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On the Impact of a Tax Shock in Portugal*

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Abstract

Tax reform in Portugal is a work in progress. Motivated primarily by combating tax evasion and promoting faster growth, the policy changes are as broad in scope as they are complex in detail. During the debate, Cavaco Silva synthesized most of the concerns into a tax reform package he dubbed as the "tax shock". In this paper we use an applied general equilibrium model to study the macroeconomic impact it would have on the Portuguese economy. Simulation results suggest that, by 2050, GDP would be somewhere between 1.5% and 2.75% higher, mostly depending on how distortionary the combat to tax evasion turns out to be. However, these gains could come at the expense of welfare losses as a result of less leisure *and less* consumption along the way. To avoid such a trade-off between GDP and welfare, tax policy changes (in their stimulus and financing components) have to mindful of the need to increase after-tax wages. In this sense, tax reform in Portugal should be oriented towards reductions in tax margins that increase the demand for labor, but should refrain from financing these tax breaks with increases in value-added and excise taxes on consumption that tend to boost the supply of labor. Of course this poses a dilemma on how to finance growth- and welfare-augmenting tax reforms.

Keywords: Applied general equilibrium; Growth; Tax policy evaluation; Welfare

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

1. Introduction

People have come to expect a lot from tax policy, so much, in fact, that nowadays tax reform proposals worldwide win and lose elections. Partly, this is because taxes are so pervasive and touch almost every aspect of our lives. More importantly, though, tax policy has many, often conflicting, objectives and this always ensures a lively and politically charged debate when it comes to talking about taxes. In addition to encouraging certain behaviors (like learning, working, saving and innovating) and discouraging others (such as polluting), tax policy is called upon to make the system a little fairer, and it must do both while still providing enough resources to finance public expenditure.

In Portugal, tax reform is in the air. Both the 2001 Budget and the 2000 Tax Reform Act approved by Parliament last December set in motion a reform process that is expected to be complete by the end of this year. As the signs are confirmed that the Greek economy is now performing quite well on a number of accounts, there is a growing sense that Portugal is falling behind. Also, as Europe becomes increasingly integrated, persisting tax differentials are a strong deterrent to foreign direct investment. Once again, Portugal is a case in point. In this regard, many economists agree that only by combating tax evasion, fraud and avoidance can tax bases be broadened, thus opening the way to cut those taxes that promote growth the most.

Contrary to what some politicians would have us believe, however, applied economic research focusing on other countries has determined that the long-term effects of realistic, i.e., non-fundamental tax policy changes are rather small. Therefore, to be able to inform the Portuguese electorate, it seems like a good idea to study how big these changes can be in Portugal.

The objective of this paper is to inform and contribute to the public discussion of tax reform in Portugal. To do so, we take the "tax shock", a tax reform package proposed in 1999 by Cavaco Silva that we consider being prototypical of the tax reform debate, and we study its macroeconomic effects on the Portuguese economy through to 2050 using an applied dynamic general equilibrium model. This is a model that stresses the dynamic interactions between changes in tax rates and the corresponding tax bases, and where the endogeneity of the fundamentals of long-term growth and of labor supply play a

critical role. In particular, we ask how this tax reform package would affect both the welfare of households and the level and growth rate of GDP. We choose to look at a proposal because we consider the actual tax reform rather complex and still too uncertain at this point in time to be assessed in a serious manner.

We build on Pereira (1999a) and make two contributions to the literature: (1) We go to great strides to model the main characteristics of the Portuguese tax system in an applied general equilibrium setting; and (2) We allow for an endogenous labor supply and incorporate a matching' endogenous growth mechanism to achieve sustained economic growth.

As far as we know, innovation (1) makes this the most detailed dynamic general equilibrium model for tax policy analysis yet developed for the Portuguese economy. In conjunction with Pereira and Rodrigues (2001a, b), this is a framework where the effects of a number of different (but naturally stylized) tax reform packages can easily be simulated.

An important insight of the recent economic literature on endogenous growth (see, for example, Barro 1992, and Barro and Sala-i-Martin 1995) is that fiscal policy has the potential of affecting the fundamentals of long-term growth. In this regard, two of the most relevant channels are the public investment activities that the Government carries out and the changes in tax policy that motivate an increased demand for labor. Using the "tax shock" as an example, innovation (2) allows us to determine how important these avenues of growth are in the Portuguese case. The answer to this question, in the case of the labor market channel, carries important economic policy implications: To what extent should tax reforms such as this one be complemented with measures that make the labor market less rigid?

This research also sets the stage for an interesting follow up exercise. Pereira and Rodrigues (2000a) is a quest for the optimal tax reform package that uses this setting to build hypothetical tax reform packages and thus explores, for the Portuguese economy, the tax policy changes that would increase both GDP and welfare the most over the long term.

The plan of the paper is as follows. Section 2 elaborates on the ongoing tax reform in Portugal. Both the underlying principles and the specific policy changes are discussed. Section 3 presents the prototypical tax reform package suggested by Cavaco Silva and argues that before simulating its effects we must first frame the changes in statutory tax rates into changes in effective tax rates. Section 4 then details the economic

model used and discusses the advantages of such a setup in tax policy evaluation exercises. Section 5 elaborates on the design of the simulations and in Section 6 the results of the numerical simulations are presented and discussed. Finally, Section 7 concludes with a gist of the results and asks what tax policy in Portugal can learn from this whole exercise.

2. The ongoing tax reform in Portugal

The debate on how to reform the Portuguese tax system began in 1997. Our reading of the course of events that followed suggests that the tax policy changes that were recently approved by Parliament were essentially motivated by three principles: (A) To promote fairness; (B) To increase the competitiveness of the Portuguese economy; and (C) To strengthen tax administration.

Fairness is once again at the fore of the tax policy agenda, but not because of a more unequal distribution of wealth, something that would call for a more progressive tax system. Instead, using the words of OECD (2001), "... tax avoidance and evasion contribute to the perception of a lack of fairness of the system". In fact, combating tax evasion is the hallmark of the ongoing tax reform process in Portugal and carries important implications for all three principles. Horizontal equity says that people with similar incomes should pay similar taxes. However, because of different opportunities to evade taxes, the effective tax burdens are often very unlike. Improving tax enforcement and thus ensuring that all those that should pay do pay effectively broadens the tax base. This allows those that have always complied to pay a lower tax rate.[1]

In what regards the second principle, on economic performance, Portugal is roughly one generation behind the European Union average. In this context, some authors (see Lebre de Freitas 2000 for an allusion to the recent Irish experience) have pointed to the role that tax policy must play in the catching up process. In particular, for there to be a more rapid convergence in productivity levels, public policy must be geared at strengthening the incentives to work, save, invest and innovate. To do so, economic research suggests lowering taxes on capital income and, in general, changing the tax revenues' structure

[1] According to Tanzi and Shome (1993), in the past, because of tax evasion, statutory rates often rose to compensate for lower tax revenues.

towards a greater reliance on indirect taxes. Of course, it must be realized that, as tax bases are becoming increasingly mobile, in a context of tax competition, the ability to use tax policy to increase a country's competitiveness is quickly eroded. In this sense, combating tax evasion is also important for economic growth in that creating a level playing field helps to ensure the efficiency of the price mechanism. This is because, in general, atomized production units, despite being less productive, can often undersell because they have more opportunities to evade taxes.

