Optimal Pre-Announced Tax Reforms Under Valuable And Productive Government Spending*

Mathias Trabandt†
Humboldt University Berlin

First Version: September 29, 2005
This Version: June 23, 2006

*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, Morton 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, the Swedish Central Bank (Sveriges Riksbank), the 2006 CESifo Conference on Public Sector Economics and the 2006 Southern Workshop in Macroeconomics. 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). This research was conducted to a large extend while the author was visiting the European University Institute in Florence and the Swedish Central Bank (Sveriges Riksbank) in Stockholm. The author is very grateful for the hospitality of these institutions.

†Address: Mathias Trabandt, Humboldt University Berlin, School of Business and Economics, Institute for Economic Policy I, Spandauer Str. 1, 10178 Berlin, Tel. +49-(0)-30-2093 1680, email: trabandt@wiwi.hu-berlin.de

Abstract

This paper analyzes optimal pre-announced capital and labor income tax reforms under valuable and productive government spending. Our baseline optimal reform reveals that these model ingredients result in a reduction of welfare losses that occur when the reform is announced before its implementation. Further, the mere existence of welfare losses from pre-announcement is due to the ability of the government to initially choose very high capital taxes and negative labor taxes. A government that instead chooses optimal long run taxes from the implementation date onwards generates sizable increases of welfare gains from pre-announcing the reform. We show that 4 years pre-announcement of this reform and the baseline optimal reform deliver similar levels of welfare gains. The underlying tax structure of both reforms, however, appears to be very different.

Key words: Optimal taxation, pre-announcement, valuable and productive government spending, welfare.

JEL classification: E0, E6, H0.

1 Introduction

What are the welfare consequences of announcing an optimal capital and labor income tax reform in advance of its implementation? This paper sheds new light on this issue. In particular, our baseline optimal reform reveals that utility providing government consumption and productive government capital reduce the relative welfare losses that occur when the reform is pre-announced before its implementation. In addition, the mere existence of welfare losses from pre-announcement depends on the ability of the government to initially choose very high capital taxes and negative labor taxes. A visionary government that instead chooses optimal long run capital and

labor income taxes from the implementation date onwards generates sizable welfare gains from pre-announcing the reform. We show that 4 years pre-announcement of this "Visionary View" reform and the baseline optimal reform deliver similar levels of welfare gains. The underlying tax structure of both reforms, however, appears to be very different.

Recently, Domeij and Klein (2005) have analyzed an optimal immediate and pre-announced capital and labor income tax reform in a standard neoclassical growth model. The authors find that pre-announcement of the optimal reform has large effects on optimal fiscal policy and important consequences for welfare. In particular, the authors show that relative welfare falls by one third if the tax reform is pre-announced 4 years before its implementation. In the light of the classical optimal taxation literature, Domeij and Klein (2005) assume that government spending is purely wasteful and non-productive. What happens to the optimal pre-announced tax reform and its welfare consequences if we assume valuable and productive government spending instead?

In principle, one can think of government spending to consist of two types of expenditures. First, productive government spending that affects private sector production through i.e. a public capital stock. Second, non-productive but directly utility providing expenditures like government consumption. If these two parts of government spending adjust endogenously in general equilibrium, they will presumably affect private sector allocations as well as household utility. Hence, the properties of the optimal pre-announced tax reform and its welfare consequences are likely to be affected as well.

The goal of this paper is to analyze and compare an optimal immediate versus pre-announced capital and labor income tax reform under utility providing government consumption and productive government capital. Our analysis employs a standard neoclassical growth model with distortionary taxation. The key ingredients of the model are 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 i.e. 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. We study the properties of the Ramsey steady states, the transition from the pre-Ramsey to the Ramsey steady states as well as the welfare consequences of different pre-announcement horizons.

Figure (4) summarizes one of our main results. We 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 falls by roughly 25 percent. In addition, we depart from Domeij and Klein (2005) and consider the baseline optimal tax reform when an upper bound on capital taxes of 100 percent is imposed. In this case, relative welfare falls by roughly 15 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 by roughly 35 percent similar to Domeij and Klein (2005). Hence, for our baseline reform, valuable and productive government spending - as employed in our model - lead to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare 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. In figure (5) we show that if either the valuation of government consumption or the public capital share are low then pre-announcement is even less costly than in our baseline optimal reform. Interestingly, if both the valuation of government consumption and the public capital share are high then pre-announcement can be almost as costly as in an economy without these ingredients. However, a sensitivity analysis based on empirically reasonable parameter estimates reveals that we did not find a single case in which pre-announcement is exactly as costly or even more costly than in an economy without valuable and productive government spending. Hence, we conclude that valuable and productive government spending is likely to reduce the welfare losses from pre-announcement.

The baseline optimal tax reform is characterized by initially very high capital income taxes and negative labor income taxes. This tax structure where initially capital income is confiscated and labor income is subsidized might be difficult to implement from a political perspective. Instead, a visionary politician may wants to move capital and labor income taxes - without confiscation or subsidy - to their optimal long run values from the implementation date of the reform onwards. We call this type of reform a "Vi-

sionary's View" - visionary in the sense of moving to the long run optimal taxes as soon as possible.

In figure (4) we show that welfare gains for the "Visionary's View" tax reform increase 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. Hence, relative welfare increases by roughly 35 percent. Moreover, observe that there are large differences in terms of welfare between the baseline and the "Visionary's View" reform in case of immediate implementation. These differences in welfare become very small if both reforms are pre-announced 4 years in advance. However, and more importantly, although welfare appears to be rather similar across all three 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 respectively 100 percent if the upper bound is imposed. By contrast, the Visionary's View reform moves straight to zero percent capital taxes. The loss of revenues is made up for by moderately higher steady state labor taxes of 30 percent compared to 28.6 percent respectively 28.4 percent for the baseline optimal tax reform with and without upper bounds on capital taxes.

Finally, we show that our results prevail qualitatively even if the government has no access to government debt.

2 Related Literature

Optimal taxation in a standard neoclassical growth model with homogenous agents is studied by many authors i.e., 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). Common to these papers is that they analyze optimal taxation with immediate implementation only. Typical results of this literature are the optimal zero steady state capital income tax as well as sizable welfare gains from the tax reform.

Domeij and Klein (2005) investigate an optimal immediate versus pre-announced labor and capital income tax reform in a standard neoclassical growth model. The authors find that the initial confiscation through initially very high capital income taxes decreases with pre-announcement and that welfare gains reduce by roughly one third with 4 years pre-announcement. In the light of the above optimal taxation literature, 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.

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 (2004) study the effects of tax reforms with useful public expenditures in an endogenous growth model. In their model, public expenditures contribute to human capital for-

mation as well provide utility. The authors compare the effects of optimal tax reforms with sub-optimal revenue-neutral tax reforms. 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 fiscal policy a dynamic general equilibrium 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.

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.

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 (1987a, 1987b) 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.

Trabandt and Uhlig (2006) analyze the short-run slopes of the US and EU-15 Laffer curves for immediate and pre-announced labor and capital tax cuts. They show 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 papers 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) and the present

paper show that the baseline optimal tax reform with immediate implementation (no phase-in) generates the highest gains. However, our "Visionary View" reform shows indeed that optimal tax rates should be implemented with pre-announcement (or be phased-in) since for this type of reform welfare gains increase with pre-announcement.

Dominguez (2006) analyzes the time-inconsistency of optimal capital income taxes. 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 1 year. Referring to the terminology that is used in the present paper, the institutional delay can also be interpreted as a 1 year pre-announcement of a capital tax change. Dominguez (2006) finds that debt restructuring together with the institutional delay enforces commitment of the government to the optimal tax reform. 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.

Our "Visionary's View" reform shares one dimension of one of the reform experiments in Chari, Christiano and Kehoe (1994), Domeij and Klein (2005) and Dominguez (2006). These authors analyze the case when the government imposes a constant zero capital income tax over time in case of an immediate reform. We depart from this work in two dimensions. First, we analyze the effects of pre-announcement of this type of tax reform. Second, we analyze the effects when the government sets both, capital and labor taxes to their optimal long run levels from the implementation date of the reform onwards.

To sum up, the contribution of the present paper is that we analyze and compare the implications of optimal immediate versus pre-announced capital income tax reforms under utility providing government consumption and productive public capital. In addition, we analyze the consequences of what we call a "Visionary's view" tax reform in which the government moves capital and labor income taxes to their long run optimal levels at the implementation of the reform.

3 The Model

We 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 we draw from the model in Baxter and King (1993).

3.1 The Economic Environment

Time is discrete, $t = 0, 1, ..., \infty$. 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, 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), we add consumption taxes to the model since they are an important part of government tax revenue in US data and thus help to calibrate the model. Note further that capital income taxes are levied on dividends net-of-depreciation as in Prescott (2004) and Mendoza, Tesar and Razin (1994).

The representative firm maximizes its profits subject to a Cobb-Douglas production technology,

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

s.t.

$$f_t(k_{t-1}, n_t, k_{t-1}^g, z_t) = k_{t-1}^{\theta_k} n_t^{\theta_n} (k_{t-1}^g)^{\theta_g} z_t \tag{2}$$

where k_{t-1}^g denotes the public capital stock that is provided by the government. Further, z_t denotes total factor productivity which we assume to be exogenous. Note that equilibrium profits of the firm will be zero as long as $\theta_k + \theta_n = 1$.

The government faces the following budget constraint,

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

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

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

At this point we 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}^g contributes to private production. A minor difference is the explicit introduction of consumption taxes for the reason given above.

3.2 The Pre-Ramsey Equilibrium

Given the economic environment, we are now ready to define a competitive or pre-Ramsey equilibrium.

