the endogenous long-run taxes from the implementation date onwards. The lower left panel depicts the transition of capital taxes whereas the lower right panel plots the transition of labor taxes in case of 4 years pre-announcement for all three reforms. While welfare is rather similar for $T=4$ in all three reforms, the tax structure appears to be very different.

Figure 5: Sensitivity Analysis



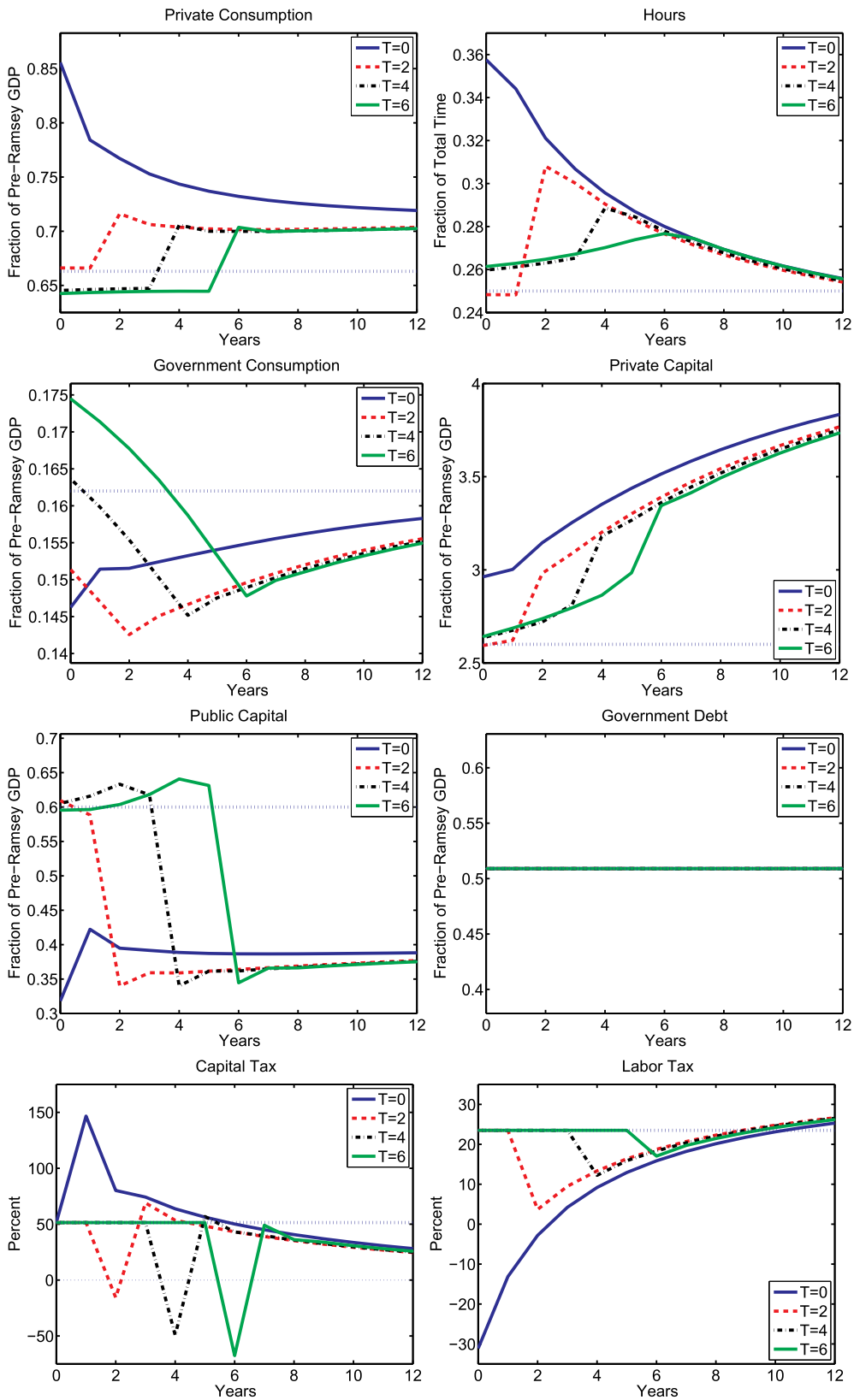
Notes: Sensitivity analysis. The upper panel plots the level of welfare gains as well as the normalized welfare gains ($T=0$ equals 100) for the baseline tax reform for different pre-announcement periods and different parameters χ and θ_g . "No Val. & Prod. Gov. Spending" corresponds to the model with no valuation and fixed government consumption and no productive public capital. The mid panel plots government consumption and the lower panel plots public capital for $T=0$ and $T=4$. The horizontal lines in the mid and lower panel are the competitive equilibrium steady states.

