Discussion Paper No. 02-39

Taxation and Unemployment: An Applied General Equilibrium Approach for Germany

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Non-Technical Summary

Persistent unemployment at high levels is a central policy problem in most OECD countries. Among the alternative policy proposals to alleviate the unemployment problem are tax policy shifts, which have received much interest. If it should turn out that tax cuts on labour can produce major positive labour market effects, this would give politicians an instrument that can be expected to be much less controversial than radical changes in the entrenched labour market institutions.

We develop an applied general equilibrium model for the German economy to study the potential impacts of changes in taxation on employment and unemployment. Reflecting empirical evidence of the German labour market institutions, a distinctive and innovative feature of our model is the sectoral heterogeneity in wage bargaining between employers' associations and trade unions that represent workers of two skill groups with different bargaining power. Given intersectoral wage differentials, we adopted a core idea of dual labour market theory to cope with intersectoral mobility of workers. Wage differentials are compensated for by different degrees of labour market tightness.

We use our model for the analysis of government policies that reduce public spending to finance cuts in labour taxes. The bottom line of our results is that the employment effects of such tax cuts are rather small. In line with the theoretical literature, we find that labour market effects can mainly be traced back to changes in the tax progression. A higher tax allowance has the largest effect on tax progression and thus reduces unemployment to the largest extent. However, it is inferior as compared to other tax instruments in terms of the standard welfare measures. Therefore, the question of whether a cut in taxes should reduce tax progression cannot unambiguously be answered.

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Abstract

This paper presents an applied general equilibrium model for Germany. The model integrates specific labour market institutions in an otherwise standard general equilibrium framework. There are sectoral wage negotiations for two skill types of workers between firms and trade unions. The bargaining setup is sensitive to the specific conditions of the respective sector (profits, output and labour demand elasticities, bargaining power) and generates wages that reflect empirical wage differentials across sectors.

The model is used to simulate the labour market effects of changes in the taxation of labour: marginal and average wage tax, and social security contributions.

Keywords: applied general equilibrium, Germany, labour market, trade unions, wage bargaining, tax policy, tax progression, labour mobility

JEL Code: D58; E62; J60

1 Introduction

Persistent unemployment at high levels is a central policy problem in most OECD countries (see OECD 2001 for a recent overview). Among the alternative policy proposals to alleviate the the unemployment problem are tax policy shifts, which have received much interest. If it should turn out that tax cuts on labour can produce major positive labour market effects, this would give politicians an instrument that can be expected to be much less controversial than radical changes in the entrenched labour market institutions.

In the public finance literature during the last decade, the effects of taxation on unemployment have been a major topic (see Sørensen 1997 for an overview). This literature combines different theories of equilibrium unemployment with the classical methods of tax incidence analysis. Although rigorous anlytical models provided a number of important insights, such as the positive impact of labour income tax progression on employment (Hoel 1990, Lockwood and Manning 1993, Koskela and Vilmunen 1996, Goerke 1997), its contribution to applied policy making remains rather limited. The reason for this is that theoretical models used in the investigation of the relationship between taxation and the labour market are highly stylised in order to keep analytical tractability. If we are interested not only in basic qualitative effects, but also in the quantification of the labour market consequences of realistic tax policy shifts, we must take the step from stylised analytical to complex numerical models. Accounting for a more detailed production structure and the specific institutional features of a country's labour market or tax system makes analytical solutions unavailable, and we have to rely on numerical solution methods. The same development occurred earlier in general tax and trade policy analysis through the standard applied general equilibrium models of the 1980s (see e.g. Shoven and

Whalley 1984, Ballard et al. 1985).

To date, even though labour market effects of policy interference have become a key interest to decision makers, little work has been done to incorporate unemployment features within the applied general equilibrium framework. One simple approach consists in the replacement of the competitive labour market of the neoclassical standard model with a "wage curve" (Blanchflower and Oswald 1994). The wage curve reflects empirical evidence on the inverse relationship between the level of wages and the rate of unemployment. In such a model, the wage curve, together with labour demand, determines the level of involuntary unemployment. A recent example is provided in Böhringer et al. (2001). The wage curve constitutes a convenient short-cut to incorporate unemployment, but it lacks an explicit micro-foundation. This makes it impossible to analyse how specific policy measures affect the wage setting mechanism.

Another, much more involved way to deal with unemployment is to look into the "black box" of the wage curve and explicitly model the wage-setting process. Examples are the efficiency-wage model provided by Hutton and Ruocco (1999) and MIMIC, a detailed model of the Dutch labour market (Bovenberg et al. 2000, Graafland et al. 2001), where wage determination is based on collective bargaining between firms and trade unions.

In this paper, we present an applied general equilibrium modelling approach designated for investigating labour market effects of tax policy intervention in the German economy. As in MIMIC, wages are determined through explicit firm-union bargaining. However, owing to the characteristics of the German labour market, our specification differs substantially from that adopted in MIMIC for the Dutch economy. The MIMIC setting reflects centralised negotiations where the wage bargaining equation contains economy-wide averages of the bargaining power, output and labour demand elasticities and is therefore nearly identical across sectors. In contrast, a characteristic feature of the German labour market is that wage negotiations are at the sectoral level. Different economic conditions across sectors produce different bargaining settings with varying bargaining power for firms and unions. Together with empirical wage differentials between sectors, this suggests a setting where wage negotiations are sensitive to the specific conditions in each sector. Furthermore, with wage differentials between sectors, special account must been taken of the mobility of workers between sectors.

Another more technical, yet potentially important difference is the derivation of wage bargaining first-order conditions. In MIMIC, it is assumed that both bargaining parties base their bargaining behaviour on a counterfactual, stylised production technology that is linear in the labour input. This implies that the labour demand elasticity in the wage negotiations, which is essential for the wage-employment trade-off, diverges from the real demand elasticity. In the context of our model, it turns out that the real demand elasticity is lower than the stylised elasticity. The latter would than give rise to "spurious wage moderation": The union moderates the wage in response to tax increases, because it fears large employment losses, but this would not be warranted in light of the real labour demand elasticity. By contrast, in our specification, the bargaining parties have rational expectations about the labour demand outcome. For each sector, an individual wage equation with specific bargaining parameters is set up and calibrated.

We use our model for the analysis of public sector policies in Germany. Since the coalition of Social-Democrats and the Green party have taken over political power in 1998, they have pursued public budget consolidation. One explicit goal for doing so is to provide some leeway for cuts in labour taxes which they hope will stimulate economic performance and labour demand. In our simulations, we quantify the welfare and employment effects of alternative reductions in labour taxes. Overall, we find that the positive employment effects of labour tax cuts are rather weak and might involve an explicit trade-off with welfare. Heterogeneity of skills with higher labour demand elasticities for low-skilled groups point to skill-targeted policies as a superior strategy vis-a-vis uniform policies. Furthermore, our results highlight the importance of tax shifting. In the short- to medium-run, where capital stocks are internationally immobile, the benefits of labour tax cuts to capital are larger than those to labour.

The contribution of our paper is twofold: From a methodological point of view, we show how sectoral wage bargaining can be incorporated into standard general equilibrium models of small open economies. From a policy point of view, we provide quantitative insights into the potential implications of tax policy shifts for employment and unemployment in Germany.

The remainder of the paper is organized as follows. Section 2 describes the algebraic model structure in detail. Data sources and calibration procedures are presented in Section 3. Section 4 provides our policy application. Section 5 concludes.

2 Model Description

The general equilibrium approach provides a micro-consistent comprehensive framework for studying the effects of policy interference on all markets of an economy. The simultaneous explanation of income origination and income spending of economic agents allows us to address both economy-wide efficiency and equity implications of policy intervention. Therefore, applied general equilibrium (AGE) models have become the standard tool for the analysis of the economy-wide impacts of policy measures on resource allocation and the associated implications for incomes of economic agents (for surveys on the use of AGE models in different policy fields, see Shoven and Whalley 1992, Peireira and Shoven 1992, Kehoe and Kehoe 1994, Fehr and Wiegard 1996, or Weyant 1999).

The main contribution of our model to the existing literature is the detailed representation of (German) labour market features: In each sector, an employers' organisation and a labour union are engaged in wage negotiations, which are modelled as a "right-to-manage" Nash-bargaining. Workers are classified into two skill types. They are mobile, but they can only change sectors during a period of unemployment. Matching of unemployed workers with vacant jobs is random. In this setting, we can analyse the tax policy implications for wages and employment in each sector.

In the following, we provide a detailed algebraic description of our modelling framework.