Definition: A pre-Ramsey equilibrium consists of prices $\{w_t, d_t, q_t\}_{t=0}^{\infty}$, quantities $\{c_t, n_t, k_t, x_t\}_{t=0}^{\infty}$, technology $\{z_t\}_{t=0}^{\infty}$, profits $\{\Pi_t\}_{t=0}^{\infty}$ and fiscal policy $\{\tau_t^c, \tau_t^n, \tau_t^k, s_t, g_t, b_t, k_t^g, x_t^g\}_{t=0}^{\infty}$ such that (1) given prices, fiscal policy and profits, the household solves its maximization problem, (2)

given prices, fiscal policy and technology, the firm solves its maximization problem, (3) the aggregate resource constraint $c_t + g_t + x_t + x_t^g = f(k_{t-1}, n_t, k_{t-1}^g, z_t)$ 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 $\frac{1}{q_t} = R_{t+1} = 1 + (1 - \tau_{t+1}^k)(d_{t+1} - \delta)$.

3.3 Calibration and Parameterization

We calibrate the pre-Ramsey model to US data from 1975 to 2005. Time is taken to be annual. We set $\bar{\tau}_{pre}^c = 0.057$, $\bar{\tau}_{pre}^n = 0.235$ and $\bar{\tau}_{pre}^k = 0.514$ as in Jonsson and Klein (2005). Further, we set $\bar{g}_{pre}$ and $\bar{b}_{pre}$ such that $\bar{g}_{pre}/\bar{y}_{pre} = 0.162$ and $\bar{b}_{pre}/\bar{y}_{pre} = 0.509$ as in the data. Moreover, we fix $\bar{k}_{pre}$ and $\bar{k}_{pre}^g$ such that $\bar{k}_{pre}/\bar{y}_{pre} = 2.6$ 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) we specify preferences of the household as follows:

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

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

The parameter χ pins down the marginal rate of substitution between private and government consumption. Formally, $MRS_{g_{pre}, c_{pre}}^{model} = \frac{u_{g_{pre}}}{u_{c_{pre}}} = \chi \frac{\bar{c}_{pre}}{\bar{g}_{pre}}$. We set $\chi = 0.2443$ to obtain a marginal rate of substitution that is

equal to 1. This choice is within the estimated two standard deviation range of the implied $MRS_{g,c}^{data} \in [0.86, 1.73]$ in Amano and Wirjanto (1998).[1]

We 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, we fix $\theta_k = 0.36$ and $\theta_n = 0.64$ which is in line with i.e., Gomme and Rupert (2005) and Domeij and Klein (2005). Further, we normalize steady state technology to one. Finally, we set $\theta_g = \bar{x}^g/\bar{y} = 0.034$ as in Baxter and King (1993). Tables (1) and (2) summarize our calibration and parameterization.

4 Optimal Pre-Announced Tax Reforms

In this section, we set up and analyze the optimal baseline as well as the "Visionary's view" immediate and pre-announced capital and labor income tax reforms. For both reforms, we also consider the cases when the government has no access to government debt.

4.1 Modeling Pre-Announcement

Similar to Domeij and Klein (2005), we assume that the Ramsey planner is benevolent and has access to a commitment technology. The Ramsey

[1] From Amano and Wirjanto (1998) we 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 deviation ranges for the parameters are $\alpha \in [0.494, 0.778]$ and $\exp(\mu) \in [0.431, 0.571]$. From the data we obtain $\frac{\bar{c}}{\bar{g}} = 4.06$. These estimates result in the range for the $MRS_{g,c}^{data}$ given in the text.

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 $t = 0, .., T-1$ the government keeps the capital and labor income tax and at their pre-reform steady states. We can translate this into the following pre-announcement constraints for the Ramsey planner,

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

In order to obtain a non-trivial Ramsey problem in case of an immediate reform, we follow Domeij and Klein (2005) and fix the initial capital tax to its historical mean i.e. $\tau_0^k = \bar{\tau}_{pre}^k$ in case of an immediate ($T = 0$) capital and labor income tax reform.[2]

4.2 Baseline Ramsey Reform

It is convenient for the formulation of the baseline Ramsey problem that the government budget constraint can be rewritten as follows,[3]

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

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

[2]If 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, we 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).

[3]We obtain this by repeated substitution of government bonds in consecutive government budget constraints. Further, we impose the transversality condition $\lim_{t\to\infty} \prod_{i=0}^{t} q_i b_t = 0$ 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.

The Ramsey planner maximizes household utility subject to the pre-Ramsey equilibrium conditions and pre-announcement constraints. Formally,

$$max \sum_{t=0}^{\infty} \beta^t \Bigg[u(c_t, n_t, g_t) + \phi \frac{U_c(t)}{1+\tau_t^c} \left(Rev_t - g_t - s_t - k_t^g + (1-\delta_g) k_{t-1}^g \right)$$

$$-\mu_t \left(U_n(t)(1+\tau_t^c) + U_c(t)(1-\tau_t^n) f_{n,t} \right)$$

$$-\gamma_t \left(c_t + g_t + k_t + k_t^g - f_t(k_{t-1}, n_t, k_{t-1}^g, z_t) - (1-\delta) k_{t-1} - (1-\delta_g) k_{t-1}^g \right)$$

$$-\omega_t \left(Rev_t - \tau_t^c c_t - \tau_t^n f_{n,t} n_t - \tau_t^k (f_{k,t} - \delta) k_{t-1} \right)$$

$$-\eta_t \left(\beta \frac{U_c(t+1)}{1+\tau_{t+1}^c} \left((1-\tau_{t+1}^k)(f_{k,t+1} - \delta) + 1 \right) - \frac{U_c(t)}{1+\tau_t^c} \right) \Bigg] - \phi \frac{U_c(0)}{1+\tau_0^c} b_{-1}$$

$$- \sum_{t=0}^{T-1} \beta^t \nu_t \left(\tau_t^k - \bar{\tau}_{pre}^k \right) - \sum_{t=0}^{T-1} \beta^t \kappa_t \left(\tau_t^n - \bar{\tau}_{pre}^n \right).$$

Given the pre-announcement horizon T, the Ramsey planner solves for the sequences $\{c_t, n_t, k_t, g_t, k_t^g, Rev_t, \tau_t^n\}_{t=0}^{\infty}, \{\tau_t^k \mid \tau_0^k = \bar{\tau}_{pre}^k\}_{t=1}^{\infty}$ 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 $T \geq 1$. The Ramsey planner takes $\eta_{-1} = 0$, k_{-1} as well as τ_t^c, z_t and s_t at their pre-Ramsey steady states as given.[4]

[4]Note that in the light of Domeij and Klein (2005), the Ramsey planner in our model chooses optimal labor and capital income taxes leaving the consumption tax unchanged at its pre-Ramsey steady state. The consumption tax in our model serves as a calibration device for the pre-Ramsey

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

Appendix A summarizes the first order conditions for the pre-announcement Ramsey problem. We follow Domeij and Klein (2005) regarding the solution technique. Appendix B explains in detail how we solve the model.

Baseline Results

Table (3) provides a comparison of the data, the pre-Ramsey 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 pre-Ramsey steady state.[5] Note that these results are independent of the pre-announcement horizon.

By contrast, the steady state labor income tax rate 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 steady state but output increases by more so that the private and government consumption to output ratios decrease.

equilibrium. Moreover, 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, we leave the consumption tax at its pre-Ramsey value and solve for the optimal labor and capital income taxes as in Domeij and Klein (2005).

[5]This is due to the public capital share $\theta_g = 0.034$. If we i.e., assume $\theta_g = 0.05$ the Ramsey planner chooses a higher public capital stock than in the pre-Ramsey 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) we 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 our model. The figure reveals that government consumption is reduced initially before it smoothly converges towards a higher level than in the pre-Ramsey steady state. Interestingly, the transition path of government consumption is smooth throughout all pre-announcement horizons and thus, the government contributes to smooth individual 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 pre-Ramsey equilibrium. Hence, the existing pre-Ramsey 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 immediate and pre-announced tax reform for different pre-announcement horizons. We measure welfare in permanent private consumption equivalents. See appendix

C 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 losses of 25 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 by roughly 35 percent similar to Domeij and Klein (2005). Hence, for our baseline reform, valuable and productive government spending - as employed in our model - lead to higher absolute welfare gains and makes pre-announcement less costly in terms of relative welfare reductions.

The higher absolute welfare gain in our 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 loss of welfare 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 pathes for government consumption and public capital irrespective of the pre-announcement horizon and hence smoothes the welfare effects. Thus, for our baseline reform valuable and productive government spending leads to higher absolute welfare gains and makes pre-announcement less costly in relative terms.

Sensitivity

These 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 $\chi \in \{0.15; 0.35\}$. We 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 pre-Ramsey 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 our baseline optimal reform. Interestingly, if both the valuation of government consumption and the public capital share are high then pre-announcement can be almost as costly as in an economy without these ingredients.

To ensure further robustness of our results, we vary our two key parameters within the following intervals: $\theta_g \in (0, 0.2)$ and $\chi \in (0.1, 0.6)$. The case of $\theta_g = 0$ implies a non-productive government capital stock resulting in 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 public capital share relative to our 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 our solution algorithm appears to be sensitive to higher values of θ_g.[6] Nevertheless, we consider the

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

range $\theta_g \in (0, 0.2)$ as still reasonably large for a useful sensitivity analysis. Our alternative choices for χ imply marginal rates of substitutions between private and government consumption in the Pre-Ramsey steady state of $MRS^{Model}_{g_{pre},c_{pre}} \in (0.4, 2.45)$ which captures more than the two standard deviation range $MRS^{data}_{g,c} \in (0.86, 1.73)$ of the empirical estimate reported in Amano and Wirjanto (1998). Using these empirically reasonable parameter intervals, we did not find a single case in which pre-announcement is exactly as costly or even more costly than in an economy without valuable and productive government spending. From this, we conclude that valuable and productive government spending is likely to reduce the welfare losses from pre-announcement.

