

A Tale of Tax Policies in Open Economies*

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Abstract

Recent financial crises in Europe and the government budget battles in the U.S. point to the importance of fiscal discipline among developed countries. This paper develops an open economy model, calibrated to either the U.S. or a subset of the EMU, to evaluate the impact of various fiscal reforms. The first set of experiments consider 25% reductions in the government debt-to-output ratio. Implementing this reduction through capital income taxes raises economic welfare owing to the beneficial effects of lower taxes in the long run since tax revenue requirements fall. Using the consumption tax yields only a very small welfare benefit: the short run costs of higher taxes largely offset the long run benefits. Policy implementation through the labor income tax generates welfare losses. The second set of experiments leave the long run debt-to-output ratio unchanged. Replacing capital income tax revenue with another tax is generally welfare-enhancing. Doing so using the labor income tax in the EMU-12 proves to be an exception: In this case, the tax has to rise quite a bit since the EMU-12 is close to the peak of its labor income tax Laffer curve. Substituting consumption tax revenue for labor income tax revenue is also welfare-improving since, in an open economy model, the burden of the consumption tax falls partly on foreign producers. Such a shift in taxes improves the domestic economy's international competitiveness.

Keywords: Fiscal policies, open economies, public deficits, tax reforms.

JEL Classification: E6, F3, F4 .

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1. Introduction

The fiscal situation in Greece, Italy, Ireland, Portugal and Spain (GIIPS) is grim. France's situation is not much better although it has, to date, avoided a crisis. Budget battles in the U.S. lead to a cutback in government services early in 2013, and a "shutdown" of the federal government in October 2013. Japan's government debt-to-GDP ratio now exceeds 200%. These observations all point to the need for developed countries to get (and keep) their fiscal houses in order.

We build a dynamic general equilibrium, two region, open economy macroeconomic model to address tax reforms. First, taking as given a desire to reduce the government debt-to-output ratio, governments should presumably choose to do so using a tax that delivers the largest welfare gain (or, at least minimizes the welfare loss). The specific experiment considered is a long run 25% reduction in the government debt-to-output ratio financed via one of: the consumption tax, the labor income tax, or the capital income tax. Such a reduction in the debt-to-output ratio implies an equiproportional reduction in the primary surplus-output ratio in the long run. To ensure stability of the debt dynamics, the government follows a fiscal policy rule that links deviations of the primary surplus from its long run target to deviations of the debt-to-output ratio from its long run target. Simply put, when the debt-to-output ratio is above target, one of the tax rates is adjusted to push the primary surplus above its long run value.

Second, we consider tax replacement scenarios that leave the long term debt-to-output ratio unchanged. The optimal fiscal policy literature suggests that lowering capital income tax rates will be beneficial. We consider using either the labor income tax or the consumption tax to finance a 10 percentage point fall in the capital income tax rate. Next, in an open economy model, part of the burden of the consumption tax is borne by foreign producers through the taxation of all consumption goods including imports. Consequently, a reduction in the labor income tax rate with an offsetting increase in the consumption tax rate will improve the domestic region's international competitiveness, and so be beneficial. We evaluate these scenarios.

Two calibrations of the model are presented. In one, the home region is the U.S. and the foreign

region is the rest of the OECD; in the other, the home region is a core subset of the European Monetary Union hereafter referred to as the EMU-12.¹ In welfare terms, achieving the targeted debt-to-output reduction through capital income taxes is best: the welfare gain is 0.6% for the U.S., 1.2% for the EMU-12. Both regions experience short-lived recessions, although consumption rises in the short run since the higher income taxes discourage investment. Of course, this short run consumption rise factors in positively in the welfare analysis. In the short term, both regions experience real exchange rate depreciations, and a rise in net exports and the current account. In the long run, the capital income tax ends up lower because the government's tax revenue requirements fall since its debt servicing falls with debt. The long run effects of lower capital income tax rates boost economic activity.

When the consumption tax is used to push down the debt-to-output ratio, there is only a very small welfare gain. In this case, the short run costs associated with the tax-induced recession almost completely offset the eventual long run benefits of lower consumption taxes.

Both the U.S. and EMU-12 experience welfare losses when the labor income tax is used to reduce the debt-to-output ratio. In this case, the short run disruptions to economic activity are both more severe and much more long-lived than under the other two taxes, and the long term benefits are insufficient to compensate for these short term losses. These observations are particularly true for the EMU-12. Current income tax rates place the EMU-12 at a fairly flat portion of its Laffer curve and so the labor income tax rate must rise a lot to raise the required tax revenue. In fact, the rise in the labor income tax rate for the EMU-12 places this tax rate very close to the peak of the Laffer curve. This particular scenario points to the importance of including transitional dynamics in computing welfare benefits of a policy change since a comparison across steady states gives reasonably large welfare gains.

The debt-neutral capital income tax reduction experiments are motivated by the observation that the optimal taxation literature typically calls for lower capital income taxes (in the long run, zero). Specifically, the capital income tax rate is lowered 10 percentage points. The lost tax

¹The EMU-12 consists of its core members: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain.

revenue is replaced by either an increase in the labor income tax or the consumption tax. As with the first set of experiments, the government follows a fiscal policy rule linking primary deficits to debt. While the policy of using the labor income tax in the EMU-12 results in welfare losses, the other scenarios deliver sizable welfare gains. These welfare gains can be attributed to the long run gains associated with lower capital income tax rates. As with the labor income tax-financed debt-reduction in the EMU-12, replacing capital income tax revenue with labor income tax revenue requires large increases in the labor income tax rate, leading to a severe and long-lived recession. Once again, the short run costs exceed the long run gains, and comparisons across steady state are misleading.

Second, financing a reduction in the labor income tax rate through a consumption tax is also expected to be beneficial. In a closed economy model, these two taxes are “equivalent” in the sense that they distort the labor-leisure choice in the same way, and a reduction in one tax rate necessitates a roughly offsetting increase in the other. However, in an open economy model, this “equivalence” is broken because the consumption tax applies to both domestically and foreign-produced consumption goods (that is, imports). Consequently, foreign producers bear part of the burden of an increased consumption tax. As a result, shifting taxation from labor income to consumption reduces the overall tax burden of the domestic economy and improves its international competitiveness. Our results bear out this intuition: Such a shift in taxes is associated with substantial welfare gains, particularly for the EMU-12 which starts with much higher labor income tax rates than the U.S.

Returning to the capital income tax-financed debt reduction exercises, it may be politically tempting to leave the capital income tax rate at its higher level, reducing either the labor income or consumption taxes. The results from the debt-neutral capital income tax reductions suggest that leaving the capital income tax rate at a higher level is likely to be welfare-reducing. Furthermore, as a complement to computing Laffer curves, we also compute tax revenues over time. This latter analysis reveals that the tax revenue potential of the capital income tax diminishes over time while that of the labor income or consumption taxes do not. In other words, higher capital income tax

rate are not a particularly effective means of raising tax revenue.

As in the early contribution of [Mendoza and Tesar \(1998\)](#), the model is unabashedly neoclassical, focusing exclusively on fiscal policy. The key differences relative to [Mendoza and Tesar](#) are that their model has only one good (producible in both countries) while we distinguish between domestic and foreign goods, and they have complete international asset markets while we do not. Our tax replacement experiments are in the same spirit as those conducted in [Mendoza and Tesar](#); they do not consider the debt reduction experiments that we motivate with reference to contemporary fiscal crises. Our paper is also related to [Mendoza et al. \(2013\)](#). The two regions they study are the European “crisis” countries (GIIPS) and the rest of the EMU. Consequently, there are no real exchange rate movements in their model. Their focus is on changes in factor income tax rates that can reduce government debt-to-output levels in the crisis region. They find that adjustments in capital income taxes cannot raise sufficient revenue.

The paper is broadly related to the body of work that studies the optimal structure of taxation. The bulk of this literature has focused on closed economy models; see [Lucas and Stokey \(1983\)](#) or [Chari and Kehoe \(1999\)](#) among many others. The open economy dimension has received decidedly less attention. Recently, [Benigno and de Paoli \(2010\)](#) characterized optimal fiscal policy in a small open economy model with a single income tax and public debt; they consider both steady state and business cycle fluctuations. In a richer environment with capital, sticky prices and a larger set of taxes, [Auray et al. \(2011\)](#) have shown that trade openness does not matter for the optimal steady state tax system when financial markets are complete, so long as one focuses on a symmetric steady state. The current paper deviates from both papers by imposing incomplete international financial markets, and an asymmetric steady state. Allowing for explicit trade relations with the rest of the world, and for potential wealth transfers (made possible by assuming incomplete international financial markets) opens up additional transmission mechanisms following tax reforms.

The current paper is related to recent work by [Trabandt and Uhlig \(2011\)](#) who present Laffer curves for capital income, labor income and consumption taxes, for the U.S. and a subset of the EU. The bulk of their analysis makes comparisons across balanced growth paths. The distinctions

between the current work and [Trabandt and Uhlig](#) are: we work with an open economy model whereas they used a closed economy model; and we do considerably more analysis of the transition paths following a policy change. The open economy provides insight into the effects of tax reforms on external trade and the real exchange rate, as well as pushing some of the burden of increased tax revenue onto the foreign sector. As [Trabandt and Uhlig](#) show, considering the transition path can lead to dramatically different welfare results relative to comparisons across steady states or balanced growth paths.

The paper complements the optimal taxation literature by quantifying the effects of various permanent tax reforms; the goal of the paper is not to characterize optimal fiscal policies. The full transition path for the economy following a reform is computed. One of the contributions of the paper is to consider a full set of policy instruments (here, tax rates); most open economy papers do not do so.

The paper is organized as follows. [Section 2](#) presents the model in detail. [Section 3](#) discusses the calibration, as well as the steady state implications of the model. [Section 4](#) proceeds to tax policy experiments and analyzes both qualitatively and quantitatively the different policy scenarios. [Section 5](#) concludes.

