Employment and output effects of reducing labor taxes in Europe: a numerical approach[1]

Francesco Daveri
University of Parma, and IGIER

Marco Maffezzoli
IEP, Bocconi University

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Abstract

We calibrate a dynamic general equilibrium model with monopoly union bargaining to numerically evaluate the effects of a reduction in labor taxes on employment and output in Europe.Our key quantitative finding is that the effects of the labor tax cut are crucially determined by the dynamic response of capital accumulation to the tax reduction. Our numerical analysis demonstrates that the impact effects of the labor tax reduction are either magnified or outright overturned over time, depending on how the reduction is financed. If one purports to use simulation models for policy analysis, investigating the dynamics of the labor market is imperative. This conclusion is at variance with the prevailing view on the causes of unemployment in Europe, where a static rendition of the functioning of European labor markets is held as a common belief. Sensitivity analysis shows that our results are representative of the 'median' behavior of the model.

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1 Introduction

The current fiscal policy outlook in Europe is radically different compared to the 1990s. The key policy issue is no longer whether labor taxes can or should be reduced, but rather if the enacted tax cuts[1] will eventually deliver higher employment and output levels. Our paper is a structured answer to this question.

As effectively summarized in Pissarides (1998) and Gruber (1997), reducing labor taxes lowers labor costs and positively affects equilibrium employment, as long as three conditions are met. First, the tax-financed benefit arising to the worker are not fully internalized by the worker herself. Second, the worker's outside option are taxed at a lower rate than labor income and, third, are not fully indexed to the net real wage. We calibrate a dynamic general equilibrium model with exogenous growth and monopoly union bargaining,[2] which fulfils the three conditions above. Then the effects of a reduction in labor taxes on employment and output in eight "laboratory" EU economies are numerically evaluated, as well as in an artificial "EU aggregate", under the constraint that the government budget be balanced in every period.

Our key quantitative finding is that the effects of the labor tax cut are crucially determined by the dynamic response of capital accumulation to the tax reduction. When perturbed away from its long-run path, the economy takes a very long time (*i.e.* decades) to return to it. Moreover, the impact effects of the tax reduction may be either magnified or outright overturned over time. For both reasons, if one purports to use simulation models for policy analysis, investigating the dynamics of the labor market is imperative.

Why and how is capital accumulation so important? In the first set of our experiments, the labor tax reduction is matched by a decrease in government lump-sum transfers. Under the three conditions above, reducing labor taxation effectively lowers labor costs and raises the level of employment and output on impact. Higher employment simply raises the marginal productivity of capital, and thus investment and output along the way to the new steady state path. In turn, capital accumulation shifts the labor demand curve to the right, while, in parallel, the rise in unemployment benefits, indexed to equilibrium output, shifts the wage setting function upwards. As a result, the gross wage rate predictably rises on the way back to its long-run equilibrium path, after the initial reduction brought about by the tax decrease. The initial employment gain is instead magnified by capital accumulation. When the adjustment is complete, the real wage is back to its initial long-run path, for nothing has happened to the permanent growth rate of the economy. Employment levels are instead permanently higher than at the beginning.

The previous analysis applies when the labor tax reduction is matched by a decrease in government lump-sum transfers. Whether governments bridge the gap by

[1] In most European countries, budget plans for the years 2001-2003 do include provisions for staged reductions in social security contributions and marginal income tax rates, as well as some lowering of VAT rates on labor intensive services.

[2] As extensively documented by Nickell (1997), Nickell and Layard (1999), and Bertola (2000), imperfect competition is a well-known crucial feature of labor markets in Europe.

cutting spending or raising additional tax revenues obviously affects the response of the economy to the tax reduction. Irrespective of how the gap is bridged, though, the crucial importance of capital accumulation stands still. In the second set of our experiments, we also explore the effects of reducing labor taxation when governments, rather than cutting spending, raise capital taxes. If this is the case, the labor tax reduction remains still beneficial in terms of employment and output, but gains are eventually entirely eaten up. The distorting effects of such strategy are fully perceived only after some time, when the lowered capital accumulation has more than offset the beneficial effects of the cut in labor taxation.

Finally, our results are the outcome of a benchmark parameterization. Sensitivity analysis exercises suggest, though, that our findings remain roughly unchanged as the deep parameters are allowed to vary in a range of model-compatible values.

The structure of the paper is as follows. Section 2 presents the set-up of the model. Section 3 describes the calibration procedure. Section 4 presents our benchmark and sensitivity analysis results. A road-map to the relations between our and previous results is in Section 5. Section 6 concludes.

2 The model

The theoretical structure of our model is described in detail throughout this Section. Its building blocks can be summarized as follows.

1. The economy is populated by many identical infinitely-lived households and firms. Both are price-takers on the markets for goods and capital services.

2. Though numerous, households are not small in labor markets. If employed, each household member works only for a fixed number of hours, selling her unit labor endowment to only one firm at a time; individual labor supply is thus indivisible. Households perceive the scope for extracting monopoly rents from the firm by organizing themselves into firm-level unions.[3]

3. Unions are delegated the function of negotiating the wage with the firm. Unions perform their function by unilaterally setting the wage in order to maximize the labor income of their members. They do not maximize capital incomes as well, for they too are price takers on the market for capital services and take the rental rate (as well as tax or replacement rates) as given. To prevent wage underbidding on the part of the unemployed (and maintain households identical over time), unions redistribute the wage bill accrued to its employed members among all union members.

[3]By clearly identifying her job-provider as well as those working with her, any household member perceives the scope for extracting some producer's surplus by forming a firm/sector-specific monopoly union, while remaining price-takers in the market for capital services. We do not model explicitly the process of union formation. Within a two-person one-firm game-theoretical framework, Horn and Wolinsky (1988) formally proved that highly substitutable workers have an incentive to form a union when contracting over their wage, while complementary workers don't. Our assumption of identical households amounts to assuming perfect substitutability among workers.

4. Firms set employment at the preset wage level.[4] In each period, firms are allowed to negotiate with only one union, while each union may negotiate with many firms; in other words, each firm, once matched with a union, buys labor services from that union only, under the closed shop assumption.[5]

5. Neither the union nor the firm can credibly commit to their future courses of actions.

Union's monopolistic behavior drives up the wage rate to a level higher than in the competitive model, with the well-known unemployment and deadweight loss consequences. However, households do not internalize that unions simply increase the labor share in their incomes at the expenses of the capital share, while decreasing the overall income level relatively to the Pareto-efficient allocation.

2.1 Firms and technology

Firms produce a homogeneous consumption good using the same constant returns to scale technology. Consequently, they can be aggregated into a representative firm that buys factor services from the owners of capital and labor endowments, *i.e.* the households. Production technology is summarized by the following CES aggregate production function:[6]

$$y_t = \left(\alpha k_t^\eta + n_t^\eta\right)^{\frac{1}{\eta}} \tag{1}$$

where $\eta < 1$ and $\alpha > 0$; in our notation, y_t represents the aggregate output level, k_t the aggregate stock of physical capital, and n_t the aggregate employment level. All aggregate variables are measured in per-capita efficiency units, *i.e.* divided by the product of total population in working age with an efficiency index. Population is constant, while exogenous technical change makes the efficiency index grow at the constant rate γ.

At each date, the representative firm maximizes the discounted flow of future profits, taking as given the sequence of rental rates (determined on the market for capital services) and the sequence of wage rates (determined by the union).

[4] Empirical and theoretical rationales can be advanced to defend the *sequential* structure of our model (see the discussion in Manning, 1987, pp. 122-124). In particular, it is widely observed that collective bargains are usually characterized by a sequential feature, and wages are commonly set in advance of employment. Moreover, there is further evidence that unions have a greater influence over the wage than the employment level, while firms usually retain a unilateral right to vary employment. The monopoly union feature remains a special case, instead, with an advantage in terms of algebraic simplicity *vis-a-vis* the right-to-manage model.

[5] This assumption is designed to rule out Bertrand competition among unions, which would reproduce the competitive outcome.

[6] The elasticity of substitution between physical capital and labor is $\xi = 1/(1-\eta)$; unlike the Cobb-Douglas, the CES functional form does not imply a unit elasticity of substitution. As shown below, this opens the route for *both* capital and labor taxes to affect employment along the transition path.