4.3 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) or Jones, Manuelli and Rossi (1993) analyze optimal immediate tax reforms with an upper bound on capital taxes - say 100 percent. In this case the Ramsey planner faces the following additional constraint:

$$\tau^k_t \leq 1 \quad \forall t = 0, .., \infty. \tag{7}$$

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 to accumulate an asset postion 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 lower the amount of periods 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 gains which are now 5.9 percent. However, the 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 falls 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 our 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.

4.4 "Visionary's View" Tax Reform

The baseline optimal tax reform is characterized by initially very high capital income taxes for immediate and pre-announced reforms as well as initially negative labor income taxes for immediate reforms. This tax structure where initially capital income is confiscated and labor income is subsidized might be difficult to implement from a political perspective. Instead, a visionary politician may wants to move capital and labor income taxes - without confiscation or subsidy - to their optimal long run values from the implementation date of the reform onwards.[7] We call this type of reform a "Visionary's View" - visionary in the sense of moving to the long run optimal taxes as soon as possible. We can translate this into the following additional constraints for the Ramsey planners problem in section 4.2,

$$\tau_t^k = \bar{\tau}_{Ramsey}^k \quad \text{and} \qquad \tau_t^n = \bar{\tau}_{Ramsey}^n \qquad \forall t = T, .., \infty. \tag{8}$$

This type of reform shares one dimension of one of the experiments in Chari, Christiano and Kehoe (1994), Domeij and Klein (2005) and Dominguez (2006). 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 reduces compared to the case when the government confiscates capital through a high initial capital income tax. However, both papers do consider the effects of this policy for an immediate reform only. Instead, we analyze the effects of pre-announcement of this type of tax re-

[7] I owe this variation to suggestions and discussions with seminar participants at Sveriges Riksbanks and especially Karl Walentin.

form. In addition, we consider the case that the government sets capital *and* labor taxes to their optimal long run Ramsey levels at the implementation date of the Ramsey tax reform.

Results "Visionary's View"

The column "Visionary's View" 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, we obtain the same private and government capital to output ratios. Since the government cannot confiscate capital through a high initial capital tax we 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 surpluses 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 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 reform.[8]

Figure (3) shows the transition of variables for the "Visionary's View" tax reform. Interestingly, the government prefers again a smooth pattern

[8]Technically, 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.

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 initial confiscation of capital anymore. 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 reduces 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 "Visionary's View" tax reform. The solid blue lines with squares show that 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. Hence, relative welfare increases 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 and hence a higher 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 net-asset position implies lower labor income taxes and therefore lower distortions. This in turn results in larger welfare gains for the pre-announced tax reform.

Moreover, notice that there are rather large differences between the level of welfare gains of the baseline and the "Visionary's View" 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 welfare appears to be rather similar across all three 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 respectively 100 percent if the upper bound is imposed. By contrast, the "Visionary's View" reform moves straight to zero percent capital taxes. The loss of revenues is made up for by moderately higher steady state labor taxes of 30 percent compared to 28.6 respectively 28.4 percent for the baseline optimal tax reform with and without upper bounds on capital taxes.

To sum up, this analysis shows that the mere existence of welfare losses from pre - announcement is due to the ability of the government to initially choose very high capital taxes and negative labor taxes. A government that chooses optimal constant long run taxes from the implementation date onwards generates sizable increases of welfare gains from pre-announcing the reform.

4.5 Pre-Announced Tax Reforms With Fixed Debt

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 we have considered the government accumulates a net asset position. Although this is a standard result in the optimal taxation literature with immediate implementation this 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 on government debt? That is, the government leaves the existing stock of government debt untouched at its pre-Ramsey steady state. Hence, we impose

$$b_t = \bar{b}_{pre} \qquad \forall t = 0, .., \infty. \tag{9}$$

Technically, the intertemporal government budget constraint in section 4.2 is replaced by its period-by-period version. In addition, we impose the constant debt requirement as well as the no-arbitrage condition. Formally,

$$\begin{aligned} g_t + s_t + k_t^g &= \tau_t^c c_t + \tau_t^n w_t n_t + \tau_t^k (\theta_k \frac{y_t}{k_{t-1}} - \delta) k_{t-1} + (1 - \delta_g) k_{t-1}^g \\ &\quad + ((1 + (1 - \tau_{t+1}^k)(\theta_k \frac{y_{t+1}}{k_t} - \delta))^{-1} - 1) \bar{b}_{pre} \end{aligned} \tag{10}$$

We study the effects of the fixed debt assumption for the baseline as well as for the "Visionary's View" tax reform.

Results Fixed Debt Reforms

Consider the column "Baseline/Visionary's View (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 lowers because output rises. Note however, that the rise in output is the lowest for all reforms.

Figures (6) and (7) show the transition of variables in response to the tax reforms.[9] And indeed, if government debt is fixed, the transition path of public capital and government consumption is not as smooth as before and depends 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 and public capital which in turn affects the transition of i.e. private consumption, hours and private capital.

Figure (8) shows the welfare effects for the baseline (dashed-dotted) as well as "Visionary's View" (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 "Vision-

[9]We do not report results when an upper bound is imposed on capital taxes. The upper bound only binds for $T = 0$ and then only for two periods. The changes of allocations are only minimal. Further, we changes in welfare gains are almost indistinguishable for $T = 0$ and identical for $T \geq 1$ to the baseline reform with fixed debt. These results make sense since the $\tau_0^k = \bar{\tau}_{pre}^k$ 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 be rather similar to the baseline reform and that's why we do not report them here.

ary's View" tax reform also generates welfare gains from pre-announcement. However, longer pre-announcement horizons are needed to obtain almost the same welfare gain than in the baseline reform with fixed debt. Nevertheless, our result that pre-announcement increases welfare gains in case of the "Visionary's View" tax reform prevails qualitatively even if the government has no access to government debt.

5 Conclusion

This paper has analyzed optimal immediate versus pre-announced capital and labor income tax reforms under valuable and productive government spending. Our baseline optimal reform reveals that these model ingredients result in a reduction of welfare losses that occur when the reform is announced before its implementation. In particular, we document that a baseline optimal tax reform that is pre-announced 4 years in advance leads to a 25 percent welfare loss compared to an immediately implemented optimal tax reform. In a model without valuable and productive government spending the relative welfare loss is roughly 35 percent for the same pre-announcement horizon. Hence, relative welfare losses reduce in the presence of utility providing government consumption and public capital. A sensitivity experiment reveals that if either the valuation of government consumption or the public capital share are low then pre-announcement is even less costly i.e., relative welfare reduces less than in our baseline case. Interestingly, if both the valuation of government consumption and the public capital share are high then pre-announcement can be almost as costly as in an economy without valuable and productive government spending. However,

a sensitivity analysis based on empirically reasonable parameter estimates reveals that we did not find a single case in which pre-announcement is exactly as costly or even more costly than in an economy without valuable and productive government spending. Hence, we conclude that valuable and productive government spending is likely to reduce the welfare losses from pre-announcement.

Further, the mere existence of welfare losses from pre-announcement is due to the ability of the government to initially choose very high capital taxes and negative labor taxes. A government that chooses optimal constant long run taxes from the implementation date onwards generates sizable welfare gains from pre-announcing the reform. In particular, we find that a 4 year pre-announced tax reform leads to welfare gains of roughly 35 percent compared to an immediately implemented reform. Moreover, we show that the level of welfare gains from this tax reform and the optimal baseline tax reform are very similar in case of a 4 years pre-announcement yet the underlying tax structures are very different. We argue that the "Visionary's View" reform is more easily implementable from a political perspective compared to the baseline optimal tax reform.

Finally, we document that our results prevail qualitatively even if the government has no access to government debt.

References

[1] Amano, R. A. and T. S. Wirjanto (1998): "Government Expenditures and the Permanent-Income Model", *Review of Economic Dynamics*, 1, 719-730.

[2] Aschauer (1989): "Is Public Expenditure Productive?", *Journal of Monetary Economics*, March 1989, 23, pp. 177-200.

[3] Atkeson, A. and V. V. Chari and P. J. Kehoe (1999): "Taxing Capital Income: A Bad Idea", *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol. 23, No. 3, Summer 1999, pp. 317

[4] Baxter, M. R. G. King (1993): "Fiscal Policy in General Equilibrium", *American Economic Review*, 83(3), 315-334.

[5] Cassou S. P. and K. J. Lansing (2004): "Tax Reform With Useful Public Expenditures", *forthcoming Journal of Public Economic Theory*.

[6] Chamley, C. (1986): "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives", *Econometrica*, Vol. 54, No. 3.

[7] Chari, V. V. and P. J. Kehoe (1999): "Optimal Fiscal and Monetary Policy", in J.B. Taylor and M.Woodford, eds., *Handbook of Macroeconomics*, Vol. 1. Amsterdam: North-Holland, 1999, pp. 1671745.

[8] Christiano L. J. and Eichenbaum, M. (1992): "Current Real-Business-Cycle Theories and Aggregate Labor-Market Fluctuations," *American Economic Review*, Vol. 82, No. 3, pp 430-50.

[9] Chari, V. V. and Christiano, L. J. and Kehoe, P. J. (1994): "Optimal Fiscal Policy in a Business Cycle Model", *Journal of Political Economy*, 102(4), 617-652.