2.1 Firms

2.1.1 Production

In each production sector, a representative firm produces a homogenous output. The production function is of the nested constant-elasticity-of-substitution (CES) type, with a nesting structure as given in Figure 1.

Materials (M) are a composite of intermediate inputs with fixed production coefficients (Leontief production structure). M is combined in an upper nest with a value added aggregate (VA). Within VA, low-skilled labour (L) is separated from a composite of high-skilled labour (H) and capital (K). This reflects empirical evidence

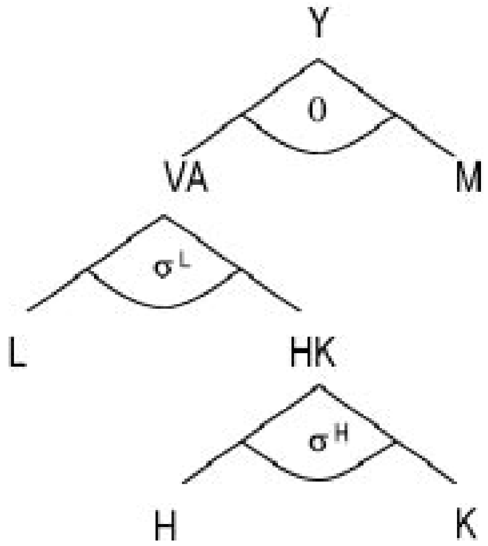

Figure 1: Nesting structure of production function

that L is a relatively good substitute for both H and K, whereas H and K are relatively bad substitutes for each other. Adopting the calibrated share form (see Appendix 1), the cost function for each sector s can be written as

$$c_s = \beta_s^{VA} c_{va,s} + \left(1 - \beta_s^{VA}\right) c_{m,s}, \tag{1}$$

with

$$c_{va,s} = \left[\beta_s^L \left(\frac{w_{L,s}(1 + t_{l,L})}{\bar{w}_{L,s}(1 + \bar{t}_{l,L})} \right)^{1-\sigma_s^L} + \left(1 - \beta_s^L\right) c_{hk,s}^{1-\sigma_s^L} \right]^{\frac{1}{1-\sigma_s^L}}, \tag{2}$$

$$c_{hk,s} = \left[\beta_s^H \left(\frac{w_{H,s}(1 + t_{l,H})}{\bar{w}_{H,s}(1 + \bar{t}_{l,H})} \right)^{1-\sigma_s^H} + \left(1 - \beta_s^H\right) \left(\frac{r(1 + t_k)}{\bar{r}(1 + \bar{t}_k)} \right)^{1-\sigma_s^H} \right]^{\frac{1}{1-\sigma_s^H}}, \tag{3}$$

$$c_{m,s} = \sum_{ss} \frac{p_{a,ss}}{\chi_{ss}}, \tag{4}$$

where:

$c_{j,s}$	:=	cost index of intermediary aggregate j,
β_s^{VA}	:=	benchmark value share of VA in total cost,
β_s^L	:=	benchmark value share of L in VA aggregate,
β_s^H	:=	benchmark value share of H in HK aggregate,
$w_{i,s}$	:=	wage of skill group i (gross of wage tax),
r	:=	rental rate of capital,
$p_{a,ss}$	:=	price of Armington good ss,
χ_{ss}	:=	fixed quantity of Armington good ss,
σ_s^L	:=	elasticity of substitution in VA nest,
σ_s^H	:=	elasticity of substitution in HK nest,
$t_{l,i}$	:=	social security contributions of labour of type i,
$t_{k,s}$	:=	capital input tax,

and the "bar" superscript denotes benchmark values.

Each individual firm is assumed to be small in relation to its respective sector. All firms in one sector interact through monopolistic competition, i.e. they produce individual variants of the sectoral output good that attract different consumers. This means that firms can exploit market power in their respective market segment. Producer output prices then consist of costs (of the three primary inputs as well as intermediary inputs) plus a fixed mark-up. The budget of the representative firm reads

$$(1 - m_s)p_{y,s}Y_s = \sum_{ss} p_{a,ss}A_{ss,s} + r(1 + t_k)K_s + \sum_i w_{i,s}(1 + t_{l,i})L_{i,s}, \tag{5}$$

where:

$$
\begin{array}{lll}
m_s & := & \text{price mark-up rate} \\
p_{y,s} & := & \text{output price} \\
Y_s & := & \text{output quantity} \\
A_{ss,s} & := & \text{intermediary input from Armington good } ss \\
K_s & := & \text{capital input} \\
L_{i,s} & := & \text{labour input of skill type } i.
\end{array}
$$

Profits in sector s are given by

$$\pi_s = m_s p_{y,s} Y_s. \tag{6}$$

2.1.2 Factor Demand

Cost minimisation yields the following demand functions for the primary factors at the sectoral level:

$$
\begin{aligned}
K_s &= Y_s \left(\frac{c_{va,s}}{c_{hk,s}}\right)^{\sigma_s^L} \left(c_{hk,s}\frac{\bar{r}(1+\bar{t}_k)}{r(1+t_k)}\right)^{\sigma_s^H}, &(7)\\
L_{H,s} &= Y_s \left(\frac{c_{va,s}}{c_{hk,s}}\right)^{\sigma_s^L} \left(c_{hk,s}\frac{\bar{w}_{H,s}(1+\bar{t}_{l,H})}{w_{H,s}(1+t_{l,H})}\right)^{\sigma_s^H}, &(8)\\
L_{L,s} &= Y_s \left(c_{va,s}\frac{\bar{w}_{L,s}(1+\bar{t}_{l,L})}{w_{L,s}(1+t_{l,L})}\right)^{\sigma_s^L}. &(9)
\end{aligned}
$$

The implied uncompensated (own and cross) price elasticities for labour are

$$
\begin{aligned}
\eta_{HH,s} &= -\beta_s^H\beta_s^L\sigma_s^L - \beta_s^H\sigma_s^H - \theta_s^H/m_s,\\
\eta_{HL,s} &= \beta_s^L\sigma_s^L - \theta_s^L/m_s,\\
\eta_{LH,s} &= (1-\beta_s^L)\beta_s^H\sigma_s^L - \theta_s^H/m_s,\\
\eta_{LL,s} &= -(1-\beta_s^L)\sigma_s^L - \theta_s^L/m_s,
\end{aligned}
$$

where

θ_s^i := value share of labour skill type i in total production costs,

m_s := price mark-up (reciprocal of the output demand elasticity).

Note that the terms on the RHS containing the σ's are the compensated labour demand elasticities; the last term in each expression accounts for the output variation. (For the relation between compensated and uncompensated elasticities, see e.g. Hamermesh 1993, pp. 22-38.)

Capital and labour are mobile across sectors (see section 2.3.2 for the representation of intersectoral labour mobility in the presence of cross-sector wage differentials). The market for capital is perfectly competitive. By default, we assume that capital is internationally immobile, which reflects a short- to medium-run model horizon. Sensitivity analysis of policy intervention with respect to international capital mobility can be performed by fixing capital rents at the international interest rate.

2.2 Private Households

The household sector consists of three representative households, two worker households and one capitalist household. For both skill groups, there is one worker household that receives both labour income and unemployment benefits. The latter is proportional to the time spent unemployed with the replacement rate fixed at a constant fraction of the net wage. Depending on model settings, the worker households may also receive a fraction of the capital (κ_i) and profit income (γ_i). The third household is only endowed with capital and property rights of the firms. If $\kappa_i = \gamma_i = 0$ (which is our default setting), the functional distribution of incomes is clear-cut. If the worker households receive part of the capital and profit incomes, we assume that it is distributed between them in proportion to their empirical bench-

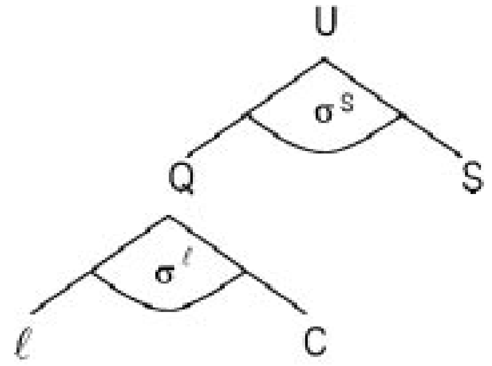

Figure 2: Utility nesting of representative worker

mark savings. In addition to the factor incomes, there is either a lump-sum tax or a transfer to balance the government's budget. This is explained in Section 2.4.

The CES utility function of workers is given in Figure 2. At the upper level, households decide over current versus future consumption, that is, savings S are determined. The "current utility" Q nest accommodates the decision between leisure (l) and the consumption good composite (C). The capitalist household does not supply labour, so its utility function consists only of the upper level.

2.2.1 Savings and Investment

The representation of the savings decision follows the approach of Ballard et al. (1985). They derive a saving function in which savings are sensitive to both the real interest rate and the price of investment goods. Households' savings then correspond to the purchase of a uniform investment good at price P_I per unit. This investment good is a fixed-coefficient composite of all Armington goods (see Section 2.5). Households derive their utility from the future stream of consumption that corresponds to the return to investment. In formal terms, the households' trade-off between current and future consumption on the upper level of their decision problem is

$$\max U_i(Q_i, C_i^F) \qquad \text{s.t.} \quad P_{Q,i}H_i + P_S C_i^F = I_{e,i}, \tag{10}$$

where

Q_i := current utility aggregate,

C_i^F := stream of future consumption,

$P_{Q,i}$:= price of Q_i,

P_S := price of C_i^F,

$I_{e,i}$:= extended income, see (16).

The crucial point in the savings calculus is the determination of P_S, which is the key determinant of savings demand. Each unit of investment (savings), S, generates a stream of ϕ units of capital services in each future period (where ϕ is a constant determined by the steady state condition). These services yield yearly income at rate r (net of taxes), which is then traded for the consumption goods composite at rate P_C. Note that P_C is not differentiated across households, because all households have the same consumption spending pattern. Under the assumption of static expectations, i.e. all prices are expected to remain at their current levels, savings will yield the following consumption possibilities:

$$C^F = \frac{\phi p_K}{P_C}. \tag{11}$$

Together with the price P_I.of the investment good, which is defined as Leontief aggregate over Armington goods, we then have

$$P_S = \frac{P_I P_C}{\phi p_K}. \tag{12}$$

In calibrated share form, U reads as

$$U_i = \left[\theta_i^Q \left(\frac{Q_i}{\bar{Q}_i} \right)^{\frac{1-\sigma_i^s}{\sigma_i^s}} + \left(1 - \theta_i^Q\right) \left(\frac{S_i}{\bar{S}_i} \right)^{\frac{1-\sigma_i^s}{\sigma_i^s}} \right]^{\frac{\sigma_i^s}{1-\sigma_i^s}}, \tag{13}$$

with θ_i^Q denoting the value share of current consumption in extended income. The associated unit expenditure function is

$$P_{U,i} = \left[\theta_i^Q \left(\frac{P_{Q,i}}{\bar{P}_{Q,i}}\right)^{1-\sigma_i^s} + \left(1-\theta_i^Q\right)\left(\frac{P_S}{\bar{P}_S}\right)^{1-\sigma_i^s}\right]^{\frac{1}{1-\sigma_i^s}}. \tag{14}$$

This yields the following savings demand function:

$$S_i = \bar{S}_i \left(\frac{P_{U,i}\bar{P}_S}{\bar{P}_{U,i}P_S}\right)^{\sigma_i^s} \frac{I_{e,i}\bar{P}_{U,i}}{\bar{I}_{e,i}P_{U,i}}. \tag{15}$$

It is important to note that the assumption of a flexible savings price drives a wedge between the amount of money actually spent on investment goods and the savings term appearing in the utility maximising problem, because P_S generally does not equal P_I. In order to assure that the households' budget constraints actually hold (i.e. outlays equal income), we have to correct for the difference between P_S and P_I. Extended income $I_{e,i}$ then becomes

$$I_{e,i} = \sum_s \tilde{w}_{i,s}L_{i,s} + b_i L_{U,i} + rV_{U,i}l_i + \kappa_i r\bar{K} + \gamma_i \Pi + (P_S - P_I)S_i - T_{LS,i}, \tag{16}$$

where

$\tilde{w}_{i,s}$:= net wage rate,

b_i := unemployment benefit,

$rV_{U,i}$:= value of unemployed time,

$\bar{K}$:= aggregated capital stock,

Π := aggregated profits,

$T_{LS,i}$:= lump-sum tax or benefit (see Section 2.4).

Equation (16) forms the basis for the benchmark value shares θ_i^Q. The savings decision of the capitalist household is derived analogously.

2.2.2 Labour Supply

On the second level of the utility maximisation problem, the households decide about leisure and current consumption. Time endowment is divided into three components: leisure, labour time, and time spent unemployed (searching for a job). Labour time per skill type $L_{i,s}$ (in value units) is given as

$$L_i = \sum_s L_{i,s}. \tag{17}$$

where

$L_{i,s}$:= labour demand by sector.

Unemployed time in the benchmark is calculated as:

$$L_{U,i} = u_i L_i / (1 - u_i), \tag{18}$$

where

u_i := benchmark unemployment
(as a fraction of total labour supply $L_{S,i} = L_i + L_{U,i}$).

Leisure (l_i) as the third component of total time endowment is finally calculated as

$$l_i = (\zeta - 1) L_{S,i}, \tag{19}$$

where

ζ := exogenous ratio of total time endowment to labour supplied.

Thus, total labour endowment $\bar{L}_i$ can be written as

$$\bar{L}_i = L_i + L_{U,i} + l_i. \tag{20}$$

A key assumption about the households' labour supply behaviour in our modelling approach is that workers cannot directly enter employment. Each additional unit of labour is first unemployed for a certain period and may then be combined with a job according to a stochastic matching process (see Section 2.3). Consequently, the marginal decision of the household depends only on the annualised value of unemployed time, $rV_{U,i}$. However, the inframarginal units of labour receive the net of tax wage $\tilde{w}_{i,s}$, when employed in sector s, or b_i, when unemployed (b_i can be chosen to be either fixed in absolute terms or as a fraction of the net wage). The net wage is derived from the gross wage by imposing a linear progressive wage tax:

$$\tilde{w}_{i,s} = w_{i,s} - t_{wm,i}(w_{i,s} - A_i). \tag{21}$$

where

$t_{wm,i}$:= marginal tax rate,

A_i := allowable tax deduction.

The average tax rate is denoted by $t_{w,i}$ and can be calculated as

$$t_{w,i} = 1 - \frac{\tilde{w}_{i,s}}{w_{i,s}} = t_{wm,i}\left(1 - \frac{A_i}{w_{i,s}}\right).$$

The CES subutility function on the second level reads

$$\frac{Q_i}{\bar{Q}_i} = \left[\theta_i^C \left(\frac{C_i}{\bar{C}_i}\right)^{\frac{1-\sigma_i^l}{\sigma_i^l}} + (1-\theta_i^C)\left(\frac{l_i}{\bar{l}_i}\right)^{\frac{1-\sigma_i^l}{\sigma_i^l}} +\right]^{\frac{\sigma_i^l}{1-\sigma_i^l}}. \tag{22}$$

with corresponding expenditure and demand functions:

$$\frac{P_{Q,i}}{\bar{P}_{Q,i}} = \left[\theta_i^C \left(\frac{P_C}{\bar{P}_C}\right)^{1-\sigma_i^l} + (1-\theta_i^C)\left(\frac{rV_{U,i}}{\bar{r}\bar{V}_{U,i}}\right)^{1-\sigma_i^l} +\right]^{\frac{1}{1-\sigma_i^l}}, \tag{23}$$

$$\frac{l_i}{\bar{l}_i} = \frac{Q_i}{\bar{Q}_i}\left(\frac{P_{Q,i}}{\bar{P}_{Q,i}}\frac{\bar{r}\bar{V}_{U,i}}{rV_{U,i}}\right)^{\sigma_i^l}, \tag{24}$$

$$\frac{C_i}{\bar{C}_i} = \frac{Q_i}{\bar{Q}_i}\left(\frac{P_{Q,i}}{\bar{P}_{Q,i}}\frac{\bar{P}_C}{P_C}\right)^{\sigma_i^l}, \tag{25}$$

where

θ_i^C := benchmark value share of consumption in the value of current utility.

2.2.3 Consumption

Aggregate consumption for each of the two representative worker households is determined together with labour supply. As we assume identical consumption spending patterns for all three households, aggregate consumption across households is:

$$C = \sum_i C_i + C_K \tag{26}$$

where

C := aggregate consumption/supply of aggregate consumption good,

C_i := consumption of worker household i,

C_K := consumption of capitalist household.

Aggregate consumption is then distributed among the different consumption goods, C_z, according to a CES function

$$\frac{P_C}{\bar{P}_C} = \left[\sum_z \theta_z^C \left(\frac{p_{c,z}(1+t_{c,z})}{\bar{p}_{c,z}(1+\bar{t}_{c,z})}\right)^{1-\sigma_c}\right]^{\frac{1}{1-\sigma_c}}, \tag{27}$$

$$\frac{C_z}{\bar{C}_z} = \frac{C}{\bar{C}} \left(\frac{P_C}{\bar{P}_C}\frac{\bar{p}_{z,c}}{p_{z,c}}\right)^{\sigma_c}, \tag{28}$$

where

P_C := consumer price index,

θ_z^C := benchmark value share of consumption good z,

$p_{c,z}$:= producer price of consumption good z,

$t_{c,z}$:= consumption tax,

σ_c := elasticity of substitution in consumption,

C_z := consumption of good z,

C := aggregate consumption.

Each consumption good, C_z, is composed of the Armington goods (see Section 2.5) in fixed proportions:

$$\frac{A_{s,z}}{\bar{A}_{s,z}} = \frac{C_z}{\bar{C}_z}, \tag{29}$$

with

$$\sum_s A_{s,z} = C_z. \tag{30}$$

2.3 Labour Market

2.3.1 Wage Bargaining

Wages are determined by sector-specific bargaining between the representative firm and a trade union. As is usual in the trade union literature, we represent the bargaining outcome as the maximisation of a Nash function that includes the objective functions of both parties and their respective fallback options. We adopt the “right to manage” approach: parties bargain over wages, and firms decide over their labour demand at the bargained wage.

The Nash bargaining solution is obtained by solving

$$\max_{w_{H,.s},w_{L,s}} \ln \Omega_s = \ln \pi_s + \rho_{H,s} \ln \Gamma_{H,s} + \rho_{L,s} \ln \Gamma_{L,s}, \tag{31}$$

where

$$
\begin{array}{lll}
\Omega_s & := & \text{Nash maximand,} \\
\pi_s & := & \text{profits of representative firm,} \\
\Gamma_{i,s} & := & \text{union utility of workers of type } i, \\
\rho_{H,s} & := & \text{bargaining power of high-skilled labour,} \\
\rho_{L,s} & := & \text{bargaining power of low-skilled labour.}
\end{array}
$$

The firms' objective is their profit, π_s. We assume that the firms' fallback option is no production and, thus, zero profits. The union represents both types of workers. For each skill type, its objective function is employment times the value of a job minus the value of unemployment:

$$\Gamma_{i,s} = L_{i,s} \left(V_{i,s} - V_{U,i} \right).$$

For a more detailed explanation of the term $V_{i,s} - V_{U,i}$ see Section 2.3.2.

Maximising the Nash objective (31) yields one first order condition (FOC) for each skill group and sector:

$$\frac{\partial \pi_s}{\partial w_{i,s}} \frac{1}{\pi_s} = \rho_{H,s} \frac{\partial \Gamma_{H.s}}{\partial w_{i,s}} \frac{1}{\Gamma_{H,s}} + \rho_{L,s} \frac{\partial \Gamma_{L,s}}{\partial w_{i,s}} \frac{1}{\Gamma_{L,s}}. \tag{32}$$

We use uncompensated own- and cross-price labour demand elasticities, η_{ij}, to write down the FOC in a compact form. Both bargaining parties know that firms will increase their output price when wages rise, leading to a fall in output. Note that in collective bargaining, the relevant output price elasticity is the elasticity of industry output, not the individual firm's output. The nesting structure of both production and consumption requires a numerical approximation of the relevant price elasticities. We calculate the latter at the benchmark point and use these values as parameters in subsequent policy counterfactuals. (The documentation of the numerical routine can be obtained from the authors upon request.) In our policy simulations, re-calculation of elasticities in the counterfactual equilibrium justifies this procedure because the deviations from the benchmark values are negligible.

For low-skilled labour the FOC in compact form then is

$$\frac{-L_{L,s}(1+t_{l,s})}{\pi_s} = \rho_{L,s}\left(\frac{\eta_{LL}, s}{w_{L,s}} + \frac{1-t_{wm,L}}{\tilde{w}_{L,s} - rV_{U,L}}\right) + \rho_{H,s}\frac{\eta_{HL}}{w_{H,s}}. \tag{33}$$

The FOC for high-skilled labour is derived analogously. (Taxes are explained in Section 2.4.)

2.3.2 Intersectoral Mobility and Wage Arbitrage

As is customary in the search literature (see e.g. Pissarides, 1990), we use value functions to characterize the surplus from working. The value of a job in sector s in period t, $V_{s,t}$, can be expressed recursively as (we drop the skill index in this section)

$$V_{s,t} = \frac{1}{1+r}\left[\tilde{w}_s + (1-\mu_s)\, V_{s,t+1} + \mu_s V_{U,t+1}\right], \tag{34}$$

where

r := discount rate,

$\tilde{w}_s$:= after-tax wage,

μ_s := separation rate.

The value of the state of unemployment, $V_{U,t}$, is expressed analogously:

$$V_{U,t} = \frac{1}{1+r}\left[b + (1-\lambda_s)\, V_{U,t+1} + \lambda_s V_{s,t+1}\right] \tag{35}$$

where

b := unemployment benefit,

λ_s := hiring rate.

While unemployed, a worker receives a benefit that does not depend on former earnings. (But it can be indexed to the net wage in general and take on the form of a fixed replacement rate.)

A steady state is characterised by

$$V_{s,t} = V_{s,t+1} \qquad \text{and} \qquad V_{U,t} = V_{U,t+1}, \tag{36}$$

which allows us to drop the time index and rewrite the value of the state of unemployment as

$$rV_U = b + \lambda_s (V_s - V_U) \qquad \forall s. \tag{37}$$

In equilibrium, job-seekers must be indifferent between any two of the sectors, i.e.

$$\lambda_s (V_s - V_U) = \lambda_{ss} (V_{ss} - V_U) \qquad \forall s, ss. \tag{38}$$

The higher the "surplus from working" $(V_s - V_U)$ is, the lower the quit rate from unemployment, λ_s, must be (see Acemoglu 2001, p. 18: "Workers who apply to bad jobs suffer shorter unemployment spells"). This condition reflects empirical evidence that high-wage jobs actually attract longer queues (Holzer et al. 1991).

In a steady state, there must be a flow equilibrium on the labour market, i.e. lay-offs equal hirings:

$$\mu_s (1 - u_s) = \lambda_s u_s. \tag{39}$$

where u_s is the sectoral unemployment rate. This allows the elimination of λ_s from the value functions using

$$\lambda_s = \frac{\mu_s (1 - u_s)}{u_s}. \tag{40}$$

We assume each single sector to be small compared to the aggregate economy, i.e. the bargaining parties treat the macro variables as given. In particular, the value of unemployment is constant from each union's point of view. We can thus replace $V_s - V_U$ in the Nash maximand by

$$V_s - V_U = \frac{\tilde{w}_s - rV_U}{r + \mu_s}, \tag{41}$$

which results in a function where $\tilde{w}_s$ is the only remaining variable. The differentiation of the rearranged Nash objective yields the FOC for low-skilled and high-skilled labour as given in (33).

The labour market setup is complicated by the fact that the empirical estimates of German wage differentials (see Section 3.3.7) are too large to be used in their raw form in the arbitrage calculus of the unemployed workers. We observe small sectors with very low wages (hotel industry, private services), which means that a large part of the economy must have high unemployment to make the unemployed indifferent between all sectors. The arbitrage condition cannot be balanced in this way by the actual unemployment rates for Germany. We therefore include a nonpecuniary wage component for employment in each sector in the value equation for $V_{s,t}$. The sector-specific nonpecuniary wage component can be conceived of as hypothetical payments that make low wage sectors more attractive than solely reflected in their wage. To maintain homogeneity, the nonpecuniary wage components δ_s are expressed as a fixed fraction of the wage, i.e. $\tilde{w}_s$ becomes $\tilde{w}_s(1 + \delta_s)$. Thus, we have a dual account for sectoral wage differences. They are partly attributed to non-pecuniary differences between the sectors (which reflects the empirical long-term stability of wage differentials) and partly to differences in labour market tightness.

2.4 Government

The government levies the following taxes to collect revenues:

$t_{l,s}$:= social security contributions of labour (payroll tax),

$t_{k,s}$:= capital input tax,

t_π := profit tax,

A_i := allowable tax deduction,

$t_{wm,i}$:= marginal tax rate on labour income,

$t_{c,z}$:= consumption tax,

$t_{y,s}$:= output tax.

Imposition of these taxes on the respective tax bases yields tax revenues:

$$T = \sum_s t_{k,s} r K_s + \sum_s t_\pi \pi_s + \sum_{i,s} \left[(t_{l,s} + t_{wm,i}) w_{i,s} - t_{wm,i} A_i \right] L_{i,s} + \sum_z t_{c,z} p_{c,z} C_z + \sum_s t_{y,s} p_{y,s} Y_s.$$

The government's budget then is

$$\sum_s p_{a,s} G_s + \sum_i \frac{u_i}{1-u_i} L_i b_i + x\overline{BOP} = T + \bar{T}_{LS}, \tag{42}$$

where

G_s := government purchases in sector s,

x := foreign exchange rate,

$\overline{BOP}$:= exogenous balance of payment deficit (or surplus, if negative),

$\bar{T}_{LS}$:= lump sum tax (or transfer, if negative) to balance the budget.

The value of $\bar{T}_{LS}$ is calibrated to assure the government's budget constraint in the benchmark. $\bar{T}_{LS}$ is then distributed among the three households in proportion to their monetary incomes.

2.5 Foreign Trade

Domestically produced goods are converted through a constant-elasticity-of-transformation function into specific goods destined for the domestic market and goods destined for the export market:

$$\frac{Y_s}{\bar{Y}_s} = \left[\theta_s^{YD} \left(\frac{D_s}{\bar{D}_s} \right)^{\frac{1+\eta}{\eta}} + \theta_s^{Ex} \left(\frac{Ex_s}{\overline{Ex}_s} \right)^{\frac{1+\eta}{\eta}} \right]^{\frac{\eta}{1+\eta}}, \tag{43}$$

with an associated price equation

$$\frac{p_{y,s}(1+t_{y,s})}{\bar{p}_{y,s}(1+\bar{t}_{y,s})} = \left[\theta_s^{YD} \left(\frac{p_{d,s}}{\bar{p}_{d,s}} \right)^{1+\eta} + \theta_s^{Ex} \left(\frac{x \cdot p_{Ex,s}}{\bar{x} \cdot \bar{p}_{Ex,s}} \right)^{1+\eta} \right]^{\frac{1}{1+\eta}}, \tag{44}$$

where

D_s	:=	good produced for the domestic market,
Ex_s	:=	goods produced for the export market,
θ_s^{YD}	:=	value share of domestic consumption in domestic production,
θ_s^{Ex}	:=	value share of exports,
$p_{d,s}$	:=	price of D_s,
$p_{Ex,s}$	:=	export prices,
η	:=	elasticity of transformation,
x	:=	foreign exchange rate.

By the small-open-economy assumption, export and import prices in foreign currency are not affected by the behaviour of the domestic economy. In other words, the small open economy faces infinitely elastic world export demand and world import supply functions.

Analogously to the export side, we adopt the Armington assumption of product heterogeneity for the import side. A CES function characterises the choice between imported and domestically produced varieties of the same good:

$$\frac{A_s}{\bar{A}_s} = \left[\theta_s^{AD} \left(\frac{D_s}{\bar{D}_s} \right)^{\frac{1-\sigma_s^{Im}}{\sigma_s^{Im}}} + \theta_s^{AM} \left(\frac{Im_s}{\overline{Im}_s} \right)^{\frac{1-\sigma_s^{Im}}{\sigma_s^{Im}}} \right]^{\frac{\sigma_s^{Im}}{1-\sigma_s^{Im}}}, \tag{45}$$

$$\frac{p_{a,s}}{\bar{p}_{a,s}} = \left[\theta_s^{AD} \left(\frac{p_{d,s}}{\bar{p}_{d,s}} \right)^{1-\sigma_s^{Im}} + \theta_s^{AM} \left(\frac{x p_{Im,s}}{\bar{x} \bar{p}_{Im,s}} \right)^{1-\sigma_s^{Im}} \right]^{\frac{1}{1-\sigma_s^{Im}}}, \tag{46}$$

where

A_s	:=	Armington good,
θ_s^{AD}	:=	value share of domestic production in domestic consumption,
θ_s^{AM}	:=	value share of imports,
Im_s	:=	Imports,
σ_s^{Im}	:=	elasticity of substitution,
$p_{a,s}$	:=	price of Armington good,
$p_{Im,s}$	:=	import prices (fixed in foreign currency).

The Armington good enters intermediate and final demand. The associated market clearing condition is

$$A_s = \sum_z A_{s,z} + G_s + I_s + \sum_{ss} A_{s,ss}, \tag{47}$$

where

$A_{s,z}$	:=	derived Armington demand from private consumption,
G_s	:=	government consumption,
I_s	:=	investment demand,
$A_{s,ss}$	:=	intermediate demand from sector ss.

The market clearing condition for the domestically produced good destined for the home market is

$$\frac{Y_s}{\bar{Y}_s} \left(\frac{p_{y,s}(1+t_{y,s})}{\bar{p}_{y,s}(1+\bar{t}_{y,s})} \frac{\bar{p}_{d,s}}{p_{d,s}} \right)^{-\eta} = \frac{A}{\bar{A}} \left(\frac{p_{a,s}}{\bar{p}_{a,s}} \frac{\bar{p}_{d,s}}{p_{d,s}} \right)^{\sigma_s^m}. \tag{48}$$

Foreign closure of the model is warranted through the balance-of-payments constraint

$$\overline{BOP} + \sum_s \overline{Ex}_s \frac{Y_s}{\bar{Y}_s} \left(\frac{p_{y,s}(1+t_{y,s})}{\bar{p}_{y,s}(1+\bar{t}_{y,s})} \frac{\bar{x}}{x} \right)^{-\eta} = \sum_s \bar{M}_s \frac{A}{\bar{A}} \left(\frac{p_a}{\bar{p}_a} \frac{\bar{x}(1+\bar{t}_{m,s})}{x(1+t_{m,s})} \right)^{\sigma_s^m} . \qquad (49)$$

The flexible exchange rate, x, adjusts so as to leave the benchmark balance of payments deficit (or surplus), $\overline{BOP}$, unchanged in terms of world market prices.

3 Calibration

3.1 Data sources

Our main data source is the input-output table (IOT) provided by the Federal Statistical Office of Germany for the benchmark year 1995, which contains a consistent data set of economic transactions for 59 sectors. Furthermore, we use complementary data from the employment statistics register and a sample of it (IABS), the Bundesbank (balance sheet data) and the federal government (tax statistics).

3.2 Aggregation level

For the sake of reduced dimensionality, we have aggregated the production side of the economy to seven sectors (see Table 2).[1]

3.3 Parameters

Table 2 lists the key parameters of the model. In the remainder of this section, we explain how the value of these parameters have been chosen.

[1] The NACE sections A to P include all 59 sectors of the German IOT.

Sectors in model	Single industries*
Agriculture	Agriculture (A), Fishing (B)
Energy & Mining	Mining (C), Electricity (E)
Manufacturing	Manufacturing (D)
Construction	Construction (F)
Trade & Transport	Wholesale and retail trade (G), Transport (I)
Banking	Financial Intermediation (J), Real estate (K)
Other Services	Public administration (L), Education (M),
	Health (N), Other community activities (O),
	Hotels and restaurants (H), Private Households (P)
	* Letters in parentheses indicate NACE-Code (section)

Table 1: Sectoral Aggregation

3.3.1 Cost shares of production factors & mark-up rates

The IOT provides a decomposition of total value-added into remuneration of capital and labour. For our model parameterisation, we must disaggregate the respective values into capital services and profits on the one hand, and labour incomes of the two skill groups on the other hand. To quantify profits, we use the Bundesbank's (1999) publication on annual accounts of West-German enterprises. We take the profit per Euro of sales ratio (before tax) to measure profits. Expenses for capital services are calculated as the difference between total capital earnings and profits. Mark-up rates result as the ratio of profits over sales. To divide the total amount of labour earnings per sector into income of high-skilled and low-skilled workers, we employ data from the employment register statistics ("Beschäftigtenstatistik"). This database covers all employees holding a regular job, i.e. those who have to pay

Symbol	Description
β_s^i	benchmark shares of factors that contribute to value added
σ_s^i	elasticity of substitution (EOS) in production
m_s	price mark-up
σ_i^l	EOS between leisure and consumption
σ_c	EOS between consumption goods
μ_s	separation rate
$b_i/\bar{w}_i$	replacement ratio in benchmark
$\bar{u}_i$	benchmark unemployment
η	EOS between domestic consumption and exports
σ_s^m	EOS between domestic production and imports
δ	depreciation rate
θ_i^H	value shares of savings and current utility
θ_i^l	value share of leisure and consumption

Table 2: Model Parameters

Industry	ε_{LL}	ε_{HH}	ε_{LH}	ε_{HL}
Agriculture	-0.50	-0.17	0.15	0.02
Energy & Mining	-0.21	-0.11	0.08	0.01
Manufacturing	-1.04	-0.57	0.45	0.08
Construction	-0.88	-0.07	0.60	0.05
Trade & Transport	-0.22	-0.16	0.02	0.00
Banking	-0.75	-0.13	0.18	0.01
Other Services	-0.49	-0.11	0.34	0.03

Table 3: Labour Demand Elasticities

social security contributions.[2] An employee without a vocational or academic degree is treated as "unskilled".

3.3.2 Elasticity of substitution in production

Our main reference for elasticities of substitution in German production is Falk and Koebel (1997) who provide estimates for five aggregated sectors. Complementary information on factor price elasticities are taken from Buslei and Steiner (1999). Table 3 summarises the uncompensated price elasticities for labour demand that underlie our model simulations.

3.3.3 Calibration of σ_i^l and σ_i^s

The elasticities of substitution σ_i^l and σ_i^s within the utility function can not be observed (estimated) directly. However, they can be inferred from empirical estimates of the uncompensated elasticity of savings with respect to the interest rate, ψ, and

[2]Information on the data can be found under: http://www.za.uni-koeln.de/data/en/iab/

the uncompensated elasticity of labour supply with respect to the net wage, ξ. Using the demand equations of Section 2.2, the following relationship between the uncompensated savings elasticity and the elasticity of substitution between current consumption and savings applies (see Rutherford 1995, index i has been dropped):

$$\psi = \sigma^s \theta^H + \frac{rK}{I_e}.$$

By default, we set the elasticity of savings with respect to the interest rate equal to 0.4 (see Bernheim 2001).

The relationship between the uncompensated labour supply elasticity and the elasticity of substitution between leisure and consumption is more involved. In our concrete model, labour supply is a complex function of not only rV_U, the price of leisure, but also all the w_s and b. Moreover, these variables are not independent of one another, but linked through equilibrium constraints. As a consistent scenario, we assume that all $\tilde{w}_s$, b and rV_U change by the same amount and match the household's reaction on this change with the empirical labour supply elasticity. Analogously to the case in Rutherford (1995), we use the following expression:

$$\xi = -\frac{dl}{d(rV_U)}\frac{rV_U}{LS} = -\left(\frac{\partial l}{\partial(rV_U)} + \frac{\partial l}{\partial I_e}\left(\frac{\partial I_e}{\partial(rV_U)} + \sum_s \frac{\partial I_e}{\partial \tilde{w}_s} + \frac{\partial I_e}{\partial b}\right) + \frac{\partial l}{\partial p_H}\frac{\partial p_H}{\partial(rV_U)} + \frac{\partial l}{\partial p_U}\frac{\partial p_U}{\partial(rV_U)}\right)\frac{rV_U}{L_S}. \quad (50)$$

This can be simplified to

$$\xi = \frac{l}{L_S}\left(\sigma^l - (\sigma^s - \sigma^l)\theta^l \frac{V_U}{\bar{V}_U}\frac{\bar{p}_H}{p_H} - (\sigma^s - 1)\theta^H\theta^l \frac{V_U}{\bar{V}_U}\frac{\bar{p}_U}{p_U} - \frac{rV_U\bar{L}}{I_e}\right). \quad (51)$$

Using the benchmark values and solving for σ^l, we get

$$\sigma^l = \frac{\bar{\xi}/(\zeta - 1) - \sigma^s\theta^l(1-\theta^H) - \theta^H\theta^l + \theta^L}{1-\theta^l}, \quad (52)$$

where

$$\theta^L = r\bar{V}_U \bar{L}/I_e.$$

By default, the uncompensated labour supply elasticity is set at 0.15, which is within the range of estimated values.[3]

3.3.4 Calibration of ρ_i

For each sector, we take the two FOC of the Nash bargain, evaluate them at the benchmark, and numerically solve for the ρ_i so that benchmark unemployment is met.

3.3.5 Unemployment and separation rates

The overall unemployment rate is taken from official statistics of the Federal Employment Office.[4] The rate for the unskilled workers is based on own calculations using the German Microcensus[5]. Separation rates are computed from the IAB-Employees sample (IABS), which is a one per cent sample of the complete employment register statistics. They are defined as outflows into unemployment within one year over the number of employees in the middle of the same year. For the sake of robustness, we take 5-year averages (1991-1995).

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[3] See e.g. Borjas (2000, p. 47) on this point. Note that we do not distinguish between male and female labour supply and that estimates for the supply elasticity of German women are relatively high (Franz, 1994, p. 84).

[4] See e.g. http://www.arbeitsamt.de/hst/services/anba/jg_1999/jz98/arbeitslose.html.

[5] This data source is documented under: http://www.social-science-gesis.de/en/social_monitoring/microdata/data/department/scientific_use_file/datenbeschreibung.htm.

3.3.6 Income tax rates and replacement ratio

The main sources for income taxes are the tax revenue statistics[6] of the Federal Ministry of Finance. In order to decompose overall tax revenues into contributions of different agents and sectors, the following approach has been used:

- Labour income tax: We assume that both representative worker households consist of a married couple with one bread-winner and one child. Both the average and the marginal wage tax of such a household (at the average income per skill type) are reported in official tax tables[7]. We employ the ratio between average tax rates for low-skilled and high-skilled workers and the coefficient of residual income progression (CRIP). The actual tax rates used in the model are then calculated such that the officially reported tax revenue is reproduced. Marginal rates are adjusted so as to keep the CRIP for both types.

- Capital income tax: We model a dual income tax where incomes from different sources are treated differently. To determine the average tax burden on capital, we sum up the revenue of the interest tax and the non-assessed income tax and add a small part of the assessed income tax according to information given by federal authorities[8].

- Tax on profits: All other taxes levied on companies are treated as a profit tax. They include the corporate tax and parts of personal income taxation.

[6] See http://www.bundesfinanzministerium.de/Anlage2330/Steuereinnahmen-1986-00.pdf

[7] These tables are called "Lohnsteuertabellen". See e.g. Bekanntmachung der Allgemeinen Lohnsteuertabellen 1993, Der Bundesminister der Finanzen, Köln: Bundesanzeiger-Verl.-Ges., 1992.

[8] See http://www.bundesfinanzministerium.de/Anlage9419/Datensammlung-zur-Steuerpolitik.pdf on this point.

Industry	Wage (relative to lowest)	
	skilled	unskilled
Agriculture	1.000	1.000
Energy & Mining	1.288	1.279
Manufacturing	1.212	1.201
Construction	1.226	1.226
Trade & Transport	1.077	1.062
Banking	1.215	1.204
Other Services	1.040	1.022

Table 4: Wage Differentials

As to the replacement ratio, we follow the specification of the unemployment insurance system, which amounts to 67% of the last net earnings for a married person with one child. In our model simulations, we have fixed the unemployment benefits relative to the net wage.

3.3.7 Wage differentials

Wage differentials are estimated using data from the German Socio-Economic Panel (SOEP Group 2001). We pool observations from five waves in the 1990s and estimate wage equations, including industry dummies. Table 4 reports on the estimated wage differentials. Wages in the lowest wage sector are normalised to one.

Other approaches that are based on more comprehensive data apply panel estimators to determine inter-industry wage differentials (Haisken-DeNew and Schmidt 1999) or are even able to exploit matched data sets that include information on the employer as well as the employee (see e.g. Abowd et al. 1999). Both ways tend to reduce the estimates, since they can take additional heterogeneity into account. The latter approach (matched employer-employee data) even eliminates almost all differentials.

3.3.8 Others

Armington elasticities are taken from Welsch (2001). They range between 0 and 2. Services and the construction sector are treated as non-tradables.

The elasticity of transformation between domestically supplied and exported goods is uniformly set to 2.

The depreciation rate of the capital stock (in our case: 4.76 %) is derived using information from the Federal Statistical Office on the net value of capital and depreciation in 1995.

Savings equal total investment, which is the sum of all expenditures on investment good in the benchmark period. To split up total savings between the two representative households, information from continuous household budget surveys is used.[9]

Concerning the consumption of leisure, households are treated identically. We assume that a working household's time endowment is 1.75 times its working time, or equivalently, leisure (including time for household work) amounts to 6 hours per day if standard working time is 8 hours.

[9] This data is gathered by the Federal Statistical office and published in the series FS 17, R 1, *Wirtschaftsrechnungen ausgewählter privater Haushalte.*

4 Simulations

Our model provides a consistent and comprehensive framework for the analysis of tax policy effects on employment. In the policy debate, the reduction of labour taxes is often considered as an important instrument to alleviate the unemployment problem. All major political parties in Germany have announced tax reduction programs to promote economic activity and boost employment. In fact, the ruling coalition of Social-Democrats and the Green party is strongly pursuing public budget consolidation to provide some leeway for cuts in labour taxes. We reflect this background in the design of our policy scenarios that address the impacts of public tax policies on employment and unemployment. More specifically, we assume that the government reduces public spending by 5%, which – for the case of Germany – amounts to a cut of public provision by around 1.15% of GDP. Lower public spending enables the government to reduce the tax burden on labour. In our simulations, we consider three alternative tax instruments that can be used to change the labour tax burden (i) the payroll tax (scenario t_l), (ii) the marginal labour income tax rate (scenario t_m), and (iii) the tax allowance (scenario A) on labour income. Which instrument should the government use for tax reduction in the context of reduced public spending in order to maximise employment gains?

For the interpretation of our results, it is useful to understand how the different instruments affect the progression of labour income taxation. With I denoting taxable income, the average tax rate of the linear-progressive tax schedule is endogenously determined by

$$t_w = t_m \frac{(I - A)}{I}.$$

The degree of tax progression is measured by the coefficient of residual income progression, $CRIP = (1 - t_m)/(1 - t_w)$, with a lower CRIP corresponding to a more progressive tax. When we assume proportional taxation, A is zero and t_w equals t_m. If we then introduce a positive tax allowance (in the A-scenario), the wage tax will become progressive (in general, the higher the tax allowance, the more progressive the tax system is). As with A, cuts in t_m also have a direct effect on tax progression: If the marginal tax rate is cut, the CRIP increases (for $A > 0$), i.e. the tax schedule becomes less progressive. The payroll tax (t_l) only has an indirect effect on tax progression through variations of the wage income. This indirect income effect which is also present in the cases of t_m and A turns out to be negligible for our simulations.

In order to keep transparency in the interpretation of the results, we develop the final counterfactual equilibrium step by step. We start with a version of the model that is simplified in four respects: (1) The wage bargaining process is replaced by competitive labour markets. (2) There is only one aggregate sector without intersectoral effects that arise in the full seven-sector version. (3) Labour supply is fixed. (4) Labour income taxes are proportional (no tax progression) and the same for both skill groups (uniform taxation). We then relax these simplifying assumptions one by one.

In each model setting, we run three simulations, one for each of the tax instruments (results are reported in Tables 4 to 7 at the end of the paper). The column labels in our tables are as follows: "t_l" indicates a cut in the payroll tax, "t_m" a cut in the marginal wage income tax, and "A" an increase in the tax allowance. The simulation results are reported as per-cent changes in the endogenous variables of the model, with the exception of unemployment rates where changes are given in percentage points.

Any reduction in public spending implies an increase in private welfare, since the utility derived from publicly provided goods and services is, by assumption, left out of account. Consequently, we observe gains in private welfare in all scenarios, but they differ in size.

Moving from simplified model settings to more complex ones, our key insights can be summarised as follows:

1. Competitive labour markets, one sector, proportional and uniform income taxation, fixed labour supply (Table 4, col. 1):

   With fixed labour supply, all initial taxes are effectively lump-sum. Changes in the labour income or payroll taxes do not affect the allocation of resources. As households and the government consume the same macro good, the government policy simply transfers income from the public sector to the worker households in proportion to their benchmark income.

2. Competitive labour markets, one sector, proportional and uniform income taxation, flexible labour supply (Table 4, col. 2, 3):

   With flexible labour supply, cuts in proportional income taxes through t_m and t_l effect higher net wages, which in turn lead to an increase in labour supply. At the same time, producer wages fall and employment rises. If taxation becomes progressive through the tax allowance A, the substitution effect – i.e. trading leisure against consumption – is weakened and gets more than compensated by the income effect of increased tax allowance. In total, demand for leisure rises and labour supply declines. The associated increase in the producer wage leads to a drop in employment. The changes in employment affect capital productivity and, hence, the rental rate. For increased employment, capital productivity and the rental rate go up (scenarios t_m and t_l); the opposite applies to the case of declining employment (scenario A). The two skill groups are now differently affected by uniform policy changes. This is because low-skilled workers are less complementary with capital than high-skilled workers. The demand for low-skilled workers is therefore more elastic and employment changes are more pronounced for this group. In the case of a cut in t_m or t_l (col. 2), this means that low-skilled workers enjoy a higher net wage increase, and hence higher welfare gains, than high-skilled workers. When the tax allowance is increased (col. 3), it is the other way round (due to the increase of producer wages).

3. Competitive labour markets, 7 sectors, proportional and uniform income taxation, fixed labour supply (Table 4, col. 4):

   Moving from the one-sector to the multi-sector model introduces a new source of heterogeneity. Public and private demands for goods are no longer the same. More than 90 per cent of the publicly demanded goods are from a single sector ("Other Services"). This sector is relatively intensive in labour, especially in high-skilled labour. The imposed decrease in the demand for public goods reduces the demand for the intensively used factor. Consequently, labour prices fall and the rental rate of capital rises. The changes in GDP that are caused by this sectoral reallocation of factor inputs are negligible.

4. Competitive labour markets, 7 sectors, proportional and uniform income taxation, flexible labour supply (Table 4, col. 5, 6):

   Again, we have quantitative changes to the one-sector model because of product heterogeneity and differences in factor intensities. However, the qualitative results are the same as in the one-sector model (compare col. 5 and col. 2 with respect to t_m and t_l; compare col. 6 and col. 3 with respect to t_A).

5. Wage bargaining, 7 sectors, proportional and uniform income taxation, fixed

labour supply (Table 5, col. 1, 2):

The labour market imperfection introduced by wage bargaining produces only minor changes as compared to a competitive labour market setting as long as taxation is proportional. In this case, policy instruments t_m and t_l work equivalently (no impacts on tax progression). Note that with involuntary unemployment, employment can rise with decreasing producer wages even when labour supply is fixed (col. 1). Introduction of the tax allowance (A) results in a progressive tax schedule (the CRIP falls below 1). This alters the union's trade-off between employment and wages. For increasing tax progression, it is "more expensive" in terms of employment to claim higher net wages. Tax progression thus leads to wage moderation and higher employment (col. 2).

6. Wage bargaining, 7 sectors, proportional and uniform income taxation, flexible labour supply (Table 5, col. 3, 4):

   Flexibility of labour supply in the wage bargaining model has only very small effects compared to the setting with fixed labour supply. All qualitative results remain the same.

7. Wage bargaining, 7 sectors, progressive and differentiated income taxation, fixed labour supply (Table 6, col. 1-3):

   With respect to A, the same reasoning as of (5) applies: An increase in the tax allowance augments the tax progression which moderates the union's wage claims and induces higher employment. With tax progression in place in the benchmark equilibrium, the effects of t_m and t_l are no longer identical. While under proportional taxation, changes in t_m do not affect tax progressivity, a cut in t_m now (i.e. given progressivity of the benchmark labour tax schedule) decreases the degree of tax progression. This leads to higher wage claims and lower employment as a result of the wage bargaining. Cuts in t_l do not affect the tax progression but directly lower producer wages, which increases labour demand. Such asymmetries between taxation of employers and employees when taxes are progressive are discussed in Koskela and Schöb (1999).

8. Wage bargaining, 7 sectors, progressive and differentiated income taxation, flexible labour supply (Table 6, col 4-6):

   Finally, in the fully detailed version of the model, flexibility of labour supply has again only small effects. The results are qualitatively the same as for the case of fixed labour supply.

The main objective of our simulations has been to identify the scope of employment gains in Germany that can be attained through cuts in labour taxes and a corresponding reduction of public spending. Summarising our results, the key conclusions are as follows:

- Overall employment effects from reducing the tax burden on labour are rather small, and the direction of employment effects can change with the tax instrument chosen for tax recycling. Reductions of the payroll tax t_l have only minor positive employment effects. Tax instruments A and t_m, which alter the progressivity of the tax system, do have stronger effects on employment: If taxation becomes more progressive through a higher tax allowance A, employment goes up, whereas it decreases when the marginal tax t_m is cut and tax progressivity decreases. The importance of progressive taxation in the context of wage bargaining is well known from the literature: "Tax progression is good for employment" (Koskela and Vilmunen 1996). Yet, our approach differs in some respects from that of Koskela and Vilmunen. They assume that the average tax burden is fixed, i.e. a rise in tax progression is equivalent to an increase in t_m. In our setting, a variation in the marginal tax rate also changes the average tax rate, which lowers the effect of changes in t_m on tax progression (through the parallel movement of t_m and t_w). By contrast, the simulations where A is raised isolate the effect of a lower average tax rate.

- While good for employment, a higher tax allowance is inferior from a welfare point of view. The welfare gains of both groups of workers are considerably smaller than with changes in the other taxes.

- A uniform tax policy affects skill groups differently. Due to differences in capital complementarity, high-skilled employment is less responsive to reductions in the tax burden than low-skilled employment. This suggests that a skill-targeted policy might be a superior strategy for reducing overall unemployment.

- The tax policies considered cause large shifts in the functional income distribution. Households that hold capital assets enjoy a large income gain, whereas workers profit less. The reallocation of factors across industries plays an important role for the distribution of income between worker households. High-skilled workers gain even less than the low-skilled because the goods purchased by the government are intensive in high-skilled labour. Finally, capital mobility is important. If we switch to a model variant with internationally mobile capital (not reported in the tables), the gains of capitalist households are strongly reduced. In such an economy, the direction of redistribution may even be reversed, i.e. labour may benefit more than capital.

5 Conclusions

High unemployment is a persistent phenomenon in many OECD countries. High taxes on labour combined with country-specific labour market institutions are often held responsible for substantial structural unemployment. Tax policy reforms may therefore be an important instrument to alleviate labour market problems.

We developed an applied general equilibrium model for the German economy to study the potential impacts of changes in taxation on employment and unemployment. Reflecting empirical evidence of the German labour market institutions, a distinctive and innovative feature of our model is the sectoral heterogeneity in wage bargaining between employers' associations and trade unions that represent workers of two skill groups with different bargaining power. Given intersectoral wage differentials, we adopted a core idea of dual labour market theory to cope with intersectoral mobility of workers. Wage differentials are compensated for by different degrees of labour market tightness.

We used our model for the analysis of government policies that reduce public spending to finance cuts in labour taxes. The bottom line of our results is that employment is rather insensitive to shifts in labour taxation. In line with the theoretical literature, we find that labour market effects can mainly be traced back to changes in the tax progression. A higher tax allowance has the largest effect on tax progression and thus reduces unemployment to the largest extent. However, it is inferior as compared to other tax instruments in terms of the standard welfare measures. Therefore, the question of whether a cut in taxes should reduce tax progression cannot unambiguously be answered.

Our simulations also point to the importance of more targeted policy measures. The effects of uniform tax policy often differ between the two skill groups, because employment of the low-skilled generally is more sensitive to wage changes. These effects might be exploited in designing a tax policy that is targeted at the lower end of the income distribution.

There are several features missing from our modelling framework that are potentially important when we assess the role of tax progression in tax policy reforms: (1) An endogenous decision on working hours may substantially reduce or even invert the employment effects of tax progression (see Sørensen 1999, Fuest and Huber 2000). (2) Taxation has a strong impact on the attractiveness of the informal sector. Black market work that contributes to official unemployment becomes the more attractive the higher the marginal labour income tax rates are. (3) Taxation affects endogenous decisions about human capital (Fuest and Huber 1998), which in turn feed back to the level of unemployment. (4) As compared to skill groups in labour markets with collective wage bargaining, tax policies might work quite differently for very high-skilled workers in competitive labour markets.

We plan to address these issues in future research extending the current model to the extent possible with available data.

6 Appendix: Calibrated Share Form

All CES functions of the model are implemented in calibrated share form. That is

$$\frac{Y}{\bar{Y}} = \left[\sum_i \theta_i \left(\frac{X_i}{\bar{X}_i} \right)^{\frac{1-\sigma}{\sigma}} \right]^{\frac{\sigma}{1-\sigma}} .$$

Associated to this production function is a cost function:

$$\frac{c_y}{\bar{c}_y} = \left[\sum_i \theta_i \left(\frac{p_{x,i}}{\bar{p}_{x,i}} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} ,$$

and demand for the individual factors of production:

$$\frac{X_i}{\bar{X}_i} = \frac{Y}{\bar{Y}} \left(\frac{c_y}{\bar{c}_y} \frac{\bar{p}_{x,i}}{p_{x,i}} \right)^{\sigma},$$

where

Y	:=	output quantity,
θ_i	:=	benchmark value share of X_i in the production of Y,
X_i	:=	input factor,
c_y	:=	cost of Y,
$p_{x,i}$	:=	input price of X_i,
σ	:=	elasticity of substitution.

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	LS fix 1 Sector t_m, t_l, A	LS flexible 1 Sector t_m, t_l	LS flexible 1 Sector A	LS fix 7 Sectors t_m, t_l, A	LS flexible 7 Sectors t_m, t_l	LS flexible 7 Sectors A
GDP	0.00	0.21	-0.69	-0.07	-0.01	-0.52
Welfare (L)	2.89	1.49	2.31	2.01	0.96	2.11
Welfare (H)	2.89	1.21	3.13	1.31	0.53	2.33
Welfare (K)	0.00	1.11	-3.48	1.78	2.35	-1.92
Employment (L)	0.00	0.40	-1.27	0.00	0.26	-1.04
Employment (H)	0.00	0.33	-1.03	0.00	0.14	-0.98
Interest rate	0.00	1.26	-3.96	1.93	2.54	-2.05
Producer wage (L)	0.00	-0.25	0.80	-0.57	-0.93	0.94
Producer wage (H)	0.00	-0.73	2.30	-1.29	-1.68	1.34
Consumer wage (L)	3.06	2.70	4.23	2.13	1.73	3.86
Consumer wage (H)	3.06	2.20	5.73	1.39	0.96	4.25

Table 4: Changes in Macroeconomic Variables (Competitive Labour Market)

	LS fix t_m, t_l	LS fix A	LS flexible t_m, t_l	LS flexible A
GDP	-0.02	0.16	-0.01	0.14
Welfare (L)	1.85	1.90	1.07	1.14
Welfare (H)	1.07	0.38	0.63	0.32
Welfare (K)	2.31	3.79	2.38	3.60
Employment (L)	0.10	0.83	0.17	0.87
Employment (H)	0.02	0.37	0.03	0.32
Unemployment (L)	-0.09	-0.71	-0.08	-0.69
Unemployment (H)	-0.02	-0.34	-0.02	-0.34
Interest rate	2.46	4.09	2.53	3.88
Producer wage (L)	-0.77	-1.82	-0.86	-1.86
Producer wage (H)	-1.53	-2.54	-1.57	-2.40
Consumer wage (L)	1.89	1.72	1.79	1.70
Consumer wage (H)	1.10	0.28	1.06	0.43

Table 5: Changes in Macroeconomic Variables (Wage Bargaining, Proportional Taxes)

	LS fix t_m	LS fix t_l	LS fix A	LS flexible t_m	LS flexible t_l	LS flexible A
GDP	-0.14	-0.02	0.16	-0.10	-0.01	0.14
Welfare (L)	1.44	1.83	0.85	0.80	1.04	0.54
Welfare (H)	1.62	1.09	0.45	0.85	0.62	0.34
Welfare (K)	1.24	2.26	3.84	1.56	2.37	3.68
Employment (L)	-0.27	0.07	0.62	-0.18	0.15	0.60
Employment (H)	-0.25	0.01	0.40	-0.17	0.03	0.36
Unemployment (L)	0.23	-0.06	-0.53	0.21	-0.05	-0.52
Unemployment (H)	0.22	-0.01	-0.36	0.22	-0.01	-0.36
Interest rate	1.28	2.40	4.14	1.62	2.52	3.97
Producer wage (L)	-0.23	-0.72	-1.52	-0.35	-0.83	-1.48
Producer wage (H)	-0.77	-1.49	-2.61	-0.99	-1.56	-2.50
Consumer wage (L)	1.57	1.88	0.69	1.43	1.76	0.75
Consumer wage (H)	1.76	1.13	0.35	1.53	1.06	0.47

Table 6: Changes in Macroeconomic Variables (Wage Bargaining, Progressive Wage Tax)

	Employment (L)	Employment (H)	Capital Services	Output	Producer wage (L)	Producer wage (H)
Agriculture	1.91	1.45	0.65	1.03	-0.92	-1.63
Energy, Mining	0.97	1.02	0.39	0.76	-0.93	-1.67
Manufacturing	1.05	1.47	0.35	1.29	-0.94	-1.69
Construction	2.57	2.13	2.13	2.15	-0.98	-1.69
Trade, Transport	0.95	0.92	0.64	0.84	-0.93	-1.66
Banking	2.38	0.99	0.46	0.64	-0.96	-1.61
Other Services	-2.64	-2.57	-3.33	-2.74	-0.93	-1.67

Table 7: Changes at the Industry Level (Scenario 8, Policy Instrument: t_l)