Figure 6: Sensitivity Analysis: Random Parameter Draws



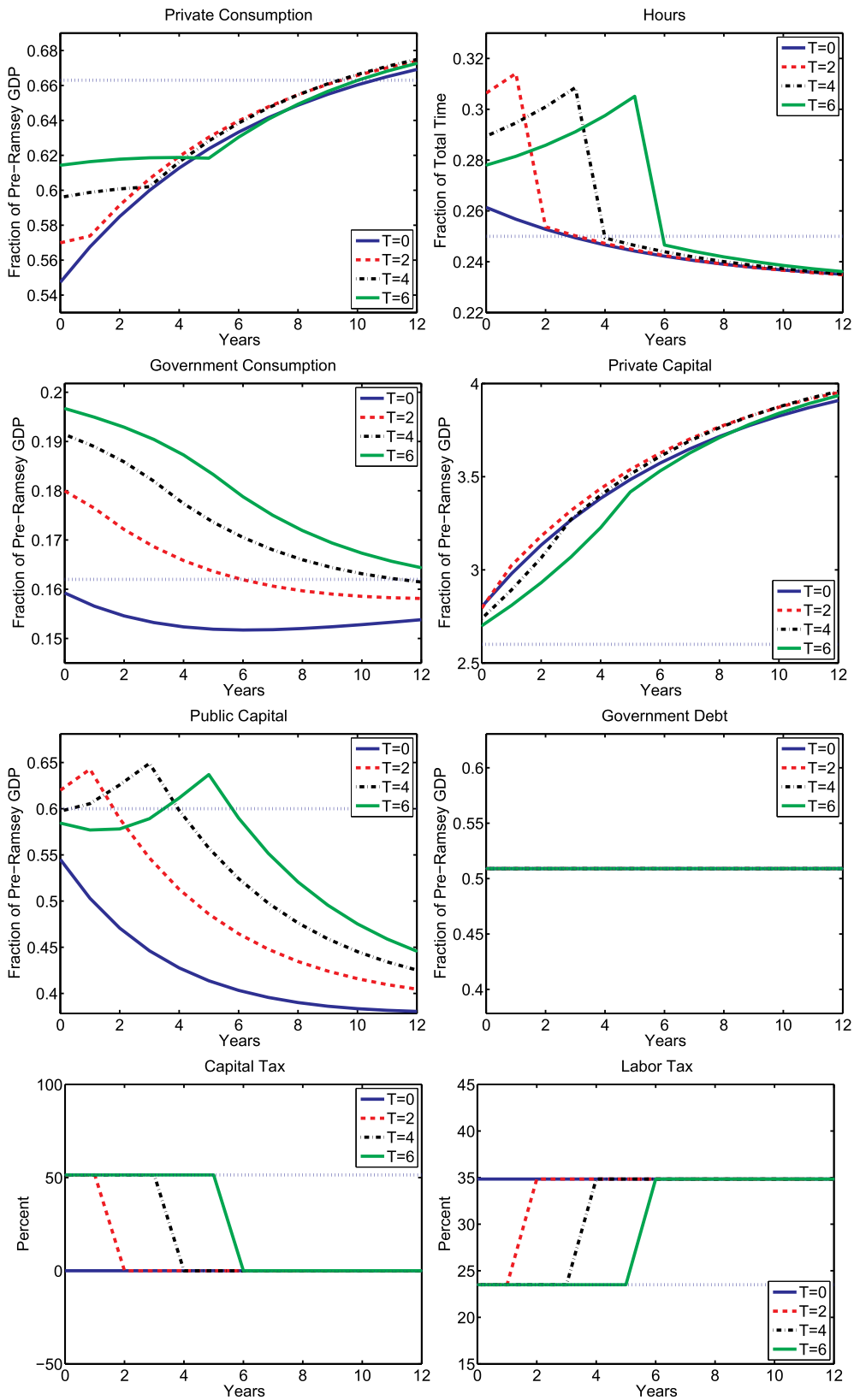
Notes: The upper left panel shows random parameter combinations of θ_g and χ that result from drawing both parameters from the following uniform distributions: $\theta_g \sim U[0.00001, 0.2]$ and $\chi \sim U[0.00001, 0.6]$. Total number of draws: 329. The upper right panel shows the resulting welfare gains for each random parameter combination for pre-announcement horizons $T \in \{0, 2, 4\}$. The bold black solid line shows my baseline parameterization and the bold black dashed line represents the model with non-valued and fixed government consumption and no productive public capital. In order to facilitate comparison with respect to the welfare losses of pre-announcement, we normalize all welfare gains such that they equal 100 for $T = 0$. Finally, the lower two panels depict the reductions of relative welfare gains that are due to moving from $T = 0$ (immediate reform) to $T = 4$ (4 years pre-announced reform) for all random parameter combinations and from different angles.