[10] Cooley, T.F. and Prescott, E.C (1995): ”Economic Growth and Business Cycles”, *in Frontiers of Business Cycle Research (ed. Thomas F. Cooley)*, Princeton University Press.

[11] Domeij, D. and P. Klein (2005): ”Pre-Announced Optimal Tax Reform”, *Macroeconomic Dynamics*, 2005, 9(2), pp. 150-169.

[12] Dominguez, B. (2006): ”On The Time-Inconsistency of Optimal Capital Taxes”, *forthcoming Journal of Monetary Economics*.

[13] Erosa, A. and Gervais, M. (2001): ”Optimal Taxation in Infinitely-Lived Agent and Overlapping Generations Models: A Review”, *Economic Quarterly*, Federal Reserve Bank of Richmond, Volume 87/2.

[14] Gomme, P. and P. Rupert (2005): ”Theory, Measurement and Calibration of Macroeconomic Models”, *Federal Reserve Bank of Cleveland*, Working Paper 05-05.

[15] Hassler, J. and Krusell, P., and Storesletten K. and Zilibotti, F. (2004): ”On the Optimal Timing of Capital Taxes”, manuscript.

[16] House, C.L. and M. D. Shapiro (2006): ”Phased-In Tax Cuts and Economic Activity”, *forthcoming American Economic Review*.

[17] Jones, L. E. and R. E. Manuelli and P. E. Rossi (1993): ”Optimal Taxation in Models of Endogenous Growth”, *Journal of Political Economy*, Vol. 101, No. 3 (1993), 485-517.

[18] Jonsson, M. and P. Klein (2005): ”Accounting for the Relationship Between Money and Interest Rates” *forthcoming in Macroeconomic Dynamics*.

[19] Judd, K. L. (1985a): ”Redistributive Taxation in a Simple Perfect Foresight Model”, *Journal of Public Economics*, 28, 59-83.

[20] Judd, K. L. (1985b): ”Short-Run Analysis of Fiscal Policy in a Simple Perfect Foresight Model”, *Journal of Political Economy*, 93, No. 2, 298-319.

[21] Judd, K. L. (1987a): ”The Welfare Cost of Factor Taxation in a Perfect-Foresight Model”, *Journal of Political Economy*, 95, No. 4, 675-709.

[22] Judd, K. L. (1987b): ”A Dynamic Theory of Factor Taxation”, *American Economic Review Papers and Proceedings*, 77, No. 2, 42-48.

[23] Klein, P. and P. Krusell and J. V. Rios-Rull (2004): ”Time-Consistent Public Expenditures”, manuscript.

[24] Lansing, K. (1998): ”Optimal Fiscal Policy in a Business Cycle Mdoel with Public Capital”, *The Canadian Journal of Economics*, Vol. 31, No 2. (May, 1998), 337-364.

[25] Ljungqvist, L. and T. J. Sargent (2004): ”Recursive Macroeconomic Theory”, MIT Press, 2nd edition.

[26] Lucas, R. E. Jr. (1990): ”Supply-Side Economics: An Analytical Review”, *Oxford Economic Papers*, New Series, Vol. 42, No. 2, April 1990, 239-316.

[27] Marcet, A. and R. Marimon (1998): ”Recursive Contracts”, manuscript.

[28] McGrattan, E. R. (1994): ”The macroeconomic effects of distortionary taxation”, *Journal of Monetary Economics*, Volume 33, Issue 3,June 1994, Pages 573-601.

[29] McGrattan, E. R. and R. Rogerson R. (2004): ”Changes in Hours Worked, 1950-2000”, *Quarterly Review*, Federal Reserve Bank of Minneapolis, July 2004.

[30] Mendoza, E. G. and Razin, A. and Tesar, L. L. (1994): ”Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption”, *Journal of Monetary Economics*, December.

[31] Prescott, E. C. (2004): ”Why do Americans Work so Much More Than Europeans?”, *Quarterly Review*, Federal Reserve Bank of Minneapolis, July 2004.

[32] Trabandt, M. and H. Uhlig (2006): ”How Far Are We From The Slippery Slope? The Laffer Curve Revisited”, manuscript.

Table 1: Calibration of the Pre-Ramsey Model

Variable	Value	Description	Restriction
$\bar{\tau}^n_{pre}$	0.235	Labor tax rate	Data
$\bar{\tau}^k_{pre}$	0.514	Capital tax rate	Data
$\bar{\tau}^c_{pre}$	0.057	Consumption tax rate	Data
$\bar{g}_{pre}/\bar{y}_{pre}$	0.162	Government consumption to output ratio	Data
$\bar{b}_{pre}/\bar{y}_{pre}$	0.509	Government debt to output ratio	Data
$\bar{k}_{pre}/\bar{y}_{pre}$	2.6	Private Capital to output ratio	Data
$\bar{k}^g_{pre}/\bar{y}_{pre}$	0.6	Public Capital to output ratio	Data

Table 2: Parameterizing the Pre-Ramsey Model

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	$\frac{u_{g_{pre}}}{u_{c_{pre}}} = 1$
σ	1.00	Det. intertemp. elast. of subst.	$-\frac{u_c}{u_{cc}\bar{c}_{pre}} = 1$
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
$\bar{z}_{pre}$	1.00	Technology (Normalization)	-
δ	0.0542	Depreciation rate of private capital	Data
δ_g	0.0567	Depreciation rate of public capital	Data

Table 3: Data, Pre-Ramsey and Ramsey reform steady states.

Variable	Data	Pre-Ramsey	Ramsey Reforms						
			Baseline		Baseline (τ^k Bound)		Visionary's View		Baseline/Visionary's View (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
$\bar{k}^g/\bar{y}$	0.60	0.60	0.348		0.348		0.348		0.348
			$T=0$	$T=4$	$T=0$	$T=4$	$T=0$	$T=4$	
$\bar{\tau}^n$	0.235	0.235	0.239	0.284	0.276	0.286	0.318	0.301	0.348
$\bar{b}/\bar{y}$	0.509	0.509	-1.185	-0.503	-0.626	-0.480	0.004	-0.248	0.459
$\bar{c}/\bar{y}$	0.675	0.663	0.627	0.628	0.628	0.628	0.629	0.629	0.630
$\bar{g}/\bar{y}$	0.162	0.162	0.148	0.147	0.147	0.147	0.146	0.147	0.145
$\bar{n}$	0.25	0.25	0.260	0.248	0.250	0.247	0.239	0.243	0.230
$\bar{y}$	-	0.397	0.500	0.476	0.480	0.475	0.457	0.467	0.440

The table provides a comparison of the data, the pre-Ramsey steady state and the Ramsey 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 for capital taxes. "Visionary's View" is the reform when the government chooses optimal constant long run taxes 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.

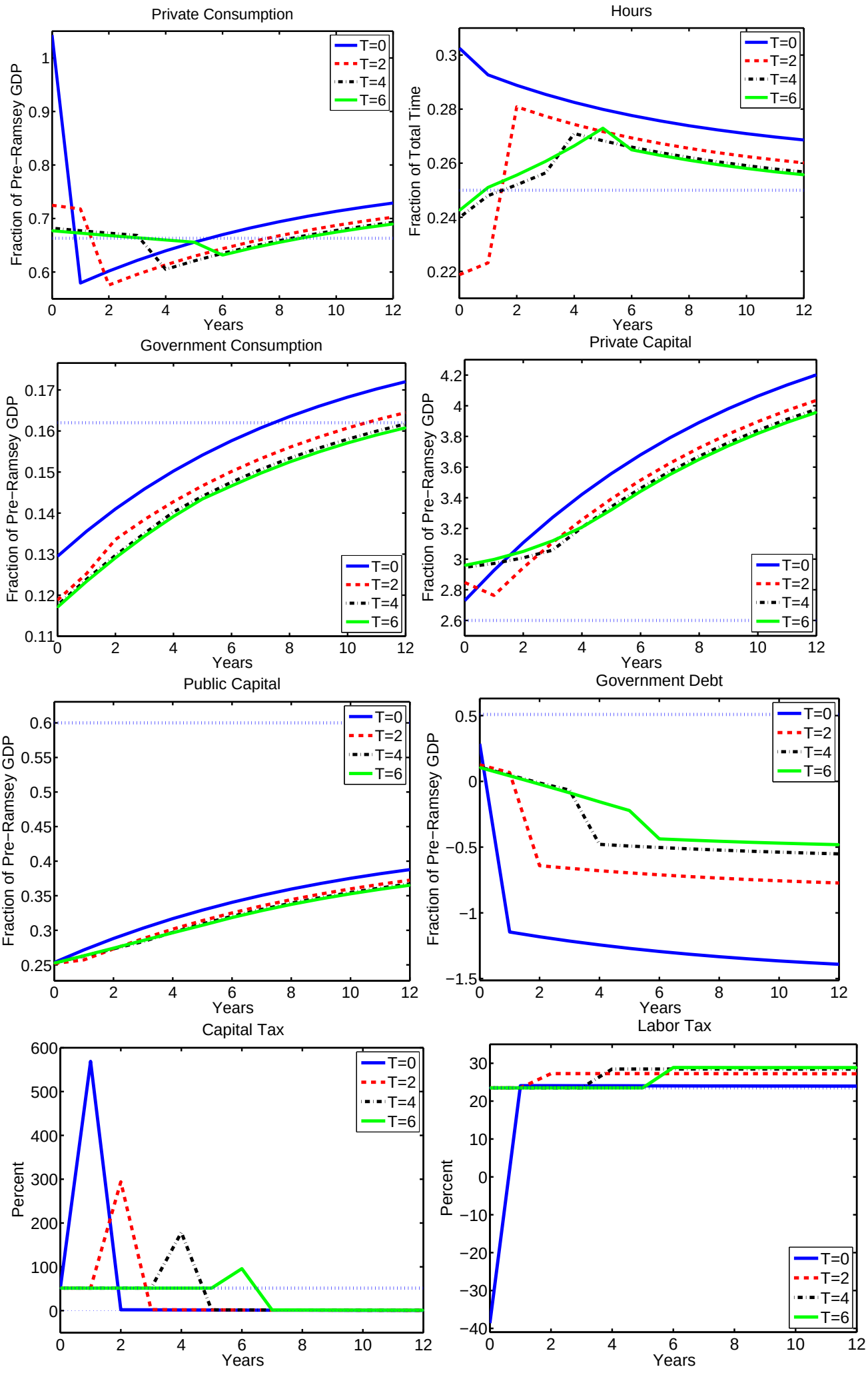

Figure 1: Baseline tax reform for different pre-announcement periods. (horizontal line: pre-Ramsey steady state).