2. The model

The model is composed of two regions: the domestic economy of size n and the rest of the world of size $1 - n$. In what follows below, rest of the world variables are denoted by an asterisk. Both areas are symmetric, except for size, their taxation system (government expenditure, tax rates and public debt), and their steady state level of total factor productivity (TFP). Regions are open to trade in final goods, and financial markets are composed of markets for local and international bonds. The market for international bonds is incomplete and does not provide perfect international risk-sharing. In each region, prices are flexible and firms operate on competitive markets. Finally, governments have access to the following instruments to finance public expenditure: taxes on final

consumption, taxes on labor income, taxes on capital income, and public debt (local bonds).

2.1. Households

Each country is populated by an infinitely lived, representative household. The household has preferences over (contingent) streams of a composite consumption good, c_t , and hours of work, h_t , summarized by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t), \quad 0 < \beta < 1 \quad (1)$$

where

$$u(c_t, h_t) = \begin{cases} \ln c - \kappa h^{1+1/\theta}, & \rho = 1 \\ \frac{c^{1-\rho} [1 - \kappa(1-\rho)h^{1+1/\theta}]^\rho - 1}{1-\rho}, & \rho \in (0, 1) \cup (1, \infty). \end{cases} \quad (2)$$

θ is the (constant) Frisch labor supply elasticity. [Trabandt and Uhlig \(2011\)](#) use the same preferences.

Details concerning the composite consumption good are formulated later in this section. The household maximizes Eq. (1) subject to the budget constraint,

$$\begin{aligned} (1 + \tau_{ct}) p_t c_t + k_t - (1 - \delta)k_{t-1} + \Phi_{kt} + b_t + s_t f_t + \Phi_{ft} \\ = (1 - \tau_{ht}) w_t h_t + (1 - \tau_{kt}) z_t k_{t-1} + \tau_{kt} \delta k_{t-1} + r_{t-1} b_{t-1} + r_{t-1}^* s_t f_{t-1} + T_t - \tau_t, \end{aligned} \quad (3)$$

and the appropriate transversality condition. Starting on the right-hand side of Eq. (3), the first term is after-tax wage income: the tax rate on earnings is τ_{ht} and the real wage is w_t . The next term is after-tax capital income: the tax rate is τ_{kt} and z_t denotes the real rental rate. The term that follows is a capital consumption allowance term that reflects the tax deductibility of depreciation from capital income. The next term is the proceeds from holding domestic bonds, b_{t-1} , where r_t is the real interest rate. Next is income from holding foreign bonds, f_t , which are denominated in units of foreign output; here, s_t is the real exchange rate (defined as the number of units of domestic output per unit of foreign output) and r_{t-1}^* is the foreign interest rate.² Finally, T_t is a

² r_t^* is the interest rate on both foreign private bonds as well as foreign government bonds because foreign agents are not subject to adjustment costs on their holding of private bonds, and so there is a no-arbitrage condition equating the returns on private foreign and government foreign debt.

social transfer received from the government and τ_t a lump-sum tax.

Now, consider the left-hand side of Eq. (3). The first term is nominal purchases of aggregated consumption goods, including payment of taxes, τ_{ct} . p_t denotes the price of aggregated consumption expressed in units of domestic output. The second term is investment in (domestic) capital, k_t , net of adjustment costs, Φ_{kt} , specified as in [Mendoza \(1991\)](#):

$$\Phi_{kt} = \frac{\phi_k}{2} (k_t - k_{t-1})^2. \quad (4)$$

The remaining terms are purchases of domestic bonds, b_t , and foreign bonds, f_t , net of intermediation costs on foreign debt, ac_{ft} :³

$$\Phi_{ft} = \frac{\phi_f}{2} (s_t f_t - s f)^2, \quad (5)$$

where variables without time subscripts denote steady state values.

The representative household chooses c_t , h_t , k_t , b_t and f_t to maximize expected lifetime utility Eq. (1) subject to the budget constraint Eq. (3). Its Euler equations are:

$$\frac{u_h(c_t, h_t)}{u_c(c_t, h_t)} + \frac{(1 - \tau_{ht})}{(1 + \tau_{ct})} w_t = 0, \quad (6)$$

$$\frac{u_c(c_t, h_t)}{(1 + \tau_{ct}) p_t} = \beta E_t \left\{ \frac{r_t u_c(c_{t+1}, h_{t+1})}{(1 + \tau_{c,t+1}) p_{t+1}} \right\}, \quad (7)$$

$$\frac{q_t u_c(c_t, h_t)}{(1 + \tau_{ct}) p_t} = \beta E_t \left\{ \frac{u_c(c_{t+1}, h_{t+1})}{(1 + \tau_{c,t+1}) p_{t+1}} (q_{t+1} + (1 - \tau_{k,t+1}) (z_{t+1} - \delta)) \right\}, \quad (8)$$

$$[1 + \phi_f (s_t f_t - s f)] \frac{s_t u_c(c_t, h_t)}{(1 + \tau_{ct}) p_t} = \beta E_t \left\{ \frac{r_t^* s_{t+1} u_c(c_{t+1}, h_{t+1})}{(1 + \tau_{c,t+1}) p_{t+1}} \right\}, \quad (9)$$

where $q_t = 1 + \phi_k (k_t - k_{t-1})$ is Tobin's q . Eq. (6) is the standard labor-leisure choice describing the intratemporal trade-off between consumption and time spent working. Eq. (7) is the intertemporal Euler equation governing purchases of domestic bonds. As such, it relates the marginal rate of substitution between consumption at dates t and $t + 1$ to the real interest rate. Eq. (8) governs the accumulation of domestic capital. Finally, Eq. (9) determines the accumulation of foreign bonds. It relates the marginal rate of substitution for consumption between two dates (accounting

³Since international bonds are denominated in foreign output, it is assumed that foreign households need not pay the intermediation cost, in the same way that domestic households do not pay intermediation costs on domestic bonds.

for changes in the consumption tax, and the intermediation cost on acquiring foreign bonds) to changes in the real exchange rate and the real interest rate on foreign bonds.

Whereas investment goods are composed exclusively of domestic output, consumption goods are composed of domestic and foreign goods. As in [Benigno and de Paoli \(2010\)](#), aggregate consumption is a composite a good produced at home (h), and a good produced in the rest of the world (f) according to:

$$c_t = \left[\varphi^{\frac{1}{\mu}} c_{ht}^{\frac{\mu-1}{\mu}} + (1 - \varphi)^{\frac{1}{\mu}} c_{ft}^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}, \quad (10)$$

where $\varphi = 1 - (1 - n)\alpha$ governs the importance of home goods in the composite; it depends on n , the relative size of the domestic economy, and α , which measures trade openness. Symmetrically, the consumption of a representative household in the rest of the world is:

$$c_t^* = \left[\varphi^*{}^{\frac{1}{\mu}} c_{ht}^*{}^{\frac{\mu-1}{\mu}} + (1 - \varphi^*)^{\frac{1}{\mu}} c_{ft}^*{}^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}, \quad (11)$$

where $\varphi^* = n\alpha$. Assuming that the law of one price holds at the producer level, consumer prices are given by

$$p_t = \left[\varphi + (1 - \varphi) s_t^{1-\mu} \right]^{\frac{1}{1-\mu}}, \quad (12)$$

$$p_t^* = \left[1 - \varphi^* + \varphi^* s_t^{\mu-1} \right]^{\frac{1}{1-\mu}}. \quad (13)$$

In these expressions, $\mu \geq 1$ is the elasticity of substitution between domestic and foreign goods.⁴

Optimal demands for domestic and foreign produced goods can be obtained from a cost minimization problem,

$$\min_{\{c_{ht}, c_{ft}\}} c_{ht} + s_t c_{ft} \quad (14)$$

subject to Eq. (10), with a similar problem for the foreign consumer. Optimal demands for domes-

⁴To derive the prices p_t and p_t^* , it is convenient to express all prices, including that of output, in terms of an abstract unit of account. p_t and p_t^* can, then, be derived by solving the consumption bundler's cost minimization problem for producing one unit of aggregated consumption. Then, choose output in a country to be that country's numeraire good so that its price is one.

tic and foreign production goods are:

$$c_{ht} = \varphi \left[\varphi + (1 - \varphi) s_t^{1-\mu} \right]^{\frac{\mu}{1-\mu}} c_t, \quad (15)$$

$$c_{ht}^* = \varphi^* \left[(1 - \varphi^*) s_t^{1-\mu} + \varphi^* \right]^{\frac{\mu}{1-\mu}} c_t^*, \quad (16)$$

$$c_{ft}^* = (1 - \varphi^*) \left[(1 - \varphi^*) + \varphi^* s_t^{\mu-1} \right]^{\frac{\mu}{1-\mu}} c_t^*, \quad (17)$$

$$c_{ft} = (1 - \varphi) \left[\varphi s_t^{\mu-1} + (1 - \varphi) \right]^{\frac{\mu}{1-\mu}} c_t. \quad (18)$$

