How Far Are We From The Slippery Slope? The Laffer Curve Revisited☆

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Abstract

We characterize Laffer curves for labor and capital income taxation quantitatively for the US, the EU-14 and individual European countries by comparing the balanced growth paths of a neoclassical growth model featuring "constant Frisch elasticity" (CFE) preferences. We derive properties of CFE preferences. We provide new tax rate data. For benchmark parameters, we find that the US can increase tax revenues by 30% by raising labor taxes and by 6% by raising capital income taxes. For the EU-14 we obtain 8% and 1%. Denmark and Sweden are on the wrong side of the Laffer curve for capital income taxation. A dynamic scoring analysis shows that 54% of a labor tax cut and 79% of a capital tax cut are self-financing in the EU-14. These results do not appear to change much when household heterogeneity is considered. However, transition effects matter: a permanent surprise increase in capital income taxes always raises tax revenues for the benchmark calibration. Finally, endogenous growth and human capital accumulation locates the US and EU-14 close to the peak of the labor income tax Laffer curve.

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1. Introduction

How do tax revenues and production adjust, if labor or capital income taxes are changed? To answer this question, we characterize the Laffer curves for labor and capital income taxation quantitatively for the US, the EU-14 aggregate economy[1] and individual Eurothe degree of valuation of course. However, an explicit welfare analysis is beyond the scope of this paper and not its point: rather, the impact on government tax receipt is the focus here, as this surely a question of considerable practical interest.

Following Mankiw and Weinzierl (2005), we pursue a dynamic scoring exercise. That is, we analyze by how much a tax cut is self-financing if we take incentive feedback effects into account. We find that for the US model 32% of a labor tax cut and 51% of a capital tax cut are self-financing in the steady state. In the EU-14 economy 54% of a labor tax cut and 79% of a capital tax cut are self-financing.

We show that the fiscal effect is indirect: by cutting capital income taxes, the biggest contribution to total tax receipts comes from an increase in labor income taxation. We show that lowering the capital income tax as well as raising the labor income tax results in higher tax revenue in both the US and the EU-14, i.e. in terms of a "Laffer hill", both the US and the EU-14 are on the wrong side of the peak with respect to their capital tax rates.

These results do not appear to change much with considerations of households heterogeneity. However, transition effects matter: a permanent surprise increase in capital income taxes always raises tax revenues for the benchmark calibration. Finally, endogenous growth and human capital accumulation locates the US and EU-14 close to the peak of the labor income tax Laffer curve. As labor taxes are increased, incentives to enjoy leisure are increased, which in turn decreases the steady state level of human capital or the growth rate of the economy: tax revenues fall as a result.

There is a considerable literature on this topic, but our contribution differs from the existing results in several dimensions. Baxter and King (1993) employ a neoclassical growth model with productive government capital to analyze the effects of fiscal policy. Garcia-Mila et al. (2001) use a neoclassical growth model with heterogeneous agents to study the welfare impacts of alternative tax schemes on labor and capital.

Lindsey (1987) has measured the response of taxpayers to the US tax cuts from 1982 to 1984 empirically, and has calculated the degree of self-financing. Schmitt-Grohe and Uribe (1997) show that there exists a Laffer curve in a neoclassical growth model, but focus on endogenous labor taxes to balance the budget, in contrast to the analysis here. Ireland (1994) shows that there exists a dynamic Laffer curve in an AK endogenous growth model framework, with their results debated in Bruce and Turnovsky (1999), Novales and Ruiz (2002) and Agell and Persson (2001). In an overlapping generations framework, Yanagawa and Uhlig (1996) show that higher capital income taxes may lead to faster growth, in contrast to the conventional economic wisdom. Floden and Linde (2001) contains a Laffer curve analysis. Jonsson and Klein (2003) calculate the total welfare costs of distortionary taxes including inflation. They find them to be five times higher in Sweden than the US, and that Sweden is on the slippery slope side of the Laffer curve for several tax instruments. Our results are in line with these findings, with a sharper focus on the location and quantitative importance of the Laffer curve with respect to labor and capital income taxes.

Our paper is closely related to Prescott (2002, 2004), who raised the issue of the incentive effects of taxes by comparing the effects of labor taxes on labor supply for the US and

European countries. We broaden that analysis here by including incentive effects of labor and capital income taxes in a general equilibrium framework with endogenous transfers. His work has been discussed by e.g. Ljungqvist and Sargent (2006), Blanchard (2004) as well as Alesina et al. (2005). The dynamic scoring approach of Mankiw and Weinzierl (2005) has been discussed by Leeper and Yang (2005).

Like Baxter and King (1993), McGrattan (1994), Lansing (1998), Cassou and Lansing (2006), Klein et al. (2004) as well as Trabandt (2007), we assume that government spending may be valuable only insofar as it provides utility separably from consumption and leisure.

The paper is organized as follows. We specify the model in section 2 and its parameterization in section 3. Section 4 discusses our results. Endogenous growth, human capital accumulation, household heterogeneity and transition issues are considered in section 5. Further details are contained in the appendix as well as in a technical appendix.

2. The Model

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

$$max_{c_t,n_t,k_t,x_t,b_t} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t, n_t) + v(g_t)\right]$$

s.t.

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

where c_t, n_t, k_t, x_t, b_t, m_t denote consumption, hours worked, capital, investment, government bonds and an exogenous stream of payments. The household takes government consumption g_t, which provides utility, as given. Further, the household receives wages w_t, dividends d_t, profits Π_t from the firm and asset payments m_t. Moreover, the household obtains interest earnings R_t^b and lump-sum transfers s_t from the government. The household has to pay consumption taxes τ_t^c, labor income taxes τ_t^n and capital income taxes τ_t^k. Note that capital income taxes are levied on dividends net-of-depreciation as in Prescott (2002, 2004) and in line with Mendoza et al. (1994).

Note that our tax system is affine-linear (with the intercept given by the transfers). For most of the paper, we ignore heterogeneity and progressivity in the tax code. Thus, a change in τ^n may be considered to be a particular, and empirically unusual, change to labor taxes overall. We take up the issue of agent heterogeneity and tax progressivity in subsection 5.2.

Note further that we assume there to be an asset ("tree"), paying a constant stream of payments m_t, growing at the balanced growth rate of the economy. We allow the payments to be negative and thereby allow the asset to be a liability. This feature captures a permanently negative or positive trade balance, equating m_t to net imports, and introduces international trade in a minimalist way. As we shall concentrate on balanced growth path equilibria, this model is therefore consistent with an open-economy interpretation with source-based capital income taxation, where the rest of the world grows at the same rate and features households with the same time preferences. Indeed, the trade balance plays a role in the reaction of steady state labor to tax changes and therefore for the shape of the Laffer curve. For transitional issues, additional details become relevant. Our model is a closed economy. Labor immobility between the US and the EU-14 is probably a good approximation. For capital, this may be justified with the Feldstein and Horioka (1980) observation that domestic saving and investment are highly correlated. For explicit tax policy in open economies, see e.g Mendoza and Tesar (1998) or Kim and Kim (2004) and the references therein.

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

$$max_{k_{t-1},n_t} \quad y_t - d_t k_{t-1} - w_t n_t \tag{1}$$

s.t.

$$y_t = \xi^t k_{t-1}^{\theta} n_t^{1-\theta} \tag{2}$$

where ξ^t denotes the trend of total factor productivity.

The government faces the budget constraint,

$$g_t + s_t + R_t^b b_{t-1} = b_t + T_t \tag{3}$$

where government tax revenues T_t are

$$T_t = \tau_t^c c_t + \tau_t^n w_t n_t + \tau_t^k (d_t - \delta) k_{t-1}. \tag{4}$$

Our goal is to analyze how the equilibrium shifts, as tax rates are shifted. We focus on the comparison of balanced growth paths. Assume that

$$m_t = \psi^t \bar{m} \tag{5}$$

where ψ is the growth factor of aggregate output. Our key assumption is that government debt as well as government spending do not deviate from their balanced growth pathes, i.e.

$$b_{t-1} = \psi^t \bar{b} \tag{6}$$

and

$$g_t = \psi^t \bar{g}. \tag{7}$$

When tax rates are shifted, government transfers adjust according to the government budget constraint (3), rewritten as

$$s_t = \psi^t \bar{b}(\psi - R_t^b) + T_t - \psi^t \bar{g}. \tag{8}$$

As an alternative, we shall also consider keeping transfers on the balanced growth path and adjusting government spending instead.

More generally, the tax rates may be interpreted as wedges as in Chari et al. (2007), and some of the results in this paper carry over to that more general interpretation. What is special to the tax rate interpretation and crucial to the analysis in this paper, however, is the link between tax receipts and transfers (or government spending) via the government budget constraint.

2.1. The Constant Frisch Elasticity (CFE) preferences

The intertemporal elasticity of substitution as well as the Frisch elasticity of labor supply are key properties of the preferences for the analysis at hand.

We do not wish to restrict ourselves to a unit intertemporal elasticity of substitution. To avoid spurious wealth effects that are inconsistent with long-run observations, it is desirable to impose that the preferences are consistent with long-run growth (i.e. consistent with a constant labor supply as wages and consumption grow at the same rate). For time-separable preferences and without including rates of technological change for leisure or in preferences, King et al. (2001) have shown that the preferences must be of the form $c_t^{1-\eta}v(n_t)/(1-\eta)$, up to a constant, if $\eta \neq 1$, and of the form $\log(c_t) + v(n_t)$ for $\eta = 1$. While this ties down the intertemporal elasticity of substitution to be constant, there is considerable liberty in choosing preferences in labor. A crucial parameter in our considerations will be the Frisch elasticity of labor supply,

$$\varphi = \frac{dn}{dw}\frac{w}{n}|_{\bar{U}_c}. \tag{9}$$

In order to see the impact of different assumptions regarding this elasticity most cleanly, it is therefore natural to focus on preferences which feature a constant Frisch elasticity, regardless of the point of approximation.

We shall call preferences with these features “constant Frisch elasticity” preferences or CFE preferences. As this paper makes considerable use of these preferences, we shall investigate their properties in some detail. The following result has essentially been stated in King and Rebelo (1999), equation (6.7) as well Shimer (2008), but without a proof.

Proposition 1. *Suppose preferences are separable across time with a twice continuously differentiable felicity function $u(c, n)$, which is strictly increasing and concave in c and $-n$, discounted a constant rate β, consistent with long-run growth and feature a constant Frisch elasticity of labor supply φ, and suppose that there is an interior solution to the first-order condition. Then, the preferences feature a constant intertemporal elasticity of substitution $1/\eta > 0$ and are given by*

$$u(c, n) = \log(c) - \kappa n^{1+\frac{1}{\varphi}} \tag{10}$$

if $\eta = 1$ and by

$$u(c, n) = \frac{1}{1-\eta}\left(c^{1-\eta}\left(1 - \kappa(1-\eta)n^{1+\frac{1}{\varphi}}\right)^{\eta} - 1\right) \tag{11}$$

if $\eta > 0, \eta \neq 1$, where $\kappa > 0$, up to affine transformations. Conversely, this felicity function has the properties stated above.

Proof: *It is well known that consistency with long run growth implies that the preferences feature a constant intertemporal elasticity of substitution $1/\eta > 0$ and are of the form*

$$u(c,n) = \log(c) - v(n) \tag{12}$$

if $\eta = 1$ and

$$u(c,n) = \frac{1}{1-\eta}\left(c^{1-\eta}v(n) - 1\right) \tag{13}$$

where $v(n)$ is increasing (decreasing) in n iff $\eta > 1$ ($\eta < 1$). We concentrate on the second equation. Interpret w to be the net-of-the-tax-wedge wage, i.e. $w = ((1-\tau^n)/(1+\tau^c))\tilde{w}$, where $\tilde{w}$ is the gross wage and where τ^n and τ^c are the (constant) tax rates on labor income and consumption. Taking the first order conditions with respect to a budget constraint

$$c + \ldots = wn + \ldots$$

we obtain the two first order conditions

$$\begin{aligned} \lambda &= c^{-\eta}v(n) && (14) \\ -(1-\eta)\lambda w &= c^{1-\eta}v'(n). && (15) \end{aligned}$$

Use (14) to eliminate $c^{1-\eta}$ in (15), resulting in

$$-\frac{1-\eta}{\eta}\lambda^{\frac{1}{\eta}}w = \frac{1}{\eta}v'(n)\left(v(n)\right)^{\frac{1}{\eta}-1} = \frac{d}{dn}\left(v(n)\right)^{\frac{1}{\eta}}. \tag{16}$$

The constant elasticity φ of labor with respect to wages implies that n is positively proportional to w^φ, for λ constant[4]*. Write this relationship and the constant of proportionality conveniently as*

$$w = \xi_1\eta\lambda^{\frac{-1}{\eta}}\left(1+\frac{1}{\varphi}\right)n^{\frac{1}{\varphi}} \tag{17}$$

for some $\xi_1 > 0$, which may depend on λ. Substitute this equation into (16). With λ constant, integrate the resulting equation to obtain

$$\xi_0 - \xi_1(1-\eta)n^{\frac{1}{\varphi}+1} = v(n)^{\frac{1}{\eta}} \tag{18}$$

for some integrating constant ξ_0. Note that $\xi_0 > 0$ in order to assure that the left-hand side is positive for $n = 0$, as demanded by the right-hand side. Furthermore, as $v(n)$ cannot be a function of λ, the same must be true of ξ_0 and ξ_1. Up to a positive affine transformation of the preferences, one can therefore choose $\xi_0 = 1$ and $\xi_1 = \kappa$ for some $\kappa > 0$ wlog. Extending the proof to the case $\eta = 1$ is straightforward. •

[4]The authors are grateful to Robert Shimer, who pointed out this simplification of the proof.

Hall (2008) has recently emphasized the importance of the Frisch demand for consumption[5] $c = c(\lambda, w)$ and the Frisch labor supply $n = n(\lambda, w)$, resulting from solving the first-order conditions (14) and (15). His work has focussed attention in particular on the cross-elasticity between consumption and wages. That elasticity is generally not constant for CFE preferences, but depends on κ and the steady state level of labor supply. The next proposition provides the elasticities of $c(\lambda, w)$ and $n(\lambda, w)$, which will be needed in (23). In particular, it follows that

$$\text{cross-Frisch-elasticity of consumption wrt wages} = \frac{\varphi}{\eta}\nu_{cn} \tag{19}$$

for some value ν_{cn}, given as an expression involving balanced growth labor supply and the CFE parameters.

In equation (43) below, we shall show that ν_{cn} can be calculated from additional balanced growth observations as well as φ and η alone, without reference to κ. Put differently, balanced growth observations as well as the Frisch elasticity of labor supply and η imply a value for the cross elasticity of Frisch consumption demand. Conversely, a value for the latter has implications for some of the other variables: it is not a "free parameter". When we calibrate our model, we will provide the implications for the cross-elasticity in table 8, which one may wish to compare to the value of 0.3 given by Hall (2008). As a start, the proposition below or, more explicitly, equation (43) further below implies, that ν_{cn} and therefore the cross elasticity is positive iff $\eta > 1$ (and is zero, if $\eta = 1$).

The proposition more generally provides the equations necessary for calculating the log-linearized dynamics of a model involving CFE preferences, or, alternatively, for solving for the elasticity of the Frisch demand and Frisch supply. Given φ, η and ν_{cn}, all other coefficients are easily calculated.

Note in particular, that the total elasticity of the Frisch consumption demand with respect to deviations in the marginal value of wealth is not equal to the (negative of) $1/\eta$, but additionally involves a term due to the change in labor supply in reaction to a change in the marginal value of wealth. This is still true, when writing the Frisch consumption demand as $c = C(\lambda, \lambda w)$ as in Hall (2008), and calculating the own elasticity per the derivative with respect to the first argument (i.e., holding λw constant). The proposition implies that

$$\text{own-Frisch-elasticity of consumption wrt } \lambda = -\frac{\varphi}{\eta}\nu_{nn} = \frac{-1}{\eta} + \frac{\varphi(1-\eta)}{\eta^2}\nu_{cn} \tag{20}$$

or (for consumption)

$$\text{own-Frisch-elasticity} = \frac{-1}{\eta} + \left(\frac{1}{\eta} - 1\right) \text{cross-Frisch-elasticity.} \tag{21}$$

[5] Hall (2008) writes the Frisch consumption demand and Frisch labor supply as $c = C(\lambda, \lambda w)$ and $n = N(\lambda, \lambda w)$.

Therefore, this expression should be matched to the benchmark value of -0.5 in Hall (2008), rather than $-1/\eta$. We shall follow the literature, though, and use $\eta = 2$ as our benchmark calibration, and will provide values for the elasticity above as a consequence, once the model is fully calibrated. For example, the cross-Frisch-elasticity of 0.3 and a value of $\eta = 2$ implies an own-Frisch-elasticity of -0.65. Conversely, an own-Frisch-elasticity of -0.5 and a cross-Frisch-elasticity of 0.3 implies $\eta = 3.5$. The proof of the following proposition is available in a technical appendix.

Proposition 2. *Suppose an agent has CFE preferences, where the preference parameter κ_t is possibly stochastic. The log-linearization of the first-order conditions (14) and (15) around a balanced growth path at some date t is given by*

$$\begin{array}{rcl} \hat{\lambda}_t & = & \nu_{cc}\hat{c}_t + \nu_{cn}\hat{n}_t + \nu_{c\kappa}\hat{\kappa}_t \\ \hat{\lambda}_t + \hat{w}_t & = & \nu_{nc}\hat{c}_t + \nu_{nn}\hat{n}_t + \nu_{n\kappa}\hat{\kappa}_t \end{array} \tag{22}$$

or, alternatively, can be solved as log-linear Frisch consumption demand and Frisch labor supply per

$$\begin{array}{rcl} \hat{c}_t & = & \left(\frac{-1}{\eta} + \frac{\varphi}{\eta^2}\nu_{cn}\right)\hat{\lambda}_t + \frac{\varphi}{\eta}\nu_{cn}\hat{w}_t - \frac{\varphi}{\eta}\nu_{c\kappa}\hat{\kappa}_t \\ \hat{n}_t & = & \frac{\varphi}{\eta}\hat{\lambda}_t + \varphi\hat{w}_t - \varphi\hat{\kappa}_t \end{array} \tag{23}$$

where hat-variables denote log-deviations and where

$$\begin{array}{rcl} \nu_{cc} & = & -\eta \\ \nu_{cn} & = & -\left(1+\dfrac{1}{\varphi}\right)(1-\eta)\left(\left(\eta\kappa\bar{n}^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \dfrac{1}{\eta}\right)^{-1} \\ \nu_{c\kappa} & = & \dfrac{\varphi}{1+\varphi}\nu_{cn} \\ \nu_{nn} & = & \dfrac{1}{\varphi} - \dfrac{1-\eta}{\eta}\nu_{cn} \\ \nu_{nc} & = & 1-\eta \\ \nu_{n\kappa} & = & 1 - \dfrac{1-\eta}{\eta}\nu_{c\kappa}. \end{array}$$

As an alternative, we also use the Cobb-Douglas preference specification

$$U(c_t, n_t) = \sigma\log(c_t) + (1-\sigma)\log(1-n_t) \tag{24}$$

as it is an important and widely used benchmark, see e.g. Cooley and Prescott (1995), Chari et al. (1995) or Uhlig (2004). The Frisch elasticity for these preferences is given by

$$\varphi_{CD}(n) = \frac{1}{n} - 1$$

and therefore decreases with increasing labor supply. The CFE specification for a unit intertemporal elasticity of substitution is instead

$$U(c_t, n_t) = \log(c_t) - \kappa n^{1+\frac{1}{\varphi}}.$$

At $\varphi = 1$ for example, this is a quadratic disutility in labor rather than a logarithmic preference in leisure in (24).

2.2. Equilibrium

In equilibrium the household chooses plans to maximize its utility, the firm solves its maximization problem and the government sets policies that satisfy its budget constraint. Inspection of the balanced growth relationships provides some useful insights for the issue at hand. Some of these results are more generally useful for examining the impact of wedges on balanced growth allocations as in Chari et al. (2007).

Except for hours worked, interest rates and taxes all other variables grow at a constant rate

$$\psi = \xi^{\frac{1}{1-\theta}}. \tag{25}$$

For CFE preferences, the balanced growth after-tax return on any asset is

$$\bar{R} = \psi^{\eta}/\beta \tag{26}$$

thereby tying β to observations on $\bar{R}$ and ψ as well as assumptions on η. We assume throughout that $\xi \geq 1$ and that parameters are such that

$$\bar{R} > 1, \tag{27}$$

but we do not necessarily restrict β to be less than one. Let $\overline{k/y}$ denote the balanced growth path value of the capital-output ratio k_{t-1}/y_t. It is given by

$$\overline{k/y} = \left(\frac{\bar{R} - 1}{\theta(1-\tau^k)} + \frac{\delta}{\theta} \right)^{-1}. \tag{28}$$

As an extreme alternative, consider the case of full international capital mobility without adjustment costs to capital and resident-based taxation of asset income. With tax rates constant in the rest of the world, the return on capital is fixed by these world-wide parameters and capital taxes will not influence the capital-to-output ratio. Such a model has an inherent instability, depending on whether the home country or the rest of the world is more patient compared to after-tax returns. In the former case, the home country "takes over" the world, whereas in the latter case, the households of the home country would seek to borrow against their entire future labor income. In the latter case, a reasonable assumption may be that the households are internationally borrowing constraint: in that case, they will not own any assets and capital income taxation will not produce any revenues. Due to these extreme conclusions, we have not pursued this line of reasoning further.