Figure 7: Baseline Tax Reform with Fixed Debt



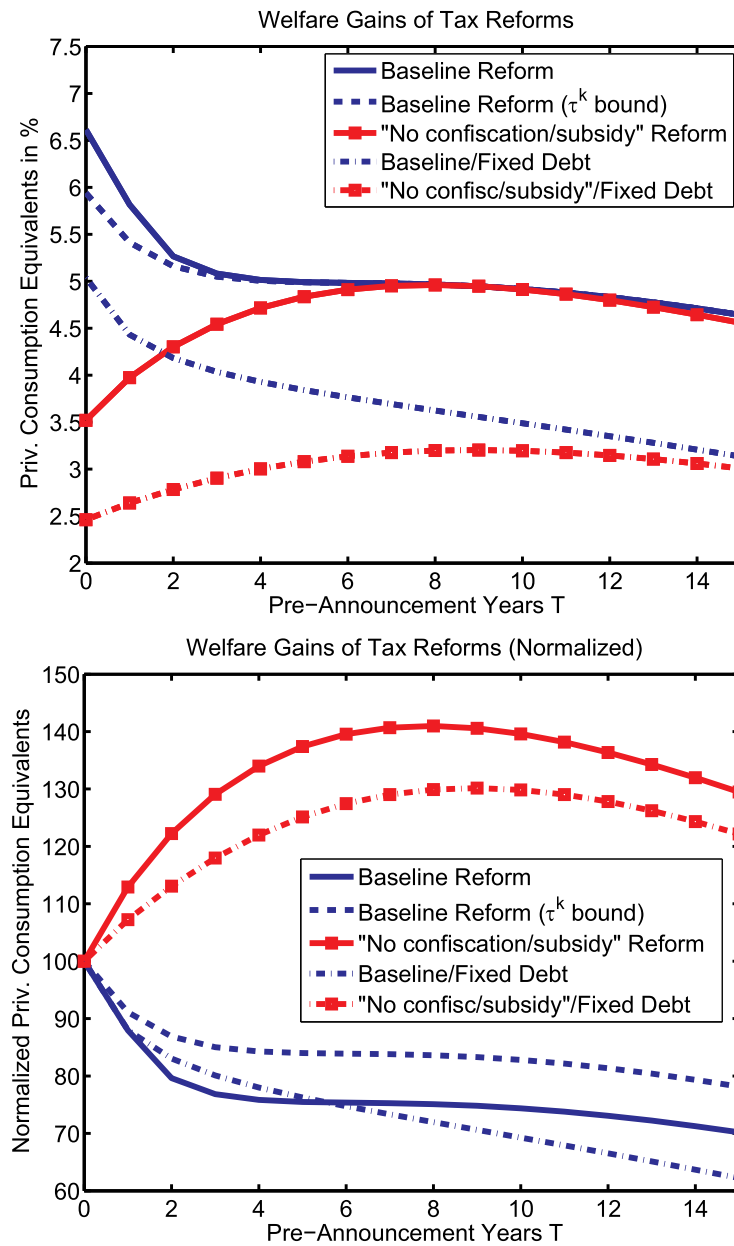
Notes: Baseline tax reform with fixed debt and different pre-announcement periods. (horizontal line: competitive equilibrium steady state).