2.2. Firms

The domestic economy has a measure n of competitive firms. The representative firm produces output, y_t , using domestic labor, \tilde{h}_t , and physical capital, \tilde{k}_{t-1} according to the following production function:

$$y_t = a_t \tilde{k}_{t-1}^\phi \tilde{h}_t^{1-\phi}, \quad (19)$$

where a_t is total factor productivity. Profit maximization implies that factors will be optimally allocated according to

$$z_t = \phi a_t \tilde{k}_{t-1}^{\phi-1} \tilde{h}_t^{1-\phi}, \quad (20)$$

$$w_t = (1 - \phi) a_t \tilde{k}_{t-1}^\phi \tilde{h}_t^{-\phi}. \quad (21)$$

2.3. Governments

Each government finances a stream of public expenditures by levying distortionary taxes on factor incomes (labor and capital), and on consumption. Each government may also issue non-state contingent local bonds to finance potential deficits. The primary deficit of the domestic government is:

$$def_t = g_t + \bar{T}_t - p_t \tau_{ct} \bar{c}_t - \tau_{ht} w_t \bar{h}_t - \tau_{kt} (z_t - \delta) \bar{k}_{t-1}, \quad (22)$$

where \bar{c}_t , \bar{h}_t , \bar{k}_{t-1} , and \bar{T}_t are per capita quantities. Its bonds evolve according to

$$d_t - r_{t-1} d_{t-1} = def_t \quad (23)$$

It is well known that the debt dynamics implied by Eq. (23) are unstable. To induce stability, one instrument of government fiscal policy will be chosen to satisfy the following feedback rule:

$$\frac{def_t}{y_t} - \left(\frac{def}{y}\right) = \omega \left[\frac{d_{t-1}}{y_{t-1}} - \left(\frac{d}{y}\right) \right] \quad (24)$$

where def/y is the target deficit-output ratio, d/y is the target debt-output ratio, and ω is a parameter that governs how aggressively the government responds to deviations of last period's debt-to-output ratio from its target. These two ratios are connected via the steady state relationship implied by Eq. (23),

$$d = \frac{def}{1-r}.$$

2.4. Equilibrium

Definition 1 *A competitive equilibrium consists of an allocation,*

$$\left\{ y_t, y_t^*, h_t, \tilde{h}_t, \bar{h}_t, h_t^*, \tilde{h}_t^*, \bar{h}_t^*, c_t, \bar{c}_t, c_t^*, \bar{c}_t^*, k_t, \tilde{k}_t, \bar{k}_t, k_t^*, \tilde{k}_t^*, \bar{k}_t^*, b_t, b_t^*, f_t, f_t^* \right\}_{t=0}^{\infty},$$

a sequence of prices,

$$\{ p_t, p_t^*, w_t, w_t^*, z_t, z_t^*, r_t, r_t^*, s_t \}_{t=0}^{\infty},$$

a sequence for exogenous government spending and transfers,

$$\{ g_t, g_t^*, \bar{T}_t, \bar{T}_t^* \}_{t=0}^{\infty},$$

and a sequence of fiscal policies,

$$\{ \tau_{ct}, \tau_{ht}, \tau_{kt}, \tau_{ct}^*, \tau_{ht}^*, \tau_{kt}^*, d_t, d_t^* \}_{t=0}^{\infty},$$

such that:

1. *The allocation for the household solves its problem given prices and fiscal policy.*
2. *The allocation for the firm solves its problem given prices.*
3. *Governments satisfy their budget constraints.*

4. *Markets clear:*

- *Final goods markets:*

$$y_t = c_{ht} + \Phi_{ft} + \left(\frac{1-n}{n} \right) c_{ht}^* + k_t - (1-\delta)k_{t-1} + \Phi_{kt} + g_t, \quad (25)$$

$$y_t^* = c_{ft}^* + \left(\frac{n}{1-n} \right) c_{ft} + k_t^* - (1-\delta)k_{t-1}^* + \Phi_{kt}^* + g_t^*. \quad (26)$$

- *Labor markets:*

$$h_t = \tilde{h}_t, \text{ and } h_t^* = \tilde{h}_t^*.$$

- *Capital goods markets:*

$$k_{t-1} = \tilde{k}_{t-1}, \text{ and } k_{t-1}^* = \tilde{k}_{t-1}^*.$$

- *Local bonds markets:*

$$b_t = d_t, \text{ and } b_t^* = d_t^*.$$

- *International bonds markets:*

$$n f_t + (1-n) f_t^* = 0.$$

5. *Finally, the aggregation of budget constraints and market clearing conditions yield the dynamics of (real) domestic net foreign assets:⁵*

$$s_t f_t - r_{t-1}^* s_t f_{t-1} = \left(\frac{1-n}{n} \right) c_{ht}^* - s_t c_{ft} \quad (27)$$

The model also makes predictions for the current account and net exports. They are given by

$$ca_t = s_t (f_t - f_{t-1}),$$

$$nx_t = \frac{1-n}{n} c_{ht}^* - s_t c_{ft}.$$

⁵This equation can be obtained by combining domestic bond market clearing condition, the domestic government budget constraint, the domestic household budget constraint, and profit condition for domestic firms.

3. Steady state and calibration

3.1. Steady state

An issue that arises in open economy models with incomplete financial markets is the steady state indeterminacy of the real exchange rate, s_t (or, equivalently, the terms of trade). In models with complete international asset markets, the real exchange rate depends on the ratio of marginal utilities for the domestic and foreign households. With incomplete markets, the model is closed with an equation for net foreign assets, namely the steady state version of Eq. (27). In the literature, there are two approaches to the steady state indeterminacy problem: calibrate the value of net foreign assets as in Benigno (2009), or normalize the steady state value of the real exchange rate, s_t . In the interests of tractability, the latter approach is employed; steady state s is normalized to equal one.

3.2. Calibration

The analysis alternatively focuses on the U.S. and the EMU-12 within a large group of OECD countries; see Section B for a complete description of the data. Thus, when we consider the U.S. (respectively the EMU-12), the rest of the world is composed of the remaining OECD countries of the group. As stated earlier, the model is symmetric except for the fiscal system, size, TFP and time allocated to work.

Common parameters. The model is quarterly and the subjective discount factor β is equal to 0.99, consistent with a 4% annual real interest rate, a common value in the macroeconomic literature. The risk-aversion parameter is set to $\rho = 2$; Backus et al. (1992) use the same value. The labor supply elasticity, θ , is set to 1 as in Trabandt and Uhlig (2011). The share of capital income in the GDP, ϕ , is set to 0.3 which is within the range of values typically found for developed countries. The depreciation rate, δ , is 7% annually which is consistent with data from the U.S. as reported in Gomme and Rupert (2007). As in Mendoza (1991), capital adjustment costs are set to $\phi_k = 0.025$. The degree of trade openness is $\alpha = 0.3$ which corresponds to the share of

total imports in GDP for the OECD countries in 2008. The intermediation parameter for foreign assets is set to $\phi_f = 0.001$, following Benigno (2009) and Schmitt-Grohé and Uribe (2003), and the elasticity of substitution between domestic and foreign goods is set to $\mu = 1.5$, as in Backus et al. (1993). Finally, the policy parameter, ω – which governs how responsive the government is to deviations of the debt-to-output ratio from target – is set to 0.05. This value implies half of this deviation will be closed in $13\frac{1}{2}$ quarters – a little over 4 years.

Specific parameters. The size n is set to the share of total population in the OECD countries included in the sample. For the U.S., $n = 0.37$ while for the EMU-12, $n = 0.29$. Total factor productivity is calculated using the output per worker. When dealing with groups of countries, TFP is computed as a weighted average of individual country TFPs where the weights are given by the output shares of the countries. Domestic TFP is normalized to one ($a = 1$). For the U.S., foreign TFP is $a^* = 0.7$ while for the EMU-12, $a^* = 1.09$. The preference parameter κ governs the importance of consumption-versus-leisure in utility. For the U.S., κ is chosen such that in steady state, hours worked are 30% of the time endowment; for the EMU-12, 27%, which matches the average total annual hours worked as a fraction of discretionary time.⁶ The share of government expenditures is taken from the data and is summarized in Table 1. Lastly, steady-state lump-sum transfers T and T^* must be determined. The steady state of the model can be solved for given the parameters already assigned values. Given targets for the steady state debt-to-output ratio, one can then determine steady state debt, d .⁷ The steady state (primary) deficit then solves $def = (1 - r)d$. The lump-sum tax, T , is computed to deliver this value for def . T^* is similarly derived. The calibration is summarized in Table 1.

Section A contains a brief description of how to solve for steady state as well as how to solve for the dynamic paths of the model economies.

⁶Source: Authors' calculations based on OECD data.

⁷Variables without time subscripts denote steady state values.

Table 1: Parameter values in the benchmark calibration

| | U.S. ^a | EMU-12 ^b |
|--|-------------------|---------------------|
| Size, n | 37.% | 29.% |
| Relative TFP, a^*/a | 70.% | 109.% |
| Domestic share of public expenditures in GDP | 28.97% | 30.64% |
| Foreign share of public expenditures in GDP | 30.69% | 29.72% |
| Labor income tax rate, τ_h | 30.12% | 46.94% |
| Labor income tax rate, τ_h^* | 36.93% | 29.76% |
| Consumption tax rate, τ_c | 6.5% | 19.15% |
| Consumption tax rate, τ_c^* | 16.92% | 8.99% |
| Capital income tax rate, τ_k | 49.77% | 45.45% |
| Capital income tax rate, τ_k^* | 44.39% | 46.70% |
| Weight on leisure in preferences, κ | 2.4719 | 2.5584 |
| Debt-to-annual-GDP ratio, $d/(4y)$ | 0.7593 | 0.7749 |
| Debt-to-annual-GDP ratio, $d^*/(4y^*)$ | 0.8555 | 0.8377 |
| Discount factor, β | | 0.99 |
| Risk-aversion, ρ | | 2 |
| Frisch labor supply elasticity, θ | | 1 |
| Share of capital income in GDP, ϕ | | 0.3 |
| Depreciation rate, δ | | 0.0175 |
| Capital adjustment costs, ϕ_k | | 0.025 |
| Foreign assets adjustment costs, ϕ_f | | 0.001 |
| Trade openness, α | | 0.3 |
| Goods elasticity of substitution, μ | | 1.5 |
| Policy parameter, ω | | 0.05 |

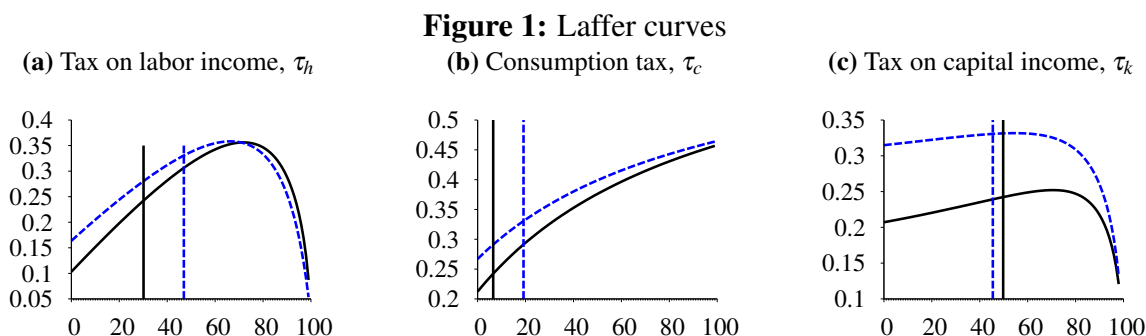
Source: OECD databases. *a* vs. (OECD less U.S.), *b*: vs. (OECD less EMU-12).