Equations (25) and (28) in turn imply the labor productivity and the before-tax wage level

$$\frac{y_t}{\bar{n}} = \psi^t \, \overline{k/y}^{\frac{\theta}{1-\theta}} \tag{29}$$

$$w_t = (1-\theta)\frac{y_t}{\bar{n}}. \tag{30}$$

This provides the familiar result that the balanced growth capital-output ratio and before-tax wages only depend on policy through the capital income tax τ^k, decreasing monotonically, and depend on preference parameters only via $\bar{R}$. It also implies that the tax receipts from capital taxation and labor taxation relative to output are given by these tax rates times a relative-to-output tax base which only depends on the capital income tax rate. The level of these receipts therefore moves with the level of output or, equivalently for constant capital income taxes, with the level of equilibrium labor.

It remains to solve for the level of equilibrium labor. Let $\overline{c/y}$ denote the balanced growth path ratio c_t/y_t. With the CFE preference specification and along the balanced growth path, the first-order conditions of the household and the firm imply

$$\left(\eta\kappa\bar{n}^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \frac{1}{\eta} = \alpha\,\overline{c/y} \tag{31}$$

where

$$\alpha = \left(\frac{1+\tau^c}{1-\tau^n}\right)\left(\frac{1+\frac{1}{\varphi}}{1-\theta}\right) \tag{32}$$

depends on tax rates, the labor share and the Frisch elasticity of labor supply.

For the benchmark $s-$Laffer curves, we vary transfers $\bar{s}$ and fix government spending $\bar{g}$. The feasibility constraint implies

$$\overline{c/y} = \chi + \gamma\frac{1}{\bar{n}} \tag{33}$$

where

$$\chi = 1 - (\psi - 1 + \delta)\,\overline{k/y} \tag{34}$$

$$\gamma = (\bar{m} - \bar{g})\,\overline{k/y}^{\frac{-\theta}{1-\theta}}. \tag{35}$$

Substituting equation (33) into (31) therefore yields a one-dimensional nonlinear equation in $\bar{n}$, which can be solved numerically, given values for preference parameters, production parameters, tax rates and the levels of $\bar{b}$, $\bar{g}$ and $\bar{m}$.

The following proposition follows in a straightforward manner from examining these equations, so we omit the proof.

Proposition 3. *Assume that $\bar{g} \geq \bar{m}$. Then, the solution for $\bar{n}$ is unique. It is decreasing in τ^c or τ^n, with $\tau^k, \bar{b}, \bar{g}$ fixed.*

In particular, for constant τ^k and τ^c, there is a tradeoff as τ^n increases: while equilibrium labor and thus the labor tax base decrease, the fraction taxed from that tax base increases. This tradeoff gives rise to the Laffer curve.

Similarly, and in the special case $\bar{g} = \bar{m}$, n falls with τ^k, creating the same Laffer curve tradeoff for capital income taxation. Generally, the tradeoff for τ^k appears to be hard to sign and we shall rely on numerical calculations instead.

For the alternative $g-$Laffer curves, we shall fix transfers $\bar{s}$ and vary spending $\bar{g}$. Rewrite the budget constraint of the household as

$$\overline{c/y} = \frac{\tilde{\chi}}{1+\tau^c} + \frac{\tilde{\gamma}}{(1+\tau^c)}\frac{1}{\bar{n}} \tag{36}$$

where

$$\tilde{\chi} = 1 - (\psi - 1 + \delta)\,\overline{k/y} - \tau^n(1-\theta) - \tau^k\left(\theta - \delta\,\overline{k/y}\right) \tag{37}$$

$$\tilde{\gamma} = \left(\bar{b}(\bar{R} - \psi) + \bar{s} + \bar{m}\right)\overline{k/y}^{\frac{-\theta}{1-\theta}} \tag{38}$$

can be calculated, given values for preference parameters, production parameters, tax rates and the levels of $\bar{b}$, $\bar{s}$ and $\bar{m}$. Note that $\tilde{\chi}$ and $\tilde{\gamma}$ do not depend on τ^c.

To see the difference to the case of fixing $\bar{g}$, consider a simpler one-period model without capital and the budget constraint

$$(1+\tau^c)c = (1-\tau^n)wn + s. \tag{39}$$

Maximizing growth-consistent preferences as in (13) subject to this budget constraint, one obtains

$$(\eta - 1)\frac{v(n)}{nv'(n)} = 1 + \frac{s}{(1-\tau^n)wn}. \tag{40}$$

If transfers s do not change with τ^c, then consumption taxes do not change labor supply. Moreover, if transfers are zero, $s = 0$, labor taxes do not have an impact either. In both cases, the substitution effect and the income effect exactly cancel just as they do for an increase in total factor productivity. This insight generalizes to the model at hand, albeit with some modification.

Proposition 4. *Fix $\bar{s}$, and instead adapt $\bar{g}$, as the tax revenues change across balanced growth equilibria.*

- *There is no impact of consumption tax rates τ^c on equilibrium labor. As a consequence, tax revenues always increase with increased consumption taxes.*
- *Suppose that*

  $$0 = \bar{b}(\bar{R} - \psi) + \bar{s} + \bar{m}. \tag{41}$$

  Furthermore, suppose that labor taxes and capital taxes are jointly changed, so that

  $$\tau^n = \tau^k\left(1 - \frac{\delta}{\theta}\,\overline{k/y}\right) \tag{42}$$

  where the capital-income ratio depends on τ_k per (28). Equivalently, suppose that all income from labor and capital is taxed at the rate τ_n without a deduction for depreciation. Then there is no change of equilibrium labor.

Proof: *For the claim regarding consumption taxes, note that the terms* $(1+\tau_c)$ *for* $\overline{c/y}$ *cancel with the corresponding term in* α *in equation (31). For the claim regarding* τ_k *and* τ_n*, note that (42) together with (28) implies*

$$\bar{R} - 1 = (1-\tau^k)\left(\frac{\theta}{\overline{k/y}} - \delta\right) = (1-\tau^n)\frac{\theta}{\overline{k/y}} - \delta.$$

Then either by rewriting the budget constraint with an income tax τ_n *and calculating the consumption-output ratio or with*

$$\tilde{\chi} = (1-\tau^n)\left(1 - \theta\frac{\Psi - 1 + \delta}{\bar{R} - 1 + \delta}\right)$$

as well as $\tilde{\gamma} = 0$*, one obtains that the right-hand side in equation (31) and therefore also* $\bar{n}$ *remain constant, as tax rates are changed.* •

This discussion highlights in particular the tax-unaffected income $\bar{b}(\bar{R} - \psi) + \bar{s} + \bar{m}$ on equilibrium labor. It also highlights an important reason for including the trade balance in this analysis.

Given $\bar{n}$, it is then straightforward to calculate total tax revenue as well as government spending. Conversely, provided with an equilibrium value for $\bar{n}$, one can use this equation to find the value of the preference parameter κ, supporting this equilibrium. A similar calculation obtains for the Cobb-Douglas preference specification.

While one could now use $\bar{n}$ and κ to calculate ν_{cn} for the coefficients in proposition 2, there is a more direct and illuminating approach. Equation (31) can be rewritten as

$$\nu_{cn} = -\left(1 + \frac{1}{\varphi}\right)(1-\eta)\left(\alpha\,\overline{c/y}\right)^{-1} \tag{43}$$

allowing the calculation of ν_{cn} from observing the consumption-output ratio, the parameter α as well as φ and η, without reference to κ. Put differently, these values imply a value for ν_{cn} and therefore for the cross-elasticity of the Frisch consumption demand with respect to wages. The values implied by our calibration below are given in table 8.

We conclude this section by providing an analytical characterization of the Laffer curves. We provide the explicit dependence on the taxation arguments. The equations for the $g-$Laffer curve in the second part exactly parallels the equations for $s-$Laffer curve of the first part, except for using $\tilde{\chi}/(1+\tau^c), \tilde{\gamma}/(1+\tau^c)$ rather than χ, γ. The expressions are a bit unwieldy and further simplification does not appear to produce much. The expressions are useful for further numerical evaluations or for further symbolic manipulations with suitable software.

Proposition 5. *Let* x *denote one of* τ^k*,* τ^n*,* τ^c*.*

1. *The $s-$Laffer curve curve $L(x)$ of total tax revenues, when varying transfers s with the the varying tax revenues, is given by*

$$L(x) = \left(\tau_c \overline{c/y}(x) + \tau^n(1-\theta) + \tau^k \left(\theta - \delta \overline{k/y}(x)\right)\right) \left(\overline{k/y}(x)\right)^{\frac{\theta}{1-\theta}} \bar{n}(x) \tag{44}$$

where $\overline{k/y}(x)$ is given by (28) and varies with x only for $x = \tau^k$, where

$$\overline{c/y}(x) = \chi(x) + \gamma(x)\frac{1}{\bar{n}(x)},$$

and where $\bar{n}(x)$ solves

$$\left(\eta\kappa(\bar{n}(x))^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \frac{1}{\eta} = \alpha(x)\chi(x) + \alpha(x)\gamma(x)\frac{1}{\bar{n}(x)} \tag{45}$$

with $\chi(x), \gamma(x)$ given by (34,35) and dependent only on τ^k via $\overline{k/y}(x)$ and with $\alpha(x)$ given by (32).

2. *The $g-$Laffer curve $\tilde{L}(x)$ of total tax revenues, when varying government spending g with the the varying tax revenues, is given by*

$$\tilde{L}(x) = \left(\tau_c \overline{c/y}(x) + \tau^n(1-\theta) + \tau^k \left(\theta - \delta \overline{k/y}(x)\right)\right) \left(\overline{k/y}(x)\right)^{\frac{\theta}{1-\theta}} \bar{n}(x) \tag{46}$$

where $\overline{k/y}(x)$ is given by (28) and varies with x only for $x = \tau^k$, where

$$\overline{c/y}(x) = \frac{\tilde{\chi}(x)}{1+\tau^c} + \frac{\tilde{\gamma}(x)}{(1+\tau^c)}\frac{1}{\bar{n}(x)}$$

and where $\bar{n}(x)$ solves

$$\left(\eta\kappa(\bar{n}(x))^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \frac{1}{\eta} = \alpha(x)\frac{\tilde{\chi}(x)}{1+\tau^c} + \alpha(x)\frac{\tilde{\gamma}(x)}{(1+\tau^c)}\frac{1}{\bar{n}(x)} \tag{47}$$

with $\tilde{\chi}(x), \tilde{\gamma}(x)$ given by (37,38) and with $\alpha(x)$ given by (32).

3. *In particular, the $g-$Laffer curve $\tilde{L}(\tau^c)$ with respect to consumption taxes $x = \tau^c$ is given by*

$$\tilde{L}(\tau^c) = \frac{\tau_c}{1+\tau^c}\left(\tilde{\chi}\bar{n} + \tilde{\gamma}\right)\left(\overline{k/y}\right)^{\frac{\theta}{1-\theta}} + \left(\tau^n(1-\theta) + \tau^k\left(\theta - \delta\overline{k/y}\right)\right)\left(\overline{k/y}\right)^{\frac{\theta}{1-\theta}} \bar{n} \tag{48}$$

where $\overline{k/y}$, $\bar{n}$, $\tilde{\chi}$ and $\tilde{\gamma}$ are independent of τ^c.

4. *Let $\alpha = \alpha(x)$ as well as $\chi = \chi(x), \gamma = \gamma(x)$ for (45) and $\chi = \tilde{\chi}(x)/(1+\tau^c), \gamma = \tilde{\gamma}(x)/(1+\tau^c)$ for (47).*
   (a) *If $\varphi = 1$, then (45) and (47) are quadratic equations in $\bar{n}(x)$, with the solution*

$$\bar{n}(x) = \frac{1}{2 + 2(\alpha\chi - 1)\eta)}\left(-\alpha\gamma\eta + \sqrt{(\alpha\gamma\eta)^2 + \frac{1}{\kappa} + (\alpha\chi - 1)\frac{\eta}{\kappa}}\right). \tag{49}$$

(b) *If $\varphi \to \infty$, then (45) and (47) become linear equations in $\bar{n}(x)$, with the solution*

$$\bar{n}(x) \to \frac{(1/\kappa) - \alpha\gamma\eta}{(\alpha\chi - 1)\eta + 1}. \tag{50}$$

Proof: *Equations (44) and (46) follow directly from calculating total tax receipts*

$$\bar{T}(x) = \frac{\bar{T}(x)}{\bar{y(x)}} \bar{y}(x)$$

and noting that

$$\bar{y}(x) = \left(\overline{k/y}(x)\right)^{\frac{\theta}{1-\theta}} \bar{n}(x).$$

Equations (45) and (47) directly follow from (31) as well as (33) resp. (36). Equation (48) follows directly from proposition 4. •

A few more closed-form solutions exist for (45) and (47), e.g. for $\varphi \in \{\frac{1}{3}, \frac{1}{2}, 2, 3\}$, relying on solution formulas for polynomials of 3rd and 4th degree. Furthermore and in the case of the Laffer curve when varying transfers, implicit differentiation of $p(\bar{n}, \tau^n)$ given by equation (45) can be used to provide reasonably tractable formulas for $d\bar{n}(\tau^n)/d\tau^n = -(\partial p(\bar{n}, \tau^n)/\partial \tau^n)/(\partial p(\bar{n}, \tau^n)/\partial \bar{n})$ and therefore for $dL(x)/d\tau^n$, but a software capable of symbolic mathematics would be highly recommended for such further analysis.

As one application, we have calculated the slope of the s-consumption-tax Laffer curve and find that it approaches zero, as $\tau_c \to \infty$: we shall leave out the somewhat tedious details. Initially, this may be a surprising contrast to our calculations below showing a single-peaked s-Laffer curves in labor taxes: since the tradeoff between consumption and labor is determined by the wedge

$$\varsigma = \frac{1 - \tau^n}{1 + \tau^c},$$

one might have expected these two Laffer curves to map into each other with some suitable transformation of the abscissa. However, while the allocation is a function of the tax wedge only, this is not the case for the tax revenues as given by the Laffer curves. This can perhaps best be appreciated in the simplest case of a one-period model, where agents have preferences given by $\log(c) - n$, facing the budget constraint (39) with wages w held constant throughout and with transfers s equal to tax receipts in equilibrium. It is easy to see that labor is equal to the tax wedge, $n = \varsigma = (1 - \tau^n)/(1 + \tau^c)$, and that $c = wn$: so, consumption taxes and labor taxes have the same equilibrium tax base. The two Laffer curves are given by

$$L(x) = (\tau_c + \tau_n) \frac{1 - \tau^n}{1 + \tau^c} w$$

where $x = \tau_c$ or $x = \tau_n$ and they cannot be written in terms of just the tax wedge and wages alone. As a further simplification, assume $w = 1$ and consider setting one of the two tax rates to zero: in that case, one achieves the same labor supply $n = \varsigma$ for $\tau_n = 1 - \varsigma$ and $\tau_c = 0$ as well as for $\tau_n = 0$ and $\tau_c = 1/\varsigma$. For the first case, i.e., when varying labor taxes, the tax revenues are $\varsigma(1 - \varsigma)$, and have a peak at $\varsigma = n = 0.5$. The tax revenues are $1 - \varsigma$ in the second case of varying consumption taxes, and are increasing to one, as the tax wedge ς, labor supply and therefore available resources fall to zero. Transfers approach one, but they are treated as income before consumption taxes: when the household attempts to consume this transfer income, it has to pay taxes approaching 100%, so that it is indeed left only with the resources originally produced.

This result is due to the tax treatment of transfer income. Indeed, matters change, if the transfers were to be paid in kind, not in cash or if the agent did not have to pay consumption taxes on them. In that case, the Laffer curve would only depend on the tax wedge and wages, and would be given by $L(\varsigma) = (1 - \varsigma)\, wn(\varsigma)$. In our model with capital and net imports, one would have to likewise exclude all other sources of income from consumption taxes along with the transfers, in order to have the Laffer curves in consumption taxes coincide with the Laffer curve in labor taxes, when written as a function of the tax wedge.

3. Calibration and Parameterization

We calibrate the model to annual post-war data of the US and EU-14 economy. Mendoza et al. (1994), calculate average effective tax rates from national product and income accounts for the US. For this paper, we have followed their methodology to calculate tax rates from 1995 to 2007 for the US and 14 of the EU-15 countries, excluding Luxembourg for data availability reasons[6]

Most of the preference parameters are standard. We set parameters such that the household chooses $\bar{n} = 0.25$ in the US baseline calibration. This is consistent with evidence on hours worked per person aged 15-64 for the US. A technical appendix contains the details.

For the intertemporal elasticity of substitution, we follow a general consensus for it to be close to 0.5 and therefore $\eta = 2$, as our benchmark choice. The specific value of the Frisch labor supply elasticity is of central importance for the shape of the Laffer curve. In the case of the alternative Cobb-Douglas preferences the Frisch elasticity is given by $\frac{1-\bar{n}}{\bar{n}}$ and equals 3 when $\bar{n} = 0.25$. This value is in line with e.g. Kydland and Prescott (1982), Cooley and Prescott (1995) and Prescott (2002, 2004), while a value close to 1 as in Kimball and Shapiro (2003) may be closer to the current consensus view.

We therefore use $\eta = 2$ and $\varphi = 1$ as the benchmark calibration for the CFE preferences, and use $\eta = 1$ and $\varphi = 3$ as alternative calibration and for comparison to a Cobb-Douglas specification. A more detailed discussion is provided in the technical Appendix B.2.

3.1. EU-14 Model and individual EU countries

As a benchmark, we keep all other parameters as in the US model, i.e. the parameters characterizing the growth rate as well as production and preferences. As a result, we calculate the differences between the US and the EU-14 as arising solely from differences in fiscal policy. This corresponds to Prescott (2002, 2004) who argues that differences in hours worked between the US and Europe are due to different level of labor income taxes.

In the technical Appendix B.3, we provide a comparison of predicted versus actual data for three key values: equilibrium labor, the capital-output ratio and the consumption-output ratio. Discrepancies remain. While these are surely due to a variety of reasons, in particular e.g. institutional differences in the implementation of the welfare state, see e.g. Rogerson (2007) or Pissarides and Ngai (2008), variation in parameters across countries may be one of the causes. For example, Blanchard (2004) as well as Alesina et al. (2005) argue that differences in preferences as well as labor market regulations and union policies rather than different fiscal policies are key to understanding why hours worked have fallen in Europe compared to the US. To obtain further insight and to provide a benchmark, we therefore vary parameters across countries in order to obtain a perfect fit to observations for these three key values. We then examine these parameters whether they are in a "plausible range", compared to the US calibration. Finally, we investigate how far our results for the impacts of fiscal policy are affected. It will turn out that the effect is modest, so that our conclusions may be viewed as fairly robust.

More precisely, we use averages of the observations on x_t/y_t, k_{t-1}/y_t, n_t, c_t/y_t, g_t/y_t, m_t/y_t and tax rates as well as a common choice for ψ, φ, η to solve the equilibrium relationships

$$\frac{x_t}{k_{t-1}} = \psi - 1 + \delta \tag{51}$$

for δ, (28) for θ, (31) for κ and aggregate feasiblity for a measurement error, which we interpret as mismeasured government consumption (as this will not affect the allocation otherwise), keeping g/y, m/y and the three tax rates calibrated as in the baseline calculations.

Table 4 provides the list of resulting parameters. Note that we shall need a larger value for κ and thereby a greater preference for leisure in the EU-14 (in addition to the observed higher labor tax rates) in order to account for the lower equilibrium labor in Europe. Some of the implications are perhaps unconvential, however, and if so, this may indicate that alternative reasons are the source for the cross-country variations. For example, while Ireland is calculated to have one of the highest preferences for leisure, Greece appears to have one of the lowest.

4. Results

As a first check on the model, table 5 compares the measured and the model-implied sources of tax revenue, relative to GDP. Due to the allocational distortions caused by the taxes, there is no a priori reason that these numbers should coincide. While the models overstate the taxes collected from labor income in the EU-14, they provide the correct numbers for revenue from capital income taxation, indicating that the methodology of Mendoza-Razin-Tesar is reasonable capable of delivering the appropriate tax burden on capital income, despite the difficulties of taxing capital income in practice. Table 6 sheds further light on this comparison: hours worked are overstated while total capital is understated for the EU-14 by the model. With the parameter variation in table 4, the model will match the data perfectly by construction, as indicated by the last line. This applies similarly to individual countries. Generally, the numbers are roughly correct in terms of the order of magnitude, though, so we shall proceed with our analysis.

