TAX POLICY AND LABOR MARKET PERFORMANCE

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Abstract

In exploring the impact of tax policy on labor-market performance, the paper first investigates how tax reform impacts labor supply and equilibrium unemployment in representative agent models. The impact of tax policy on labor market performance depends importantly on various other labor-market institutions, such as minimum wage laws, wage bargaining, and unemployment benefits. In non-competitive labor markets, employment declines if a higher tax burden makes the outside option (i.e. unemployment) relatively more attractive. Marginal tax rates typically differ substantially across individuals. To explore the impact of specific tax policies, therefore, the paper relies on an applied general equilibrium model to investigate the consequences of tax reform with heterogeneous households. The model simulations reveal several trade-offs between various objectives, such as cutting unemployment, stimulating the participation of secondary workers into the labor force, raising the quality and quantity of labor supply, and establishing an equitable income distribution. The paper also analyses how efficiency considerations affect the optimal progressiveness of labor income taxes. Finally, the optimal progression of the labor income tax is investigated in the presence of search unemployment, heterogeneous households and distributional concerns.

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1 Introduction

This paper explores the link between tax policy and labor-market performance. As far as labor-performance is concerned, we focus on labor supply, employment and the difference between these two variables: unemployment. As regards tax policy, we consider a number of elements: first, the level of taxation as measured by average tax burdens for major groups of workers; second, the composition of the tax burden over payroll taxes, personal labor income taxes, capital income taxes, and consumption taxes; third, the progressiveness of the tax system (as measured by the speed with which average tax rates rise with income levels) and – related to this – the magnitude of marginal tax rates for workers with middle- and high incomes; and fourth, marginal tax rates faced by low-income earners and non-participating or unemployed individuals as a result of means-tested safety-net provisions and retirement benefits. The analysis is mainly theoretical. Nevertheless, at several stages we survey evidence on the empirical importance of various theoretical mechanisms.

The paper is structured as follows. After section 2 provides information about the tax and benefit systems in various OECD countries, the paper turns to the labor-market effects of taxation in representative agents models. Section 3 explores how tax reform impacts employment through the channels of labor supply and equilibrium unemployment. Section 4 investigates how efficiency considerations affect the optimal progressiveness of labor income taxes. Sections 5 and 6 account for distributional considerations by allowing for heterogeneous workers. In particular, Section 5 employs an applied general equilibrium model with heterogeneous agents to investigate the consequences of tax reform for not only the labor market but also the income distribution. Section 6 constructs a framework for exploring the optimal progression of the labor income tax in the presence of search unemployment, heterogeneous households and distributional concerns. Section 7, finally, summarizes the main policy conclusions.

2 Taxes and labor-market performance

Labor-market performance can be assessed in several ways. This paper focuses on unemployment and labor supply, which can be measured as the participation rate (i.e. the labor force as percentage of the working age population (15-65)) and average number of hours worked by employees (see Table 1). Together, unemployment and labor supply yield employment. The fifth column of Table 1 gives the average hours worked per member of the working-age population as a percentage of a full-time work-week (of 40 hours). This can be considered as the best available aggregate measure of labor-market performance. It in fact measures the share of the potential labor-market endowment that is actually used. Table 1 ranks countries in decreasing order of this utilization rate of labor resources. On this measure, the United States, Canada and Japan perform better than Europe and continental Europe in particular. Within Europe, the largest continental European countries (Germany, France and Italy) do worse than most other European countries.

Also tax policy can be assessed in different ways. Table 2, which ranks countries according to their aggregate labor-market performance, contains average tax rates and marginal tax rates at different income levels for a single-person household.[1] The tax wedges used here include personal income taxes, employers' and employees' social

[1] The data are for an average production worker who is 40 years of age. For more details, see OECD (2002b).

Table 1. Indicators of labor market performance, 2001							
	Labour force participation rate (%) (c)	Unemployment rate (%) (c)	Employment/population ratio (%) (c)	Average hours worked per person in employment	Employment indicator (d)	Employment/population ratio for older workers (55-64)	Long-term unemployment share (e)
UK	74,9	4,8	71,3	1711	58,7	52,2	27,7
Sweden	79,3	5,1	75,3	1603	58,0	67,0	22,3
Finland	74,6	9,2	67,7	1694	55,1	45,9	26,2
Denmark	79,2	4,2	75,9	1482	54,1	56,6	22,2
Ireland	67,5	3,7	65,0	1674	52,3	46,6	55,3 (b)
Spain	65,8	10,5	58,8	1816	51,3	39,2	44,0
Greece	62,1	10,4	55,6	1921	51,3	38,0	52,8
Netherlands	75,7	2,1	74,1	1346	48,0	39,3	43,5 (b)
Germany	71,6	8,0	65,9	1467	46,5	36,8	51,5 (a)
France	68,0	8,8	62,0	1532	45,7	36,5	37,6
Belgium	63,6	6,2	59,7	1528	43,9	25,2	51,7
Italy	60,7	9,6	54,9	1606	42,4	18,6	63,4
Portugal	71,8	4,3	68,7	n.a.	n.a.	50,3	38,1
Austria	70,7	4,0	67,8	n.a.	n.a.	27,4	23,5
Luxembourg	64,2	1,9	63,0	n.a.	n.a.	24,8	27,6
US	76,8	4,8	73,1	1821	64,0	58,4	6,1
Canada	76,5	7,3	70,9	1801 (a)	61,4	48,3	9,5
Japan	72,6	5,2	68,8	1821 (a)	60,2	62,0	26,6
OECD Europe	66,8	8,6	61,1	n.a.		37,9	40,4
Total OECD	69,8	6,4	65,3	n.a.		48,4	27,5

Source: OECD (2002a)

(a) Data refer to 2000

(b) Data refer to 1999

(c) Persons aged 15-64 years

(d) (column 3 x column 4)/2080

(e) The share of long-term (12 months and over) in employment in total unemployment

n.a. Not available

Table 2. Effective tax (a) rates on labor Income, 1999						
	Total average tax rate (ta) % of gross labor costs (b)			Total marginal tax rate (tm) for a single-person household % of gross labor costs (c)		
	0,67*APW (d)	**APW (d)**	**1,67*APW (d)**	**0,67*APW (d)**	**APW (d)**	**1,67*APW (d)**
UK	37,2	41,4	43,7	49,4	49,4	41,9
Sweden	59,9	61,3	64,9	64,6	62,8	71
Finland	53,9	57,7	63,3	63,6	67,2	70,7
Denmark	54,9	57,4	63	62,4	62,4	71,9
Ireland	37,1	45,8	53,8	47,2	66	63,4
Spain	42,7	46,9	50,1	52,3	53,8	56,4
Greece	45,2	46,4	50	48	53,4	61,7
Netherlands	50	53,4	53,3	60,6	65	58,1
Germany	55	59,2	62,5	66,1	68,9	68,9
France	52,1	58,4	59,8	78,7	62,5	60,9
Belgium	59,3	64,2	68,4	71,9	72,8	75,7
Italy	54,5	57	59,8	59,8	63,6	63,6
Portugal	43,1	45,7	50,1	50,6	51,3	57,9
Austria	52,7	56,2	60,1	60,9	64,5	68,6
Luxembourg	43,9	48	54,6	53,3	60	67,1
US	35,2	37	42,2	40,4	40,4	51,5

Source: Cnossen (2001)

(a) Taxes include direct taxes, i.e. personal income taxes, employers' and employees' social security contributions, and payroll taxes (if levied), plus indirect taxes, i.e. VAT and excises.

(b) ta = (a+c)/(1+c), where a is the total direct average tax rate and c is the average effective indirect tax rate.

(c) tm = (m+c)/(1+c), where m is the total direct marginal tax rate.

(d) APW stands for the income level of an average productive worker. For a definition, see OECD (2002b)

security contributions,[2] payroll taxes, and indirect consumption taxes (such as VAT and excises). The marginal tax wedge drives a wedge between marginal labor costs (which a competitive, profit-maximizing employer equates to the marginal productivity of labor (i.e. the social benefit of labor)) and after-tax disposable income from work (which a utility-maximizing household sets equal to the monetary value of the marginal disutility of labor (i.e. the reservation wage or the social costs of labor)).

Tax rates are quite high. Marginal tax rates for the average production worker exceed 60 % in most countries on the European continent. Although marginal rates of personal income tax generally rise with income, overall marginal tax rates do not rise substantially with income. This is because social security contributions are typically due only on incomes below a ceiling. The United Kingdom and the United States combine high employment rates with relatively low marginal and average tax burdens. Within continental Europe, however, labor-market performance and tax rates do not show a clear correlation.

Also other taxes may harm the reward to labor, even though they are not assessed on labor income. To illustrate, by reducing labor productivity, source-based taxes on capital may be shifted unto labor in a small open economy with internationally mobile capital. These implicit taxes on labor are not included in Table 2. The same holds true for labor-market regulations that give rise to implicit taxes on employment. Minimum wage policies, for example, in effect levy implicit taxes on employers hiring low-skilled workers, with the revenues being transferred to these workers.[3] Other implicit taxes on employers are employment regulations that constrain the ability of employers to reduce the labor force in response to weak business conditions. By reducing labor demand, the implicit taxes associated with these regulations harm employment.

For low income levels, the average and marginal tax burdens as contained in Table 2 become a less reliable indicator of the incentives to supply labor because social insurance benefits and means-tested welfare benefits (including other safety-net benefits, such as housing allowances) imply significant implicit tax burdens on work. Indeed, many of these benefits are withdrawn when a worker finds work or works more hours. To provide some information about the magnitude of these implicit tax rates, Table 3 contains the replacement rates (in after-tax terms) for both short-term and long-run unemployed. The desire to protect households with young children from poverty implies that lone-parent families and two-parent families feature the highest replacement rates. These replacement rates are closely related to the effective marginal tax rate on finding a full-time job. In particular, to arrive at the overall implicit rate on work $\bar{t}$, one should perform the following calculation: $\bar{t} = t + (1-t)r$, where t is the (average) tax wedge (as given in the first three columns of Table 2, but then for the relevant household types) and r is the net replacement rate (as provided in Table 3).

[2] The marginal tax rates assume that social security contributions are not linked to insurance benefits on an individual level.

[3] Neary and Roberts (1980) show how rigid wages and prices can be modelled as implicit tax rates.

Table 3. Net replacement Rates for three family types at two earnings levels, 1999

After tax and including unemployment benefits, family and housing benefits in the first month of benefit receipt

	APW (a)			66,7% of APW (a)		
	Single	Couple, 2 children	Lone parent, 2 children	Single	Couple, 2 children	Lone parent, 2 children
UK	46	49	49	66	54	55
Sweden	71	78	85	82	90	93
Finland	65	83	87	79	88	92
Denmark	63	73	78	89	95	96
Ireland	31	57	52	42	67	59
Spain	74	73	76	76	76	77
Greece	47	44	47	48	46	50
Netherlands	82	89	81	88	85	80
Germany	60	70	71	67	75	76
France	71	72	72	78	82	83
Belgium	64	64	65	85	79	81
Italy	42	53	50	39	49	47
Portugal	79	79	80	88	87	87
Luxembourg	82	87	87	82	88	88
Austria	60	76	73	61	82	78
US	58	57	58	59	49	49
Canada	62	91	91	62	97	97
Japan	67	64	70	82	77	82

After tax and including unemployment benefits, family and housing benefits in the sixtiest month of benefit receipt

	APW (a)			66,7% of APW (a)		
	Single	Couple, 2 children	Lone parent, 2 children	Single	Couple, 2 children	Lone parent, 2 children
UK	46	80	71	66	88	81
Sweden	54	85	59	79	110	70
Finland	53	89	62	73	100	69
Denmark	60	80	79	85	102	97
Ireland	31	56	56	41	66	64
Spain	23	39	37	32	57	51
Greece	8	10	11	8	11	12
Netherlands	60	71	61	74	85	76
Germany	54	65	63	63	71	71
France	30	42	43	43	59	60
Belgium	45	68	69	60	84	86
Italy	0	18	14	0	21	17
Portugal	49	63	64	70	87	87
Luxembourg	50	75	59	70	93	82
Austria	55	72	69	58	78	74
US	7	46	38	10	59	48
Canada	24	62	60	35	81	80
Japan	33	68	61	49	87	84

Source: OECD (2002b)

(a) APW stands for the income level of an average productive worker. For a definition, see OECD (2002b)

Table 4. Average effective tax rates on transitions for two-earner couples, 1999 (a)				
	From unemployed breadwinner and non-employed partner to		From full-time employed breadwinner and non-employed partner to	
	Part-time (40%) employed breadwinner/non-employed partner	Full-time employed breadwinner/ non-employed partner	Full-time employed breadwinner/ part-time (40%) employed partner	Full-time employed breadwinner/ full-time employed partner
UK	18	56	15	26
Sweden	87	84	29	34
Finland	86	87	21	34
Denmark	86	81	51	51
Ireland	101	61	21	34
Spain	166	76	18	19
Greece	103	43	16	18
Netherlands	84	92	50	46
Germany	52	75	51	53
France	80	72	32	37
Belgium	107	74	46	51
Italy	80	60	33	41
Portugal	174	81	15	20
Austria	142	79	21	30
Luxembourg	17	87	13	26
US	99	63	19	25
Canada	73	92	30	34
Japan	151	68	14	14

Source: OECD (2002b)

(a) If employed, the earnings are as a percentage of the full-time employed salary of an average production worker.

Table 4 contains the implicit tax rates for several transitions.[4] In particular, the first two columns consider the transition of an unemployed average production worker, with a non-employed spouse and two children, to part-time employment (40 %) and full-time employment, respectively. The third and fourth columns present the effective tax rates for a secondary earner previously out of the labor force who starts working part-time or full-time, while the principal earner within the same household continues to work full-time. These data reveal that effective tax rates on principal earners typically substantially exceed those on secondary earners. The main reason is the benefit system. In particular, means-tested benefits and unemployment benefits are withdrawn if the principal earner finds work. Secondary earners do not have access to welfare benefits if the primary worker (i.e. the breadwinner) is employed. Moreover, if they do not have an employment history, these workers are also ineligible for benefits from unemployment insurance. Table 4 reveals that effective tax rates differ substantially across various households, even within the same country.

The first two columns of Table 4 suggest that marginal effective tax rates are relatively high for primary workers at the bottom of the labor market, especially since many OECD countries have cut top marginal tax rates over the last two decennia. Another important reason why marginal tax rates are highest at the bottom of the labor market is that unemployment insurance benefits for high-income earners are typically only limited in duration. For high-income earners, therefore, the short-run replacement rates on which the data in Table 4 are based may overstate disincentives to seek work. For low-income earners, in contrast, safety-net provisions, which are typically unlimited in duration, imply high replacement rates for longer periods of time. A comparison between the short-run and long-run replacement rates in Table 3 does indeed reveal that benefits tend to drop less over time for low-income earners, thus producing higher long-run replacement rates than for those earning higher incomes. This implies substantial disincentives for low-income earners. Indeed, the duration rather than the magnitude of unemployment benefits may be the main determinant of disincentives to work and maintain human capital.