In the not so remote future, the Portuguese economy is set to face serious budgetary pressures. The projected aging of the population, alone, will require a very significant fiscal adjustment. (See Pereira and Rodrigues 2001c, 2001d and Gouveia and Rodrigues 2001 for a discussion of the impact on public pensions and health care expenditure, respectively.) Also, the stringency of institutional constraints such as the Stability and Growth Pact practically preclude deficit financing. Thus, it is in a context of growing fiscal arrest that we must frame the third principle underlying the debate on tax reform in Portugal. Strengthening tax administration is about increasing the productivity of the tax system. If more tax revenues can be raised under the same statutory tax rates then the tax system can be made more productive. In Portugal many think that tax evasion is once again the culprit at work. Moreover, according to Tanzi and Shome (1993), tax evasion carries an excess burden as, in anticipation, tax legislators make the tax code increasingly complex. More importantly though, in a society where bad practices such as these are condoned, people naturally become skeptic about the role of the public sector.

Even though the three underlying principles are straightforward, the ongoing tax reform is as overarching in scope as it is complex in detail. As yet, it is also incomplete as to how it will be financed. A comprehensive account of the ongoing tax reform in Portugal can be found in OECD (2001). Therefore, we provide only a rough sketch here.

The tax breaks are at the corporate income and personal income tax margins, and are aimed at reducing the burden of those that already comply with their tax obligations. In addition, the reporting of income is further simplified so as to facilitate tax compliance. In what regards the personal income tax margin, under the motto "making work pay", dependent workers and all those with low to medium incomes will pay less in taxes. The Tax Incentives Statute is also changed and greater benefits are aimed at family protection, education, and saving. As for the corporate income tax margin, there is a scheduled reduction

in tax rates with a special focus on micro enterprises and businesses located in non-urban areas. Also, to encourage research and development activities, there are now more significant investment tax credits.

These tax cuts and tax expenditures are to be financed through improved tax collection as well as increased indirect taxation.[2] Stepping up the fight against tax evasion and tax avoidance has naturally become a policy priority. In this regard, the ongoing tax reform envisages most of the solutions that have been proposed in the literature (see, once again, Tanzi and Shome 1993): presumptive methods whereby a particular income is assigned to a tax payer and is deduced from indicators of wealth will be adopted to facilitate tax auditing; self-employed workers will be subject to the payment of a minimum tax; tax data bases will be crossed; the access to bank records will be facilitated under certain circumstances; and finally, a new legislation for tax crimes will effectively increase the penalties of non-compliance.

In what regards the increases in indirect taxation, the specifics have yet to be proposed and approved, but it seems likely that immovable property taxes will be replaced by a value added tax, and environmental taxes (essentially excise taxes on petroleum products and motor vehicles) will be harmonized in accordance with European Union directives.

3. A prototypical tax reform package

Just as economists build stylized models of reality to focus on an issue at hand, our task as tax policy analysts would be greatly simplified if the major concerns surrounding the debate were to be synthesized into a prototypical tax reform package. Fortunately, this work has already been done as such a proposal was brought forward during the debate.

3.1. Cavaco Silva's "tax shock"

At a conference held in Lisbon towards the end of May 1999, Professor Anibal 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 that he later termed as a "tax

[2] In addition, capital gains will be subject to personal income tax under a progressive tax schedule.

shock" (Cavaco Silva 1999). This tax reform package immediately attracted widespread attention in the political circles, mostly because Cavaco Silva is still a central reference in the political arena, in particular when it comes to economic policy matters.

Being a prototypical tax reform package, the "tax shock" is very simple. (See Table 1 for details.)

[Table 1]

The stimulus component is oriented towards a reduction in direct taxation, and comprises (I) A 4 pp reduction in the corporate income tax rate, (II) A 4 pp reduction in the employers' social security contributions rate, and (III) A 5 pp reduction in the personal income tax rate corresponding to the highest income bracket. On the financing side, the foregone revenues are made up with (i) A more effective combat to tax evasion as a result of prohibiting tax amnesties and abolishing bank and other professional secrecies for tax inspection purposes, and (ii) A reduction of the wastefulness in public health care spending. If, even with (i) and (ii), there is still a shortfall in tax revenues then, to meet the budget deficit targets the Government has committed itself to, (iii) The general value added tax rate can be increased up to a maximum of 2 pp. The drop in the overall personal income tax rate is negligible but is admittedly included as a way to overcome any resistance to abolishing the banking privilege.

By referring the need to curtail the wastefulness in Government spending, Cavaco Silva's prototypical tax reform package also takes on board the urgency of a public expenditure reform in Portugal.

Just like most tax reform proposals, the "tax shock" makes a number of minor qualifications. These provisos, however, do not fundamentally alter the nature of the package; they are simply meant to avoid predictable lines of criticism. For the sake of completeness, we document them here. The tax breaks could be phased in over a period of two years. Part of the value added tax revenues could be earmarked towards the Social Security budget to compensate for the shortfall in contributions. Finally, to counteract the regressiveness of the value added tax increase, services that are intensive in low skilled labor could be made exempt.

3.2. Implementing the prototypical tax reform package

By and large, tax reform proposals are formulated in terms of changes in statutory tax rates. From the perspective of the tax policy analyst, however, these rates are close to irrelevant. This is because, for the analysis of the incentives to work, save, invest and innovate that are induced by the tax code, what matters most is the economic 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. However, because marginal tax rates are notoriously difficult to obtain, an approximation that is often used in tax policy evaluation is the average or effective tax rate.

We have already described the policy changes suggested by Cavaco Silva's "tax shock". In light of the above considerations, then, to simulate the effects of such a package, one must first frame the changes in statutory tax rates into the corresponding changes in effective tax rates.

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 depends also on data information which is either not available or comes from varied and not necessarily compatible 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 (2001a, b) present a detailed account of the Portuguese tax system and formally discuss the correspondence between statutory and effective tax rates in the Portuguese economy. These two articles 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, t_{tax}, translate into changes in the effective tax rates, τ_{tax}. Using this information, Table 2 reports on how the effective tax rates at the various tax margins would be affected by the "tax shock".

[Table 2]

4. The setup

In this section we detail the dynamic general equilibrium model used as well as its application to the Portuguese economy. Before doing so, however, we briefly discuss the advantages of such a setup.

In real life, a country's overall budgetary position depends on its macroeconomic performance (see, for example, CBO 2000). This is because, among other things, tax bases are endogenous and respond to changes in tax rates. Therefore, in the evaluation of alternative tax policies it is particularly important to have a model that takes this into account. In this paper, we use an applied general equilibrium model in the tradition of Auerbach and Kotlikoff (1987) that captures the dynamic feedbacks between the private sector and the public sector.

Applied dynamic general equilibrium or ADGE models are a class of macroeconomic models that are becoming the preferred apparatus in the analysis of economic policy. By building the bridge between solid microeconomic foundations and macroeconomic policy, this class of models offers three advantages (Bovenberg 1990). *First,* ADGE models are the best context in which to evaluate the effects of policy changes that are mostly structural in nature. Whereas atheoretical approaches may fall victims to the Lucas Policy Evaluation Critique, in applied dynamic general equilibrium models, economic agents interact in an optimizing framework by trading in the labor, financial, and goods and services markets. Market prices are thus the signals that guide their behavior. Preferences and technology are the basic building blocks, the parameters of which are said to be 'deep' in the sense that they are invariant to policy changes. *Second,* because these models are dynamic, they focus on the linkages across time as well as across markets. This is especially important in the evaluation of alternative tax policies that entail different intertemporal distortions and imply unequal transitional effects. Also, considering the agents' expectations opens the door to analyzing the effects of a policy maker's imperfect credibility. Furthermore, working with intertemporal budget constraints allows us to study the long-term sustainability of competing fiscal policies. *Finally,* because individuals maximize their intertemporal utility and this is made explicit in ADGE models, alternative economic policies are ranked in a more natural way according to their welfare effects.

The model used here 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 fiscal policy has the potential for affecting the fundamentals of long term growth and not just for generating temporary level effects.

A number of interesting policy questions regarding the Portuguese economy have recently been answered by other incarnations of this model. These include an analysis of the macroeconomic impact of an aging population (Pereira and Rodrigues 2001d), an evaluation of the long-term sustainability of the public pension schemes (Pereira and Rodrigues 2001c), a discussion of the effects of adopting the euro (Pereira 1999b), and finally an appraisal of the Structural Funds (Gaspar and Pereira 1995). This list of recent applications suggests that applied general equilibrium analyses are an increasingly valued input to economic policy in Portugal.

4.1. The setting

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. Only the first three have an endogenous behavior but all four sectors are interconnected through competitive market equilibrium conditions, the evolution of the stock variables and their relevant shadow prices. Economic agents are price-takers in all markets and are assumed to have perfect foresight. This implies that planned actions for the future are always carried out without any revisions whatsoever. Other that the non-neutrality of public debt (see below), the setup

chosen is of a neoclassical type. We do this because this is the best, i.e., the most neutral setting in which to study the long-term effects of tax policy changes.

The intertemporal trajectory of 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.

4.2. The production sector

Aggregate output, Y_t, is assumed to be produced with a Cobb-Douglas technology (see equation 1 in Table 3) 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, meaning that if public investment is absent then decreasing returns set in. 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.

[Table 3 - Equations of the production sector]

Private capital accumulation is characterized by equation (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 2). As a result, firms will gradually approach their desired long-term capital stock.

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 (2), the equation of motion for private capital accumulation.

At time t, the firms' net cash flow, NCF, is given by equation (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 (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 (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 (6) which can be re-written as (6a). Investment as 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_{t+1}^K, 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 (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 (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 the corporate veil is pierced, i.e., 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.

4.3. 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 8 in Table 3) subject to the consolidated budget constraint, equation (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.

[Table 3 - Equations of the household sector]

Preferences, $u_{a+v,t+v}$, are assumed 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 (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 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 12), represents the present discounted value of the household's future income stream from labor and net transfers after personal income taxes, τ_{PIT}, and workers' Social Security contributions, τ_{WSSC}, have been paid. Note that only (net) income that is agent-specific and disappears once the agent dies should be included in human wealth. Thus, in addition to labor income, we include social security transfers. Furthermore, we assume that the lump sum taxes paid are of an agent-specific type. As a result, γ, the probability of survival, enters the relevant discount rate in equation (12). Future earnings of this type have to be discounted at a higher rate because they cannot be transferred to another household at the time of death.

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 4.4.) is exclusively augmented by public investment expenditure on education.

Income net of spending adds to net financial wealth (see equation 13). A household's income is aug-

mented 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.

By considering public bonds as net wealth we have dismissed the Ricardian Equivalence. In this setting, there are a number of reasons for the non-neutrality of public debt. (See Pereira and Rodrigues, 2001e, for a discussion of this and other issues related to public indebtedness.) The first and arguably the most important reason is that, in the model we consider, taxes are distortionary. As a result, the timing of one's taxes is not irrelevant. Second, public investment expenditures are endogenously determined and do not remain unchanged. And last but not least, because households must factor in the probability of surviving through to the next period, they effectively discount the future at a higher rate than an infinitely lived Treasury. As a result, the Government can borrow funds from the capital market at a lower interest rate.

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 (14) and (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 (10), is binding, the household's intertemporal optimization problem can be formulated as a trivial static program. The relevant Lagrangean is

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

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

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

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 (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

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

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

Finally, to help in the evaluation of the effects of alternative policies, we calculate the subjectively discounted sum of the aggregate private consumption and leisures streams as summary indicators of private welfare (see equations 9 and 9a).

4.4. The public sector

The equation of motion for public debt, PD_t, represented by equation (16) in Table 3, reflects the fact that government outlays can be financed either by taxation or by increases in the level of public indebtedness. Total tax revenues, T_t, are given by equation (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.

[Table 3 - Equations of the public sector]

The public sector pays interest on public debt at a rate of r_t^{PD}, engages in 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 activities in human capital and infrastructure are assumed to be determined in an optimal fashion by the fiscal authorities. Being Q-theoretic in nature, they respond to market incentives and thus constitute the engine of sustained endogenous growth. We said that the economy-wide production function exhibits decreasing returns to scale in labor and capital, but constant returns to scale when public investment is also carried out. When such a matching' mechanism is present, the decreasing marginal products of capital and labor are circumvented. This causes a fundamental linearity in the production function which allows GDP to grow without bounds. Unlike traditional exogenous growth models, in the tradition of Solow (1956), where exogenous technical progress has to be posited to ensure sustained growth, this matching' process is endogenous to the system because it is determined by the choices of optimizing agents. For other ways of modeling sustained endogenous growth, see Myles (2000).

The public investment decisions consist 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 16), the stock of public capital, (equation 19) and the stock of human capital, (equation 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 (21) for public debt, (22)–(24) for public investment and equation (25)–(27) for investment in human capital.

Equations (23) and (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 (22) and (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.

4.5. The foreign sector

The equation of motion for foreign financing, FD_t, is given by expression (31) in Table 3 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 imports, NQ_t, can be written as $C_t + CG_t + I_t + IH_t + IG_t - Y_t$.

[Table 3 - Equations of the foreign sector]

Net imports 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.

4.6. 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 3, 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 (28), (29), (30) and (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 (30) and (31). The labor market clearing condition that equates the demand for labor with its supply is given by equation (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 (29) reflects the

fact that, private capital formation and public indebtedness are financed by household savings and foreign financing.

4.7. 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.

4.8. 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.

4.9. 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.

The data set is reported in Table 4 and reflects the GDP and stock variable values in 1999. 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.

[Table 4]

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 5 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.

[Table 5]

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.

5. On the design of the simulations

5.1. On the unchanged policy scenario

In the central simulation scenario, the model incorporates the endogenous growth and the endogenous labor supply mechanisms as described in the previous section. In the absence of any institutional constraints, and therefore, if the evolution of the public debt were 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, 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 (Ministério das Finanças, 2001), 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 (see Ministério das Finanças, 2001, for further details). These targets postulate a declining public deficit as a fraction of the GDP 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.

5.2. On the counterfactual scenarios

The numerical simulations that were carried out were guided by the objective of this paper: to determine the macroeconomic effects of the "tax shock". At first, one would think that one counterfactual scenario is all that is needed. However, though the stimulus component of the tax reform package has been comprehensively quantified and is, therefore, straightforward to model, when it comes to the financing part there are some crucial uncertainties.

To make the discussion as informative as possible, we have framed these uncertainties into three questions.

What revenues will fighting tax evasion produce?

To keep things as simple as possible, we consider two possibilities: that the measures taken provide *just enough* revenues to finance the stimulus component, and that fighting tax evasion proves to be completely unsuccessful in that *no extra* revenues are generated. In the latter case, because the "tax

shock" contemplates increasing the general VAT rate if necessary, we assume that this is the only margin used to finance the package and thus adhere to the budget deficit targets. Given that the risk of failure of fighting tax evasion must have been envisaged by Cavaco Silva, it is interesting to determine whether the 2 percentage points increase he set as an upper limit would be sufficient.

If fighting tax evasion is successful, how distortionary will it be?

In Portugal, the corporate income tax and the personal income tax margins are the ones most plagued by tax evasion. Most people suspect that corporate firms are the only ones responsible, but independent workers are also to blame. This is so, even though no one knows the relative importance of tax evasion at each of these margins. In principle, fighting tax evasion must always be somewhat distortionary. Nevertheless, the strategy we adopted here was to consider the cases where the full stimulus component is exclusively financed with lump sum, corporate income, and personal income taxes, respectively. Admittedly, though, lump sum tax financing is a rather unrealistic scenario but we consider it all the same because it is a benchmark case.

How much of public consumption is waste, and how much of it can be trimmed?

If we knew the answer to the above three questions, simulating the macroeconomic effects of the "tax shock" would be a piece of cake. In fact, in such a setting, we would be able to establish with more certainty whether the 2 percentage points increase in the general VAT rate is a safe margin or not, i.e., whether the tax reform package is in fact self-financing. Alas, just as it is practically impossible to predict what revenues fighting tax evasion with the new measures will produce, so too it is very difficult to put a number on the wastefulness in public spending. Gomes and Barros (2000) estimate that a more active prescription of generic drugs or white-label pharmaceuticals could permanently save the Treasury each year up to PTE 25 billion, something like 0.12% of GDP. It can be argued that the scope for efficiency gains in health care as well as in other subsectors such as public education is much larger, but the truth is that it has still yet to be quantified.

To proceed, though, we consider the case where the full stimulus component of the "tax shock" is financed through lower public consumption. Unrealistic as this scenario admittedly is, because even in

the face of identified inefficiencies there is always some resistance that has to be won, it is interesting to know what cuts as a percentage of GDP would be required to safeguard the Stability and Growth Pact commitment. Note that, because the tax bases are endogenous and respond to the growth effects induced by the "tax shock", the necessary cut in public consumption will be smaller than the value of the stimulus component as a percentage of GDP. In this sense, the endogenous adjustment of the economy to a new tax policy provides part of the necessary financing.

To sum up, given the uncertainties as to how the stimulus component will be paid for, we consider the following financing arrangements: lump sum, corporate income, personal income, value added and excise taxes, and public consumption, respectively.

We now present the simulation results, discussing them in the above order.

6. Simulation results

Here we present and discuss the results of the simulations we performed. At the core of this section are the numerical simulation results that determine the macroeconomic effects of the stimulus component of the "tax shock" under alternative financing arrangements. Before doing so, however, to give us a better idea of what is driving the results, we first examine the effects of the tax policy changes one margin at a time. In the guise of a sensitivity analysis, we then rerun all the scenarios under different modeling assumptions. In particular, we do so to determine the contribution of an endogenous labor supply and an endogenous growth mechanism, towards the GDP and welfare effects.

Table 6 is a snapshot of the baseline or unchanged policy scenario – its main purpose is to serve as reference point. Tables 7 – 11 detail the macroeconomic effects (as percentage deviations from the baseline scenario) of the "tax shock" under different types of financing, and focus on three groups of indicators: the fundamentals of long-term growth, public finance variables, and measures of private welfare. Private welfare is a composite of the present and future streams of consumption and leisure discounted back to the base year, i.e., to 1999. It should be noted that the value of this indicator read at 2020, for example, is what is most relevant for an individual that dies that year.

[Table 6]

Although Tables 7– 11 certainly contain a lot of interesting information they can sometimes be an overload. As such, in the discussion that follows, we will make use of summary tables, such as Tables 12 – 14. It should be pointed out at the start that, in these tables, the measures of private welfare correspond to infinitely discounted sums of private consumption and leisure. We do so to preclude situations where distant future consumption and leisure streams are much higher as a result of tax policy changes, but the welfare measure does not capture this because it is truncated.

6.1. Decomposed effects of the stimulus component

6.1.1. A reduction in the corporate income tax rate

We contrast the *status quo*with the case with a corporate income tax rate falls by 4 percentage points in statutory terms (a stimulus of 0.36% of GDP) and lump sum taxes provide the financing. Simulation results (see Table 12) suggests that, after 50 years, GDP is 0.94% higher. Also, because the steady state rate which GDP grows accelerates by 0.02 percentage points *per annum*, the GDP gains will increase over time. The improvement in GDP performance can be traced back to the effects of this tax policy change on the different types of capital accumulation, as well as on employment. Private investment shows an improvement of 1.64% by 2050. This result, corrected for adjustment costs and depreciation, leads to gains in the stocks of private, public, and human capital of 1.32%, 0.81%, and 0.44%, respectively. As a consequence, employment is 0.24% higher by the end of the horizon.

[Table 12]

The tax policy change leads to an increase in the optimal accumulation of the different types of capital. This induces an increase in the marginal product of labor and leads to an increase in the after-tax wage of 0.25%. The increase in after-tax wage is rather weak. With a corporate income tax rate financed with lump sum taxation, the households feel this as a pure wealth loss. Because such a tax policy change ultimately improves GDP performance, the households' financial wealth eventually increases on account of higher net cash flows. However, because capital under installation is subject to adjustment costs,

higher corporate profits take some time to materialize. As a result, even though consumption is 0.22% higher in 2050, the infinitely discounted sum of private consumption shows a decline of 0.14%. This is because consumption in 2000 is 0.53% lower. Also, because reducing the corporate income tax promotes employment, the leisure component of private welfare is down 0.09%. Total welfare is thus 0.23% lower as a result.

6.1.2. A reduction in the firm's social security contributions rate

Given that Tables 7 – 12 detail the results of tax policy changes, having walked through the results in the previous case, it seems pointless and redundant to repeat the exercise for every simulation run. As such, we will simply highlight the differences from case to case.

When the firm's social security contributions rate is reduced by 4 percentage points in statutory terms (a stimulus of 0.8% of GDP) and financed with lump sum taxes, the effects on long-term GDP are quantitatively similar to the reduction in the corporate income tax, i.e., around 1%, as are the increases in the different types of capital. A sharp difference, however, is that employment and the after-tax wage are much higher. Reducing the firm's social security contributions rate lowers the non-wage costs of labor and this induces firms to demand more of it. As a result, the previous trade-off between GDP and welfare that appeared in the previous case has now disappeared because consumption is now higher in the present as well as in the future. Unsurprisingly then, the consumption component of private welfare shows an increase of 0.75%.

6.1.3. A reduction in the personal income tax rate

Consider a five percentage points reduction in the statutory rate of the highest personal income bracket (a stimulus of 0.13% of GDP), financed with lump sum taxes. Of the three cases so far, this is the most potent tax policy change because, as a result of it, GDP increases the most, i.e., 1.15% by 2050. While the effects on the different types of capital are within the same ballpark, this reduction in the personal income tax rate induces a greater supply of labor and, as a result, employment increases the most, i.e., 0.76%, but the after-tax wage is only 0.25% higher. The consumption component of private welfare is

thus reduced by 0.36% because the increase in after-tax wage, along with the eventually higher net cash flows, are insufficient to compensate for the higher lump sum taxes paid.

6.2. The stimulus component under different kinds of financing

6.2.1. Lump sum tax financing

The full stimulus component represents 1.29% of GDP. It could be asked if the effects of the full stimulus component under lump sum financing are equal to the sum of effects when the margins are changed individually. Apart from the interaction effects one would expect in a general equilibrium framework where tax bases are endogenously determined, the joint effects upon GDP, in particular, are generally smaller than the sum of the individual effects because of convexities that exist in the installation of the different types of capital. These adjustment costs impose gradual increases in such stocks in spite of even more favourable conditions to invest that exist when all three tax policy changes are made. Unrealistic as this scenario is, it is important as a benchmark case, the reference scenario in relation to which alternative financing scenarios will be compared. By 2050, GDP is 2.91% higher and the growth rate will have accelerated 0.05 percentage points. With the private capital, public capital, and human capital stocks higher by 3.11%, 2.50%, and 1.35%, respectively, this stage is set for employment and after-tax wages to be 1.51% and 2.39% higher. Unsurprisingly then, the consumption component of private welfare is 0.33% higher.

6.2.2. Corporate income tax financing

With the stimulus component financed with corporate income taxes, instead of lump sum taxes, the gains in GDP performance are reduced by 67.4%. By 2050, GDP is only 0.95% higher. Naturally, the private capital stock is 0.20% lower as a result of tax policy change. Nevertheless, because employment and the after-tax wage still do relatively well, there are still some welfare gains, if we focus just consumption component, which rises 0.12% by the end of the of the projection period. It should be pointed out, however, that this scenario is far from rosy: because of the deleterious effect on the capital stocks, in particular on the private capital stock, the long-term net cash flows taking a beating. As a result, consumption

in 2050 is 1.08% lower. Contrary to the case where just corporate income taxes were reduced and lump sum taxes increased to finance this, now consumption is higher in the present at the cost of lower future consumption.

6.2.3. Personal income tax financing

In this case, financing the stimulus component with personal income taxes proves to be even more damaging. By 2050, GDP is only 0.72% higher, meaning that the performance gains are reduced by as much as 75.3%. While the different types of capital are all lower than they might have been under lump sum tax financing, what is most striking, is that employment only rises by 0.13% *vis-á-vis* the baseline and, more importantly, the after-tax wage is lower 1.21%, as a result of higher personal income taxes. Naturally, despite the long-term gain in GDP, the consumption component of the private welfare indicator is 1.04% lower.

6.2.4. Value added and excise taxes on consumption financing

In fact, the "tax shock" mentions an increase in the general VAT rate. We choose to use just value added and excise taxes on consumption to finance the stimulus. The reason for this is that, from economic point of view, changes in VATET on public investment and on public consumption are relevant, and increasing VATET on investment is counter-productive. In practice, we acknowledge how difficult it would be just to apply the increased to consumption goods. Simulation results suggest that, if no other means were available to finance the stimulus component then the general statutory VAT rate would have to increase to 2.23 percentage points in 2000 and gradually for to 1.73 percentage points in 2050. This means that the increase in VAT would have to be permanent. Coincidence or not, it is curious to note that the required increases are very much in the neighborhood of the maximum increase allowed. Under VAT financing at the consumption margin, the "tax shock" yields a GDP that in 2050 is 2.77% higher than in the *status quo*. This represents the last in performance gains of around 4.8% when compared with the lump sum financing arrangement. As a result, the various types of capital do well, and employment is 1.46% higher, but the after-tax wage is only 0.92% higher. This is because the increase in the VAT rate penalizes consumption. With leisure being a complement good of consumption, households naturally increase their

supply of labor. Under such a setting, in spite of higher corporate profits down the road, we should not be surprised that the GDP welfare trade-off makes its appearance once more.

6.2.5. Public consumption financing

When the stimulus component is financed with public consumption, long-term GDP increases 2.56%. Contrary to what might be expected, lump sum tax financing still yields the largest gains in GDP performance. This is mainly because, under this arrangement, the public sector is doing the required saving and private consumption needn't fall as much. With leisure being a normal good that is also a complement of consumption, households choose to supply much less labor. For this reason, the after-tax wage rises the most of all scenarios, i.e., 2.41%. Naturally then, consumption is always higher and the respective component of private welfare increases 1.24%.

6.2.6. On the composition of the stimulus and financing

In each of the above cases, a given margin was chosen to provide the funds that are needed to ensure deficit neutrality. We focus on deficit neutrality rather than on revenue neutrality because, under endogenous growth, the accumulation of public capital and human capital stocks is optimum and responds to market conditions. This means that, as a result of the stimulus component that promotes growth, further funds are needed to finance these public investments.

[Table 13]

We have said one more than one occasion that, depending on how the tax package is financed, the tax bases will change endogenously. This means that the margin that is financing the stimulus needn't do all the work. In fact, if the hypothesis behind Laffer's curve were true, the stimulus component would finance itself through the growth of the economy. Table 5 examines this issue and details, for each of the margins used and the three distinct time periods, how this financing effort would be split between the margin used and the endogenous adjustment of the other tax bases. In no case is the Laffer hypothesis confirmed; at most, the stimulus component is self-financed in 64% by 2050 when the VAT margin is used. It is also

interesting to note that the lump sum taxes and VAT financing arrangements provide quite significant second round effects that over time provide the supplementary tax revenues.

6.3. Sensitivity analysis

Most of the gains in GDP performance that are induced by the "tax shock" are predicated on positive changes in public and human capital accumulation, as well as on the labor supply. In this subsection we explore how sensitive the simulation results are to the assumptions of an endogenous supply of labor, and an endogenous growth mechanism, whereby public investment activities in infrastructures and in education are smart, i.e., they respond to market incentives and thus guarantee sustained economic growth.

The simulation results (see Table 14) suggest that, when the labor market channel is closed off and employment is thus held fixed and unresponsive to improved market conditions, then the GDP gains are reduced by around 80%. Generally speaking, because the effects of more investment on consumption are minimized, the consumption component of private welfare is almost always lower.

[Table 14]

Under exogenous growth (that with an endogenous labor supply), curiously enough, the GDP gains are also reduced by around 80%, but the consumption component of private welfare is always higher. This is because no further public investments are made and therefore compensating taxes do not increase as much. Of course, an implication of this is that the growth effects of the "tax shock" are seriously dampened and more consumption in the present replaces less consumption in the future.

7. Concluding remarks

Here we distil the simulation results into a single, hopefully coherent, view on the macroeconomic effects of the "tax shock". We also ask what tax policy in Portugal can learn from the whole exercise.

We start with the tax package *per se*. Many scenarios had to be built because the way the stimulus component will be financed is uncertain. Our reading of the simulation results suggests there are two

possible outcomes. If the financing is obtained with an equal combination of a reduction in the wastefulness of public spending, and a non-distortionary combat to tax evasion, then GDP in 2050 would be around 2.75% higher and the consumption and leisure components of private welfare will change by 0.75 and –0.4%, respectively. In this case, our calculations suggest that the ratio of public consumption to GDP would have to be reduced by a further 0.5 percentage points. But, under a far more likely scenario, where the necessary financing is made up with an equal combination of VAT, PIT, and CIT financing, GDP would be around 1.5% higher, but the changes in the consumption and leisure components of private welfare would be –0.5 and –0.2%, respectively. In this case, focusing just on the consumption component, there would be a trade-off between GDP and welfare.

We think that the nature of this trade-off provides an important and interesting lesson for tax policy in Portugal. It goes something like this. Tax reform proposals, in addition to improving the incentives to invest, should focus exclusively on increasing the demand for labor (a reduction in the CIT and in the FSSC are good examples of this). When it comes to financing these tax breaks, the margins used should *not* induce an increased supply of labor (an increase in the VAT or in the PIT, for example, should not be used to finance the tax breaks) because doing so can exacerbate the GDP welfare trade-off. This is because the increased supply of labor will induce a fall in the after-tax wage, and this is crucial for the household's decision of how much to consume.

Clearly, this trade-off between long-term GDP and private welfare can be construed as an indictment of the "tax shock". One should be careful, however, to note that this conflict is a direct consequence of the current institutional constraints in Portugal (namely the budgetary rules imposed under the EMU) and is induced by the need to trade off distortionary tax margins. Indeed, reductions in public consumption above and beyond those required by the Stability and Growth Pact do not seem particularly realistic. Excesses and inefficiencies in public consumption, just like evasion, avoidance and fraud at the various tax margins are issues that should always be addressed irrespective of the need to finance a given tax reform package. This is because, desirable as they are, their success is always uncertain.

In this setting, it seems legitimate to ask what the alternatives are, i.e., how should a growth-augmenting (or a labor demand increasing) tax reform package be financed? It can be argued on the grounds of an intertemporal and intergenerational smoothing of private consumption that such policy changes should be

deficit-financed, just like public investment projects are. This is because, otherwise, the present generations bear most of the brunt in favor of future generations. Once again, though, desirable as such a plan may seem, if such initiatives were made widespread then real interest rates on international capital markets would be bid upwards and through the financial crowding out channel, some of the benefits of the tax reform package would be undone. Of course, only developing or catching up countries, such as Portugal, could be allowed to do deficit finance growth augmenting tax reforms, but that would raise sensitive issues on cross-border tax competition. Anyway, to implement such a form of financing, a method to minimize abusive behaviors by Governments would have to be devised, and it is not at all clear whether such can be done.

On a different, but equally arguable plane, maybe balanced budgets should always be safeguarded and tax policy should not be used to promote the growth of nations. In that case we must look elsewhere to promote a faster catch-up. In the various simulations we ran, there were two where we compared the effects of the "tax shock" under exogenous and endogenous labor supply. We concluded that, when the level of employment is held fixed because the supply of labor is unresponsive to improved market conditions, the long-term growth effects are dampened by as much as 80%. Now, the Portuguese labor market is far from perfectly competitive and is well known for its rigidities that mostly come from an overly protective employment legislation. Dismissal costs, for example, are high by international standards and serve as an important obstacle in the demand for labor. It is a factor that makes an employer think twice before giving a worker a lifetime tenure. In this regard, a careful re-examination of the employment protection legislation in Portugal could be a recipe for economic growth, one that additionally does not require compensating sources of financing.

Which of the two alternatives put forward here is the best one for the Portuguese economy in its current form is a open question for future research.

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Table 1 - *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
$t_{VAT,5}$	$\leq$ 2pp	0.1700	0.1900
Part of the increase earmarked as 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		

Table 2 - *How the package changes effective tax rates*

Statutory Change	Effective Impact	From	To
$\Delta t_{CIT} = -4\text{pp}$	$\Delta\tau_{CITd} = -0.04 \cdot 0.30734$	0.10449	0.09219
$\Delta t_{FSSC} = -4\text{pp}$	$\Delta\tau_{FSSC} = -0.04 \cdot 0.54656$	0.13984	0.11797
$\Delta t_{PIT,4} = -5\text{pp}$	$\Delta\tau_{PIT} = -0.05 \cdot 0.07100$	0.09964	0.09609
$\Delta t_{VAT,5} = +2\text{pp}$	$\Delta\tau_{VATET,C} = +0.02 \cdot 0.67402$	0.21344	0.22692

Table 3 - *The dynamic general equilibrium model*

Equations of the Production Sector

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

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

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

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

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

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

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

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

Table 3 - *The dynamic general equilibrium model*

Equations of the Household Sector

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

$$\text{Consumption component of } U_t = \sum_{n=t_0}^{\infty}(\beta\gamma)^{n-t_0}C_n \tag{9}$$

$$\text{Leisure component of } U_t = \sum_{n=t_0}^{\infty}(\beta\gamma)^{n-t_0}\ell_n \tag{9a}$$

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

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

$$\begin{aligned} HW_{a,t} = {} & \sum_{m=0}^{\infty}\left(\frac{\gamma}{1+(1-\tau_r)r_{t+m}}\right)^m \cdot \\ & \cdot\{(1-\tau_{WSSC})(1-\tau_{PIT})\cdot[W_{t+m}HK_{t+m}(\bar{L}-\ell_{a+m,t+m})] + (1-\tau_{PIT})\cdot \\ & \cdot\varphi TR1_{t+m} + (1-\varphi)TR1_{t+m} + TR2_{t+m} + TR3_{t+m} + R_{t+m} - LST_{t+m}\} \end{aligned} \tag{12}$$

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

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

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

Table 3 - *The dynamic general equilibrium model*

Equations of the Public Sector

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

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

$$TR_t = TR1_t + TR2_t + TR3_t + TR4_t$$

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

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

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

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

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

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

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

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

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

Table 3 - *The dynamic general equilibrium model*

Conditions for Market Equilibrium

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

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

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

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

Table 4 - *The model: data set (1990-1998 averages)*

Variable	Description	Value
	Domestic spending data (% of Y_0)	
Y_0	Domestic production at market prices in 1999 (10^{12} PTEs)	20.36300
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	0.70875
R_0	Unilateral transfers	7.26420
CAD_0	Current account deficit (+) (CAL)	0.505119
FD_0	Foreign debt in 1999	13.50000
	Population and employment data	
POP_0	Population in 1999	9,979,450
YOU_0	Population aged 0-14	1,681,540
ACT_0	Population aged 15-64	6,778,900
ELD_0	Population aged 65 and over	1,519,010
$PARTR$	Participation rates in 1999	
$PARTRY_0$	Participation rate of those aged 0-14 young	0.00000
$PARTRA_0$	Participation rate of those aged 15-64	72.47210
$PARTRE_0$	Participation rate of those aged 65 and over	11.23917
UR_0	Unemployment rate	5.70000
	Capital stocks (% of Y_0)	
K_0	Private capital stock (CAL)	204.21222
KG_0	Public capital stock (CAL)	53.70281
HK_0	Human capital stock (CAL)	341.10706

Table 4 (Cont'd) - *The model: data Set (1990-1998 averages)*

Variable	Description	Value
	Public Account data (% of Y_0)	
TR_0	Total public transfers	14.20069
T_0	Total tax revenues	36.33026
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	4.46074
$TrCGA_0$	Transfers to the CGA included in CG_0	2.51000
$WSSC_0$	Workers' social security contribution revenues	3.99042
$WSSC1_0$	on private sector workers	2.97383
$WSSC2_0$	on public sector employees	1.05659
LST_0	Lump sum tax revenues (CAL)	4.33128
$r_0^{PD} PD_0$	Interest payments on public debt	2.96625
DEF_0	Public deficit (+) (CAL)	1.49725
PD_0	Public debt in 1999	56.50000

Note: All values are 1990-1998 averages unless otherwise stated.

Table 5 - *The model: structural parameters*

Symbol	Description	Type	Value
	Household parameters		
β	Discount factor = (1+ discount rate)$^{-1}$	CAL	0.97705
γ	Probability of survival	DAT	0.97449
$gPOP$	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	0.05866
μ_I	Adjustment cost coefficient	CAL	2.20037
AC_I	Adjustment cost as a % of private investment	CAL	0.25000
$\dot{A}/A$	Exogenous rate of technological progress	ARB	0.00000
	Public sector parameters - outlays parameters		
δ_{KG}	Public infrastructure's depreciation rate	CAL	0.02997
μ_{KG}	Adjustment cost coefficient	CAL	3.32028
AC_{IG}	Adjustment cost as a % of public investment	CAL	0.25000
δ_{HK}	Human capital's depreciation rate	CAL	0.01000
μ_{HK}	Adjustment cost coefficient	CAL	11.36713
AC_{IH}	Adjustment cost as a % of human capital investment	CAL	0.25000
	Real interest rates		
r, r^{FD}, r^{PD}	Basic rate, *idem* on foreign debt, *idem* on public debt	DAT	0.05250

Table 5 (Cont'd) - *The model: structural parameters*

Symbol	Description	Type	Value
	Public sector parameters - tax parameters		
τ_{PIT}	Effective personal income tax rate	DAT	0.10533
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	0.12291
τ_{WSSC}	Workers' effective social security contributions rate	DAT	0.10995
$gLST$	Growth of lump sum taxes	CAL	0.02650

Table 6 - *Simulation results of the baseline scenario (units 1999 = 100.00)*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth						
GDP	102.58	133.00	172.38	223.33	289.22	374.40
GDP growth rate (in percent)	2.63	2.63	2.63	2.62	2.62	2.61
Private capital	102.63	133.07	172.48	223.50	289.53	374.98
Public capital	102.63	133.06	172.48	223.53	289.62	375.21
Labor input	102.51	132.93	172.27	223.14	288.85	373.68
Human capital	102.64	133.19	172.80	224.18	290.80	377.20
Employment	99.87	99.81	99.69	99.53	99.33	99.07
Welfare						
Private welfare – total	1.42	7.65	12.64	16.63	19.83	22.39
Private welfare – consumption component	1.98	10.67	17.61	23.17	27.62	31.19
Private welfare – leisure component	1.40	6.68	9.93	11.93	13.16	13.92
Public finance (as a percentage of GDP)						
Public debt	57.01	46.82	36.19	27.85	21.49	16.58
Public consumption	11.19	10.08	10.57	10.95	11.26	11.50
Total tax revenues	36.37	36.26	26.20	36.17	36.17	36.19
Personal income tax	6.11	6.00	5.89	5.80	5.73	5.67
Corporate income tax	3.10	3.10	3.10	3.10	3.10	3.10
Value added and excise taxes	14.23	14.21	14.26	14.32	14.40	14.48
Employers' SS contributions	5.00	5.00	5.00	4.99	4.99	4.99
Employees' SS contributions	4.10	4.10	4.10	4.10	4.10	4.09
Lump sum taxes	3.83	3.84	3.85	3.85	3.86	3.87

Table 7 - *Effects of the tax reform package under lump sum tax financing*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth (deviations from the baseline scenario in percent)						
GDP	0.52	1.03	1.51	1.96	2.43	2.91
GDP growth rate (in pp)	0.06	0.05	0.05	0.05	0.05	0.05
Private capital	0.09	0.85	1.49	2.06	2.59	3.11
Public capital	0.05	0.55	1.04	1.53	2.01	2.50
Labor input	1.02	1.34	1.67	2.03	2.42	2.88
Human capital	0.02	0.26	0.52	0.79	1.06	1.35
Employment	0.99	1.07	1.15	1.23	1.35	1.51
Welfare (deviations from the baseline scenario in percent)						
Private welfare – total	–0.59	–0.47	–0.37	–0.28	–0.22	–0.18
Private welfare – consumption component	–0.15	–0.02	0.10	0.20	0.27	0.33
Private welfare – leisure component	–0.44	–0.45	–0.46	–0.47	–0.48	–0.49
Public finance (deviations from the baseline scenario in pp of GDP)						
Public debt	–0.26	–0.42	–0.48	–0.49	–0.46	–0.42
Public consumption	–0.05	–0.09	–0.14	–0.20	–0.25	–0.30
Total tax revenues	0.02	–0.11	–0.23	–0.34	–0.45	–0.56
Personal income tax	–0.04	–0.04	–0.04	–0.04	–0.03	–0.03
Corporate income tax	–0.39	–0.39	–0.39	–0.39	–0.39	–0.39
Value added and excise taxes	–0.05	–0.07	–0.09	–0.12	–0.16	–0.20
Employers' SS contributions	–0.70	–0.70	–0.70	–0.70	–0.69	–0.69
Employees' SS contributions	0.08	0.08	0.08	0.08	0.08	0.09
Lump sum taxes	1.10	1.00	0.90	0.89	0.73	0.66

Table 8 - *Effects of the tax reform package under corporate income tax financing*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth (deviations from the baseline scenario in percent)						
GDP	0.27	0.28	0.36	0.51	0.70	0.95
GDP growth rate (in pp)	0.00	0.01	0.01	0.02	0.02	0.03
Private capital	–0.04	–0.32	–0.43	–0.43	–0.34	–0.20
Public capital	0.01	0.16	0.30	0.45	0.62	0.80
Labor input	0.60	0.79	1.01	1.27	1.56	1.91
Human capital	0.01	0.08	0.16	0.25	0.34	0.44
Employment	0.59	0.71	0.85	1.02	1.22	1.47
Welfare (deviations from the baseline scenario in percent)						
Private welfare – total	0.59	0.40	0.22	0.06	–0.09	–0.24
Private welfare – consumption component	0.85	0.68	0.53	0.39	0.27	0.14
Private welfare – leisure component	–0.26	–0.28	–0.30	–0.32	–0.33	–0.35
Public finance (deviations from the baseline scenario in pp of GDP)						
Public debt	–0.17	–0.12	–0.11	–0.11	–0.11	–0.11
Public consumption	–0.04	–0.03	–0.03	–0.04	–0.06	–0.08
Total tax revenues	–0.06	–0.03	–0.03	–0.05	–0.08	–0.12
Personal income tax	–0.11	–0.11	–0.12	–0.12	–0.12	–0.12
Corporate income tax	0.64	0.71	0.75	0.78	0.81	0.84
Value added and excise taxes	0.04	0.00	–0.04	–0.08	–0.14	–0.22
Employers' SS contributions	–0.70	–0.70	–0.70	–0.69	–0.69	–0.69
Employees' SS contributions	0.08	0.08	0.08	0.08	0.08	0.09
Lump sum taxes	–0.01	–0.01	–0.01	-0.02	–0.02	–0.03

Table 9 - *Effects of the tax reform package under personal income tax financing*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth (deviations from the baseline scenario in percent)						
GDP	–0.09	0.06	0.20	0.35	0.52	0.72
GDP growth rate (in pp)	0.02	0.02	0.02	0.02	0.02	0.02
Private capital	0.03	0.30	0.52	0.71	0.90	1.09
Public capital	0.01	0.09	0.20	0.32	0.46	0.60
Labor input	–0.21	–0.13	–0.04	0.08	0.24	0.46
Human capital	0.00	0.05	0.11	0.18	0.25	0.33
Employment	–0.22	–0.19	–0.16	–0.10	–0.01	0.13
Welfare (deviations from the baseline scenario in percent)						
Private welfare – total	–1.23	–1.12	–1.04	–0.99	–0.97	–0.98
Private welfare – consumption component	–1.32	–1.21	–1.12	–1.07	–1.04	–1.04
Private welfare – leisure component	0.10	0.09	0.09	0.08	0.07	0.07
Public finance (deviations from the baseline scenario in pp of GDP)						
Public debt	0.12	0.02	–0.04	–0.07	–0.08	–0.09
Public consumption	0.02	0.01	–0.01	–0.03	–0.04	–0.06
Total tax revenues	0.12	0.07	0.03	0.00	–0.04	–0.08
Personal income tax	1.21	1.16	1.13	1.11	1.09	1.09
Corporate income tax	–0.38	–0.38	–0.38	–0.38	–0.38	–0.38
Value added and excise taxes	–0.11	–0.10	–0.10	-0.11	–0.13	–0.18
Employers' SS contributions	–0.69	–0.69	–0.69	–0.69	–0.69	–0.69
Employees' SS contributions	0.09	0.09	0.09	0.09	0.09	0.09
Lump sum taxes	0.01	0.00	0.00	–0.01	–0.01	–0.02

Table 10 - *Effects of the tax reform package under value added and excise tax financing*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth (deviations from the baseline scenario in percent)						
GDP	0.29	0.77	1.23	1.71	2.22	2.77
GDP growth rate (in pp)	0.05	0.05	0.05	0.05	0.05	0.05
Private capital	0.07	0.73	1.32	1.87	2.41	2.96
Public capital	0.04	0.47	0.92	1.39	1.87	2.36
Labor input	0.55	0.88	1.26	1.68	2.17	2.76
Human capital	0.02	0.24	0.48	0.73	1.00	1.27
Employment	0.53	0.65	0.78	0.94	1.16	1.46
Welfare (deviations from the baseline scenario in percent)						
Private welfare – total	–1.04	–0.98	–0.91	–0.88	–0.87	–0.90
Private welfare – consumption component	–0.81	–0.72	–0.64	–0.58	–0.55	–0.55
Private welfare – leisure component	–0.23	–0.25	–0.27	–0.29	–0.30	–0.32
Public finance (deviations from the baseline scenario in pp of GDP)						
Public debt	–0.76	–0.76	–0.71	-0.65	–0.58	–0.51
Public consumption	–0.15	–0.18	–0.22	–0.27	–0.32	–0.37
Total tax revenues	–0.36	–0.43	–0.51	–0.60	–0.70	–0.81
Personal income tax	–0.10	–0.10	–0.09	–0.09	–0.08	–0.08
Corporate income tax	–0.42	–0.42	–0.42	–0.41	–0.41	–0.41
Value added and excise taxes	0.93	0.86	0.77	0.68	0.58	0.46
Employers' SS contributions	–0.75	–0.74	–0.74	–0.73	–0.73	–0.72
Employees' SS contributions	0.03	0.04	0.04	0.05	0.06	0.06
Lump sum taxes	–0.05	–0.07	–0.08	–0.09	–0.11	–0.11

Table 11 - *Effects of the tax reform package under public consumption financing*

Variable	2000	2010	2020	2030	2040	2050
GDP and fundamentals of long-term growth (deviations from the baseline scenario in percent)						
GDP	0.27	0.72	1.15	1.59	2.05	2.56
GDP growth rate (in pp)	0.05	0.04	0.04	0.04	0.05	0.05
Private capital	0.07	0.70	1.25	1.76	2.27	2.77
Public capital	0.04	0.44	0.86	1.29	1.73	2.18
Labor input	0.51	0.82	1.16	1.55	1.99	2.51
Human capital	0.02	0.22	0.44	0.68	0.92	1.18
Employment	0.49	0.60	0.72	0.87	1.06	1.32
Welfare (deviations from the baseline scenario in percent)						
Private welfare – total	0.91	0.95	0.97	0.97	0.96	0.91
Private welfare – consumption component	1.13	1.19	1.23	1.26	1.26	1.24
Private welfare – leisure component	–0.21	–0.23	–0.25	–0.27	–0.28	–0.29
Public finance (deviations from the baseline scenario in pp of GDP)						
Public debt	–0.19	–0.34	–0.40	–0.41	–0.40	–0.38
Public consumption	–1.07	–1.05	–1.04	–1.03	–1.04	–1.05
Total tax revenues	–1.01	–1.05	–1.10	–1.14	–1.20	–1.28
Personal income tax	–0.04	–0.04	–0.04	–0.04	–0.04	–0.04
Corporate income tax	–0.39	–0.39	–0.39	–0.39	–0.39	–0.39
Value added and excise taxes	0.07	0.03	0.00	–0.04	–0.10	–0.18
Employers' SS contributions	–0.70	–0.70	–0.70	–0.70	–0.70	–0.70
Employees' SS contributions	0.08	0.08	0.08	0.08	0.08	0.08
Lump sum taxes	–0.01	–0.03	–0.04	–0.06	–0.07	–0.09

Table 12 - *Effects of the tax reform package – a summary table*

Case	GDP in 2050	Welfare (total)	Consumption component	Leisure component
Effects of the stimulus component margin by margin under lump sum tax financing				
Effects of a reduction in the CIT rate	+0.94	–0.23	–0.14	–0.09
Effects of a reduction in the FSSC rate	+1.02	+0.49	+0.75	–0.25
Effects of a reduction in the PIT rate	+1.15	–0.55	–0.36	–0.17
The full stimulus component financed by...				
Lump sum tax	+2.91	–0.18	+0.33	–0.49
Corporate income tax	+0.95	–0.27	+0.12	–0.35
Personal income tax	+0.72	–0.99	–1.04	+0.07
Value added and excise taxes	+2.77	–0.91	–0.55	–0.32
Public consumption	+2.56	+0.90	+1.24	–0.30

Table 13 - *Composition of the stimulus and financing in 2000, 2025, and 2050*

		Margins						Change in
	% GDP	PIT	CIT	VATET	FSSC	LST	CG	tax bases
Stimulus	1.29	9.08	29.09	–	61.83	–	–	–
				In 2000				
Financed by...								
LST	1.29	–	–	–	–	85.27	–	14.73
CIT	1.29	–	49.61	–	–	–	–	50.39
PIT	1.29	93.80	–	–	–	–	–	6.20
VATET,C	1.29	–	–	72.09	–	–	–	27.91
CG	1.29	–	–	–	–	–	82.95	17.05
				In 2025				
Financed by...								
LST	1.29	–	–	–	–	66.67	–	33.33
CIT	1.29	–	59.69	–	–	–	–	40.31
PIT	1.29	86.82	–	–	–	–	–	13.18
VATET,C	1.29	–	–	56.59	–	–	–	43.41
CG	1.29	–	–	–	–	–	80.62	19.38
				In 2050				
Financed by...								
LST	1.29	–	–	–	–	51.25	–	48.75
CIT	1.29	–	65.04	–	–	–	–	34.96
PIT	1.29	84.62	–	–	–	–	–	15.38
VATET,C	1.29	–	–	35.99	–	–	–	64.01
CG	1.29	–	–	–	–	–	81.56	18.44

Table 14 - *Effects of the tax reform package under different modeling assumptions*

Case	GDP in 2050	Welfare (total)	Consumption component	Leisure component
The tax reform package financed with LST				
Effects under central assumptions	+2.91	–0.18	+0.33	–0.49
Effects under alternative assumptions				
Exogenous labor supply	+0.56	+0.30	+0.30	+0.00
Exogenous growth	+0.78	+0.20	+0.56	–0.36
The tax reform package financed with CIT				
Effects under central assumptions	+0.95	–0.27	+0.12	–0.35
Effects under alternative assumptions				
Exogenous labor supply	–1.93	–0.79	–0.79	+0.00
Exogenous growth	+0.15	+0.13	+0.43	–0.28
The tax reform package financed with PIT				
Effects under central assumptions	+0.72	–0.99	–1.04	+0.07
Effects under alternative assumptions				
Exogenous labor supply	+0.56	–1.00	–1.00	+0.00
Exogenous growth	+0.07	–0.50	–0.62	+0.12
The tax reform package financed with VATET				
Effects under central assumptions	+2.77	–0.91	–0.55	–0.32
Effects under alternative assumptions				
Exogenous labor supply	+0.56	–1.18	–1.18	+0.00
Exogenous growth	+0.69	–0.29	–0.08	–0.20
The tax reform package financed with CG				
Effects under central assumptions	+2.56	+0.90	+1.24	–0.30
Effects under alternative assumptions				
Exogenous labor supply	+0.56	+0.66	+0.66	+0.00
Exogenous growth	+0.53	+1.47	+1.63	–0.16