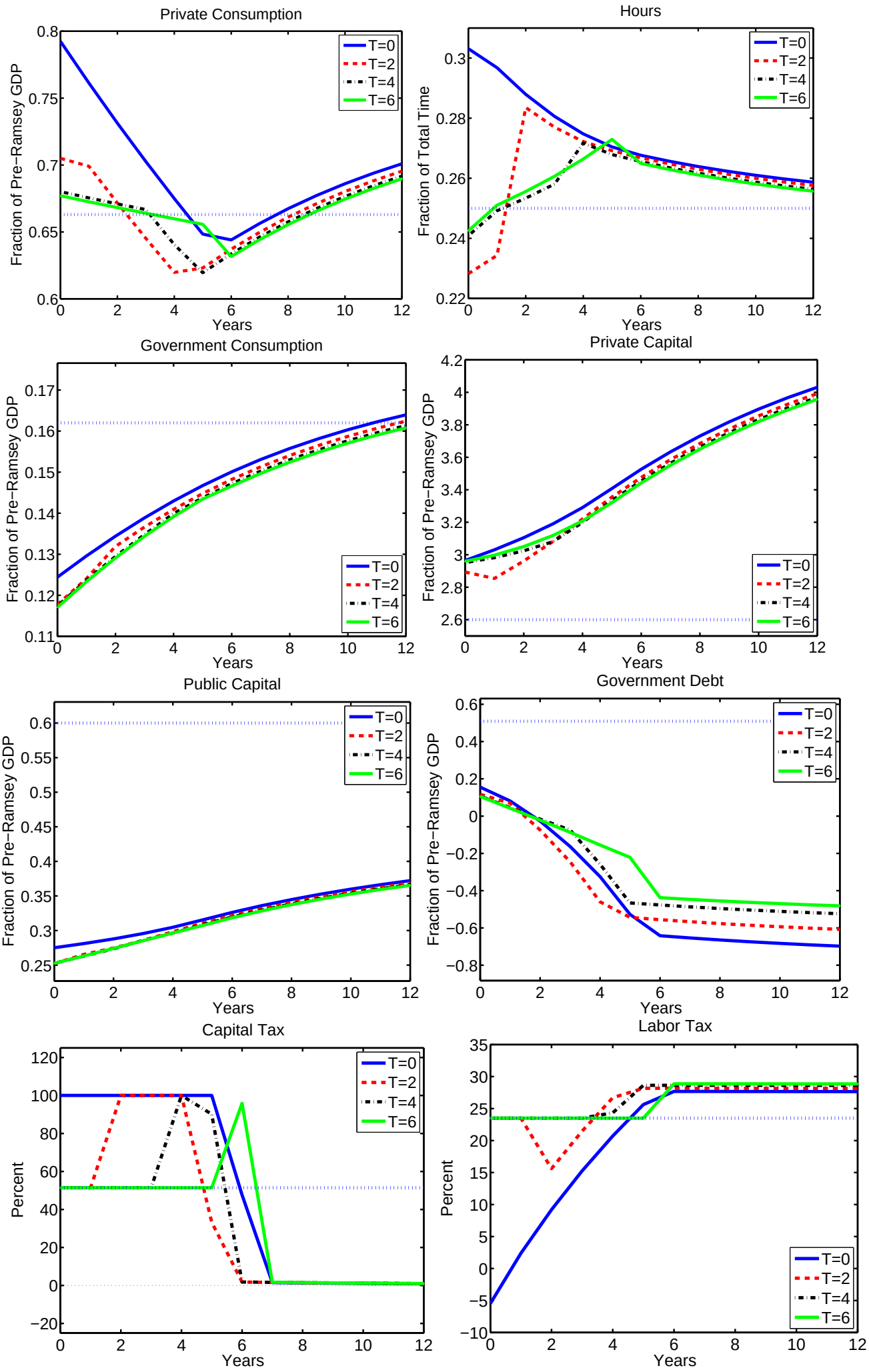

Figure 2: Baseline tax reform with upper bound for capital taxes for different pre-announcement periods. (horizontal line: pre-Ramsey steady state).

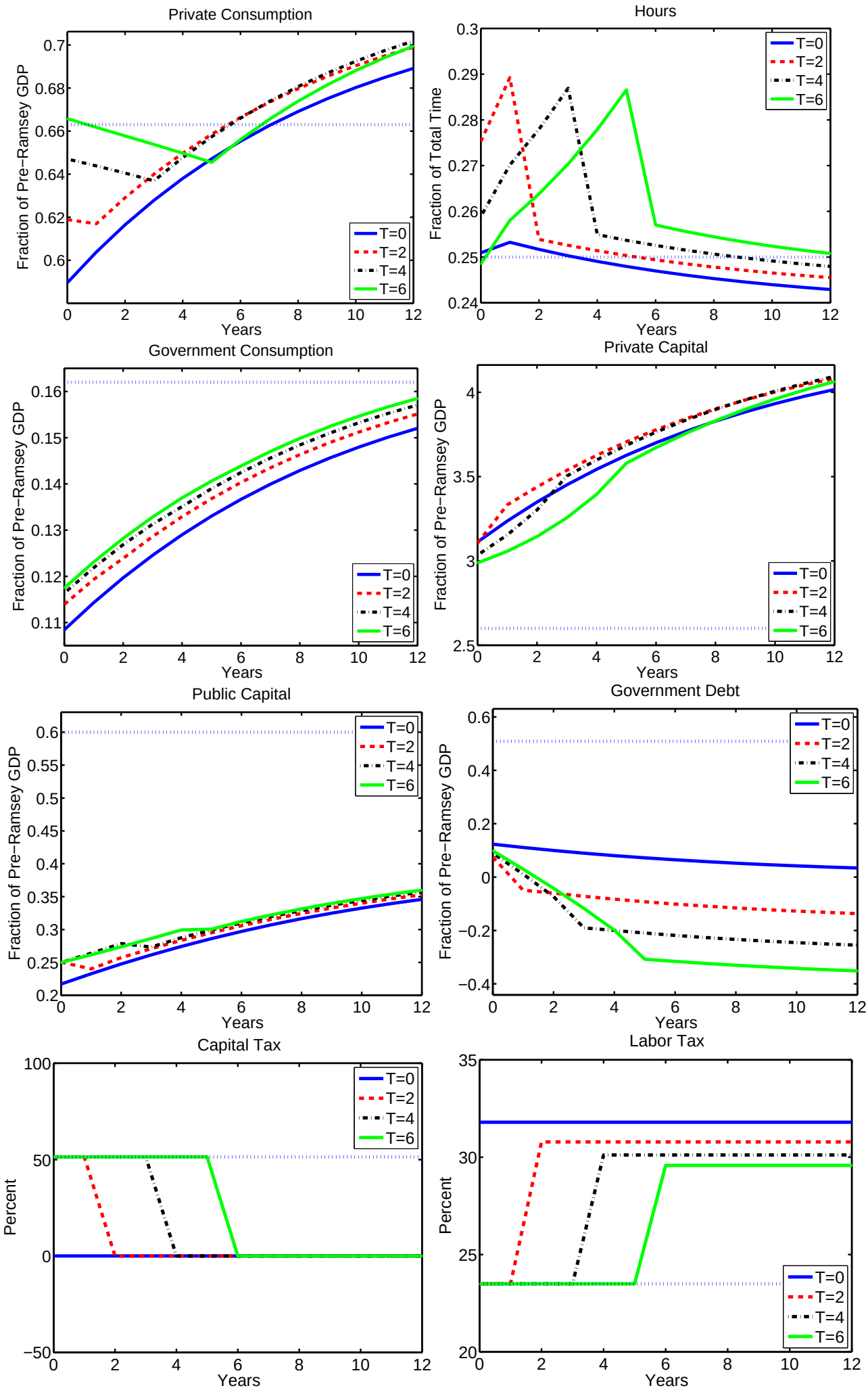

Figure 3: ”Visionary’s View” tax reform for different pre-announcement periods. (horizontal line: pre-Ramsey steady state).