Table 2: Benchmark steady state values

| | U.S. vs OECD less U.S. | |
|--------------------------|----------------------------|-----------------|
| | Home economy | Foreign economy |
| Output, y | 0.7305 | 0.4649 |
| Consumption, c | 0.4609 | 0.2279 |
| Hours worked, h | 0.3000 | 0.3106 |
| Capital stock, k | 5.8269 | 3.9103 |
| 100× Capital rental, z | 3.7610 | 3.5664 |
| Real wage, w | 1.7045 | 1.0476 |
| Primary deficit (% GDP) | −3.0679 | −3.4566 |
| | EMU-12 vs OECD less EMU-12 | |
| | Home economy | Foreign economy |
| Output, y | 0.6697 | 0.8617 |
| Consumption, c | 0.3320 | 0.4957 |
| Hours worked, h | 0.2700 | 0.3087 |
| Capital stock, k | 5.5786 | 7.0919 |
| 100× Capital rental, z | 3.6017 | 3.6451 |
| Real wage, w | 1.7364 | 1.9538 |
| Primary deficit (% GDP) | −3.1309 | −3.3846 |

3.3. Benchmark steady state

The implied benchmark steady state is summarized in Table 2. Perhaps the most salient feature of the steady states is that both the U.S. and EMU-12 are predicted to have modest surpluses of around 3.1% of output. The fact that the model versions of the U.S. and EMU-12 have steady state primary surpluses follows from the fact that both are calibrated to have positive government debt, and the equation linking steady state debt to the primary deficit. In brief, in steady state, the government must run a primary surplus in order to service its interest payments on its debt. One means to square the model's prediction of primary surpluses with the data would be to incorporate balanced growth into the model. In this case, the relationship between debt and the primary deficit is given by $d = def/(\gamma - r)$ where γ is the balanced growth rate. If γ is larger than r , then the model can have both outstanding debt and a primary government deficit.



Legend: Black, solid line: U.S.; blue dotted line: EMU-12. Vertical lines indicate current tax rates. Tax rates are measured on the horizontal axis.

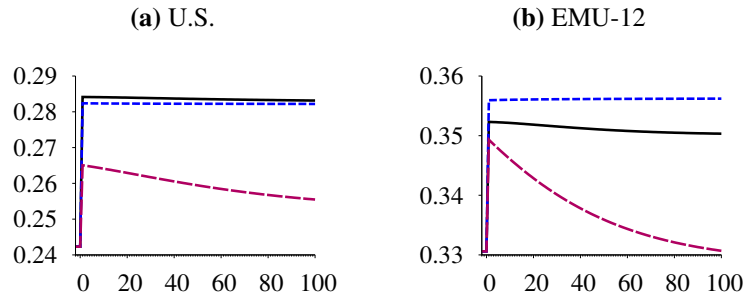
3.4. Laffer Curves

To understand some of the results to come, it is helpful to know the revenue potential of the model's taxes. Figure 1 presents Laffer curves for the two regions (the U.S. and EMU-12) for the three tax rates in the model. These Laffer curves are computed from the dynamic simulations of the model, varying one tax at a time and tracing out the total revenue in the final steady state.⁸ Our model shows that both the U.S. and EMU-12 have tax rates that are well below their revenue-maximizing levels. The consumption tax shows the greatest potential for raising more tax revenue in the long run, followed by the labor income tax. The long run revenue potential of the capital income tax is more limited, with a fairly flat Laffer curve up to the revenue-maximizing tax rate. These results are fairly similar to those in [Trabandt and Uhlig \(2011\)](#) for a closed economy version of the U.S.

Of course, in the experiments below, the short run tax revenue potential of the taxes is also an important consideration. Figure 2 presents tax revenues over time for either a 10 percentage point increase (labor income or consumption tax) or a 20 percentage point increase (capital income tax) in tax rates. For the labor income and consumption taxes, the short run revenue increase is quite close to the long run increase. The story is much different for the capital income tax rate: in the short run, increasing this tax rate raises more revenue than in the long run. This latter observation

⁸To render the dynamics of government debt stationary, for the Laffer curve calculations, government spending adjusts to bring the primary deficit into balance with the stock of debt. Laffer curves based on steady states are broadly similar, the difference being attributable to the fact that in steady state calculations, the exchange rate is set to one while the dynamic simulations allow the exchange rate to be endogenously determined.

Figure 2: Tax Revenues



Legend: Black, solid line: τ_h ; blue, dotted line: τ_c ; red, dashed line: τ_k . Time is measured on the horizontal axis.

is particularly true for the EMU-12 which exhibits a fairly quick fall in revenue over time. The explanation is that a higher capital income tax rate reduces capital accumulation, resulting in a lower capital stock and so a lower tax base. The other taxes have much smaller effects on the capital stock.

4. Policy experiments

Several sets of experiments are conducted here. First, in light of the fiscal woes of both Europe and North America, we look at tax increases that reduce the government debt-to-output ratio by 25%. Second, motivated by the optimal taxation literature, we consider a 10 percentage point (ppt) reduction in the capital income tax rate with this revenue replaced through an increase in either the labor income or consumption tax rates. Finally, since our open economy model breaks the closed economy equivalence between the labor income and consumption taxes, we consider a 10 ppt fall in the labor income tax rate paid for through a higher consumption tax.

4.1. Debt reduction

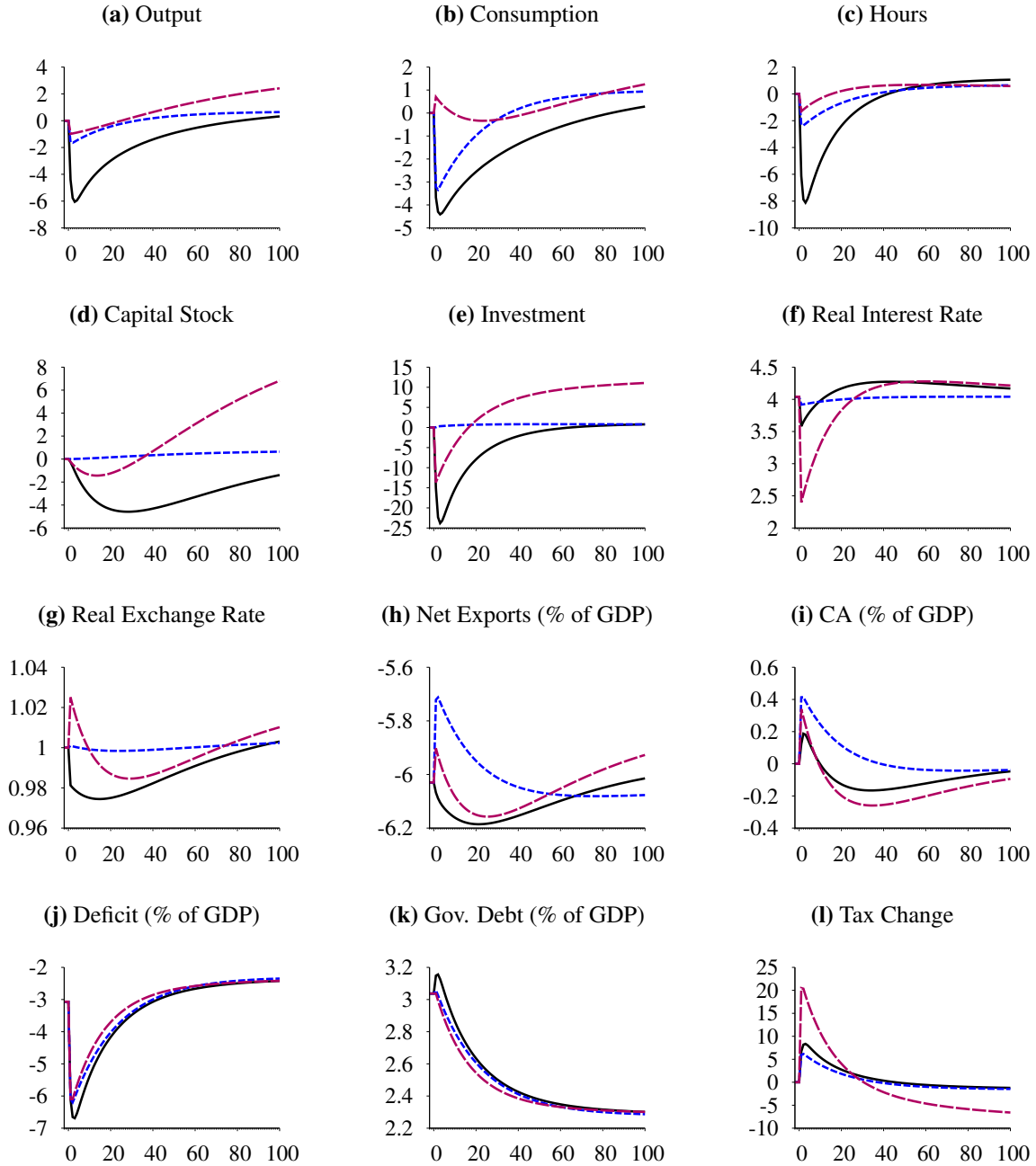
Here, we consider a 25% reduction in the (long run) government debt-to-output ratio. From Eq. (23), such a reduction also implies a 25% fall in the long run primary deficit. Throughout, the policy rule Eq. (24) is in place, and we consider adjusting one tax at a time to satisfy this rule.