2.2 Unions

As in the standard monopoly union model,[7] the union unilaterally sets the wage in order to maximize the average income of its members:

$$n_t w_t (1 - \tau^N) + (1 - n_t) s_t (1 - \tau^S) \tag{2}$$

where s_t represents the per-capita unemployment subsidy, τ^N the average tax rate on labor income, and τ^S the average tax rate on subsidies.

Following Anderson and Devereux (1988), we extend the standard setting by including the firm's decision as to the demand for physical capital services, under the assumption that neither the union nor the firm can credibly commit, respectively, to a sequence of wage rates and demands for capital services.

As a result of the bargaining process, some members of the union remain unemployed. If employed, a household member supplies one unit of labor and is rewarded at the monopoly wage rate. The unemployed, instead, cash an unemployment subsidy from the government.

What prevents wage underbidding on the part of the unemployed? Although being employed or unemployed may be unknown *ex-ante*, the unemployed may well feel uneasy *ex-post* with the bargaining outcome, and leave the union when unemployed. In the anticipation of this outcome, unions preserve their membership by redistributing the wage bill accrued to its employed members among all union members. This extreme form of redistribution - somehow reminiscent of actual union practices - guarantees the same labor income to all, independently of labor market outcomes. As discussed in Pencavel (1985), unions act as substitutes for complete insurance markets. This also serves the important (technical) purpose of preserving agents' homogeneity over time.[8]

2.3 Union-firm bargaining

Building on one of the equilibrium concepts discussed in Anderson and Devereux (1988), we assume that the sequences of employment rates, wages, and demands for physical capital services are determined in a noncooperative game between unions and firms.

The strategic variables are respectively the sequences of wage rates for the unions and demands for capital services for the firms, yet scope for pre-commitment is barred on both sides. In other words, if strategic dominance is the relative power to commit to a strategy, neither party is strategically dominant.[9]

[7] The "monopoly union" model was originally introduced by Dunlop (1944) and Oswald (1982).

[8] This extreme form of redistribution is not necessarily desirable in more general settings, though. Had leisure been valued in the workers' utility function, the desirable amount of egalitarianism pursued by the union would be less than full (so as not to penalize those exerting a work effort vis-a-vis the unemployed). In the absence of full insurance, partial egalitarianism would however introduce heterogeneity among the households, with all the related technical difficulties.

[9] In the partial equilibrium models due to Grout (1984) and Van der Ploeg (1987), the firm can commit to its capital stock. It may thus be locked-in by the union, *i.e.* quasi-rents may be extracted

In *Appendix A* we show that, under our assumptions, employment, wage and the demand for physical capital services are jointly determined by the following equations:

$$r_t = \alpha \left(\frac{k_t}{y_t} \right)^{\eta - 1} \tag{3}$$

$$w_t = \left(\frac{n_t}{y_t} \right)^{\eta - 1} \tag{4}$$

$$\left(\frac{n_t}{y_t} \right)^{\eta - 1} \left[\eta + (1 - \eta) \left(\frac{n_t}{y_t} \right)^{\eta} \right] = \frac{1 - \tau^S}{1 - \tau^N} s_t \tag{5}$$

We restrict then our attention to Markov strategies, only dependent on the current state variable, *i.e.* the capital stock.

2.4 Intertemporal household choice

Under our set of assumptions, all household members are and remain effectively identical at any moment in time. Thus both the employed and unemployed household members can be aggregated into a representative household that maximizes an intertemporal utility function:

$$U_t = \sum_{s=t}^{\infty} \hat{\beta}^{s-t} \frac{\tilde{c}_s^{1-\mu}}{1 - \mu} \tag{6}$$

where $\mu < 1$ and $\hat{\beta} \equiv \beta \gamma^{1-\mu}$ (a tilde identifies individual-level variables), subject to the following intratemporal budget constraint:

$$\begin{gathered} \tilde{c}_t + \tilde{\imath}_t = r_t \tilde{k}_t - \tau^K (r_t - \delta) \tilde{k}_t + \\ n_t w_t (1 - \tau^N) + (1 - n_t) s_t (1 - \tau^S) + t_t \end{gathered} \tag{7}$$

where τ^K is the tax rate on the real return on physical capital, δ is the physical capital depreciation rate, and t_t the per-capita lump-sum government transfer, and the following accumulation equation:

$$\gamma \tilde{k}_{t+1} = (1 - \delta) \tilde{k}_t + \tilde{\imath}_t \tag{8}$$

Equation (7) embodies full tax deductibility of physical capital depreciation. Moreover, the expression $n_t w_t (1 - \tau^N) + (1 - n_t) s_t (1 - \tau^S)$ is the average net-of-tax labor income after the redistribution carried out by the union. Note that the sequences of prices $\{w_s, r_s\}_{s=t}^{\infty}$ and aggregate variables $\{n_s, s_s, t_s\}_{s=t}^{\infty}$ are taken as given by the

from the installed machines by claiming higher wages than agreed *ex-ante*. Note however that, in our framework, if a centralized union were able to take into account the effects of its behavior on the rental rate, it would maximize the average total income of its members, and so full employment would emerge as the only possible solution. In other words, the centralized union would have no role in such a general equilibrium setting, since full employment is the natural competitive outcome.

representative household.

Finally a set of aggregate constraints must be satisfied. In each period, the government has to satisfy the following aggregate per-capita budget constraint:

$$\tau^K(r_t - \delta)k_t + \tau^N n_t w_t + \tau^S(1 - n_t)s_t = t_t + (1 - n_t)s_t \tag{9}$$

On the left-hand side, total tax revenues are the sum of the revenue from capital and labor income taxes, and from the taxes on the unemployment benefits. On the right-hand side, total spending consists of two items, lump-sum transfers and unemployment benefits. Government transfers are there to allow us to separately evaluate the effects of a change in the tax rates from the effects of a change in the subsidy rate.

A recursive equilibrium for our economy can be defined as:

- a sequence of prices, $\{w_s, r_s\}_{s=t}^{\infty}$;
- a sequence of *individual* consumption levels and capital stocks, $\left\{\tilde{c}_s, \tilde{k}_s\right\}_{s=t}^{\infty}$;
- a sequence of *aggregate* consumption levels and capital stocks, $\{c_s, k_s\}_{s=t}^{\infty}$;
- a sequence of employment rates $\{n_s\}_{s=t}^{\infty}$;
- a sequence of unemployment benefits $\{s_s\}_{s=t}^{\infty}$ and per-capita lump-sum transfers $\{t_s\}_{s=t}^{\infty}$;

such that:

- the individual quantities $\left\{\tilde{c}_s, \tilde{k}_s\right\}_{s=t}^{\infty}$ solve the representative household optimization problem for the given sequences $\{w_s, r_s, n_s, s_s, t_s\}_{s=t}^{\infty}$;
- the aggregate quantities $\{n_s, k_s\}_{s=t}^{\infty}$ solve the representative firm's optimization problem for the given sequences $\{w_s, r_s\}_{s=t}^{\infty}$;
- the individual and aggregate quantities are consistent, $\tilde{c}_t = c_t$ and $\tilde{k}_t = k_t$;
- the goods market clears, $c_t + \gamma k_{t+1} - (1 - \delta)\, k_t = y_t$;
- the employment levels $\{n_s\}_{s=t}^{\infty}$ solve the union's optimization problem for the given sequences $\{r_s, s_s, k_t\}_{s=t}^{\infty}$;
- the government budget constraint is satisfied.

The following set of difference equations fully characterize the previously described dynamic recursive equilibrium:[10]

$$\left(\frac{n_t}{y_t}\right)^{\eta-1}\left[\eta + (1-\eta)\left(\frac{n_t}{y_t}\right)^{\eta}\right] = \frac{1-\tau^S}{1-\tau^N}s_t \tag{10}$$

[10] Our solution procedure focuses on invariant policy functions generating stationary paths; this guarantees that the two transversality condition we implictly imposed are satisfied.

$$\gamma c_t^{-\mu} = \hat{\beta} c_{t+1}^{-\mu} \left[(r_{t+1} - \delta) \left(1 - \tau^K\right) + 1 \right] \tag{11}$$

$$\gamma_t k_{t+1} = (1-\delta) k_t + y_t - c_t \tag{12}$$

$$y_t^{\eta} = \alpha k_t^{\eta} + n_t^{\eta} \tag{13}$$

$$r_t = y_t^{1-\eta} \alpha k_t^{\eta-1} \tag{14}$$

Equations (10) and (11) are respectively the Euler equation for the union and the household, while (12) corresponds to the accumulation equation. We add equations (13) and (14) for notational convenience.