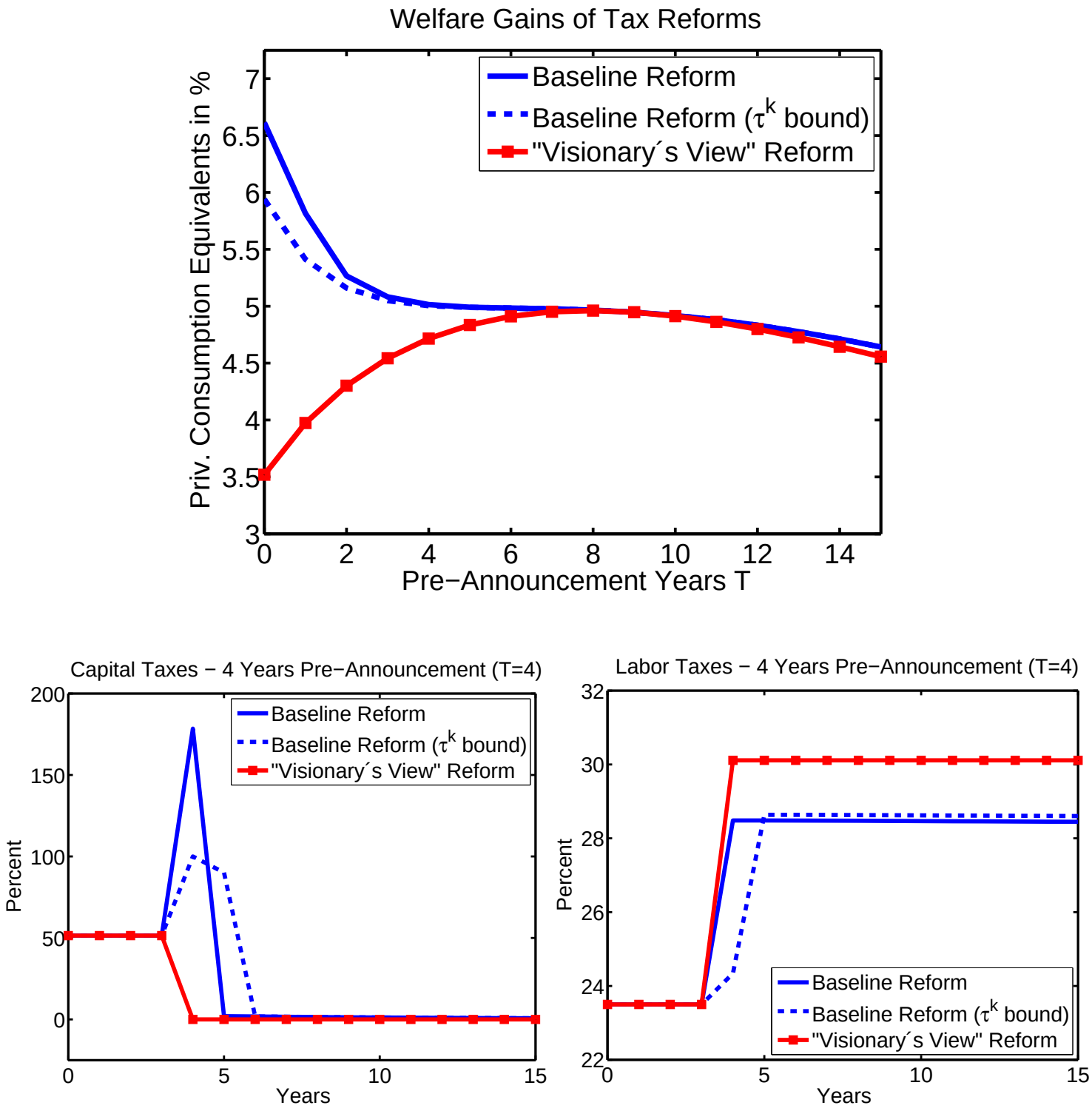

Figure 4: The upper panel plots welfare gains measured in permanent increases of private consumption for the baseline tax reform, the baseline tax reform with an upper bound on capital taxes as well as for the "Visionary's view" tax reform. In the latter reform, the government chooses optimal constant 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.

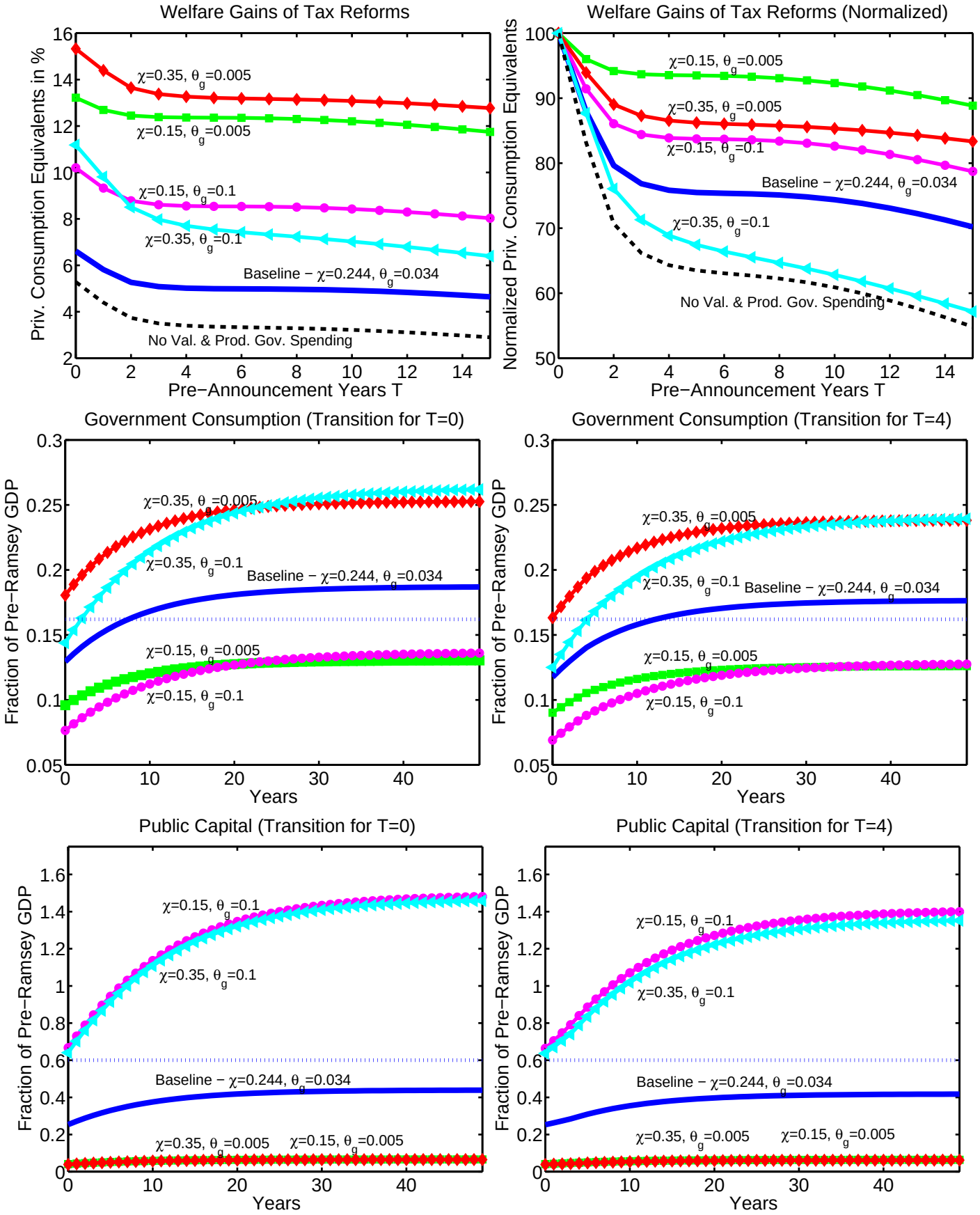

Figure 5: Sensitivity analysis: the upper panel plots the level of welfare gains as well as the normalized welfare gains (T=0 equals 100) from the baseline tax reform for different pre-announcement periods. "No Val. & Prod. Gov. Spending" corresponds to a model with no valuation and fixed government 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 is the pre-Ramsey steady state.