Figure 8: “No confiscation/subsidy” Tax Reform with Fixed Debt



Notes: “No confiscation/subsidy” tax reform with fixed debt and different pre-announcement periods. (horizontal line: competitive equilibrium steady state).

Figure 9: Welfare Gains of Tax Reforms with and without Fixed Debt



Notes: The upper panel plots welfare gains measured in permanent increases of private consumption for the baseline tax reform, the baseline tax reform with an upper bound on capital taxes as well as for the "No confiscation/subsidy" tax reform. Further, the plot also depicts welfare gains of the baseline optimal tax reform as well as the "no confiscation/subsidy" tax reform with fixed government debt. The lower panel plots the corresponding welfare gains where I have normalized consumption equivalents to 100 for $T = 0$ in all reforms that I consider.

A Appendix

A.1 Ramsey Problem - First Order Conditions

A.1.1 First order conditions for periods $t > T$ (if $T = 0$) or $t \geq T$ (if $T \geq 1$):

$$\begin{aligned}
c_t : \quad & U_c(t) + \phi \frac{U_{cc}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) \\
& - \mu_t (U_{nc}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cc}(t)f_{n,t}) - \gamma_t + \omega_t \tau_t^c \\
& + \eta_t \frac{U_{cc}(t)}{1 + \tau_t^c} - \eta_{t-1} \frac{U_{cc}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) = 0
\end{aligned} \tag{12}$$

$$\begin{aligned}
g_t : \quad & U_g(t) + \phi \frac{U_{cg}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) - \phi \frac{U_c(t)}{1 + \tau_t^c} \\
& - \mu_t (U_{ng}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cg}(t)f_{n,t}) - \gamma_t + \eta_t \frac{U_{cg}(t)}{1 + \tau_t^c} \\
& - \eta_{t-1} \frac{U_{cg}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) = 0
\end{aligned} \tag{13}$$

$$\begin{aligned}
n_t : \quad & U_n(t) + \phi \frac{U_{cn}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) \\
& - \mu_t (U_{nn}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cn}(t)f_{n,t} + (1 - \tau_t^n)U_c(t)f_{nn,t}) \\
& + \gamma_t f_{n,t} + \omega_t \tau_t^n f_{nn,t} n_t + \omega_t \tau_t^n f_{n,t} + \omega_t \tau_t^k k_{t-1} f_{kn,t} + \eta_t \frac{U_{cn}(t)}{1 + \tau_t^c} \\
& - \eta_{t-1} \frac{U_{cn}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) - \eta_{t-1} \frac{U_c(t)}{1 + \tau_t^c} (1 - \tau_t^k) f_{kn,t} = 0
\end{aligned} \tag{14}$$

$$\begin{aligned}
k_t : \quad & -\mu_{t+1} \beta (1 - \tau_{t+1}^n) U_c(t+1) f_{nk,t+1} - \gamma_t + \gamma_{t+1} \beta (f_{k,t+1} + 1 - \delta) \\
& + \omega_{t+1} \beta \left(\tau_{t+1}^n f_{nk,t+1} n_{t+1} + \tau_{t+1}^k f_{kk,t+1} k_t + \tau_{t+1}^k (f_{k,t+1} - \delta) \right) \\
& - \beta \eta_t \frac{U_c(t+1)}{1 + \tau_{t+1}^c} (1 - \tau_{t+1}^k) f_{kk,t+1} = 0
\end{aligned} \tag{15}$$

$$Rev_t : \phi \frac{U_c(t)}{1 + \tau_t^c} - \omega_t = 0 \quad (16)$$

$$\begin{aligned} k_t^s : & -\phi \frac{U_c(t)}{1 + \tau_t^c} + \beta \phi \frac{U_c(t+1)}{1 + \tau_{t+1}^c} (1 - \delta_g) - \mu_{t+1} \beta (1 - \tau_{t+1}^n) U_c(t+1) f_{nks,t+1} \\ & - \gamma_t + \beta \gamma_{t+1} (f_{ks,t+1} + 1 - \delta_g) + \beta \omega_{t+1} (\tau_{t+1}^n f_{nks,t+1} n_{t+1} + \tau_{t+1}^k k_t f_{kks,t+1}) \\ & - \eta_t \beta \frac{U_c(t+1)}{1 + \tau_{t+1}^c} (1 - \tau_{t+1}^k) f_{kks,t+1} = 0 \end{aligned} \quad (17)$$

$$\tau_t^k : \omega_t (f_{k,t} - \delta) k_{t-1} + \eta_{t-1} \frac{U_c(t)}{1 + \tau_t^c} (f_{k,t} - \delta) = 0 \quad (18)$$

$$\tau_t^n : \mu_t U_c(t) f_{n,t} + \omega_t f_{n,t} n_t = 0 \quad (19)$$

$$\eta_t : \beta \frac{U_c(t+1)}{1 + \tau_{t+1}^c} \left((1 - \tau_{t+1}^k) (f_{k,t+1} - \delta) + 1 \right) - \frac{U_c(t)}{1 + \tau_t^c} = 0 \quad (20)$$

$$\mu_t : U_n(t) (1 + \tau_t^c) + U_c(t) (1 - \tau_t^n) f_{n,t} = 0 \quad (21)$$

$$\begin{aligned} \gamma_t : & c_t + g_t + k_t + k_t^s - f_t(k_{t-1}, n_t, k_{t-1}^s) - (1 - \delta) k_{t-1} \\ & - (1 - \delta_g) k_{t-1}^s = 0 \end{aligned} \quad (22)$$

$$\omega_t : Rev_t - \tau_t^c c_t - \tau_t^n f_{n,t} n_t - \tau_t^k (f_{k,t} - \delta) k_{t-1} = 0 \quad (23)$$

$$\phi : \sum_{t=0}^{\infty} \beta^t \frac{U_c(t)}{1 + \tau_t^c} [Rev_t - g_t - s_t - k_t^s + (1 - \delta_g) k_{t-1}^s] - \frac{U_c(0)}{1 + \tau_0^c} b_{-1} = 0 \quad (24)$$

A.1.2 First order conditions for periods $1 \leq t \leq T - 1$:

$c_t, g_t, n_t, k_t, Rev_t, k_t^s, \eta_t, \mu_t, \gamma_t, \omega_t, \phi$: equations (12) to (17) as well as equations (20) to (24). In addition, the following first order conditions need to be changed to

$$\tau_t^k : \quad \omega_t(f_{k,t} - \delta)k_{t-1} + \eta_{t-1} \frac{U_c(t)}{1 + \tau_t^c} (f_{k,t} - \delta) - v_t = 0 \quad (25)$$

$$\tau_t^n : \quad \mu_t U_c(t) f_{n,t} + \omega_t f_{n,t} n_t - \kappa_t = 0 \quad (26)$$

$$v_t : \quad \tau_t^k - \bar{\tau}^k = 0 \quad (27)$$

$$v_t : \quad \tau_t^n - \bar{\tau}^n = 0 \quad (28)$$

A.1.3 First order conditions for period $t = 0$ (if $T > 0$):

$k_t, Rev_t, k_t^s, \eta_t, \mu_t, \gamma_t, \omega_t, \phi, \tau_t^k, \tau_t^n, v_t, \kappa_t$: equations (15) to (17) as well as equations (20) to (24) and equations (25) to (28). Now, the following first order conditions need to be adjusted:

$$\begin{aligned} c_t : \quad & U_c(t) + \phi \frac{U_{cc}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^s + (1 - \delta_g)k_{t-1}^s) \\ & - \mu_t (U_{nc}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cc}(t)f_{n,t}) - \gamma_t + \omega_t \tau_t^c \\ & + \eta_t \frac{U_{cc}(t)}{1 + \tau_t^c} - \eta_{t-1} \frac{U_{cc}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) - \phi \frac{U_{cc}(0)}{1 + \tau^c(0)} b_{-1} = 0 \end{aligned} \quad (29)$$

$$\begin{aligned}
g_t : \quad & U_g(t) + \phi \frac{U_{cg}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) - \phi \frac{U_c(t)}{1 + \tau_t^c} \\
& - \mu_t (U_{ng}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cg}(t)f_{n,t}) - \gamma_t + \eta_t \frac{U_{cg}(t)}{1 + \tau_t^c} \\
& - \eta_{t-1} \frac{U_{cg}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) - \phi \frac{U_{cc}(0)}{1 + \tau^c(0)} b_{-1} = 0 \quad (30)
\end{aligned}$$

$$\begin{aligned}
n_t : \quad & U_n(t) + \phi \frac{U_{cn}(t)}{1 + \tau_t^c} (Rev_t - g_t - s_t - k_t^g + (1 - \delta_g)k_{t-1}^g) \\
& - \mu_t (U_{nn}(t)(1 + \tau_t^c) + (1 - \tau_t^n)U_{cn}(t)f_{n,t} + (1 - \tau_t^n)U_c(t)f_{nn,t}) \\
& + \gamma_t f_{n,t} + \omega_t \tau_t^n f_{nn,t} n_t + \omega_t \tau_t^n f_{n,t} + \omega_t \tau_t^k k_{t-1} f_{kn,t} + \eta_t \frac{U_{cn}(t)}{1 + \tau_t^c} \\
& - \eta_{t-1} \frac{U_{cn}(t)}{1 + \tau_t^c} \left((1 - \tau_t^k)(f_{k,t} - \delta) + 1 \right) - \eta_{t-1} \frac{U_c(t)}{1 + \tau_t^c} (1 - \tau_t^k) f_{kn,t} \\
& - \phi \frac{U_{cn}(0)}{1 + \tau^c(0)} b_{-1} = 0 \quad (31)
\end{aligned}$$

A.1.4 First order conditions for period $t = 0$ (if $T = 0$):

$c_t, g_t, n_t, k_t, Rev_t, k_t^g, \eta_t, \mu_t, \gamma_t, \omega_t, \phi, \tau_t^n$: equations (29) to (31), equations (15) to (17), equation (19) and equations (20) to (24).

Note that the Ramsey planner does not choose τ_0^k here in order to avoid the initial confiscation. Instead, for this case, I directly impose $\tau_0^k = \bar{\tau}^k$ in all equations listed above.

A.2 Solution Method for the Ramsey Model

I follow Domeij and Klein (2005) regarding the solution technique.¹⁹ In particular, I make the system of equations derived in appendix A.1 finite dimensional by assuming that the economy converges to the Ramsey steady state in finitely many periods.

¹⁹I use MATLAB to solve the model. However, I am thankful to Paul Klein for sending example GAUSS code of the numerical solution technique used in Domeij and Klein (2005).

To that end, I choose 100 years as the finite time horizon. This implies that if time starts in $t = 0$ I know the terminal values of our state variables in period $t = 99$, i.e.

$$k_{99} = \bar{k}_{Ramsey}, k_{99}^g = \bar{k}_{Ramsey}^g \text{ and } \eta_{99} = \bar{\eta}_{Ramsey}.$$

In addition, since the economy reaches the Ramsey steady state at latest in the terminal period the three Euler equations for the terminal period $t = 99$ that look forward to the period $t = 100$ in the system of equations derived in the appendix A.1 are not longer required. This leaves me with a system of non-linear equations with as many equations as unknowns which I can solve with non-linear numerical solver.