4.1. Labor Tax Laffer Curves

The Laffer curve for labor income taxation in the US is shown in figure 1. Note that the CFE and Cobb-Douglas preferences coincide closely, if the intertemporal elasticity of substitution $1/\eta$ and the Frisch elasticity of labor supply φ are the same at the benchmark steady state. Therefore, CFE preferences are close enough to the Cobb-Douglas specification, if $\eta = 1$, and provide a growth-consistent generalization, if $\eta \neq 1$.

For marginal rather than dramatic tax changes, the slope of the Laffer curve near the current data calibration is of interest. The slope is related to the degree of self-financing of a tax cut, defined as the ratio of additional tax revenues due to general equilibrium incentive effects and the lost tax revenues at constant economic choices. More formally and precisely, we calculate the degree of self-financing of a labor tax cut per

$$\text{self-financing rate} = 1 - \frac{1}{w_t \bar{n}} \frac{\partial T_t(\tau_n, \tau_k)}{\partial \tau_n} \approx 1 - \frac{1}{w_t \bar{n}} \frac{T_t(\tau_n + \epsilon, \tau_k) - T_t(\tau_n - \epsilon, \tau_k)}{2\epsilon}$$

where $T(\tau_n, \tau_k, \tau_c; g, b)$ is the function of tax revenues across balanced growth equilbria for different tax rates, and constant paths for government spending g and debt b. This self-financing rate is a constant along the balanced growth path, i.e. does not depend on t. Likewise, we calculate the degree of self-financing of a capital tax cut.

We calculate these self-financing rates numerically as indicated by the second expression, with ϵ set to 0.01 (and tax rates expressed as fractions). If there were no endogenous change of the allocation due to a tax change, the loss in tax revenue due to a one percentage point reduction in the tax rate would be $w_t\bar{n}$, and the self-financing rate would calculate to 0. At the peak of the Laffer curve, the tax revenue would not change at all, and the self-financing rate would be 100%. Indeed, the self-financing rate would become larger than 100% beyond the peak of the Laffer curve.

For labor taxes, table 7 provides results for the self-financing rate as well as for the location of the peak of the Laffer curve for our benchmark calibration of the CFE preference parameters, as well as a sensitivity analysis. Figure 3 likewise shows the sensitivity of the Laffer curve to variations in φ and η. The peak of the Laffer curve shifts up and to the right, as η and φ are decreased. The dependence on η arises due to the nonseparability of preferences in consumption and leisure. Capital adjusts as labor adjusts across the balanced growth paths.

Table 7 also provides results for the EU-14: there is considerably less scope for additional financing of government revenue in Europe from raising labor taxes. For our preferred benchmark calibration with a Frisch elasticity of 1 and an intertemporal elasticity of substitution of 0.5, we find that the US and the EU-14 are located on the left side of their Laffer curves, but while the US can increase tax revenues by 30% by raising labor taxes, the EU-14 can raise only an additional 8%.

To gain further insight, figure 2 compares the US and the EU Laffer curve for our benchmark calibration of $\varphi = 1$ and $\eta = 2$, benchmarking both Laffer curves to 100% at the US labor tax rate. As the CFE parameters are changed, so are the cross-Frisch elasticities and own-Frisch elasticities of consumption: the values are provided in table 8.

Table 9 as well as the top panel of figure 4 provide insight into the degree of self-financing as well as the location of the Laffer curve peak for individual countries, when varying them according to table 4. The results for keeping parameters the same across countries are very similar.

It matters for the thought experiment here, that the additional tax revenues are spent on transfers, and not on other government spending. For the latter, the substitution effect is mitigated by an income effect on labor: as a result the Laffer curve becomes steeper with a peak to the right and above the peak coming from a "labor tax for transfer" Laffer curve, see figure 5.

4.2. Capital Tax Laffer Curves

Figure 6 shows the Laffer curve for capital income taxation in the US, comparing it to the EU and for two different parameter configurations, benchmarking both Laffer curves to 100% at the US capital tax rate. Numerical results are in table 10. Figure 6 already shows that the capital income tax Laffer curve is surprisingly invariant to variations of the CFE parameters. A more detailed comparison figure is available in a technical appendix to this paper. For our preferred benchmark calibration with a Frisch elasticity of 1 and an intertemporal elasticity of substitution of 0.5, we find that the US and the EU-14 are located on the left side of their Laffer curves, but the scope for raising tax revenues by raising capital income taxes are small: they are bound by 6% in the US and by 1% in the EU-14.

The cross-country comparison is in the right column of figure 4 and in table 11. Several countries, e.g. Denmark and Sweden, show a degree of self-financing in excess of 100%: these countries are on the “slippery side” of the Laffer curve and can actually improve their budgetary situation by cutting capital taxes, according to our calculations. As one can see, the additional revenues that can be obtained from an increased capital income taxation are small, once the economy has converged to the new balanced growth path. The key for capital income are transitional issues and the taxation of initially given capital: this issue is examined in subsection 5.3.

It is instructive to investigate, why the capital Laffer curve is so flat e.g. in Europe. Figure 7 shows a decomposition of the overall Laffer curve into its pieces: the reaction of the three tax bases and the resulting tax receipts. The labor tax base is falling throughout: as the incentives to accumulate capital are deteriorating, less capital is provided along the balanced growth equilibrium, and therefore wages fall. The capital tax revenue keeps rising quite far, though. Indeed, even the capital tax base $(\theta - \delta\overline{k/y})\bar{y}$ keeps rising, as the decline in $\overline{k/y}$ numerically dominates the effect of the decline in $\bar{y}$. An important lesson to take away is therefore this: if one is interested in examining the revenue consequences of increased capital taxation, it is actually the consequence for labor tax revenues which is the “first-order” item to watch. This decomposition and insight shows the importance of keeping the general equilibrium repercussions in mind when changing taxes.

Table 12 summarizes the range of results of our sensitivity analysis both for labor taxes as well as capital taxes for the US and the EU-14.

Furthermore, one may be interested in the combined budgetary effect of changing labor and capital income taxation. This gets closer to the literature of Ramsey optimal taxation, to which this paper does not seek to make a contribution. But figure 8, providing the contour lines of a “Laffer hill”, nonetheless may provide some useful insights. As one compares balanced growth paths, it turns out that revenue is maximized when raising labor taxes but lowering capital taxes: the peak of the hill is in the lower right hand side corner of that figure. Indeed, many countries are on the “wrong” side of the “Laffer hill”, i.e. do not feature its peak in the northeast corner of that plot.

5. Variations

5.1. Endogenous Growth and Human Capital Accumulation

In our analysis, we have emphasized the comparison of long-run steady states. The macroeconomic literature on long-run phenomena generally emphasizes the importance of endogenous growth, see e.g. the textbook treatments of Jones (2001), Barro and i Martin (2003) or Acemoglu (2008). While a variety of engines of growth have been analyzed, the accumulation of human capital appears to be particularly relevant to our analysis. In that case, labor income taxation actually amounts to the taxation of a capital stock, and this may potentially have a considerable effects on our results. While it is beyond the scope of this paper to analyze the many interesting possibilities, some insight into the issue can be obtained from the following specification incorporating learning-by-doing as well as schooling, following Lucas (1988) and Uzawa (1965). While first-generation endogenous growth models have stressed the endogeneity of the overall long-run growth rate, second-generation growth models have stressed potentially large level effects, without affecting the long-run growth rate. We shall provide an analysis, encompassing both possibilities.

Consider the following modification to the baseline model. Assume that human capital can be accumulated by both learning-by-doing as well as schooling. The agent splits total non-leisure time n_t into work-place labor $q_t n_t$ and schooling time $(1 - q_t)n_t$, where $0 \leq q_t \leq 1$. Agents accumulate human capital according to

$$h_t = (A q_t n_t + B(1 - q_t)n_t)^{\omega} h_{t-1}^{1-\Omega} + (1 - \delta_h)h_{t-1} \tag{52}$$

where $A \geq 0$ and $B > A$ parameterize the effectiveness of learning-by-doing and schooling respectively and where $0 < \delta_h \leq 1$ is the depreciation rate of human capital. Furthermore, we let

$$\Omega = 0$$

for the "first-generation" version and

$$\Omega = \omega$$

for the "second-generation" version of the model. For the "first-generation" version of the model, production is given by

$$y_t = k_{t-1}^{\theta} (h_{t-1} q_t n_t)^{1-\theta} \tag{53}$$

while it is given by

$$y_t = \xi^t k_{t-1}^{\theta} (h_{t-1} q_t n_t)^{1-\theta} \tag{54}$$

for the "second generation" version. Note that non-leisure time n_t is multiplied by human capital h_{t-1} and the fraction q_t devoted to work-place labor. For both versions, wages are paid per unit of labor and human capital, i.e. with

$$w_t = (1 - \theta)\frac{y_t}{h_{t-1} q_t n_t}$$

so that the after-tax labor income is given by

$$(1 - \tau_t^n) w_t h_{t-1} q_t n_t.$$

Consider the problem of a representative household. Let λ_t be the Lagrange multiplier for the budget constraint and let μ_t be the Lagrange multiplier on the human accumulation constraint (52). We shall analyze the "second generation" case first, as the algebra is somewhat simpler. The first-order condition with respect to human capital is

$$\mu_t = \beta E_t \left(\left((1 - \omega)\frac{h_{t+1}}{h_t} + \omega(1 - \delta_h) \right) \mu_{t+1} + \left(1 - \tau_{t+1}^n\right) w_{t+1} n_{t+1} \lambda_{t+1} \right). \tag{55}$$

Along the balanced growth path,

$$\bar{h} = \delta_h^{-1/\omega} \left(B + (A - B)\bar{q}\right) \bar{n} \tag{56}$$

and $\mu_t = \bar{\mu}\psi^{(1-\eta)t}$ grows with the product of $\lambda_t = \bar{\lambda}\psi^{-\eta t}$ and $w_t = \bar{w}\psi^t$, where ψ is given by (25). Thus,

$$\bar{\mu} = \frac{(1-\tau^n)\bar{w}\bar{n}}{(\psi^{1-\eta}/\beta) - 1 + \omega\delta_h}\bar{\lambda}. \tag{57}$$

This equation has an intuitive appeal. Essentially, the shadow value of an extra unit of human capital corresponds to the discounted sum of the additional after-tax wage payments that it generates for the agent.

The first-order condition with respect to labor along the balanced growth path yields

$$\begin{aligned}
\bar{u}_n &= (1-\tau^n)\bar{w}\bar{h}\bar{\lambda} + \omega\delta_h\frac{\bar{\mu}\bar{h}}{\bar{n}} \\
&= (1-\tau^n)\bar{w}\bar{h}\bar{q}\bar{\lambda}\left(1 + \frac{\omega\delta_h}{(\psi^{1-\eta}/\beta) - 1 + \omega\delta_h}\right).
\end{aligned}$$

where the first term is as in the benchmark model, except for the additional factor $\bar{h}$, and the second term due to the consideration of accumulating human capital. With $\bar{w}\bar{h}\bar{q}\bar{n} = (1-\theta)\bar{y}$ and in close similarity to (31), this implies

$$\left(\eta\kappa\bar{n}^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \frac{1}{\eta} = \alpha''\,\overline{c/y} \tag{58}$$

where

$$\alpha'' = \left(\frac{1+\tau^c}{1-\tau^n}\right)\left(\frac{1+\frac{1}{\varphi}}{1-\theta}\right)\vartheta'', \text{ with } \vartheta'' = \frac{(\psi^{1-\eta}/\beta) - 1 + \omega\delta_h}{(\psi^{1-\eta}/\beta) - 1 + 2\omega\delta_h}. \tag{59}$$

The Kuhn-Tucker condition for the split q_t along the balanced growth path yields

$$\bar{q} = \min\left\{1; \frac{B}{B-A}\vartheta''\right\} \tag{60}$$

after some algebra, and is independent of tax rates. As a check on the calculations, note that $\alpha'' = \alpha$, if $\omega = 0$, as indeed should be the case. For small values of ω, the “correction” to α is small too. Perhaps more importantly, note that κ in (31) as well as (58) should be calibrated so as to yield $\bar{q}\bar{n}_{US} = 0.25$. In particular, if $\eta = 1$ and noting that the split $\bar{q}$ of non-leisure time devoted to work-place labor remains constant, a proportional change in α just leads to a similar proportional change in κ.

The key impact of taxation then lies in the impact of the level of human capital, per equation (56): all other equations remain essentially unchanged. Heuristically, as e.g. labor taxes are increased, non-leisure time is decreased, which in turn leads to a decrease in human capital. This in turn leads to a loss in tax revenue, compared to the benchmark case of no-human-capital accumulation. Put differently, the taxation of labor does not impact some intertemporal trade-off directly, as it appears to be the case for capital taxation, but rather “indirectly” via a level effect, as human capital is proportional to non-leisure time along the balanced growth path.

The analysis of the "first-generation" case is rather similar. The first-order condition with respect to human capital, using (52), is

$$\mu_t = \beta E_t \left(\frac{h_{t+1}}{h_t} \mu_{t+1} + \left(1 - \tau^n_{t+1}\right) w_{t+1} n_{t+1} \lambda_{t+1} \right). \tag{61}$$

Along the balanced growth path,

$$\frac{h_{t+1}}{h_t} \equiv (B + (A - B)\bar{q})^{\omega} \bar{n}^{\omega} + 1 - \delta_h = \psi \tag{62}$$

where this equation rather than (25) now determines the economic growth rate ψ. Thus, $h_{t-1} = \psi^t \bar{h}$, where we normalize $\bar{h} = 1$. Wages per unit of human capital do not grow, so that $\mu_t = \bar{\mu}\psi^{-\eta t}$ grows with $\lambda_t = \bar{\lambda}\psi^{-\eta t}$, where ψ is now given by (62). Thus,

$$\bar{\mu} = \frac{(1 - \tau^n)\bar{w}\bar{n}}{\bar{R} - \psi} \bar{\lambda} \tag{63}$$

where $\bar{R} = \psi^{\eta}/\beta$ as before, except that ψ is given per (62). The first-order condition with respect to labor along the balanced growth path yields

$$\bar{u}_n = (1 - \tau^n)\bar{w}\bar{\lambda} \left(1 + \frac{\omega(\psi - 1 + \delta_h)}{\bar{R} - \psi} \right)$$

In close similarity to (31) and (58), this implies

$$\left(\eta\kappa\bar{n}^{1+\frac{1}{\varphi}} \right)^{-1} + 1 - \frac{1}{\eta} = \alpha' \, \overline{c/y}. \tag{64}$$

where

$$\alpha' = \left(\frac{1 + \tau^c}{1 - \tau^n} \right) \left(\frac{1 + \frac{1}{\varphi}}{1 - \theta} \right) \vartheta', \text{ with } \vartheta' = \frac{\bar{R} - \psi}{\bar{R} - \psi + \omega(\psi - 1 + \delta_h)}. \tag{65}$$

The first order condition for the work-school split yields

$$\bar{q} = \min \left\{ 1; \frac{B}{B - A} \vartheta' \right\}. \tag{66}$$

One therefore reaches almost the same conclusions as in the "second generation" formulation above, but there is a minor and a major difference. The minor difference concerns the last factor in (65) compared to the last factor in (59): they are numerically different. In the case that $\eta = 1$, and due to the necessity to calibrate κ, this does not make a difference. The major difference is the impact of labor supply on the endogenous growth rate per (62). For example, as the labor tax rate is changed, this leads to changes in labor supply, thereby to changes in the growth rate, the steady state return $\bar{R}$, and therefore to changes in the capital-output ratio per equation (28) and the consumption-output ratio, influencing in turn the coefficients in the equation for $\bar{n}$ and the solution for $\bar{q}$. This is a fixed point problem, which requires different algebra and additional analysis. While it may be of some interest to solve these equations and investigate the resulting numerical changes, it appears rather evident that the impact will be quantitatively small. First, the effect is truly indirect: except for the impact on the steady state return $\bar{R}$ (and the numerical difference in the last factor of (65) vs (59), the analysis is exactly as above in the "second generation" case. Second and empirically, little evidence has been found that taxation impacts on the long-run growth rate, see Levine and Renelt (1992). Thus, a sufficiently rich and appropriately calibrated extension of this "first-generation" version should feature at most a modest impact on the long-run growth rate in order to be in line with the available empirical evidence.

We examine the quantitative implications of human capital accumulation for the Laffer curves. To do so, we apply the same calibration strategy for the initial steady state as before, except assuming now $\bar{q}\bar{n}_{US} = 0.25$. Further, we set $\omega = 0.5$ and $\delta_h = \delta$ for simplicity. We set A such that initial $\bar{q}_{US} = 0.8$. In the first generation model, B is set to imply an initial growth rate $\psi_{US} = 1.02$. In the second generation model we set B to have $h_{US} = 1$ initially. Figures 9 depicts the labor tax Laffer curve for the US with and without human capital accumulation. It turns out that the peak moves to the left and the Laffer curve as such shifts down once human capital accumulation is accounted for. The second generation model predicts larger deviations from the baseline model without human capital accumulation, than the first-generation version. Furthermore, while the second-generation version is rather insensitive to η, this is not so for the first-generation model. Indeed, for $\eta = 1$, the labor tax Laffer curve for the first-generation version actually exceeds the baseline version, and the peak moves to the right. Examination of the results for the first-generation version with $\eta = 2$ reveals, that raising labor taxes results in a modest fall of real interest rates, inducing households to substantially shift the fraction of non-leisure time away from work-place labor towards schooling, thereby accelerating human capital accumulation. Since this effect works only through the shift of long-term interest rates, we judge it to be implausibly large and lead us to favor the results from the second-generation version over the first-generation specification. Figure 10 recalculates the labor tax Laffer curve for the EU 14 parameterization. Importantly and interestingly, the EU-14 is very close to the peak, given the second-generation version.

Figure 11 compares the impact of human capital accumulation on consumption taxes: for illustration, we show consumption tax rates up to the surely unreasonably high level of 500%. As explained at the end of section 2.2, the allocation depends on the joint tax wedge created by consumption and labor taxes, while the Laffer curves do not: since tax revenues are used for transfers, which are then consumption-taxed in turn: as a result, the consumption Laffer curve keeps rising throughout. However, the human capital accumulation now has a rather dramatic effect on the scale of the Laffer curve: the higher tax wedge leads to lower human capital or less growth, and therefore, resources are lost overall. By contrast, the capital tax Laffer curves move little, when incorporating human capital accumulation in the model: their graphs are available in a technical appendix to this paper.

These results show that human capital accumulation is likely to have an important impact on tax revenues and the Laffer curve, especially for labor income taxes: for $\eta = 2$ as well as other reasonable parameters, current labor tax rates appear to be considerably closer to the peak.

5.2. Heterogeneity and marginal tax rates

So far, we have considered a model with a representative agent, facing an affine-linear tax schedule. How much will the analysis be affected, if agent heterogeneity and nonlinear tax schedules are incorporated? A full, quantitative analysis requires detailed knowledge about the distributions of incomes from various sources, tax receipts, labor supply elasticities and so forth. While desirable, this is beyond the scope of this paper. However, some insights can be provided, when imposing additional and appealing restrictions.

We shall consider two extensions of the baseline model to investigate this issue. For both, replace the assumption of the representative household with a population of heterogeneous and exogenously given human capital h. We shall denote the aggregate distribution function for human capital $h \geq 0$ with H and assume the normalization

$$1 = \int hH(dh).$$

For other variables, we shall use the subscript h to denote the dependence on h. Variables without $h-$subscript denote economy-wide averages. These averages shall normally be calculated per integrating across the population, with exceptions as noted. In particular, we shall let $\bar{n}$ denote the human-capital weighted average of individual labor supplies,

$$\bar{n} = \int h\bar{n}_h H(dh) \tag{67}$$

as this is the aggregate labor supply of relevance for the production function. Wages are paid per unit of time and unit of human capital, so that an agent of type h receives labor income $w_t h n_{h,t}$ in period t, before paying labor income taxes.

As a first extension, suppose that the agent "type" h is known to the government, and that the government sets a marginal labor income tax rate τ_h^n, which differs across agent types. Thus, the after-tax labor income is $(1-\tau_h^n)w_t h n_{h,t}$. The first-order conditions for consumption and labor are now changed, compared to the benchmark model. Detrend all variables appropriately to $t = 1$. The first-order condition with respect to labor is

$$\bar{u}_{n;h} = (1-\tau_h^n)\bar{w}h\bar{\lambda}_h$$

where it is useful to denote the additional factor h, compared to the benchmark model. Replacing $(1+\tau^c)\bar{\lambda}_h$ with $\bar{u}_{c;h}$, one obtains a version of equation (31):

$$\left(\eta\kappa\bar{n}_h^{1+\frac{1}{\varphi}}\right)^{-1} + 1 - \frac{1}{\eta} = \alpha_h \frac{\bar{n}}{\bar{y}}\frac{\bar{c}_h}{h\bar{n}_h} \tag{68}$$

where α_h is given by

$$\alpha_h = \left(\frac{1+\tau^c}{1-\tau_h^n}\right)\left(\frac{1+\frac{1}{\varphi}}{1-\theta}\right). \tag{69}$$

This model already features considerable complexity, and can be enriched even further, when also considering heterogeneity in wealth and transfers. The analysis simplifies considerably with the following high-level assumption however. Let

$$z_h = \frac{\bar{c}_h}{(1-\tau_h^n)\bar{w}h\bar{n}_h}$$

be the ratio of consumption to after-tax labor income for an agent of type h, given tax rates.