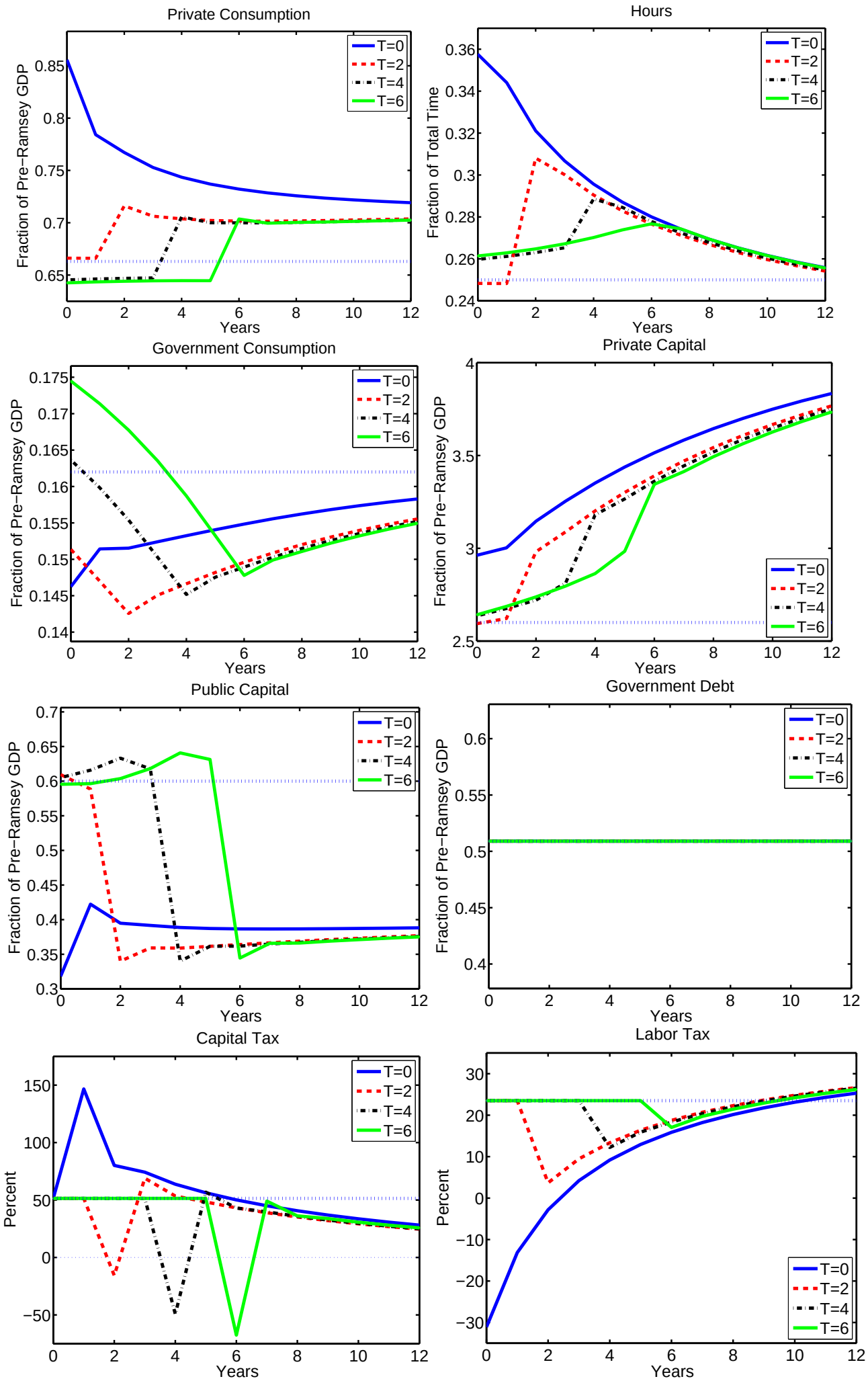

Figure 6: Baseline tax reform with fixed debt and different pre-announcement periods. (horizontal line: pre-Ramsey steady state).

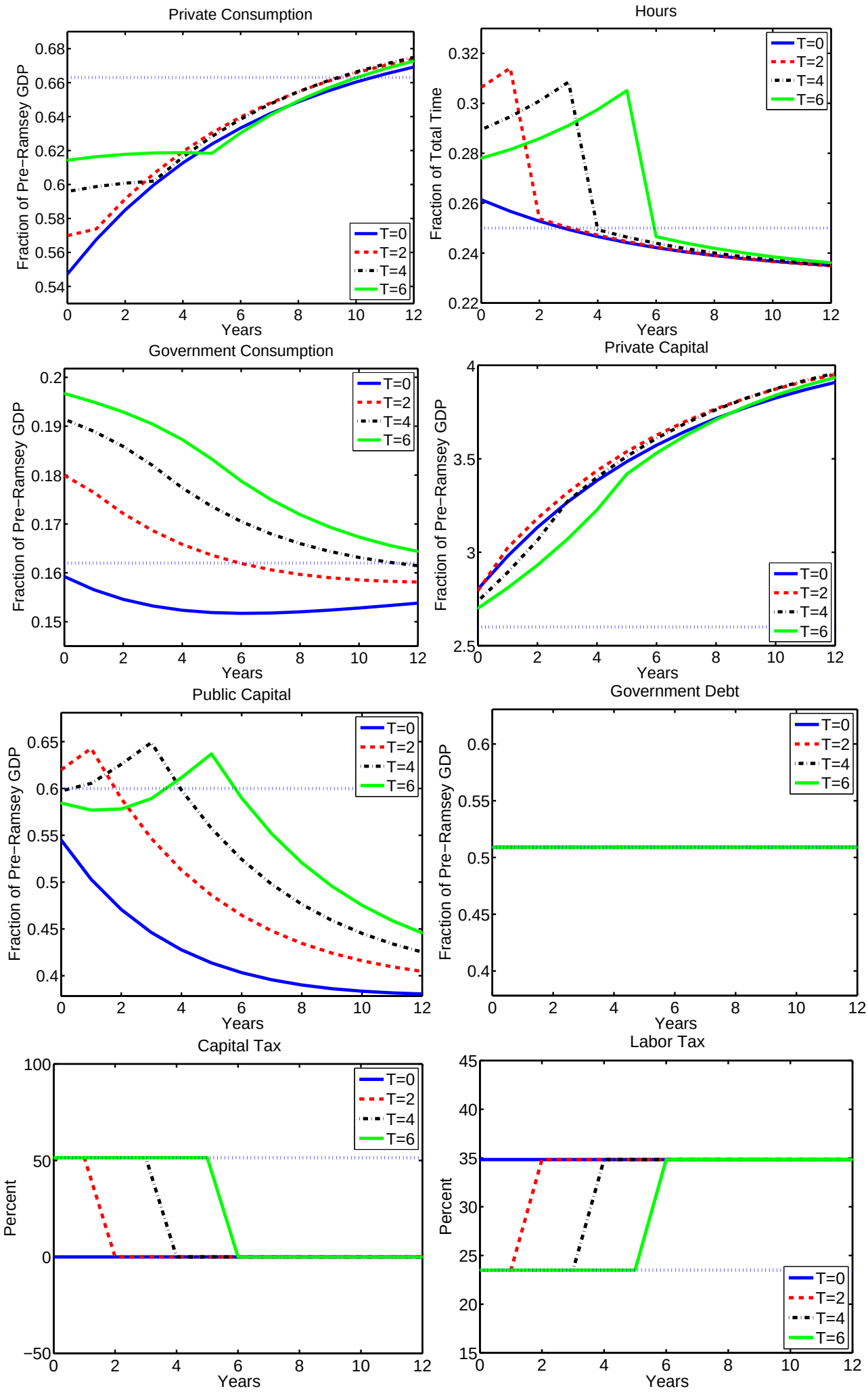

Figure 7: "Visionary's View" tax reform with fixed debt and different pre-announcement periods. (horizontal line: pre-Ramsey steady state).

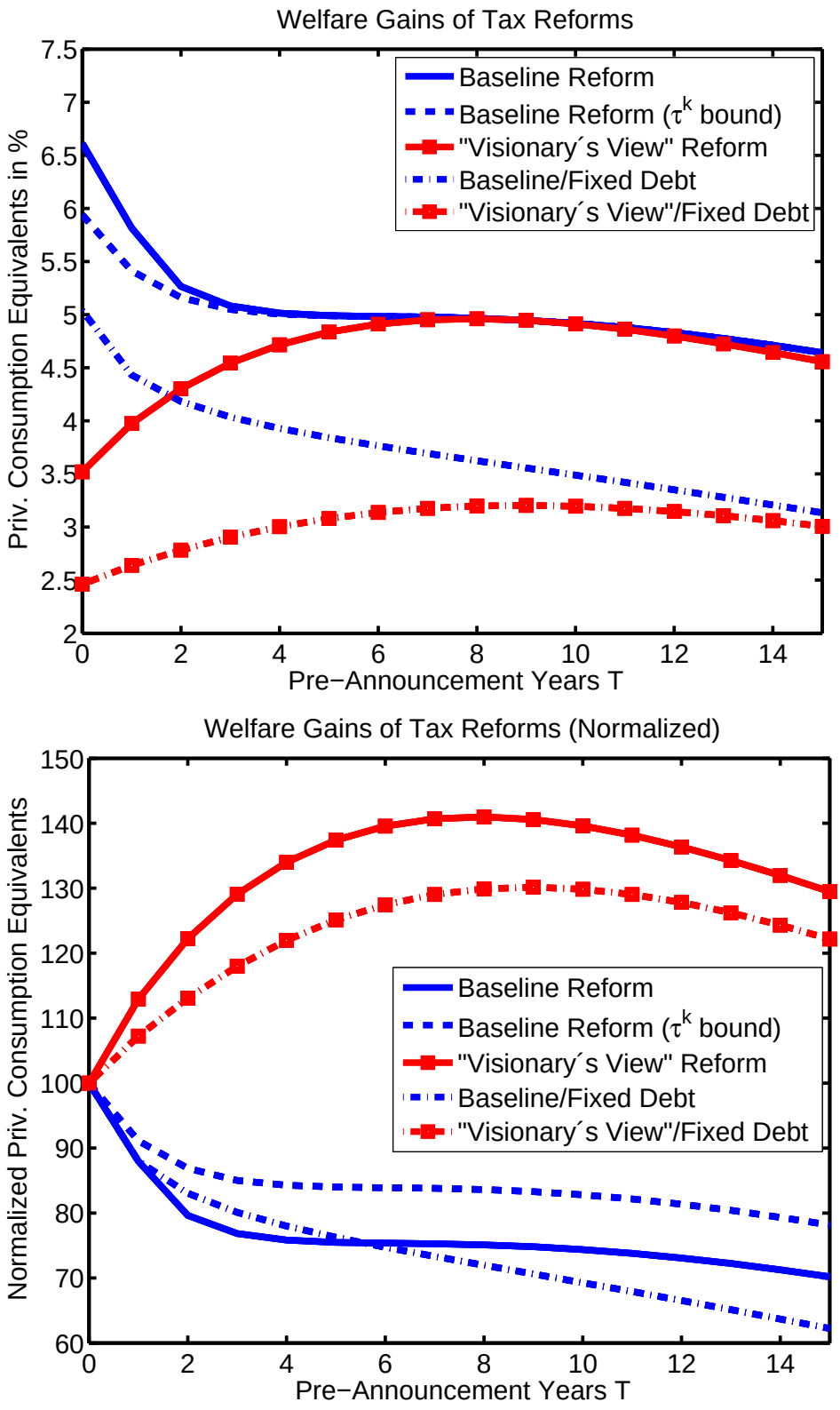

Figure 8: The upper panel plots welfare gains measured in permanent increases of private consumption for the baseline tax reform, the baseline tax reform with an upper bound on capital taxes as well as for the "Visionary's view" tax reform (with variable as well as fixed debt). The lower panel plots welfare gains where we have normalized consumption equivalents to 100 for $T = 0$ in all reforms that we consider.