In particular, using the derivations of appendix A.1 for, e.g. $T = 0$, I guess a value for the multiplier ϕ and then solve for the sequences of variables $\{c_t, n_t, g_t, Rev_t, \tau_t^n, \mu_t, \gamma_t, \omega_t\}_{t=0}^{99}$, $\{\tau_t^k\}_{t=1}^{99}$ and $\{k_t, k_t^g, \eta_t\}_{t=0}^{98}$ knowing that $k_{99} = \bar{k}_{Ramsey}$, $k_{99}^g = \bar{k}_{Ramsey}^g$ and $\eta_{99} = \bar{\eta}_{Ramsey}$. Hence, I have $8 \times 100 + 1 \times 99 + 3 \times 99 = 1196$ unknown variables. Given ϕ , appendix A.1 shows that for $T = 0$ in period 0 there are 11 equations and for periods $t = 1, \dots, 99$ there are 12 equations that determine the equilibrium. Thus, $12 \times 99 + 11$ minus the three Euler equations for the terminal period gives exactly 1196 equations. The case of $T > 0$ applies accordingly. I solve the system of non-linear equations using the `fsolve.m` function of MATLAB with a solution precision of $1e - 8$. Technically, given the guess for the multiplier ϕ , I am able to calculate the Ramsey steady state which in turn serves as an initial guess, $\{\bar{c}_{Ramsey}, \bar{n}_{Ramsey}, \bar{g}_{Ramsey}, \bar{Rev}_{Ramsey}, \bar{\tau}_{Ramsey}^n, \bar{\mu}_{Ramsey}, \bar{\gamma}_{Ramsey}, \bar{\omega}_{Ramsey}\}_{t=0}^{99}$, $\{\bar{\tau}_{Ramsey}^k\}_{t=1}^{99}$, $\{\bar{k}_{Ramsey}, \bar{k}_{Ramsey}^g, \bar{\eta}_{Ramsey}\}_{t=0}^{98}$ for the above sequences of variables I wish to solve for.

Having obtained a potential solution, I check whether the intertemporal government budget constraint is satisfied with a precision of $1e - 6$. If not, I update ϕ and repeat calculations until the desired solution precision is achieved. For a given pre-announcement horizon T it takes roughly one hour to solve the model with an up-to-date unix machine.

In order to check whether my solution represents the global maximum, I have done the following diagnostic checks. First, we have randomized my initial guess for the multiplier ϕ . In particular, I have drawn ϕ from a uniform distribution on the interval $[0, 3]$.²⁰ Consider the case of e.g. $T = 0$. Due to random draws for ϕ , the Ramsey steady states are randomized as well and hence the initial guess $\{\bar{c}_{Ramsey}, \bar{n}_{Ramsey}, \bar{g}_{Ramsey}, \bar{Re}v_{Ramsey}, \bar{\tau}_{Ramsey}^n, \bar{\mu}_{Ramsey}, \bar{\gamma}_{Ramsey}, \bar{\omega}_{Ramsey}\}_{t=0}^{99}$, $\{\bar{\tau}_{Ramsey}^k\}_{t=1}^{99}$, $\{\bar{k}_{Ramsey}, \bar{k}_{Ramsey}^g, \bar{\eta}_{Ramsey}\}_{t=0}^{98}$ for the sequences $\{c_t, n_t, g_t, Re v_t, \tau_t^n, \mu_t, \gamma_t, \omega_t\}_{t=0}^{99}$, $\{\tau_t^k\}_{t=1}^{99}$ and $\{k_t, k_t^g, \eta_t\}_{t=0}^{98}$ we wish to solve for is randomized as well. The case of $T > 0$ applies accordingly. Given that the solution algorithm was able to find a solution, I always obtained the solution for the baseline and “no confiscation/subsidy” reforms discussed in the paper.

Second, as a further check that my solution represents the global maximum I draw the multiplier ϕ from a uniform distribution on the interval $[0, 3]$ and in addition perturb my initial guesses for the sequences of variables. In particular, I generate e.g. $\{\bar{c}_{rand} = \bar{c}_{Ramsey} \times \epsilon\}_{t=0}^{99}$ where ϵ is drawn from a uniform distribution on the interval $[0.5, 1.5]$.²¹ Similarly, I perturb the other variables using alternative and independent draws for ϵ and formulate the following initial guess for the sequences of variables I wish to solve for: $\{\bar{c}_{rand}, \bar{n}_{rand}, \bar{g}_{rand}, \bar{Re}v_{rand}, \bar{\tau}_{rand}^n, \bar{\mu}_{rand}, \bar{\gamma}_{rand}, \bar{\omega}_{rand}\}_{t=0}^{99}$, $\{\bar{\tau}_{rand}^k\}_{t=1}^{99}$ and $\{\bar{k}_{rand}, \bar{k}_{rand}^g, \bar{\eta}_{rand}\}_{t=0}^{98}$ for $T = 0$. The case of $T > 0$ applies accordingly. Hence, this way, I have randomized our initial guess in two dimensions. First, the underlying Ramsey steady state is randomized by random draws of ϕ . Second, our initial guess for the sequences of variables itself consists now of random elements that are unrelated to e.g. the Ramsey steady state. Hence, I argue that my initial

²⁰In most of the solutions discussed in the paper, ϕ took values below one. From that perspective, three as an upper bound is reasonably large. However, for values of ϕ larger than 3 it turns out that the solution algorithm has difficulties to calculate a solution at all.

²¹Hence, this implies that the initial guess is at most 50 percent smaller or larger than the Ramsey steady state. Note, however, that the Ramsey steady state itself varies considerably due to the random guesses for the multiplier ϕ . Hence, there is substantial random variation. However, for bounds lower than 0.5 or higher than 1.5 of the uniform distribution, the solution algorithm has difficulties to find a solution. Further, we have also attempted to examine randomly time varying initial guesses for each variable by e.g. drawing a randomly time varying initial sequence for consumption etc. However, the solution algorithm was not able to find a solution in this case.

guesses display now a considerable degree of randomization. Nevertheless, given that the solution algorithm was able to find a solution, I did not find a single solution that generated higher utility respectively welfare gains for the baseline and “no confiscation/subsidy” reforms. In other words, the solution for the baseline and “no confiscation/subsidy” reforms discussed in the paper represent very likely the global maximum.

A.3 Welfare Calculations

In order to evaluate welfare consequences of the tax reforms we calculate permanent private consumption equivalents Δ_c^* that make the household indifferent between the competitive equilibrium steady state and the Ramsey allocation.

Taking transitional dynamics into account, private consumption equivalents Δ_c^* can be calculated as:

$$\sum_{t=0}^{\infty} \beta^t u((1 + \Delta_c^*)\bar{c}, \bar{n}, \bar{g}) = \sum_{t=0}^{\infty} \beta^t u(c_{t,Ramsey}, n_{t,Ramsey}, g_{t,Ramsey}). \quad (32)$$

Given the preference specification of section 2.3 I can explicitly solve for private consumption equivalents that take transitional dynamics into account. Formally,

$$\Delta_c^* = \begin{cases} \exp\left[\frac{(1-\beta)(u_{Ramsey}^{trans} - u^{ss})}{\alpha}\right] - 1 & \text{for } \sigma = 1 \\ \left(\frac{(1-\sigma)(1-\beta)u_{Ramsey}^{trans} + 1}{(1-\sigma)(1-\beta)u^{ss} + 1}\right)^{\alpha(\sigma-1)} - 1 & \text{for } \sigma \neq 1 \end{cases} \quad (33)$$

with the abbreviations $u_{Ramsey}^{trans} = \sum_{t=0}^{\infty} \beta^t u(c_{t,Ramsey}, n_{t,Ramsey}, g_{t,Ramsey})$ and $u^{ss} = u(\bar{c}, \bar{n}, \bar{g})$.