Assumption A. 1. *Assume that the ratio z_h of consumption to after-tax labor income is constant across the population, $z_h \equiv z$, regardless of tax rates. I.e., the ratio z may change in the aggregate, as tax rates are changed, but not on the individual level.*

We regard this assumption as a benchmark and point of orientation for a richer analysis. The assumption is immediately appealing in a model without capital income and without transfers: in fact, there it must hold by construction. It is still appealing in the richer model here, if the distribution of wealth and transfers is "in line" with after-tax labor income. The assumption is appealing if all labor tax net factors $(1-\tau_h^n)$ change by a common factor, but not, if e.g. some τ_h^n are changed, whereas others are not. While it may be interesting to derive specifications on primitives, which deliver (1) as a result, rather than as assumption, we shall proceed without doing so.

The assumption directly implies that $\bar{n}_h$ is constant across the population, given tax rates:

$$\bar{n}_h \equiv \bar{n}.$$

As another exception from our aggregation-per-integration rule, denote with τ^n the human-capital weighted average of the individual labor income tax rates,

$$\tau^n = \int \tau_h^n h H(dh). \tag{70}$$

Indeed, this is the tax rate we implicitly calculate in our empirical results section 4, as we are aggregating tax receipts $\tau_h^n h\bar{n}_h$ and not tax rates τ_h^n across the population. Per integration of $c_h = z((1-\tau_h^n)\bar{w}h\bar{n}_h)$, we see that

$$\bar{c} = (1-\tau^n)\bar{n}.$$

With that, equation (68) and (69) turn into equations (31) with (32), and the analysis therefore proceeds as there.

Proposition 6. *With assumption 1, the Laffer curves remain unchanged.*

An interesting alternative benchmark is provided by the following assumption, distinguishing between transfer receivers and tax payers, and replacing assumption 1:

Assumption A. 2. *Assume that the human capital distribution is constant between $h_1 < h_2$, i.e. $\lim_{h>h_1, h\to h_1} H(h) = H(h_2)$. For some range of taxes, assume that agents with $h \leq h_1$ either choose not to work, $\bar{n}_h = 0$, or cannot generate labor income $h = 0$, but are the receivers of all transfers.*

In that case, we immediately get

Proposition 7. *Impose assumption (2). Then, for the range of taxes of that assumption, the Laffer curves coincide with the Laffer curves obtained in the benchmark model for $s = 0$ and all additional revenues spent on g.*

From the perspective of the tax paying agents, the transfers to the transfer-receiving-only part of the population has the same allocational consequences as general government spending.

As a second extension, we shall draw on Heathcote et al. (2010). These authors have recently pointed out that it may be reasonable to model the increase in the marginal tax rates as a constant elasticity of net income. To make their assumption consistent with the long-run growth economy here and to furthermore keep the analysis simple, suppose that net labor income is given by

$$(1 - \tau^n) w \bar{n}^{1-\upsilon} \left(h \bar{n}_h\right)^{\upsilon} \tag{71}$$

for some general proportionality factor $(1 - \tau^n) w \bar{n}^{1-\upsilon}$ and some elasticity parameter υ: Heathcote et al. (2010) estimate $\upsilon = 0.74$. The actual tax rate paid is therefore

$$\tau_h^n = 1 - (1 - \tau^n) \bar{n}^{1-\upsilon} \left(h \bar{n}_h\right)^{\upsilon - 1} \to 1 \text{ for } h \bar{n}_h \to \infty$$

and is actually negative for sufficiently small values of $h\bar{n}_h$, implying a subsidy. With (71) and in contrast to the first extension, the agent takes into account the effect of changing marginal tax rates, as she is changing labor supply. Similar to the first extension, the first-order conditions imply

$$\left(\eta \kappa \bar{n}_h^{1+\frac{1}{\varphi}} \right)^{-1} + 1 - \frac{1}{\eta} = \frac{1}{\upsilon} \alpha \, \frac{\bar{n}}{\bar{y}} \frac{\bar{c}_h}{\bar{n}^{1-\upsilon} (h \bar{n}_h)^{\upsilon}} \tag{72}$$

where α_h is given by (32). There are a few differences between (68) and (72): the most crucial one may be the extra factor $1/\upsilon$ on the right hand side of the latter.

To say more requires additional assumptions. Let

$$z_h = \frac{\bar{c}_h}{(1 - \tau^n) w \bar{n}^{1-\upsilon} \left(h \bar{n}_h\right)^{\upsilon}}$$

be the ratio of consumption to after-tax labor income for an agent of type h, given tax rates. As argued above, we shall proceed with assumption 1, that this ratio is independent of h, but may depend on aggregate conditions. Again, the labor supply will then be independent of h, i.e. $\bar{n}_h \equiv \bar{n}$, where the latter may change with aggregate conditions. Per integration, one finds that $\bar{n}$ satisfies

$$\left(\eta \kappa \bar{n}^{1+\frac{1}{\varphi}} \right)^{-1} + 1 - \frac{1}{\eta} = \frac{1}{\upsilon} \alpha \, \overline{c/y} \tag{73}$$

with α given by (32). The difference to the benchmark model (31) is the additional factor $1/\upsilon$ on the right hand side. Similar to the human capital accumulation calculations of subsection 5.1, note that κ should be calibrated, so that $\bar{n}_{US} = 0.25$ solves the steady state equations. In particular, for $\eta = 1$, the additional factor $1/\upsilon$ will just result in multiplication of the previous value for κ with υ, with the remaining analysis unchanged.

Proposition 8. *With assumption 1, with $\eta = 1$ and with κ calibrated to US data, the Laffer curves in τ^k, τ^n, τ^c remain unchanged.*

For $\eta \neq 1$, the constant $1 - (1/\eta)$ in (73) will result in some changes from the additional factor $1/\upsilon$, but they remain small, if η is near unity and κ is calibrated to US data. Finally, (73) now allows the analysis of changes in the progressivity parameter υ of the tax code and its impact on tax revenues.

5.3. Transition

So far, we have only compared long-run steady states. The question arises, how the results may change, if we consider the transition from one steady state to the next. Indeed, if e.g. the capital stock falls towards the new steady state, when taxes are raised, there will be a transitory "windfall" of tax receipts during that transition, compared to the eventual steady state. This windfall can potentially be large.

Investigating that issue requires additional assumptions about the dynamics. Following Jermann (1998) and using his parameter, we assume that it is costly to adjust capital, in dependence of the investment-to-capital ratio: note that this did not matter for the steady state considerations up to now. We assume a transition from the current "status quo" steady state to the new steady state, by assuming that some tax rate is permanently changed to its new, long-run value and allow transfers and/or government spending to adjust during the transition. We then compute the net present value of tax revenues along the entire transition path, taking into account the change in the discounting rates along that path.

These calculations require numerical approximations. There are (at least) two routes available. One is to make precise functional form assumptions e.g. on the capital adjustment costs and calculate the transition as precisely as possible. The second route is to rely on a log-linear approximation around the new steady states: in that case, only local "elasticities" are required. The log-linearization is now easy with the results provided in subsection 2.1. Additional details on the log-linearization can be found in Uhlig (2010), where a somewhat related model is solved. One could then in principle attempt to "back-solve" for the higher-order functional form assumptions that justify this procedure as correct. We proceed with the latter, due to its appealing simplicity. Further, figure 12 shows how much capital is predicted to change eventually, when starting from the new steady state and changing the capital income tax rate back to its old level: the prediction based on the log-linearization around the new steady state is reasonably close to the exact steady state calculation (whereas a log-linearization around the original steady state only leads to a straight line and should not be used).

The results for the US calibration, at $\eta = 2$ and $\varphi = 1$, are in figure 13 for the labor tax Laffer curve and in figure 14 for the capital income tax Laffer curve. The figures compare the transition results to the original steady state comparison. The peak of the labor tax Laffer curve shifts somewhat to the right and up. This result is easy to understand:

as the labor tax rate is increased, this will eventually decrease labor input and therefore decrease the capital stock. Along the transition, the capital stock is "too high", producing additional tax revenue beyond the steady state calculations. The change appears to be modest enough that much of the steady state comparison analysis is still valid. Notice in particular, that the slope of the Laffer curve around the original tax rate has not changed much, so that the local degree of self-financing of a labor tax cut remains largely the same.

The results are rather dramatically different for the capital income tax Laffer curve in figure 14, however. While the steady state comparison indicates a very flat Laffer curve, the transition Laffer curve keeps rising, generating substantial additional tax revenues, even for very high capital income tax rates. The results are surprising only at first glance, however. One way to gain some intuition here is to consider the change $\Delta \bar{k}$ in the steady state capital stock. Ignoring the adjustment of the discount rate along the transition path for the sake of the argument, one can see that the owners of this "excess" capital now earn less than the steady state return. Since the value of the capital stock is the discounted sum of its returns, this amounts to a considerable appropriation of that capital stock by the government. Indeed, for $\tau^k = 1$, this argument is equivalent to the government taxing away the entire initial wealth. Since the capital stock is several times larger than GDP, this is a substantial amount of tax revenue, which dwarves the steady-state comparison results.

Put differently, a sudden and surprising increase in the capital income tax contains a large initial wealth tax. A sudden, one-time wealth tax is not distortionary and can indeed raise substantial revenue. As a piece of practical policy advice, there may nonetheless be good reasons to rely on the steady state comparison rather than this transition path. Surprise tax increases are rare in practice. With sufficient delay, the distortionary effect on future capital accumulation can quickly outweigh the gains, that would be obtained for an immediate surprise rise, see e.g. Trabandt (2007). Furthermore, a delayed, but substantial raise in capital income taxes is likely to lead to large efforts of hiding tax returns, to tax evasions and to capital flight, rather than increases in tax receipts. These considerations have been absent from the analysis above, and it would be important to include them in future research on this issue. Additional issues then certainly arise. For example, a related analysis by Strulik and Trimborn (2010) finds a net present value Laffer curve with a peak when considering marginal capital tax rate changes in a model with an extended corporate sector.

6. Conclusion

This paper examines the following question: how does the behavior of households and firms in the US compared to the EU-14 adjust if fiscal policy changes taxes? The Laffer curve provides us with a framework to think about the incentive effects of tax cuts. Therefore, the goal of this paper is to examine the shape of the Laffer curve quantitatively in a simple neoclassical growth model calibrated to the US as well as to the EU-14 economy. We show that there exist robust steady state Laffer curves for labor taxes as well as capital taxes. According to the model the US and the EU-14 area are located on the left side of their Laffer curves. However the EU-14 countries are much closer to the slippery slopes than the US. More precisely, we find that the US can increase tax revenues by 30% by raising labor taxes but only 6% by raising capital income taxes, while the same numbers for EU-14 are 8% and 1% respectively. An overview of the sensitivity of these results to alternative values for the Frisch elasticity of labor supply and the intertemporal elasticity of substitition has been provided in table 12.

In addition, our results indicate that tax cuts in the EU-14 area are self-financing to a much higher degree compared to the US. We find that for the US model 32% of a labor tax cut and 51% of a capital tax cut are self-financing in the steady state. In the EU-14 economy 54% of a labor tax cut and 79% of a capital tax cut are self-financing.

These results do not appear to change much with considerations of households heterogeneity. However, transition effects matter: a permanent surprise increase in capital income taxes always raises tax revenues for the benchmark calibration. Finally, endogenous growth and human capital accumulation locates the US and EU-14 close to the peak of the labor income tax Laffer curve. As labor taxes are increased, incentives to enjoy leisure are increased, which in turn decreases the steady state level of human capital or the growth rate of the economy: tax revenues fall as a result.

We therefore conclude that there rarely is a free lunch due to

Cassou, S. P., Lansing, K. J., 2006. Tax reform with useful public expenditures. Journal Of Public Economic Theory 8(4), 631–676.

Chari, V. V., Christiano, L. J., Kehoe, P. J., 1995. Policy analysis in business cycle models. Thomas F. Cooley, Ed., Frontiers Of Business Cycle Research, Princeton, New Jersey: Princeton University Press, 357–91.

Chari, V. V., Kehoe, P. J., Mcgrattan, E. R., 2007. Business cycle accounting. Econometrica 75 (3), 781–836.

Cooley, T. F., Prescott, E., 1995. Economic growth and business cycles. Frontiers Of Business Cycle Research (Ed. Thomas F. Cooley), Princeton University Press, 1–38.

Domeij, D., Floden, M., 2006. The labor-supply elasticity and borrowing constraints: Why estimates are biased. Review Of Economic Dynamics 9, 242–262.

Feldstein, M., Horioka, C., 1980. Domestic saving and international capital flows. The Economic Journal 90, 314–329.

Floden, M., Linde, J., 2001. Idiosyncratic risk in the United States and Sweden: Is there a role for government insurance? Review Of Economic Dynamics 4, 406–437.

Garcia-Mila, T., Marcet, A., Ventura, E., 2001. Supply-side interventions and redistribution, manuscript.

Gruber, J., 2006. A tax-based estimate of the elasticity of intertemporal substitution. NBER Working Paper (11945).

Hall, R. E., 1988. Intertemporal substitution of consumption. Journal Of Political Economy 96(2), 339–357.

Hall, R. E., 2008. Sources and mechanisms of cyclical fluctuations in the labor market, draft, Stanford University.

Heathcote, J., Storesletten, K., Violante, G., 2010. Redistributive taxation in a partial-insurance economy, draft, New York University.

House, C. L., Shapiro, M. D., 2006. Phased-in tax cuts and economic activity. Forthcoming American Economic Review.

Ireland, P. N., 1994. Supply-side economics and endogenous growth. Journal Of Monetary Economics 33, 559–572.

Jermann, U., April 1998. Asset pricing in production economies. Journal Of Monetary Economics 41(2), 257–275.

Jones, C. I., 2001. Introduction to Economic Growth, 2nd Edition. W.W. Norton & Company.

Jonsson, M., Klein, P., 2003. Tax distortions in Sweden and the United States. European Economic Review 47, 711–729.

Kim, J., Kim, S. H., 2004. Welfare effects of tax policy in open economies: Stabilization and cooperation, manuscript.

Kimball, M. S., Shapiro, M. D., 2003. Labor supply: Are the income and substitution effects both large or small?, manuscript.

King, R. G., Plosser, C. I., Rebelo, S. T., October 2001. Production, growth and business cycles: Technical appendix. Computational Economics 20(1-2), 87–116.

King, R. S., Rebelo, S. T., 1999. Resuscitating real business cycles. Handbook Of Macroeconomics, Edited By J. B. Taylor And M. Woodford, Amsterdam: Elsevier 1B, 927–1007.

Klein, P., Krusell, P., Rios-Rull, J. V., 2004. Time-consistent public expenditures, manuscript.

Kniesner, T. J., Ziliak, J. P., 2005. The effect of income taxation on consumption and labor supply, manuscript.

Kydland, F. E., Prescott, E. C., 1982. Time to build and aggregate fluctuations. Econometrica 50, 1345–1370.

Lansing, K., 1998. Optimal fiscal policy in a business cycle model with public capital. The Canadian Journal Of Economics 31(2), 337–364.

Leeper, E. M., Yang, S.-C. S., 2005. Dynamic scoring: Alternative financing schemes. NBER Working Paper (12103).

Levine, R., Renelt, D., September 1992. A sensitivity analysis of cross-country growth regressions. American Econommic Review 82(4), 942–63.

Lindsey, L. B., 1987. Individual taxpayer response to tax cuts: 1982-1984: With implications for the revenue maximizing tax rate. Journal of Public Economics 33(2), 173–206.

Ljungqvist, L., Sargent, T. J., 2006. Do taxes explain european employment? Indivisible labor, human capital, lotteries, and savings, manuscript.

Lucas, R. E., 1988. On the mechanics of economic development. Journal of Monetary economics 22, 3–42.

Mankiw, G. N., Weinzierl, M., 2005. Dynamic scoring: A back-of-the-envelope guide. Forthcoming Journal Of Public Economics.

McGrattan, E. R., 1994. The macroeconomic effects of distortionary taxation. Journal Of Monetary Economics 33(3), 573–601.

Mendoza, E. G., Razin, A., Tesar, L. L., 1994. Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption. Journal Of Monetary Economics 34, 297–323.

Mendoza, E. G., Tesar, L. L., 1998. The international ramifications of tax reforms: Supply-side economics in a global economy. American Economic Review 88, 402–417.

Novales, A., Ruiz, J., 2002. Dynamic laffer curves. Journal Of Economic Dynamics And Control 27, 181–206.

Pissarides, C., Ngai, L. R., 2008. Welfare policy and the sectoral distribution of employment, draft, London School of Economics.

Prescott, E. C., 2002. Prosperity and depression. American Economic Review 92, 1–15.

Prescott, E. C., July 2004. Why do americans work so much more than europeans? Quarterly Review, Federal Reserve Bank Of Minneapolis.

Prescott, E. C., 2006. Nobel lecture: The transformation of macroeconomic policy and research. Journal Of Political Economy 114(2), 203–235.

Rogerson, R., 2007. Taxation and market work: Is scandinavia an outlier? NBER Working Paper 12890.

Schmitt-Grohe, S., Uribe, M., 1997. Balanced-budget rules, distortionary taxes, and aggregate instability. Journal Of Political Economy 105(5), 976–1000.

Shimer, R., 2008. Convergence in macroeconomics: The labor wedgeManuscript, University of Chicago.

Strulik, H., Trimborn, T., 2010. Laffer strikes again: Dynamic scoring of capital taxes, manuscript.

Trabandt, M., 2007. Optimal pre-announced tax reforms under valuable and productive government spending, european University Institute, EUI Working Paper ECO 2007/52.

Uhlig, H., 2004. Do technology shocks lead to a fall in total hours worked? Journal Of The European Economic Association 2(2-3), 361–371.

Uhlig, H., May 2010. Some fiscal calculus. American Economic Review: Papers and Proceedings 100(2), 30–34.

Uzawa, H., 1965. Optimum technical change in an aggregative model of economic growth. International Economic Review 6, 18–31.

Wanniski, J., Winter 1978. Taxes, revenues, and the laffer curve. The Public Interest.

Yanagawa, N., Uhlig, H., 1996. Increasing the capital income tax may lead to faster growth. European Economic Review 40, 1521–1540.