Appendix

A Ramsey Problem - First Order Conditions

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

$$\begin{aligned} c_t: \quad & U_c(t) + \phi \frac{U_{cc}(t)}{1+\tau_t^c}\left(Rev_t - g_t - s_t - k_t^g + (1-\delta_g)k_{t-1}^g\right) \\ & -\mu_t\left(U_{nc}(t)(1+\tau_t^c) + (1-\tau_t^n)U_{cc}(t)f_{n,t}\right) - \gamma_t + \omega_t\tau_t^c \\ & +\eta_t\frac{U_{cc}(t)}{1+\tau_t^c} - \eta_{t-1}\frac{U_{cc}(t)}{1+\tau_t^c}\Big((1-\tau_t^k)(f_{k,t}-\delta)+1\Big) = 0 \end{aligned} \tag{11}$$

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

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

$$\begin{aligned} k_t: \quad & -\mu_{t+1}\beta(1-\tau_{t+1}^n)U_c(t+1)f_{nk,t+1} - \gamma_t + \gamma_{t+1}\beta\left(f_{k,t+1}+1-\delta\right) \\ & +\omega_{t+1}\beta\Big(\tau_{t+1}^n f_{nk,t+1}n_{t+1} + \tau_{t+1}^k f_{kk,t+1}k_t + \tau_{t+1}^k(f_{k,t+1}-\delta)\Big) \\ & -\beta\eta_t\frac{U_c(t+1)}{1+\tau_{t+1}^c}(1-\tau_{t+1}^k)f_{kk,t+1} = 0 \end{aligned} \tag{14}$$

$$Rev_t: \quad \phi\frac{U_c(t)}{1+\tau_t^c} - \omega_t = 0 \tag{15}$$

$$k_t^g: \quad -\phi\frac{U_c(t)}{1+\tau_t^c}+\beta\phi\frac{U_c(t+1)}{1+\tau_t^c}(1-\delta_g)-\mu_{t+1}\beta(1-\tau_{t+1}^n)U_c(t+1)f_{nk^g,t+1}$$
$$-\gamma_t+\beta\gamma_{t+1}(f_{k^g,t+1}+1-\delta_g)+\beta\omega_{t+1}(\tau_{t+1}^n f_{nk^g,t+1}n_{t+1}+\tau_{t+1}^k k_t f_{kk^g,t+1})$$
$$-\eta_t\beta\frac{U_c(t+1)}{1+\tau_{t+1}^c}(1-\tau_{t+1}^k)f_{kk^g,t+1}=0 \tag{16}$$

$$\tau_t^k: \quad \omega_t(f_{k,t}-\delta)k_{t-1}+\eta_{t-1}\frac{U_c(t)}{1+\tau_t^c}(f_{k,t}-\delta)=0 \tag{17}$$

$$\tau_t^n: \quad \mu_t U_c(t)f_{n,t}+\omega_t f_{n,t}n_t=0 \tag{18}$$

$$\eta_t: \quad \beta\frac{U_c(t+1)}{1+\tau_{t+1}^c}\Big((1-\tau_{t+1}^k)(f_{k,t+1}-\delta)+1\Big)-\frac{U_c(t)}{1+\tau_t^c}=0 \tag{19}$$

$$\mu_t: \quad U_n(t)(1+\tau_t^c)+U_c(t)(1-\tau_t^n)f_{n,t}=0 \tag{20}$$

$$\gamma_t: \quad c_t+g_t+k_t+k_t^g-f_t(k_{t-1},n_t,k_{t-1}^g,z_t)-(1-\delta)k_{t-1}$$
$$-(1-\delta_g)k_{t-1}^g=0 \tag{21}$$

$$\omega_t: \quad Rev_t-\tau_t^c c_t-\tau_t^n f_{n,t}n_t-\tau_t^k(f_{k,t}-\delta)k_{t-1}=0 \tag{22}$$

$$\phi: \quad \sum_{t=0}^{\infty}\beta^t\frac{U_c(t)}{1+\tau_t^c}\left[Rev_t-g_t-s_t-k_t^g+(1-\delta_g)k_{t-1}^g\right]-\frac{U_c(0)}{1+\tau_0^c}b_{-1}=0 \tag{23}$$

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

$c_t, g_t, n_t, k_t, Rev_t, k_t^g, \eta_t, \mu_t, \gamma_t, \omega_t, \phi$: equations (11) to (16) as well as equations (19) to (23). In addition, the following first order conditions need to be changed to

$$\tau_t^k: \qquad \omega_t(f_{k,t}-\delta)k_{t-1} + \eta_{t-1}\frac{U_c(t)}{1+\tau_t^c}(f_{k,t}-\delta) - \nu_t = 0 \tag{24}$$

$$\tau_t^n: \qquad \mu_t U_c(t) f_{n,t} + \omega_t f_{n,t} n_t - \kappa_t = 0 \tag{25}$$

$$\nu_t: \qquad \tau_t^k - \bar{\tau}_{pre}^k = 0 \tag{26}$$

$$\nu_t: \qquad \tau_t^n - \bar{\tau}_{pre}^n = 0 \tag{27}$$

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

$k_t, Rev_t, k_t^g, \eta_t, \mu_t, \gamma_t, \omega_t, \phi, \tau_t^k, \tau_t^n, \nu_t, \kappa_t$: equations (14) to (16) as well as equations (19) to (23) and equations (24) to (27). Now, the following first order conditions need to be adjusted.

$$\begin{aligned} c_t: \qquad & U_c(t) + \phi\frac{U_{cc}(t)}{1+\tau_t^c}\left(Rev_t - g_t - s_t - k_t^g + (1-\delta_g)k_{t-1}^g\right) \\ & -\mu_t\left(U_{nc}(t)(1+\tau_t^c) + (1-\tau_t^n)U_{cc}(t)f_{n,t}\right) - \gamma_t + \omega_t\tau_t^c \\ & +\eta_t\frac{U_{cc}(t)}{1+\tau_t^c} - \eta_{t-1}\frac{U_{cc}(t)}{1+\tau_t^c}\left((1-\tau_t^k)(f_{k,t}-\delta)+1\right) - \phi\frac{U_{cc}(0)}{1+\tau^c(0)}b_{-1} = 0 \end{aligned} \tag{28}$$

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

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

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 (28) to (30), equations (14) to (16), equation (18), equations (19) to (23).

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

B Solution Method for the Ramsey Model

We follow Domeij and Klein (2005) regarding the solution technique. In particular, we make the system of equations derived in appendix A finite dimensional by assuming that the economy converges to the Ramsey steady state in finitely many periods. For the moment we choose 100 years as the finite time horizon. This implies that if time starts in $t = 0$ we know the terminal values of our state variables in period $t = 99$ i.e.,

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

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 are not longer required. This leaves us with a system of highly non-linear equations with as many equations as unknowns which we can solve with non-linear numerical solver.

In particular, using the derivations of appendix A for i.e., $T = 0$, we guess a value for the multiplier ϕ and then solve for the sequences

$$\{c_t, n_t, g_t, Rev_t, \tau^n_t, \mu_t, \gamma_t, \omega_t\}^{99}_{t=0}, \{\tau^k_t\}^{99}_{t=1} \text{ and } \{k_t, k^g_t, \eta_t\}^{98}_{t=0}$$

knowing that $k_{99} = \bar{k}_{Ramsey}$, $k^g_{99} = \bar{k}^g_{Ramsey}$ and $\eta_{99} = \bar{\eta}_{Ramsey}$. Hence, we have $8 \times 100 + 1 \times 99 + 3 \times 99$=1196 unknown variables. Given ϕ, appendix A shows that for $T = 0$ in period 0 there are 11 equations and for periods $t = 1, .., 99$ 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. We solve the system of non-linear equations using the `fsolve.m` function of `MATLAB` with a solution precision of $1e - 8$.

Finally, we check whether the intertemporal government budget constraint is satisfied with a precision of $1e-6$. If not, we update ϕ and repeat calculations until the desired solution precision is achieved.

C Welfare Calculations

In order to evaluate welfare consequences of the tax reforms we calculate permanent private consumption equivalents $\triangle_c$ that make the household indifferent between the pre-Ramsey and Ramsey allocation.

In the presence of transitional dynamics, private consumption equivalents $\triangle_c^*$ can be calculated as:

$$\sum_{t=0}^{\infty} \beta^t u\left((1+\triangle_c^*)\bar{c}_{pre}, \bar{n}_{pre}, \bar{g}_{pre}\right) = \sum_{t=0}^{\infty} \beta^t u\left(c_{t,Ramsey}, n_{t,Ramsey}, g_{t,Ramsey}\right) \tag{31}$$

Given the preference specification of section 3.3 we can explicitly solve for private consumption equivalents that take transitional dynamics into account. Formally,

$$\triangle_c^* = \begin{cases} \exp[\frac{(1-\beta)(u_{Ramsey}^{trans} - u_{pre}^{ss})}{\alpha}] - 1 & \text{for } \sigma = 1 \\ \left(\frac{(1-\sigma)(1-\beta)u_{Ramsey}^{trans}+1}{(1-\sigma)(1-\beta)u_{pre}^{ss}+1}\right)^{\alpha(\sigma-1)} - 1 & \text{for } \sigma \neq 1 \end{cases} \tag{32}$$

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