The foreign government adjusts its spending to satisfy its version of the policy rule Eq. (24). As is well-known from the fiscal policy literature, such a reduction in the debt-to-output ratio lowers the debt servicing costs of the government, and so the need for government tax revenue. Consequently, while these experiments have tax rates increases in the short term, in the longer term the tax rates fall below their initial steady state levels.

The U.S. case is considered first, starting with the labor income tax. The effects of this tax operate primarily through distortions to the labor-leisure choice as seen in Eq. (6). As seen in Figure 3, on impact the labor income tax rate rises by 6.7 ppt. The resulting fall in the after-tax real wage leads to a 6.1% decline in hours. In turn, output falls 4.4% while consumption declines 3.7%. The decline in hours worked is quite persistent: hours remain below their initial steady state level for just over 12 years (53 quarters). To understand the effect on capital, notice that Eq. (8) implies that a *permanent* reduction in hours would lead to an equiproportional decline in the capital stock (this equation implies that the rental rate for capital remains unchanged, and the Cobb-Douglas production function then implies that the capital-labor ratio is unchanged). Of course, along the transition path, the intertemporal marginal rate of substitution is varying, but the intuition is that a long-lived decline in hours will be accompanied by a similarly long-lived decline in capital. As a consequence, investment falls precipitously, remaining below its initial steady state level for a considerable period of time (nearly 19 years). In the longer term, the labor income tax rate falls 1.6 ppt below its initial steady state level, and macroeconomic variables end up around 1.1% higher.⁹ Turning to international variables, on impact the real exchange rate appreciates by nearly 2%. By making foreign goods relatively less expensive, this real appreciation encourages imports and discourages exports. The dynamics of the current account may be more easily understood by looking to those of the capital account. Here, there are two effects at work. The fall in net exports reduces the capital account (domestic households are decumulating foreign assets and so funds are flowing in) while the exchange rate appreciation increases the capital account. On net, the

⁹Unlike a closed economy model, in our open economy model, the long run percentage changes in aggregated consumption can be different from that of other macroeconomic variables owing to real exchange rate movements that differentially affect consumption of foreign goods.

Figure 3: U.S.: Tax-financed Debt Reductions



Legend: Solid lines correspond to increase in τ_h ; dotted lines, increase in τ_c ; and dashed lines, increase in τ_k .

exchange rate effect dominates. Since the current account and capital account move in opposite directions, this means that the current account rises on impact. Farther down the road, the exchange rate depreciates slightly and so in the long run net exports rise.

Turn next to what happens in the U.S. when the consumption tax is used to reduce the debt-to-output ratio. The effects of the consumption tax operate through both the labor-leisure choice (where its effects are similar to those of the labor income tax) and the capital accumulation equation, Eq. (8). In this latter equation, what matters is the temporal pattern of the consumption tax. As shown in Figure 31, the consumption tax rises sharply on impact (6.0 ppt), then slowly declines. The initial rise is a surprise and so has no effect on capital accumulation. However, the slow decline in this tax rate means that $(1 + \tau_{ct}) / (1 + \tau_{ct+1}) > 1$ which acts much like a subsidy to capital accumulation. As a result, the dynamics of the capital stock are much different under the consumption tax than the labor income tax, with capital actually rising throughout. That output falls (1.6%) is a consequence of the fall in hours (2.3%). The fall in consumption (3.2%) is exacerbated by the rise in investment that is needed to increase the capital stock. The real exchange rate appreciates, although not as much as under the labor income tax. In this case, while imports rise when measured in terms of foreign output, they fall when measured in domestic output owing to the real exchange rate appreciation. Consequently, net exports rise in this case. As with the labor income tax, there are opposing effects on the capital account, and so the current account. Again, the real exchange rate appreciation dominates the dynamics of these accounts. In the longer term, the consumption tax falls 1.6 ppt relative to its original steady state, and macroeconomic variables are around 0.8% higher.

The final U.S. case is when the policy instrument is the capital income tax rate. Here, policy acts primarily through the capital accumulation equation. On impact, the capital income tax rate jumps 20.5 ppt. This rise discourages capital accumulation and so investment. On impact, consumption actually rises 0.7% even though output falls 1.0%. Once more, the real exchange rate appreciates and net exports initially decline. As in the previous two cases, the capital and current account dynamics are dominated by those of the real exchange rate. Over the longer term, the capital

income tax rate ends up 8.6 ppt lower than its initial steady state value. As a result, macroeconomic variables all end up higher: capital, 12.7%; hours, 0.3%; output, 3.9%; and consumption, 2.7%.¹⁰

The EMU-12 debt reduction experiments are summarized in Figure 4. For the consumption tax and capital income tax scenarios, the dynamics for the EMU-12 are fairly similar to those of the U.S. However, the labor income tax scenario leads to much different behavior. While the path for the labor income tax has a slight hump shape for the U.S. case (peaking 3 quarters into the simulation), the EMU-12 case exhibits a very distinct and drawn out hump shape: the response peaks with nearly a 17.1 ppt increase after 30 quarters (7.5 years). The dynamics of the labor income tax rate follow those of the debt-to-output ratio in Figure 4k: Under the other two taxes, this ratio is brought down fairly quickly while the path associated with the labor income tax remains above the other two for quite some time. In turn, the dynamics of the debt-to-output ratio owes much to the behavior of output which falls precipitously under the labor income tax rule, in contrast to the other taxes. This fall in output is driven largely by the fall in hours resulting from the large increases in the labor income tax rate. As discussed in the U.S. case, such a decline in hours also results in a fall in capital. The Laffer curve analysis in Section 3.4 helps explain some of this peculiar behavior. To start, Figure 1a shows that the labor income tax Laffer curve is flatter for the EMU-12 than for the U.S. which helps to explain why the labor income tax rate increases more in the EMU-12 than in the U.S.: To raise a given amount of additional tax revenue, the labor income tax rate must rise much more in the EMU-12 than in the U.S. Next, the EMU-12 is closer to the revenue-maximizing labor income tax rate than is the U.S. In fact, the maximum rise in the EMU-12 labor income tax rate, 17.1 ppt, brings this tax rate close to the peak of the Laffer curve. Of course, since the Laffer curve flattens out at its peak, as tax rates approach the peak, they have to rise more to generate the same tax revenue gain. Looking at the Laffer curve in Figure 1, one might wonder why the EMU-12 does not run into similar difficulties when using the capital income tax rate as its policy instrument. The answer in this case lies in Figure 2 which shows the

¹⁰With the consumption and labor income taxes, the steady state capital accumulation equation implies no change in the capital-labor ratio and so capital, labor and output must change equiproportionately. However, when the capital income tax changes, this relationship no longer holds and so macroeconomic variables change, in the long run, by differing percentages.

dynamic response of tax revenues to a given increase in tax rates. Figure 2b shows that in the short run, the EMU-12 can generate considerable extra tax revenue from a capital income tax rate boost. Figure 4l show that the EMU-12 is, in fact, raising the capital income tax rate only for a relatively short period of time (less than 10 years), thereby capturing the short run potential of the capital income tax to raise revenue.

All of these debt reduction exercises involve short term pain (higher tax rates and generally a decline in economic activity) to achieve long run gain (eventually lower tax rates and a higher level of economic activity). A natural question at this stage is: Given the decision to reduce the debt-to-output ratio, how should this decision be implemented? This question is answered by computing the welfare benefit of these policy changes. The specific welfare criterion is the constant percentage of consumption that can be taken from the representative household that leaves it indifferent between a particular policy intervention and the original (steady state) path; that is, the value of ξ that satisfies

$$\sum_{t=0}^J \beta^t u(c_t(1 + \xi), h_t) = u(c^{ss}, h^{ss}) \sum_{t=0}^J \beta^t. \quad (28)$$

To capture the idea that politicians – who would need to implement the debt reduction policies – operate at relatively short horizons, these welfare benefits are computed at horizons of one year (4 quarters), four years, ten years, and the infinite horizon.

Table 3 also reports welfare benefits computed by comparing steady state allocations. Since all of the policies result in lower tax rates in the steady state, all generate welfare benefits when measured across steady states. When measured across steady states, the potential welfare gains are large, ranging from 0.3% of consumption (U.S. case, consumption tax) to 5.45% (EMU-12 case, capital income tax). Of course, the right calculation of the welfare benefit takes into account the transition path between the initial and final steady states. The difference between these two ways of computing welfare benefits is striking. For the U.S., only the capital income tax generates a sizable welfare gain (0.6%); the welfare gain associated with the consumption tax is a meager 0.05% while the labor income tax is associated with a welfare *loss* of 0.4%. The story is much

Table 3: Debt reductions: Welfare benefit as a percentage of consumption

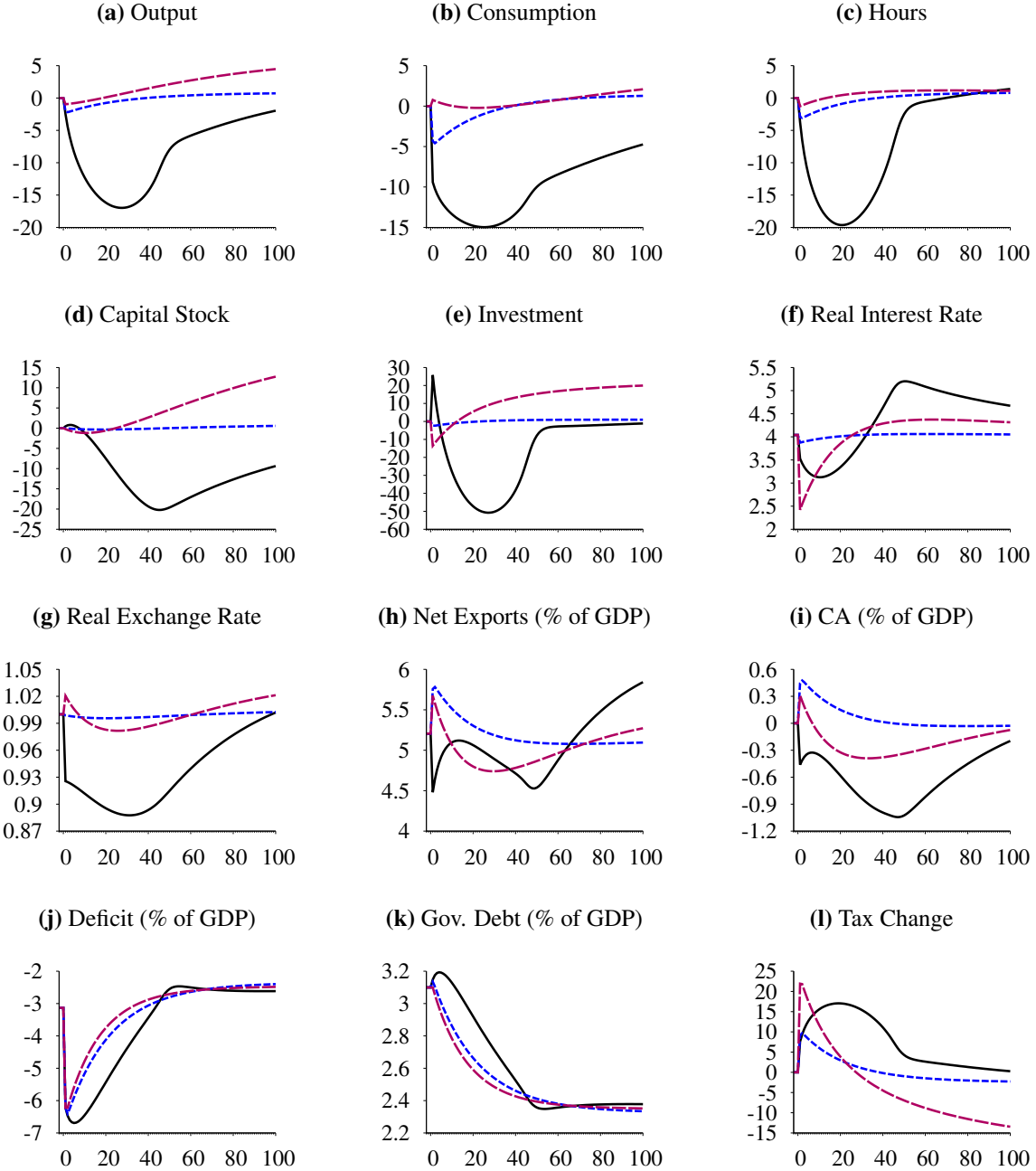
| Horizon | U.S. | | | EMU-12 | | |
|--------------|----------|----------|----------|----------|----------|----------|
| | τ_h | τ_c | τ_k | τ_h | τ_c | τ_k |
| 4 | 1.03 | -1.63 | 1.32 | -6.81 | -2.68 | 1.27 |
| 16 | 0.32 | -1.20 | 0.51 | -5.30 | -2.03 | 0.49 |
| 40 | -0.46 | -0.66 | -0.09 | -5.43 | -1.19 | -0.09 |
| ∞ | -0.42 | 0.05 | 0.62 | -5.14 | 0.06 | 1.20 |
| steady state | 0.45 | 0.31 | 2.49 | 1.86 | 0.83 | 5.45 |

the same for the EMU-12: the welfare gain of associated with using the capital income tax falls from 5.4% when measured across steady states to 1.2% when the transition is included. In the case of the labor income tax, the severe and prolonged recession in the EMU-12 case dominates the welfare cost calculation, turning a 1.9% welfare gain (steady state) into a 5.1% welfare *loss* when including the transition.

When the welfare benefits are measured at shorter, electoral frequencies, the really big change for the EMU-12 occurs under the consumption tax: There is substantial short term pain (a welfare loss of 2.7% of consumption at the one year horizon) and only a very small welfare gain over the entire transition path. However, the capital income tax is associated with welfare gains at relatively short horizons (certainly at one and four years) reflecting the fact that consumption initially rises, but a small welfare loss at somewhat longer horizons (ten years). Recall that in this case, there is a sizable welfare benefit when measured over the representative household's infinite horizon (1.2%).

For the U.S., at short horizons the welfare benefits associated with the capital income tax scenario are remarkably similar to those for the EMU-12. For the consumption tax, the U.S. scenario is qualitatively similar to that of the EMU-12. However, when the labor income tax rate is the instrument of policy, there are substantive differences between the two regions. Recall that in this case, the EMU-12 experiences welfare *losses* at all horizons. In contrast, for the U.S. there are welfare gains in the short term, but welfare *losses* at the medium and long terms.

Figure 4: EMU-12: Tax-financed Debt Reductions



Legend: Solid lines correspond to increase in τ_h ; dotted lines, increase in τ_c ; and dashed lines, increase in τ_k .

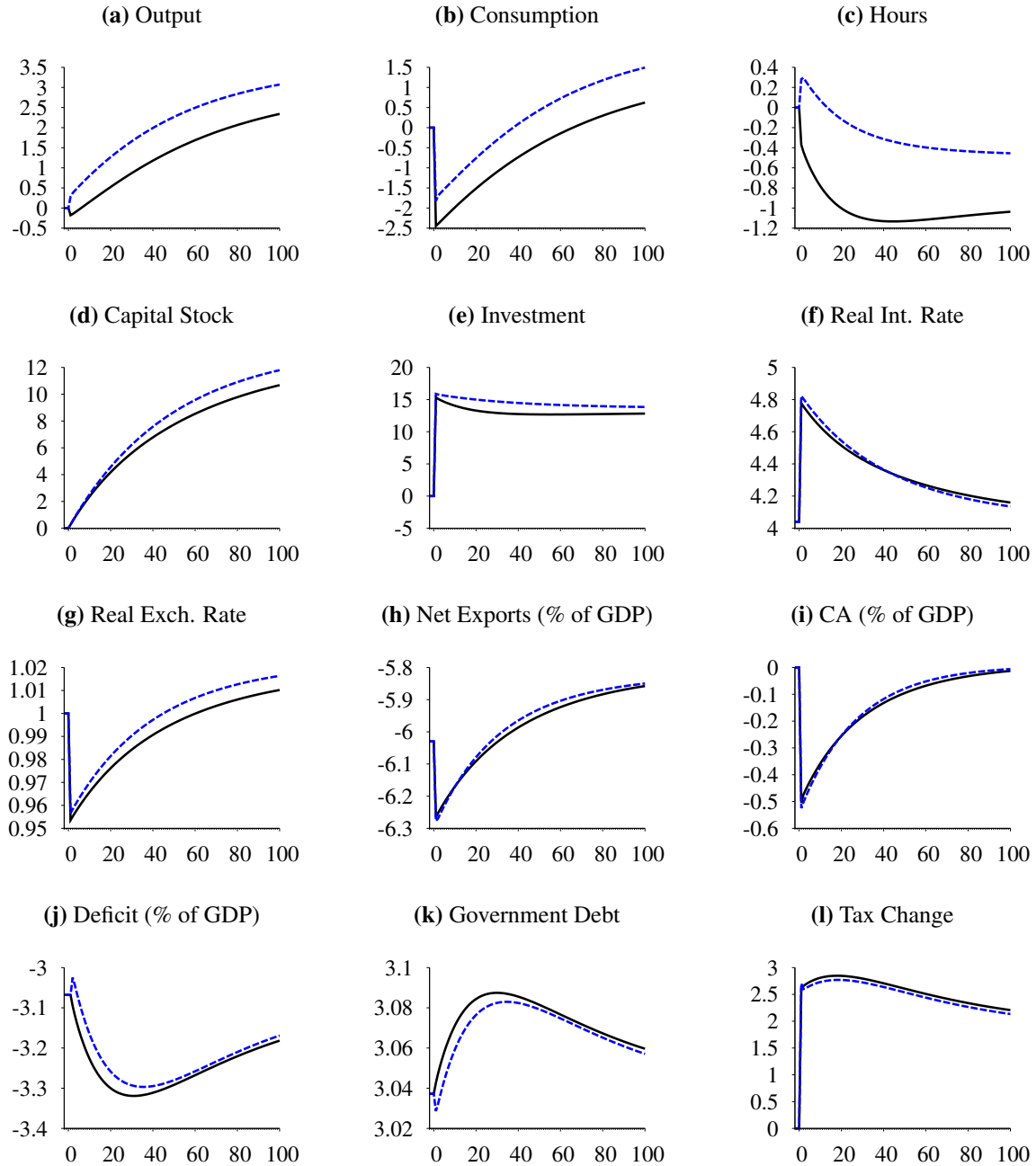
4.2. Debt-neutral capital tax reductions

The optimal fiscal policy literature typically finds that capital income tax rates should be quite low – usually, zero in the long run – see [Judd \(1985\)](#), [Chamley \(1986\)](#) and [Atkeson et al. \(1999\)](#). In this spirit, this section considers tax reforms involving a permanent 10 ppt reduction in the capital income tax rate financed by changes in either the labor income tax or the consumption tax rates. As with the debt reduction exercises, the government adjusts its tax rate to satisfy the policy rule Eq. (24).

For the U.S., the implications for either the consumption tax or labor income tax are remarkably similar; see [Figure 51](#). On impact, both rise 2.6 ppt; in the long run, both are 1.8 ppt higher than their initial steady state values. In the new steady state, capital ends up higher: 13.1% in the case of the labor income tax; 13.7% for the consumption tax. The results from the debt-reduction experiment financed through a capital income tax suggest that much of this eventual rise in the capital stock can be attributed to the effects of the lower capital income tax rate. In the short term, consumption falls below its initial steady state level as households build up their stock of capital. One place where the two policies differ markedly is on their predictions for the path of hours. When the labor income tax is the instrument of policy, hours falls below their initial level for quite some time (89 quarters) whereas the consumption tax sees a rise in hours. While the two taxes affect the labor-leisure choice in much the same way, the temporal pattern of the consumption tax also affects capital accumulation. As discussed earlier, a falling consumption tax acts as like a subsidy to capital. This second channel helps explain why the path for capital under the consumption tax lies above that associated with the labor income tax. In the long run, hours rise under both scenarios, although the increase is larger for the consumption tax (2.0% compared to 1.4%). The behavior of international variables (the real exchange rate, net exports and the current account) are quite similar across the two policies: The real exchange rate initially appreciates (around 7%), leading to a fall in net exports and the current account.

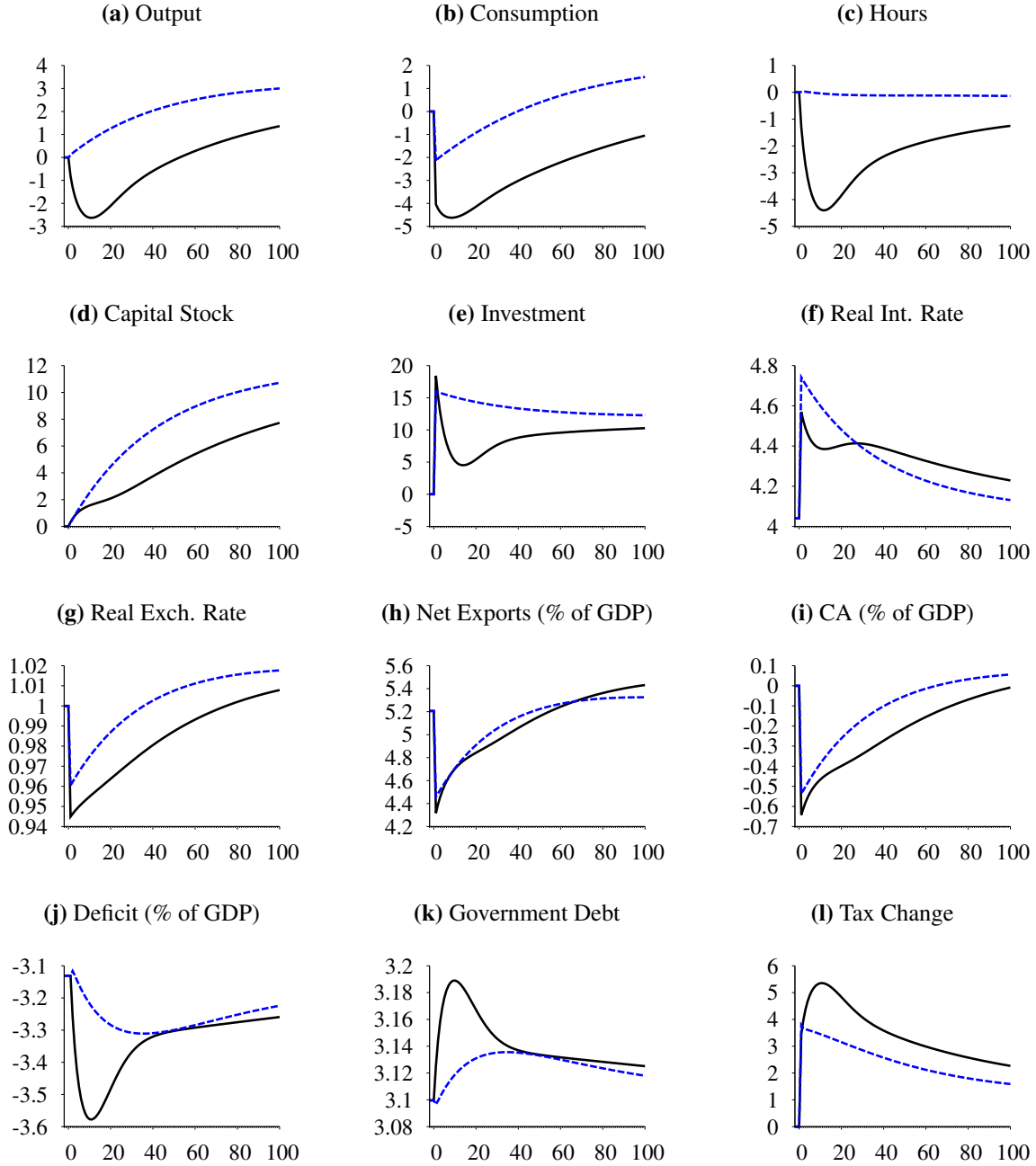
Given the results of the debt-reduction exercises, it probably is not too surprising that for the

Figure 5: Debt-neutral capital income tax cut in the U.S.



Legend: Solid lines, increase in τ_h ; dotted lines, increase in τ_c .

Figure 6: Debt-neutral capital income tax cut in the EMU-12.



Legend: Solid lines, increase in τ_h ; dotted lines, increase in τ_c .

Table 4: Debt-neutral tax changes: Welfare gain as a percentage of consumption

| | U.S. | | | EMU-12 | | |
|----------------|----------|----------|----------|----------|----------|----------|
| Reduce: | τ_k | τ_k | τ_h | τ_k | τ_k | τ_h |
| Increase: | τ_h | τ_c | τ_c | τ_h | τ_c | τ_c |
| <i>Horizon</i> | | | | | | |
| 4 | -2.08 | -1.92 | 0.54 | -2.97 | -2.08 | 1.74 |
| 16 | -1.61 | -1.47 | 0.61 | -2.32 | -1.65 | 1.89 |
| 40 | -0.95 | -0.80 | 0.68 | -2.02 | -1.00 | 2.04 |
| ∞ | 0.61 | 0.90 | 0.87 | -0.67 | 0.74 | 2.61 |
| steady state | 2.28 | 2.48 | 0.89 | 2.26 | 2.82 | 3.55 |

EMU-12, the two policies have very different implications in the short run. On impact, both tax rates rise: 3.8 ppt in the case of the consumption tax, 3.5 ppt for the labor income tax. Thereafter, the consumption tax declines monotonically and the behavior of variables for the EMU-12 looks similar to that of the U.S. In contrast, the labor income tax exhibits a hump-shaped pattern, peaking 5.4 ppt above its initial steady state level after 10 quarters. This rise in the labor income tax rate induces a prolonged slump in economic activity: the maximum decline in output is 2.6% after 11 quarters; consumption, 4.6 after 8 quarters; and hours, 4.4% after 12 quarters. Output takes 52 quarters (13 years) to recover to its initial steady state level; consumption takes 157 quarters (nearly 40 years); and hours are permanently lower. Of course, there is a feedback effect at work: the increase in the labor income tax rate reduces the after-tax wage rate leading to a decline in hours and output. In turn, this fall in output pushes up the debt-to-output ratio which, then, requires future increases in the labor income tax rate, and so on. The behavior of the international variables when the policy instrument is the labor income tax is fairly similar to that under the consumption tax, although there is a stronger response of the real exchange rate and so the current account.

The welfare implications of the policies described in this section are summarized in Table 4. The welfare criterion is again given by the percentage change in consumption that satisfies Eq. (28). The welfare gain, measured across steady states, is substantial: between 2.3% and 2.8% of consumption depending on the specific tax used to replace the lost capital income tax revenue, and whether one considers the U.S. or the EMU-12. When the entire transition path is included in the

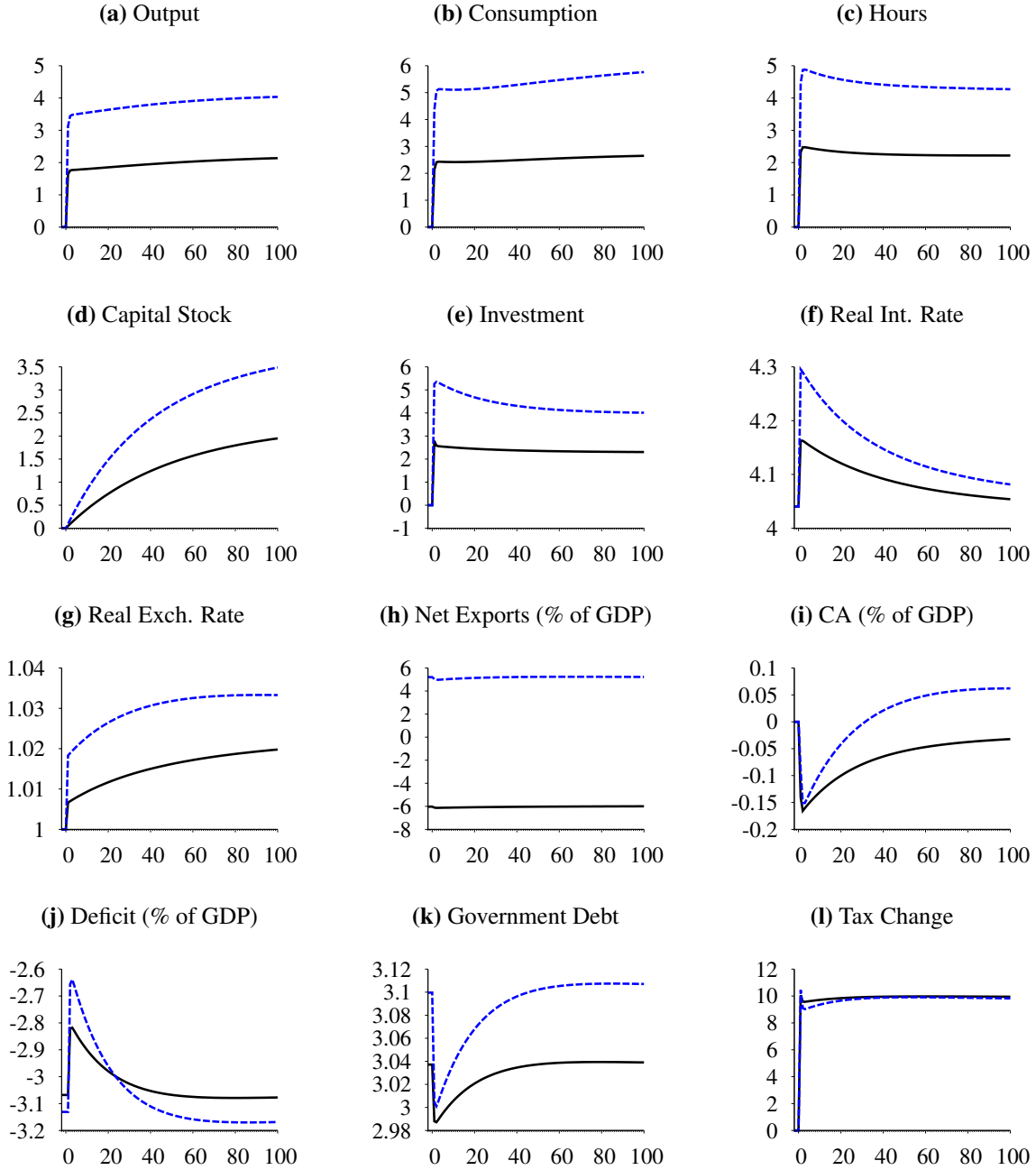
welfare calculation, these gains are more modest (although still large) at between 0.6% and 0.9% *except* for the EMU-12 when using the labor income tax rate as the policy instrument. This latter difference can be attributed to the severe and prolonged decline in consumption in the short to medium term under this policy. At ‘electoral frequencies,’ these policies all generate substantial welfare losses. For example, when measured at the 4 year horizon, the welfare losses range from 1.5% to 2.3% of consumption.

4.3. Debt-neutral labor income tax reductions

There has been a debate among economists and policymakers whether a reduction in labor income taxes, accompanied by an increase in consumption taxes to offset the lost labor income tax revenue, may be beneficial. In a closed economy, it is unlikely that such a policy will have much effect since the size of the increase in the consumption tax rate will almost exactly offset the effects of the decrease in the labor income tax rate. However, in an open economy, part of the incidence of the consumption tax falls on foreign producers since all goods, including imports, are taxed. Consequently, the thought is that the increase in the consumption tax will be smaller than the decrease in the labor income tax, thereby reducing the distortion to the labor-leisure choice and so improving the country’s international competitiveness. The final experiment reduces the labor income tax rate by 10 ppt, adjusting the consumption tax as above to ensure that the long run debt-to-output ratio is unchanged (and so the primary deficit-to-output ratio is similarly unchanged).

As seen in Figure 7, such a policy change results in a broadly-based boom in both the U.S. and the EMU-12. For the U.S., on impact output rises by 1.6%, consumption by 2.1% and hours 2.3%; the exchange rate depreciates 0.7% while net exports fall (from –6.0% of output to –6.1%). The EMU-12 exhibits stronger impact responses: output increases 3.1%, consumption 4.4% and hours 4.5%. The real exchange rate depreciates more (2%) and net exports fall (from 5.2% of output to 5%). The long run responses in the EMU-12 are roughly double that of the U.S.: 4.1% compared to 2.3%. In both regions, the long run depreciation of the real exchange rate is 2.7% and both regions experience a 0.2 ppt decline in their net exports-to-output ratios.

Figure 7: Debt-neutral labor income tax reduction



Legend: Solid lines, U.S.; dotted lines, EMU-12.

For the U.S., the steady state welfare gain of such a policy change is 0.89% of consumption – virtually the same as that computed using the entire transition path, 0.87%. No doubt this is because the impulse responses show that the economy more-or-less jumps to its new long run steady state. The situation is similar for the EMU-12: steady state calculations give a welfare gain of 3.6% while using the transition path implies a 2.6% gain. Furthermore, at shorter horizons there are welfare gains of roughly the same magnitude suggesting that such a policy change would be politically attractive. That the welfare gains for the EMU-12 are larger than for the U.S. is due to the fact that the EMU-12 labor income tax rate is close to its revenue-maximizing value, and so a large reduction in this tax rate has smaller revenue implications than for the U.S.

5. Conclusion

This paper constructed an open economy macroeconomic model. Key features included a full set of tax instruments (capital income, labor income, consumption) and incomplete financial markets (allowing for wealth transfers following a policy change). The model was calibrated to two economies, the first being the U.S., the other a subset of the EMU.

Broadly speaking, two sets of policy experiments were conducted. The first consisted of permanent 25% reductions in the government debt-to-output ratio. This scenario was motivated by the need for fiscal reform in a number of developed countries. Throughout, a fiscal policy rule was in place that linked the primary deficit to deviations of government debt. This policy rule was used to back out a path for one of the tax rates (capital income, labor income or consumption). Since a reduction in the debt-to-output ratio necessarily implies an (eventual) fall in the primary deficit, such policies involve short term pain (higher taxes and dampened economic performance) for long term gain (eventually, lower taxes and higher economic performance). While short term economic performance under the capital income and consumption taxes was quite similar between the U.S. and EMU-12, the story for the labor income tax was much different. In particular, for the EMU-12, the labor income tax rate rises more and has a drawn out hump-shape, leading to a prolonged

recession. These dynamics appear to be due to the fact that the EMU-12 is closer to its maximum revenue potential at its current labor income tax rate, necessitating a much larger increase in the tax rate to raise the required tax revenue.

Our welfare analysis shows that it is important to include the transition path in the calculation of the potential welfare gains of such policy changes. For both the U.S. and EMU-12, the steady state analysis of a labor income tax rate financed debt reduction yields reasonably large welfare gains, but welfare *losses* when computed with the transition path. Similarly, both regions have reasonably large gains when the debt reduction is accomplished via the consumption tax, yet the calculation with the transition suggests that the gain is quite small. Finally, using the capital income tax as the policy instrument yields sizable welfare gains when computed with the transition path, the steady state analysis overstated these gains by roughly a factor of four. Given a desire to reduce the government debt-to-output ratio, our welfare analysis suggests that achieving this goal through capital income taxes is preferable to the other two taxes.

Results from the optimal taxation literature suggest that a reduction in capital income tax rates should be welfare-improving. We considered a 10 percentage point reduction in the capital income tax rate financed either through labor income or consumption taxes, with the long run debt-to-output ratio unchanged. For the U.S., while there are some short term differences in economic performance (most notably, hours fall under the labor income tax whereas they rise with the consumption tax), in the long run economic performance rises. The EMU-12 is a different story. As with the debt-reduction experiments, the labor income tax has to rise more than the consumption tax, leading to a long-lived recession.

We also looked at the effects of shifting the burden of taxes from labor income to consumption. Intuitively, this policy experiment should improve international competitiveness of the domestic economy since part of the incidence of the higher consumption tax is borne by foreign producers. In this case, the economy moves quickly to its new steady state.

With the exception of using the labor income tax to replace capital income tax revenue in the EMU-12, all of the experiments involving shifting the tax burden generate welfare gains. The

Welfare benefit for a household living through the transition is smaller welfare than that associated with jumping from one steady state to another.

Appendix A: Steady State and the Dynamic Solution Method

Solving for steady state can be reduced to solving for $c, c^*, h^*, k, k^*, y, y^*, z, z^*, w, w^*$ and κ using steady state versions of Eqs. (6)–(9) and (23)–(27) (along with their foreign counterparts, where appropriate) along with the target for steady state hours in the domestic economy. In solving for steady state, recall that $s = 1$ which means $p = 1$ and $p^* = 1$. Also, $r = 1/\beta$ and $r^* = 1/\beta$. g and g^* are obtained from the targets for the government spending-to-output ratios. Finally, c_h, c_f, c_h^* and c_f^* are derived from steady state versions of Eqs. (15)–(18).

At time t , there are 14 unknowns are $c_t, c_t^*, h_t, h_t^*, k_t, k_t^*, d_t, d_t^*, f_t, s_t, r_t, r_t^*, g_t^*$ and one of $\tau_{ht}, \tau_{ct}, \tau_{kt}$ or g_t where Eqs. (12), (13) and (15)–(22) (and where appropriate, their foreign counterparts) are used to solve out for $z_t, z_t^*, w_t, w_t^*, y_t, y_t^*, p_t, p_t^*, c_{ht}, c_{ft}, c_{ht}^*, c_{ft}^*, def_t, def_t^*$. These 14 unknowns can be solved for using Eqs. (6)–(8), (23) and (24) along with their foreign counterparts as well as Eqs. (9) and (25)–(27). These equations are solved using non-linear methods as a two-point boundary problem where one point is the initial steady state and the other point is a set of “no change” conditions (the variables being solved for do not change between the last two periods). An alternative would be to specify initial and final steady states as the boundary conditions. This latter approach is problematic because of the indeterminacy of the real exchange rate discussed in the text. The “no change” terminal condition lets the algorithm “find” the terminal steady state, and so the terminal exchange rate is determined endogenously.

Appendix B: Data for calibration

We use data from various OECD databases to calibrate our models. We consider the following OECD countries: Australia, Austria, Belgium, Canada, Czech, Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, and United States. The following elements are used:

- Total labor wedge on labor income for average wage in 2008 (extracted from the OECD tax database).
- VAT rate in 2008 (extracted from the OECD tax database).
- Corporate and personal income tax rate on dividends in 2008 (extracted from the OECD tax database).
- Total GDP in 2008, in millions of U.S.\$, in 2000 constant prices and constant PPP.
- Total imports in 2008, in millions of U.S.\$, in 2000 constant prices and constant PPP.
- Total population in 2008, in thousands of persons.
- Total employment (domestic concept) in 2008, in thousands of persons.
- Average annual hours actually worked in 2008.
- Government expenditure in 2008, as a % of annual GDP (extracted from national annual accounts).
- Social transfers in 2008, as a % of annual GDP (extracted from national annual accounts).

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