Variable	US	EU-14	Description	Restriction
τ^n	28	41	Labor tax	Data
τ^k	36	33	Capital tax	Data
τ^c	5	17	Consumption tax	Data
$\overline{b/y}$	63	65	Gov. debt to GDP	Data
$\overline{g/y}$	18	23	Gov.cons+inv. to GDP	Data
($\overline{s/y}$	8	15	Gov. transfer to GDP	Implied)
ψ	2	2	Growth rate	Data
$\bar{R}$	4	4	Real interest rate	Data
$\overline{m/y}$	4	-1	Net imports to GDP	Data
($\overline{b/y}(\bar{R}-\psi)+\overline{s/y}+\overline{m/y}$	12	16	Untaxed income	Implied)

Table 1: Baseline calibration, part 1

Var.	US	EU-14	Description	Restriction
θ	0.38	0.38	Capital share on prod.	Data
δ	0.07	0.07	Depr. rate of capital	Data
η	2	2	Inverse of IES	Benchmark
φ	1	1	Frisch elasticity	Benchmark
κ	3.46	3.46	Weight of labor	$\bar{n}_{us}=0.25$
η	1	1	Inverse of IES	Alternative
φ	3	3	Frisch elasticity	Alternative
κ	3.38	3.38	Weight of labor	$\bar{n}_{us}=0.25$
σ	0.32	0.32	Cons. weight in C-D	$\bar{n}_{us}=0.25$

Table 2: Baseline calibration, part 2

	$\bar{\tau}^n$	$\bar{\tau}^k$	$\bar{\tau}^c$	$\psi b/\bar{y}$	$\bar{m}/\bar{y}$	$\bar{g}/\bar{y}$	$\bar{s}/\bar{y}$
USA	28	36	5	63	4	18	8
EU-14	41	33	17	65	-1	23	15
GER	41	23	15	62	-3	21	15
FRA	46	35	18	60	-1	27	15
ITA	47	34	15	110	-2	21	19
GBR	28	46	16	44	2	21	13
AUT	50	24	20	65	-3	20	23
BEL	49	42	17	107	-4	24	21
DNK	47	51	35	50	-4	28	27
FIN	49	31	27	46	-8	24	22
GRE	41	16	15	100	10	20	15
IRL	27	21	26	43	-13	19	11
NET	44	29	19	58	-6	27	12
PRT	31	23	21	57	8	23	11
ESP	36	30	14	54	3	21	13
SWE	56	41	26	58	-7	30	21

Table 3: Country calibration

	θ	δ	κ	$\bar{g}_{other}/\bar{y}$
USA	0.35	0.083	3.619	0.004
EU-14	0.38	0.070	4.595	-0.017
GER	0.37	0.067	5.179	-0.002
FRA	0.41	0.069	5.176	0.004
ITA	0.39	0.070	5.028	0.004
GBR	0.36	0.064	4.385	0.005
AUT	0.39	0.071	3.985	0.006
BEL	0.39	0.084	5.136	0.005
DNK	0.40	0.092	3.266	0.007
FIN	0.34	0.070	3.935	0.014
GRE	0.40	0.061	3.364	-0.005
IRL	0.36	0.086	5.662	0.006
NET	0.38	0.077	5.797	0.001
PRT	0.39	0.098	3.391	0.005
ESP	0.42	0.085	5.169	0.003
SWE	0.36	0.048	2.992	0.004

Table 4: Parameter Variations, given CFE preferences with $\varphi = 1$, $\eta = 2$

	Labor Tax Rev.		Cap. Tax Rev.		Cons. Tax Rev.	
	US	EU-14	US	EU-14	US	EU-14
Data	14	19	9	8	3	10
Model						
$\varphi = 1, \eta = 2$	17	25	7	6	3	8
$\varphi = 3, \eta = 1$	17	25	7	6	3	8
C-D	17	25	7	6	3	8
Varied params., $\varphi = 1, \eta = 2$	17	25	7	6	3	8

Table 5: Comparing measured and implied sources of tax revenue

	Priv. Cons.		Capital		Hours Worked	
	US	EU-14	US	EU-14	US	EU-14
Data	61	51	238	294	25	20
Model						
$\varphi = 1, \eta = 2$	60	50	286	294	25	**23**
$\varphi = 3, \eta = 1$	60	50	286	294	25	23
C-D	60	50	286	294	25	23
Varied params., $\varphi = 1, \eta = 2$	61	51	238	294	25	20

Table 6: Comparing measured and calculated key macroeconomic aggregates: consumption, capital (in % of GDP) and hours worked (in % total time)

Parameter	% self-fin.		max. τ^n		max. add. tax rev.	
Region:	US	EU-14	US	EU-14	US	EU-14
$\varphi = 1, \eta = 2:$	32	54	63	62	30	8
$\varphi = 3, \eta = 1:$	38	65	57	56	21	4
$\varphi = 3, \eta = 2:$	49	78	52	51	14	2
$\varphi = 1, \eta = 2:$	32	54	63	62	30	8
$\varphi = 0.5, \eta = 2:$	21	37	72	71	47	17
$\varphi = 1, \eta = 2:$	32	54	63	62	30	8
$\varphi = 1, \eta = 1:$	27	47	65	65	35	10
$\varphi = 1, \eta = 0.5:$	20	37	69	68	43	15

Table 7: Labor Tax Laffer curves: degree of self-financing, maximal tax rate, maximal additional tax revenues. Shown are results for the US and the EU-14, and the sensitivity of the results to changes in the CFE preference parameters.

Parameter	cross-Frisch-elast.		own-Frisch-elast.	
Region:	US	EU-14	US	EU-14
$\varphi = 1, \eta = 2:$	0.4	0.3	-0.7	-0.7
$\varphi = 3, \eta = 1:$	-0.0	-0.0	-1.0	-1.0
$\varphi = 3, \eta = 2:$	1.1	0.9	-1.0	-1.0
$\varphi = 1, \eta = 2:$	0.4	0.3	-0.7	-0.7
$\varphi = 0.5, \eta = 2:$	0.2	0.2	-0.6	-0.6
$\varphi = 1, \eta = 2:$	0.4	0.3	-0.7	-0.7
$\varphi = 1, \eta = 1:$	-0.0	-0.0	-1.0	-1.0
$\varphi = 1, \eta = 0.5:$	-0.7	-0.6	-2.7	-2.6

Table 8: Cross-Frisch elasticities of consumption wrt wages and own-Frisch elasticities of consumption wrt to the Lagrange multiplier on wealth.

Parameters:	% self-fin. same	% self-fin. varied	max. τ_n same	max. τ_n varied	max. add. tax rev. same	max. add. tax rev. varied
USA	32	30	63	64	30	33
EU-14	54	55	62	61	8	7
GER	50	51	64	64	10	10
FRA	62	62	63	63	5	5
ITA	63	62	62	62	4	4
GBR	42	42	59	59	17	17
AUT	71	70	61	62	2	2
BEL	69	68	61	62	3	3
DNK	83	79	55	57	1	1
FIN	70	68	62	63	3	3
GRE	54	55	60	59	7	7
IRL	35	34	68	69	30	32
NET	53	53	67	67	9	9
PRT	45	44	59	60	14	15
ESP	46	46	62	62	13	13
SWE	83	86	63	61	1	0

Table 9: Labor Tax Laffer curves across countries, for $\varphi = 1, \eta = 2$: degree of self-financing, maximal tax rate, maximal additional tax revenues. Shown are results for keeping the same parameters for all countries and for varying the parameters so as to obtain observed labor, capital-output ratio, investment-output ratio and aggregate feasibility.

Parameter Region:	% self-fin. US	% self-fin. EU-14	max. τ^k US	max. τ^k EU-14	max. add. tax rev. US	max. add. tax rev. EU-14
$\varphi = 1, \eta = 2$:	51	79	63	48	6	1
$\varphi = 3, \eta = 1$:	55	82	62	46	5	1
$\varphi = 3, \eta = 2$:	60	87	60	44	4	0
$\varphi = 1, \eta = 2$:	51	79	63	48	6	1
$\varphi = 0.5, \eta = 2$:	45	73	64	50	7	1
$\varphi = 1, \eta = 2$:	51	79	63	48	6	1
$\varphi = 1, \eta = 1$:	48	77	64	49	6	1
$\varphi = 1, \eta = 0.5$:	45	73	64	50	7	1

Table 10: Capital Tax Laffer curves: degree of self-financing, maximal tax rate, maximal additional tax revenues. Shown are results for the US and the EU-14, and the sensitivity of the results to changes in the CFE preference parameters.

	% self-fin.		max. τ_k		max. add. tax rev.	
Parameters:	same	varied	same	varied	same	varied
USA	51	46	63	68	6	7
EU-14	79	80	48	47	1	1
GER	70	71	49	49	2	2
FRA	88	89	44	43	0	0
ITA	88	88	42	42	0	0
GBR	73	73	57	58	1	1
AUT	88	88	35	35	0	0
BEL	103	98	40	43	0	0
DNK	137	126	30	35	1	1
FIN	92	90	38	40	0	0
GRE	73	74	42	39	2	2
IRL	50	48	62	67	8	8
NET	75	74	50	52	1	1
PRT	65	61	50	55	3	3
ESP	68	67	52	53	2	2
SWE	109	116	33	29	0	0

Table 11: Capital Tax Laffer curves across countries, for $\varphi = 1, \eta = 2$: degree of self-financing, maximal tax rate, maximal additional tax revenues. Shown are results for keeping the same parameters for all countries and for varying the parameters so as to obtain observed labor, capital-output ratio, investment-output ratio and aggregate feasibility.

	US	EU-14
	Potential additional tax revenues (in %)	
labor taxes	14 - 47	2 - 17
capital taxes	4 - 7	0 - 1
	Maximizing tax rate (in %)	
labor taxes	52 - 72	51 - 71
capital taxes	60 - 64	44 - 50
	Percent self-financing of a tax cut (in %)	
labor taxes	20 - 49	37 - 78
capital taxes	45 - 60	73 - 87

Table 12: *The range of results for the parameter variations considered in the benchmark model, i.e. no human capital accumulation.*

Figure 1: The US Laffer Curve for Labor Taxes

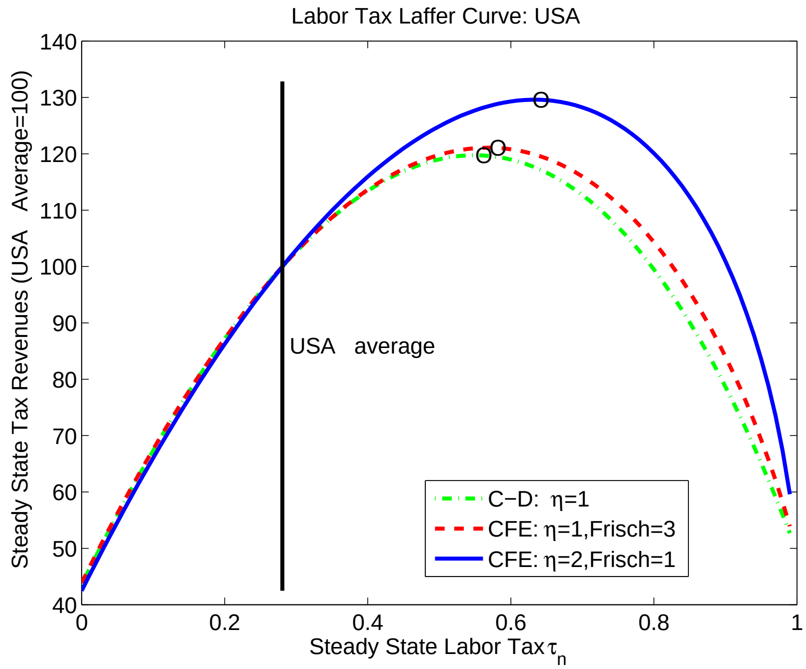


Figure 2: Comparing the US and the EU Labor Laffer Curve

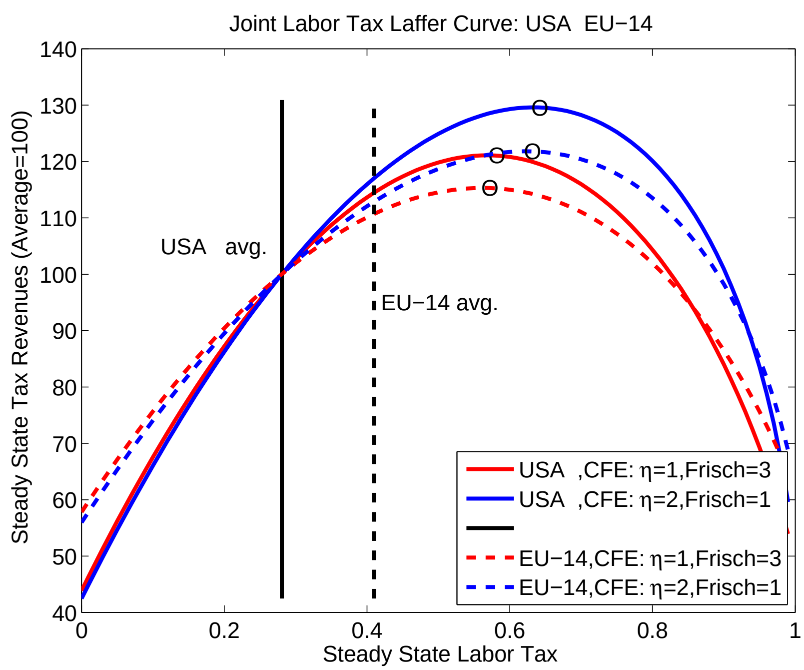
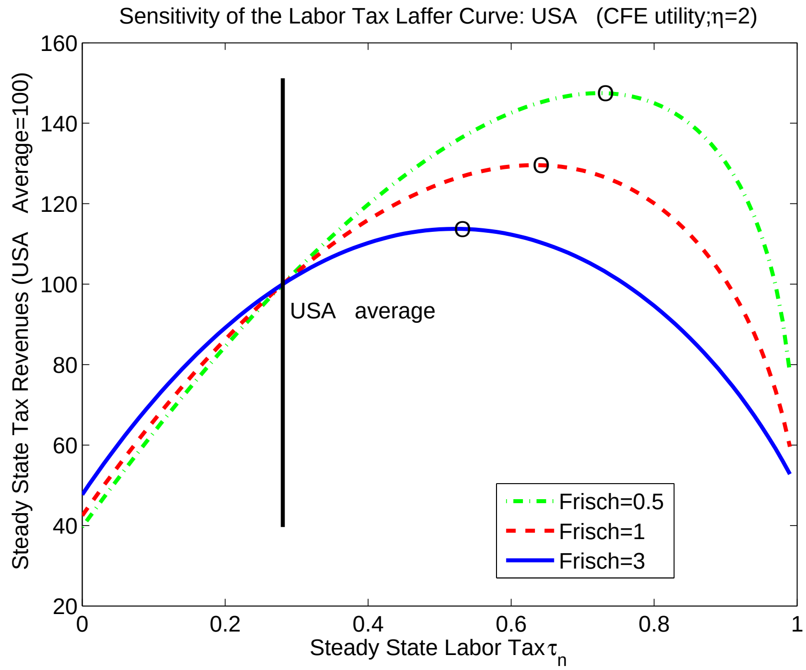


Figure 3: Sensitivity to φ and η: Labor Tax Laffer Curve

Sensitivity to φ:



Sensitivity to η:

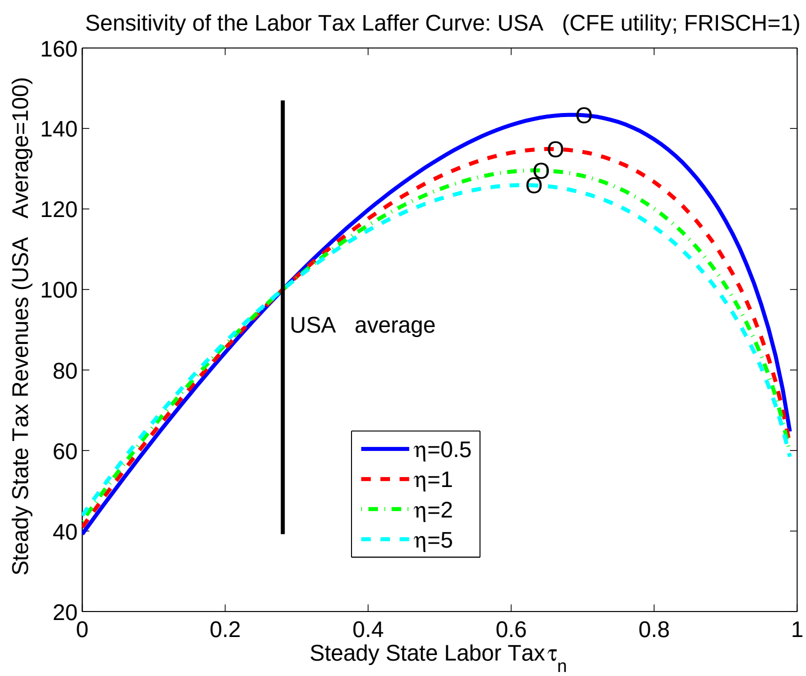
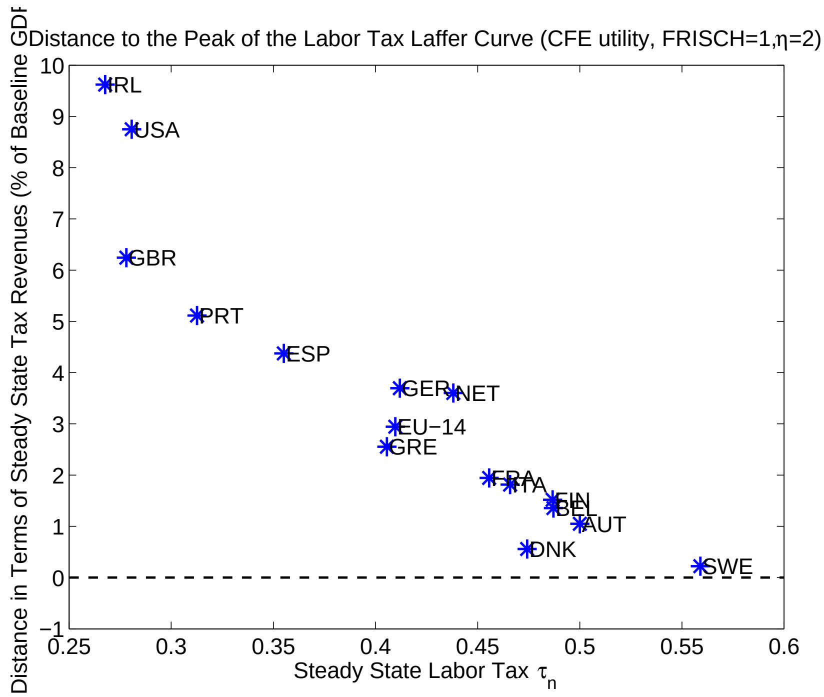


Figure 4: Distances to the Laffer Peak across countries (Varied Parameters)

Labor Tax Laffer Curves:



Capital Tax Laffer Curves:

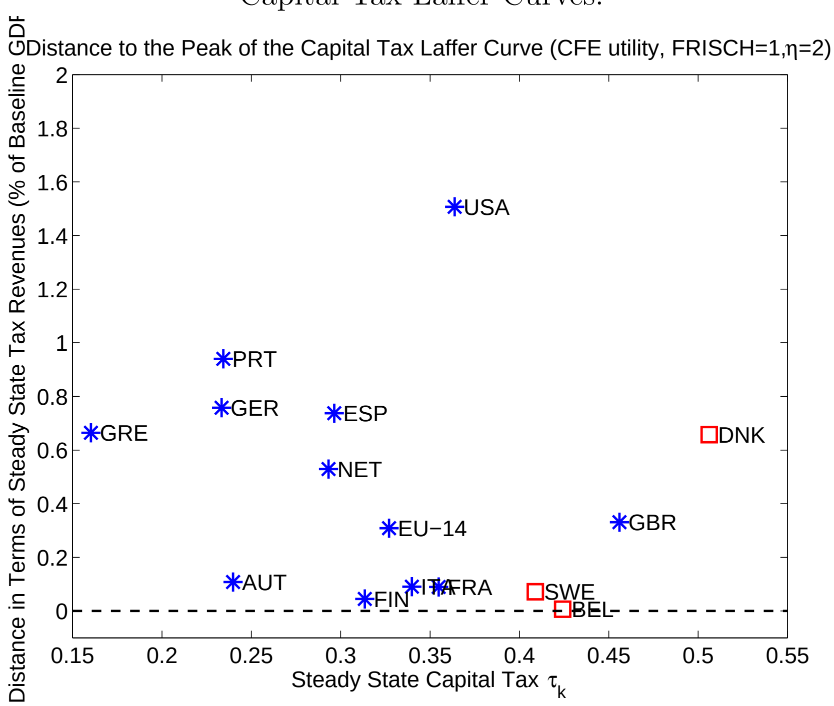


Figure 5: Labor Taxes Laffer Curve: Spending versus Transfers

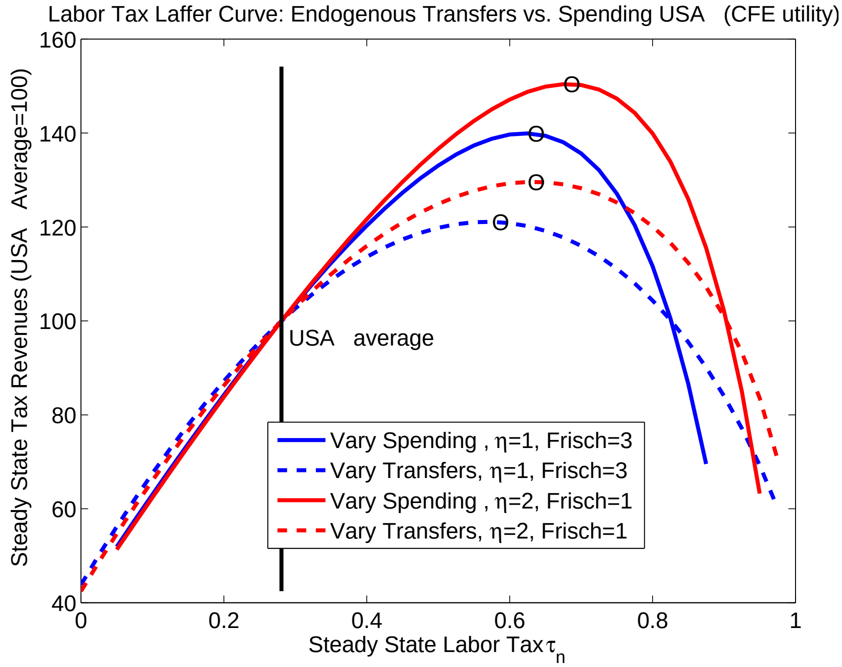


Figure 6: Comparing the US and the EU Capital Laffer Curve

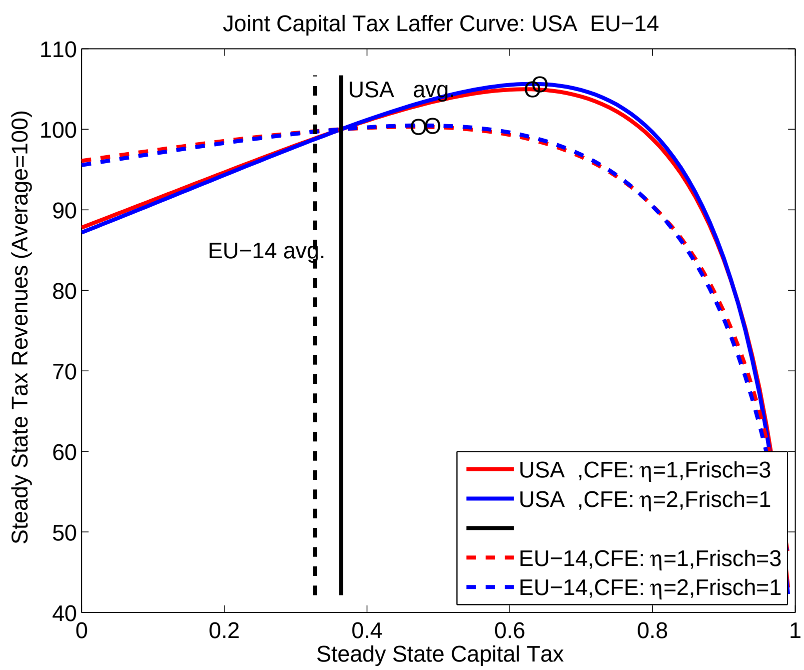


Figure 7: Decomposing Capital Taxes: EU 14

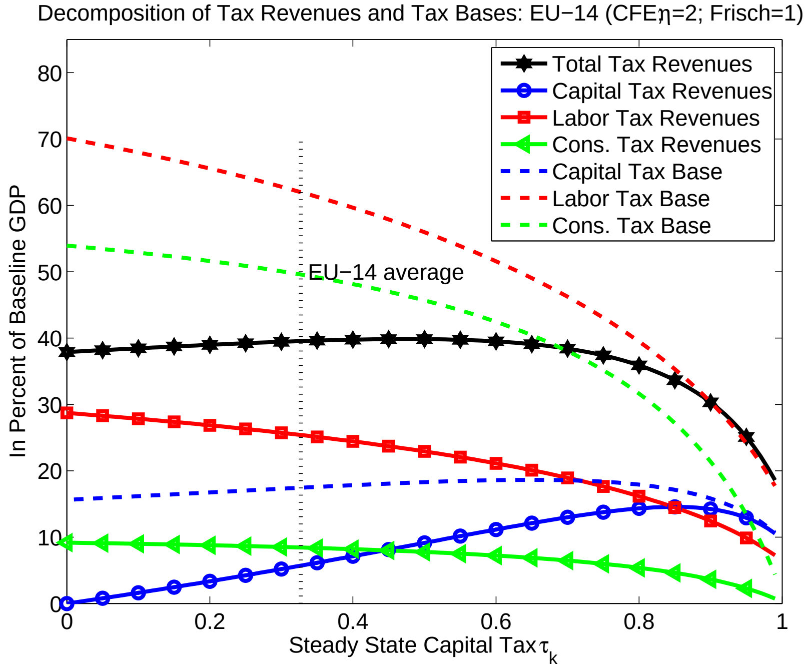


Figure 8: The "Laffer hill" for the US ($\eta = 2, \varphi = 1$).

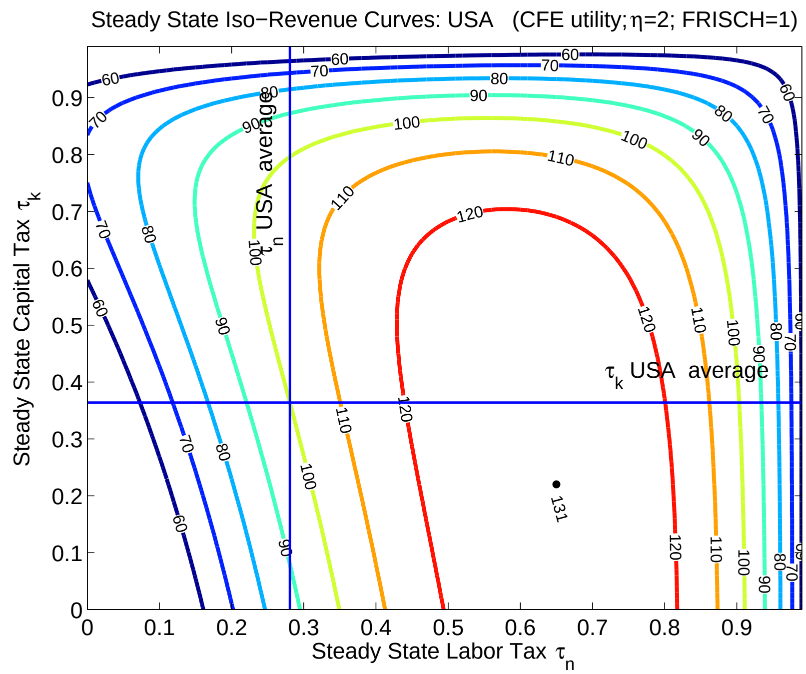


Figure 9: Labor tax Laffer curve, US data: the impact of endogenenous human capital accumulation

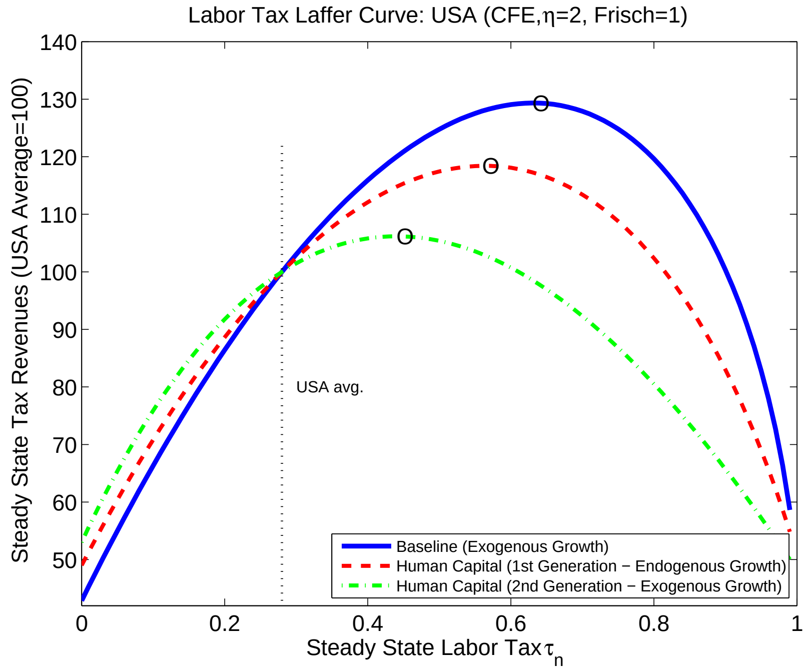


Figure 10: Labor tax Laffer curve, EU data: the impact of endogenenous human capital accumulation

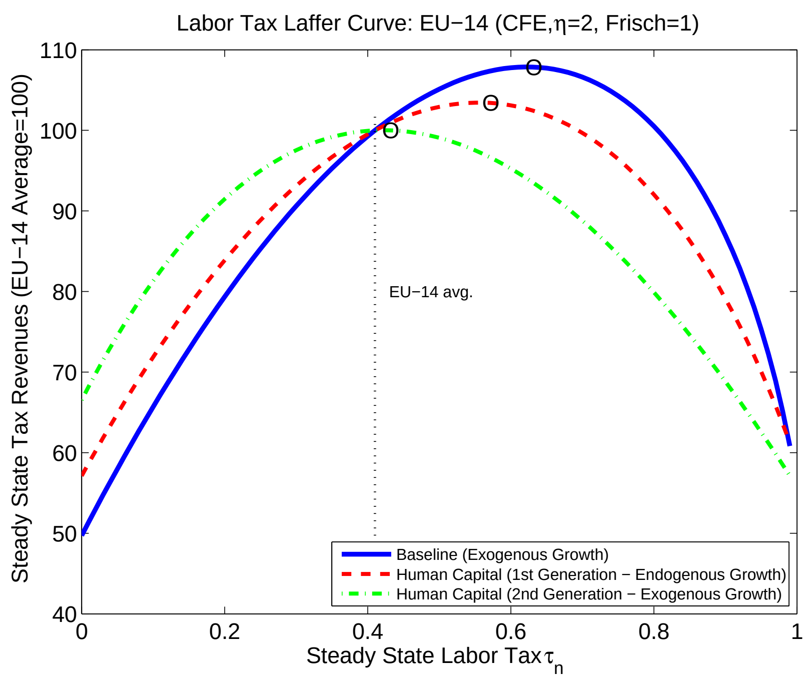


Figure 11: Consumption tax Laffer curve, US data: the impact of endogenenous human capital accumulation

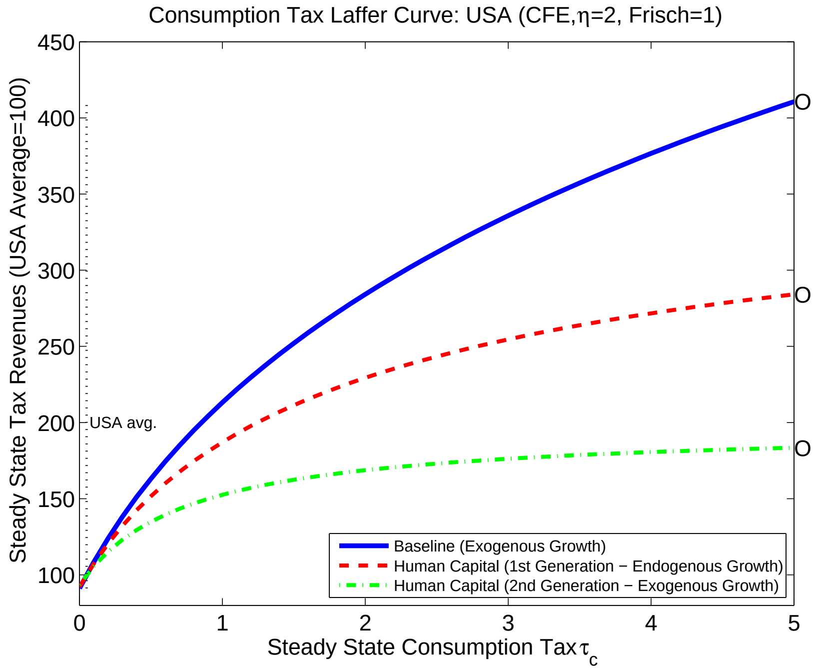


Figure 12: Comparing log-linearly predicted and exact change in capital, due to a permanent change in the capital tax rate.

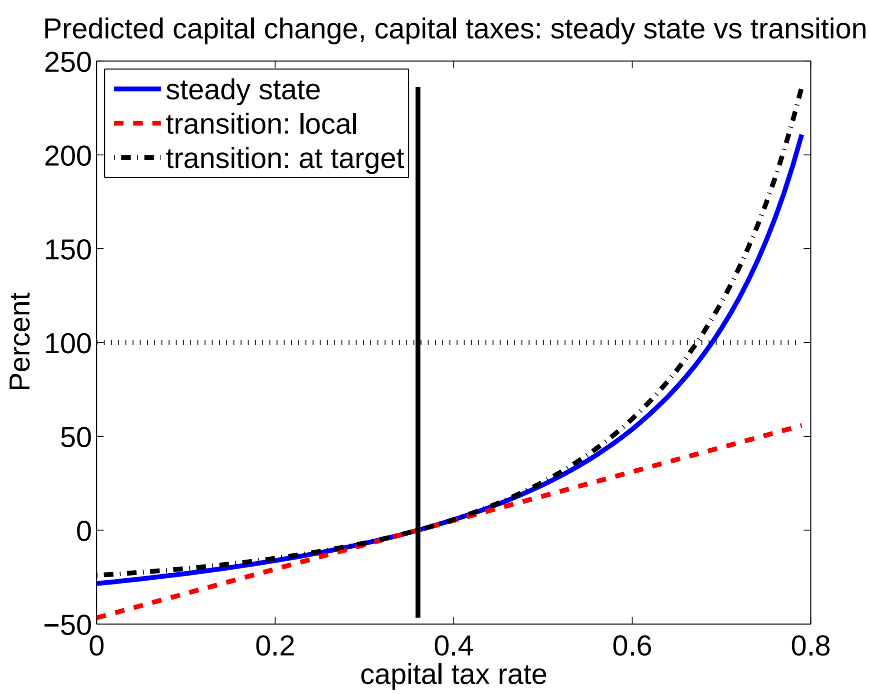


Figure 13: Labor tax Laffer curves: steady state vs transition. US calibration, $\eta = 2$, $\varphi = 1$.

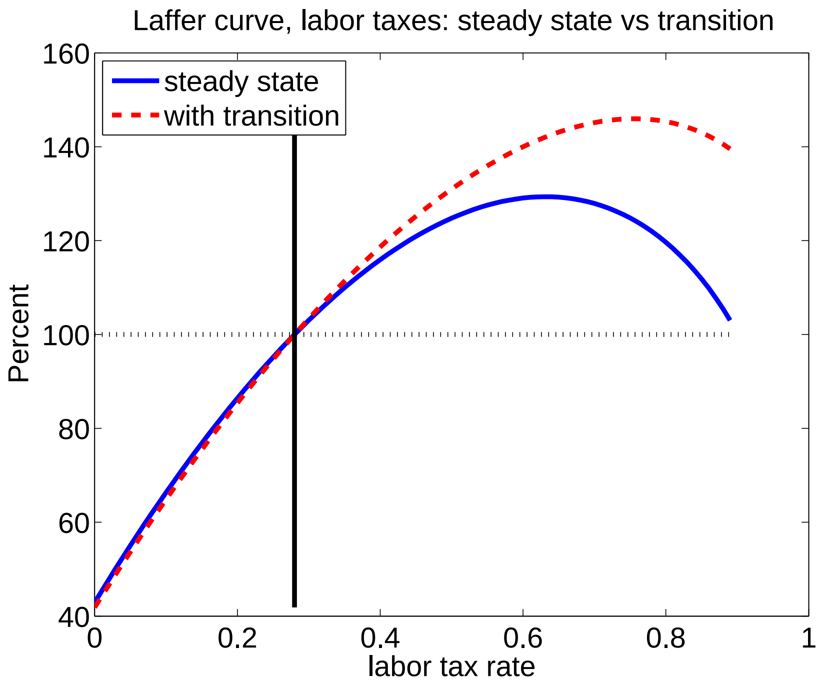
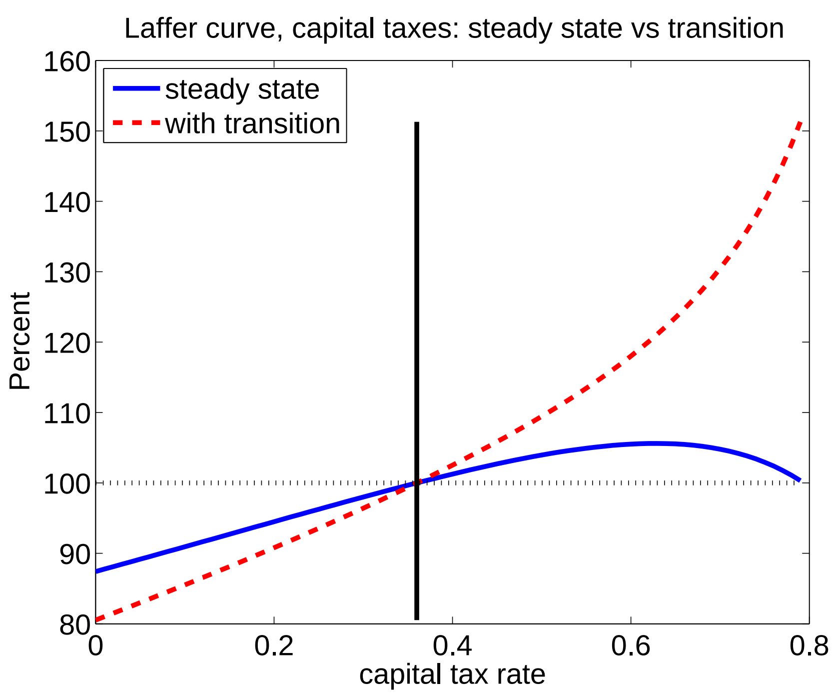


Figure 14: Capital income tax Laffer curves: steady state vs transition. US calibration, $\eta = 2$, $\varphi = 1$.



Appendix

Appendix A. EU-14 Tax Rates and GDP Ratios

In order to obtain EU-14 tax rates and GDP ratios we proceed as follows. E.g., EU-14 consumption tax revenues can be expressed as:

$$\tau^c_{EU-14,t} c_{EU-14,t} = \sum_j \tau^c_{j,t} c_{j,t} \tag{A.1}$$

where j denotes each individual EU-14 country. Rewriting equation (A.1) yields the consumption weighted EU-14 consumption tax rate:

$$\tau^c_{EU-14,t} = \frac{\sum_j \tau^c_{j,t} c_{j,t}}{c_{EU-14,t}} = \frac{\sum_j \tau^c_{j,t} c_{j,t}}{\sum_j c_{j,t}}. \tag{A.2}$$

The numerator of equation (A.2) consists of consumption tax revenues of each individual country j whereas the denominator consists of consumption tax revenues divided by the consumption tax rate of each individual country j. Formally,

$$\tau^c_{EU-14,t} = \frac{\sum_j T^{Cons}_{j,t}}{\sum_j \frac{T^{Cons}_{j,t}}{\tau^c_{j,t}}}. \tag{A.3}$$

The methodology of Mendoza et al. (1994) allows to calculate implicit individual country consumption tax revenues so that we can easily calculate the EU-14 consumption tax rate $\tau^c_{EU-14,t}$. Likewise, applying the same procedure we calculate EU-14 labor and capital tax rates. Taking averages over time yields the tax rates we report in table 1.

In order to calculate EU-14 GDP ratios we proceed as follows. E.g., the GDP weighted EU-14 debt to GDP ratio can be written as:

$$\frac{b_{EU-14,t}}{y_{EU-14,t}} = \frac{\sum_j \frac{b_{j,t}}{y_{j,t}} y_{j,t}}{\sum_j y_{j,t}} \tag{A.4}$$

where b_j and y_j are individual country government debt and GDP. Likewise, we apply the same procedure for the EU-14 transfer to GDP ratio. Taking averages over time yields the numbers used for the calibration of the model.

Tables A.13, A.14 and A.15 contain our calculated panel of tax rates for labor, capital and consumption respectively.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
USA	27.6	28.2	28.6	28.9	29.2	29.6	29.4	27.2	26.3	26.1	27.4	27.9	28.4
EU-14	42.3	42.2	42.0	41.3	41.5	40.5	40.2	39.7	40.1	40.1	40.5	41.0	41.3
GER	42.0	40.9	41.4	41.9	41.7	41.4	41.7	40.8	40.6	40.0	40.2	41.2	41.5
FRA	46.2	46.8	46.6	45.4	45.8	45.3	44.7	44.4	45.0	44.7	46.0	45.9	45.7
ITA	46.4	48.5	49.7	45.9	46.3	45.7	45.5	45.6	45.9	46.2	46.1	46.2	47.8
GBR	26.8	26.1	25.7	26.9	27.4	27.8	27.7	27.2	27.7	28.8	29.3	29.8	30.4
AUT	47.5	48.7	50.0	50.1	50.3	49.4	50.8	50.7	50.7	50.8	50.3	50.3	50.3
BEL	48.1	48.0	48.6	49.0	48.4	48.3	48.3	49.0	49.3	49.6	49.5	48.5	48.8
DNK	46.4	46.8	47.4	46.6	48.6	48.8	48.7	47.5	47.7	46.6	47.0	46.7	47.9
FIN	51.9	52.6	50.4	49.9	48.9	49.4	48.6	48.0	46.6	45.8	46.6	47.1	47.2
GRE	NaN	NaN	NaN	NaN	NaN	40.2	39.8	41.0	42.3	40.5	40.3	40.0	40.3
IRL	NaN	NaN	NaN	NaN	NaN	NaN	NaN	25.4	25.6	26.9	27.0	27.4	28.5
NET	49.4	46.4	46.8	42.3	43.6	43.6	40.4	40.7	41.0	41.8	42.8	45.8	45.0
PRT	29.4	29.8	30.1	29.9	30.1	30.8	31.2	31.4	32.0	31.9	32.5	32.7	34.4
ESP	NaN	NaN	NaN	NaN	NaN	34.1	34.8	35.1	35.1	35.1	35.9	36.6	37.4
SWE	52.9	54.6	56.3	58.1	60.7	57.2	55.2	53.6	55.2	55.9	56.0	56.5	54.6

Table A.13: *Labor income taxes in percent across countries and time*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
USA	37.8	37.3	37.1	37.5	37.3	38.3	36.1	32.9	33.6	34.0	36.4	36.4	38.2
EU-14	29.6	30.9	32.6	33.3	35.2	34.7	33.7	31.7	30.6	31.0	32.7	34.8	34.4
GER	23.1	22.8	22.8	23.9	25.9	27.0	21.6	21.4	22.0	21.6	22.3	24.4	24.8
FRA	27.9	30.3	32.2	34.9	37.5	36.9	38.0	36.0	34.6	36.6	37.1	40.1	39.2
ITA	32.7	34.0	36.2	32.3	35.1	32.2	33.7	32.9	31.7	31.8	32.8	37.4	39.1
GBR	40.3	39.9	42.8	45.9	47.4	52.1	52.5	45.8	42.4	42.5	46.9	49.2	45.1
AUT	20.4	23.5	25.6	25.6	24.0	23.6	28.7	24.4	24.0	23.6	22.9	22.3	23.2
BEL	38.1	40.4	41.9	44.9	44.9	44.3	46.6	45.3	42.8	41.4	40.8	40.5	39.6
DNK	43.3	44.6	44.9	52.5	47.8	46.2	49.5	50.7	51.5	52.3	57.3	58.3	59.3
FIN	28.2	32.0	32.4	33.3	33.3	39.2	31.4	31.1	29.3	29.5	30.1	28.4	29.3
GRE	NaN	NaN	NaN	NaN	NaN	20.1	17.1	16.7	15.0	14.8	15.5	14.5	14.5
IRL	NaN	NaN	NaN	NaN	NaN	NaN	NaN	17.5	19.0	20.3	21.0	24.2	22.5
NET	27.6	30.4	30.3	30.9	31.4	30.3	31.3	29.5	26.9	27.4	30.8	28.2	26.1
PRT	18.9	20.6	21.2	21.0	23.4	26.1	24.4	25.2	23.4	23.2	24.0	25.6	27.6
ESP	NaN	NaN	NaN	NaN	NaN	25.9	24.8	26.6	27.1	29.1	32.6	35.0	36.2
SWE	30.1	36.2	39.0	39.8	41.5	49.8	47.2	40.4	40.3	40.7	44.0	40.8	41.8

Table A.14: *Capital income taxes in percent across countries and time*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
USA	5.1	5.1	5.0	5.0	4.9	4.8	4.6	4.5	4.5	4.4	4.5	4.4	4.2
EU-14	17.0	17.1	17.1	17.4	17.7	17.5	17.0	16.9	16.8	16.7	16.6	16.7	16.9
GER	15.4	15.3	15.0	15.2	15.9	16.0	15.5	15.5	15.6	15.1	14.9	15.2	16.6
FRA	18.5	19.4	19.5	19.5	19.7	18.7	18.0	17.9	17.5	17.5	17.6	17.4	17.2
ITA	15.4	14.4	14.2	15.1	14.7	15.6	14.9	14.6	14.1	13.7	13.7	14.3	14.0
GBR	16.9	17.2	17.2	17.1	17.1	16.7	16.1	15.9	16.0	15.9	15.4	15.1	14.9
AUT	18.6	19.1	20.2	20.4	20.9	19.7	19.4	19.9	19.4	19.5	19.4	18.8	19.2
BEL	16.4	16.7	17.1	17.0	18.0	17.7	16.6	17.0	16.8	17.5	17.8	18.0	18.2
DNK	32.4	33.9	34.2	35.4	36.4	35.7	35.8	35.7	35.0	34.8	34.9	35.2	34.3
FIN	26.5	26.5	29.0	28.7	29.0	28.1	26.8	26.9	27.3	26.3	26.2	25.8	25.0
GRE	15.8	16.0	16.5	15.7	16.2	15.2	15.8	15.7	14.9	14.5	14.2	15.1	14.9
IRL	24.2	24.6	25.1	26.3	26.6	27.3	24.2	25.1	24.9	26.1	26.6	27.1	25.6
NET	17.9	18.4	18.5	18.7	19.5	19.3	19.9	19.1	19.2	19.8	20.8	20.2	20.5
PRT	19.8	20.4	20.1	21.3	21.4	20.3	20.4	21.1	20.9	20.5	21.3	21.6	21.5
ESP	12.8	13.1	13.5	14.3	15.0	15.0	14.5	14.6	15.0	14.9	15.1	15.2	14.7
SWE	26.8	25.3	25.1	25.5	25.1	24.8	25.2	25.1	25.3	25.4	25.8	26.1	26.5

Table A.15: *Consumption taxes in percent across countries and time*

Appendix B. Additions to the main text

Appendix B.1. A proof

Proof: **[Proof for Proposition 2.]** *Log-linearization generally leads to (22), where*

$$\begin{aligned}
\nu_{cc} &= \frac{u_{cc}c}{u_c} \\
\nu_{cn} &= \frac{u_{cn}n}{u_c} \\
\nu_{c\kappa} &= \frac{u_{c\kappa}\kappa}{u_c} \\
\nu_{nn} &= \frac{u_{nn}n}{u_n} \\
\nu_{nc} &= \frac{u_{cn}c}{u_n} \\
\nu_{n\kappa} &= \frac{u_{c\kappa}\kappa}{u_n}.
\end{aligned}$$

For the explicit expressions, calculate. For the Frisch demand and supply, use matrix inversion for (22) together with the explicit expressions for the coefficients, and calculate.
•

Appendix B.2. Details on the Calibration Choices

Empirical estimates of the intertemporal elasticity vary considerably. Hall (1988) estimates it to be close to zero. Recently, Gruber (2006) provides an excellent survey on estimates in the literature. Further, he estimates the intertemporal elasticity to be two. Cooley and Prescott (1995) and King and Rebelo (1999) use an intertemporal elasticity equal to one. The general current consensus seems to be that the intertemporal elasticity of substitution is closer to 0.5, which we shall use for our baseline calibration, but also investigating a value equal to unity as an alternative, and impose it for the Cobb-Douglas preference specification.

There is a large literature that estimates the Frisch labor supply elasticity from micro data. Domeij and Floden (2006) argue that labor supply elasticity estimates are likely to be biased downwards by up to 50 percent. However, the authors survey the existing micro Frisch labor supply elasticity estimates and conclude that many estimates range between 0 and 0.5. Further, Kniesner and Ziliak (2005) estimate a Frisch labor supply elasticity of 0.5 while and Kimball and Shapiro (2003) obtain a Frisch elasticity close to 1. Hence, this literature suggests an elasticity in the range of 0 to 1 instead of a value of 3 as suggested by Prescott (2006).

In the most closely related public-finance-in-macro literature, e.g. House and Shapiro (2006), a value of 1 is often used. We shall follow that choice as our benchmark calibration, and regard a value of 3 as the alternative specification.

We therefore use $\eta = 2$ and $\varphi = 1$ as the benchmark calibration for the CFE preferences, and use $\eta = 1$ and $\varphi = 3$ as alternative calibration and for comparison to a Cobb-Douglas specification for preferences with an intertemporal elasticity of substitution equal to unity and imposing $\bar{n} = 0.25$, implying a Frisch elasticity of 3.

Appendix B.3. Comparing the model to the data

Figure B.15 shows the match between model prediction and data for equilibrium labor as well as for the capital-output ratio: the discrepancies get resolved by construction in the right-hand column, with the varied parameters as in table 4. Figure B.16 shows the implications for tax revenues relative to output: the predictions do not move much with the variation in the parameters. Generally, though, the model overpredicts the amount of labor tax revenues and underpredicts the amount of capital tax revenues collected, compared to the data.

Figure B.15: Model-Data Comparison Without and with Varying the Parameters

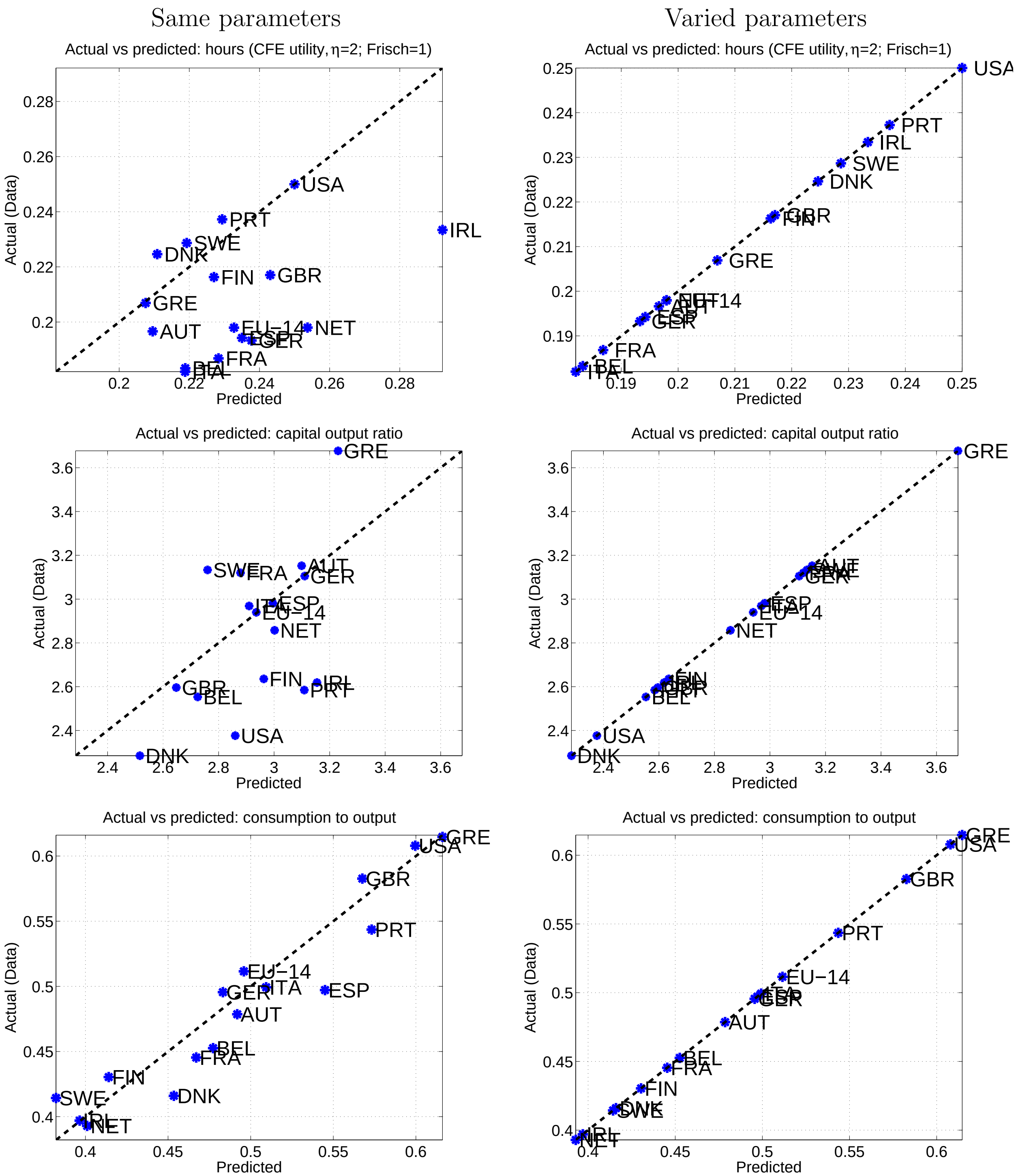
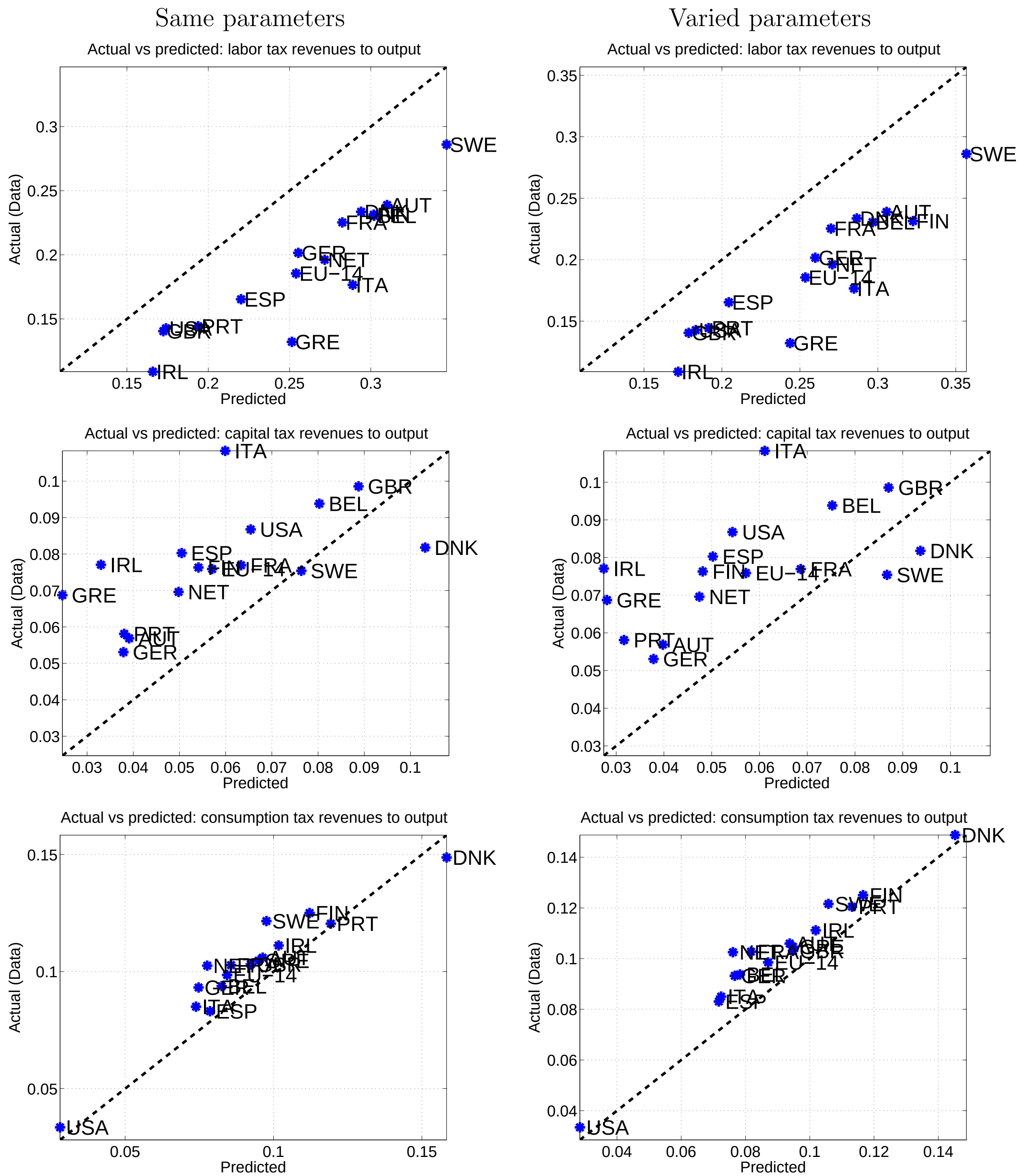


Figure B.16: Model-Data Comparison Without and with Varying the Parameters



Appendix C. Data Discussion and Overview

Figure C.17 shows the resulting time series for taxes as well as the macroeconomic series we have used. For the calibration, we equate the values on the balanced growth path with the averages of these time series over the period from 1995 to 2007.

Using this methodology necessarily fails to capture fully the detailed nuances and features of the tax law and the inherent incentives. Nonetheless, several arguments may be made for why we use effective average tax rates instead of marginal tax rates for the calibration of the model. First, we are not aware of a comparable and coherent empirical methodology that could be used to calculate marginal labor, capital and consumption tax rates for the US and 15 European countries for a time span of, say, the last 15 years. By contrast, our calculations along with Mendoza et al. (1994) and Carey and Rabesona (2002) calculate effective average tax rates for labor, capital and consumption for our countries of interest. There is some data available from the NBER for marginal tax rates on the federal and state level: however and at least for the US, the difference between marginal and average tax rates are modest.

Second, if any we probably make an error on side of caution since effective average tax rates can be seen as as representing a lower bound of statutory marginal tax rates. Third, marginal tax rates differ all across income scales. To analyze that, a model with heterogeneous households is needed, as in subsection 5.2 of the paper. Fourth, statutory marginal tax rates are often different from realized marginal tax rates due to a variety of tax deductions etc. So that potentially, the effective tax rates computed and used here may reflect realized marginal tax rates more accurately than statutory marginal tax rates in legal tax codes. Fifth, using effective tax rates following the methodology of Mendoza et al. (1994) facilitates comparison to previous studies that also use these tax rates as e.g. Mendoza and Tesar (1998) and many others. Nonetheless, a further analysis taking these points into account in detail is a useful next step on the research agenda.

Appendix D. Data Details

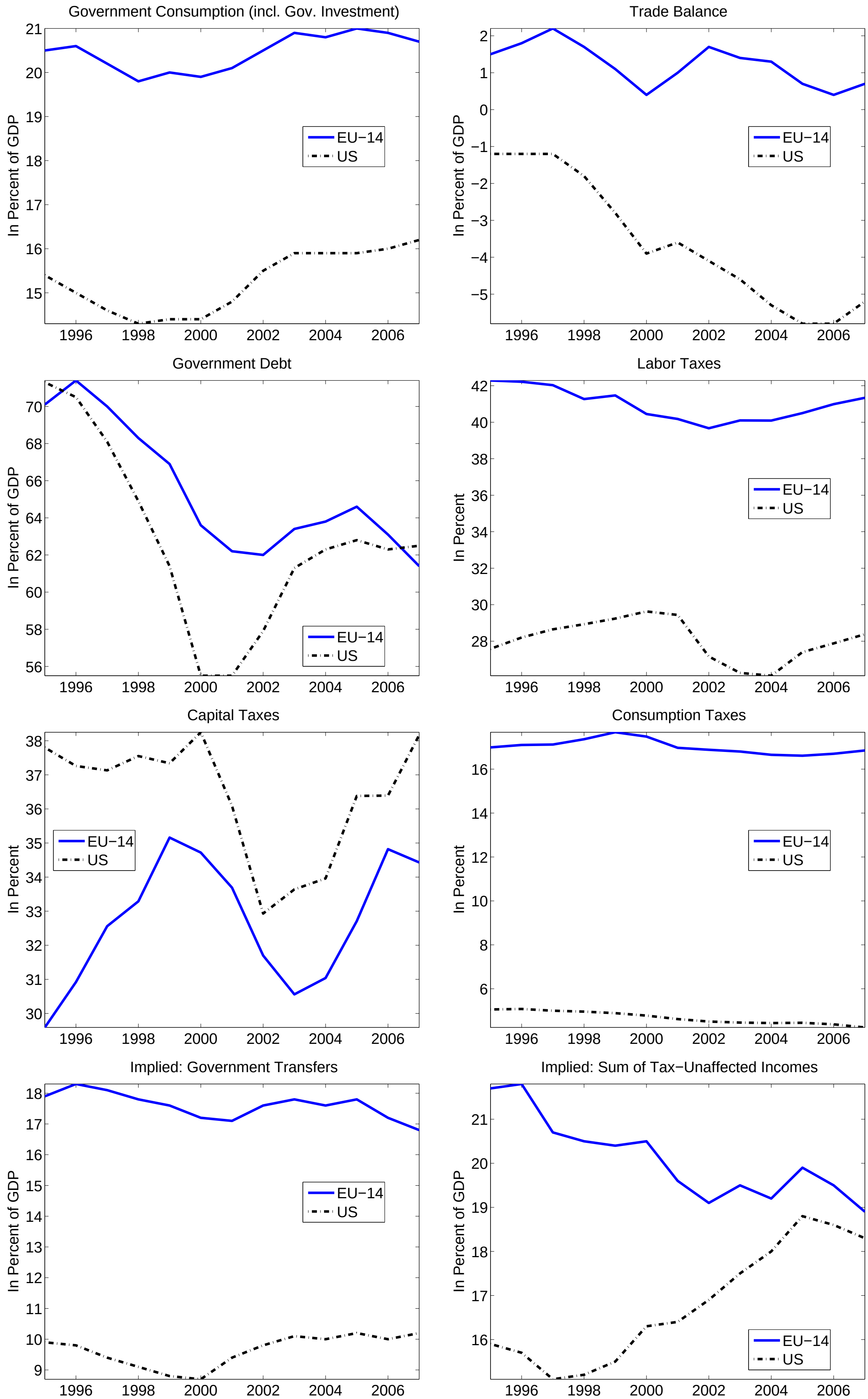
This appendix describes the data used in the main part of the paper. We use annual data from 1995 to 2007 for the following countries: USA, Germany (GER), France (FRA), Italy (ITA), United Kingdom (UK), Austria (AUT), Belgium (B), Denmark (DEN), Finland (FIN), Greece (GRE), Ireland (IRL), Netherlands (NET), Portugal (PRT), Spain (ESP) and Sweden (SWE).

Appendix D.1. Databases used

AMECO: Database of the European Commission available at:
http://ec.europa.eu/economy_finance/db_indicators/db_indicators8646_en.htm.

OECD: Databases for annual national accounts, labor force statistics and revenue statistics of the OECD. Available at:

Figure C.17: Data used for Calibration of the Baseline Models



$http://stats.oecd.org/wbosdos/Default.aspx?usercontext = sourceoecd$

GGDC: Groningen Growth and Development Centre and the Conference Board total economy database, January 2008 available at: $http://www.ggdc.net$ or $http://www.conference-board.org/economics/downloads/TED08I.xls$

NIPA: National income and product accounts provided by the BEA. Available at: $www.bea.gov$.

Appendix D.2. Macro Data

Appendix D.2.1. Raw Data

All data below except for population and hours are in $, EUR or local currency for Denmark, Sweden and United Kingdom:

Nominal GDP: Gross domestic product at current market prices (AMECO, UVGD).

Nominal government consumption: Final consumption expenditure of general government at current prices (AMECO, UCTG).

Nominal total government expenditures: Total current expenditure: general government; ESA 1995 (AMECO, UUCG).

Nominal total government expenditures excluding interest payments: Total current expenditure excluding interest - general government - ESA 1995 (AMECO, UUCGI).

Nominal government debt: General government consolidated gross debt - Excessive deficit procedure (based on ESA 1995) and former definition (linked series) (AMECO, UDGGL).

Nominal total private consumption: Private final consumption expenditure at current prices (AMECO, UCPH).

Nominal total private investment: Gross fixed capital formation at current prices: private sector (AMECO, UIGP).

Real capital stock: Net capital stock at constant (2000) prices; total economy (AMECO, OKND).

Real GDP: Gross domestic product at constant (2000) market prices (AMECO, OVGD).

Nominal exchange rate: ECU-EUR exchange rates - Units of national currency per EUR/ECU (AMECO, XNE).

Net exports: Net exports of goods and services at current prices (National accounts) (AMECO, UBGS).

Nominal government investment: Gross fixed capital formation at current prices: general government; ESA 1995 (AMECO, UIGG0).

Total Hours Worked: Total annual hours worked (GGDC).

Nominal durable consumption: Final consumption expenditure of households, P311: durable goods, old breakdown, national currency, current prices, national accounts database (OECD).

Population: Population 15-64, labor force statistics (OECD).

Appendix D.2.2. Data Calculations

Consumption and Investment. Total consumption in the data consists of non-durable consumption of goods and services and and durable consumption. In the model consumption is meant to be non-durable consumption only. In order to align the data with the model we therefore substract durable consumption from total consumption and add it to private investment in the data. Unfortunately, durable consumption data is available only for FRA, IRE, NET, UK and US. The sample covered is somewhat different across these countries. However, in order to proxy durable consumption data for the remaining countries we proceed as follows. We compute the ratio of durable consumption and total private consumption per year for the available country data. Interestingly, the shares for FRA, IRE and NET are twice as large as those for the UK and the US. We then calculate the total average share per year of the average UK/US and average FRA/IRE/NET shares. For the countries where there is no durable consumption data this total average share per year is applied to the annual total private consumption data in order to obtain a measure of durable consumption.

Government Interest Payments. Government interest payments are calculated as the difference between total government expenditures and total government expenditures excluding interest payments.

Implied Government Transfers and Tax-Unaffected Income. Government transfers that are consistent with the model are calculated by substracting government consumption, government interest payments and government investment from total government expenditures in the data.

Similarly, tax-unaffected income consistent with the model is calculated by adding government interest payments, government transfers and net imports in the data.

GDP Growth. Per capita GDP growth is calculated by dividing real GDP by population and then calculating annual percentage changes.

Hours Worked. In order to obtain a measure of annual hours worked per person we divide total annual hours by population. Furthermore, we assume 14.55 hours per day to be allocated between leisure and work in the US and EU-14 similar to Ragan (2005) who assumes 14 hours. We obtain a normalized average US hours per person measure of 0.25 as used in the main part of the paper.

Ratios of Variables to GDP. Based on the above data we calculate the GDP ratios for the countries. We also require the weighted EU-14 GDP ratios which are calculated according to the description in appendix A.1.

Note that variables that describe the fiscal sector such as e.g. government debt etc. are only available in nominal terms. Consistent with the model, we divide these nominal variables by nominal GDP i.e. deflate nominal variables with the GDP deflator. We also deflate all other nominal variables with the GDP deflator. Since we are interested in GDP ratios only we do not need to divide the time series by population since the division would appear in the numerator as well as in the denominator and therefore would cancel out.

Appendix D.3. Tax Rates Data

We calculate effective tax rates on labor income, capital income and consumption following the methodology of Mendoza, Razin and Tesar (1994) and used in Mendoza, Razin and Tesar (1997).

Appendix D.3.1. Raw Data

All data below are nominal in $, EUR or local currency for Denmark, Sweden and United Kingdom:

5110: General taxes, revenue statistics (OECD).

5121: Excise taxes, revenue statistics (OECD).

3000: Payroll taxes, revenue statistics (OECD).

4000: Property taxes, revenue statistics (OECD).

1000: Income, profit and capital gains taxes, revenue statistics (OECD).

2000: Social security contributions, revenue statistics (OECD).

2200: Social security contributions of employers, revenue statistics (OECD).

1100: Income, profit and capital gains taxes of individuals, revenue statistics (OECD).

1200: Income, profit and capital gains taxes of corporations, revenue statistics (OECD).

4100: Recurrent taxes on immovable property, revenue statistics (OECD).

4400: Taxes on financial and capital transactions, revenue statistics (OECD).

GW: Compensation of employees: general government - ESA 1995 (AMECO, UWCG).

OS: Net operating surplus: total economy (AMECO, UOND). This is net operating surplus plus net mixed income or equivalently the gross operating surplus minus consumption of fixed capital. For the USA OS is not available in AMECO. We obtained OS from NIPA table 11000 line 11.

W: Gross wages and salaries: households and NPISH (AMECO, UWSH). For the USA W is not available in AMECO. We obtained W from NIPA table 11000 line 4.

PEI: Net property income: households and NPISH (AMECO, UYNH). Note that in contrast to the data available to Mendoza, Razin and Tesar (1994) the present PEI data does not contain entrepreneurial income of households anymore. Instead household entrepreneurial income is contained in OSPUE defined below. For the USA PEI is not available in AMECO. We calculate this from OECD property income received (SS14 S15: Households and non-profit institutions serving households, SD4R: Property income; received, national accounts) minus property income paid (SS14 S15: Households and non-profit institutions serving households, SD4P: Property income; paid, national accounts).

OSPUE: Gross operating surplus and mixed income: households and NPISH (AMECO, UOGH). OSPUE in Mendoza, Razin and Tesar (1994) is operating surplus of private unincorporated enterprises. This data is called mixed income now. Note that all we need for the tax rate calculations below is the sum OSPUE+PEI. We miss data on household entrepreneurial income in PEI above. Therefore, we use gross operating surplus and mixed income of households in order to obtain a measure of household entrepreneurial and mixed income. For the USA OSPUE is not available in AMECO. We calculate this from the OECD (HH. Operating surplus and mixed income, gross, national accounts, detailed aggregates). We substract consumption of fixed capital obtained from the OECD (SS14 S15: Households and non-profit institutions serving households, national accounts) from gross operating surplus and mixed income in order to obtain a measure of net operating surplus and mixed income to be used for the tax rate calculations below.

For some European countries the above data starts at a later date than 1995. In addition, for a few country data time series observations for 2007 are missing. In order to obtain estimates for 2007 we apply the average growth rates of the last 5 to 20 years to the observation in 2006. Finally, we use all available individual country data for calculating weighted averages for the period 1995-2007.

Appendix D.3.2. Tax Rate Calculations: Effective Tax Rates

Following the methodology of Mendoza, Razin and Tesar (1994) we calculate the following effective tax rates:

Consumption tax:	$\tau^c = \frac{5110+5121}{C+G-GW-5110-5121}$
Personal income tax:	$\tau^h = \frac{1100}{OSPUE+PEI+W}$
Labor income tax:	$\tau^n = \frac{\tau^h W+2000+3000}{W+2200}$
Capital income tax:	$\tau^k = \frac{\tau^h (OSPUE+PEI)+1200+4100+4400}{OS}$

Where C, G and W denote nominal total private consumption, government consumption and wages and salaries.

For the overlapping years 2000 to 2005, our effective tax rates on consumption and labor income are close to those obtained by Carey and Rabesona's (2002) recalculation of the

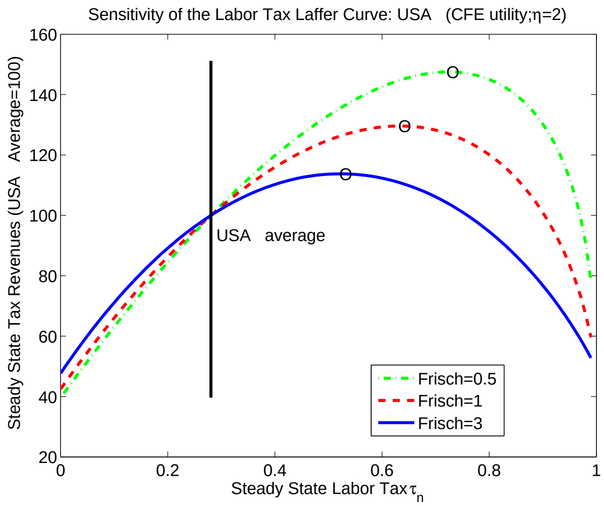
Mendoza, Razin and Tesar (1994). In particular, the average cross country difference in consumption taxes from 2000 to 2005 is -0.3% percent and 0.7% for labor income taxes. For capital income taxes the difference is somewhat larger i.e. -4.9%.

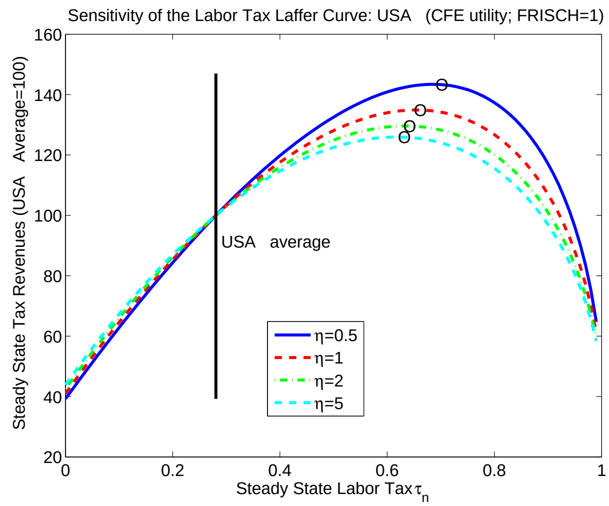
<u>Sources of Tax Revenues to GDP Ratios.</u> In the main part of the paper we require data for sources of tax revenue to GDP ratios. According to the Mendoza, Razin and Tesar (1994) methodology e.g. the capital tax is calculated as the ratio of capital tax revenues and the capital tax base. With the above data at hand it is easy to calculate capital tax revenues and divide them by nominal GDP to obtain the desired statistic. Labor and consumption tax revenues to GDP ratios are calculated in a similar way.

Figure D.18: Sensitivity to φ and η

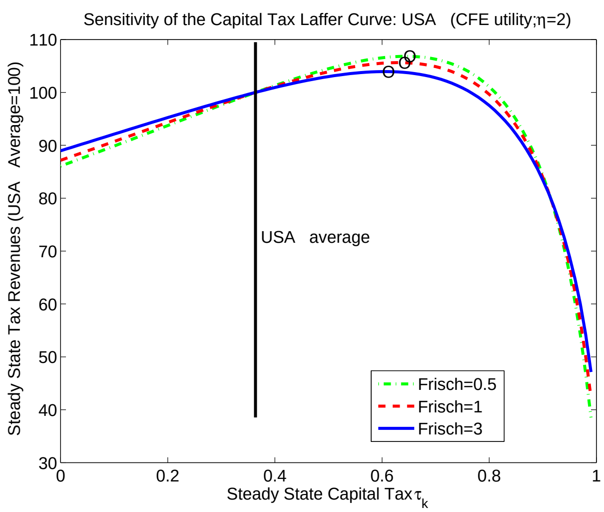
Sensitivity to φ | Sensitivity to η

Labor Tax Laffer Curves:





Capital Tax Laffer Curves:



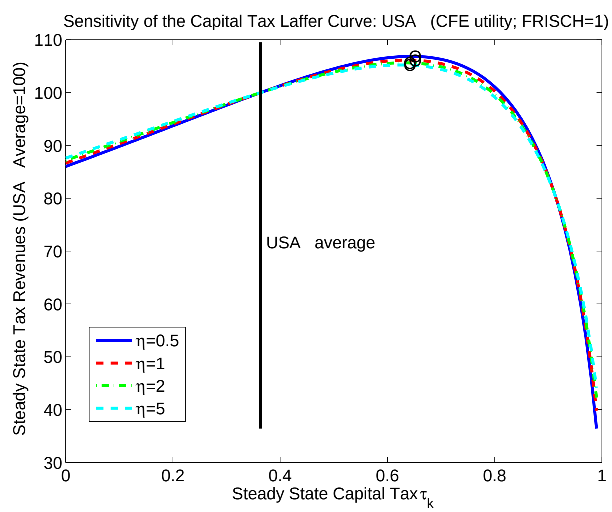


Figure D.19: Distances to the Laffer Peak across countries

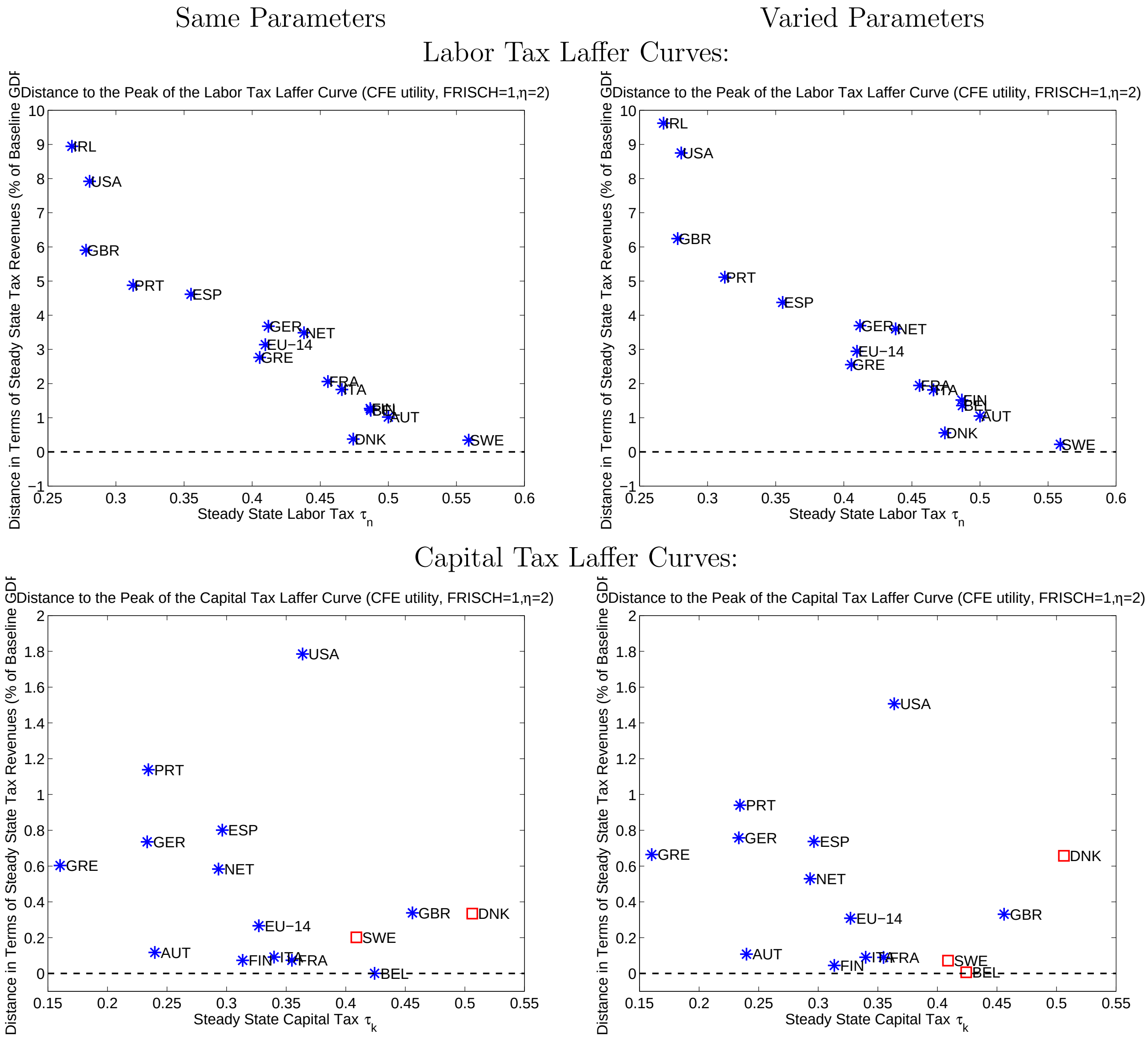


Figure D.20: The US Laffer Curve for Capital Taxes

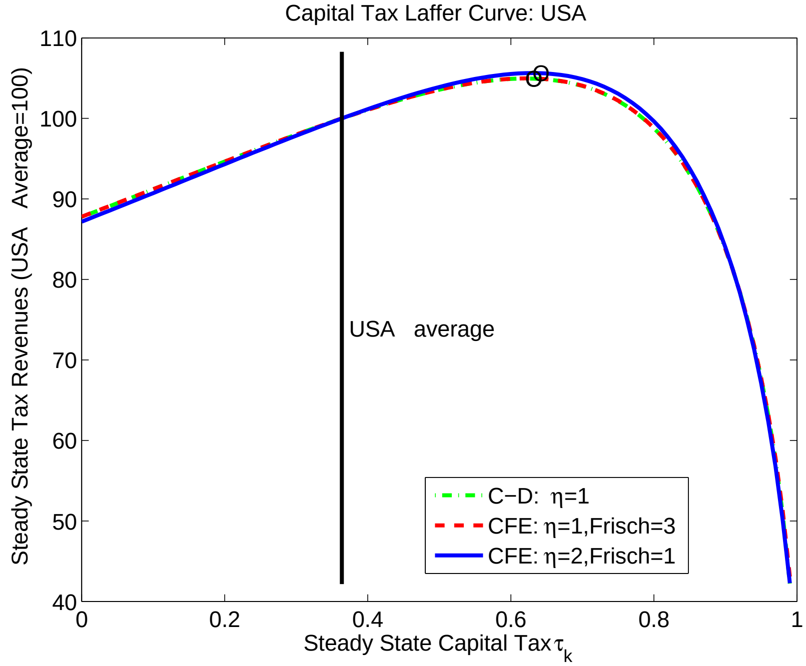


Figure D.21: Capital tax Laffer curve, US data: the impact of endogenenous human capital accumulation

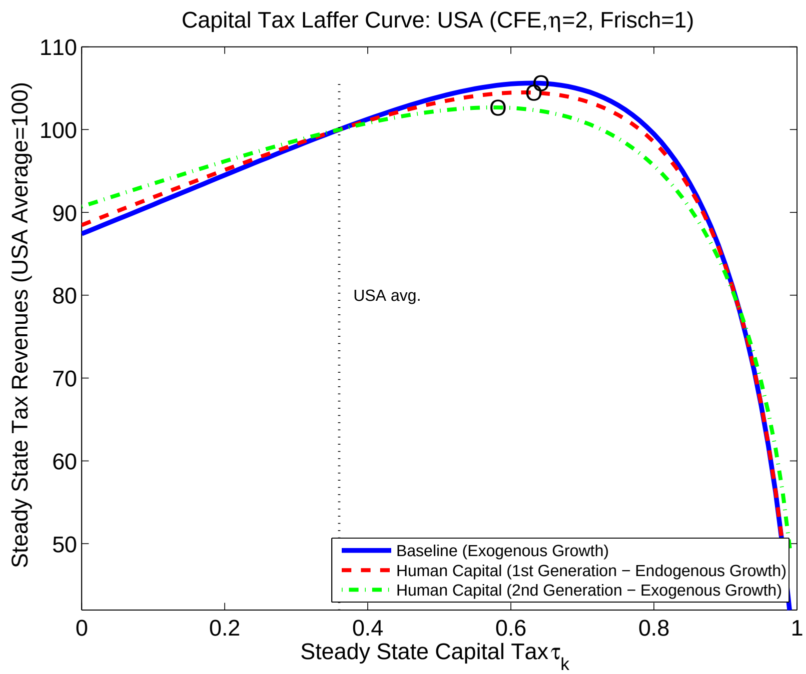


Figure D.22: Capital tax Laffer curve, EU data: the impact of endogenenous human capital accumulation