We assume that the unemployment benefit is a constant fraction of output, *i.e.* $s_t = \sigma y_t$, where $0 < \sigma < 1$. In what follows, we refer to σ as the subsidy share. This specification has strong implications, since any shock to Total Factor Productivity influences immediately the union's outside option, and so the wage rate.

Furthermore, we assume that the tax rate on the unemployment benefits is directly proportional to the tax rate on labor income, *i.e.* that $\tau^S = \phi \tau^N$, with $\phi > 0$. As shown below, unemployment benefits are usually taxed at somewhat lower rates than wages, so that the actual ϕ is less than one. An important consequence of this specification is that any change in the labor tax rate translates immediately in a proportional change in the subsidy tax rate, dampening this way the reaction of employment to fiscal shocks. Yet, as long as $\phi < 1$, any change in the labor tax rate effectively discourages employment by driving a wedge between the employed and unemployment statuses.

3 Calibration

To perform any numerical experiment with our model, we need to parameterize it carefully. First of all, it is desirable that our results do not depend on unobservable cross-country differences in preferences, technology and depreciation parameters. Thus, we assume that the intertemporal elasticity of substitution in consumption, the intertemporal discount factor, the instantaneous elasticity of substitution between capital and efficient labor, and the depreciation rate do not differ across countries and are equal to:

$$\beta = 0.99, \quad \mu = 2, \quad \xi = 0.6, \quad \delta = 7.5\%$$

The discount factor and the elasticity of intertemporal substitution are standard in the literature. An elasticity of substitution between capital and labor equal to 0.6 implies a value for η equal to -0.67. In the next section, we perform a careful sensitivity analysis on the latter three parameters. In particular, we let the elasticity of substitution vary between 0.4 and 0.8, remaining therefore inside the "low elasticity" region.[11]

[11] Pissarides (1998) chooses a benchmark value of ξ equal to 0.7. Caballero and Hammour (1999) explore the consequences of assuming a very high elasticity of substitution between capital and labor.

The remaining parameters are all country-specific. They are either taken from other studies or calibrated. We borrow the 1960-1995 average effective tax rates on labor and capital , τ^N and τ^K, from the data set employed by Daveri and Tabellini.[12] Moreover, using data on gross and net replacement rates[13] provided by the *OECD Jobs Study* (1994, ch. 8, Annex 8.13), we can recover an (admittedly crude) estimate of the effective tax rate on employment benefits, and indirectly of the parameter $\phi = \tau^S/\tau^N$. The size of the parameter ϕ is crucial to determine the ultimate effect of a tax on labor income on employment (and growth). Were ϕ equal or close to one, this would imply that the tax rate on wages and unemployment benefits are very similar. Therefore, a change in τ^N would leave the equilibrium value of n unaffected.

The calibrated values for ϕ are summarized in **Table 2**: ϕ is quite low in Italy and Germany, close to 0.5 in Finland and Spain, and fairly high (some 0.75) in France, Belgium, the Netherlands, and Sweden. This implies that the unemployed enjoy a relatively more favorable tax treatment in Italy, Germany, Finland and Spain, than in France, Belgium, the Netherlands and Sweden. Reducing labor taxes is thus more likely effective in the former than in the latter group of countries. In the next section, this will be identified as the key mechanism driving results for individual countries.

Now we are left with a set of "hard-to-measure" parameters. In particular, we need values for α, the parameter of the CES related to the capital income share, and σ, the benefit-income share. Empirical estimates of the employment rate, n, the long-run growth rate, γ, and of the steady-state investment-output ratio, s_i, are readily obtained.[14] A little manipulation of the first order conditions gives:

$$\frac{k}{y} = \frac{s_i}{\delta - 1 + \gamma} \tag{15}$$

Furthermore, some further manipulation leads to:

$$r = \frac{\gamma - \hat{\beta}[1 - (1 - \tau^K)\delta]}{\hat{\beta}(1 - \tau^K)} \tag{16}$$

Since $s_K \equiv rK/Y$, clearly $s_K = r \cdot k/y$. Evaluating (14) at the steady-state and solving it for α gives:

$$\alpha = s_K \left(\frac{k}{y}\right)^{\eta} \tag{17}$$

[12] The data on effective tax rates have been computed by Mendoza et al. (1994) and filled by Daveri and Tabellini for a few observations.

[13] Replacement rates are usually defined as the ratio between he unemployment subsidy and the previous labor income, *i.e.* in steady-state. The replacement rates employed here are the OECD summary measures of "entitlement benefits" (an average of the replacement rates for different categories of unemployed).

[14] We coherently measure n as the ratio between civilian employment and total population in working age, and γ as the yearly growth rate of GDP per worker.

Since $s_N = (n/y)^\eta$, we can evaluate (10) at the steady-state and rewrite it as:

$$s_N \left[1 - (1-\eta) s_K\right] = \sigma n \frac{1 - \phi\tau^N}{1 - \tau^N} \tag{18}$$

The parameter σ can be explicitly derived from (18).

Table 2 presents the long-run properties we aim at replicating (column 1 through 3), together with the implied values for the calibrated parameters α and σ (column 4 through 5). The calibrated values for α are all strictly positive, as predicted by the theory of production. The implied steady-state labor income shares and capital-output ratios are fairly close to their measured counterparts.

The values of σ implied by our calibration procedures can be contrasted with those computed from a transformation of National Accounts data as well. The procedure is the following. Given the OECD gross replacement rates, one can compute the labor income shares from National Accounts data. This is enough to recover the implied value for the parameter σ from the following expression:

$$\sigma = \frac{s}{y}\frac{n}{n}\frac{w}{w} = \frac{s}{w}\frac{s_N}{n} \tag{19}$$

The $\sigma's$ computed from this indirect procedure are compared in **Table 3** with those implied by the calibration in **Table 2.** The correlation coefficient between the two series is 0.75. Most coefficients are very similar, one important exception being Italy.[15] In our fiscal policy experiments, our calibrated values, not the actual ones, are employed.

Table 4 reports some endogenously determined long-run features of the model, and in particular the labor shares and capital-output ratios (columns 1 and 2), together with the ratios between the tax revenues from capital, labor and subsidies, and output.

The list of parameters derived in this section provides the benchmark parameterization of our fiscal policy experiments for each individual country. We also calibrated our model to reproduce the long-run properties of an artificial European aggregate, obtained as a weighted average of the countries in our sample. The weights are the 1960-1995 average ratios between the working age population in each country and the corresponding total figure.[16] The weighted long-run properties for the European aggregate are equal to $n = 0.61$, $s_i = 0.23$ and $\gamma = 1.025$. The weighted policy parameters are $\tau_K = 0.26$, $\tau_N = 0.39$, and $\phi = 0.47$. The implied calibrated parameters are $\alpha = 0.46$ and $\sigma = 0.39$.

[15] The OECD measure of replacement rates most likely underestimates the actual protection granted to the unemployed in Italy, for the *Cassa Integrazione Guadagni*, *i.e.* the mechanism though which firms in financial distress were allowed not to fire redundant workers until the 1991 reform, is not accounted for.

[16] The weights are: 0.257 for Germany, 0.213 for France, 0.234 for Italy, 0.056 for he Netherlands, 0.041 for Belgium, 0.145 for Spain, 0.034 for Sweden, and 0.02 for Finland.

4 The effects of reducing labor taxes

In this section, the numerical experiments conducted to explore the effects of a labor tax reduction on employment and output are described at length.

In order to provide both a preview and a concise summary of our main findings, we first present results for an artificial European aggregate, constructed as described in the last paragraph of the previous section. Then some sensitivity analysis exercises are carried out to investigate the dependence of the model's conclusions on our benchmark parameterization. Results for individual countries are presented last.

The starting point is the steady-state or balanced-growth equilibrium, where GDP per worker grows at the exogenous growth factor γ, while the employment rate n stays constant. In other words, along the balanced growth path, the economy enjoys the "Phelps property", that is the natural rate of unemployment is independent of the rate of growth of productivity.[17]

The initial steady state is perturbed through two types of policy experiments, which differ in the way the revenue loss entailed by the labor tax cut is made up for by the government. In both cases, at an initial date, a one percentage point reduction in the labor tax rate is introduced. In the first experiment, government transfers are reduced, while, in the second experiment, barred spending cuts, the tax rate on capital incomes is raised. The government budget is balanced in all periods.

Given that the main focus of our paper is to document the importance of looking at labor market dynamics, we consider the effects of the experiments on impact ("$t = 1$" in our Tables), after five, ten, and fifteen years ("$t = 5$", "$t = 10$", and "$t = 15$" in our Tables) and in the steady state.

4.1 European aggregate: results

A short qualitative rendition of the main results of the first experiment is as follows. As the labor tax reduction is financed through a cut in government transfers, this effectively reduces the cost of labor and raises labor demand for a given capital stock. The rise in employment is dampened, but not fully absorbed, by the parallel rise in unemployment benefits due to output indexation of the benefits. In turn, the rise in employment raises the marginal productivity of capital, thereby encouraging investment and capital accumulation. Hence, the economy temporarily grows faster than its long-run growth rate. The increased growth rate further shifts the labor demand curve to the right, and this results in both higher equilibrium employment and real wage. In the end, the employment response to the labor tax cut gains momentum over time, while the real wage rate falls on impact and then goes back to its long-run path. In the new steady state the employment rate is permanently higher than before the tax was introduced in the first instance.

Table 5 (and **Figures 1-2**) translates such qualitative statements in figures.

[17] Aghion and Howitt (1994) have a model where the "Phelps property" may break down in both directions, depending on whether the "capitalization" or the "rate of return" effect of an increase of productivity growth prevails.

As a result of a one percentage point reduction in the labor tax, employment rises by 0.35 points on impact, by 0.40 after five years, by 0.45 after ten years and by 0.65 in the steady state. On impact, gross wages fall short of their long-run path by 0.34 percentage points. Afterwards, they gradually rise as the effects of capital accumulation set in. Going back to the balanced growth path takes time, however. After ten years, they are still below their long-run trend by 0.2 percentage points. The impact fall in wages is associated to an impact increase in the real rate of return on capital investment by 0.07 percentage points. As capital accumulation occurs, the marginal productivity of capital falls, and so does its real rate of return. The output gain (compared to its long-run path) is rather limited however: 0.5 points after 5 years, and a bare one percentage point in the steady state.

In **Table 5**, the budgetary consequences of the fiscal manoeuvre are reported as well. On the tax side, revenues from labor taxes (and from taxes on unemployment benefits) fall, while capital tax revenues slightly increase on impact as a result of the rise in the real rate of return. The reduction in the labor tax revenues amounts to some 0.7 percentage points of GDP. On the spending side, the reduction in the number of unemployed people makes government spending in unemployment benefits smaller. This is not large enough to bridge the revenue gap created by the labor tax reduction. Hence, government transfers have to fall as well. The transfer cut that preserves the balance of the budget is about 0.6 percentage points on impact and 0.5 points in the steady state.

What if the labor tax cut is financed by raising capital taxes, while leaving government transfers untouched? This is the thrust of our second set of experiments, whose results are shown in **Table 6** (and **Figures 3-4**). As above, first a short account of the qualitative results is useful. Conflicting forces are at work here. The causal chain from labor taxes to wages, employment and growth, which was described above as permanently beneficial for employment and temporarily beneficial for growth is still there. Yet, the labor tax reduction is now financed through a distorting instrument. The parallel increase in the capital tax rate decreases the pace of accumulation from period $t = 2$ onwards (at $t = 1$, capital is in place already). As a result of the increase in τ_K, the marginal productivity of capital falls relatively to experiment I. Accordingly, investment starts falling and the capital stock adjusting downwards with a one-period lag.

Table 6 shows how these conflicting effects get compounded numerically. Employment and output are positively affected on impact to the same extent as in the first set of experiments. This is because the disincentive effects of capital taxation are not operational yet. Even when their distorting effects are perceived, however, the expansionary effects on employment and output remains positive for, respectively, twelve and seven years. Afterwards, employment and output begin falling. The cost of the capital tax in terms of forgone employment and output shows up, however, from $t = 2$ onwards. Unlike in the previous experiment, gross wages fall on impact by some 0.35 percentage points, but then they keep falling due to the declining pace of capital accumulation. To keep the level of transfers unchanged, the capital tax rate has to go up by 3.2 percentage points on impact, 3.5 after five years and 3.6 after ten years. The required rise in the capital tax goes up as time goes by, but the increase gets smaller and smaller over time as the revenue loss fades away with the employment gain.

The budgetary consequences of this experiment are also radically different from the ones arising from the previous experiment. The revenue loss from labor taxes is roughly of the same order of magnitude as in experiment I, although slightly increasing - rather than decreasing - over time. Yet here, due to the parallel increase in the tax rates on capital incomes, the overall loss in tax revenue is much smaller (around 0.1 points) than in experiment I. On the spending side, nothing happens to transfers by construction, while the outlays for unemployment benefits are initially smaller but eventually get bigger than at the beginning. This is entirely due to the behavior of employment, which first goes up and ultimately falls.

The results in this sub-section may be conveniently rephrased in terms of GDP percentage points. A labor tax reduction of about two thirds of a percentage point of GDP has sharply different effects on employment and output, depending on its time horizon and method of financing. When financed by cutting government transfers, it results in a sizable employment gain of about one third of a percentage point on impact - about half as much as its long-run effect. Balancing the budget requires here government spending be cut by a roughly similar amount as a share of GDP. When the labor tax reduction is instead financed by raising capital taxes, employment gains are temporary, although they remain positive for a few years. The increase in capital tax revenues necessary to balance the budget is about one percentage point of GDP.

4.2 European aggregate: sensitivity analysis

Looking at the EU aggregate is useful to highlight the main quantitative results implicit in the model presented in the previous sections. Our conclusions may depend on the specific parameterization chosen, though. Here we demonstrate that the results discussed in the previous sub-section are representative of the "median" behavior of the model when some of the key deep parameters - in particular, those over which the opinions of the profession are less precise - are allowed to vary over a range of economically meaningful values. We do that for the first set of experiments in the previous section.

We separately study the effects of changes in the elasticity of substitution between capital and labor, the differential tax treatment of subsidies, the depreciation rate, and the elasticity of intertemporal substitution. We simply repeat the first experiment letting each of the previously described parameters in turn assume equally spaced values in the following ranges: [0.4;0.8] for ξ, [0.15;0.75] for ϕ, [0.05;0.10] for δ, and [0.5;3.5] for μ.[18] The remaining parameters remain unchanged. Results are summarized in **Tables 7-10**.

Table 7 shows the effects of changes in the elasticity of substitution between capital and labor. As the elasticity varies from 0.4 to 0.8, the parameter η ranges

[18] We check that all the steady-state properties of the model remain economically meaningful.

from -1.5 to -0.25. The effects on employment of a decrease in the tax rate on labor increase with the elasticity of substitution. Their average and, more importantly, median values are extremely similar to the figures reported in **Table 5**, however. This implies that limited changes in the benchmark value of the elasticity of substitution have obvious quantitative effects on the results of our experiment, but leave our qualitative conclusions unaffected. Furthermore, it confirms that the qualitative results obtained under our benchmark parameterization represents the "median" behavior of the model.

Similar conclusions may be drawn analyzing the remaining Tables. **Table 8** summarizes the effects of a change in the differential tax treatment of subsidies. Note that this is the only parameter affecting the steady state of the model. The effects of a drop in the tax rate on labor this time decrease with ϕ - the higher ϕ, the more an increase in the tax rate on labor reflects in a decrease in the tax rate on subsidies. **Table 9** shows the effects of a change in the depreciation rate: the reaction to a labor tax cut increase with δ - a higher δ implies a less pronounced effect of an increase in investment on the dynamics of capital accumulation. Finally, **Table 10** reports the effects of a change in the elasticity of intertemporal substitution, which instead decrease with μ - a higher μ implies a lower elasticity of intertemporal substitution, the representative household is less willing to substitute current for future consumption, and therefore the dynamics of capital accumulation is again dampened.

In the end, our sensitivity analysis drives us to conclude that the results described in **Table 5** and **6** are not the outcome of a special parameterization, but can be taken as largely representative of the model's "median" behavior. Our findings exhibit a remarkable robustness to parameter changes spanning over a wide range of values.

4.3 Individual countries

Being reassured that the results in **Table 5** and **6** are close to the average behavior of the model (over a certain range of parameters), now we move to the analysis of what the model predicts for the eight countries in our sample. Looking at how employment and output react in each country is instructive to learn more about the working of the model.

Table 11 shows the employment and output effects of reducing the tax rate on labor incomes by one percentage point in Germany, France, Italy, the Netherlands, Belgium, Spain, Sweden and Finland, while simultaneously decreasing government transfers. The maximum effects are observed in Germany and Italy, where employment goes up by 0.4 or more on impact and by 0.8 or more in the new steady state. Output goes up by 0.5 percentage point on impact and by 1.4 or more in the steady state. The other EU countries exhibit employment and output increases for slightly more than one half as much as Germany and Italy, both on impact and in the steady state. The fraction of the impact adjustment over the overall adjustment is instead roughly the same across all countries (about 55-60% for employment,and about one third for output).

Table 12 shows employment and output effects of a labor tax reduction when capital taxation is raised as well. By and large, the same pattern of results as in **Table 11** emerges. Germany and Italy benefits from the tax reduction to a greater extent than the other countries, in terms of both employment and output, in the short run as well as in the long run. Employment gains actually persist into the new steady state. The shape of the impulse response function remains the same for all countries, with employment and output gains reaped on impact, and then gradually left on the ground as time goes by.

What makes Germany and Italy "special"? The simple structure of the model and our choice of ruling out unobservable cross-country differences in technology and preference parameters from our calibration procedure leaves just one plausible candidate. Employment and output effects are strongest where the tax treatment of subsidies is most favorable. In Germany and Italy the imputed values for ϕ are quite low (in the order of 0.3), while ϕ is close to 0.5 in Finland and Spain, and about 0.75 in France, Belgium, the Netherlands, and Sweden.

But this is not all we can learn from individual country results. The high similarity in the time profile of the impulse responses across countries is suggestive that our main finding on the overwhelming importance of timing and labor market dynamics, survives qualitatively unabated irrespective of parameter differences.

5 Relating our results to the literature

Our paper mainly builds and contributes to the by now huge literature on the causes of unemployment in Europe, but is also related to other strands of macroeconomics and public finance.

The calibration methodology followed here has a long tradition in macroeconomics. Within the dynamic general equilibrium framework, labor market imperfections have been modelled in a variety of ways, though. Danthine and Donaldson (1990) had efficiency wages; Merz (1995), Andolfatto (1996), and Den Haan *et al.* (2000) had costly search; Gali (1996) had a mark-up wage setting equation in principle compatible with various market imperfections. None of this paper was focussed on fiscal policy issues.

Another strand of research - with a more applied bent - has dealt with the analysis of welfare and tax reform within static general equilibrium models. In particular, our findings are complementary to Bovenberg, Graafland and de Moji (2000). They studied the consequences of tax reform in the Dutch labor market. Their one-country study can cope with a broader set of issues than we can possibly cover in our simple framework, including the effects of changing marginal tax rates on skilled *vs.* unskilled, male *vs.* female employment and labor supply. Yet their analysis only developed the static implications of a tax reform. The main insight from our paper is, instead, that framing labor market imperfections within a dynamic model is a necessary step to fully understand the effects of labor tax reductions.

Our concern about the importance of looking at labor market dynamics is in the same spirit as Blanchard and Giavazzi (2001), where short-run and long-run effects of shocks to labor market institutions are shown to produce significantly different employment outcomes. The dynamic twist of their analysis is represented by the free entry equilibrium in a monopolistically competitive framework, without an explicit treatment of capital accumulation.

Our results on the persistence of employment effects in the presence of vanishing wage effects can also be paralleled to the 'hysteresis' phenomenon, popularized by Blanchard and Summers (1986) and recently empirically rejuvenated by Ball (1999). In our framework, hysteresis is not a theoretical curiosum, but simply the backlog of the adjustment process of the economy in the aftermath of the tax shock.

Lastly, our results also have some bearing on the empirical literature on the relation between labor taxes and unemployment. Aggregate evidence has proven so far inconclusive, partly as a consequence of the difficulty of finding reliable instruments. Daveri and Tabellini (2000) found a sizable effect of labor taxes on unemployment for countries in Continental Europe. Their findings are the upper bounds within this strand of literature. At the other extreme, Blanchard and Wolfers (2000) found a much smaller (close to zero) impact of taxes on unemployment, with Nickell and Layard's (1999) findings lying somewhere in between. The micro evidence, surveyed in Gruber (1999), has almost unanimously shown that labor taxes affect net, rather than gross, wages, thus leaving labor costs and employment unchanged. [19] The micro-econometric studies carried out so far concern countries, such as the US and Chile, whose labor market institutions are less conducive to forward shifting of labor taxation onto wages than those in place in European countries. Hence, the lesson to be drawn from these studies for Europe remains unclear. As demonstrated in the sensitivity analysis section, the 'average' functioning of our numerical model provides results closer to those of Daveri and Tabellini than to those of Blanchard and Wolfers.

6 Conclusions

In this paper the numerical steady-state properties of an infinite-horizon exogenous growth model with equilibrium unemployment have been spelled out at length. The model was calibrated to reproduce some observed long-run properties for the eight largest EU countries and for an artificial European aggregate. The calibrated model has then been used to investigate the employment and output effects of reducing labor taxes under the constraint that the budget be balanced.

Our main finding is that the dynamic response of capital accumulation crucially determines the eventual effects of a labor tax reduction, by either magnifying or overturning its impact effects, depending on how the labor tax reduction is financed. This conclusion is at variance with the prevailing view on the causes of

[19] The only notable exception is Anderson and Meyer (2000) presents evidence from the US State of Washington, where unemployment insurance payroll taxes were largely, but less than fully, shifted onto workers.

unemployment in Europe, where a static rendition of the functioning of European labor markets is held as a common belief. We find this a promising route for further research aimed at understanding the persistence of unemployment in Europe and the observed lack of correlation between real wages and unemployment.

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A Appendix: the wage equation

The representative firm maximizes its discounted flow of future profits:

$$\max_{\{k_s,n_s\}_{s=t}^{\infty}} \sum_{s=t}^{\infty} R_{t,s}\left[\left(\alpha k_s^{\eta}+n_s^{\eta}\right)^{\frac{1}{\eta}}-w_s n_s-r_s k_s\right] \tag{20}$$

where $R_{t,s} \equiv \prod_{i=t}^{s}\left(1+r_i\right)^{-1}$ and $R_{t,t} \equiv 1$. The sequences $\{w_j\}_{j=t}^{\infty}$ and $\{r_j\}_{j=t}^{\infty}$ are taken as given.

The first order conditions with respect to k_t and n_t are the following:

$$\left(\alpha k_t^\eta + n_t^\eta\right)^{\frac{1-\eta}{\eta}} \alpha k_t^{\eta-1} = r_t \tag{21}$$

$$\left(\alpha k_t^\eta + n_t^\eta\right)^{\frac{1-\eta}{\eta}} n_t^{\eta-1} = w_t \tag{22}$$

The representative union maximizes the discounted flow of future average labor incomes:

$$\max_{\{w_s,n_s\}_{s=t}^{\infty}} \sum_{s=t}^{\infty} R_{t,s}\left[\left(1-\tau^N\right) n_s w_s + \left(1-\tau^S\right)\left(1-n_s\right) s_s\right] \tag{23}$$

subject to (22), taking the sequences $\{k_j\}_{j=t}^{\infty}$, $\{s_j\}_{j=t}^{\infty}$, and $\{r_j\}_{j=t}^{\infty}$ as given.

We can substitute w_t away and maximize with regard to n_t, obtaining:

$$\begin{gathered}\frac{1-\eta}{\eta}\left(\alpha k_t^\eta + n_t^\eta\right)^{\frac{1-\eta}{\eta}-1} \eta n_t^{\eta-1} n_t^{(\eta-1)+1} + \\ +\left(\alpha k_t^\eta + n_t^\eta\right)^{\frac{1-\eta}{\eta}} \eta n_t^{\eta-1} = \frac{1-\tau^S}{1-\tau^N} s_t\end{gathered} \tag{24}$$

The sequences of employment rates, wage rates, and demands for capital services that jointly solve problems (20) and (23) for given sequences of rental rates and unemployment benefits, form a Nash equilibrium for the previously described noncooperative dynamic game. Note that (i) the services of physical capital and labor are to be purchased at the given prices in each period, since households own both factors of production; (ii) pre-commitment is ruled out; (iii) unions are small at the level of the entire economy, and take as given the rental price of capital, as well as the set of policy variables. Hence, unions fail to internalize the dynamic consequences of today's wage setting on capital accumulation. We restrict then our attention to Markov strategies depending only on the two current state variable, *i.e.* the capital stock and the past employment rate, via the current rental rate and unemployment subsidy.

We can rewrite (24) as:

$$\left(\frac{n_t}{y_t}\right)^{\eta-1}\left[\eta + (1-\eta)\left(\frac{n_t}{y_t}\right)^{\eta}\right] = \frac{1-\tau^S}{1-\tau^N} s_t \tag{25}$$

B Appendix: the solution method

If a recursive solution to (10)-(14) exists, it can be represented as couple of time-invariant policy functions expressing the optimal level of consumption and employment as a function of the state variable k_t.

These policy functions have to satisfy the following functional equations:

$$\left[\frac{n(k)}{y}\right]^{\eta}\left\{\eta + (1-\eta)\left[\frac{n(k)}{y}\right]^{\eta}\right\} = \frac{1-\tau^S}{1-\tau^N} \sigma n(k) \tag{26}$$

$$c\left(k^{'}\right)=c\left(k\right)\left\{\frac{\hat{\beta}}{\gamma}\left[\left(r^{'}-\delta\right)\left(1-\tau^{K}\right)+1\right]\right\}^{\frac{1}{\mu}} \tag{27}$$

where:

$$k^{'}=\frac{\left[(1-\delta)k+y-c\left(k\right)\right]}{\gamma} \tag{28}$$

$$y^{\eta}=\alpha k^{\eta}+n\left(k\right)^{\eta} \tag{29}$$

$$\left(y^{'}\right)^{\eta}=\alpha\left(k^{'}\right)^{\eta}+n\left(k^{'}\right)^{\eta} \tag{30}$$

$$r=y^{1-\eta}\alpha k^{\eta-1} \tag{31}$$

$$r^{'}=\left(y^{'}\right)^{1-\eta}\alpha\left(k^{'}\right)^{\eta-1} \tag{32}$$

Following Judd (1992), we approximate the policy functions for c and n over an interval $D\equiv[\underline{k},\overline{k}]\in R_{+}$ with a linear combination of Chebyshev polynomials. In other words, we approximate them with:

$$\widehat{c}\left(k;\mathbf{a}_{c}\right)=\sum_{j=0}^{d}a_{j}^{c}\psi_{j}\left(k\right) \tag{33}$$

$$\widehat{n}\left(k;\mathbf{a}_{n}\right)=\sum_{j=0}^{d}a_{j}^{n}\psi_{j}\left(k\right) \tag{34}$$

where

$$\psi_{j}\left(k\right)\equiv T_{i}\left(2\frac{k-\underline{k}}{\overline{k}-\underline{k}}-1\right) \tag{35}$$

Each T_n represents a n-order Chebyshev polynomial[20], while the parameter d denotes the maximum polynomial order used in our approximation.

To choose the vectors a_c and a_n, we apply the Galerkin projection method. First of all, we define the residual functions as:

$$R_{c}\left(k;\mathbf{a}_{c}\right)\equiv\widehat{c}\left(k^{'};\mathbf{a}_{c}\right)-\widehat{c}\left(k;\mathbf{a}_{c}\right)\left\{\frac{\hat{\beta}}{\gamma}\left[\left(r^{'}-\delta\right)\left(1-\tau^{K}\right)+1\right]\right\}^{\frac{1}{\mu}} \tag{36}$$

$$R_{n}\left(k;\mathbf{a}_{n}\right)\equiv\left[\frac{\widehat{n}\left(k;\mathbf{a}_{n}\right)}{y}\right]^{\eta}\left\{\eta+(1-\eta)\left[\frac{\widehat{n}\left(k;\mathbf{a}_{n}\right)}{y}\right]^{\eta}\right\}-\frac{1-\tau^{S}}{1-\tau^{N}}\sigma\widehat{n}\left(k;\mathbf{a}_{n}\right) \tag{37}$$

where:

$$r^{'}=\left[\alpha\left(k^{'}\right)^{\eta}+\widehat{n}\left(k^{'};\mathbf{a}_{n}\right)\right]^{\frac{1-\eta}{\eta}}\alpha\left(k^{'}\right)^{\eta-1} \tag{38}$$

$$k^{'}=\frac{\left[(1-\delta)k+\left[\alpha k^{\eta}+\widehat{n}\left(k;\mathbf{a}_{n}\right)^{\eta}\right]^{\frac{1}{\eta}}-\widehat{c}\left(k;\mathbf{a}_{c}\right)\right]}{\gamma} \tag{39}$$

[20] The Chebyshev polynomials are defined over [-1,1] by the formula $T_n(x)=\cos(n\arccos x)$.

Then, we look for $m > d+1$ suitable values for k; relaying on the Chebyshev Interpolation Theorem, we obtain m zeros of Chebyshev polynomials in $[-1, 1]$ and find the corresponding values in $[\underline{k}, \overline{k}]$. Finally, we numerically solve for $\mathbf{a}$ the following system of equations, using a version of the well-known Gauss-Newton algorithm:

$$P_j^c(\mathbf{a}) = \sum_{i=1}^{m} R_c(k_i; \mathbf{a}) \psi_j(k_i) = 0 \tag{40}$$

$$P_j^n(\mathbf{a}) = \sum_{i=1}^{m} R_n(k_i; \mathbf{a}) \psi_j(k_i) = 0 \tag{41}$$

where $j = 0...d$.

Table 1
Average tax rates and
tax treatment of unemployment subsidies

	Tax rates		Rep. rates		Tax on subs.	
	[1] τ^K	[2] τ^N	[3] Gross	[4] Net	[5] τ^S	[6] ϕ
Ger	0.28	0.39	0.29	0.42	0.12	0.30
Fra	0.24	0.41	0.29	0.34	0.31	0.76
Ita	0.24	0.38	0.03	0.04	0.06	0.17
Net	0.31	0.50	0.40	0.49	0.39	0.78
Bel	0.35	0.44	0.43	0.52	0.32	0.73
Spa	0.15	0.31	0.24	0.29	0.17	0.54
Swe	0.52	0.47	0.16	0.19	0.36	0.77
Fin	0.37	0.32	0.19	0.23	0.15	0.48
Avg	**0.31**	**0.40**	**0.25**	**0.31**	**0.24**	**0.57**

Notes: τ^K=average effective tax rate on capital income; τ^N=average effective tax rate on labor income; τ^S=average effective tax rate on subsidies; ϕ=differential tax treatment of subsides. Figures on gross and net replacement rates are obtained as averages of the 1961,1971, 1981, and 1991 replacement rates on gross and net of tax bases reported in the OECD Jobs Study (1994), ch. 8, Annex 8.13. The average 1960-95 effective tax rates on labor come from an updated version of the DT data set. The values of the effective tax rates on the unemployment subsidies, τ^S, are obtained from $net = gross \cdot (1-\tau^S)/(1-\tau^N)$.

Table 2
Calibration

	[1] $n\%$	[2] $s_i\%$	[3] γ	[4] $\sigma\%$	[5] α
Ger	66	23	1.020	38	0.43
Fra	63	23	1.024	48	0.43
Ita	56	23	1.027	41	0.43
Net	56	23	1.020	51	0.44
Bel	57	19	1.026	58	0.35
Spa	56	22	1.031	56	0.39
Swe	75	19	1.021	39	0.40
Fin	70	27	1.026	25	0.60
Avg	**62**	**22**	**1.024**	**45**	**0.43**

Notes: n = employment over total population in working age; s_i = share of gross fixed investment over GDP; γ = growth factor of GDP per worker; σ = ratio of unemployment subsidies over GDP; α = share parameter in the CES production function.

Table 3
Estimated σ

	[1] S/W	[2] n	[3] s_N	[4] $\hat{\sigma}$	[5] σ
Ger	31	66	69	32	38
Fra	36	63	72	41	48
Ita	4	56	77	6	41
Net	54	56	64	62	51
Bel	53	57	68	63	58
Spa	37	56	72	48	56
Swe	21	75	72	20	39
Fin	23	70	58	19	25
Avg	**32**	**62**	**69**	**36**	**45**

Notes: The replacement rate corresponds to "entitlement benefits", as defined by the OECD. The employment rate is defined as total employment over working age population. The labor share in value added is computed from National Accounts. The values of $\hat{\sigma}$ in the fourth column are those implied by the values of the replacement rates, employment rates and labor incomes shares in the first three columns. The values of σ are the previously reported calibrated ones. All figures are 1960-1997 averages expressed in percentage points, and are based on annual OECD data.

Table 4
Steady-state properties

	[1] s_N	[2] K/Y	[3] R_k/Y	[4] R_n/Y	[5] R_s/Y	[6] R/Y
Ger	64	1.9	3.8	26.2	1.5	31.5
Fra	67	1.9	3.5	27.5	5.6	36.5
Ita	66	1.8	3.7	25.2	1.2	30.1
Net	67	1.9	4.4	33.4	8.8	46.5
Bel	70	1.5	5.1	30.1	8.1	44.1
Spa	69	1.7	2.2	21.3	4.1	27.6
Swe	67	1.6	9.0	21.5	3.4	43.8
Fin	57	2.1	8.0	18.3	1.2	27.4
Avg	**66**	**1.8**	**5.0**	**25.4**	**4.2**	**35.9**

Notes: All figures, except the capital-output ratio, are expressed in percentage points. s_N = labor share in value added; $K\,/Y$ = capital-output ratio; $R_k\,/\,Y$ = ratio between the tax revenues on capital and output; $R_n\,/\,Y$ = ratio between the tax revenues on labor and output; $R_s\,/\,Y$ = ratio between the tax revenues on subsidies and; $R\,/\,Y$ = ratio between total tax revenues (capital, labor, and subsides) and output.

Table 5
Labor tax cut with offsetting spending cuts

	[1]	[2]	[3]	[4]	[5]
	$t=1$	$t=5$	$t=10$	$t=15$	$t=\infty$
Δn	0.35	0.40	0.45	0.49	0.65
ΔY	0.37	0.48	0.60	0.69	1.06
ΔW	-0.34	-0.28	-0.22	-0.18	0.00
Δr	0.07	0.06	0.05	0.04	0.00
$\Delta T/Y$	-0.61	-0.59	-0.58	-0.57	-0.53
$\Delta R_k/Y$	0.04	0.03	0.03	0.02	0.00
$\Delta R_n/Y$	-0.68	-0.67	-0.67	-0.66	-0.65
$\Delta R/Y$	-0.72	-0.72	-0.73	-0.73	-0.74

Notes: the table summarizes the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y. All figures, except the ones for output and wages, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 6

Labor tax cut with offsetting increases in the capital tax

	[1]	[2]	[3]	[4]
	$t = 1$	$t = 5$	$t = 10$	$t = 15$
Δn	0.35	0.21	0.05	-0.10
ΔY	0.37	0.04	-0.33	-0.66
ΔW	-0.34	-0.50	-0.67	-0.83
Δr	-0.20	-0.18	-0.16	-0.14
$\Delta T/Y$	0.00	0.00	0.00	0.00
$\Delta R_k/Y$	0.64	0.70	0.76	0.81
$\Delta R_n/Y$	-0.68	-0.69	-0.71	-0.73
$\Delta R/Y$	-0.11	-0.07	-0.01	0.03
$\Delta\tau^K$	3.26	3.44	3.64	3.81

Notes: the table summarizes the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting ongoing increases in the tax rate on captial to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y. All figures, except the ones for output and wages, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 7
Labor tax cut with offsetting spending cuts:
sensitivity analysisis on η

		[1]	[2]	[3]	[4]	[5]
		$t=1$	$t=5$	$t=10$	$t=15$	$t=\infty$
Δn	Avg	0.33	0.37	0.41	0.45	0.65
	Med	0.35	0.40	0.45	0.49	0.65
	Max	0.53	0.56	0.59	0.61	0.65
	Min	0.07	0.09	0.12	0.15	0.65
ΔY	Avg	0.35	0.45	0.56	0.64	1.06
	Med	0.37	0.48	0.60	0.69	1.06
	Max	0.56	0.68	0.79	0.87	1.06
	Min	0.07	0.11	0.16	0.21	1.06

Notes: the table summarizes the empirical distribution of the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y, when the elasticity of substitution between captial and labor varies over the 0.4-0.8 range. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 8
Labor tax cut with offsetting spending cuts:
sensitivity analysisis on ϕ

		[1]	[2]	[3]	[4]	[5]
		$t=1$	$t=5$	$t=10$	$t=15$	$t=\infty$
Δn	Avg	0.35	0.40	0.45	0.49	0.65
	Med	0.36	0.41	0.46	0.50	0.66
	Max	0.48	0.55	0.62	0.68	0.90
	Min	0.19	0.21	0.24	0.26	0.35
ΔY	Avg	0.37	0.48	0.60	0.69	1.06
	Med	0.38	0.49	0.61	0.71	1.09
	Max	0.51	0.67	0.83	0.96	1.48
	Min	0.20	0.26	0.32	0.37	0.57

Notes: the table summarizes the empirical distribution of the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y, when the policy parameter summarizing the tax treatment of subsidies varies over the 0.15-0.75 range. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 9
Labor tax cut with offsetting spending cuts:
sensitivity analysisis on δ

		[1]	[2]	[3]	[4]	[5]
		$t=1$	$t=5$	$t=10$	$t=15$	$t=\infty$
Δn	Avg	0.35	0.40	0.45	0.49	0.65
	Med	0.35	0.40	0.45	0.49	0.65
	Max	0.37	0.43	0.49	0.53	0.65
	Min	0.32	0.35	0.39	0.43	0.65
ΔY	Avg	0.36	0.48	0.59	0.69	1.06
	Med	0.37	0.48	0.60	0.69	1.06
	Max	0.40	0.54	0.68	0.78	1.06
	Min	0.31	0.39	0.49	0.57	1.06

Notes: the table summarizes the empirical distribution of the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y, when the depreciation rate varies over the 5%-10% range. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 10
Labor tax cut with offsetting spending cuts:
sensitivity analysisis on μ

		[1]	[2]	[3]	[4]	[5]
		$t=1$	$t=5$	$t=10$	$t=15$	$t=\infty$
Δn	Avg	0.35	0.40	0.45	0.49	0.65
	Med	0.35	0.40	0.45	0.49	0.65
	Max	0.43	0.53	0.60	0.63	0.65
	Min	0.24	0.27	0.30	0.33	0.65
ΔY	Avg	0.37	0.50	0.61	0.70	1.06
	Med	0.37	0.48	0.60	0.69	1.06
	Max	0.54	0.78	0.93	1.00	1.06
	Min	0.21	0.27	0.33	0.39	1.06

Notes: the table summarizes the empirical distribution of the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y, when the elasticity of intertemporal substitution varies over the 0.5-3.5 range. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 11
Labor tax cut with offsetting spending cuts:
country-level results

		[1]	[2]	[3]	[4]	[5]
		$t = 1$	$t = 5$	$t = 10$	$t = 15$	$t = \infty$
Ger	Δn	0.46	0.52	0.58	0.64	0.85
	ΔY	0.45	0.58	0.72	0.83	1.30
Fra	Δn	0.20	0.23	0.25	0.28	0.37
	ΔY	0.20	0.27	0.33	0.38	0.58
Ita	Δn	0.42	0.48	0.55	0.60	0.80
	ΔY	0.48	0.63	0.79	0.92	1.43
Net	Δn	0.21	0.24	0.27	0.29	0.40
	ΔY	0.24	0.31	0.38	0.44	0.71
Bel	Δn	0.23	0.26	0.29	0.32	0.40
	ΔY	0.27	0.35	0.43	0.49	0.70
Spa	Δn	0.25	0.29	0.33	0.36	0.45
	ΔY	0.29	0.40	0.50	0.57	0.80
Swe	Δn	0.27	0.30	0.33	0.36	0.51
	ΔY	0.22	0.28	0.34	0.39	0.67
Fin	Δn	0.24	0.28	0.31	0.34	0.63
	ΔY	0.18	0.24	0.31	0.37	0.90

Notes: the table summarizes the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting lump-sum transfers to keep the budget balanced - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

Table 12
Labor tax cut with offsetting increases in the capital tax:
country-level results

		[1]	[2]	[3]	[4]
		$t=1$	$t=5$	$t=10$	$t=15$
Ger	Δn	0.46	0.34	0.21	0.09
	ΔY	0.45	0.19	-0.09	-0.35
Fra	Δn	0.20	0.00	-0.22	-0.41
	ΔY	0.20	-0.23	-0.72	-1.16
Ita	Δn	0.42	0.33	0.22	0.13
	ΔY	0.48	0.24	-0.02	-0.26
Net	Δn	0.21	0.04	-0.16	-0.34
	ΔY	0.24	-0.20	-0.69	-1.13
Bel	Δn	0.23	0.00	-0.25	-0.47
	ΔY	0.27	-0.30	-0.92	-1.47
Spa	Δn	0.25	0.09	-0.10	-0.25
	ΔY	0.29	-0.12	-0.58	-0.98
Swe	Δn	0.27	-0.00	-0.30	-0.58
	ΔY	0.22	-0.27	-0.83	-1.33
Fin	Δn	0.24	0.09	-0.08	-0.25
	ΔY	0.18	-0.09	-0.42	-0.721

Notes: the table summarizes the effects of a one percentage point decrease in the average tax rate on labor - holding the other parameters constant and with offsetting increases in the tax rate on capital - on the employment rate n, the output level Y, the wage rate W, the rental rate r, the transfers-output ratio T/Y, the tax revenues from capital-output ratio R_k/Y, the tax revenues from labor-output ratio R_n/Y, and the total tax revenues-output ratio R/Y. All figures, except the ones for output and the wage, represent percentage deviations from the intial steady state. The figures for the output level and the wage rate represent instead percentage deviations from the initial balanced growth path.

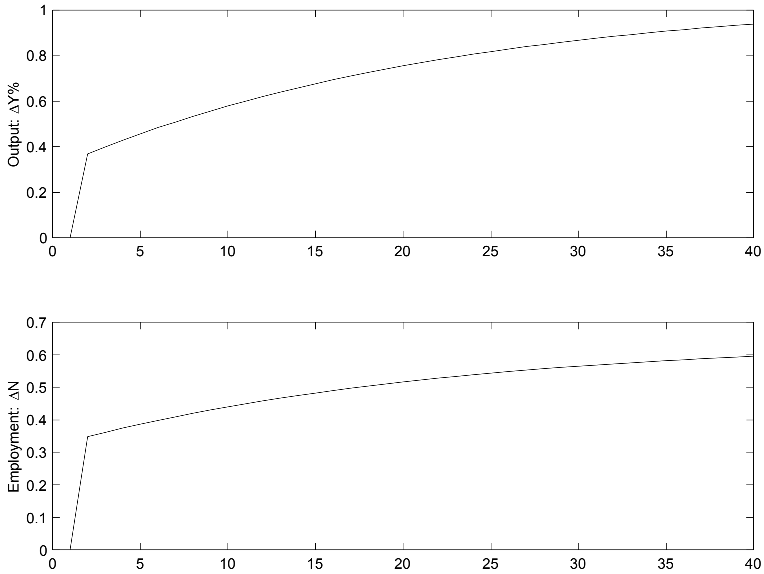

Figure 1: Decrease in τ^N with offsetting spending cuts: output and employment

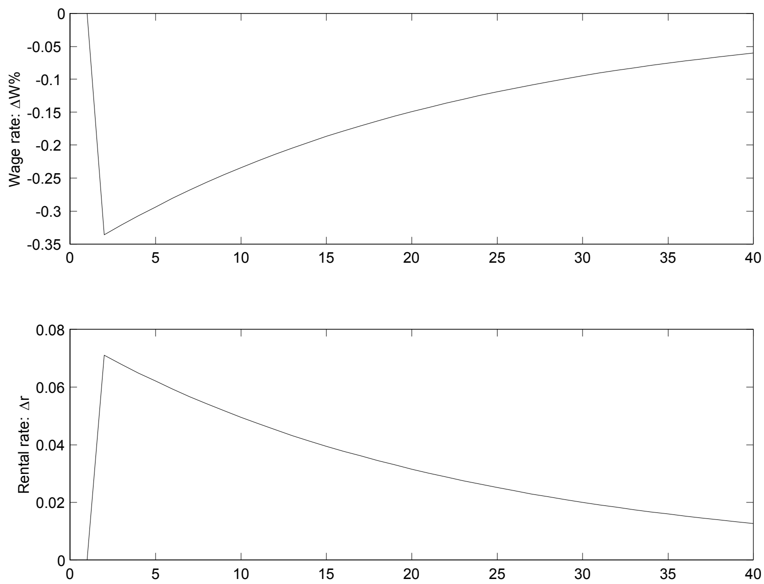

Figure 2: Decrease in τ^N with offsetting spending cuts: wage and rental rates

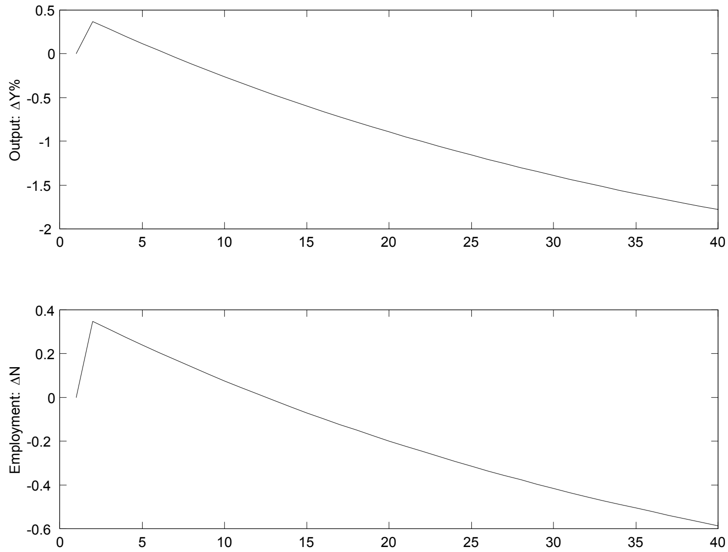

Figure 3: Decrease in τ^N with offsetting increases in τ^K: output and employment

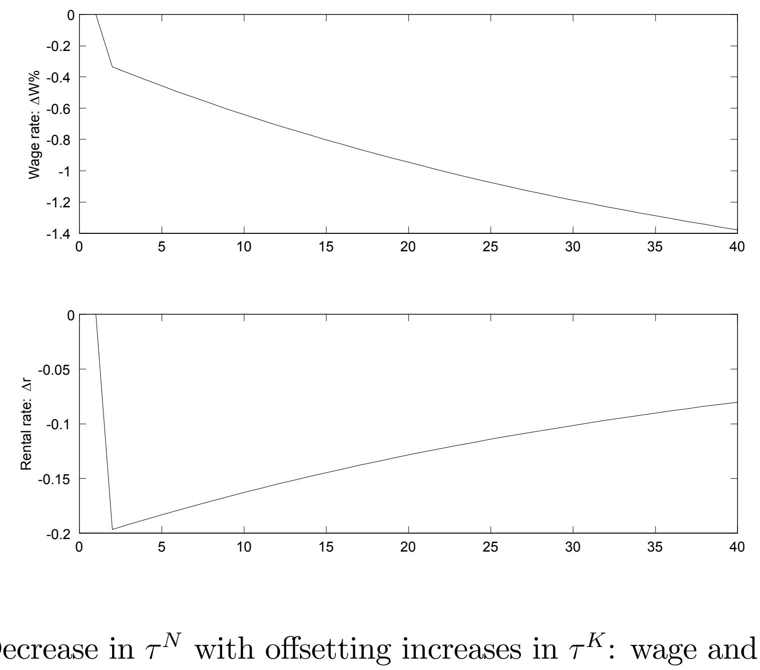

Figure 4: Decrease in τ^N with offsetting increases in τ^K: wage and rental rates