Older workers often face very high marginal tax rates on continuing to work because early retirement benefits are withdrawn if workers continue to work instead of retire. In any case, pension benefits are typically not increased in an actuarially fair manner if older workers delay retirement. Gruber and Wise (1999) show that marginal tax rates for older workers may sometimes exceed 100 %. Their analysis reveals that high marginal tax rates on older workers are strongly correlated with labor-force participation of older workers, which is in fact quite low in most European countries (see the next-to-last column in Table 1). In addition to workers facing these high explicit tax rates, employers of older workers may be subject to implicit tax rates as a result of downward rigid wages. The government could offset these implicit taxes by explicit job subsidies for employers who employ older workers. These job subsidies, however, need to be financed through distortionary taxation. A more direct way to protect employment of older workers is to make wages of older workers more flexible. In this way, wages can be more in line with individual productivity. To achieve this, age-related pay schemes have to be reconsidered. For example, occupational pension systems that link pension benefits to final pay discourage gradual retirement through occupational downgrading with lower rates of pay. Ljungqvist and Sargent (1998) show how generous unemployment and disability benefits that are based on previous earnings prevent the labor market from easily adjusting to adverse shocks. In particular, in the face of generous insurance benefits that exceed their labor productivity, older skilled

[4] In contrast to the figures in Table 2, these figures abstract from indirect taxes on consumption.

workers who suffer a substantial capital loss on their human capital (e.g. as a result of being laid off) are discouraged from searching for new jobs and from reducing their reservation wage in line with their reduced productivity. In this way, social insurance sets in motion a vicious circle of high unemployment and skill loss. This explains the high incidence of long-term unemployment and disability among European workers (see the last column of Table 1). As the work force ages, these moral hazard problems associated with social insurance benefits based on previous earnings become more serious. Indeed, social insurance benefits based on final pay discourage workers from maintaining their human capital, since workers can rely on generous social benefits when their human capital becomes obsolete. Private insurance policies supplementing public disability and unemployment insurances worsen these moral hazard problems (see Pauly (1974)).[5]

Welfare, unemployment and early retirement benefits are typically *conditional* benefits. In particular, unemployment benefits are paid only if one has left one's job involuntarily and if one is actively looking for work. Furthermore, many countries are enforcing obligations on welfare recipients, sometimes in the form of welfare-to-work programs or workfare programs. Early retirement benefits may be similar to disability benefits in that they are conditional on failing health. Countries may differ substantially in the eligibility criteria for categorical benefits like unemployment and disability benefits and in how strictly they enforce these criteria.[6] In interpreting the replacement rates and implicit tax rates in Tables 3 and 4, one needs to be aware of these considerations. Indeed, the duration of the benefits and the obligations associated with social benefits (workfare, training, work tests) are key aspects of the design of unemployment insurance.[7]

3 Tax reform and employment

This section uses representative agent models to explore the impacts of tax reform on employment. It first considers the channel of labor supply before it turns to the channel of equilibrium unemployment. The analysis in this section is positive rather than normative. Normative aspects of labor taxation in representative agent models are explored in section 4.

3.1 Labor supply

A representative household derives utility from consumption of goods (C) and leisure (V). The utility function $U(C, V)$ is concave and homothetic. Total time available to each household is normalized to one, which can be used to enjoy leisure V or to work $L^s = 1 - V$. The only source of income is labor income. The household budget constraint is thus given by $P^c C = (1 - T^a)WL^s$, where P^c stands for the consumer price and W denotes the market wage. $T^a \equiv T(WL^s)/WL^s$ represents the average personal income tax rate on labor, where the income tax paid by the household $T(WL^s)$ is a function of the market value of labor supply. Households determine labor supply from the condition that the marginal rate of substitution between leisure and

[5] The data in Tables 3 and 4 only account for publicly provided unemployment benefits. Supplementary, private benefits, which may be provided by the previous employer, sometimes raise replacement rates further.

[6] To illustrate, many countries do not strictly enforce on older unemployed persons the obligation to look for work in order to be eligible for unemployment or welfare benefits.

[7] For a recent overview of the literature on the optimal design of these important elements for unemployment insurance, see Frederiksson and Holmlund (2003) .

consumption should equal the marginal consumer wage, i.e. $U_v/U_c = (1-T^m)W/P^c$, where subscripts stand for partial derivatives. $T^m \equiv dT(WL^s)/d(WL^s)$ denotes the marginal tax rate on labor income. Both the marginal and the average tax rates depend on the market value of wage income WL^s.[8]

A measure of the progressivity of the income tax is the elasticity of after-tax labor income with respect to pre-tax labor income, i.e. $S \equiv d\log(WL^s - T(WL^s))/d\log(WL^s) = (1-T^m)/(1-T^a)$. This coefficient is also known as the coefficient of residual income progression (Musgrave and Musgrave, 1976). In a proportional tax system, the average and the marginal tax rates coincide so that $S = 1$. In a progressive tax system, in contrast, the average tax rate $T^a \equiv T(WL^s)/WL^s$ rises with pre-tax labor income WL^s, so that the marginal tax rate exceeds the average tax rate (i.e. $T^m > T^a$) and thus $S < 1$.

We use lower-case variables to denote loglinear deviations from an initial equilibrium (*e.g.*, $c \equiv dC/C$), except for the tax rates where we define $t^i \equiv dT^i/(1-T^i)$, $i = a, m$. The logarithmic change in the degree of progressivity is thus given by $s = t^a - t^m$. The household budget constraint in relative changes is given by $p^c + c = S(w + l^s) - t^a$. Together with the loglinearised optimality condition, i.e. $c - v = \sigma(w - t^m - p^c)$ where $\sigma \equiv -d\log(C/V)d\log(U_c/U_v)$ represents the elasticity of substitution between leisure and consumption goods in utility, we obtain the relative change in labor supply:[9]

$$l^s = \epsilon^u(w - p^c) - \epsilon^c t^m - \epsilon^i t^a = \epsilon^u(w - t^a - p^c) + \epsilon^c s. \tag{1}$$

Here, $\epsilon^i \equiv -V < 0$, $\epsilon^c \equiv V\sigma > 0$, and $\epsilon^u \equiv V(\sigma - 1) = \epsilon^c + \epsilon^i$ stand for the income, compensated wage, and uncompensated wage elasticities of labor supply, respectively.

Ceteris paribus the average tax rate T^a and the market wage W, a higher marginal tax rate $t^m > 0$ reduces the opportunity cost of leisure at the margin. Hence, households substitute leisure for consumption and thus reduce labor supply. The compensated elasticity of labor supply ϵ^c reflects the strength of this substitution effect on account of a more progressive tax system (i.e. $s < 0$ with $t^a = 0$).

For a given marginal tax rate T^m, a higher average tax $t^a > 0$ makes workers poorer and thus increases the incentive to work. The magnitude of this income effect is reflected in the income elasticity of labor supply ϵ^i. The average and marginal tax rates thus exert opposite effects on labor supply: whereas higher marginal tax rates harm labor supply through the substitution effect, higher average tax rates raise it through the income effect.

If both the marginal and average tax rates are increased in tandem such that the progression of the tax system is unaffected (i.e. $t^m = t^a$ so that $s = 0$), the uncompensated wage elasticity of labor supply (i.e. $\epsilon^u = \epsilon^c + \epsilon^i$) captures the combined labor-supply impact of the substitution effect of a higher marginal tax rate and the income effect of a higher average tax rate. The negative substitution effect dominates the positive income effect on labor supply if the elasticity of substitution between leisure and consumption goods exceeds unity (*i.e.* $\sigma > 1$) so that the uncompensated wage elasticity of labor supply is positive.

The previous analysis has assumed that the market wage W is constant. To explore the impact on the market wage, we model the demand side of the labor

[8] These tax rates may also depend on the personal characteristics of the individual. Moreover, since the tax authorities observe individual labor incomes, the tax schedule may be non linear in individual labor income WL^s.

[9] Here we have assumed that the initial coefficient of residual income progression is unity. If this assumption is not met, labor supply is given by $[(S-1)V + 1]l^s =$
$\epsilon^c(w - t^m - p^c) + \epsilon^i(Sw - t^a - p^c)$.

market. A representative firm maximizes profits, taking wages as given. It may have some market power on the commodity market in that the (absolute value of) price elasticity of demand for its output ε remains finite. Profits are given by $\Pi \equiv P_y(AF(L^d))AF(L^d) - (1+T^l)WL^d$, where T^l denotes the payroll tax rate and L^d represents labor demand. $AF(L^d)$, $F' > 0, F" < 0$ stands for a production function with diminishing returns to labor. These diminishing returns are due to a second production factor (e.g. capital), which is taken as fixed in the short run. Hence, profits originate in not only market power on commodity markets but also this second production factor. Exogenous technology shocks are captured by changes in the productivity parameter A. Firms hire labor until the marginal revenue from the last worker equals the producer wage, i.e. $P_y(1-\frac{1}{\varepsilon})AF'(L^d) = (1+T^l)W$. Using $t^l \equiv dT^l/(1+T^l)$, loglinearizing the marginal productivity condition for firms, and taking the producer price P_y as numeraire, we obtain the relative change in the demand for labor:[10]

$$l^d = -\epsilon^d(w + t^l - a), \tag{2}$$

where ϵ^d stands for the wage elasticity of labor demand.[11] Expression (2) reveals that an adverse productivity shock (i.e. $a < 0$) acts like a payroll tax. Indeed, we investigate not only changes in explicit taxes on labor income but also exogenous changes in labor productivity. This enables us to explore the impact of implicit labor taxes that reduce the productivity of labor. To illustrate, in a small open economy, source-based taxes on capital act like implicit taxes on labor by reducing the productivity of labor if capital is perfectly mobile internationally. In the same fashion, if world prices of energy are fixed, a tax on the intermediate use of energy into production exerts similar adverse effects on labor productivity.[12]

In a competitive labor market, the market wage ensures that aggregate labor supply equals labor demand. Ignoring open economy considerations, we define the consumer price as $P^c \equiv 1 + T^c$, where T^c denotes the consumer tax rate. Using $t^c \equiv dT^c/(1+T^c) = p^c$ and imposing equilibrium on the labor market (*i.e.* $NL^s = L^d$ where N denotes the fixed number of households), we can solve for employment, wage costs per unit of output, and the consumer wage:

$$l = -\left[\epsilon^d/\left(\epsilon^u + \epsilon^d\right)\right]\left[\epsilon^c t^m + \epsilon^i t^a + \epsilon^u\left(t^l - a + t^c\right)\right] = \left[\epsilon^d/\left(\epsilon^u + \epsilon^d\right)\right]\left[\epsilon^c s + \epsilon^u\left(a - t\right)\right] \tag{3}$$

[10] We assume here that firms face a constant price elasticity of demand for their output ε. An increase in market power, reflected in a decrease in ε, amounts to an implicit tax on labor. Indeed, a relative change in ε would enter (2) in the same way as t^l (but with the opposite sign).

If other production factors besides labor are fixed, the labor demand elasticity is given by $\epsilon^d \equiv 1/\left[\frac{1-\alpha}{\sigma^f} + \frac{\alpha}{\varepsilon}\right]$, where σ^f is the substitution elasticity between labor and the other production factor(s), and $\alpha \equiv F'(L)L/F(L)$. With a Cobb-Douglas production function (i.e. $\sigma^f = 1$) and a constant price elasticity ε, the labor demand elasticity is constant, i.e. $\epsilon^d \equiv 1/\left[1 - \alpha(1 - \frac{1}{\varepsilon})\right]$. In that case, a smaller share of fixed factors (i.e. a higher value for α) raises ϵ^d.

[11] Two important aspects of the labor-demand elasticity are the time horizon and the aggregation level to which the elasticity applies. As regards the time horizon, other production factors may respond to changes in wage costs, especially in the longer run. The long-run wage elasticity of labor demand is therefore likely to exceed the corresponding short-run elasticity. As regards the aggregation level, the labor-demand elasticity on a macroeconomic level is likely to be smaller than on a sectoral or microeconomic level.

[12] Another reason for investigating the impact of changes in productivity is that modern economies experience steady growth in labor productivity while the rate of unemployment remains more or less stationary. In the face of this empirical observation, most models impose conditions that ensure that changes in labour productivity do not impact unemployment. Sub-section 3.2 develops models in which, in contrast to productivity, the tax burden does affect the structural rate of unemployment.

$$w + t^l - a = \left[\epsilon^u(t-a) - \epsilon^c s)/(\epsilon^u + \epsilon^d)\right] \tag{4}$$

$$w - t^a - p^c = \left[\epsilon^d(a-t) - \epsilon^c s\right]/(\epsilon^u + \epsilon^d) \tag{5}$$

where $s = t^a - t^m$, $t \equiv t^a + t^l + t^c$, and the labor-demand elasticity ϵ^d applies to the macroeconomic level.

3.1.1 tax progression and overall tax burden

We consider the impact of three exogenous policy shocks, namely (i) a higher marginal tax rate *ceteris paribus* the average tax wedge (i.e. $t^m = -s > 0$; $t = 0$); (ii) a higher average tax wedge *ceteris paribus* the marginal tax rate (i.e. $t = t^a = s > 0$; $t^m = 0$); and (iii) a higher average tax wedge *ceteris paribus* the coefficient of residual income progression (i.e. $t = t^m > 0$; $s = 0$). The average tax wedge between the producer wage and the consumer wage consists of the sum of the employees' tax rate, employers' tax rate and consumer tax rate.[13]

The first two shocks are driven by labor-supply effects (compare the impact of t^m and t^a in (1) and (3)). As described above, the marginal average and average tax rates shift the labor supply curve down and up, respectively. How the impact is distributed over employment and wage responses depends on the labor-demand elasticity. If this latter elasticity is large (in absolute value), employment moves substantially while wages do not change much. In any case, a higher marginal tax rate associated with a more progressive tax system harms employment. Under a linear tax system, therefore, cutting the marginal tax rate, while at the same time lowering tax allowances or the tax credit in order to keep the average tax rate on labor income unaffected, enhances labor market participation. The incentive mechanism operates entirely through the substitution effect in labor supply. Raising the average tax rate on labor for a given marginal tax rate (e.g., by reducing tax allowances) depresses wage costs and boosts employment as $\epsilon^i < 0$. This shock is transmitted entirely through the income effect in labor supply.

We now turn to the impact of a higher average tax wedge (i.e. $t > 0$) while leaving the tax structure in terms of the degree of progressivity unaffected (i.e. $s = 0$). If the uncompensated wage elasticity of labor supply is positive, a larger tax burden on labor income ($t > 0$) is partially shifted onto firms by raising the producer wage. Workers are particularly successful in doing so if labor supply is rather elastic and labor demand relatively inelastic. A higher average tax wedge between the producer and consumer wage lowers employment and raises the producer wage if the substitution effect dominates the income effect in labor supply (i.e. $\sigma > 1$ so that $\epsilon^c > -\epsilon^i$), i.e. if the uncompensated wage elasticity of labor supply is positive (i.e. $\epsilon^u > 0$).[14] If the uncompensated labor-supply curve bends backwards, however, employment rises as the producer wage declines. In this case, workers bear more than 100 percent of the tax burden.

Unemployment benefits do not have a natural place in this equilibrium model of the labor market. However, if one is willing to interpret unemployment as leisure, one can model unemployment benefits as a subsidy to leisure (see Pissarides (1998) and van der Ploeg (2003)). Unemployment benefits hurt labor supply through both

[13] In analyzing these policy changes, we do not explicitly consider the government budget constraint. The analysis implicitly assumes that changes in government revenues are transmitted into corresponding changes in government spending that is separable from other arguments in the utility function in households. Hence, the changes in government spending produced by public revenue effects do not affect private decisions.

[14] Empirical evidence suggests that this elasticity is indeed positive, being quite small for men (see also section 5).

substitution and income effects. Indeed, unemployment benefits raise the effective marginal tax on work while reducing the overall average tax rate.[15]

3.1.2 composition of tax burden

All components of the average tax wedge exert the same impact on employment. The reason is that flexible wages ensure that firms can partially shift a higher payroll tax (i.e. $t^l > 0$) onto workers through lower wages, while higher wages allow workers to shift higher income taxes and consumption taxes (i.e. t^a, $t^c > 0$) onto employers. This equivalence of various taxes depends on flexible wages. If market wages W were rigid, in contrast to income and consumption taxes, payroll taxes would hurt employment. In the presence of a fixed binding statutory minimum wage, therefore, replacing payroll taxes by income taxes boosts employment. Such a tax reform in effect undoes some of the implicit labor tax that workers impose on employers as a result of the minimum wage. Why the same employment effect cannot be achieved by simply lowering the implicit tax by reducing the minimum wage directly is unclear. Indeed, if the statutory minimum wage is raised to protect the purchasing power of workers after raising the income tax to replace the payroll tax, the tax reform does not succeed in raising employment.

An adverse productivity shock ($a < 0$) yields exactly the same effects as a rise in the payroll tax rate, namely a drop in after-tax wages and a fall in (boost to) employment if the substitution effect dominates (is outweighed by) the income effect in labor supply.[16] Hence, an adverse supply shock amounts to an implicit labor tax. To keep employment constant in the face of a steady increase in productivity, one needs to impose a unitary elasticity of substitution between leisure and consumption of goods (King, Plosser and Rebelo, 1998). In that case, not only productivity shocks but also changes in the average tax rate leave employment unaffected.[17]

3.1.3 human capital

Labor taxes impact not only the quantity of labor (i.e. hours worked) but also the quality of labor (i.e. effort and human capital).[18] With exogenous labor supply, proportional labor taxes do not affect human capital accumulation if all costs of training are deductible against the proportional tax rate. Intuitively, just as cash-flow taxes leave capital investment unaffected,[19] proportional labor taxes affect the costs and benefits of investments in human capital in the same way. The neutrality of proportional labor taxes no longer holds if hours worked is endogenous. At lower hours worked, human capital accumulation becomes less attractive because human capital

[15] The latter effect on the average tax rate drops out if one imposes government budget balance with exogenous public spending on other purposes besides unemployment benefits. In that case, higher tax rates required to finance the additional benefits may further raise effective marginal tax rates.

[16] If other production factors besides labor enter the production function, labor productivity may decline as a result of higher taxes on either these factors or (depending on the degree of complementarity between labor and these factors) labor itself.

[17] Alternatively, one could assume that A increases productivity not only of labor in the formal sector but also the productivity of leisure time (see, e.g. Heckman (1976)). In that case, one does not have to impose $\sigma = 1$ to reconcile productivity growth with a constant employment level. Hence, in contrast to productivity changes, proportional taxes may affect employment.

[18] Human capital is another channel through which tax policy may affect long-run productivity growth. In fact, in endogenous growth models in which human capital drives growth (see e.g. Lucas (1988)), labor taxes may exert permanent effects on growth.

[19] In the presence of uncertain returns, proportional taxes may boost investments in human capital by risk-averse agents. Indeed, in the presence of such a tax, the government in effect shares in the risk of the investment. For the role of taxes as an insurance device, see Eaton and Rosen (1980).

is utilized less intensively. This so-called utilization effect makes schooling and labor supply complementary activities.[20]

This indirect complementarity is further strengthened in learning-by-doing models (see Heckman, Lochner, and Cossa (2002)). In these models, learning and working are directly complementary, whereas in the traditional learning-or-doing model work and schooling compete for a worker's time. Nevertheless, if the labor market appropriately prices the benefits from learning-by-doing in wages[21], the implications of learning-by-doing turn out to be equivalent to those of learning or doing. In any case, with endogenous leisure, both models predict that permanent tax policies that stimulate labor supply also boost human capital accumulation. At the same time, policies that encourage schooling increase long-run labor supply. Labor supply and human capital thus exert positive feedback effects on each other.

Apart from the utilization and learning-by-doing effects, labor taxes may harm human capital if not all costs of schooling are tax deductible (see, e.g. Trostel (1993)). Similarly, if marginal taxes rise with income, benefits of schooling may be taxed at higher rates than the rates against which costs are tax deductible, thereby discouraging human capital accumulation (see Bovenberg and van Ewijk (1997)). Residence-based taxes on capital income, in contrast, stimulate schooling because they encourage agents to substitute human capital for financial capital. These taxes can therefore help to offset the human-capital distortions due to non-deductible training costs or rising marginal tax rates (see Nielsen and Sørensen (1998)). Alternatively, training subsidies or compulsory schooling may be employed to alleviate the adverse effect of progressive labor taxes on human capital accumulation (see Bovenberg and Jacobs (2002)).

3.2 Equilibrium unemployment

Turning to the analysis of labor taxes in imperfect labor markets, we enter the realm of second-best economics. Distortionary labor taxes may either alleviate or exacerbate non-tax distortions in the labor market that give rise to involuntary unemployment. Whereas the previous sub-section considered only a representative agent and did not address distributional issues at all, this sub-section investigates the separate impacts of taxes on employed and unemployed agents. Workers, however, are still homogeneous.[22]

3.2.1 right-to-manage model

To illustrate the impact of taxes in imperfect labor markets, we formulate a right-to-manage model of the labor market.[23] Many symmetric decentralized unions exert market power in a labor-market segment but are too small to internalize the effects of higher wages on prices, profits and the government budget constraint. Unions and employers bargain about wages, after which firms set employment.

[20] Jacobs (2002) demonstrates that positive feedback effects between human capital and labor supply raise the long-run wage elasticity of effective labor supply above the corresponding standard elasticities that assume exogenous levels of human capital. If the government optimally employs schooling subsidies to undo the effect of taxation on schooling, effective elasticities again correspond to the standard elasticities. The utililization effects depends on human capital being more productive in work time than leisure time. Heckman (1976), in contrast, assumes that human capital is equally productive in leisure and work.

[21] Heckman, Lochner, and Cossa (2002), however, seriously doubt whether firms can differentiate wages on the basis expected future human capital benefits of current work. Indeed, they cite empirical evidence for the learning-by-doing model (*without* sufficient wage discrimination).

[22] For a more complete distributional analysis, see section 5, which introduces heterogeneous workers.

[23] The effects of labor taxes on wages and unemployment are very similar in efficiency wage models and search models, although the normative implications for welfare may be different. See Bovenberg and van der Ploeg (1994), Sørensen (1997), and Pissarides (1998).

Union preferences are characterized by the following objective function[24]

$$Lv(W^a) + (N - L)\,WU^r \;;\; v'(W^a) > 0, v"(W^a) \leq 0, \tag{6}$$

where N denotes the number of trade union members of which L are employed. $W^a \equiv W - T(W)$ represents after-tax wages earned in the industry, where W and $T(W)$ represent the market wage and the personal income tax function respectively. A concave felicity function $v(W^a)$ implies risk-averse workers. In several cases, we will assume that felicity is isoelastic, i.e. $v(W^a) = (W^a)^{1-\rho}/(1-\rho)$, where ρ stands for the (constant) coefficient of relative risk aversion.

In wage bargaining, the union takes the outside option (i.e. expected utility outside the industry U^r) as given and accounts for labor-demand behavior by firms which is modelled along the lines of sub-section 3.1. The perceived wage elasticity of labor demand ϵ^d depends on the price elasticity of demand for the bargaining unit as a whole (i.e. the industry). This price elasticity is likely to be smaller than the price elasticity facing an individual firm. Nash bargaining maximizes $[L(v(W^a) - U^r)]^{\beta}\Pi^{1-\beta}$ with respect to W, where profits Π are given by $P_y(AF(L))AF(L) - (1+T^l)WL$. This yields

$$\frac{v(W^a) - U^r}{v(W^a)} = Sm, \tag{7}$$

where $m \equiv \frac{\frac{v'(W^a)W^a}{v(W^a)}}{[\epsilon^d + \frac{1-\beta}{\beta}\frac{(1+T^l)WL}{\Pi}]}$. The union sets utility in work as a mark up on outside utility U^r.[25] A more progressive tax system, which implies a lower coefficient of residual income progression S, moderates wages. Intuitively, a high marginal tax rate implies that higher wages accrue mainly to the government rather than union members. Hence, from the union's point of view, the pay off from higher wage costs (and the associated loss in employment) in terms of higher net incomes for working members is only low so that the union moderates wages. By affecting wage setting behavior, a more progressive tax system for workers thus combats inequality between employed union members enjoying utility $v(W^a)$ and union members who only obtain outside utility U^r.

Apart from S, however, tax policy cannot affect this inequity as measured by the ratio $v(W^a)/U^r$. In particular, unions undo the effect on $v(W^a)/U^r$ of a higher tax on union members employed in the sector by raising the before-tax reward to work, W, so that $v(W^a)/U^r$ does not decline. In this way, union behavior limits the scope for redistribution between workers and the unemployed.[26]

Various non-tax factors affect the mark-up m. To explore these factors, we assume that other production factors besides labor are fixed. In that case, the mark-up can be written as $\frac{v'(W^a)W^a}{v(W^a)} \Big/ \left[\frac{1}{\left(\frac{1-\alpha}{\sigma^f} + \frac{\alpha}{\varepsilon}\right)} + \frac{1-\beta}{\beta}\frac{\alpha(1-\frac{1}{\varepsilon})}{[1-\alpha(1-\frac{1}{\varepsilon})]}\right]$. Wages are thus moderated if bargaining firms as a unit do not yield much market power on the commodity market (i.e. $\frac{1}{\varepsilon}$ is small), labor is a good substitute for the fixed factor (i.e. σ^f is large), profits account only for a small share of value added (i.e. α is large), and unions do not exert

[24] The objective function can be interpreted as an expected utility function of union members. (6) assumes that hours worked in a full-time job are exogenously fixed. For a model in which unions also set hours worked in a full-time job, see Sørensen (1997). Alternatively, employed individual workers can determine working time after wages have been set. For this formulation of endogenous individual labor supply within a bargaining framework, see Kilponen and Sinko (2003) for a monopoly union model, and Holmlund (2000) for individual bargaining with home production.

[25] An efficiency wage model in which effort by workers, e, is given by $e = (W^a - W^r)^{\zeta}$ and firms set wages to maximize profits yields a similar expression for the wage mark-up, except that the mark-up m is replaced by the exponent ζ in the effort function.

[26] The same holds true in an efficiency wage model; see Stiglitz (1999).

much bargaining power (i.e. β is small).[27] The first two conditions ensure that the (quasi-)rents parties bargain over are only small.

In order to solve for wages in general equilibrium in which outside utility U^r is endogenous, we use the following expression for outside utility

$$U^r = g(u)[v(B) + \delta] + (1 - g(u))v(\bar{W}^a), \tag{8}$$

where B and $\bar{W}^a$ denote the unemployment benefit and after-tax wages of workers employed in other sectors, respectively, and $\delta \geq 0$ is the utility of leisure if unemployed.[28] $(1 - g(u))$, measures the probability of finding a job outside the current sector. This probability is decreasing with the aggregate unemployment rate (i.e. $dg/du > 0$). In a symmetric equilibrium, all unions set the same wages, so that $\bar{W}^a = W^a$. Using this equilibrium condition in (8) to eliminate $\bar{W}^a$ and using the result in (7) to eliminate U^r, we arrive at the following expression for equilibrium unemployment u :

$$g(u) = \frac{Sm}{[1 - (v(B) + \delta)/v(W^a))}. \tag{9}$$

This expression can be interpreted as the wage-setting curve. Together with the labor-demand function (2), the curve determines labor-market equilibrium. Thus, compared to the competitive equilibrium analyzed in sub-section 3.1, the wage-setting curve rather than the labor-supply curve affects actual wages. The labor-supply curve implicit in the reservation wage is given by $v(B) + \delta$. It is thus horizontal in (L, w) space, reflecting an infinite elasticity of labor supply associated with constant utility of leisure δ.

3.2.2 net replacement rate fixed

We first look at the special case in which the effective net (i.e. after-tax) replacement rate $R \equiv B/W^a$ is fixed, utility is isoelastic, utility of leisure is absent (i.e. $\delta = 0$), and S and the mark-up m are fixed. In these circumstances, the wage curve determines equilibrium unemployment

$$g(u) = \frac{Sm}{[1 - R^{1-\rho}]}.$$

The wage curve is vertical in (L, W) space. Intuitively, an increase in the wage rate does not make work more attractive because the fixed replacement implies that such a wage increase is accompanied by an equivalent increase in the unemployment benefit B.

tax progression The tax system affects employment through the coefficient of residual income progression S. The employment impacts of a higher marginal tax rate (*ceteris paribus* the average tax wedge, i.e. $t^m = -s > 0$) and a higher average tax wedge (*ceteris paribus* the marginal tax rate, i.e. $t = t^a = s > 0$) have the opposite sign as the employment impacts established in sub-section 3.1. In particular, whereas sub-section 3.1 showed that a higher marginal tax rate hurts employment by harming

[27] In case of a Cobb-Douglas production function, a fixed price elasticity ε, an isoelastic utility function $v(C) = C^{1-\rho}$, and a fixed S, this mark-up is constant and given by $\frac{S(1-\rho)[1-\alpha(1-\frac{1}{\varepsilon})]}{1+\frac{1-\beta}{\beta}\alpha(1-\frac{1}{\varepsilon})}$. Hence, more risk aversion (i.e. a higher value for ρ) moderates wages.

[28] With an isoelastic utility function $v(C) = C^{1-\rho}$, one can interpret the coefficient of risk aversion ρ also as the reciprocal of the substitution elasticity between consumption and leisure. A lower substitution elasticity makes unemployment less attractive and thus moderates wages. In principle, δ can be negative if the unemployed are stigmatized.

labor supply, we now find that it actually boosts employment by moderating wages.[29] Indeed, in our second-best setting, a high marginal tax rate alleviates the distortions implied by the market power of unions.

overall tax burden Given a fixed effective replacement rate $R = B/W^a$, a higher average tax wedge (*ceteris paribus* the coefficient of residual income progression, i.e. $t = t^m > 0;\ s = 0$) leaves equilibrium unemployment unaffected. Raising the tax burden while maintaining the structure of taxation (as measured by the coefficient of residual income progression) thus does not impact labor-market transactions. Workers completely accommodate the higher tax burden in terms of lower after-tax wages so that wage costs (and hence labor demand) remain constant. This is known in the literature as the complete absence of real wage resistance.

The intuition behind this lack of real wage resistance is that the unemployed are in effect subject to the higher tax burden. With the outside option thus effectively being taxed, the bargaining position of the union weakens so that wages are moderated. Indeed, the key effective tax rate in this model is the effective (after-tax) replacement rate. As long as the tax system does not affect this key variable, it leaves unemployment unaffected. With a vertical wage-setting curve, also payroll taxes or capital taxes harming labor productivity (thereby shifting the labor-demand curve) do not affect employment but are transmitted fully as changes in market wages.

This result of lack of real wage resistance has been quite popular for both theoretical and empirical reasons. Regarding the theoretical reasons, one would like to clearly separate the unemployment impact of the tax burden and that of the social insurance system (and the replacement rate). A higher tax burden affects equilibrium unemployment only through the channel of the effective (after-tax) replacement rate. Another reason for the popularity of this result is that most labor-market models impose conditions that ensure that productivity growth does not impact unemployment. Fixing the replacement rate ensures that the models replicate this stylized fact. As regards empirical reasons, several cross-country studies could not establish significant empirical correlation between average tax rates and unemployment (see e.g. Layard, Nickell and Jackman (1991)). Indeed, as long as one measures the after-tax replacement rate $R = B/W^a$ and the coefficient of residual income progression S correctly, one would not expect to find an additional separate effect of the tax burden.

composition of the tax burden Changes in the tax structure, i.e. replacing payroll taxes by consumption taxes, do not affect equilibrium unemployment. A upward shift in the labor-demand curve as a consequence of lower payroll taxes results in higher wages. This protects the purchasing power of workers and benefit recipients after the increase in consumption taxes.

3.2.3 gross replacement rate fixed

Daveri and Tabellini (2000) have challenged the result that a higher tax burden does not affect unemployment, which has been supported by empirical studies that could not find any significant correlation between cross-section variations in unemployment and tax rates. They argue that labor-market institutions differ significantly across countries and that fixed effects thus dominate cross-sectional variations in unemployment rates. Accordingly, they rely on time-series instead of cross-section evidence to establish the link between the labor tax burden and unemployment. They find that time variation

[29] The wage moderating effects of high marginal tax rates have been established empirically by Lockwood and Manning (1993), Tyrvainen (1995), and Graafland and Huizinga (1999).

in labor taxes tends to be strongly correlated with unemployment changes in highly unionized countries of continental Europe. The correlation is substantially less strong, however, in the Scandinavian countries with centralized trade unions. Hence, the unemployment impact of labor taxes depends importantly on the non-tax institutions of a country.

To establish real wage resistance theoretically, Daveri and Tabellini (2000) assume that the replacement rate is fixed in before-tax terms and that unemployment benefits are not subject to income tax.[30] With isoelastic utility but without leisure (i.e. $\delta = 0$), equilibrium employment amounts to

$$g(u) = \frac{Sm}{[1-(R^g/(1-T^a))^{1-\rho}]}, \tag{10}$$

where $R^g = B/W$ is the fixed gross (i.e. before-personal tax) replacement rate.

overall tax burden At fixed S, a higher average tax burden T^a raises unemployment by in effect increasing the net replacement rate $R^g/(1-T^a)$, thereby making unemployment relatively more attractive. Union members pay for the higher tax burden less in terms of lower after-tax wages, and more in terms of a higher probability of becoming unemployed. The intuition behind the higher unemployment rate can be understood as follows. (7) implies that the utility of non-employed union members is proportional to employed union members. Hence, a higher tax burden raising the net replacement rate does not make non-employed union members better off compared to employed members. The effect of a higher net replacement rate is offset by a higher unemployment rate increasing the expected duration of unemployment. Indeed, a change in the net replacement rate is powerless to affect the relative position of the unemployed compared to the employed.

Whether the higher tax burden makes the employed and the unemployed worse off depends on the elasticity of labor demand.[31] With inelastic labor demand, a higher tax burden may even raise after-tax wages so that workers can shift more than 100 % of the tax burden unto employers. The intuition for the overshifting is that higher wages increase unemployment benefits, thereby improving the outside option and thus increasing wage pressure. If at the same time labor demand is inelastic, the higher wages do not result in much additional unemployment, so that wage pressures remain.[32] Indeed, with inelastic labor demand, workers are able to shift the tax burden onto profits, consumers and other taxpayers. With overshifting, despite the higher unemployment rate increasing the expected duration of unemployment, also the unemployed in effect gain because higher wages raise income not only in employment but also in unemployment (since unemployment benefits are linked to wages).

One way to justify the separate unemployment effect of T^a in empirical wage equations (even if they directly measure S and the after-tax replacement rates from

[30] Similar results would be found if the unemployment benefits were taxed but at a lower average rate $\bar{T}^a$ than wages and if the coefficient $(1-\bar{T}^a)/(1-T^a)$ would increase with the tax burden. If the tax schedule features a constant coefficient of residual income progression S and unemployment benefits would be subject to the same income tax schedule, the coefficient $(1-\bar{T}^a)/(1-T^a)$ would not vary with the overall tax burden but would depend only on S. Indeed, as shown below in (11), equilibrium unemployment is given by $g(u) = \frac{Sm}{1-(R^g)^S}$, where $R^g = B/W$ stands for the fixed replacement rate in before-tax terms.

[31] Similar conditions determine the distributional effects of a higher replacement rate R^g. Note that the (absolute value of the) elasticity of labor demand is likely to increase with the time horizon considered. In particular, the long-term labor elasticity is likely to exceed the labor-demand elasticity that the union employs to estimate the employment impact of higher wage costs.

[32] With higher wages raising unemployment benefits and profits, the negative external effects on the government budget and profits become more substantial.

social insurance benefits) is that, in addition to taxed unemployment benefits, unemployed may derive untaxed incomes from the informal sector (see Bovenberg and van der Ploeg (1998) and Holmlund (2000)) or enjoy utility of untaxed leisure (see Sørensen (1997)). The official replacement rates, which include only public unemployment benefits, thus do not correctly measure the *effective* replacement rates. Indeed, with a fixed net replacement rate from unemployment insurance R, isoelastic utility and positive non-taxed other income in unemployment δ, the wage-setting curve is given by (from (9))

$$g(u) = \frac{Sm}{[1 - R^{1-\rho} - \delta/(W(1-T^a)^{1-\rho}]}.$$

With non-taxed sources of unemployment income, productivity growth is consistent with stationary unemployment if non-taxed incomes rise with productivity in the formal economy so that $\delta^* \equiv \delta/W$ is fixed. In that case, the wage-setting curve is vertical again. With a fixed net official replacement rate R, in contrast to the situation without non-tax sources of unemployment income, an increase in the average tax burden T^a moves this vertical curve to the right.[33] Hence, conditions that ensure that changes in labor productivity do not impact unemployment do not necessarily imply that a higher tax burden leaves unemployment unaffected.

The result that the tax burden raises the equilibrium unemployment rate is an important, and controversial policy conclusion. In the Netherlands, for example, the empirical result that – even if one controls for the official replacement rate – the tax wedge significantly affects equilibrium unemployment has been quite robust (see, e.g. Graafland and Huizinga (1999)). It has played an important role in supporting policies to contain the tax burden. Indeed, the numerical impacts of a lower tax wedge can be substantial. To illustrate, Daveri and Tabellini (2000) find that the rise of 10 percentage points in the rate of effective labor tax in continental Europe in the seventies and eighties can explain about 3 percentage points of the increase in European unemployment during this period. Nickell and Layard (1999) estimate an unemployment effect of about 2 percentage points of such a tax increase.[34]

tax progression Tax progression raises the net replacement rate if unemployment benefits are subject to the same tax schedule as wage income, while the replacement rate is fixed in before-tax terms. This is in fact the case in many OECD countries (see OECD (2002b)). In that case, more progression exerts two offsetting effects in equilibrium unemployment. In addition to moderating wages, it boosts wages by raising the net replacement rate. To illustrate these two effects, we assume a tax schedule featuring a constant coefficient of residual income progression S. In particular, the tax schedule is given by $T(Y) = Y - gY^S$, where g and S are positive constants and Y is gross (labor or unemployment) income. This tax schedule implies that the coefficient of residual income progression is fixed at S. With this tax schedule, equilibrium unemployment amounts to

$$g(u) = \frac{Sm}{1 - (R^g)^S}, \tag{11}$$

[33] Also an increase in the consumption tax moves this curve to the right is the price of output in the formal sector is proportional to consumer prices.

[34] The macro-economic model of CPB Netherlands Bureau of Economic Policy Analysis implies that rise in the tax wedge of one percentage point reduces equilibrium unemployment effect by about 1/4 percentage point.

where R^g denotes the fixed replacement rate (in before-tax terms).[35] In that case, the wage moderation effect of more progression still dominates the replacement rate effect. Accordingly, more progression alleviates unemployment, even if high gross replacement rates imply that more progression raises effective net replacement substantially.[36] Replacing a proportional consumption tax by a progressive income tax thus boosts employment.

This result is modified if we allow for positive income from leisure δ. In that case, a more progressive tax schedule may actually raise equilibrium unemployment. Intuitively, with high leisure, the replacement rate effect becomes relatively more important compared to the wage-moderation effect. At high replacement rates, a progressive tax system thus becomes less powerful in boosting employment. Indeed, a more progressive tax schedule raises unemployment if non-taxable income $\delta^* = \delta/W(1-T^a)$ and the gross replacement rate R^g are large while the tax system is quite progressive to start with (i.e. S is small). All these three factors contribute to a high net replacement rate.

Starting from a proportional income tax system, the introduction of some progression may help to fight unemployment. At higher levels of progression, however, further increasing progression may be counterproductive in terms of the objective of reducing unemployment. There is thus a level of progression that minimizes unemployment defined by the following implicit equation for S [37]

$$1-\delta^* = (R^g)^\alpha(1-\alpha\log R^g).$$

The optimal tax system is progressive (i.e. $\alpha < 1$) as long as the gross replacement rate and utility from leisure δ^* are not very large, so that $(R^g)(1-\log R^g) < 1-\delta^*$.

This example suggests that the unemployment impacts of taxes and unemployment benefits are related. If tax systems are progressive, a given gross replacement rate implies a higher after-tax replacement rate, so that this replacement rate worsens unemployment more. At the same time, at higher replacement rates, changes in progression are less likely to reduce unemployment, as the replacement rate effect of more progression becomes stronger compared to the wage-moderating effect.

composition of the tax burden The differential impacts of productivity and explicit labor taxes in case the gross compensation ratio is fixed generate scope for tax

[35] Note that a higher average tax burden raising the parameter g does not impact unemployment. Hence, a higher tax burden does not affect unemployment even if, as documented by Daveri and Tabellini (2000), the unemployed pay less taxes than the employed do. Hence, just as in the case with a fixed after-tax replacement rate (see sub-section 3.2.2), the average tax rate does not affect equilibrium unemployment.

[36] The unemployment effect of more progression (with a fixed gross effective replacement rate) is very similar to that of more risk aversion (with a fixed net effective replacement rate). To determine these effects, one takes the derivative of the function $f(a) = a/(1-b^a)$ with respect a. The sign of this derivative is determined by $1-b^a(1-a\log b)$. This expression is non-negative because $g(a,b) \equiv b^a(1-a\log b) \leq 1$. This inequity can be established by showing that $\delta g/\delta a$ and $\delta g/\delta b$ are both positive for $a > 0$ and $0 < b < 1$ so that $g(a,b)$ reaches a maximum of 1 at $a = 1$ and $b = 1$ (we impose the restriction $a \leq 1$, $b \leq 1$).

[37] Here we assume that δ is proportional to gross wages W, while T^a is constant. We thus vary progression at a constant average tax burden on workers. The expression is found by taking the first derivative of $g(u) = \alpha/(1-\delta^*-(R^g)^\alpha)$ with respect to α. The sign of this derivative depends on $h(R^g,\alpha) \equiv 1-\delta^*-(R^g)^\alpha(1-\alpha\log R^g)$. This function is decreasing in R^g and increasing in α. Since we have $h(R^g,0) = -\delta$, $h(R^g,1) > 0$ (i.e. $(R^g)(1-\log R^g) < 1-\delta$) is a sufficient condition for the existence of a unique optimal value for $0 < \alpha < 1$ if $\delta^* > 0$. At this unique value of α, we have $1-\delta^*-(R^g)^\alpha = -\alpha(R^g)^\alpha \log R^g > 0$ if $R^g < 1$. Hence, at the optimal value of α, $g(u) = \alpha/(1-\delta^*-(R^g)^\alpha)$ is well defined (as the denominator is positive). Note that the optimal marginal tax rate is 100 % (i.e. $\alpha = 0$) if $\delta^* = 0$ or $R^g = 0$.

policies to boost employment. In particular, replacing explicit labor taxes by implicit labor taxes boosts employment. Intuitively, such a tax switch in effect reduces the net replacement rate and shifts the tax burden onto non-labor income. With their non-taxed incomes being tied to before-tax wages, the unemployed bear the burden of the implicit labor taxes (since these taxes reduce before-tax wages), yet escape the burden of explicit labor taxes. Hence, this tax reform succeeds in shifting the tax burden towards the unemployed so that the outside option becomes less attractive. This stimulates wage moderation and thus employment.

Implicit labor taxes can take various forms. Source-based capital income taxes in small open economies are one example. With mobile capital, these taxes are shifted onto labor (and with unemployment benefits and other non-labor income δ being linked to wages also onto the unemployed) in the form of lower labor productivity. Environmental taxes on tradable intermediate inputs such as energy are another example. Indeed, Bovenberg and van der Ploeg (1998) and Koskela and Schob (1999) show that green tax reforms may boost employment if they succeed in shifting the tax burden to non-labor income and income of the unemployed, in particular. If they succeed in increasing employment, these reforms are thus an indirect way to cut the effective net replacement rate. These conclusions are consistent with Bovenberg (1995), who argues that a green tax reform boosts employment only if the tax burden is shifted away from workers to people outside the active labor force (e.g. pensioners, owners of natural resources, transfer recipients). A change in the tax structure thus succeeds in alleviating unemployment if it replaces a tax that is borne by workers only by a tax that is also paid by the unemployed.[38]

The role of the bargaining level The employment effect of labor taxes depends crucially on wage-setting institutions (see also Daveri and Tabellini (2000)). Up to now, we have assumed decentralized wage setting. Some countries, however, feature more centralized wage setting. Centralized unions may internalize the adverse impacts of high unemployment on the government budget constraint, thereby moderating wages (see Calmfors and Driffill (1988) and Summers, Gruber and Vergara (1993)).[39] In fact, taxes may no longer affect unemployment at all. Intuitively, unions see through the veil of the government budget constraint and offset changes in the tax rate through transfers that exactly offset the real effects of taxes. This is a mixed blessing. The good news is that a higher average tax burden is less harmful for employment if (part of) income in unemployment is untaxed.[40] The bad news is, however, that a high marginal tax rate becomes less effective in reducing the monopoly distortion. This latter distortionis absent, however, if unions also internalize the impact of wages

[38] If unemployment benefits are indexed to producer prices, for example, replacing the payroll tax, the income tax or implicit labor taxes by an indirect tax on consumption raises employment by shifting the tax burden towards the unemployed (i.e. imposing a larger burden on the outside option of unions). Whereas replacing consumption taxes by implicit taxes thus boosts employment if unemployment benefits are linked to gross wages, such a tax reform hurts employment if these unemployment benefits are linked to producer prices. Accordingly, whether replacing implicit taxes by consumption taxes raises or reduces employment thus crucially depends on how unemployment benefits respond to prices and wages and how unemployment benefits are taxed.

[39] This explains why smaller European countries feature lower unemployment rates than larger ones. An alternative explanation, however, is that small countries features less market power on commodity markets (i.e. ε^d and ε are larger) so that the union mark-up m in (9) is smaller.

[40] Indeed, Nickell and Layard (1999, pp. 3059) find empirical evidence that coordination in wage bargaining reduces the impact of taxes on equilibrium unemployment. If unions also set working hours (as in Sørensen (1997) for example), taxes also leave labor supply unaffected if unions internalize the government budget constraint. Hence, in contrast to the competitive model with endogenous labor supply (see sub-section 3.1), taxes are non distortionary.

on profits (e.g. because union members derive their pensions from shareholdings in the firms) and consumer prices (because union members consume the commodities produced at home). Indeed, unions may internalize the effect of high wages on not only the government budget constraint but also on profits and prices.[41]

In addition to centralization, another important aspect of wage-setting institutions is the time horizon unions consider in setting wages. In particular, if they have a short-term horizon, unions can take the capital stock as given. Hence, the labor-demand elasticity in wage bargaining is rather low, implying a relatively high wage mark-up m and thus a high equilibrium unemployment rate. If reputational considerations allow unions to commit, in contrast, unions use a longer time horizon in considering the effects of high wages. Hence, they in effect employ larger labor-demand elasticity in setting wages. With a smaller union mark-up, changes in labor taxes exert a smaller impact on unemployment.[42]

unemployment benefits linked to consumer prices Unemployment benefits may be linked to prices rather than wages, especially in the short run.[43] Indeed, these benefits may be associated with an exogenous minimum income a country wants to maintain to keep liquidity-constrained households above the poverty line. In this case, the wage-setting curve is no longer vertical but slopes upward. Intuitively, higher wages are no longer transmitted into higher income during unemployment. This makes a higher wage more effective in equilibrating the labor market. In particular, a higher wage makes work more attractive compared to unemployment, thereby boosting employment.

If unemployment benefits are linked to consumer prices and are thus fixed in real terms, the wage-setting curve describing the target real wage (in terms of producer prices) is given by (from (9))

$$v(W(1-T^a)/(1+T^c)) = [v(B)+\delta]\left[1-\frac{Sm}{g(u)}\right]^{-1}.$$

In this case, taxes are paid only by workers, while the unemployed are protected. Since higher taxes make work less attractive compared to unemployment, a higher overall tax burden raises unemployment, just as in the case in which the gross replacement rate is fixed. Moreover, there is real wage resistance in that after-tax wages do not fully absorb a higher tax burden.

How much wage costs increase and after-tax wages decline in response to a higher tax burden depends on the slopes of the labor-demand and wage-setting curves. Workers shift most of the tax burden onto firms if labor demand is inelastic (i.e. horizontal in (L,W) space) and unemployment does not affect the target real wage much, so that the wage-setting curve is vertical in (L,W) space. In that case, employed union members and non-employed union members do not experience much of a loss in utility. Utility of non-employed union members, U^r, does not decline much, as unemployment does not increase substantially. The initial decrease in inequity between workers and unemployed is thus restored mainly through an increase in W^a. The other extreme case involves elastic labor demand and elastic wage setting (with respect to

[41] Indeed, if all budget constraints are linked through one representative agent, policy becomes completely neutral (see Bernheim and Bagwell (1988)).

[42] For commitment problems facing unions, see van der Ploeg (1987). In a small open economy with mobile capital, the long-run wage elasticity of labor demand may become very large. This explains why smaller European countries feature lower unemployment rates than larger European countries.

[43] If this link would be maintained in the long run, productivity growth reduces the replacement rate so that unemployment declines over time.

unemployment). In this case, the initial gap between utilities of workers and unemployed agents is re-established through higher unemployment reducing U^r rather than through higher market wages increasing W^a.

4 Optimal taxes: efficiency

4.1 Progressive taxation and efficiency

In a second-best world, progressive taxes may help to alleviate various imperfections. The previous section considered one specific labor-market imperfection, namely monopsony power of unions. In the particular model we explored, a 100 % marginal tax rate (i.e. $S = 0$) would be optimal to eliminate the mark-up of unions on the reservation wage. High marginal tax rates may also help to combat leapfrogging of employers when they set efficiency wages. To illustrate, if effort depends on relative wages (i.e. the wage paid in a firm compared to the average wage level in the economy), employers impose adverse externalities on other firms if they raise wages in order to stimulate effort of their own workers. High marginal taxes on wage increases may help to internalize these externalities.

Marginal labor taxes may internalize adverse externalities also if utility from consumption depends in part on one's relative position in society (see Layard (1980)). In that case, an individual raising his consumption by working harder reduces the utility of others. Marginal taxes help to combat these negative external effects of additional consumption.

In addition to labor-market imperfections, progressive tax systems may also help to alleviate distortions on capital markets. In particular, poor agents and young agents may suffer from liquidity constraints when they want to borrow in order to invest in human capital or to smooth consumption over their lifecycle. Progressive taxes redistribute income towards the poor and the young (since young workers tend to earn less than older workers) and thus help to alleviate these capital-market imperfections (see Hubbard and Judd (1986)).

Another relevant non-tax market failure concerns insurance markets. Parents can not sign contracts insuring their children against career risks. Moreover, insurance against various human capital risks suffers from adverse selection. Hence, private insurance contracts are not available or are excessively expensive. Agents may thus demand a high risk premium on their investments, which inhibits risk taking and entrepreneurship (see Sinn (1995)). By helping to pool human capital risks, a progressive labor tax helps to create the missing market for insurance of human capital (see Eaton and Rosen (1980)). Indeed, from an ex-ante point of view (i.e. behind the veil of ignorance), a redistributive labor tax can be viewed as insurance of human capital; what is insurance ex ante (before the uncertainty has been realized) becomes redistribution ex post (after one knows the outcome).

Two considerations are important when considering whether or not to employ high marginal tax rates on labor income as an instrument to address these imperfections. As a first consideration, benefits must be weighed against costs. Indeed, high marginal tax rates impose various costs. Section 3.1 focussed on labor-leisure distortions. However, other potential costs are diminished work effort and human capital accumulation, thereby harming not only the quantity but also the quality of labor supply. Moreover, high marginal taxes may hamper labor mobility, stimulate tax avoidance and tax evasion, and redistribute activities from the formal sector into the informal sector or the black economy. Finally, they may encourage jobs with

substantial nontaxable non-pecuniary benefits.

The second, related, consideration is whether alternative instruments are available to combat market imperfections. Often more direct instruments are available to address the market imperfections.

4.2 Optimal progressivity from an efficiency point of view

This sub-section explores the optimal progressivity of the labor income tax in a standard search model of the labor market. With homogeneous households, a progressive income tax does not generate any distributional benefits. Hence, optimal progressivity is explored from a pure efficiency point of view. In emphasizing the pure efficiency case for tax progressivity in imperfect labor markets, the approach is similar to that of Sørensen (1999), who investigates the optimal progressivity of the labor income tax in various labor-market models. Whereas Sørensen (1999) relies on numerical simulations, we derive an explicit analytical solution for the optimal labor income tax. This allows us to gain more insight into the determinants of optimal progression.

To investigate optimal progression in imperfect labor markets, we simplify the workhorse of modern labor economics – the search model developed by Mortensen and Pissarides (see, e.g., Pissarides (1990) and Mortensen and Pissarides (1999)) – by formulating a one-shot, static version of the model. While facilitating the interpretation of the results considerably, the simplified model still contains the main determinants of the optimal system. Most importantly, it retains the major market failure of the standard search model: search activities, which amount to specific investments in a labor-market relationship, are non-contractible and may thus be held up.[44] We explore how the tax system, by acting as a commitment device, can avoid hold-up of search activities. By efficiently allocating property rights, the tax system in effect acts as a substitute for complete contracts in protecting the appropriate incentives for search activities. In this way, the tax system internalizes both positive and negative search externalities.

The crucial element here is that wages are negotiated *after* search efforts on both sides of the labor market have been sunk. The quasi rents from the search activities are thus distributed on the basis of ex-post bargaining power rather than the marginal effectiveness of search in generating matches. Accordingly, if the marginal productivity of search activities exceeds the ex-post bargaining power, specific investments in the match are held up. This hold-up problem arises because the party with excessive bargaining power cannot credibly commit to reward his partner according to her contribution to concluding the match. Indeed, parties can bargain only after they have met. Since contracts can thus be signed only after the contracting parties have sunk their search activities, the market for search is missing. The missing market for specific investments in the match is the key non-tax distortion in the model.

4.2.1 model

The sequencing of decisions is as follows. In the first stage of the one-shot game, tax policy is set. In the second stage, firms enter. In the third stage, workers and firms (or entrepreneurs or employers), which are unmatched, search for a partner on the labor market. At the supply side of the labor market, workers $i \in [0,1]$ select their search intensities $0 \leq X_i \leq 1$ at a cost $\gamma(X_i) \geq 0$, with $\gamma''(.) > 0$ and $\lim_{X_i \uparrow 1} \gamma'(X_i) \rightarrow +\infty$. At the demand side, entrepreneurs simultaneously decide how many vacancies

[44] Also Hosios (1990) and Acemoglu and Shimer (1998) formulate static versions of the search model. See also Boone and Bovenberg (2002).

to create. Vacancy costs are linear, so that economy-wide vacancy costs amount to cD, where D denotes the economy-wide number of vacancies and c are the per-unit vacancy costs.

In the fourth stage of the game, workers and entrepreneurs are matched; the number of matches equals $m(X, D)$, where $X = \int_0^1 X_i di$. The matching function $m(.,.)$ is increasing in its two arguments. Moreover, it exhibits constant returns in both arguments together, but decreasing returns in each of the arguments separately. Since a Cobb Douglas matching function fits the data rather well,[45] we assume that the matching function is of the Cobb Douglas form where the exponent of the vacancies is given by η.

After they have been matched, workers and entrepreneurs bargain about the (after-tax) wage rate W in the fifth stage of the game. Entrepreneurs and workers who do not find a match receive a payoff of, respectively, zero and the (after-tax) unemployment (or welfare) benefit B. The unemployment benefit B can be interpreted as the minimum standard of living that the government guarantees.[46] Finally, output is produced, taxes are collected and tax revenues G are spent on a public good.

The model is solved backwards. Accordingly, before determining search intensities X and labor-market tightness $\theta \equiv \frac{D}{X}$, we solve for (after-tax) wages.

production Each matched firm-worker combination produces Y units of output. Output is the numeraire. Output net of search costs, Ω, is given by

$$\Omega = m(X, D)Y - \gamma(X) - cD, \tag{12}$$

where $m(X, D)Y$ represents total output and $\gamma(X) + cD$ stands for total search costs. The exogenous public good G and the exogenous unemployment benefit B are financed by a linear tax on wages:

$$G + B = m(X, D)(\tau(W - B) + \tau_a + B). \tag{13}$$

Here, τ represents the proportional (or ad valorem) tax on wages (net of the unemployment benefit B). The other component of the linear wage tax, τ_a, is a fixed (or specific) tax on the match. This tax depends only on the existence of a match and is not conditioned on how the quasi-rents from the match are shared between firms and workers. Wage taxation is progressive (i.e. the average tax burden rises with the wage) if the specific tax τ_a is negative.

wage setting Wages are determined by Nash bargaining after a match has been found. The bargaining is about the (after-tax) quasi rent (or surplus) from the match, $Y - \tau(W - B) - \tau_a - B$. The after-tax wage W that maximizes the Nash Bargaining function $(W - B)^{\beta}(Y - W - \tau(W - B) - \tau_a)^{1-\beta}$ is given by

$$W = \frac{\beta(Y - \tau_a + \tau B) + (1 - \beta)(1 + \tau)B}{1 + \tau}. \tag{14}$$

This is the value of the match for the worker. The value of a match for the entrepreneur, Π, amounts to

$$\Pi \equiv Y - W(1 + \tau) + \tau B - \tau_a = (1 - \beta)(Y - \tau_a - B). \tag{15}$$

[45] See, e.g., Broersma and Van Ours (1999).

[46] This is in fact optimal if the utility function of individuals is given by $u(Y) = \begin{cases} -\infty & \text{if } Y < B \\ Y & \text{if } Y \geq B \end{cases}$. Note that the unemployment benefit is not subject to the labor income tax. Boone and Bovenberg (2002) explore the model developed here with $B = 0$.

The burden of the fixed tax component τ_a is shared between the worker (i.e. the supply side of the labor market) and the firm (i.e. the demand side of the labor market) in proportion to their respective bargaining powers β and $(1-\beta)$; after-tax wages W decline and before-tax wages (i.e. wage costs) $W(1+\tau)+\tau_a$ rise with τ_a. The proportional tax rate τ, in contrast, reduces only the worker's value of a match (14); before-tax wages $W+\tau(\ W-\ B)+\tau_a$ and the firm's value of the match (15) are not affected by τ. The proportional tax rate thus bears on the supply side rather than the demand side of the labor market. Intuitively, by taxing the quasi rents that accrue to workers (i.e. the after-tax wage W), the proportional tax not only reduces the (after-tax) surplus from the match but also raises the effective bargaining strength of employers. In the presence of a higher proportional tax, employers bargain more aggressively because a given increase in the after-tax wage W results in a larger increase in wage costs $W(1+\tau)+\tau_a$.

search intensity and vacancies The wage agreed upon in ex-post bargaining (i.e. after the match has been concluded) affects the incentives facing workers and firms to search for a partner in the preceding stage of the game. In selecting their search intensity, workers trade off additional search costs against the higher probability of finding a job. With a constant-returns-to-scale matching function, the probability that a worker with search intensity X_i is matched with a firm can be written as a function of labor-market tightness only: $\frac{X_i}{X}m(X,\ D)=X_i m(\theta)$ where $m(\theta)\equiv m(1,\theta)$. The risk-neutral worker selects search intensity X_i so as to maximize the expected surplus from search

$$\max_{X_i\geq 0}\{X_i m(\theta)(W-B)-\gamma(X_i)\}.$$

With homogeneous individuals, all households feature the same search intensity

$$\gamma'(X)=m(\theta)(W-B), \tag{16}$$

where the left-hand side represents the marginal costs from higher search intensity and the right-hand side the corresponding expected marginal benefit in terms of raising the probability of finding a job. The net expected surplus for the worker, $Xm(\theta)(\ W-\ B)-\gamma(\ X)=X\gamma'(\ X)-\gamma(\ X)$, is assumed to be positive.

The expression for optimal search intensity (16) can be interpreted as the implicit labor-supply equation. With the aid of (14), labor supply can alternatively be written as

$$\gamma'(X)=m(\theta)\frac{\beta(Y-\tau_a-B)}{1+\tau}. \tag{17}$$

Demand for labor is determined by firms. The probability that a firm is matched with a worker equals $\frac{m(X,D)}{D}=\frac{m(\theta)}{\theta}$. With free entry of firms, expected profits from posting an additional vacancy are zero

$$c=\frac{m(\theta)}{\theta}\Pi=\frac{m(\theta)}{\theta}(1-\beta)(Y-\tau_a-B). \tag{18}$$

Here the left-hand side represents the costs for a firm entering the labor market, while the right-hand side stands for the firm's expected benefits of doing so. By reducing the probability of filling a vacancy $\frac{m(\theta)}{\theta}$, a tighter labor market decreases the expected benefits from posting a vacancy. Since labor-market tightness θ is the only endogenous variable in (18), the free-entry condition determines tightness as a function of τ_a. As

in most non-competitive models of the labor market, a more progressive tax system (i.e. a smaller value for τ_a) raises the employment rate (i.e. the number of matches per unit of labor supply) $m(X,D)/X = m(\theta)$.

Welfare Substituting the government budget constraint, $Xm(\theta)Y = Xm(\theta)\left[W+\Pi\right] + G + (1-\ Xm(\theta))\ B$ into the expression for Ω in (12), we find

$$\begin{aligned}\Omega &= Xm(\theta)\left[W-B+\Pi\right]+G+B-\gamma(X)-c\theta X \\ &= X\gamma'(X)-\gamma(X)+G+B.\end{aligned}$$

With the free-entry condition ensuring a zero expected return for entrepreneurs, welfare consists of the ex-ante return to workers $Xm(\theta)(\ W-\ B)-\gamma(\ X)+\ B$ and the resources allocated to the government G. The second equality follows from (16) (to eliminate W) and (18) (to eliminate Π). Since G and B are exogenously given and $X\gamma'(X)-\gamma(X)$ is rising in X, maximizing welfare is equivalent to maximizing search X.

Optimal progressiveness If the government employs τ and τ_a to maximize welfare and search, it sets τ_a according to (see the Appendix)

$$\tau_a \equiv \frac{1-\beta-\eta}{1-\beta}Y - B. \tag{19}$$

The optimal degree of progressiveness of the income tax ensures that the matching process is efficient by establishing an efficient distribution of property rights over the fruits from non-contractible specific investments in search. In particular, the party that carries out the most important non-contractible investments should be able to reap most of the quasi rents from the relationship. In this way, property rights act as a substitute for complete contracts in protecting the incentives for specific investments. By moderating wages, a progressive tax system in effect allows firms to increase their share in the quasi rents from search. A progressive tax system is thus optimal if firms can not reap the full social benefits of their search effort in a laissez-faire equilibrium. This is the case if vacancies are important in generating matches (as reflected in a high value for η) and workers can appropriate a large share of the surplus from the match because of substantial bargaining power β and a good outside option B.[47] In that case, workers in effect levy an implicit tax on the specific investments of employers (i.e. the posting of vacancies) by expropriating part of the marginal social benefits of these investments.[48] With employers being held up by workers, labor demand (i.e. the posting of vacancies) is too low from a social point of view. A progressive tax undoes the implicit 'hold-up' tax levied by workers on employers so that employers face adequate incentives to enter the labor market. By in effect subsidizing labor demand and taxing labor supply, tax policy restores the socially optimal mix of labor demand and supply.

[47] A proportional tax is optimal if unemployment benefits are absent (i.e. $B=0$) and the so-called Hosios condition holds. The latter condition (see Hosios (1990)), which reads $1-\beta=\eta$, states that the bargaining power of firms $1-\beta$ should correspond to the effectiveness of firms in producing matches as measured by η.

[48] Unions can affect hold-up problems. On the one hand, they may worsen these problems if, by monopolizing labor supply in an industry, they are able to hold up firms' investments that are specific to this industry. On the other hand, unions tend to feature a longer time horizon than individual workers do. The reputational mechanism may thus induce them to keep their commitments to moderate wages, thereby alleviating the hold-up problem. These opposite effects of unions resemble the opposite effects of industry unions worsening monopoly distortions and national unions internalizing externalities (as discussed in sub-section 3.2.3).

Tax policy, which is set before search activities are determined, allows workers to commit to not expropriate firms. In this way, tax policy effectively creates the market for search that is missing in the laissez-faire equilibrium. Before workers and firms meet each other after they match, tax policy in effect allows them to conclude a contract stipulating that their search activities will be rewarded according to the marginal contribution to the match. Indeed, if workers would vote on the tax rate in the first stage of the game (i.e. when they are still unmatched and in effect face infinitely elastic labor demand), they would vote for the optimal social contract (i.e. the optimal allocation of property rights) implicit in the optimal tax structure.

The results can be interpreted also in terms of the distortions due to imperfect competition. If workers exercise too much power ex post (i.e. $\frac{1-\beta-\eta}{1-\beta}Y- B < 0$ so that θ is too low), the market can be characterized as being monopolized. Tax policy corrects the associated monopoly distortions by levying a tax on the excessive wages. In this way, tax policy offsets the implicit taxes imposed by the party with excessive market power.

An efficient matching process maximizes the incentives of workers to participate in this matching process through labor supply. If the bargaining power of workers is too strong (i.e. $\tau_a - \frac{1-\beta-\eta}{1-\beta}Y+ B > 0$), workers are discouraged from looking for a job by a low probability of finding a job on account of a lax labor market (as reflected in a low value for tightness θ).[49] The unemployment rate is too high in that case. If workers' bargaining power is too weak (i.e. $\tau_a - \frac{1-\beta-\eta}{1-\beta}Y+ B < 0$), workers' search is depressed by excessively low wages. Accordingly, beyond the point at which $\tau_a \equiv \frac{1-\beta-\eta}{1-\beta}Y- B$ a more progressive tax system harms the efficiency of the matching process by reducing labor supply and in effect giving the supply side of the labor market insufficient bargaining power compared to labor demand.[50] As a direct consequence, labor supply is too low compared to labor demand. The resulting excessively tight labor market implies that the unemployment rate $1 - m(X, D)/X$ is too low from a pure efficiency point of view.

The optimal τ_a does not depend on revenue requirements. The intuition behind this result is the following. The linear vacancy costs imply that demand for labor is infinitely elastic. Hence, firms are able to shift the entire tax burden required to finance government spending to workers. Thus, whereas a tax on labor supply, τ, taxes the supply side directly through a lower after-tax wage W, a tax on labor demand τ_a is also borne by labor supply – albeit indirectly (namely, through the general equilibrium effect of fewer firms entering the labor market, which reduces the probability of finding a job by producing a less tight labor market). It is more efficient to tax workers directly through τ than indirectly through the general equilibrium effect on θ; both ways distort search intensity, but the second way distorts also labor-market tightness.[51]

This result is closely related to the celebrated Diamond-Mirrlees (1971) result on the optimality of production efficiency. With constant-returns-to-scale production (or tax instruments to tax away rents due to decreasing returns) and sufficient tax

[49] Thus, progressive taxation and wage moderation may raise labor supply if workers have excessive bargaining power in the laissez-fair equilibrium. This contrasts with models (explored in the section 3.1) that focus on the intensive rather than the extensive margin of labor supply and in which labor supply is set after workers have found a job. In these models, the discouraged-worker effect is absent and the unemployment rate thus does not depress labor supply.

[50] This contrasts with the union model explored in section 3.2. In that model, which abstracts from endogenous labor supply, the optimal marginal tax rate is 100 %, resulting in the elimination of involuntary unemployment.

[51] This strong result no longer holds if labor demand is not infinitely elastic with respect to wage costs because firms cannot freely enter the labor market and a lump-sum profit tax is not feasible (see Boone and Bovenberg (2002)). In that case, not only τ but also τ_a rises with the government revenue requirement.

instruments to tax consumers directly, the government should ensure production efficiency. The government finds it optimal to tax consumers directly through consumer taxes rather than indirectly through taxes that violate production efficiency. Similarly, in the current context, the government should not distort labor-market tightness, θ, by raising revenues through τ_a. Indeed, keeping labor-market tightness at its first-best level can be viewed as maintaining efficiency in the production of matches.

A higher unemployment benefit is translated into an equivalent increase in in-work benefits τ_a (i.e. $-d\tau_a = dB$). A higher unemployment benefit thus results in a more progressive tax system, as a higher in-work benefit in effect offsets the adverse impact of the unemployment benefit on job creation. The benefit system thus determines the optimal progressiveness of the labor tax. The combination of an employment benefit and a job subsidy can be interpreted as a basic income. Indeed, if the Hosios condition is met, the overall tax on job creation is zero (i.e. $\tau_a + B = 0$). The higher marginal tax rates depress labor supply but it is more efficient to depress labor supply through lower after-tax wages than to depress labor supply indirectly through violating production efficiency.[52] A progressive tax (i.e. $\tau_a < 0$) thus offsets the distortions of the welfare system.

5 Employment and distribution: applied general equilibrium analysis

This section explores the impact of labor tax reform with the help of an applied general equilibrium model for the Netherlands, the so-called MIMIC model developed at CPB Netherlands Bureau for Economic Policy Analysis. The model combines a rich theoretical framework based on modern economic theories, a firm empirical foundation, and an elaborate description of the actual tax and social insurance systems in the Netherlands. The model considers the two main transmission channels through which tax policy impacts the labor market, namely, labor supply and wage determination. In addition, it considers various other ways through which taxes and benefits affect the labor market namely, the black economy, human capital accumulation, efficiency wages, costly job matching, and search behavior of the unemployed. Hence, in addition to wages, unemployment and the quantity of labor supply, taxes affect the quality of labor supply. Through the replacement rate, the benefit system affects not only wage setting but also search intensity and the reservation wages of the unemployed.

5.1 MIMIC model

This sub-section provides a bird-eye's view of MIMIC (Graafland e.a. (2001) provides a more detailed overview of the model). MIMIC allows for considerable heterogeneity among households. In particular, the model accounts for heterogeneity in household composition (including the number of children), educational level, age, ability, preferences for leisure, and labor-market status. Incorporating this heterogeneity allows one to explore the income distribution and hence various trade-offs between equity and efficiency. Moreover, Tables 3 and 4 document on fact that replacement rates and marginal tax rates vary considerably across various individuals, depending on household composition and income level. The same holds true for labor-supply elas-

[52] With less than infinitely elastic labor demand, higher unemployment benefits would in part be financed through lower job subsidies τ_a so that $\tau_a + B > 0$. A similar result holds in a model in which labor supply is endogenous on not only the extensive margin but also the intensive margin (see section 6).

ticities.[53] Whereas particular policies may have little impact on a representative individual, they may significantly affect the behavior of particular types of individuals, such as secondary part-time workers, low-skilled agents and older employees close to retirement (see also Disney (2000)). A careful analysis of the labor-supply effects of tax policy therefore requires substantial disaggregation. Indeed, representative agent models conceal this variation in effective tax rates and labor-supply behavior.

MIMIC embeds a standard microsimulation model in a general equilibrium setting. As an applied general equilibrium model, MIMIC draws on microeconomic theory to derive supply and demand from optimizing behavior by decentralized agents. This allows one to interpret the model results in terms of microeconomic behavior of households and firms. In modelling equilibrium on the labor market, the model departs from the traditional assumption of market clearing in most general equilibrium models. In modelling labor-market imperfections that give rise to involuntary unemployment, MIMIC employs modern labor-market theories. In particular, in addition to legal minimum wages, it includes elements of wage bargaining, efficiency wages and costly job matching. In this way the model describes equilibrium unemployment in terms of the structure of the tax system, minimum wages and the features of social insurance and assistance.

MIMIC has a firm empirical basis. Various crucial relationships in the model, including contractual wage formation and the production function, have been estimated from time series data. Furthermore, microeconometric estimates on Dutch labor supply helped to calibrate the labor-supply model. Moreover, income distributions are based on micro data.

MIMIC describes the institutional features of taxation and social insurance in much detail. This institutional detail makes the model especially relevant for policy making because actual policy proposals typically involve particular details of the tax and social insurance systems. Moreover, as section 3.2 documents, the impact of tax policies depend crucially on how unemployment and welfare benefits respond to changes in wages and taxes.

Incorporating the main transmission channels of tax policy in an empirically based model with substantial household heterogeneity is not without costs. In particular, the various sub-models are not fully consistent with each other. To illustrate, the wage setting model does not take into account endogenous labor supply. Moreover, the labor-supply model assumes that households are not rationed on the labor market. At the same time, the models describing search behavior of the unemployed and training and schooling are not part of the household model describing labor supply.

5.1.1 households and labor supply

MIMIC distinguishes 40 types of households in order to adequately describe labor supply and explore the income distribution. In particular, MIMIC distinguishes couples, single persons, single parents, pensioners and students. To model the specific labor-supply behavior of those close to retirement, people aged between 55 and 65 years are represented by a separate household type. Couples consist of a so-called breadwinner (i.e. the individual with the highest personal income) and a partner (i.e. the adult with the lowest personal income). Couples are subdivided into families with children and families without children. Individuals within each household may differ with respect to their skill level (high skilled, low skilled or unskilled) and their job status (i.e

[53] This is shown by microeconometric evidence. Econometric work on labor-supply behavior is increasingly exploiting this microeconomic variation and is hence moving away from macroeconomic estimation.

holding a job in the formal sector, unemployed and collecting a social benefit, or not participating in the labor force).

For each household type, MIMIC employs class-frequency income distributions based on micro data to describe the distribution of gross incomes. These income distributions are important determinants of the efficiency costs of high marginal tax rates: the more people are concentrated in a particular income range, the higher become the efficiency costs of high marginal rates in this income range. By applying the corresponding statutory tax and premium rates to gross incomes, MIMIC determines net incomes and the average and marginal tax rates that affect labor-supply decisions.

The labor-supply model has been calibrated so that the model reproduces labor-supply elasticities estimated in the empirical literature for the Netherlands. In particular, the uncompensated wage elasticity of labor supply by partners is set at 1.0, single persons feature a corresponding elasticity of 0.25 and most breadwinners of around 0.1. Older breadwinners, who may change their retirement decisions in response to changes in wages, feature a somewhat higher elasticity of 0.15. The income elasticities of labor supply are smaller than the corresponding wage elasticities – namely, 0.2 for partners, 0.05 for single persons and almost zero for breadwinners. In addition to supplying labor to the formal labor market, households can supply labor to the black labor market. The model has been calibrated to reproduce the size of the black economy in the Netherlands, which is estimated at about 3% of GDP, and an uncompensated wage elasticity of black labor supply of 0.75.

A separate training model endogenizes the distribution of the labor force over unskilled, low-skilled and high-skilled workers. By engaging in training activities, workers can increase the transition rates to higher skill levels with higher wages. In setting their training level, workers trade off (non-taxable) effort costs and the benefits of training (in terms of a higher probability of moving towards a higher skill level earning a higher wage). Based on Groot and Oosterbeek (1995), the model is calibrated such that a 10 % increase in after-tax wage differentials raises the share of workers participating in training by 8 %.

5.1.2 wage formation

The black labor market is modelled as the competitive labor market in section 3.1; for each of the three skill categories, the wage clears this market. Firms in the sheltered sector and the construction sector[54] demand labor from the black market. The elasticity of substitution between black and formal labor in the production function is set at 2, which is based on empirical evidence in Baartmans et al. (1986). Furthermore, firms may pay formal labor in part informally, i.e. without reporting the wages to the tax authorities. Firms determine this informal labor by trading off lower taxes against a potential penalty for fraud.

The formal labor markets for the three skill categories do not clear. The imperfections of this market originate in market power of unions, efficiency wages and costly job matching. To describe wage formation in these markets, MIMIC distinguishes between contractual wages, which are determined in collective bargaining between employers and unions, and incidental wages, which are set by individual employers based on the tightness of the skill-specific labor markets. Social benefits are linked to contractual, rather than incidental, wages.

[54] In addition to these two sectors, MIMIC includes a mining sector, a residential sector and an exposed sector, which consists not only of capital-intensive manufacturing industries subject to intense foreign competition but also of agriculture and transport. The sheltered sector includes trade, banking and insurances, and other private services.

Contractual wages are determined by a right-to-manage model in which employers and unions bargain over wages at the industry level. The rents that unions and employers bargain over originate in the market power of firms on product markets. In particular, each industry produces a good that is an imperfect substitute for goods produced by other domestic industries or by foreign firms. The unions are small compared to the labor market as a whole and therefore do not internalize the impact of their bargain on the government budget constraint, profits and prices.

The resulting wage equation is calibrated on the basis of estimates by Graafland and Huizinga (1999). Using macro data, they found that the positive elasticity of the average tax rate is six times as large in absolute value as the negative elasticity of the marginal tax rate (-0.1). The elasticity of the consumer price equals the sum of the elasticities of the marginal and average tax rates, which is 0.5. Accordingly, at constant unemployment and replacement rates, the incidence of a higher tax wedge (by simultaneously increasing average and marginal tax rates) is split equally between employers and employees through higher gross wages and lower after-tax wages. On average, the wage elasticity of the replacement rate is about 0.2.[55]

The wage structure among skills is further modified by a skill-specific, so-called incidental, wage component. The employer uses this incidental wage component to minimize search costs. The incidental wage can thus be interpreted as an efficiency wage associated with hiring costs. It is set as a mark-up on the contractual wage. This mark up rises with the tightness of the labor market.

5.1.3 job matching

To model labor-market tightness and mismatch, MIMIC incorporates costly job matching. Heterogeneity in the matching process allows MIMIC to model also the adverse impact of high minimum wages and high reservation wages on the efficiency of the matching process. In particular, low-productivity matches may fail because they do not meet the minimum productivity standard of the employer (determined by the minimum wage) or the reservation wage of the unemployed.

In the matching model, the behavior of the unemployed is described in terms of the reservation wage and search intensity. In particular, in setting search intensity, the unemployed trade off the loss of leisure against the increased probability of moving into the employed state. The optimal search intensity increases in the average transition rate into employment (because it raises the marginal return on search) and decreases in the replacement rate (which decreases the difference in life-time utility between the employed and unemployed states). The second variable describing the behavior of the unemployed is the reservation wage, which is the wage at which an unemployed job seeker is indifferent between the employed and the unemployed states. The reservation wage rises with both the unemployment benefit and the average transition rate into employment. Together with the lognormal wage distribution of job offers, the reservation wage determines the acceptance rate of the unemployed (i.e. the share of contacts that is acceptable to unemployed job seekers). A higher replacement rate thus exacerbates the mismatch on the labor market by lowering search intensity and raising the reservation wage. This pushes up incidental wages, thereby raising unemployment in equilibrium.

[55] Since both skill-specific and macroeconomic factors play a role in determining skill-specific wages, skill-specific wages are determined by both a macroeconomic wage equation, which adopts macro-aggregates for the average tax rate, the marginal tax rate, the replacement rate and unemployment, and a corresponding skill-specific wage equation, which employs skill-specific explanatory variables. Based on Graafland and Lever (1996), the macro and skill-specific wage equations carry equal weights in determining the contractual wage for a specific skill.

The long-term unemployed typically differ from the short-term unemployed in their search behavior, reservation wage and productivity. MIMIC therefore distinguishes between short- and long-term unemployment by using a steady-state flow model for job matches akin to Holmlund and Linden (1993).[56] In particular, the long-term unemployed are less productive than the short-term unemployed because they lost some human capital during their prolonged period of unemployment. If they find a job, the long-term unemployed face some (exogenous) probability to restore their human capital. The long-term unemployed take into account this benefit of entering work and hence feature a relatively low reservation wage. Accordingly, rather than the reservation wage, the minimum effective productivity standard of the employer, which is determined mainly by the minimum wage, mainly restricts the number of successful matches for the long-term unemployed. For the short-term unemployed, in contrast, a relatively high reservation wage is the most important barrier to successful job matches. As a relatively large number of long-term unemployed are unskilled, the minimum effective productivity standard (and hence the minimum wage) is the most important barrier in the job-matching process of the unskilled. The model is calibrated so as to conform closely to the observed transition rates between the various states and to the main empirical findings on search intensities and reservation wages.

5.1.4 public institutions

MIMIC contains several public institutions, including the Dutch personal income tax system in 1998. The personal income tax features a tax-free allowance and three tax brackets. A partner whose labor income remains below the tax-free allowance can transfer the tax-free allowance to the breadwinner. The rate in the first tax bracket is about 36% in 1998. The tax rate in the second bracket is 50% and has to be paid on incomes above about 25,000 euro. The marginal rate in the third tax bracket, which amounts to 60%, is paid on incomes above about 50,000 euro. Workers benefit from a special earned-income tax deduction, which amounts to 12% of labor income with a maximum of around 1500 euro. Unemployment benefits are subject to the progressive personal income tax. VAT in the Netherlands imposes a low rate on necessary goods (6%) and a high rate for other goods (17%). Other public institutions in MIMIC include employee and national social insurance schemes,[57] the employers' and employees' contributions to employee social insurances, premiums for health insurance, the statutory minimum wage (which is linked to the average contractual wage rate), social assistance (which is linked to the statutory minimum wage), and a number of policy instruments targeted at specific groups, such as the long-term unemployed and the unskilled. Households with incomes just above the minimum wage face overall effective marginal tax rates close to 80 % on account of employee insurance premiums, income-dependent public health care premiums, and means-tested housing allowances. Indeed, overall marginal taxes in this income range exceed marginal tax rates (of 60 %) facing high-income earners.

[56] A detailed description of this model can be found in Jongen and Graafland (1998).

[57] Employee insurances apply only to working people and cover employment risks – namely, unemployment, disability, and sickness. Benefits depend on previously earned wages. All residents are entitled to national social insurance, which involves family allowances, disability benefits for the handicapped, special health costs, and a basic pension. In contrast to benefits from employee insurances, benefits from national social insurance are not related to previously earned wages.

5.2 Cutting taxes in MIMIC

This section employs the MIMIC model to investigate the long-run effects of a number of tax cuts. In all experiments, the ex-ante (i.e. before behavioral responses have been taken into account) reduction in tax revenues amounts to 0.25 % of GDP. A cut in public consumption balances the government budget ex post (i.e. after the effects of the behavioral responses on the public budget have been taken into account). Hence, the required cut in public consumption reflects the impact of behavioral responses on the public budget. In particular, if the reduction in public consumption is less than the ex-ante cut in revenues of 0.25 % of GDP, behavioral responses help to mitigate budgetary costs.

This section consists of three parts. The first part explores cuts in personal income taxes. The second part turns to cuts in social security contributions (i.e. payroll taxes) paid by employers. Finally, the third part investigates various forms of an Earned Income Tax Credit (EITC) aimed at increasing the reward of work in general and of low-skilled work in particular.

5.2.1 personal income taxation

Cutting marginal tax rates The detailed modelling of the personal income tax system allows MIMIC to explore the labor-market effects of various parameters of the Dutch tax system. The first three columns of Table 5 contain the long-run effects of cuts in each of the three tax brackets of the Dutch personal income tax (of respectively 1.2, 6.9 and 24.5 % points). These tax cuts reduce both marginal and average tax rates. However, the tax cut in the first bracket is inframarginal for many workers whose incomes reach into the second and third tax brackets. Hence, this particular tax cut reduces the average marginal tax rate (i.e. the marginal tax rate averaged over the various workers) substantially less than tax cuts in the higher brackets do (see the third next-to-last row of Table 5). Indeed, in contrast to a reduction in the tax rates in the upper brackets, a tax cut in the lowest bracket makes the tax system somewhat more progressive (as measured by the coefficient of residual income progression).

Table 5. Macroeconomic effects of cuts in income and payroll taxes						
	First income tax bracket	**Second income tax bracket**	**Third income tax bracket**	**Basic income tax allowance**	**General cut in payrol tax**	**Targeted cut in payrol tax**
	percentage deviations					
Private consumption	0,51	0,64	0,62	0,39	0,48	0,43
Exports	0,36	0,53	0,53	0,12	0,29	0,28
Imports	0,21	0,30	0,30	0,09	0,17	0,17
Formal Production	0,37	0,57	0,57	0,09	0,29	0,27
Black production	-0,02	-0,20	-0,63	0,06	-0,02	1,42
Employment	0,39	0,47	0,44	0,07	0,29	0,47
- unskilled	0,46	0,20	0,20	0,18	0,40	3,92
- low-skilled	0,50	0,17	0,07	0,10	0,36	0,05
- high-skilled	0,35	0,60	0,60	0,04	0,25	0,04
Labour supply (pers.)	0,39	0,05	-0,02	-0,07	0,05	0,10
Labour supply (hours)	0,18	0,26	0,30	-0,04	0,10	0,10
- breadwinners	0,03	0,28	0,54	-0,02	0,03	0,02
- partners	0,39	0,02	-0,20	-0,16	0,19	0,31
- single persons	0,26	0,31	0,08	-0,06	0,13	0,19
- 55+	0,09	0,42	0,77	0,03	0,06	0,06
Black labour (hours)	-0,03	-0,14	-0,33	0,07	-0,02	1,45
Training						
- unskilled and low-skilled	0,04	0,10	0,03	-0,05	0,00	-0,83
- high-skilled	-0,09	0,65	0,89	-0,06	-0,02	-0,02
	absolute deviations					
Unemployment rate	-0,13	-0,12	-0,08	-0,08	-0,12	-0,23
- unskilled	-0,21	-0,37	-0,27	-0,07	-0,20	-1,41
- low-skilled	-0,18	-0,12	-0,08	-0,13	-0,17	-0,24
- high-skilled	-0,10	-0,08	-0,04	-0,07	-0,10	-0,08
Share long term unemployment	-1,29	-0,74	-0,47	-0,48	-0,75	-1,61
Replacement rate (a)	-0,03	-0,29	-0,18	0,15	-0,01	-0,15
Average tax burden (a)	-0,35	-0,36	-0,33	-0,25	-0,32	-0,29
Marginal tax burden (a)	-0,32	-0,91	-1,07	-0,07	-0,20	0,38
Government consumption (b)	-0,17	-0,15	-0,14	-0,21	-0,18	-0,16

Source: Graafland et. al. (2001)

(a) Average over all households

(b) In percentage of GDP

Labor supply

All three tax cuts boost aggregate labor supply (in hours) because the substitution effect associated with a lower marginal tax rate dominates the income effect on account of a lower average tax rate. The composition of additional labor supply, however, differs. In particular, a lower tax rate in the first bracket raises especially the labor supply of partners (i.e. secondary earners). This is because partners tend to work in part-time jobs with relatively low (annual) labor incomes. Hence, their marginal labor income is typically subject to the tax rate in the first bracket. A cut in this tax rate therefore encourages partners to work longer hours, especially in view of the relatively large uncompensated wage elasticity of partner's labor supply.

Breadwinners and older workers generally earn higher labor incomes than partners do. Indeed, the incomes of many of these workers reach into the second or third tax brackets. For these workers, a lower tax rate in the first bracket reduces the average tax rate without affecting the marginal tax rate. The inframarginal character of the tax cut in the first bracket for many breadwinners explains why such a cut barely affects aggregate labor supply of breadwinners and older workers; the income effect is relevant for all breadwinners and older workers, while the substitution effect applies only to those workers whose marginal labor income falls in the first bracket.

In contrast to tax cuts in the first bracket, tax cuts in the second and third brackets are effective in stimulating labor supply of breadwinners and older workers. Although these groups feature relatively low labor-supply elasticities, the relatively large cuts in marginal tax rates produce significant labor-supply responses. The impact on aggregate labor supply (in hours) is substantial because breadwinners, single persons and elderly account for a large share of aggregate labor supply (in hours). Tax cuts in the highest bracket discourage partners from supplying labor, because the income effect rather than the substitution effect mainly impacts the labor supply of partners. In particular, by raising the incomes of breadwinners, a tax cut in the highest bracket reduces partners' labor supply through the channel of higher household incomes. At the same time, the substitution effect is not important because only few partners earn incomes that are sufficiently high to be marginally taxed in the third bracket.

These simulations illustrate the added value of the extensive labor-supply model of MIMIC, which accounts for heterogeneity in preferences and wages, incorporates the actual Dutch tax system, and explicitly models labor supply of partners. The incorporation of the actual income distribution and the institutional detail of the Dutch tax system allows MIMIC to determine to what extent cuts in particular tax brackets are (infra)marginal. Furthermore, the explicit modelling of labor-supply behavior of partners and breadwinners modifies the predictions from aggregate models. To illustrate, tax cuts in the first brackets are more inframarginal and thus reduce marginal tax rates, on average, only a third as much as tax cuts in the higher brackets do (see the next-to-last row of Table 5). Despite the relatively small decline in average marginal tax rates, tax cuts in the first bracket are still quite effective in stimulating aggregate labor supply. The reason is that these tax cuts reduce marginal tax rates of partners – the group featuring the most elastic labor supply. Indeed, these tax cuts are most effective in raising labor supply in persons, as more partners are encouraged to enter the labor force.

Black labor supply and training

All three tax cuts reduce the size of the black economy. Supply of black-market labor declines because lower marginal income taxes make formal labor supply more attractive. Firm demand for black labor decreases because formal wage costs decline

on account of a lower average tax burden. This encourages firms to hire formal rather than informal labor. Tax cuts in the higher brackets are most effective in combatting the black economy because these tax cuts reduce marginal tax rates most.

The lower marginal tax rates in the upper tax brackets raise the marginal return on training activities. Accordingly, human capital and labor productivity increase and the expansion of production exceeds the rise in employment.

Unemployment

The income tax cuts reduce equilibrium unemployment for two main reasons.[58] The first is the drop in the average tax burden, which moderates contractual wages. The lower marginal tax wedge produces upward wage pressure, but the positive elasticity of the average tax burden in the contractual wage equation (of 0.6) substantially exceeds the absolute value of the negative elasticity of the marginal tax burden (of 0.1). Hence, the overall effect of the tax cut is to moderate wages, thereby reducing equilibrium unemployment. Cutting taxes in the first bracket is most effective in reducing unemployment through this channel because it combines the decline in the average tax burden (the magnitude of which is similar for tax cuts in each of the three brackets) with the smallest decline in the marginal tax rate.

The second factor explaining the decline in unemployment is the lower replacement rate; workers tend to benefit more from lower marginal rates of personal income tax than transfer recipients do because the incomes of workers tend to exceed those of transfer recipients. This is especially so for tax reductions in the second bracket of the income tax.[59]

Subtracting the results of the second column from those of the first column, one finds the impact of increasing tax progression by using revenues from a higher tax rate in the second tax bracket to cut the first tax bracket. Increasing progression in this way leaves the unemployment rate more or less unaffected. The replacement rate effect thus offsets the direct wage moderation effect associated with a higher marginal tax rate.[60]

Employment

The three tax cuts raise aggregate employment through the channels of both lower unemployment and higher labor supply. In fact, all tax cuts generate a similar increase in aggregate employment. However, the composition of the employment gains differs. A tax cut in the first bracket is most effective in raising employment for the unskilled, low skilled and partners. The other tax cuts are somewhat more effective in boosting aggregate labor supply (in hours) and high-skilled employment and in combatting the black economy.

raising the tax allowance We now turn to the effects of raising the general tax allowance (see the fourth column in Table 5). Partners who do not earn sufficient labor income to fully use the tax allowance can transfer the allowance to the breadwinner. The tax credit is thus in fact refundable for households with non-participating partners. Hence, this tax credit reduces the average tax burden but leaves the marginal tax

[58] According to these simulations, a cut of one percentage point in the average tax burden reduces the unemployment rate by about 0.3 percentage point. This is somewhat higher than the estimates of Nickell and Layard (1999) and similar to the estimates of Daveri and Tabellini (2000).

[59] The tax rate in the third bracket exerts a smaller effect on the replacement rate because this income range is less relevant for unemployed persons.

[60] Sub-section 3.2.3 identifies these two effects in an analytical right-to-manage model in which unemployment benefits are subject to the progressive labor income tax.

burden unaffected, even for partners with small part-time jobs.[61] The tax allowance applies to both transfer recipients and workers.

Formal labor supply falls because the tax credit exerts only income effects on labor supply. Unemployment declines despite an increase in the average replacement rate. The unemployed benefit relatively more from a tax credit than those in work because the unemployed typically collect lower incomes than the employed. The main reason for lower equilibrium unemployment is that the lower average tax burden together with the constant marginal tax burden moderates contractual wages.

To summarize, a lower average tax rate at a constant marginal tax rate reduces both labor supply and unemployment. On balance, aggregate employment expands somewhat. The main difference with the cuts in tax brackets is thus that labor supply falls.

5.2.2 payroll taxes

This sub-section explores two alternative ways to reduce social security contributions (SSC) that are imposed on employers, namely an across-the-board reduction in the rate of SSC and a targeted reduction of SSC for unskilled workers (see the last two columns of Table 5).

Across-the-board reductions of employers' SSC The fifth column of Table 5 shows the effects of an across-the-board cut in payroll tax paid by employers. Cuts in the rate of SSC reduce the average tax rate more than the marginal tax rate, thereby raising the coefficient of progression. This is because the contributions are paid only on labor incomes up to 36,000 euro. Indeed, the impact of the cut in the SSC rate on the marginal tax rate and hence on the labor market is quite similar to a weighted average of a reduction in the tax rate in the first bracket of the personal income tax and an increase in the general tax allowance (which are explored in sub-section 5.2.1).

The lower SSC burden directly reduces labor costs. Accordingly, employment for all types of labor expands, while unemployment falls. Workers succeed in collecting part of the SSC cut in the form of higher net wages. In particular, employees increase their wage claims in contractual wage formation as the higher profit margin raises the rents that are bargained over. Moreover, incidental wages rise as firms try to attract more applicants to fill the increasing number of vacancies. Also recipients of social security benefits gain because of the institutional link between benefits and contractual wages. Higher wages mildly stimulate labor supply because substitution effects dominate the income effects.

Targeted SSC cut In order to enhance the employability of low productivity workers, the SSC cut can be targeted at unskilled labor. We investigate a targeted SSC cut for low-skilled labor, which amounts to 1500 Euro for full-time workers earning the statutory minimum wage. It is phased out between hourly wages of 100% and 130% of the statutory minimum wage.[62] The phasing out of the cut raises the marginal tax rates on higher hourly wages in this range. However, it does not raise the marginal tax rate on hours worked because the SSC cut is based on hourly wages and hence increases proportionally for workers who work longer hours.

[61] For students with low annual incomes, however, the tax allowance reduces the marginal tax rate. This explains the minor decline in the average marginal tax rate in the next-to-last row of the fourth column of Table 6.

[62] The Dutch government has introduced a reduction in employer's SSC that is structured similarly: the so-called SPAK (SPeciale AfdrachtsKorting).

A comparison between the fifth and sixth columns of Table 5 reveals that a targeted SSC cut is more effective in raising employment than an across-the-board SSC cut is, especially as far as unskilled employment is concerned. The cut in SSC for unskilled workers boosts the demand for these workers through substitution towards unskilled labor. Moreover, lower labor costs at the minimum wage level facilitate job matching. In particular, the lower wage costs reduce the minimum productivity standards due to minimum wage scales. Accordingly, an increasing number of unskilled unemployed, which often feature rather low productivities, meet the minimum productivity standards of employers. Indeed, as described in sub-section 3.1.2, the minimum wage can be viewed as a tax on employers. With a cut in SSC paid by employers, the overall tax rate on labor demand (consisting of the implicit tax rate implied by minimum wages and explicit taxes) is reduced.

The targeted SSC cut suffers from a number of drawbacks. First, gradual reductions in the tax allowance cause the marginal tax rate on increases in hourly wages to rise. Accordingly, increasing the net hourly wage is rather expensive because it substantially raises SSC. The high marginal tax burden on higher hourly wages harms the incentives for training by unskilled employees. The productivity level of workers therefore drops. Indeed, the last column of Table 5 reveals that production rises less than employment, which reflects the loss in human capital of the low skilled. Another disadvantage of a high marginal tax burden for employers is that it stimulates substitution between formal labor and informal labor. In particular, a high marginal tax burden encourages firms to pay additional wage income above the formal minimum wage in an informal fashion.

Tabel 6. Macroeconomic effects of an earned income tax credit					
	fixed	**annual**	**hourly 80**	**hourly 50**	**hourly 30**
	percentage deviations				
Private consumption	0,56	0,30	0,51	0,51	0,51
Investment	0,47	0,12	0,46	0,48	0,45
Export	0,52	0,17	0,50	0,51	0,48
Imports	0,29	0,09	0,28	0,29	0,28
Formal production	0,55	0,13	0,53	0,55	0,52
Black production	0,09	-0,17	0,55	0,64	0,67
Employment	0,61	0,17	0,67	0,74	0,71
- unskilled	1,00	1,50	2,89	3,81	4,07
- low-skilled	0,72	0,14	0,47	0,28	0,08
- high-skilled	0,51	-0,03	0,39	0,42	0,39
Labour supply (pers.)	0,11	0,58	0,11	0,13	0,16
Labour supply (hours)	0,19	-0,22	0,12	0,14	0,13
- breadwinners	0,01	-0,33	-0,13	-0,12	-0,17
- partners	0,44	0,54	0,42	0,50	0,59
- single persons	0,28	-0,55	0,26	0,30	0,31
- 55+	0,10	-0,29	0,06	0,05	0,03
Black labour (hours)	0,09	-0,19	0,55	0,69	0,78
Training	-0,08	-0,49	-0,94	-1,29	-1,42
- unskilled and low-skilled	-0,14	-0,14	-0,26	-0,37	-0,28
- high-skilled	-0,03	-0,07	-0,17	-0,24	-0,20
	absolute deviations				
Unemployment rate	-0,26	-0,28	-0,36	-0,39	-0,37
- unskilled	-0,40	-0,16	-0,23	-0,22	-0,32
- low-skilled	-0,37	-0,47	-0,62	-0,70	-0,66
- high-skilled	-0,21	-0,25	-0,32	-0,35	-0,33
Share long term unemployment	-1,64	-1,75	-2,30	-2,54	-2,45
Replacement rate (a)	-0,42	-0,28	-0,60	-0,78	-0,74
Average burden (a)	-0,50	-0,43	-0,51	-0,52	-0,51
Marginal burden (a)	-0,14	0,63	0,80	0,67	0,38
Government consumption (b)	-0,12	-0,16	-0,09	-0,08	-0,08

Source: Graafland et. al. (2001)

(a) Average over all households

(b) In percentage of GDP

5.2.3 earned income tax credit

Table 6 contains the long-term effects of introducing various forms of a tax credit that applies only to workers – the so-called Earned Income Tax Credit (EITC). In several EU countries, this instrument is increasingly perceived as an attractive instrument to combat unemployment by raising the return to low-skilled work. This policy in effect directly reduces the net replacement rate, as the unemployed do not benefit from the EITC. Hence, an EITC corresponds to the case in which unemployment benefits are not subject to tax (see sub-section 3.2.3).[63]

Flat EITC The first column of Table 6 contains the impact of a flat EITC of 140 euro per year (corresponding to about 0.5% of the median gross wage). This non-refundable EITC reduces the marginal tax rate on small part-time jobs so that partners find it more attractive to enter the labor force. Accordingly, the participation rate (i.e. labor supply in persons) increases.

Unemployment declines substantially. The reason is that the EITC accrues only to those in work and hence reduces the replacement rate. The lower replacement rate enhances job matching by reducing the reservation wage and by encouraging the unemployed to search more intensively for a job. Moreover, it moderates contractual wages. This wage moderation reduces the current incomes from transfer recipients because social benefits are linked to gross wages.

Targeted EITC based on annual labor incomes The second column of Table 6 explores the impact of an EITC that focuses on raising the reward to low-skilled work. The EITC analyzed here depends on annual labor income of an individual.[64] It amounts to 3 % of annual labor income of the individual in a phase-in range up to the statutory minimum wage (13,500 euro) and stays at 340 euro in a flat range up to 115 % of the minimum wage. Subsequently, the EITC is phased out linearly up to 180 % of the minimum wage.

The EITC reduces the marginal tax burden on small part-time jobs, thereby encouraging partners to join the labor force. Accordingly, the participation rate increases. However, aggregate labor supply measured in hours drops. Only partners raise their average labor supply (in hours) because many partners fall in the phase-in range of the EITC. Breadwinners and single persons, in contrast, reduce their labor supply because of a positive income effect and, to the extent that they fall in the phase-out range, a negative substitution effect associated with a higher marginal tax rate. On balance, for labor supply in hours, the reduction in labor supply on account of the substitution effect in the phase-out range and the income effect dominates the positive effect on the participation rate.

The high marginal tax rate in the phase-out range harms the incentives for training. This reduces the transition rates into higher skill levels. Hence, unskilled labor supply rises at the expense of low-skilled labor supply. The changing composition of labor supply affects the distribution of employment and unemployment over skill levels. Whereas the training effect mitigates the decline in unskilled unemployment, it raises unskilled employment. Since unskilled workers face a higher replacement ratio than low skilled workers do, this tends to contain the decline in the average replacement ratio, thereby moderating the employment gains.

[63] In case of a cut in SSC, in contrast, not only workers enjoy higher net wages but also benefit recipients gain because of the institutional link between wages and benefits.

[64] Hence, this EITC differs from the EITC implemented in the US, which depends on family income and the number of children in a family.

Targeted EITC based on hourly wages If the objective is to reduce the number of unskilled who collect unemployment and welfare benefits, the targeted EITC explored above suffers from the disadvantage that it accrues also to part-time workers with high hourly wages but low annual incomes. This is relevant especially in the Netherlands, which features the highest share of part-time work of all OECD countries. Hence, in the Dutch policy discussion, a targeted EITC has been proposed that depends on hourly wages rather than annual incomes. Workers who earn the hourly minimum wage and hold a full-time job are eligible for the full EITC. Just as the targeted SSC cut considered in sub-section 5.2.2, the credit is reduced proportionally for workers who work less than a full-time job. It gradually drops also with the level of the hourly wage rate. By reducing the credit for part-time workers with high wages, the EITC for full-time workers who earn an hourly wage up to 115 % of the statutory minimum wage can almost be doubled to 625 euro. The phase-out range runs up to an hourly wage of 180% of the minimum wage.

This EITC reduces the marginal tax burden only on part-time jobs with low hourly wages. Hence, the effect on the participation rate is smaller than in the previous experiment. The higher marginal tax rate in the phase-out range applies only to higher hourly wages and not to higher labor incomes on account of more hours worked. In fact, additional hours worked raise the credit for unskilled workers. This explains why, in contrast to the case with an EITC based on annual labor income, labor supply (in hours) increases slightly.

The marginal tax rate on higher hourly wages in the phase-out range is higher than in the previous experiment because the maximum credit is about twice as large. This harms the incentives to accumulate human capital. Hence, compared to an EITC that depends on annual incomes, an EITC that depends on hourly wages does less harm to the quantity of labor supply but does more harm to the quality of labor supply. Another drawback of this variant of the EITC is that it relies on additional information (namely the number of hours worked in the formal sector) that is vulnerable to fraud. Indeed, the black economy expands substantially.

Unemployment

This EITC reduces the replacement rate for low-skilled workers more substantially than the other EITCs explored above. Through skill-specific wage formation, this decline in the replacement rate reduces low-skilled wages, thereby boosting demand for low-skilled labor. Moreover, the lower replacement rate stimulates search and lowers the reservation wage, thereby facilitating the matching process for low-skilled labor. Accordingly, the unemployment rate for the low skilled drops more substantially than under the EITCs analyzed above.

Trade-offs

The comparison between an EITC that depends on annual incomes and an EITC that depends on hourly wages reveals a trade-off between two objectives: increasing the participation rate of partners and reducing the unemployment rate for the low skilled. An EITC that depends on annual incomes advances the first objective, while an EITC that depends on hourly wages is more effective in cutting low-skilled unemployment. This trade-off is similar to that uncovered in studies for the U.S. and the U.K. (see, e.g., Blundell e.a. (2000)). In these countries, the EITC depends on household rather than individual incomes. The advantage is that the tax incentives can be better targeted at low-income households who often face high replacement rates, thereby stimulating employment of primary wage earners and single mothers. The disadvantage, however, is that income effects and higher marginal tax rates in the phase-out range harm labor-

supply incentives facing secondary earners with working partners. This illustrates how reducing one obstacle to employment may increase another obstacle.

Another trade-off involves the quality versus the quantity of labor supply. Compared to an EITC that depends on annual incomes, an EITC that depends on hourly wages enhances the quantity of labor supply (in hours) but harms its quality (in terms of human capital).

Targeting the EITC The last two columns of Table 6 show the effects of two EITC's (based on hourly wages) that are phased out more rapidly than the previous experiment, namely, at 150% (the fourth column) and 130% (the fifth column) of the minimum wage. Fewer people fall in the phase-out range, but those who remain in the phase out range face even higher marginal tax rates. The advantage of more targeting is that the maximum credit for people who earn the minimum wage rate can be larger, thereby cutting the replacement rate of the unskilled more substantially. The disadvantage is that the marginal tax rate in the phase-out range increases more sharply and the (larger) decline in the replacement rate applies to fewer persons.

A moderately targeted version of the EITC (in the fourth column of Table 6) is slightly more effective in reducing the aggregate unemployment rate than the most targeted EITC (in the fifth column of Table 6). Also, compared to the less targeted EITC (in the third column of Table 6), the moderately targeted EITC is more effective in reducing the aggregate unemployment rate. This suggests that an inverse U-shaped curve describes how the effectiveness of the EITC in cutting unemployment varies with the degree of targeting. Hence, moderately targeting the EITC seems the most effective way to reduce the overall unemployment rate. At the same time, these simulations illustrate the drawbacks of targeting: more targeting implies that more workers remain unskilled. Indeed, the adverse shift in the skill composition boosts unskilled employment at the expense of low-skilled employment and limits the decline in unskilled unemployment.

5.2.4 targeted SSC cut versus targeted EITC

A comparison between the targeted cut in SSC paid by employers (see the last column in Table 5) with a similar targeted EITC (see the last column in Table 6) reveals that the SSC cut is more effective in fighting unemployment among the unskilled but less effective in reducing aggregate unemployment. The SSC cut enhances the efficiency of the matching process primarily through lower minimum wage costs. This substantially reduces unskilled unemployment because the minimum productivity standard is the most restrictive factor in the matching process for the unskilled. Indeed, with rigid wages, cuts in payroll taxes boost employment more than cuts in income taxes do (see sub-section 3.1)

The EITC improves the matching process primarily through a lower replacement rate reducing the reservation rate of the unemployed. A lower reservation wage is less important for the matching process of the unskilled than a lower minimum productivity standard. However, a lower replacement rate also moderates wages in collective bargaining. This makes the targeted EITC more effective in reducing aggregate unemployment.

The substantial decline in the replacement rate produced by the EITC is associated with a decline in the current incomes of transfer recipients. In case of a targeted SSC, in contrast, benefit recipients are better off because wages (to which benefits are linked) rise rather than fall. Tables 7 and 8 illustrate these income effects. These tables use MIMIC's search model to compute the welfare effects of the

various policies considered here. The temporal welfare gains correspond to the static welfare effects (i.e. abstracting from changes in employment prospects). For the unemployed, the measure corresponds to after-tax income in unemployment (analogous to B in sub-section 3.2). The intertemporal welfare effects incorporate changes in future employment prospects (for the unemployed analogous to U^r in sub-section 3.2). For the unemployed, the contrast between the temporal and intertemporal measures can be striking. In particular, whereas the EITC produces temporal losses for the unemployed, the intertemporal gains for the unemployed are large because employment prospects improve substantially as a result of lower unemployment rates. The scope for Pareto-improving policies increases substantially if one considers the impact on life-time rather than static incomes.[65]

[65] Note, however, that even an EITC is not without costs, as public spending must be cut.

Table 7. Welfare effects of cuts in income and payroll taxes						
	First income tax bracket	**Second income tax bracket**	**Third income tax bracket**	**Basic income tax allowance**	**General cut in payroll tax**	**Targeted cut in payroll tax**
Temporal welfare	*percentages of base path current income*					
Unemployed (long-term)						
- unskilled	0,3	0,1	0,2	1,0	0,4	1,3
- low-skilled	0,4	0,2	0,2	0,9	0,4	0,2
- high-skilled	0,4	0,3	0,1	0,8	0,4	0,1
Employed						
- unskilled	0,5	0,3	0,2	0,6	0,5	2,6
- low-skilled	0,5	0,5	0,3	0,5	0,5	0,4
- high-skilled	0,5	1,1	0,6	0,4	0,4	0,2
Intertemporal welfare						
Unemployed (long-term)						
- unskilled	0,6	0,7	0,5	0,9	0,7	3,8
- low-skilled	0,8	0,6	0,4	0,9	0,8	0,7
- high-skilled	0,9	1,1	0,6	0,8	0,8	0,4
Employed						
- unskilled	0,5	0,4	0,3	0,7	0,5	3,0
- low-skilled	0,6	0,6	0,3	0,5	0,5	0,5
- high-skilled	0,6	1,1	0,6	0,5	0,5	0,2

Source: Graafland et. al. (2001)

Table 8. Welfare effects of an earned income tax credit					
	fixed	annual	hourly 80	hourly 50	hourly 30
Temporal welfare	*percentages of base path current income*				
Unemployed (long-term)					
- unskilled	-0,3	-0,8	-1,2	-1,6	-1,8
- low-skilled	-0,2	-0,2	-0,1		
- high-skilled	-0,1	-0,1	-0,1	-0,1	-0,1
Employed					
- unskilled	0,9	1,6	3,2	4,2	4,2
- low-skilled	0,7	0,2	0,5	0,6	0,3
- high-skilled	0,6	0,2	0,4	0,4	0,4
Intertemporal welfare					
Unemployed (long-term)					
- unskilled	0,9	0,8	1,5	1,9	2,0
- low-skilled	1,1	1,0	1,5	1,7	1,5
- high-skilled	1,1	1,0	1,4	1,5	1,4
Employed					
- unskilled	0,9	1,4	2,8	3,7	3,8
- low-skilled	0,8	0,4	0,7	0,8	0,6
- high-skilled	0,7	0,4	0,6	0,6	0,5

Source: Graafland et. al. (2001)

6 Optimal redistribution

We now turn to a model of risk-averse agents with heterogeneous abilities. Accordingly, progressive taxes not only affect the efficiency of the labor market but also insure agents against the risk of being born with heterogenous abilities. Moreover, in addition to an extensive labor-supply margin, we allow taxes to impact labor supply on the intensive margin. Hence, whereas progressive taxes may stimulate job search, they may harm the incentives of workers to exert effort and work long hours after workers have found a job. Compared to the analysis in section 4, we thus include both an additional benefit of progressive taxation (namely income redistribution) and an additional cost (namely lower labor supply on the intensive margin). As another extension, welfare benefits may be set optimally. Moreover, the income tax does not have to be linear, but may be non linear as the government can observe individual labor incomes. Furthermore, the government can imperfectly monitor the search effort of agents. This allows us to investigate how the monitoring technology affects the optimal welfare benefit and the optimal tax system.

In order to incorporate the additional complications of heterogenous, risk-averse agents with endogenous work effort, we simplify the model of section 4 in two ways. First, we abstract from wage bargaining and search (and the associated externalities) at the demand side of the labor market: workers are paid their marginal product.[66] Second, we simplify the formulation of search at the supply side so that the search margin is relevant for low-skilled workers only. Our formulation of labor-market matching allows for two types of unemployment: first, involuntary unemployment of high-skilled agents and, second, voluntary unemployment of low-skilled agents who do not face sufficient incentives to search. As regards this last type of unemployment, optimal unemployment benefits in effect set a wage floor below which agents no longer search for work. Hence, the desire to protect the involuntary unemployed produces an optimal rate of voluntary unemployment.

6.1 The model

The economy is populated by agents featuring homogeneous preferences but heterogeneous skills. A worker of ability (or skill or efficiency level) n working E hours (or providing E units of work effort) supplies nE efficiency units of homogeneous labor. With constant unitary labor productivity, these efficiency units are transformed in the same number of units of output. With output as the numeraire, the before-tax wage per hour is thus given by exogenous skill n. Hence, overall gross output produced by a worker of skill n, $Z(n)$, amounts to $Z(n) = nE(n)$. Since workers collect only labor income, this gross output $Z(n)$ corresponds to total gross (i.e. before-tax) income collected by a worker of that skill n. The density of agents of ability n is denoted by $f(n)$, and $F(n)$ represents the corresponding cumulative distribution function. The support of the distribution of abilities is given by $[n_0, n_1]$, while $f(.)$ is differentiable.

Workers share the following quasi-linear utility function over consumption C and hours worked (or work effort) E

$$u(C, E) = v(C) - E,$$

where $v(C)$ is increasing and strictly concave: $v'(C) > 0, v''(C) < 0$ for all $C \geq 0$. The specific cardinalization of the utility function affects the distributional preferences of a utilitarian government. In particular, the concavity of $v(.)$ implies that a utilitarian

[66] In terms of the model of section 4, $\beta = 1$ and $\eta = 0$ so that the Hosios condition is met.

government aims to fight poverty. In other words, such a government wants to insure agents against the risk of a low consumption level.

As in Lollivier and Rochet (1983), Weymark (1987), Ebert (1992), and Boadway, Cuff and Marchand (2000), utility is linear in work effort E and separable in work effort and consumption C. This has three important consequences. First, consumption C is not affected by income effects. A higher average tax rate thus induces households to raise work effort E rather than to cut consumption C. Second, the specific quasi-linear utility function allows for a closed-form solution of the standard optimal income tax problem. Third, a utilitarian government cares only about aggregate work effort in the economy. Such a government thus aims at an equal distribution of consumption (i.e. the alleviation of poverty) rather than an equal distribution of work effort over the various agents.

In line with the optimal income tax literature, the government is assumed not to be able to observe skills n but to know the distribution function $f(n)$ and before-tax income of each individual $Z(n)$. We depart from the standard optimal tax literature by incorporating job search: agents have to search for a job and the government can only imperfectly monitor agents' search effort (see below). In particular, we allow agents to adjust their labor supply not only on the intensive margin (i.e. by varying hours of work) but also on the extensive margin (i.e. by deciding whether or not to look for a job). In particular, by searching with intensity $X \in [0,1]$, agents find a job with probability X. