On the Impact of a Tax Reform Package in Portugal *

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Abstract. In this paper we analyze a tax reform package recently proposed in Cavaco Silva (1999). We do so in the context of a dynamic general-equilibrium model of the Portuguese economy and we focus on the efficiency, welfare, and tax revenue effects of this package. Simulation results suggest that the tax reform package would induce, over the next twenty-five years, a GDP gain of between 0.36% and 0.89%, depending on the design of the compensatory changes necessary to achieve deficit neutrality. The proposed compensatory hike in the VAT rates is, in itself, insufficient to ensure deficit neutrality. Nevertheless, the reduction in private consumption it would induce, would lead to a net welfare loss over the same time span. In this case, the tax reform package would improve efficiency at the cost of reducing welfare. If the whole package were financed exclusively through increased non-distortionary taxation or through reductions in public consumption, the welfare losses would be avoided and welfare gains of up to 0.66% could be generated. It could be argued, however, that under the current institutional constraints associated with the Stability and Growth Pact it is difficult to realistically design the financing mechanisms in a way that would avoid the efficiency-welfare trade-off.

Keywords: Dynamic general-equilibrium; Endogenous growth, Tax reform

JEL Classification: C68; D58; E62; H21; H30

1. Introduction

At a conference held in Lisbon towards the end of May 1999, Cavaco Silva, the Prime Minister of Portugal from 1985 to 1995, suggested that the Government consider a series of changes in the Portuguese tax system. In effect, he presented a tax reform package which he later termed as a "fiscal shock" (Cavaco Silva, 1999). This tax reform package immediately attracted widespread attention in the political circles. This was to be expected since the issue of tax reform is currently at the forefront of the policy debate in Portugal and Cavaco Silva is still a central reference in the political arena, in particular, regarding economic policy matters.

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The tax reform package presented in Cavaco Silva (1999) is rather comprehensive and has the overall objective of promoting economic growth by improving economic incentives for domestic producers. Consistent with the current institutional conditions, it is designed keeping in mind the need for revenue neutrality. Specifically, the tax reform package proposes that direct taxes, like the personal income tax, the corporate income tax and employers' social security contributions should be reduced. The foregone tax revenues would be made up with a more effective combat on tax evasion, reduced wastefulness in public spending and, if necessary, with an increase in indirect taxes, in particular through an increase in the general value-added tax. Despite the fact that the design of this tax reform package reflects clear-cut objectives and seems *a priori* adequate to achieve such objectives under the prevailing institutional constraints, it remains to be determined what its actual effects on the Portuguese economy would be.

The meaningful simulation into the future of tax revenues is critical for the evaluation of the effects of any tax reform proposal. Nowadays, a widely accepted fact, both in the economics profession and in the policy-making world, is that the meaningful simulation of tax revenues has to take into consideration the feedbacks, in particular the dynamic feedbacks, between the private and public sectors. It is true that, for given policy rules, the performance of the economy will determine the path of future tax revenues. It is also true that the choice of policy rules is not, in general, neutral and will, therefore, affect the evolution of the economy. Accordingly, meaningful projections require a model of the economy that allows for the dynamic interactions between the public and private sectors and, in particular, incorporates different channels through which tax policies may affect private incentives and, ultimately, private sector performance. Ultimately, it boils down to recognizing that changes in tax rates affect the future evolution of the corresponding tax bases.

In this paper we analyze the effects of the tax reform package proposed in Cavaco Silva (1999). We do so in the context of a dynamic general-equilibrium model of the Portuguese economy where the endogeneity of the fundamentals of long-term growth and of the labor supply play a critical role. This modeling strategy allows for a detailed identification of the efficiency, welfare, and budgetary effects of the tax reform package while stressing the dynamic interactions between changes in the tax rates and the corresponding tax bases.

The dynamic general-equilibrium model in this paper brings together two important strands of the taxation literature. On one hand, it follows in the footsteps of the computable general-equilibrium modeling in the tradition of Auerbach and Kotlikoff (1984, 1987), Ballard, Fullerton, Shoven and Whalley (1985), Bovenberg (1986), Fullerton and Gordon (1983), Goulder and Thalman (1993), Goulder and Summers (1989), Kotlikoff (1995, 1996), Pereira (1994, 1999a) and Shoven and Whalley (1984). It shares with this literature the ability to consider the tax system in great detail and to analyze the effects of large and simultaneous changes in the tax parameters. On the other hand, the dynamic general-equilibrium model incorporates many of the insights of the endogenous growth literature in the tradition of Barro (1990), Barro and Sala-i-Martin (1992, 1995), Gaspar and Pereira (1995), Lucas (1988), Osang and Pereira (1996), Pecorino (1993), Rebelo (1991, 1992), Romer (1986), and Saint-Paul (1992) among many others. In particular, it recognizes that tax policy has the potential for

affecting the fundamentals of long-term growth and not just for generating temporary level effects.

This paper is organized as follows. In Section 2 we present the dynamic general-equilibrium model. In Section 3 we discuss the implementation of the model and its application to the Portuguese economy. In Section 4, we discuss the details of the tax reform package. In Section 5 we analyze the efficiency, welfare, and budgetary effects of the tax proposal under its basic design. In Section 6 we analyze the effects of versions of the basic tax reform package modified to achieve deficit neutrality. In Section 7 we focus on the sources of the efficiency-welfare trade-off. In section 8, we present sensitivity analysis results designed to test the importance of some of the critical modeling assumptions. Finally, in Section 9, we provide some concluding remarks.

2. The dynamic general-equilibrium model

We consider a decentralized economy in a dynamic general-equilibrium framework. With money absent, the model is framed in real terms. There are four sectors in the economy – the production sector, the household sector, the public sector and the foreign sector. The first three have an endogenous behavior and the four sectors are interconnected through competitive market equilibrium conditions and the evolution of the stock variables and their relevant shadow prices.

The intertemporal trajectory for the economy can be summarized by the optimal evolution of seven stock variables and three shadow price variables. These are – private capital, public capital, and human capital – as well as their respective shadow prices, and public debt, foreign debt, private financial wealth, and human wealth. In the long-term, endogenous steady-state growth is determined by the optimal accumulation of private capital as well as public capital and human capital. The last two are publicly provided, which implies that the command optimum cannot be replicated by a decentralized economy in the absence of public intervention that is, itself, responsive to market incentives.

In this section we present the basic details of the dynamic general-equilibrium model. See Pereira and Rodrigues (2000a) for further details.

2.1. *The production sector*

Aggregate output, Y_t, is produced with a Cobb-Douglas technology (see equation A.1 in Table I) exhibiting constant returns to scale in the reproducible inputs – effective labor, $L_t^d HK_t$, private capital, K_t, and public capital, KG_t. Only the demand for labor, L_t^d, and the private capital stock, K_t, are directly controlled by the firm. Public infrastructure, KG_t, and the economy-wide stock of knowledge, HK_t, are publicly financed and constitute positive externalities to the extent that they increase the firms' marginal productivity. The capital and labor shares, θ_K and θ_L respectively, are computed from national income accounts and $\theta_{KG} = 1-\theta_K-\theta_L$ is a public capital externality parameter residually determined so as to impose constant returns to scale. Exogenous productivity disturbances enter into the production function through the term η_t and A is simply a size parameter.

Private capital accumulation is characterized by equation (A.2) where physical capital depreciates at a rate of δ_K. Gross investment, I_t, is dynamic in nature. The optimal evolution of investment is induced by the presence of adjustment costs, AC_t^I. These costs comprise learning and installation costs and are internal to the firm. In turn, they are modeled as a loss in capital accumulation and are meant to reflect rigidities in the accumulation of capital towards its optimal level. Adjustment costs are assumed to be non-negative, monotonically increasing, and strictly convex. In particular, we assume adjustment costs to be quadratic in investment per unit of installed capital (see the last term of equation A.2).

Optimal production behavior consists in choosing the investment and effective labor demand levels, I_t and $L_t^d HK_t$ respectively, that maximize the firms' market value, i.e., the present value of their future net cash flows, subject to (A.2), the equation of motion for private capital accumulation.

At time t, the firms' net cash flow, NCF, is given by equation (A.3) and represents the after-tax position when revenues from sales are netted of wage payments and investment spending. The after-tax net revenues reflect the presence of an investment tax credit at an effective rate of τ_{ITC}, taxes on corporate profits at a rate of τ_{CIT}, and Social Security contributions paid by the firms on gross salaries, $W_t L_t^d HK_t$, at an effective rate of τ_{FSSC}.

Buildings make up a fraction, $0 < (1 - \rho_I) < 1$, of total private investment expenditure. Only this fraction is subject to value-added and other excise taxes, the remainder is exempt. This situation is modeled by assuming that total private investment expenditure is taxed at an effective rate of $\tau_{VATET,I}$. The corporate income tax base is calculated as Y_t net of total labor costs, $(1 + \tau_{FSSC})W_t L_t^d HK_t$, and net of fiscal depreciation allowances over past and present capital investments, αI_t. A straight-line fiscal depreciation method over $NDEP$ periods is used and investment is assumed to grow at the same rate at which output grows. Depreciation allowances are thus

$$(I_t + I_{t-1} + ... + I_{t-NDEP+1})/NDEP \tag{1}$$

which, under the assumptions made, simplifies to αI_t, with α given by equation (A.4), that is obtained by computing the difference of two infinite geometric progression sums.

The firms' labor demand and investment functions are obtained by setting up the following current value Hamiltonian function

$$\mathcal{H}_f = NCF_t + \frac{q_{t+1}^K K_{t+1}}{1 + r_{t+1}} \tag{2}$$

where q_{t+1}^K is the shadow price of the installed private capital stock, or conversely, the cost incurred in replacing part of it by resorting to capital markets.

The first-order condition for the firms' demand for labor to be optimal is written as $\partial \mathcal{H}_f / \partial (L_t^d HK_t) = 0$, the solution to which yields equation (A.5). This condition reflects the assumption that the demand for labor is free from any form of adjustment costs such as those derived from search, hiring or firing.

For the firms' investment decision to be optimal, the two necessary conditions that have to be satisfied are $\partial \mathcal{H}_f / \partial I_t = 0$ and $\partial \mathcal{H}_f / \partial K_t = q_t^K$. The solution to the first condition yields equation (A.6) which can be re-written as (A.6a). Investment as

Table I. Equations of the dynamic general-equilibrium model

The production sector

$$Y_t = (1+\eta_t)A(L_t^d HK_t)^{\theta_L} K_t^{\theta_K} KG_t^{1-\theta_L-\theta_K} \tag{A.1}$$

$$K_{t+1} = (1-\delta_K)K_t + I_t - \mu_I \frac{I_t^2}{K_t} \tag{A.2}$$

$$\begin{aligned} NCF_t = {} & Y_t - (1+\tau_{FSSC})W_t L_t^d HK_t - I_t - (1-\rho_I)\tau_{VATET,I} I_t + \\ & -\tau_{CIT}\cdot[Y_t - (1+\tau_{FSSC})W_t L_t^d HK_t - \alpha I_t] + \tau_{ITC} I_t \end{aligned} \tag{A.3}$$

$$\alpha = [1-(1+g)^{-NDEP}]/NDEP[1-(1+g)^{-1}] \tag{A.4}$$

$$\theta_L Y_t = (1+\tau_{FSSC})W_t L_t^d HK_t \tag{A.5}$$

$$\frac{q_{t+1}^K}{1+r_{t+1}}(1-2\mu_I \frac{I_t}{K_t}) = 1 + (1-\rho_I)\tau_{VATET,I} - \alpha\tau_{CIT} - \tau_{ITC} \tag{A.6}$$

$$\frac{I_t}{K_t} = \frac{1}{2\mu_I} - [1+(1-\rho_I)\tau_{VATET,I} - \alpha\tau_{CIT} - \tau_{ITC}](2\mu_I q_{t+1}^K)^{-1}(1+r_{t+1}) \tag{A.6a}$$

$$q_t^K = (1-\tau_{CIT})\theta_K \frac{Y_t}{K_t} + \frac{q_{t+1}^K}{1+r_{t+1}}\left[1-\delta_K + \mu_I\left(\frac{I_t}{K_t}\right)^2\right] \tag{A.7}$$

The household sector

$$U_{a,t} = \frac{\sigma}{\sigma-1}\sum_{v=0}^{\infty}\gamma^v\beta^v[c_{a+v,t+v}^{\frac{\sigma}{\sigma-1}} + B\ell_{a+v,t+v}^{\frac{\sigma}{\sigma-1}}] \tag{A.8}$$

$$PWELF_t = \sum_{n=t_0}^{t}\beta^{n-t_0}C_n \tag{A.9}$$

$$\sum_{v=0}^{\infty}\gamma^v[1+(1-\tau_r)r_{t+v}]^{-v}(1+\tau_{VATET,C})c_{a+v,t+v} \le TW_{a,t} \tag{A.10}$$

$$TW_{a,t} \equiv HW_{a,t} + FW_{a,t} + K_t \tag{A.11}$$

$$\begin{aligned} HW_{a,t} = {} & (1-\tau_{WSSC})(1-\tau_{PIT})\sum_{m=0}^{\infty}\left(\frac{\gamma}{1+(1-\tau_r)r_{t+m}}\right)^m \cdot \\ & \cdot W_{t+m}HK_{t+m}(\bar{L} - \ell_{a+m,t+m}) \end{aligned} \tag{A.12}$$

$$\begin{aligned} FW_{a,t} = {} & [1+(1-\tau_r)r_{t-1}^{PD}]PD_{t-1} + (1-\tau_\pi)NCF_{t-1} + \\ & -(1+r_{t-1}^{FD})FD_{t-1} + (1-\tau_{PIT})[(1-\tau_{WSSC})W_{t-1}HK_{t-1}\cdot \\ & \cdot(\bar{L} - \ell_{a-1,t-1}) + \varphi TR1_{t-1}] + (1-\varphi)TR1_{t-1} + TR2_{t-1} + TR3_{t-1} + \\ & + R_{t-1} - (1+\tau_{VATET,C})C_{a-1,t-1} - LST_{t-1} \end{aligned} \tag{A.13}$$

$$(1+\tau_{VATET,C})C_t = \{1-[1+(1-\tau_r)r]^{\sigma-1}\gamma\beta^\sigma\}[HW_t + (PD_t - FD_t) + K_t] \tag{A.14}$$

$$\ell_t = \left(\frac{B(1+\tau_{VATET,C})}{(1-\tau_{WSSC})(1-\tau_{PIT})W_t}\right)^\sigma C_t \tag{A.15}$$

Table I. Equations of the dynamic general-equilibrium model (cont'd)

The public sector

$$PD_{t+1} = (1 + r_t^{PD})PD_t + (1 + \tau_{VATET,CG})CG_t + (1 + \tau_{VATET,IG})IG_t + \\ +(1 + \tau_{VATET,IH})IH_t + TR_t - T_t \tag{A.16}$$

$$\begin{aligned} T_t &= PIT_t + CIT_t + VATET_t + WSSC_t + FSSC_t + LST_t \\ &= \tau_{PIT}[(1 - \tau_{WSSC})W_t HK_t(\bar{L} - \ell_t) + \varphi TR1_t] + \tau_r r_t^{PD} PD_t + \tau_\pi NCF_t + \\ &\quad +\tau_{CIT}[Y_t - (1 + \tau_{FSSC})W_t HK_t(\bar{L} - \ell_t) - \alpha I_t] - \tau_{ITC} I_t + \\ &\quad +\tau_{VATET,C} C_t + (1 - \rho_I)\tau_{VATET,I} I_t + \tau_{VATET,IH} IH_t + \tau_{VATET,IG} IG_t + \\ &\quad +\tau_{WSSC} W_t HK_t(\bar{L} - \ell_t) + \\ &\quad +\tau_{FSSC} W_t HK_t(\bar{L} - \ell_t) + \\ &\quad +LST_t \end{aligned} \tag{A.17}$$

$$TR_t = TR1_t + TR2_t + TR3_t \tag{A.18}$$

$$KG_{t+1} = (1 - \delta_{KG})KG_t + IG_t - \mu_{IG}\frac{IG_t^2}{KG_t} \tag{A.19}$$

$$HK_{t+1} = (1 - \delta_{HK})HK_t + IH_t - \mu_{IH}\frac{IH_t^2}{HK_t} \tag{A.20}$$

$$\frac{q_{t+1}^{PD}}{1+(1-\tau_r)r_{t+1}^{PD}} = \frac{q_t^{PD}}{1+(1-\tau_r)r_t^{PD}} \tag{A.21}$$

$$-q_{t+1}^{PD} = q_{t+1}^{KG}(1 - 2\mu_{IG}\frac{IG_t}{KG_t}) \tag{A.22}$$

$$q_t^{KG} = [-\frac{\partial T_t}{\partial KG_t}q_{t+1}^{PD} + q_{t+1}^{KG}(1 - \delta_{KG} + \mu_{IG}\left(\frac{IG_t}{KG_t}\right)^2)]/[1 + (1 - \tau_r)r_{t+1}^{PD}] + \frac{(1-\theta_L-\theta_K)Y_t}{KG_t} \tag{A.23}$$

$$\frac{\partial T_t}{\partial KG_t} = [\tau_\pi(1 - \tau_{CIT}) + \tau_{CIT}](1 - \theta_L - \theta_K)Y_t/KG_t \tag{A.24}$$

$$-q_{t+1}^{PD} = q_{t+1}^{HK}(1 - 2\mu_{IH}\frac{IH_t}{HK_t}) \tag{A.25}$$

$$q_t^{HK} = [-\frac{\partial T_t}{\partial HK_t}q_{t+1}^{PD} + q_{t+1}^{HK}(1 - \delta_{HK} + \mu_{IH}\left(\frac{IH_t}{HK_t}\right)^2)]/[1 + (1 - \tau_r)r_{t+1}^{PD}] + \frac{\theta_L Y_t}{HK_t} \tag{A.26}$$

$$\frac{\partial T_t}{\partial HK_t} = \frac{\theta_L Y_t}{HK_t}[\tau_{PIT}(1 - \tau_{FSSC}) - (1 - \tau_\pi)(1 + \tau_{CIT})\tau_{FSSC} + \tau_{WSSC}] \tag{A.27}$$

Conditions for market equilibrium

$$L_t^d = (1 - UR_t)(\bar{L} - \ell_t) \tag{A.28}$$

$$FW_t = PD_t - FD_t \tag{A.29}$$

$$Y_t = C_t + CG_t + I_t + IG_t + IH_t + NX_t \tag{A.30}$$

$$FD_{t+1} = (1 + r_t^{FD})FD_t + C_t + I_t + CG_t + IG_t + IH_t - Y_t - R_t \tag{A.31}$$

a fraction of the capital stock responds positively to positive changes in depreciation allowances, in the investment tax credit, τ_{ITC}, and in the shadow price of capital, q^K_{t+1}, and responds negatively to positive changes in the real interest rate, r_{t+1}, and in the value added and other excise taxes on investment, $\tau_{VATET,I}$. The solution to the second condition is (A.7), a difference equation that defines the shadow price of private capital recursively as the present value of the future stream of contributions that the physical capital stock will make towards production, i.e., the marginal product of private capital. This contribution is measured in after-tax terms and is net of depreciation and adjustment costs.

The corporate income tax, τ_{CIT}, affects the investment to capital ratio in two offsetting ways. On one hand, with fiscal depreciation allowances, a higher tax rate makes investment more attractive. On the other hand, as (A.7) reveals, a higher τ_{CIT} will reduce the after-tax marginal product of capital, the shadow price of capital, and thus make it less worthwhile to invest. With the parameterization used, the second effect dominates the first and the expected negative relationship between corporate income taxes and investment is obtained.

The final component of the modeling of the production sector is the closure or the financial link of the firm with the rest of the economy. Here, to simplify matters, we assume that at the end of each operating period the net cash flow is transferred to the consumers and can thus be interpreted as the return to capital accumulation in previous periods.

2.2. *The household sector*

A conventional overlapping generations specification following Yaari (1965), Blanchard (1985), Buiter (1988) and Weil (1989) was adopted here. See Frenkel and Razin (1996) for a detailed discussion of this type of household model.

In this framework, the planning horizon is finite but in a non-deterministic fashion. A large number of identical agents are faced with a probability, $\gamma \in (0,1)$, of surviving through to the next period. The assumption that γ is constant over time and across age-cohorts yields the perpetual youth specification by which all agents face a life expectancy of

$$1 + \gamma + \gamma^2 + \gamma^3 + ... = \frac{1}{1-\gamma}. \tag{3}$$

The probability of being alive j periods ahead is simply γ^j.

The population is assumed to be constant requiring that the birth rate, the number of agents that are born into every new age-cohort, equal the death rate which is simply $(1-\gamma)$ times the size of the population which, without loss of generality is normalized to one. A consequence of this is that *per capita* and aggregate values are equal.

The household, aged a at time t, has to choose present and future consumption and leisure streams, $\{c_{a+v,t+v}\}_{v=0}^{\infty}$ and $\{\ell_{a+v,t+v}\}_{v=0}^{\infty}$ respectively, that maximize its utility (see equation A.8) subject to the consolidated budget constraint, equation (A.10). The objective function is simply lifetime ($\sum_{v=0}^{\infty}$) expected (γ^v) instantaneous utility ($u_{a+v,t+v}$) subjectively discounted at the rate of β.

Preferences, $u_{a+v,t+v}$, are additively separable in private consumption and leisure, and take on the constant elasticity of (intertemporal) substitution (CES) form

$$u_{a+v,t+v} \equiv \frac{\sigma}{\sigma-1}\left(c_{a+v,t+v}^{\frac{\sigma-1}{\sigma}} + B \cdot \ell_{a+v,t+v}^{\frac{\sigma-1}{\sigma}}\right) \tag{4}$$

where B is a size parameter and σ is the constant elasticity of substitution.

The effective subjective discount factor can be written as $\gamma\beta$ meaning that a lower probability of survival will reduce the effective discount factor making the household relatively more impatient or conversely with a greater propensity to consume in the present.

Constraint (A.10), reflects the fact that real consumption is subject to an excise and value-added tax rate of $\tau_{VATET,C}$ and states that the households' expected consumption expenditure stream, $\gamma^v(1+\tau_{VATET,C})c_{a+v,t+v}\}_{v=0}^{\infty}$, discounted at the after-tax market real interest rate, $1+(1-\tau_r)r_{t+v}$, should not exceed the households' total wealth, $TW_{a,t}$, evaluated at time t.

The gross after-tax market real interest rate is $1+(1-\tau_r)r_{t+v}$, but the one-period loan rate at which households borrow and lend among themselves in a perfectly competitive market is γ^{-1} times greater. In effect, the probability of dying, $(1-\gamma)$, acts as a perceived default rate. To ensure a before-tax return of $1+r_{t+v}$ with certainty, creditors charge $(1+r_{t+v})\gamma^{-1} > 1+r_{t+v}$ because $\gamma < 1$. Their expected *before-tax* rate of return on loans made in $t+v-1$ is then

$$\gamma \cdot \frac{1+r_{t+v}}{\gamma} + 0 \cdot (1-\gamma) = 1 + r_{t+v}. \tag{5}$$

For the household of age a at t, total wealth, $TW_{a,t}$ (see equation A.11), is age-specific and is composed of human wealth, $HW_{a,t}$, net financial worth, $FW_{a,t}$, and physical capital, K_t. Human wealth (equation A.12), represents the present discounted value of the household's future labor income stream net of personal income taxes, τ_{PIT}, and workers' Social Security contributions, τ_{WSSC}. W_t is labor's reward per efficiency unit.

The household's wage income is influenced by its endogenous decision of how much labor to supply, $\bar{L}-\ell_t$, out of a total time endowment of $\bar{L}$, as well as by the stock of knowledge or human capital, HK_t, that (see sub-section 2.3) is exclusively augmented by public investment expenditure on education. Note how γ, the probability of survival, enters the relevant discount rate in equation (A.12). The reason why future labor earnings have to be discounted at a higher rate is that human wealth is household-specific and cannot be transferred to another household at the time of death.

Income net of spending adds to net financial wealth (see equation A.13). A household's income is augmented by net interest payments received on public debt, PD_t, net profits distributed by corporations, i.e., their net cash flows, NCF_t, international transfers such as emigrants' remittances, R_t, public transfers such as old-age pensions, $TR1_t$ (only a fraction φ of which enter into the personal income tax base), unemployment subsidies, $TR2_t$, solidarity oriented social action funds, $TR3_t$ and finally labor income earnings, $W_t HK_t(\bar{L}-\ell_{a,t})$. Note that then, wage income net of workers' Social Security contributions is subject to a personal income tax at an rate of τ_{PIT}. Given that loans among private sector agents do not alter the economy-

wide financial worth because they cancel out upon the consolidation of households' financial assets, these are omitted.

On the spending side, debts to foreigners are serviced, taxes are paid and consumption expenditures are made. All other taxes enter the lump-sum taxes term, LST_t. Under the assumption that no bequests are made, households are born without any financial wealth, that is $FW_{0,t-a} = 0$. Note also that total wealth is age-specific on account of age-specific labor supplies and consumption streams. Equations (A.14) and (A.15) are the aggregate private consumption and household labor supply functions.

Assuming a constant expected real interest rate profile, $\{r_{t+v}\}_{v=0}^{\infty} = r$, and that the consolidated budget constraint, equation (A.10), is binding, the household's intertemporal optimization problem can be formulated as a trivial static program. The relevant Lagrangean is

$$\mathcal{L}_{hh} = U_{a,t} - \lambda_{hh}\{\sum_{v=0}^{\infty} \frac{\gamma^v}{[1+(1-\tau_r)r_{t+v}]^v}(1+\tau_{VATET,C})c_{a+v,t+v} - TW_{a,t}\}. \quad (6)$$

A necessary condition for optimal private consumption is $\partial\mathcal{L}_{hh}/\partial c_{a+v,t+v} = 0$ that, after some algebra, yields the following consumption function for a household aged a at time t

$$(1+\tau_{VATET,C})c_{a,t} = \{1-[1+(1-\tau_r)r]^{\sigma-1}\gamma\beta^{\sigma}\}TW_{a,t}. \quad (7)$$

As the population is normalized to one, *per-capita* and aggregate are equal. Under the simplifying assumptions made, the marginal propensity to consume out of total wealth is age independent and aggregation over all age cohorts is extremely simplified. This is a characteristic of this type of overlapping generations models. Aggregate, or *per-capita* consumption, as a function of the economy-wide stock of total wealth is then given by equation (A.14).

The households' labor supply is residually determined out of a fixed endowment of time, $\bar{L}$, after having computed its demand for leisure. A necessary condition for optimality is $\partial\mathcal{L}_{hh}/\partial\ell_{a+v,t+v} = 0$ that, after some algebra, yields the following demand for leisure by a household aged a at t

$$\ell_{a,t} = \left[\frac{B(1+\tau_{VATET,C})}{(1-\tau_{WSSC})(1-\tau_{PIT})W_t}\right]^{\sigma} c_{a,t}. \quad (8)$$

An age-independent coefficient enables us to write the aggregate demand for leisure as a function of aggregate consumption. This yields equation (A.15).

Finally, to help in the evaluation of the effects of alternative policies, $PWELF_t$ (see equation A.9), the subjectively discounted sum of the aggregate private consumption stream is used as a summary indicator of private welfare.

2.3. *The public sector*

The equation of motion for public debt, PD_t, represented by equation (A.16) in Table I, reflects the fact that government outlays have to be financed by taxation and increases in the level of indebtedness. Total tax revenues, T_t, are given by equation (A.17) and are the result of taxing labor income, non-labor personal income, corporate income, and consumption and investment spending, in addition to collecting

residual taxes, which are modeled as lump sum taxes, LST_t, and are assumed to grow at an exogenous rate.

The public sector pays interest on public debt at a rate of r_t^{PD}, engages in utility-enhancing public consumption expenditures, CG_t, and productivity-enhancing public investment, IG_t and IH_t respectively, that are subject to value-added and other excise taxes at different effective rates. In addition to these outlays, the public sector transfers funds to households in the form of old-age, survivors and disability pensions, $TR1_t$, unemployment subsidies, $TR2_t$, and social action transfers, $TR3_t$. Public consumption and these different categories of public transfers are assumed to grow at an exogenous rate.

Public investment in human capital and infrastructure, are determined in an optimal fashion by the fiscal authorities, respond to economic incentives and thus constitute an engine of endogenous growth. The public investment decision consists in choosing the levels of IH_t and IG_t that maximize the net present value of the future stream of GDP, subject to three constraints. These are the equations of motion relative to the evolution of the stock of public debt, (equation A.16), the stock of public capital, (equation A.19) and the stock of human capital, (equation A.20).

The accumulations of HK_t and KG_t are subject to non-zero depreciation rates, δ_{HK} and δ_{KG}, respectively. Public investment decisions are dynamic and induced by adjustment costs that are a fraction, AC_{IH} and AC_{IG}, of the respective investment levels. As with private investment, the adjustment cost functions for public investment activities are strictly convex and quadratic.

The optimal public investment schedules that solve the dynamic program are obtained by setting up the following current value Hamiltonian function

$$\mathcal{H}_G = Y_t + \frac{q_{t+1}^{PD} PD_{t+1}}{1+(1-\tau_r)r_{t+1}^{PD}} + \frac{q_{t+1}^{KG} KG_{t+1}}{1+(1-\tau_r)r_{t+1}^{PD}} + \frac{q_{t+1}^{HK} HK_{t+1}}{1+(1-\tau_r)r_{t+1}^{PD}} \tag{9}$$

where the q_{t+1}^{i}s are the respective shadow prices. For optimal public investment, the relevant discount rate is $(1-\tau_r)r_{t+1}^{PD}$ because this is the financing rate for the public sector.

For public investment activities to be optimal, the following necessary conditions must be satisfied: $\partial\mathcal{H}_G/\partial PD_t = q_t^{PD}$, $\partial\mathcal{H}_G/\partial IG_t = 0$, $\partial\mathcal{H}_G/\partial KG_t = q_t^{KG}$, $\partial\mathcal{H}_G/\partial IH_t = 0$ and $\partial\mathcal{H}_G/\partial HK_t = q_t^{HK}$, the solutions to which yield equations (A.21) for public debt, (A22)–(A.24) for public investment and equation (A25)–(A27) for investment in human capital.

Equations (A.23) and (A.26) define the shadow price of public capital and human capital as the present value of the respective marginal products, that is, their marginal contribution to private output, plus the marginal tax value of the installed capital stock. The marginal products are measured net of depreciation and adjustment costs. Finally, equations (A.22) and (A.25) simply suggest that the level of public investment per unit of the respective installed stock, changes positively with the shadow price of the stock.

As is clear from this discussion, public investment and investment in human capital are, in general, determined by two motives. First, the objective of the government is to maximize the net present value of the GDP. At the same time the government recognizes that these investment activities, by increasing future GDP, also increase

the tax base in the future and, therefore, future tax revenues. While in terms of the first margin the government acts in the best interest of the economy as a whole, in terms of the second objective the government pursues its narrow self-interest, tax revenue maximization. To ensure that the maximization of the net present value of the future stream of GDP overrides the maximization of tax revenues as an objective of the fiscal authorities, $\partial T_t/\partial KG_t$ and $\partial T_t/\partial HK_t$ are set to zero in the practical implementation of the model in this paper.

2.4. *The foreign sector*

The equation of motion for foreign financing, FD_t, is given by expression (A.31) in Table I and provides a stylized description of the balance of payments. It is equivalent to an open economy's intertemporal budget constraint. Domestic production, Y_t, and imports are absorbed by domestic expenditure on private and public consumption and private and public investment, as well as exports. Net exports, NX_t, can be written as $C_t + CG_t + I_t + IH_t + IG_t - Y_t$.

Net exports are financed through either foreign international transfers, R_t, or foreign borrowing. Foreign transfers are assumed to grow at an exogenous rate. Furthermore, the domestic economy is assumed to be a small, open economy. This means that it can obtain the desired level of foreign financing at a rate r_t^{FD}, which is determined on international financial markets. This is assumed to be the prevailing rate for all domestic agents, households, firms, and the public sector.

2.5. *A perfect foresight equilibrium*

All agents are assumed to be atomistic. This implies that all agents take prices as given and have no market power. In addition, all agents have perfect foresight. This means that they fully anticipate future prices and other exogenous variables. Therefore, their planned future actions will be implemented without the need for any changes. Finally, all markets are assumed to clear. Under these assumptions, the intertemporal path for the economy is completely described by the different behavioral equations in Table I, the equations of motion of the different stock and shadow price variables, as well as by the market equilibrium conditions.

The market equilibrium conditions in the labor, financial and product markets are given by equations (A.28), (A.29), (A.30) and (A.31), respectively. Different agents contribute differently to the overall economy-wide equilibrium. Households demand consumption goods and services as well as securities, and supply labor services. Firms supply output and financial securities to finance their investment plans, and demand investment goods and labor services. Finally, the public sector supplies public debt securities and demands goods and services for different consumption and investment purposes.

Given these actions, the product market equalizes demand and supply for goods and services. Given the open nature of the economy, part of the demand is satisfied through the recourse to foreign production, hence equations (A.30) and (A.31). The labor market clearing condition that equates the demand for labor with its supply is given by equation (A.28). A structural unemployment rate of UR_t is exogenously considered and from a fixed-time endowment of $\bar{L}$, households demand ℓ_t in leisure,

and implicitly supply the remainder, $\bar{L} - \ell_t$, in the form of labor services. Finally, the financial market equilibrium, equation (A.29) reflects the fact that, private capital formation and public indebtedness are financed by household savings and foreign financing.

2.6. *On the existence of a long-term steady-state equilibrium*

We define a steady-state growth path as a long-term equilibrium in which all the flow and stock variables grow at the same rate, g, while market prices and shadow prices are constant. The existence of a steady state path solution for the dynamic general-equilibrium model imposes restrictions on the values that can be assumed by the exogenous variables and parameters in the model.

There are three major types of restrictions imposed by the existence of a steady-state growth path. First, the existence of a steady state determines the value of critical production parameters, like adjustment costs and depreciation rates in addition to the initial stocks of private capital, public capital, human capital, and human wealth. Second, the need for constant public debt and foreign debt to GDP ratios implies that the steady-state public account deficit and the current account deficit are a fraction, g, of the respective stocks of debt. This despite the fact that the initial values for public debt and foreign debt are not subject to steady state restrictions and are set at the observed values. Finally, the exogenous variables, as public transfers or international unilateral transfers, have to grow at the steady-state growth rate, g.

3. Implementation issues

3.1. *Numerical implementation strategy*

The characterization of the solution to the dynamic general-equilibrium model can be interpreted as a two-point boundary problem. Indeed, the evolution of the economy could be summarized in ten highly non-linear difference equations with six initial conditions and four terminal transversality conditions. Given the complexity of the problem, no attempt is made to develop an analytic solution. Instead, the model is parameterized and solved numerically. Comparative dynamic analysis is approximated by solving the model numerically for different configurations of the relevant exogenous variables and comparing the results with the base case simulation.

The numerical implementation is based on a strategy similar to that in Jones, Manueli, and Rossi (1993), Pereira (1994), and Gaspar and Pereira (1995). To solve the infinite-horizon problem numerically, truncated versions with finite time horizons are considered. To minimize any terminal effects associated with truncation, terminal constraints are introduced which are consistent with post-terminal steady-state values. Simulations were found to be very robust to truncation for a time horizon of 100 years or even more. Indeed, the assumption of a steady-state base case trajectory and the explicit consideration of the steady-state restrictions of parameter values completely eliminates the approximation errors induced by truncation.

Given truncation, the problem is solved using nonlinear programming methods. The ten difference equations are programmed as restrictions to an artificial optimization problem. This implementation strategy is particularly efficient since these

numerical optimization algorithms are particularly fast in obtaining a feasible solution for the optimization problem. By definition, this problem has only one feasible solution, the long-term dynamic equilibrium, which is promptly identified numerically by the nonlinear programming algorithm.

The non-linear optimization algorithm consists of a sequential programming method where each iteration solves a linear approximation to the nonlinear problem. Each iteration generates a search direction for the maximization of an augmented-Lagrangian merit function. Final convergence of the sequence of linear approximation is achieved according to preset default levels of a modified quadratic penalty function. See Gill, Murray, and Wright (1981) and Murtaugh and Saunders (1982) for a discussion of these techniques. The numerical optimization techniques are very flexible, have been widely tested, have known error properties, and are very robust for ill-conditioned problems. They also guarantee, by the use of non-negativity constraints on both state and shadow price variables, that the solution generated is a *bona fide* saddle-point solution to the optimization problem under consideration.

3.2. *Data set, parameter specification, and calibration*

The dynamic model is implemented numerically using a detailed data and a detailed parameter set for the Portuguese economy. Detailed information on the model implementation is also documented in Pereira and Rodrigues (2000a).

The data set is reported in Table II and reflects the GDP and stock variable values in 1998. In addition, the decomposition of the aggregate variables follows the average for the period 1990-98. The period 1990-98 was chosen to reflect the most recent available information and to cover, broadly speaking, a complete business cycle. The choice of averages for the decomposition of the aggregate variables reflects the nature of this dynamic simulation model. Since the model captures the behavior of the economy around a smooth trend but does not capture the fluctuations of the business cycle, this choice allows a better approximation of the actual long-run trend using the available data. As a corollary, temporary deviations of the actual economy from its long-run trend will not be captured in the simulations.

Among the basic data it is worth mentioning how the private capital, public capital, and human capital stocks were determined. Clearly, there is no good available information on these variables. The values for these variables were obtained in an indirect fashion from the steady-state restrictions. It was assumed that in the base year, 1998, the levels of investment were such that the capital output ratios did not change. This means that the stock of capital grew in the base year at the same growth rate as output. In the determination of these stocks, the depreciation rates and the adjustment cost parameters play a critical role.

Parameter values are reported in Table III and are specified in different ways. Whenever possible, parameter values are taken from the available data sources or the literature. This is the case, for example, of the population growth rate, the probability of survival, the share of private consumption in private spending, the output scale parameter, and the different effective tax rates. In turn, consistent with the conditions for the existence of a steady-state equilibrium, the exogenous variables were set to grow at the observed long-term steady-state growth rate. This is the case, for example, of public consumption, public transfers, residual lump sum taxes, as

well as international transfers. All these parameters have in common the fact that they do not play a direct role in the calibration of the model.

All the other parameter values were obtained by calibration, i.e., in such a way that the data for 1998 was exactly replicated and the trajectory of the economy for the period 1990–98 was exactly extrapolated as the steady-state trajectory into the future. Therefore, calibration parameters are central to the descriptive power of the simulation results.

Calibration parameters assume two different roles in the calibration process. In some cases, the calibration parameters can be chosen freely in that they are not implied by the state-state restrictions. This is the case, for example, of the discount rate, the intertemporal elasticity of substitution, the shares of labor and capital in production, and the public capital externality.

Although free, these parameters have to be carefully chosen since their values affect the value of the remaining calibration parameters. In other words, values of the remaining calibration parameters are conditional on the values assumed by these free calibration parameters. Accordingly, these parameters were chosen using either central values (as setting the intertemporal elasticity of substitution to one) or using available data as guidance (as in the case of the input expenditure shares in production) or, ultimately, by trial and error to generate meaningful calibration values for the remaining parameters.

The remaining calibration parameters are obtained using the steady-state restrictions as discussed above. This is the case of the adjustment cost parameters and the depreciation rates, as well as the initial values for the shadow prices of the different types of capital.

3.3. *On the central simulation scenario*

In the central simulation scenario, the model incorporates the endogenous growth and the endogenous labor supply mechanisms as described in Section 2. In the absence of any institutional constraints, and therefore, if the evolution of the public debt is free of any constraints, the numerical simulation would generate a steady-state path.

There are, however, important institutional constraints. Portugal as a member of the European Monetary Union, has to comply with the Stability and Growth Pact. In accordance with the European Council Regulation no. 1466/97 on the strengthening of the surveillance of budgetary positions and the coordination of macroeconomic policies, every two years domestic fiscal authorities commit themselves to a multi-annual stability program. To accomplish budgetary consolidation and to strengthen public finances, thus safeguarding against excessive deficits, the Portuguese authorities recently updated their Stability and Growth Program (Ministry of Finance, 2000), having accorded upon a downward trend in the overall general government deficit. A balanced budget is expected to be obtained in 2004.

In terms of the general-equilibrium model, consistent with the institutional environment the domestic economic authorities have to face, a balanced budget condition is imposed on the government budget from the year 2004 onwards. More specifically, the deficit constraint follows the central scenario Stability and Growth Program targets (cf Ministry of Finance, 1998 and Ministry of Finance, 2000 for further details). These targets postulate a declining public deficit as a fraction of the GDP

Table II. Data set for 1998

Variable	Description	Value
	Domestic spending data (% of Y_0)	
Y_0	Domestic production at market prices (in 10^{12} PTEs)	19.20800
g	GDP growth rate	2.65000
C_0	Private consumption	64.90000
I_0	Private investment	21.50000
CG_0	Public consumption	11.10000
IG_0	Public investment in infrastructure	3.80000
IH_0	Public investment in human capital	6.50000
	Foreign Account data (% of Y_0)	
TB_0	Trade deficit	7.80000
$r_0^f FD_0$	Interest payments	0.79895
R_0	Unilateral transfers	8.20745
CAD_0	Current account deficit (+)	0.39150
FD_0	Foreign debt	14.50000
	Public Account data (% of Y_0)	
TR_0	Total public transfers	13.80000
T_0	Total tax revenues	36.93337
PIT_0	Personal income tax revenues	6.10000
CIT_0	Corporate income tax revenues (including *derramas*)	3.24781
$derramas_0$	Municipal corporate income tax revenues	0.24781
$VATET_0$	Value added and excise tax revenues	14.20000
$VATET, C_0$	on private consumption expenditure	11.41600
$VATET, I_0$	on private investment expenditure	1.84100
$VATET, CG_0$	on public consumption expenditure	0.47100
$VATET, IG_0$	on public investment in infrastructure	0.38000
$VATET, IH_0$	on public investment in human capital	0.09200
$FSSC_0$	Firms' social security contribution revenues	5.00000
$TrCGA_0$	Transfers to the CGA included in CG_0	2.00000
$WSSC_0$	Workers' social security contribution revenues	4.10000
$WSSC1_0$	on private sector workers	2.90000
$WSSC2_0$	on public sector employees	1.20000
LST_0	Lump sum tax revenues	4.53377
$r_0^{PD} PD_0$	Interest payments on public debt	3.39967
DEF_0	Public deficit (+)	1.66590
PD_0	Public debt	61.70000
	Population and employment data (% of POP_0)	
POP_0	Population (normalized)	1.00000
L_0	Active population	67.09000
ELD_0	Elderly population	14.45000
$PARTR_0$	Participation rate	70.69800
UR_0	Unemployment rate	5.70000
	Capital stocks (% of Y_0)	
K_0	Private capital stock (CAL)	162.96581
KG_0	Public capital stock (CAL)	42.79345
HK_0	Human capital stock (CAL)	169.88342

Table III. Structural parameters

Symbol	Description	Type	Value
	Household parameters		
β	Discount factor = (1+ discount rate)$^{-1}$	CAL	0.95859
γ	Probability of survival	DAT	0.98666
$gPOP$	Population growth rate	DAT	0.00000
σ	Elasticity of substitution	ARB	1.00000
σ^{Social}	Social elasticity of substitution	ARB	1.00000
	Production parameters		
θ_L	Labour share	DAT	0.47500
θ_K	Capital share	DAT	0.37500
$1-\theta_L-\theta_K$	Public capital externality	CAL	0.15000
δ_K	Private capital's depreciation rate	CAL	0.07275
μ_I	Adjustment cost coefficient	CAL	2.11392
AC_I	Adjustment cost as a % of private investment	CAL	0.29954
$\dot{A}/A$	Exogenous rate of technological progress	ARB	0.00000
	Public sector parameters - tax parameters		
τ_{PIT}	Effective personal income tax rate	DAT	0.10579
φ	Fraction of pensions taxed	DAT	0.07500
τ_{π}	Effective distributed profits tax rate	DAT	0.10000
τ_r	Effective (and Statutory) Interest income tax rate	DAT	0.20000
τ_{CITd}	Effective Corporate income tax and *derramas* rate	DAT	0.11645
$NDEP$	Time for fiscal depreciation of investment (years)	DAT	16.0000
ρ_I	Fraction of private investment that is VAT exempt	DAT	0.68000
τ_{ITC}	Effective investment tax credit rate	DAT	0.00446
τ_{VATET}	Effective Value added and excise taxes rate	DAT	0.15171
$\tau_{VATET,C}$	VAT and excise taxes on private consumption	DAT	0.21801
$\tau_{VATET,I}$	*idem* on private investment	DAT	0.08561
$\tau_{VATET,CG}$	*idem* on public consumption	DAT	0.04241
$\tau_{VATET,IG}$	*idem* on public investment in infrastructure	DAT	0.10006
$\tau_{VATET,IH}$	*idem* on public investment in human capital	DAT	0.01421
τ_{FSSC}	Firms' effective social security contributions rate	DAT	0.13984
τ_{WSSC}	Workers' effective social security contributions rate	DAT	0.11467
$gLST$	Growth of lump sum taxes	CAL	0.02650
	Public sector parameters - outlays parameters		
δ_{KG}	Public infrastructure's depreciation rate	CAL	0.03938
μ_{KG}	Adjustment cost coefficient	CAL	3.18747
AC_{IG}	Adjustment cost as a % of public investment	CAL	0.30000
δ_{HK}	Human capital's depreciation rate	CAL	0.00992
μ_{HK}	Adjustment cost coefficient	CAL	8.52535
AC_{IH}	Adjustment cost as a % of human capital investment	CAL	0.37500
	Real interest rates		
r, r^{FD}, r^{PD}	Basic rate, *idem* on foreign debt, *idem* on public debt	DAT	0.05250

and a balanced budget by the year 2004. Furthermore, changes in public spending needed to accommodate the deficit targets come from appropriate reductions in public consumption.

Naturally, the imposition of these institutional constraints makes the simulated base case path for the Portuguese economy deviate, albeit only marginally, from a strict steady-state trajectory.

4. The tax reform package and its implementation

4.1. *The tax reform package*

The tax reform package presented in Cavaco Silva (1999) is oriented towards a reduction in direct taxation, namely in the corporate income tax, in the personal income tax, and in employers' social security contributions. The foregone revenues would be compensated in different ways: first, by a more effective combat on tax evasion and fraud, e.g., by abolishing the banking privilege for tax inspection purposes; second, by further restraint in public expenditure, in particular, through a reduction in the wastefulness in the health sector; and, finally, if necessary, by a limited increase in indirect taxes, i.e., in the general value-added tax.

More specifically, aimed at improving business conditions for domestic producers, it is proposed that the corporate income tax, t_{CIT}, be lowered four percentage points from 34% to 30% within two years. Furthermore, to reduce non-wage related total labor costs, the employers' social security contributions rate should fall four percentage points from 23.75% to 19.75%, also within two years. For tax purposes only, to boost effectiveness in the combat of tax evasion and tax fraud, the banking privilege would be abolished. In addition, the Assembly of the Republic would approve legislation prohibiting tax amnesties and tax pardons. To partially accommodate this controversial measure and ease its opposition by the wealthiest of individuals, however, the personal income tax rate corresponding to the highest income bracket would to be reduced five percentage points from 40% to 35%.

To comply with the Stability and Growth Pact, and in particular, to meet the budget deficit targets that the Government has committed itself to, the value-added tax rate would be allowed to increase a maximum of two percentage points from 17% to 19%. This tax increase, however, would only be carried out if improved tax collection and a reduction in the primary public expenditure proved to be insufficient in safe-guarding the institutional commitment. Also, the increase in the value-added tax could be temporary lasting from two to three years. To compensate for the reduction in social security revenue loss stemming from the reduction in the employers' social security contributions rate, part of the newly generated VAT revenues would be earmarked as a "social VAT". Furthermore, to counteract the regressiveness of the value-added tax increase, services that are intensive in low-skilled labor could be exempt from it.

Table IV summarizes the main points of the tax reform package and highlights the fact that, despite being quite comprehensive in nature, the only changes that have been quantified are the changes in the different statutory tax rates. As such, our analysis of the tax reform package will focus exclusively on the evaluation of

Table IV. Cavaco Silva's tax reform package

Instrument	Change	From	To
t_{CIT}	− 4pp	0.3400	0.3000
t_{FSSC}	− 4pp	0.2375	0.1975
$t_{PIT,4}$	− 5pp	0.4000	0.3500
$t_{VAT,5}$	≤ 2pp	0.1700	0.1900
Part of the increase is consigned to Social VAT			
The increase could be temporary – 2 to 3 years			
Services intensive in low-skilled labor could be exempt			
Banking privilege and tax amnesties	abolished		
Public consumption, in particular in the health sub-sector	restrained		

the components of the tax reform package that have been quantified. Implicitly, in the bulk of the discussion, we will assume that the outcome of measures to fight tax evasion and to reduce the wastefulness in public spending are too uncertain to be included in any serious quantitative evaluation of this tax reform package. Also, even though the package refers to changes phased in over a time span of two years, simulation results (available from the authors upon request) revealed that, from the standpoint of this evaluation, this additional detail is irrelevant.

4.2. *On the implementation of the tax reform package*

Having described the tax reform package in statutory terms, we must now discuss how its effects are to be simulated in the dynamic general-equilibrium model. In a highly aggregated model such as ours, the implementation of the package requires that the changes in statutory tax rates be framed in effective or average rates.

Indeed, from the standpoint of the practitioner of tax policy evaluation, the formulation of tax reform proposals in terms of statutory tax rates presents several challenges. In general terms this is because, from the perspective of tax policy evaluation, statutory tax rates are close to irrelevant. In fact, for the economic analysis of the incentives to work, consume, save and invest, induced by the tax code, what matters most is the agent's behavior at the margin. As such, ideally, the proposed tax rate changes should be framed in terms of changes in the marginal tax rates. These, however, are notoriously difficult to obtain. As such, an approximation that is often used in tax policy evaluation is the average or effective tax rate.

The relationship between statutory and effective tax rates is a rather complex matter. It depends, first and foremost, on the details of the tax law, which was clearly not written by nor for economists or policy analysts. It also depends on data information which is either not available or comes from varied and not necessarily compatible

Table V. How the package changes effective tax rates

Statutory Change	Effective Impact	From	To
$\Delta t_{CIT} = -4$pp	$\Delta\tau_{CITd} = -0.04 \cdot 0.32932$	0.11645	0.10327
$\Delta t_{FSSC} = -4$pp	$\Delta\tau_{FSSC} = -0.04 \cdot 0.69916$	0.13984	0.11787
$\Delta t_{PIT,4} = -5$pp	$\Delta\tau_{PIT} = -0.05 \cdot 0.07099$	0.10579	0.10224
$\Delta t_{VAT,5} = +2$pp	$\Delta\tau_{VATET,C} = +0.02 \cdot 0.80571$	0.21801	0.23412
	$\Delta\tau_{VATET,I} = +0.02 \cdot 0.28510$	0.08561	0.09131
	$\Delta\tau_{VATET,CG} = +0.02 \cdot 0.20965$	0.04241	0.04660
	$\Delta\tau_{VATET,IG} = +0.02 \cdot 0.58860$	0.10006	0.11183
	$\Delta\tau_{VATET,IH} = +0.02 \cdot 0.08360$	0.01421	0.01588

sources. Furthermore, it depends on behavioral parameters for the economy that are often difficult to identify and that, at any rate, reflect the priors of the tax policy analyst.

Pereira and Rodrigues (2000b) present a detailed account of the Portuguese tax system and formally discuss the correspondence between statutory and effective tax rates in the Portuguese economy. They present estimates of the effective tax rates at the most important tax margins as well as estimates on how changes in the statutory tax rates translate into changes in the effective tax rates. Table V uses results based on Pereira and Rodrigues (2000b) to determine how effective tax rates would be affected under the tax reform package under consideration.

5. On the effects of the tax reform package

5.1. *On the efficiency effects of the tax reform package*

We start by discussing the overall effects of the tax reform package in its initial design. To do so, we compare and contrast the *status quo* with a case in which the *status quo* is modified *quo* to include the tax reform package in its basic design as detailed above. Details of the simulation results are reported in Table VI. Here and in the subsequent discussions we consider results within a time horizon of twenty-five years. This time horizon seems reasonable from a policy-making perspective. Clearly a larger time horizon could have been considered but its usefulness would be implausible given the nature of the political process.

Simulation results suggest that the tax reform package induces a long-term accumulated gain in GDP *per capita* of 0.357%. Accordingly, the tax reform package under consideration has positive long-term efficiency effects. Furthermore, since the positive effects of the tax reform package are associated with a permanent, albeit small, increase in the GDP steady-state growth rate, the measure of the efficiency gains tends to increase with time.

Table VI. Simulation results (units: 1998 = 1.00000)

Results of the *Status Quo*

Variable	2000	2005	2010	2015	2020	2025
GDP and fundamentals of long-term growth						
GDP	1.05371	1.20089	1.36859	1.55967	1.77741	2.02552
Private investment	1.05356	1.20068	1.36833	1.55939	1.77713	2.02528
Public investment	1.05348	1.20059	1.36824	1.55930	1.77704	2.02520
Human investment	1.05355	1.20072	1.36845	1.55961	1.77748	2.02579
Employment	1.00003	1.00001	0.99995	0.99985	0.99972	0.99957
Labor input	1.05373	1.20092	1.36861	1.55965	1.55965	2.02528
Welfare						
Private welfare	2.95189	7.56483	11.82099	15.74895	19.37469	22.72191
Private consumption	1.05352	1.20079	1.36896	1.56104	1.78037	2.03073
Public consumption	1.04048	1.03590	1.21912	1.42831	1.66706	1.93951
Public finance						
Public debt / GDP	0.61670	0.57660	0.50586	0.44380	0.38936	0.34160
Total tax revenues	1.05348	1.19745	1.36255	1.55082	1.76551	2.01029
Lump-sum replacement	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Results of the basic tax reform package

Variable	2000	2005	2010	2015	2020	2025
GDP and fundamentals of long-term growth						
GDP	1.05623	1.20403	1.37250	1.56450	1.78333	2.03276
Private investment	1.05463	1.20214	1.37026	1.56189	1.78031	2.02926
Public investment	1.05662	1.20460	1.37332	1.56568	1.78503	2.03517
Human investment	1.05536	1.20292	1.37110	1.56280	1.78130	2.03033
Employment	1.00447	1.00459	1.00467	1.00472	1.00473	1.00473
Labor input	1.05844	1.20657	1.37537	1.56772	1.78692	2.03673
Welfare						
Private welfare	2.93489	7.50571	11.72033	15.60748	19.19331	22.50157
Private consumption	1.04428	1.18952	1.35525	1.54443	1.76032	2.00658
Public consumption	1.04048	1.03590	1.21912	1.42831	1.66706	1.93951
Public finance						
Public debt / GDP	0.61034	0.57094	0.50083	0.43933	0.38539	0.33807
Total tax revenues	1.05369	1.19834	1.36363	1.55214	1.76710	2.01221
Lump-sum replacement	0.06686	0.07238	0.07358	0.07469	0.07576	0.07685

To determine the importance of these efficiency gains it is informative to compare the effects of the tax reform package with the estimated effects of other recent or ongoing policy changes. Pereira (1999b), suggests that the European Union transfers under the structural transfer programs for Portugal for the period of 1996-2006 have a long-term positive effect on GDP *per capita* of 3.4%. Accordingly, the long-term GDP effects of the stimulus package under consideration are comparable to the effects of approximately one year of international transfer programs. For the sake of comparison it may be mentioned that the European Union transfers are expected to average 3% of the GDP for the period in question while the stimulus component of the tax reform package corresponds to approximately 1.5% of the GDP (see Table VIII).

The improvement in the GDP performance can be traced to the impact of the package on the different types of investment and, therefore, on the different types of capital accumulation as well as on the labor supply. Private investment, public investment, and investment in human capital show an improvement of 0.196%, 0.492% and 0.224%, respectively. These gains, adjusted for depreciation and adjustment costs lead to gains in the stocks of private, public, and human capital of 0.135%, 0.253%, and 0.050%, respectively. Overall, the labor input, measured as a composite of workers and human capital embodied in workers, shows a clear increase of 0.566% as a consequence of the tax reform package. This suggests that most of the GDP gains induced by the tax reform package come through the evolution of the labor input. The changes in taxation lead to an increase in the optimal human capital accumulation. This induces an increase in the marginal productivity of the labor input and leads to an increase in the after-tax wage rate of 1.365%. The consumers, in turn, react to this greater after-tax wage rate by increasing the supply of labor by 0.516%. Ultimately, the 75.1% of the long-term GDP gains come through changes in the labor input while 14.3% are due to increased private capital formation and the remaining 10.6% to increases in the accumulation of public capital.

5.2. *On the welfare effects of the tax reform package*

Let us now consider the effects of the tax reform package on private welfare. The private welfare effects are directly related to the effects of the tax reform package on private consumption. Indeed, the private welfare indicator is the present value of the intertemporal stream of private consumption over the next twenty-five years discounted using the private subjective discount rate. Since the stream of consumption is truncated and discounted, it is possible that, in terms of our private welfare indicator, medium term transitional changes in one direction in the path of private consumption dominate long-term changes in the opposite direction. This also means tax changes may have opposite effects in terms of long-term GDP performance and welfare.

Simulation results indicate that the tax reform package would lead to a long-term reduction of private consumption of −1.189%. A tendency for a reduction in private consumption was to be expected. This is because of its emphasis on reducing taxes to stimulate investment activities at the cost of increasing taxes that in fact directly penalize consumption, in particular VAT. Ultimately, the tax reform package leads to a long-term accumulated reduction in private welfare of −0.970%.

Table VII. Effects of changes in the different tax margins

Case	GDP	Welfare
Effects of the basic tax reform package	0.357	−0.970
Tax margins		
Effects of a change in the PIT rate	0.093	0.043
Effects of a change in the CIT rate	0.222	0.230
Effects of a change in the VAT rate on private consumption	−0.183	−0.760
Effects of a change in the VAT on private investment	−0.360	−0.113
Effects of a change in the FSSC rate	0.577	−0.275

5.3. *On the effects of the different margins of the tax reform package*

Since the basic stimulus package involves changes in five major areas of the Portuguese tax code, it would be interesting to find out the relative contribution of these different areas to the overall results discussed above. To this effect, we run five different simulation scenarios. In each of these five cases, only one of the five margins of the tax reform package is considered. For example, in one case only changes in the PIT are considered as the other effective tax rates remain at their level as in the *status quo*. The efficiency and welfare effects of changes at each margin are reported in Table VII.

Consider first the efficiency effects of the tax reform package. The reductions in the PIT, CIT, and FSSC effective tax rates all generate positive effects in terms of the long-term GDP performance. The contributions of the changes in the PIT and in the ITC are, however, secondary *vis-à-vis* the effects of the changes in the FSSC. The changes in the FSSC, account for 64.7% of the total GDP gains induced by the tax reform package, while the reduction in the CIT accounts for 24.9% and the changes in the PIT account for the remaining 10.4%. The relative importance of the effects at these three margins closely mimics their relative importance in terms of the tax reform package. Indeed, the changes in the PIT, CIT, and FSSC, account for 7.7%, 24.8%, and 67.5% of the package, respectively (see Table VIII). Therefore, the relative small efficiency effects of the changes at the PIT and CIT margins are a direct consequence of the relatively small changes involved.

In turn, the compensatory increases in the VAT tax rates are clearly detrimental for the long-term GDP performance. In fact, long-term GDP per capita is reduced in −0.183% with the changes in the VAT levied on private consumption and by −0.360% by the increase in the VAT taxation of private investment spending. These figures suggest that the benefits of the tax reform package are greatly reduced, by as much as 61.0% of the observed gains, by the need for compensatory changes in the VAT tax structure. Accordingly, the benefits of the tax reform package could be greatly enhanced if other forms of financing were available.

Consider now the welfare effects of the tax reform package. Changes in the VAT on private consumption, the VAT on private investment, and in the FSSC, all have

Table VIII. Composition of stimulus and financing of the basic tax reform package (% of total)

Package	Total	Margins						Growth
		PIT	CIT	VAT,C	VAT,I	SST	LST	
Stimulus	1.5% of GDP	7.7	24.8	–	–	67.5	–	–
Financing	1.5% of GDP	–	–	55.8	7.4	–	20.9	15.9

negative welfare effects. While the change in the VAT on private investment has a rather marginal welfare effect, about 9.7% of the total observed welfare loss, the other two margins have more substantial effects. Changes in the VAT on private consumption spending account for 76.0% of the welfare reduction while changes in the FSSC account for the remaining 24.1%. The negative welfare effects of the changes in the VAT on private consumption are not surprising since this tax change directly penalizes private consumption. Furthermore, the negative effects induced by the reduction in FSSC reflect the fact that a reduction in labor taxes increases the after-tax wage rate and increases the supply of labor. While it also increases disposable income, it seems to substitute away from consumption, i.e., the substitution effects is dominant. Finally, the reductions in the PIT and the CIT have positive welfare effects that are equivalent to 23.5% of the observed welfare loss.

5.4. *On the budgetary impact of the basic tax reform package*

Let us now consider the effects of the basic tax reform package on the evolution of total tax revenues. In particular, is the package in its basic design self-financing, i.e., is it revenue-neutral? The issue of revenue neutrality is relevant for different reasons. Clearly, the tax reform package in its basic design is not and could not be very specific in terms of the VAT tax changes required to compensate the reduction of the other tax revenues. It only suggests a compensatory change in the VAT statutory tax rate that would be capped at 2 percentage points. This is exactly what we consider in the analysis of the basic package. Even if the proposal were more specific, however, it could only consider revenue neutrality in the short term. Since, however, we should expect the tax bases to change with changes in the corresponding tax rates, even if a package is revenue-neutral in the short-term it may not be so in the longer term. Our dynamic general-equilibrium approach is uniquely designed to address this point.

To take the argument to another level, given the current institutional constraints, we should concern ourselves with deficit neutrality and not just with revenue neutrality. This is so for two reasons. First, because of the changes in public investment and investment spending in human capital formation that may be induced by the tax changes. Under the deficit constraints imposed by the Stability and Growth Pact, greater public investment in public capital or human capital will be translated directly into the need for greater tax revenues. Second, given the nature of the deficit targets under the Stability and Growth Pact, defined in terms of percentages of the GDP, in the early years of the simulations, any policy that increases the GDP will also increase the tax revenues needed to achieve the deficit targets. These two reasons

explain why the tax reform package under consideration would increase tax revenues in the long term.

Overall, the tax reform package postulates a stimulus which corresponds to 1.5% of the GDP in the long term, that is, the financing required has to add up to 1.5% of the GDP. If the tax revenues proposed in the tax package together with any increased tax revenues generated by an expanded tax base cover these 1.5% of the GDP we say that the proposal is deficit-neutral.

Simulation results suggest that the tax reform package in its basic design is *not* deficit-neutral in the long-term (see Table VIII). The proposed increase in the VAT revenues would cover only 63.2% of the stimulus component of the package, i.e., of the 1.5% of the long-term GDP which is proposed in the form of reduced direct taxation. Of this percentage, 55.8% corresponds to VAT on private consumption and 7.4% to VAT on private investment spending. The shortage in financing is made up in two different ways. First, increased GDP growth due to the stimulus component of the tax reform package increases the tax base. This translates in an increase of tax revenues that corresponds to 15.9% of the total financing needed for the package. Second, and more importantly, the remaining 20.9%, which corresponds to 0.314% of the GDP, are generated through increases in lump sum taxation. In fact, deficit neutrality would require an additional increase in lump-sum taxation of between 6.5% and 7.5% for neutrality to be achieved, that is for the Stability and Growth Program targets to be met.

The numbers above are rather plausible. In fact, broadly speaking, the tax reform package suggests reductions of four percentage points at tax margins that represent tax revenues of about 8% of the GDP (corporate income tax is 5% and the social security contributions are 3.1%). In turn, the tax increases are about two percentage points on tax margins that represent tax revenues of about 8.9% of the GDP (7.1% corresponding to the eligible private consumption spending and 1.8% to private investment spending). Accordingly, the increase in VAT tax rates could not cover much more than half of the foregone tax revenues.

The numbers above also lend themselves to an interesting interpretation. Suppose that the increase in the VAT tax rate is applied permanently to the full extent considered in the tax reform package, i.e., two percentage points. In this case, the success in fighting tax evasion and in reducing wastefulness in public spending would have to account for 0.5% of the GDP on a permanent basis for the targets of the Stability and Growth Program to be achieved. Furthermore, since the proposed increase in VAT taxation is considered as only a temporary measure, ultimately the success in these two areas would have to translate into a permanent change of 1.5% of the GDP. Given the uncertainty as to the success of fighting tax evasion and reducing wastefulness in public spending, this seems to be a rather questionable outcome.

6. On the effects of modified tax reform packages

We have argued above that the tax reform package in its initial design is not deficit-neutral and that an increase in lump sum tax revenues would be necessary to achieve neutrality. Clearly, lump sum taxation is not available as a realistic tax instrument to make up the shortage of tax revenues to finance the stimulus component of the tax

Table IX. Effects of tax reform packages modified to achieve deficit neutrality

Case	GDP	Welfare
Effects of the basic package	0.357	−0.970
Deficit neutrality achieved through changes in ...		
PIT	0.127	−0.851
CIT	0.116	−1.196
VAT on private consumption	0.286	−1.275
VAT on private investment	−0.967	−1.379
FSSC	0.112	−0.992

reform package. We consider, therefore, different marginal modifications of the tax reform package that are designed to achieve revenue neutrality with more realistic tax instruments, that is, with distortionary tax instruments. In each case, the necessary compensations in tax revenues to achieve deficit neutrality are obtained by modifying one of the five margins in the package. For example, neutrality could be achieved through an endogenous reduction in the changes in the PIT margin. The effects of these modified packages are summarized in Table IX.

Compensatory adjustments at each and every margins would reduce the overall efficiency gains. This is because compensatory changes in each of the tax margins translate in less of a stimulus component to the package, i.e., lower reduction in the respective tax burdens or in a greater increase in distortionary taxation. Consistent with the results above, however, we find that deficit neutrality could be achieved while preserving most of the gains in long-term GDP performance by allowing for greater VAT taxation of private consumption spending. In this case the long-term would be 0.286% or 80% of the estimates for the basic package. In turn, compensatory adjustments at the PIT, CIT, and FSSC margins would reduce the gains by about two-thirds of the initial estimates. Finally, compensatory changes in the VAT taxation of private investment spending would make the whole package counter-productive. In this case the overall package would generate a loss of -0.967% of the GDP in the long term. This loss is due to the fact that the increase in the VAT of private investment spending beyond what was postulated in the basic package would represent a very substantial change due to the relatively small tax base. Furthermore, the VAT on private investment spending works like a negative investment tax credit and is therefore, very distortionary.

Consider now the welfare effects of these modified packages. As a general pattern, we should expect a tendency for greater welfare losses. This is again because under the modified packages we replace lump sum compensatory increases with lesser decreases or greater increases in distortionary taxes. The reduced efficiency effects induced thereby translate into a smaller positive or a greater negative income effect from the tax package on consumers. Simulation results suggest that packages with compensatory changes in PIT, CIT, and FSSC would generate only marginal changes in the welfare losses while packages with compensatory changes in the VAT

Table X. Effects under different financing of the stimulus component of the tax reform package

Case	GDP	Welfare
Effects of the basic package	0.357	−0.970
Instead of VAT, the stimulus component is financed by ...		
An increase in lump-sum taxation	0.889	−0.099
A decrease in public consumption	0.619	0.655

on private consumption and on private investment would increase the welfare losses substantially. If the VAT on private consumption were to pick up the slack to achieve neutrality, then the after-tax price of private consumption would increase by more than under the basic package and, therefore, optimal consumption demand would be even more reduced, i.e., there would now be an increased negative price effect. In turn, if the VAT on private investment spending were to pick up the slack that generates an overall loss in GDP in the long term, then a supply-induced reduction in long-term private consumption, i.e., a negative income effect would be obtained.

It is important to notice that compensatory modifications in the VAT on private consumption would minimize the reduction in efficiency while worsening the welfare effects. Changes in the other tax margins would clearly reduce efficiency without deteriorating substantially the welfare effects. The exception is the case of a compensatory change in the VAT on private investment spending that would substantially worsen both the efficiency and the welfare effects.of the package. Again we witness the critical nature of the efficiency-welfare trade off. Achieving deficit neutrality in the context of the tax instruments under consideration can only be achieved in a way that preserves the efficiency gains if we are willing to allow for further welfare losses or conversely allowing for a deterioration of the efficiency benefits without further worsening the welfare effects in a substantial manner.

7. Effects of the tax reform package under different financing assumptions

So far we have considered a formulation of the tax reform package that stresses the aspects of the proposal that are directly quantifiable. In particular, in terms of the financing of the stimulus component of the package, we have allowed for the maximum increase in the VAT considered in the tax reform package. The remaining revenues necessary to achieve deficit neutrality were obtained through increased non-distortionary taxation. The tax reform proposal, however, explicitly mentions increased tax revenues through a more effective combat to tax evasion, and a decrease of public consumption spending as the major sources of financing. These financing mechanisms are difficult to implement and even more so to quantify. Nevertheless, we perform two experiments that allow us to evaluate the outcome of the tax reform

proposal under such financing mechanisms. The results from these experiments are summarized in Table X.

Suppose first, that instead of the compensatory increase in the VAT taxation proposed in the basic package, the goal of deficit neutrality is achieved exclusively through increases in lump-sum taxation. This means that the package would include no changes in VAT taxation. We look at this alternative as a *proxy* for increased tax collection within the confines of the current tax code, i.e., the case of financing the tax package through a more effective combat to tax evasion. In reality, however, this means of financing would be distortionary and, as such, the efficiency effects of the basic package would be smaller than the ones measured here. One can look at our results as the upper bounds of the effects of the tax reform package if all of the financing were to be generated by a more effective combat to tax evasion.

We observe that under lump-sum financing, the efficiency gains more than double but more importantly that the welfare losses are greatly reduced. In fact, in this case we avoid the distortionary effects on private consumption of the VAT taxation while still not avoiding the income effects common to both distortionary and lump sum taxation. Accordingly, some reduction in private consumption, and therefore private welfare, is still to be expected under this alternative scenario. The welfare loss, however, is now minimal, i.e., less than 0.1%.

Consider further the case in which deficit neutrality of the tax reform package is achieved through a reduction in public consumption. This corresponds to the case of the tax reform package being exclusively financed through a reduction in the wastefulness in public consumption spending. Again, no VAT or any other tax increases are now considered.

We observe that under public consumption financing, the efficiency effects are again substantially increased. The changes in the welfare effects are even more striking. In this case, private consumption is allowed to even increase with the economy while, clearly, public consumption would experience a compensatory decline. The important point, however, is that in this case the private welfare indicator would show an increase of 0.655% and the trade-off between efficiency and welfare would disappear.

The point of these experiments is very important. If we accept, as we should, that the public deficit targets imposed by the Stability and Growth Pact are binding, we close a potential channel for financing tax changes. Furthermore, if we believe that reducing public consumption beyond what is contemplated in the Stability and Growth Program is not a particularly realistic option, we close another potential channel for financing such packages. With these two channels closed we are reduced to using compensatory changes in distortionary taxation to finance a fiscal stimulus package. Here the doors are open for the trade-off between efficiency and welfare. In particular, under the current institutional onditions if we promote investment at the cost of penalizing private consumption we have to be ready accept a reduction in long-term private welfare.

Table XI. Effects of the basic tax reform package under different modeling assumptions

Case	GDP	Welfare
The basic package		
Effects under the central assumptions	0.357	−0.970
Effects under alternative assumptions		
Free deficits	0.093	0.635
Exogenous labor supply	−0.097	−1.295
Exogenous growth	0.277	−1.121
The stimulus component of the package		
Effects under the central assumptions	0.889	−0.099
Effects under alternative assumptions		
Free deficits	0.442	2.156
Exogenous labor supply	0.214	−0.544
Exogenous growth	0.691	−0.434

8. Sensitivity analysis

In our discussion above, we have identified changes in the taxation of the labor input as an important source, in fact the most important source, of the efficiency gains induced by the tax reform package. These gains are predicated on positive changes in human capital accumulation and labor supply. They also imply an ability to increase tax revenues in a balanced budget framework. Accordingly, the results seem to hinge directly on the assumptions of endogeneity of the labor supply, the existence of mechanisms of endogenous growth (optimal investment in public capital and human capital), as well as the existence of a binding balanced budget constraint.

To identify the contributions of the different modeling assumptions to the overall results, in addition to the basic modeling scenario followed until now, we consider three alternative modeling scenarios where we relax each of the three modeling assumptions discussed above. In our sensitivity analysis exercises we consider both the basic tax reform package and the stimulus component of the tax reform package under the different modeling assumptions. The effects of the tax reform package under the different modeling assumptions are summarized in Table XI.

Simulation results suggest that the efficiency gains of the tax reform package would be reduced under all alternative model specifications. In fact, the effects of the stimulus component of the package, would be reduced in 50% in the absence of target deficits, in 76% in the absence of endogenous labor supply, and in 22% in the absence of endogenous growth mechanisms. These reductions in the efficiency effects of the

tax reform package under different modeling assumptions were to be expected. First, free public deficits would potentially deviate funds to public spending activities and crowd out private investment. Second, the investment incentives generated by the tax reform package would increase capital accumulation and the marginal productivity of labor. With endogenous labor supply, higher market wages would lead to a higher supply of labor and to greater long-term gains. This cross effect is not present when labor supply is exogenous. Finally, with exogenous growth the increased marginal product of public capital and human capital induced by a greater public capital accumulation would not translate into higher public and human capital investment.

In terms of the welfare effects, the relaxation of the assumptions of endogeneity of labor supply and long-term endogenous growth would both increase the welfare losses induced by the tax reform package. In fact, while the stimulus component of the package, for example, is essentially welfare neutral under the central modeling assumptions, it would be clearly negative under both alternatives. This is because under these alternative modeling assumptions, increased private investment would translate into less of an increase in the market wage rate and less of an increase in labor income. The boost in private consumption induced by the investment stimulus is, therefore, minimized.

Consistent with the discussion in Section 7 above, however, if we had assumed free public deficits, the tax reform package would generate large welfare effects. This is because the additional tax revenues needed to finance the package would be generated through additional public deficits and not through taxation. The negative welfare effects of either the basic package or the stimulus component of the package would, therefore, be greatly minimized.

In terms of the welfare effects, the exogeneity of labor supply would only marginally change the estimated effects. Consistent with the discussion above, however, assuming free deficits would greatly reduce the welfare losses induced by the basic package. This is because the additional tax revenues needed to finance the package would be generated through additional deficit financing and not through taxation. The negative effects on private consumption would, therefore, be greatly minimized.

9. Conclusions

In this paper we analyze the tax reform package recently proposed in Cavaco Silva (1999). We conduct our analysis in a dynamic general-equilibrium framework where the endogeneity of long-term growth and of the labor supply play a critical role. In addition, the general-equilibrium framework takes into consideration the constraints imposed by the Stability and Growth Pact. This modeling strategy allows for a detailed identification of the efficiency, welfare, and budgetary impact of the tax reform package while stressing the dynamic interactions between changes in the tax rates and the corresponding tax bases.

Simulation results suggest that, when the maximum compensatory increase in the VAT of two percentage points is considered in a permanent manner, the tax reform package would induce a long term gain in GDP per capita of 0.357%. This is equivalent to the effects of approximately one year of European Union structural transfers programs. This gain in long-term GDP per capita is mostly induced by the

reduction in the employers' contributions to Social Security. The gains are filtered mostly through the labor markets and depend critically on the ability of workers to increase their supply of labor and on the ability of the government to increase investment in human capital formation. While the efficiency gains are clear, the mechanism to make up for foregone revenues, i.e., the increase in VAT tax rates, induces a reduction in private consumption. The overall package induces, therefore, a reduction in long-term private welfare. Finally, simulation results suggest that, even under this extreme formulation of a two percentage points permanent increase in the VAT tax rate, the tax reform package would not be deficit neutral. If the additional tax revenues required by neutrality are to be obtained through a further increase in the VAT tax rates on private consumption then the overall efficiency gains can be maintained but the welfare losses are further increased.

The overall evaluation of the tax reform package in Cavaco Silva (1999) is clear. The strategy of shifting from direct to indirect taxation and from taxing production activities to taxing spending is successful in promoting GDP growth. It is very likely, however, that this success would come at the cost of reducing private welfare.

In fact, our results suggest that despite the formulation of the tax reform package, the proposed increase in the value added tax, could hardly be regarded as an instrument of last resort. Clearly, the increase in tax revenues from fighting tax evasion and the reduction in wastefulness in public spending are difficult to implement and even more so to predict. The simulation results suggest that, if the VAT tax rates were to be increased by two percentage points on a permanent basis, to achieve deficit neutrality this increase in tax revenues/decrease in public spending would have to amount to about 0.5% of the GDP. If the increase in the VAT tax rates were temporary as suggested in the package, however, the result of less tax evasion and less wastefulness in government spending would have to be approximately 1.5% of GDP on a permanent basis. To put things in perspective, public consumption is about 11% of the GDP of which about 80% are wages. This leaves only 2.2% of the GDP in non-wage expenditures. Furthermore, the Stability and Growth Program stipulates an already significant deceleration in public consumption spending. In fact, real public consumption expenditure is projected to grow at most 1% *per annum* over the period 2000–2004 (see Ministério das Finanças, 2000). According to this projection, by 2004, public consumption will be around 9.7% of GDP.

Given the limited ability to fight tax evasion and the difficulty in reducing public spending beyond the requirements of the Stability and Growth Pact, it would seem that a realistic implementation of the tax reform package would require changes in the VAT tax rates well above the ones proposed. Likely changes would have to be between three and four percentage points on a permanent basis. The result would be a reduction in the present discounted value of the intertemporal path of private consumption over the next twenty-five years, our indicator of private welfare.

Clearly, this conflict between efficiency and welfare effects can be construed as an indictment of the tax reform package. One should be careful, however, to note that, this trade-off is a direct consequence of the current institutional constraints in Portugal [see Pereira and Rodrigues (2000c) on this issue]. The conflict between efficiency and welfare is induced by the need to trade-off distortionary tax margins since financing tax reform packages through decreases in public consumption and/or

increased public deficits do not seem to be particularly realistic options. Indeed, as mentioned above, simulation results suggest that the conflict between efficiency and welfare would be eliminated if the stimulus component of the tax reform package could be financed by compensatory reductions in public consumption.

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