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Fiscal Policy Reforms and Dynamic Laffer Effects*

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Abstract

We examine the impact of fiscal policy reforms on the long-run government budget balance in a one-sector model of endogenous growth with factor income taxes, a tax on consumption, non-productive public goods expenditures, and a labour-leisure trade-off. In addition, we allow for different structures of government expenditures and public debt. We analytically show that, when performing a dynamic Laffer effect analysis, there exists a set of conditions that hold for a number of endogenous growth models. We find that for the euro area an improvement in the long-run government budget balance is always obtained for a lower tax rate on capital income but is only obtained for a substantial lower tax rate on labour income. Moreover, we show that when lower taxes on factor income are financed by higher taxes on consumption, there exists a wide array of combinations for which there is an improvement in both the long-run government budget balance and lifetime welfare. These combinations, however, differ in their implications for labour supply and immediate welfare effects.

JEL Classification: E62; H30; J22; O41

Keywords: Dynamic Scoring; Laffer Effect; Factor Income Taxation; Endogenous Growth

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1 Introduction

The notion that the direct negative effect of a lower tax rate on government revenues is fully or partly offset by its stimulating effect on the economy has been around for quite some time and is best illustrated by the Laffer curve, Laffer (1979). Recently, renewed attention has been paid to the impact of lower tax rates on government revenues in particular and to the impact of fiscal policy reforms on the government budget balance more generally. Feedback effects of changes in tax rates or public expenditures on the economy are now analysed in dynamic rather than in traditional static frameworks[1] and are labelled 'dynamic scoring exercises.' In a dynamic general equilibrium framework, we analyse the effects of several fiscal policy reforms on the long-run government budget balance and welfare. More specifically, we are interested in the conditions under which fiscal policy reforms lead to an improvement in the long-run government budget balance. Hence, we ask ourselves the question; when does a dynamic Laffer effect occur?

For this purpose, we analyse the effect of changes in the capital income tax rate, the labour income tax rate, the consumption tax rate, and the public expenditures-to-output ratio on the long-run government budget balance in an endogenous growth framework.[2] Our analysis is closely related to the work of Ireland (1994), Bruce and Turnovsky (1999), and Agell and Persson (2001), who all use a one-sector endogenous growth model with exogenous labour supply to analyse the impact of changes in fiscal policy instruments on the long-run government budget balance in a closed economy. These studies, however, differ in the assumptions made on the structure of government expenditures and public debt, leading to seemingly conflicting results and therefore a lack of consensus on the conditions under which a dynamic Laffer effect occurs.

Other related literature is the work of Turnovsky (2000a) and Chen (2007) who employ a one-sector endogenous growth model driven by productive government spending. However, Turnovsky (2000a) compares fiscal policy reforms in a centrally planned and decentralized economy and Chen (2007) analyses the dynamics of fiscal policy reforms by introducing public capital. Hence, we differ in our analysis by extensively examining the effects of fiscal policy reforms on the long-run government budget balance. Novales and Ruiz (2002) and Frederiksson (2007) employ a two-sector rather than a one-sector endogenous growth model with endogenous labour supply to analyse the effects of fiscal policy reforms on the economy. This, however, either restricts or makes an analytical analysis of the effects of fiscal policy reforms on the long-run government budget balance impossible.

We contribute to this literature in several ways. First, we decompose the overall effect of fiscal

[1] For example, Fullerton (1982) employs a static framework to analyse the Laffer curve.

[2] Mankiw and Weinzierl (2006) and Trabandt and Uhlig (2009) also analyse the effects of such fiscal policy reforms on the long-run government budget balance. However, their approach is quite different since they use a framework in which the growth rate of the economy is exogenously given and therefore cannot be permanently affected by changes in fiscal instruments.

policy reforms on the long-run government budget balance in three basic effects; the direct budget effect, the growth rate effect, and the discount rate effect. In addition, we take different specifications with respect to the structure of government expenditures and public debt into account. This allows us to uncover the reasons for the different results found in the existing literature. Second, by allowing labour supply to be endogenous instead of exogenous, we include a labour-leisure trade-off which allows us to study a wide variety of fiscal policy reforms. That is, changes in the labour income tax rate and the consumption tax rate now have real effects instead of acting as lump-sum taxes. Third, we calibrate the model to represent the economy of the euro area and analyse a wide array of fiscal policy reforms to see when a dynamic Laffer effect occurs. Hereby we also look at discrete changes in fiscal instruments of the government instead of restricting attention to marginal changes only. Moreover, we separately analyse the effects of allowing for endogenous labour supply and different assumptions on government debt.

We analytically show that, when performing a dynamic Laffer effect analysis, there exists a set of conditions that hold for a number of endogenous growth models.[3] If the initial stock of public debt is set to zero, then an improvement in the long-run government budget balance can only be obtained when assuming that the path of lump-sum transfers is fixed. The possibility that such an improvement occurs is increasing in the initial lump-sum transfer-to-output ratio and does not exist when the latter is zero. Moreover, the possibility is increasing in the intertemporal elasticity of substitution and this relationship extends to the case where the initial stock of public debt is positive although the overall likelihood of obtaining a dynamic Laffer effect is lower when the intertemporal elasticity of substitution is smaller than unity. If the government acts as a creditor to the private sector so that the initial stock of public debt is negative, then the relationship between the possibility to obtain a dynamic Laffer effect and the intertemporal elasticity of substitution is ambiguous, although the overall likelihood is higher when the intertemporal elasticity of substitution is smaller than unity.

Using a numerical illustration, we show that for the euro area an improvement in the long-run government budget balance is always obtained for a lower tax rate on capital income but is only obtained for a substantial lower tax rate on labour income. For the case of the capital income tax rate, we show that neglecting the stock of initial debt or the labour-leisure trade-off leads to an overestimation or underestimation of the dynamic Laffer effect, respectively. The assumption that the path of lump-sum transfers is fixed is crucial for these dynamic Laffer effects to occur. Financing lower tax rates on factor income by a higher tax rate on consumption gives combinations of tax rates that lead to an improvement in both the long-run government budget balance and welfare. When the tax rate on capital income is lowered, these combinations of tax rates lead to a decrease in labour supply and negative immediate welfare effects. However, when the tax rate

[3]These apply to the analysis of a marginal change in a single fiscal instrument.

on labour income is lowered, these combinations of tax rates lead to an increase in labour supply and positive immediate welfare effects. In both cases, substantial changes in tax rates are needed to obtain these effects.

The remainder of the paper is structured as follows. The analytical framework is discussed in Section 2. The analytical results, consisting of comparative static effects of changes in fiscal policy instruments and the effects on the long-run government budget balance, are discussed in Section 3. Numerical results are discussed in Section 4. The final section concludes.

2 Analytical Framework

The closed economy is characterized by three economic actors, namely firms, households, and the government, which are discussed here in turn.

2.1 Firms

The production side of the economy is characterized by a continuum of identical firms operating under perfect competition. For convenience, the total number of firms is normalized to unity. Following Benhabib and Farmer (1994), the production technology for firm i is given by:

$$\begin{aligned} Y_i(t) &= K_i(t)^a L_i(t)^b X(t), && a+b=1, \\ X(t) &= \bar{K}(t)^{\alpha-a} \bar{L}(t)^{\beta-b}, && a<\alpha\leq 1,\ b<\beta<1,\ \alpha+\beta>1, \end{aligned}$$

where $Y_i(t)$ is output of firm i and the production factors $K_i(t)$ and $L_i(t)$ represent the private capital stock and the amount of labour used by firm i, respectively. From the perspective of the representative firm, the Cobb-Douglas production technology exhibits constant returns to scale, that is, $a+b=1$. The term $X(t)$ represents positive external returns that are increasing in the economy-wide average levels of the capital stock $\bar{K}(t)$ and amount of labour $\bar{L}(t)$. Output is taken as the numeraire and the corresponding price is normalized to unity.

The stock market value of firm i is given by the present value of current and future cash flows:

$$V_i(0) \equiv \int_0^\infty \left[Y_i(t) - w(t)L_i(t) - I_i(t)\right] e^{-\int_0^t r(s)ds} dt,$$

where $r(t)$ is the rate of return to capital, $w(t)$ is the wage rate, and $I_i(t)$ denotes gross investments, all denoted in real terms. Firms maximize their stock market value subject to the capital accumulation constraint $\dot{K}_i(t) = I_i(t) - \delta K_i(t)$, where δ is the depreciation rate. In symmetric equilibrium it holds that $K_i(t) = \bar{K}(t) = K(t)$, $L_i(t) = \bar{L}(t) = L(t)$, and $Y_i(t) = \bar{Y}(t) = Y(t)$. We assume that capital externalities are large enough for the aggregate production technology to be

linear in capital so that:

$$Y(t) = K(t)L(t)^{\beta}. \tag{1}$$

Competitive factor payments, resulting from the maximization problem of the firm, are given by:

$$r(t) = aL(t)^{\beta} - \delta, \tag{2}$$

$$w(t) = bK(t)L(t)^{\beta-1}. \tag{3}$$

2.2 Households

Infinitely lived households have identical and time separable preferences.

$$\Lambda(0) \equiv \int_0^{\infty} U(t)e^{-\rho t}dt, \quad \rho > 0, \tag{4}$$

where ρ is the pure rate of time preference and $U(t)$ represents the felicity function:[4]

$$U(t) \equiv \frac{[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma} - 1}{1-\sigma} \quad \text{if} \quad \sigma \neq 1 \tag{5}$$

where $C(t)$ is private goods consumption and $G(t)$ is public goods consumption. Leisure is represented by $1 - L(t)$, where the amount of time available to the household has been normalized to unity. Preferences for private goods consumption, public goods consumption, and leisure are non-separable and their respective weights are given by $\phi > 0$, $\theta > 0$, and $\eta > 0$. The parameter $\sigma > 0$ represents the inverse of the intertemporal elasticity of substitution. Moreover, the felicity function is assumed to be jointly concave in private goods consumption, public goods consumption, and leisure, resulting in the following constraints on the preferences weights:

$$1 - (1-\sigma)\phi > 0, \quad 1 - (1-\sigma)(\phi+\eta) > 0, \quad \text{and} \quad 1 - (1-\sigma)(\phi+\theta) > 0. \tag{6}$$

Households receive income from labour and claims on physical capital and government bonds. Following Turnovsky (2000b), government bonds are assumed to be perpetuities that every period pay out a coupon equal to one unit of output. The nominal value of the stock of bonds held by the households is denoted by $B(t)$, which is defined as the number of bonds multiplied by their price $p(t)$, where the latter is defined in terms of the numeraire.[5] Households receive lump-sum transfers from the government, denoted by $T(t) > 0$. The budget constraint of the household is

[4] $U(t) \equiv \phi \log C(t) + \eta \log[1 - L(t)] + \theta \log G(t)$ if $\sigma = 1$.

[5] This specification allows for immediate adjustment of the price of bonds such that constant portfolio shares of physical capital and government bonds in equilibrium are guaranteed. Hence, the specification abstracts from transitional dynamics in portfolio shares associated with fixed-price bonds, see Turnovsky (2000b, p. 438).

then given by:

$$\dot{K}(t)+\dot{B}(t)=(1-\tau_A)r(t)K(t)+(1-\tau_A)q(t)B(t)+(1-\tau_L)w(t)L(t)-(1+\tau_C)C(t)+T(t), \quad (7)$$

where $q(t)$ is the rate of return on government bonds and is defined as $q(t)=\frac{1+\dot{p}(t)}{p(t)}$. Income of households is taxed, where τ_A and τ_L denote the tax rates on capital income and labour income, respectively. Moreover, private goods consumption is taxed, where τ_C is the corresponding *ad valorem* tax rate. Note that these tax rates are assumed to be time invariant. The representative household chooses private goods consumption, $C(t)$, labour, $L(t)$, capital, $K(t)$, and government bonds, $B(t)$, to maximize utility (4) subject to the budget constraint (7). The first-order conditions for this problem are:

$$[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma}\phi C(t)^{-1} = \lambda(t)(1+\tau_C), \quad (8a)$$

$$[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma}\eta(1-L(t))^{-1} = \lambda(t)w(t)(1-\tau_L), \quad (8b)$$

$$\rho-\frac{\dot{\lambda}(t)}{\lambda(t)} = (1-\tau_A)r(t), \quad (8c)$$

$$\rho-\frac{\dot{\lambda}(t)}{\lambda(t)} = (1-\tau_A)q(t), \quad (8d)$$

where $\lambda(t)$ is the shadow price of assets. The transversality conditions are given by:

$$\lim_{t\to\infty}\lambda(t)K(t)e^{-\rho t}=0, \quad \text{and} \quad \lim_{t\to\infty}\lambda(t)B(t)e^{-\rho t}=0. \quad (9)$$

Combining equations (8c) and (8d) gives the no-arbitrage equation $r(t)=q(t)$, which says that the return on physical capital should equal the return on government bonds.

2.3 Government

To link the provision of public goods to the size of the economy, the government uses a constant fraction ω_G of output for the provision of unproductive public goods:

$$G(t)=\omega_G Y(t), \qquad 0<\omega_G<1. \quad (10)$$

Besides the provision of public goods for consumption, government expenditures are interest payments on outstanding bonds and lump-sum transfers to households. Revenues of the government consist of the receipts of taxes on asset income, labour income, and private goods consumption. Any fiscal deficit has to be financed by issuing bonds. Taking into account the no-arbitrage

condition, $r(t) = q(t)$, the periodic budget constraint of the government becomes:

$$\dot{B}(t) = \omega_G Y(t) + T(t) + (1-\tau_A) r(t) B(t) - \tau_A r(t) K(t) - \tau_L w(t) L(t) - \tau_C C(t). \tag{11}$$

2.4 The Balanced Growth Path

The equilibrium of the decentralized equilibrium is characterized by a first-order differential equation in labour supply, which is obtained by number of steps.[6] First, we make use of the intratemporal optimality condition between leisure and private goods consumption that can readily be obtained by dividing (8a) by (8b):

$$\frac{C}{1-L}\frac{\eta}{\phi} = \frac{1-\tau_L}{1+\tau_C} w, \tag{12}$$

which states that at each point in time the marginal rate of substitution between leisure and private goods consumption should equal its relative price. We also make use of the aggregate resource constraint that follows from combining the budget constraint of the household (7) and the budget constraint of the government (11):

$$\dot{K} = rK + wL - C - G = (1-\omega_G) Y - \delta K - C, \tag{13}$$

where we have used (1)-(3), (10), and $a+b=1$ in deriving (13). The set of equations that is used to derive the first-order differential equation in labour supply is given by:[7]

$$\frac{\dot{L}}{L} = \left[((1-\sigma)\phi - 1)\frac{\dot{C}}{C} + (1-\sigma)\theta\frac{\dot{K}}{K} - \frac{\dot{\lambda}}{\lambda} \right] \left[(1-\sigma)\eta\frac{L}{1-L} - (1-\sigma)\theta\beta \right]^{-1}, \tag{14a}$$

$$\frac{\dot{C}}{C} = \left[-\frac{L}{1-L} + \beta - 1 \right] \frac{\dot{L}}{L} + \frac{\dot{K}}{K}, \tag{14b}$$

$$\frac{\dot{K}}{K} = \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L} \right] L^\beta - \delta, \tag{14c}$$

$$\frac{\dot{\lambda}}{\lambda} = \rho - (1-\tau_A)(aL^\beta - \delta). \tag{14d}$$

By using equations (14b), (14c), and (14d) in equation (14a), we obtain the expression for the first-order differential equation in labour supply:

$$\frac{\dot{L}}{L} = \frac{\Theta^N(L)}{\Theta^D(L)}, \tag{15}$$

[6] In the derivations we omit time indices for convenience of notation.

[7] Substituting (1) and (10) in (8a) and subsequently taking the logarithm and time derivate of the resulting expression gives equation (14a). Substituting (3) in (12) and subsequently taking the logarithm and time derivate of the resulting expression gives equation (14b). Equation (14c) is obtained by dividing both sides of (13) by K and making use of the expression of the consumption-capital ratio. The latter can be obtained by substituting (3) in (12) and rearranging terms. Finally, substituting (2) in (8d) and rearranging terms gives equation (14d).

where

$$\Theta^N(L) \equiv \left[\left(1-\omega_G-\frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right)L^\beta-\delta\right]\left[(1-\sigma)(\phi+\theta)-1\right] + (1-\tau_A)(aL^\beta-\delta)-\rho, \tag{16a}$$

$$\Theta^D(L) \equiv -\left[1-(1-\sigma)(\phi+\eta)\right]\frac{L}{1-L}+\beta\left[1-(1-\sigma)(\phi+\theta)\right]-\left[1-(1-\sigma)\phi\right]. \tag{16b}$$

We define the balanced growth path as a situation in which private goods consumption, physical capital, government bonds, and output grow at the same rate. However, along the balanced growth path labour supply is constant $\dot{L}=0$. The overall growth rate of the economy is given by $\gamma \equiv \frac{\dot{C}}{C}=\frac{\dot{K}}{K}=\frac{\dot{B}}{B}=\frac{\dot{Y}}{Y}$. Using that labour supply is constant along the balanced growth path, it can be seen from equation (15) that $\Theta^N(L)=0$ must hold. This is the case if:

$$\frac{(1-\tau_A)(aL^\beta-\delta)-\rho}{1-(1-\sigma)(\phi+\theta)}=\left[1-\omega_G-\frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right]L^\beta-\delta. \tag{17}$$

We follow Turnovsky (2000a) and describe the balanced growth path by two loci, where one is associated with portfolio balance equilibrium (left-hand side of (17)) and one with product market equilibrium (right-hand side of (17)). These are given by

$$\gamma_P(L) \equiv \frac{(1-\tau_A)(aL^\beta-\delta)-\rho}{1-(1-\sigma)(\phi+\theta)}, \tag{18a}$$

$$\gamma_Q(L) \equiv \left[1-\omega_G-\frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right]L^\beta-\delta. \tag{18b}$$

A sufficient condition for a unique balanced growth path to exist is if:

$$\sigma > 1-\frac{1-\omega_G-(a-\delta)(1-\tau_A)+\rho}{(1-\omega_G)(\phi+\theta)}. \tag{19}$$

We choose $\sigma>1$ so that the intertemporal elasticity of substitution is smaller than unity.[8] When in addition $1-\omega_G-(a-\delta)(1-\tau_A)+\rho>0$, there always exists a unique equilibrium. Moreover, the unique equilibrium is locally unstable if $\Theta^D(\tilde{L})<0$, where $\tilde{L}$ is the level of labour supply for which (17) holds. See the Appendix for a derivation of these results. The transversality conditions (9) hold if $\rho>(1-\sigma)(\phi+\theta)\gamma$, which is satisfied given a positive growth rate and $\sigma>1$. We assume that both of the above conditions are satisfied so that the economy always lies on its balanced growth path.[9]

[8] Attanasio and Weber (1993) find that the intertemporal elasticity of substitution ranges from 0.3 (when using aggregate data drawn from national accounts) to 0.8 (when using cohort data drawn from a household survey) so that our choice can be justified empirically.

[9] We have checked whether $1-\omega_G-(a-\delta)(1-\tau_A)+\rho>0$ and $\Theta^D(\tilde{L})<0$ when performing the numerical exercises in Section 4.

3 Analytical Results

3.1 Comparative Static Effects

The labour supply effects of fiscal policy reforms, which are represented by changes in the fiscal policy instruments τ_A, τ_L, τ_C, and ω_G, are obtained by fully differentiating (17). To keep the government budget balanced, we assume that any changes in government expenditures or revenues as a result of a fiscal policy reform are offset in a non-distorting way via lump-sum taxes or lump-sum transfers. The effects are given by:

$$\frac{d\tilde{L}}{d\tau_A} = \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{a\tilde{L}^{\beta} - \delta}{1-(1-\sigma)(\phi+\theta)} < 0, \tag{20a}$$

$$\frac{d\tilde{L}}{d\tau_L} = \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{b\phi}{\eta}\tilde{L}^{\beta}\frac{1-\tilde{L}}{\tilde{L}}\frac{1}{1+\tau_C} < 0, \tag{20b}$$

$$\frac{d\tilde{L}}{d\tau_C} = \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{b\phi}{\eta}\tilde{L}^{\beta}\frac{1-\tilde{L}}{\tilde{L}}\frac{1}{1+\tau_C}\frac{1-\tau_L}{1+\tau_C} < 0, \tag{20c}$$

$$\frac{d\tilde{L}}{d\omega_G} = \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} (-\tilde{L}^{\beta}) > 0, \tag{20d}$$

where $\Omega_P(L) \equiv \partial\gamma_P(L)/\partial L$, $\Omega_Q(L) \equiv \partial\gamma_Q(L)/\partial L$ and $\Omega_P(\tilde{L}) > \Omega_Q(\tilde{L})$ in equilibrium (see the Appendix). Effects of fiscal policy reforms on the growth rate of the economy are obtained by fully differentiating (18a) and are given by:

$$\frac{d\gamma(\tilde{L})}{d\tau_A} = \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_A} - \frac{a\tilde{L}^{\beta} - \delta}{1-(1-\sigma)(\phi+\theta)} < 0, \tag{21a}$$

$$\frac{d\gamma(\tilde{L})}{d\tau_L} = \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_L} < 0, \tag{21b}$$

$$\frac{d\gamma(\tilde{L})}{d\tau_C} = \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_C} < 0, \tag{21c}$$

$$\frac{d\gamma(\tilde{L})}{d\omega_G} = \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\omega_G} > 0. \tag{21d}$$

From (20) and (21) it is clear that both labour supply and the growth rate of the economy will decrease with higher proportional tax rates and will increase when the government increases the public expenditures-to-output ratio. We proceed by discussing the effects of the changes in fiscal policy instruments on the growth rate separately.

The effect of a higher capital income tax rate is given in panel (a) of Figure 1 and is represented by a rotation of the line associated with portfolio balance equilibrium from P to P'. Given that labour supply does not grow, a higher tax rate on capital income lowers the after-tax return on assets so that it falls below the return on consumption, where the difference is given by the vertical distance between A and B.[10] Consequently, households respond by increasing private

[10]The return on private goods consumption is given by the left-hand side of (8c) and (8d). See Turnovsky

goods consumption and leisure. The resulting fall in labour supply has a negative effect on the growth rate. The overall effect is given by the shift from A to C along the line Q.

The effect of a higher labour income tax rate or consumption tax rate is given in panel (b) of Figure 1 and is represented by a rotation of the line associated with product market equilibrium from Q to Q'. Both a higher labour income tax rate and a higher consumption tax rate make private goods consumption relatively expensive compared to leisure. Given that labour supply does not grow, households respond by lowering private goods consumption to retain the intratemporal optimality condition between leisure and private goods consumption. This releases resources available for investment, leading to a higher growth rate, which is given by the vertical distance between A and B.[11] The higher growth rate raises the return on consumption so that households respond by increasing private goods consumption and leisure. The resulting fall in labour supply has a negative effect on the growth rate. The overall effect given by the shift from A to C along the line P.

3.2 Three Basic Effects on the Long-run Government Budget Balance

A dynamic Laffer effect is defined as an improvement in the long-run government budget balance in response to a fiscal policy reform. To analyse the effects of fiscal policy reforms on the long-run government budget balance, we use the intertemporal budget constraint of the government, which can be obtained by integrating (11) and making use of the customary No-Ponzi Game condition, which says that $\lim_{t\to\infty} B(t)e^{-(1-\tau_A)(aL^\beta-\delta)t} = 0$. When deriving the intertemporal budget constraint of the government, we have assumed that lump-sum transfers from the government, $T(t)$, grow at the same rate as the economy. Choosing transfers to grow at a different growth rate implies that in the long run the size of transfers will become either very small (large) compared to output when the growth rate is chosen to be smaller (greater) than the growth rate of the economy. The intertemporal budget constraint of the government then becomes:

$$\Delta \equiv \frac{\tau_A(a\tilde{L}^\beta - \delta)K(0) + \tau_L bK(0)\tilde{L}^\beta + \tau_C C(0) - \omega_G K(0)\tilde{L}^\beta - T(0)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} - B(0) = 0. \tag{22}$$

All of the proposed fiscal policy reforms that we analyse are a one-off permanent and unanticipated change in a fiscal policy instrument, which are $d\tau_A < 0$, $d\tau_L < 0$, $d\tau_C < 0$, and $d\omega_G > 0$, leading to an increase in labour supply and an increase in the growth rate of the economy. For

(2000b, p. 233) for an explanation of the return on consumption.

[11] Given that labour supply does not grow, available resources for investment fall with a higher public expenditures-to-output ratio since the intratemporal optimality condition between leisure and private goods consumption is not affected. The effect is the opposite of a higher labour income tax rate or consumption tax rate.

the proposed fiscal policy reforms, the existence of a dynamic Laffer effect requires that:

$$-\frac{d\Delta}{d\tau_A} > 0, \quad -\frac{d\Delta}{d\tau_L} > 0, \quad -\frac{d\Delta}{d\tau_C} > 0, \quad \frac{d\Delta}{d\omega_G} > 0$$

We distinguish three basic effects when analysing the overall effect of the proposed fiscal policy reforms on the long-run government budget balance :(i) the *direct budget effect*, covering the direct impact of fiscal policy reforms on government revenues and expenditures; (ii) the *growth rate effect*, covering the impact on government revenues and expenditures over time; and (iii) the *discount rate effect*, aligning the changes in current and future government revenues and expenditures. The effects are obtained by fully differentiating (22) with respect to the policy instrument of choice:

$$\frac{d\Delta}{di} = \Delta_i = \xi_i + \xi_i^l + \upsilon_i + \upsilon_i^l + \pi_i + \pi_i^l - \zeta_i - \zeta_i^l, \tag{23}$$

where ξ_i, υ_i, and π_i for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$ represent the direct budget effect, the discount rate effect, and the growth rate effect, respectively. ζ_i for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$ is part of the growth rate effect when the path of lump-sum government transfers is fixed and is not affected by the change in the growth rate resulting from a fiscal policy reform. When the term is not included, that is, $\zeta_i = 0$, lump-sum government transfers grow at the new growth rate resulting from a fiscal policy reform. The superscript l indicates that when labour supply is endogenous, fiscal policy reforms have an additional effect on the long-run government budget balance corresponding to the three basic effects. The effects are discussed in turn. Hereby we make use of the following expression for initial private consumption, $\tilde{C}(0) = [(1-\omega_G)\tilde{L}^\beta - (\tilde{\gamma}+\delta)]K(0)$, which is derived by making use of the relationship between the growth rate and labour supply associated with product market equilibrium (see (18b)).

3.2.1 The Direct Budget Effect

Given the discount rate, the growth rate, and exogenous labour supply, the effect of a change in a fiscal instrument on the long-run government budget balance is given by:

$$\xi_{\tau_A} \equiv \frac{(a\tilde{L}^\beta - \delta)K(0)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \left[1 + \frac{\tau_C}{1-(1-\sigma)(\phi+\theta)}\right] > 0, \tag{24a}$$

$$\xi_{\tau_L} \equiv \frac{bK(0)\tilde{L}^\beta}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} > 0, \tag{24b}$$

$$\xi_{\tau_C} \equiv \frac{\tilde{C}(0)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} > 0, \tag{24c}$$

$$\xi_{\omega_G} \equiv -\frac{K(0)\tilde{L}^\beta}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} [1+\tau_C] < 0, \tag{24d}$$

so that all proposed fiscal policy reforms lead to a deterioration in the long-run government budget balance. The bracketed terms in equations (24a) and (24d) indicate that a change in a fiscal policy instrument not only affects its own tax base but also other tax bases. More specifically, a lower tax rate on capital income increases the firm's incentives to invest, which comes at the cost of lower private goods consumption. A higher public expenditures-to-output ratio crowds out private goods consumption directly. Both effects decrease the consumption tax base, which in turn leads to a deterioration of the long-run government budget balance. When labour supply is endogenous there is an additional effect given by:

$$\xi_i^l \equiv \frac{\tau_A a + \tau_L b + \tau_C \left[1 - \omega_G - \frac{(1-\tau_A)a}{1-(1-\sigma)(\phi+\theta)}\right]}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \beta K(0) \tilde{L}^{\beta-1} \frac{d\tilde{L}}{di} - \frac{\omega_G}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \beta K(0) \tilde{L}^{\beta-1} \frac{d\tilde{L}}{di} \gtrless 0, \tag{25}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. Under the proposed fiscal policy reforms, the first line of equation (25) is positive since a, b, and the bracketed term in the numerator are all positive.[12] However, the second term of equation (25) is negative. Thus the sign of ξ_i^l is ambiguous, implying that endogenous labour supply may improve or deteriorate the long-run government budget balance.

3.2.2 The Discount Rate Effect

When labour supply is exogenous, the discount rate effect on the long-run government budget balance is given by:

$$\upsilon_{\tau_A} \equiv B(0) \frac{a\tilde{L}^\beta - \delta}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}}, \tag{26a}$$

$$\upsilon_{\tau_L} \equiv \upsilon_{\tau_C} \equiv \upsilon_{\omega_G} \equiv 0, \tag{26b}$$

and, when labour supply is endogenous, the additional effect is given by:

$$\upsilon_i^l \equiv -B(0) \frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \frac{d\tilde{L}}{di}, \tag{26c}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. From (26) it can be seen that the effect of a change in the discount rate on the long-run government budget balance depends on the initial stock of public debt denoted by $B(0)$. In the plausible case where it is positive all of the proposed fiscal policy reforms lead to a deterioration in the long-run government balance. When it is negative, so that the government acts as a creditor to the private sector, the reverse holds. Effects are absent when it is zero. The intuition behind these findings is as follows. All of the proposed fiscal policy reforms lead to a

[12] The bracketed term is positive if $\sigma > 1 - \frac{1-\omega_G - a(1-\tau_A)}{(1-\omega_G)(\phi+\theta)}$, which holds if an equilibrium exists (see (19)).

higher discount rate, lowering the present value of the government's net cash flows over time. If $B(0) > 0$, then a budget surplus over time is required for the long-run government budget to be balanced. In this case, a higher discount rate leads to a lower present value of positive cash flows over time, deteriorating the long-run government budget balance. The reverse holds if $B(0) < 0$. Because the discount rate is increasing in labour hours supplied, which increase for all of the proposed policy reforms, the qualitative effects do not change under endogenous labour supply.

3.2.3 The Growth Rate Effect

The growth rate effect on the long-run government budget balance has a similar structure to that of the discount rate effect. When labour supply is exogenous, it is given by:

$$\pi_{\tau_A} \equiv -B(0)\frac{(a\tilde{L}^{\beta} - \delta)}{[(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]}\frac{1}{[1-(1-\sigma)(\phi+\theta)]}, \tag{27a}$$

$$\pi_{\tau_L} \equiv \pi_{\tau_C} \equiv \pi_{\omega_G} \equiv 0, \tag{27b}$$

and the additional effect when labour supply is endogenous:

$$\pi_i^l = B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{[(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]}\frac{1}{[1-(1-\sigma)(\phi+\theta)]}\frac{d\tilde{L}}{di}, \tag{27c}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. Also here it can be seen that the growth rate effect depends on the initial stock of public debt. Given the concavity of the felicity function (see (6)), the sign of the growth rate effect is the opposite of that of the discount rate effect. Again, the qualitative effects do not change under endogenous labour supply.

The growth rate effect corresponding to lump-sum government transfers in particular is implicitly captured by π_i.[13] When labour supply is exogenous, it explicitly can be given by:

$$\zeta_{\tau_A} \equiv \frac{T(0)(a\tilde{L}^{\beta} - \delta)}{[1-(1-\sigma)(\phi+\theta)][(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]^2} \tag{28a}$$

$$\zeta_{\tau_L} \equiv \zeta_{\tau_C} \equiv \zeta_{\omega_G} \equiv 0, \tag{28b}$$

and, when labour supply is endogenous, the additional effect is given by:

$$\zeta_i^l \equiv -\frac{T(0)(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{[1-(1-\sigma)(\phi+\theta)][(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]^2}\frac{d\tilde{L}}{di}, \tag{28c}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. When lump-sum transfers are positive the growth rate effect is always negative. Intuitively, it leads to an increase in negative cash flows over time leading to a deterioration

[13] Given that the long-run government budget is balanced in the initial equilibrium there is a direct link between the stock of debt and the government's net cash flows over time, where the latter includes lump-sum government transfers, see (22).

of the long-run government budget balance.

A common assumption made in the literature on the dynamic Laffer effect is that the path of lump-sum transfers is fixed and is not affected by the higher growth rate resulting from a permanent lower distortionary tax rate.[14] It is straightforward to see that this assumption eliminates a negative effect on the long-run government budget balance and, hence, makes it more likely to find a dynamic Laffer effect. Moreover, notice that the growth rate effect is increasing in the intertemporal elasticity of substitution.

3.2.4 The Overall Effect

For analytical tractability, we take the discount rate effect and the growth rate effect together. More specifically, we replace $\upsilon_i + \upsilon_i^l + \pi_i + \pi_i^l$ in equation (23) by the equations given in (26) and (27). The overall effect of a change in a fiscal instrument on the long-run government budget balance is then given by:

$$\begin{aligned}\Delta_i = {} & \xi_i + \xi_i^l - \zeta_i - \zeta_i^l \\ & + B(0)\frac{(a\tilde{L}^\beta - \delta)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}}\left[1 - \frac{1}{1-(1-\sigma)(\phi+\theta)}\right] \\ & - B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}}\left[1 - \frac{1}{1-(1-\sigma)(\phi+\theta)}\right]\frac{d\tilde{L}}{di},\end{aligned} \tag{29}$$

for $i = \tau_A$, and

$$\begin{aligned}\Delta_i = {} & \xi_i + \xi_i^l - \zeta_i - \zeta_i^l \\ & - B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}}\left[1 - \frac{1}{1-(1-\sigma)(\phi+\theta)}\right]\frac{d\tilde{L}}{di},\end{aligned} \tag{30}$$

for $i \in \{\tau_L, \tau_C, \omega_G\}$. The discount rate effect dominates the growth rate effect if the bracketed terms in equations (29) and (30) are positive. The reverse holds if they are negative and both effects cancel out when they are zero. The sign of the bracketed term is determined by the intertemporal elasticity of substitution, $1/\sigma$. Table 1 gives an overview of all of the above discussed effects in a convenient manner and can be used to replicate the main findings in the literature.

The effect of the fiscal policy reform as discussed in Ireland (1994) are replicated by $B(0) = 0$, and noting that the path of lump-sum transfers is fixed. Since labour supply is exogenous in his analysis, the overall effect of the fiscal policy reform can be given by the sign of $\xi - \zeta$, which is ambiguous. Possibly there exists a range of non-trivial conditions for which this is positive so that the fiscal policy reform leads to an improvement in the long-run government budget balance. Ireland (1994) shows that a dynamic Laffer effect can even be obtained when $\sigma > 1$. Agell and

[14] See, for example, Ireland (1994), Agell and Persson (2001), Novales and Ruiz (2002), and Frederiksson (2007).

Persson (2001) find that when the path of lump-sum transfers is fixed, an improvement of the long-run budget balance is more likely to occur if the lump-sum transfers-to-output ratio, $T(0)/Y(0)$, is relatively high. From equations (24) and (28) it is straightforward to see that this means that ζ is relatively large compared to ξ so that $\xi - \zeta$ is more likely to be positive.

Bruce and Turnovsky (1999) show that it is possible to achieve an improvement in the long-run government budget balance even when government expenditures cannot be directly influenced.[15] This is the case if the initial stock of public debt is positive and the intertemporal elasticity of substitution is larger than unity. Setting $B(0) > 0$ and $\sigma < 1$, it can be seen from Table 1 that the overall effect is given by $\xi + \nu + \pi$, which may be positive. Intuitively, if the intertemporal elasticity of substitution is larger than unity, then the growth rate effect dominates the discount rate effect, which means that the present value of positive government's cash flows increases.

The finding of Bruce and Turnovsky (1999) that a dynamic Laffer effect is only possible if $\sigma < 1$ seems to contradict the results of Ireland (1994). From Table 1 it can be seen that this contradiction can be explained by the assumption on the initial stock of public debt. The explanation put forward by Agell and Persson (2001) that this contradiction can be explained by different structure of government spending should thus be extended. Agell and Persson (2001) also analyse a case of a higher lump-sum transfer-to-output ratio that must be kept constant after a fiscal policy reform. They show that in this case a dynamic Laffer effect is not possible even if the intertemporal elasticity of substitution is larger than unity.[16]

The next section provides a numerical illustration to see when a dynamic Laffer effect occurs.

4 Numerical Results

In this section we perform a numerical analysis to see whether there are fiscal policy reforms that lead to an improvement in the long-run government budget balance. To this end, we define a benchmark economy representing the 15 members of the euro area, treating all the countries together as a closed economy.[17] When defining the initial balanced growth path of the economy, we use parameters and variables representative for the euro area over the period 1995-2006.

4.1 Calibration and Fiscal Stylized Facts

Although in practice fiscal systems are complex, consisting of a variety of statutory taxes and corresponding tax bases, we use the implicit tax rates provided by the European Commission (2008) to pin down our initial tax rates. These implicit tax rates are fairly constant over time

[15] Although the analysis of Bruce and Turnovsky (1999) differs from ours, the mechanism is basically the same.

[16] This can be represented by the sum of ξ and, since expenditures increase, a negative term, which is always negative.

[17] These countries are Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, and Spain.

and on average are 25.2, 39.1, and 19.4 percent for the tax rate on capital income, labour income, and consumption, respectively. For total public consumption and lump-sum transfers, we use data on final government consumption and social transfers from the AMECO database of the European Commission (2007).[18] On average, these are 20.1 and 16.6 percent for final government consumption and social transfers, respectively. Based on these figures, we set $\tau_A = 0.25$, $\tau_L = 0.39$, $\tau_C = 0.19$, $\omega_G = 0.20$, and $T(0)/Y(0) = 0.17$.

For the structural parameters of the model, we follow the literature when data are unavailable. The production elasticities of capital and labour are taken from the European Commission (2007). The labour share of income, which is on average 65.2 percent of GDP. We choose $a = 0.35$ and $b = \beta = 0.65$, hereby abstracting from the externalities associated with the use of labour in production. For the pure rate of time preference, we follow Agell and Persson (2001) and Mendoza and Tesar (2005) and set $\rho = 0.02$. The intertemporal elasticity of substitution is set to a half, so that $\sigma = 2$, somewhere half way the range of values found by Attanasio and Weber (1993).[19] The depreciation rate is obtained by averaging the values used by Mendoza and Tesar (2005) and Itaya (2008), leading to $\delta = 0.08$. For the choice of utility weights we follow Novales and Ruiz (2002) and Itaya (2008) by setting ϕ/η to 1/2 and Turnovsky (2000a) by setting θ/ϕ to 1/3. Under the assumption that the utility weights sum up to one, this leads to $\phi = 0.30$, $\eta = 0.60$, and $\theta = 0.10$ four our basic specification. Finally, the initial physical capital stock is normalized to one. Given the lack of consensus on the choice of utility weights in the literature, we perform a sensitivy analysis using different ratios of utility weights.

The model should be able to replicate fiscal stylized facts of the euro area. Tax revenues as a percentage of GDP are fairly constant over time and on average are 2.8, 21.3, and 10.9 percent for tax revenues related to the capital income tax, labour income tax, and consumption tax, respectively. The private consumption-to-output ratio is on average 57.4 percent, the debt-to-output ratio is on average 70.4 percent over the period 1997-2006, and the growth rate is 1.2 percent, where the latter two are less stable over time. For labour supply we use data on annual hours worked per employee, which on average is $1,700$. The ratio of labour supply to total time should lie between 0.19 and 0.29.[20]

In the top panel of Table 2, ϕ/η is varied from 2/3 to 2/5, corresponding to an increase in the relative weight of leisure to private consumption. This is reflected in the ratio of labour supply

[18]The method for calculating the implicit tax rates is based on Mendoza, Razin, and Tesar (1994). For the implicit tax rate on capital income we use the implicit tax rate related to the taxation of income and profits of firms and neglect the taxation of capital stocks and the taxation of capital transfers. The social transfers are defined as social transfers other than in kind, mainly consisting of social benefits in the form of cash.

[19]Similar values are used by Turnovsky (2000a), Mendoza and Tesar (2005), and Itaya (2008).

[20]Data on tax revenues is taken from the European Commission (2008), data on the private consumption-to-output ratio, the debt-to-output ratio, and the growth rate from the AMECO database (European Commission 2007), and data on hours per year worked from the Total Economy Database provided by Conference Board (2009). The ratio of labour supply to total time is calculated as follows: min. $1,700/(24 * 365) \approx 0.19$ and max. $1,700/(16 * 365) \approx 0.29$.

to total time, which decreases as leisure becomes relatively higher valued. The lower amount of labour supply in turn leads to a lower growth rate. In the bottom panel of Table 2, θ/ϕ is varied from 0 to 2, corresponding to an increase in the relative weight of public goods consumption to private goods consumption. The growth rate is decreasing in the utility weight of public goods consumption. This, however, is not caused by the relative utility weights but by their sum, which reflects a lower effective intertemporal elasticity of substitution. This in turn leads to a lower growth rate of the economy.

Overall, the model performs surprisingly well in replicating tax revenues as a percentage of GDP, the growth rate of the economy, and the private consumption-to-output ratio. For tax revenues the largest deviation is that of labour income and is around four percentage points, however, this is the same for all cases considered. The ratio of labour supply to total time never falls outside the bounds of 0.19 and 0.29. The model performs the least in replicating the debt-to-output ratio. This may be the result of imposing the restriction of a balanced initial long-run government budget, which may not hold in practice. We stick to our basic specification when performing the numerical analyses.

4.2 Basic Fiscal Policy Reforms

Given our choice of the parameters, we analyse whether the proposed fiscal policy reforms lead to a dynamic Laffer effect. Instead of restricting the analysis to marginal changes in the tax rates on the long-run government budget balance, we analyse a wide range of discrete changes in the tax rates. More specifically, we analyse a series of lower tax rates whereby the difference between the initial tax rate and the tax rate after the fiscal policy reform is repeatedly increased up to the point where the difference is 15 percentage points, where the balanced growth path corresponding to the new tax rate is calculated for every change. The same procedure is followed for the public expenditures-to-output ratio, which eventually is increased up to the point where the ratio is 15 percentage points higher than the initial ratio.

The solid lines in panels (a)-(d) of Figure 2 represent the overall effect of the proposed fiscal policy reforms on the long-run government budget balance (the magnitude is given on the right vertical axis.) All fiscal policy reforms result in an equilibrium that is unique. Moreover, all equilibria are unstable so that the economy jumps right to the new equilibrium. This means there are no transitional dynamics. It can be seen that an improvement in the long-run government budget balance is always obtained for a lower tax rate on capital income but in the case of labour income it is only obtained for a substantial lower tax rate. Lowering the tax rate on consumption or increasing the public expenditure-to-output ratio never leads to a dynamic Laffer effect.

The stacked bars in Figure 2 give the relative contribution of the basic effects to the change in the long-run government budget balance, where a distinction is made between the direct budget

effect, $\xi + \xi^l$, the combined discount rate effect and growth rate effect, $\pi + \pi^l + \nu + \nu^l$, and the growth rate effect corresponding to the case where the path of lump-sum transfers is fixed, $\zeta + \zeta^l$ (the magnitudes are given on the left vertical axis and sum up to one.) The dashed bars correspond to the case where labour supply is endogenous. It can be seen that the increase in the growth rate induced by a lower consumption tax rate or a higher public expenditure-to-output ratio is insufficient to obtain a dynamic Laffer effect. Moreover, the fiscal policy reforms that do lead to a dynamic Laffer effect hinge on the assumption that the path of lump-sum transfers remains fixed after the reforms. That is, when $\zeta + \zeta^l$ is set to zero, there is never an improvement in the long-run government budget balance.[21]

For the case of the tax rate on capital income, the quantitative effects of taking into account the initial stock of public debt and endogenous labour supply are given in Figure 3. The solid (dashed) lines represent the cases where the stock of initial public debt is assumed to be zero (positive) and the thin (thick) lines represent the cases where labour supply is assumed to be exogenous (endogenous.) It can be seen that neglecting the stock of initial public debt leads to an overestimation and ignoring the labour-leisure trade-off leads to an underestimation of the dynamic Laffer effect. In all cases considered here, a marginal decrease in the capital income tax rate always leads to an improvement in the long-run government budget balance. However, it can be shown that if the lump-sum transfer-to-output ratio is low enough this is not always the case.[22] Assumptions on the initial stock of public debt and labour supply then affect the size of the tax rate reduction needed to obtain a dynamic Laffer effect, where the size is decreasing and increasing when neglecting the initial stock of public debt and the labour-leisure trade-off, respectively.

As said, all of the observed improvements are the result of assuming that the path of lump-sum is fixed. This, however, implies that the transfers-to-output ratio goes to zero over time after a fiscal policy reform, which seems a rather strong assumption. By looking at composite fiscal policy reforms we analyse whether a dynamic Laffer effect is also possible when lump-sum transfers always grow at the same rate as the economy so that the the transfers-to-output ratio remains constant over time.

4.3 Composite Fiscal Policy Reforms

We define a composite fiscal policy reform as a combination of changes in the tax rates on capital income, labour income, and consumption while letting transfers grow at the same rate as the economy. More specifically, we analyse a range of lower tax rates on capital income or labour income in combination with a range of higher tax rates on consumption to see under which

[21] Note that the above described effects are not the marginal effects as discussed in Section 3.2 but are related since we analyse discrete changes here. Notes on the specific method used are available on request.

[22] This depends on the calibration. For example, when the initial lump-sum transfers-to-output ratio is 0.10, substantial rather than marginal changes in the capital income tax rate are needed to obtain a dynamic Laffer effect.

conditions a dynamic Laffer effect exists. For each combination that we analyse we start at the initial tax rates of the benchmark economy and impose the additional condition that the combinations should lead to an improvement in lifetime welfare. We define the change in lifetime welfare as the percentage change in private goods consumption before the fiscal policy reform necessary to obtain the same present discounted value of utility as after the fiscal policy reform. Moreover, we make a distinction between immediate and long-run welfare effects.[23] The area in panel (a) of Figure 4 represents the combinations of capital income tax rates and consumption tax rates that lead to an improvement in both the long-run government budget balance and lifetime welfare. The area in panel (b) represents the combinations of the labour income tax rates and the consumption tax rates for which this holds. From now on, these combinations are called "feasible combinations."[24]

For all feasible combinations in panel (a) of Figure 4 labour supply is decreasing, which leads to a lower after-tax return on capital. The lower tax rates on capital income, however, lead to a higher after-tax return on capital. Here, the latter effect dominates the former so that the growth rate of the economy is increasing for all feasible combinations. This finding is in contrast with the fiscal policy reforms analysed in Section 4.2 where both the supply of labour and the growth rate of the economy always increase. According to Table 1, an improvement in the long-run government budget balance can now only occur if the direct budget effect is positive since lump-sum transfers grow at the same rate of the economy, the initial stock of public debt is positive, and the intertemporal elasticity of substitution is smaller than unity. This is indeed the case. Although the lifetime welfare effect is positive, the immediate welfare effect is always negative, raising the question whether the reforms will be implemented in the first place.

From (20) it can be seen that a rise in the tax rate on consumption and a fall in the tax rate on labour income of similar magnitude always leads to an increase in the supply of labour.[25] From panel (b) of Figure 4, however, it can be seen that for all feasible combinations the rise in the tax rate on consumption is always larger than the fall in the tax rate on labour income so that the effect is ambiguous. Here, all feasible combinations lead to an increase in labour supply and, hence, to an increase in the growth rate of the economy since the growth rate in this case is only affected by changes in labour supply. Also here the direct budget effect is positive and dominates the negative combined discount rate effect and growth rate effect, so that there is an improvement in the regular government budget balance. For all feasible combinations, however, both the immediate and long-run welfare effects are positive. This means that these fiscal policy

[23] Again, notes on the method used are available on request.

[24] For all combinations of the tax rates, the conditions for existence of the equilibrium (19) and the dynamics around the balanced growth path (31) are examined. All composite fiscal policy reforms result in an equilibrium that is unique. Moreover, all equilibria are unstable so that the economy jumps right to the new equilibrium.

[25] From a technical point of view this is not the case if initially the subsidy to labour income exceeds the tax rate on consumption. This, however, is irrelevant for the current analysis.

reforms may be more likely to be implemented.

5 Concluding Remarks

Using a one-sector model of endogenous growth with endogenous labour supply and allowing for different structures of government spending and public debt, we are able to explain and reconcile the seemingly different conclusions that are found in the literature. We analytically show that, when performing a dynamic Laffer effect analysis, there exists a set of conditions that hold for a number of endogenous growth models. For the euro area, we find that lowering the tax rate on capital income is the best candidate for obtaining a dynamic Laffer effect. However, this hinges on the assumption that the path of lump-sum transfers is kept fixed after a fiscal policy reform. When this assumption is relaxed, an improvement in the long-run government budget balance is still possible when lower tax rates on factor income, here capital income and labour income, are financed by a higher tax rate on consumption. The combinations of tax rates for which this is possible differ in their implications for labour supply and immediate welfare effects though.

A direction for further research is the inclusion of a political economy model that allows a more thorough analysis of issues concerning the political feasibility of the fiscal policy reforms discussed in our analysis. A first step would be an adjustment of the framework such that an explicit distinction between current and feature generations is possible. Another avenue for future research is an extensive analysis of the effect of fiscal policy reforms on the debt-to-output ratio over time. It then can be examined whether after a fiscal policy reform the debt-to-output ratio exceeds legal thresholds imposed by the Growth and Stability Pact, thereby providing additional criteria for the implementation of the reforms. More importantly, potential large debt-to-output ratios resulting from a fiscal policy reform are likely to give rise to a risk-premium for bonds. Together with uncertainty, the risk-premium would make the return on bonds endogenous and may alter the current analysis.

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Mathematical Appendix

Existence of the Equilibrium

Both (18a) and (18b) are defined for $L \in (0, 1]$. Over this interval it holds that:

$$
\begin{aligned}
\gamma_P(L) &= \frac{(1-\tau_A)(aL^\beta - \delta) - \rho}{1-(1-\sigma)(\phi+\theta)}, \\
\frac{\partial \gamma_P(L)}{\partial L} &= \frac{(1-\tau_A)a\beta L^{\beta-1}}{1-(1-\sigma)(\phi+\theta)} > 0, \\
\frac{\partial^2 \gamma_P(L)}{\partial L^2} &= -\frac{(1-\tau_A)a\beta(1-\beta)L^{\beta-2}}{1-(1-\sigma)(\phi+\theta)} < 0, \\
\gamma_Q(L) &= L^\beta \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b}{\beta}\frac{b\phi}{\eta}\frac{1-L}{L}\right] - \delta, \\
\frac{\partial \gamma_Q(L)}{\partial L} &= L^\beta \left[\frac{(1-\omega_G)\beta}{L} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{1-\beta}{L} + \frac{1}{1-L}\right)\right] > 0, \\
\frac{\partial^2 \gamma_Q(L)}{\partial L^2} &= L^\beta \left[\frac{(1-\omega_G)\beta^2}{L^2} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{\beta(1-\beta)}{L^2} + \frac{2\beta}{L(1-L)}\right)\right] \\
&\quad - L^\beta \left[\frac{(1-\omega_G)\beta}{L^2} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{2(1-\beta)}{L^2} + \frac{2}{L(1-L)}\right)\right] < 0,
\end{aligned}
$$

where we used that $0 < \beta < 1$. Moreover:

$$
\begin{aligned}
\lim_{L\to 0} \gamma_P(L) &= \frac{-\delta(1-\tau_A) - \rho}{1-(1-\sigma)(\phi+\theta)}, & \lim_{L\to 0} \gamma_Q(L) &= -\infty, \\
\gamma_P(1) &= \frac{(a-\delta)(1-\tau_A) - \rho}{1-(1-\sigma)(\phi+\theta)}, & \gamma_Q(1) &= 1 - \omega_G - \delta.
\end{aligned}
$$

Now, a unique equilibrium exists if $\gamma_P(1) < \gamma_Q(1)$. This is the case if:

$$
\sigma > 1 - \frac{1 - \omega_G - (a-\delta)(1-\tau_A) + \rho}{(1-\omega_G)(\phi+\theta)}.
$$

Stability of the Equilibrium

We define $\Omega_P(L) \equiv \partial\gamma_P(L)/\partial L$ and $\Omega_Q(L) \equiv \partial\gamma_Q(L)/\partial L$. The sign of the derivative of the rate of growth

of labour supply (15) with respect to labour, valued at $\tilde{L}$, is given by:

$$sgn\left\{\left.\frac{d\dot{L}/L}{dL}\right|_{L=\tilde{L}}\right\} = sgn\left\{\frac{1-(1-\sigma)(\phi+\theta)}{\Theta^D(\tilde{L})}\left[\Omega_P(\tilde{L})-\Omega_Q(\tilde{L})\right]\right\}. \tag{31}$$

When (31) is positive, small deviations in labour supply lead to a permanent deviation from $\tilde{L}$ so that the equilibrium is locally unstable and said to be locally determinate. When (31) is negative, small deviations of the supply of labour will force labour supply back to $\tilde{L}$ so that the equilibrium is locally stable and said to be locally indeterminate. Since $\Omega_Q(\tilde{L}) > \Omega_P(\tilde{L})$, when a unique equilibrium exists and $1-(1-\sigma)(\phi+\theta) > 0$ by the concavity of the felicity function, the equilibrium is locally unstable if $\Theta^D(\tilde{L}) < 0$.

Table 1 Effects of the Proposed Fiscal Policy Reforms on the Long-Run Government Budget Balance

exogenous labour supply											
	ξ_i	ζ_i	$\nu_i+\pi_i$ $B(0)>0$			$\nu_i+\pi_i$ $B(0)=0$			$\nu_i+\pi_i$ $B(0)<0$		
			$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$
d $\tau_A<0$	-	-	+	0	-	0	0	0	-	0	+
d $\tau_L<0$	-	0	0	0	0	0	0	0	0	0	0
d $\tau_C<0$	-	0	0	0	0	0	0	0	0	0	0
d $\omega_G>0$	-	0	0	0	0	0	0	0	0	0	0
endogenous labour supply											
	ξ_i^l	ζ_i^l	$\nu_i^l+\pi_i^l$ $B(0)>0$			$\nu_i^l+\pi_i^l$ $B(0)=0$			$\nu_i^l+\pi_i^l$ $B(0)<0$		
			$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$
d $\tau_A<0$	+/-	-	+	0	-	0	0	0	-	0	+
d $\tau_L<0$	+/-	-	+	0	-	0	0	0	-	0	+
d $\tau_C<0$	+/-	-	+	0	-	0	0	0	-	0	+
d $\omega_G>0$	+/-	-	+	0	-	0	0	0	-	0	+

Notes: ξ denotes the direct budget effect, ζ is part of the growth effect corresponding to the case where the path of lump-sum transfers is predetermined, υ denotes the discount rate effect, and π denotes the growth rate effect. σ denotes the inverse of the intertemporal elasticity of substitution and $B(0)$ denotes the initial stock of debt, where $B(0)>0$ denotes the situation where initial debt is positive and $B(0)<0$ denotes the situation where the government acts as a creditor to the private sector.

Table 2 Comparing Stylized Facts under Different Scenarios

Variable/Scenario	Actual	$\theta = 0.10$ $\phi = 0.30$ and $\eta = 0.45$	$\theta = 0.10$ $\phi = 0.30$ and $\eta = 0.60$	$\theta = 0.10$ $\phi = 0.30$ and $\eta = 0.75$
τ_A: as % of GDP	2.8	4.2	3.5	3.0
τ_L: as % of GDP	21.3	25.4	25.4	25.4
τ_C: as % of GDP	10.9	10.6	10.5	10.4
$\tilde{\gamma}$	1.2	2.6	1.5	0.8
$\tilde{L}$	0.23	0.28	0.23	0.20
$\tilde{B}/\tilde{Y}$	0.70	1.06	0.93	0.74
$\tilde{C}/\tilde{Y}$	0.57	0.56	0.55	0.55
Variable/Scenario	Actual	$\eta = 0.60$ $\phi = 0.30$ and $\theta = 0.00$	$\eta = 0.60$ $\phi = 0.30$ and $\theta = 0.30$	$\eta = 0.60$ $\phi = 0.30$ and $\theta = 0.60$
τ_A: as % of GDP	2.8	3.6	3.6	3.5
τ_L: as % of GDP	21.3	25.4	25.4	25.4
τ_C: as % of GDP	10.9	10.5	10.6	10.7
$\tilde{\gamma}$	1.2	1.7	1.3	1.1
$\tilde{L}$	0.23	0.23	0.23	0.23
$\tilde{B}/\tilde{Y}$	0.70	0.96	0.90	0.87
$\tilde{C}/\tilde{Y}$	0.57	0.55	0.56	0.56

Notes: Fiscal parameters are given by $\tau_A = 0.25$, $\tau_L = 0.39$, $\tau_c = 0.19$, $\omega_G = 0.20$, and $T(0)/Y(0) = 0.170$. Structural parameters are given by $a = 0.35$, $b = 0.65$, $\beta = 0.65$, $\delta = 0.08$, $\rho = 0.02$, and $\sigma = 2.00$. The initial capital stock is normalized to one, $K(0) = 1$.

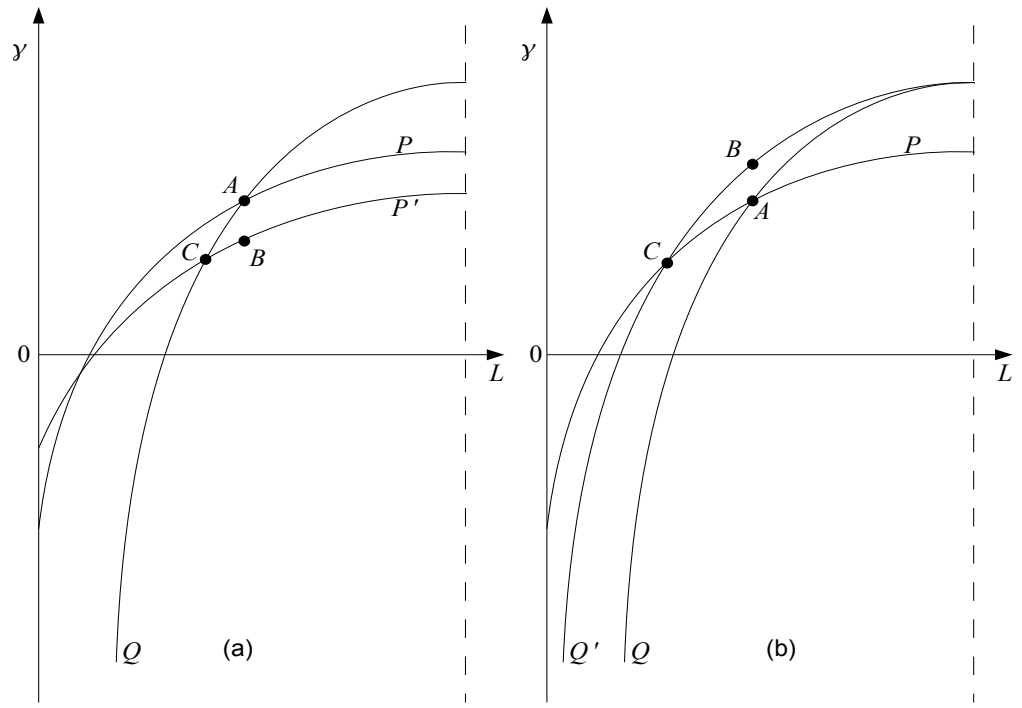

Figure 1 Growth Rate Effects of Changes in Fiscal Policy Instruments

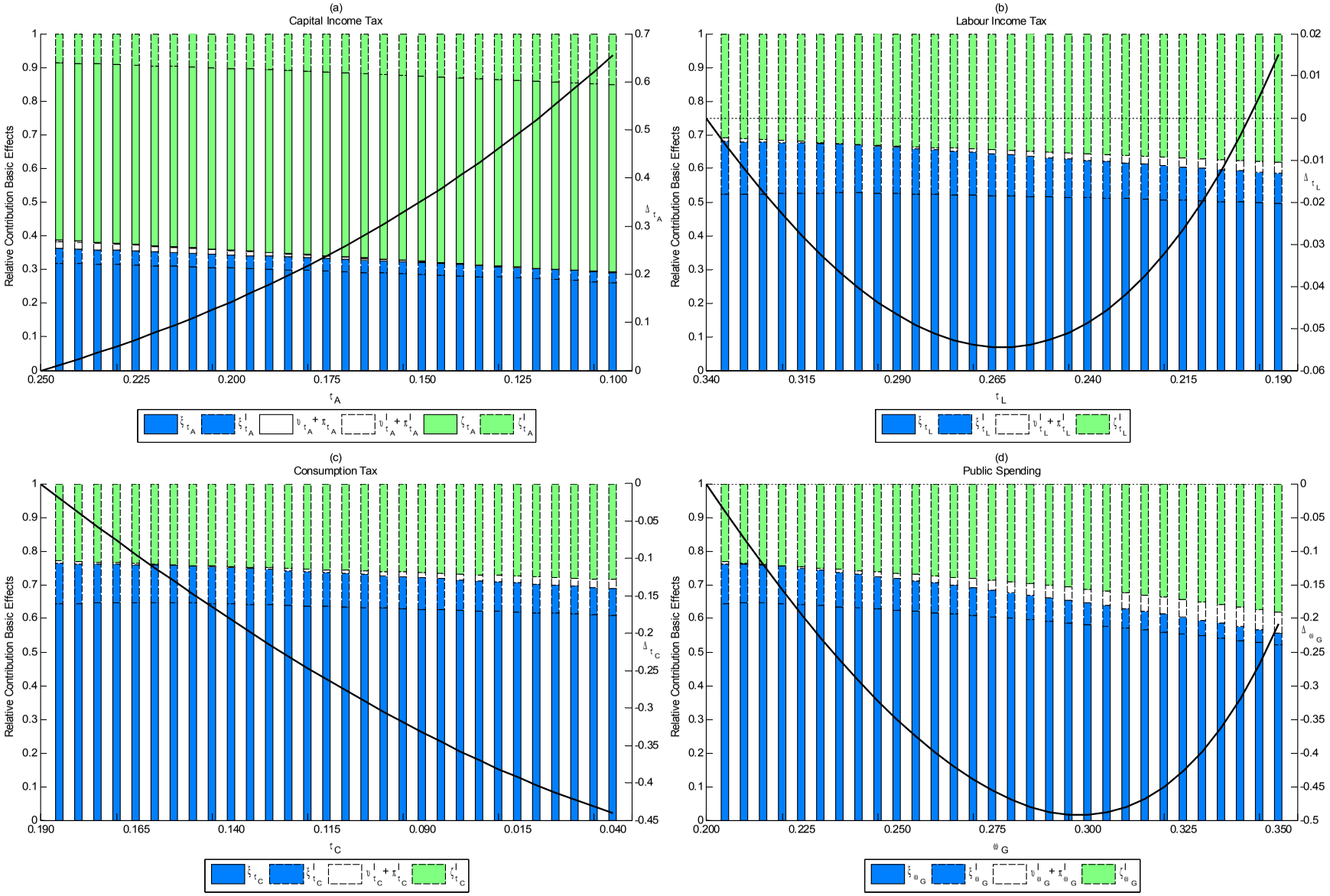

Figure 2 Effects of the Proposed Fiscal Policy Reforms for τ_A, τ_L, τ_C, and ω_G

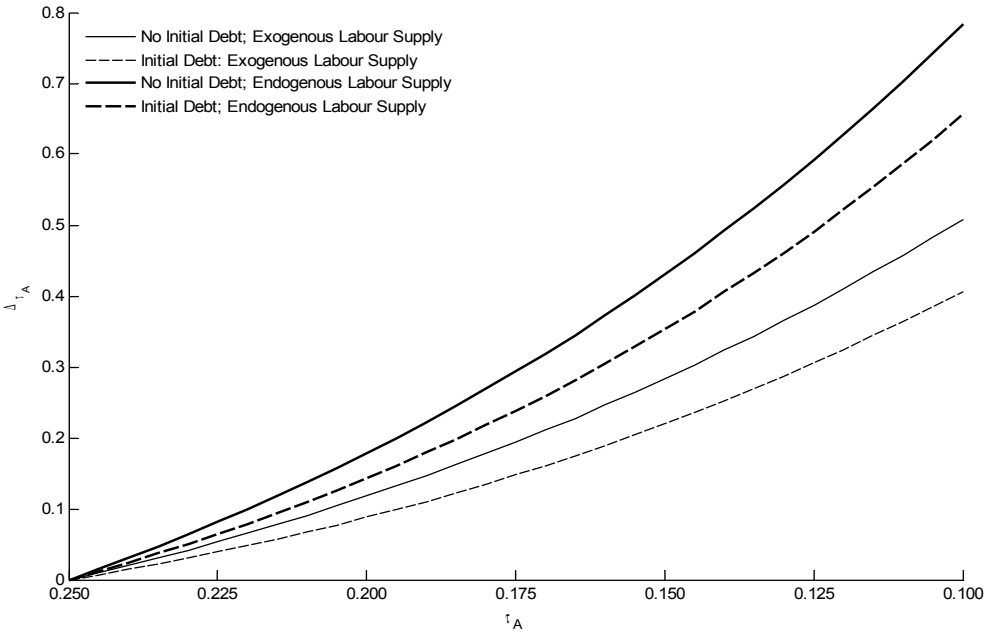

Figure 3 Different Scenarios for the Capital Income Tax Rate Reform

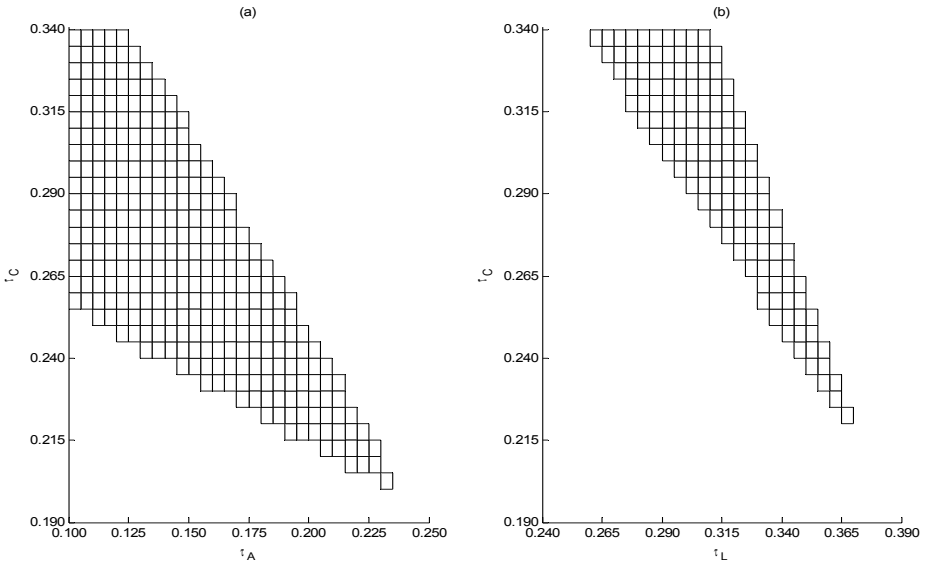

Figure 4 Composite Fiscal Policy Reforms

Notes: The areas represent combinations of after-reform tax rates for which there is an improvement in both the long-run government budget balance and overall welfare. Initial tax rates are $\tau_A = 0.25$, $\tau_L = 0.39$, and $\tau_C = 0.19$ for the tax rate on capital income, labour income, and consumption, respectively.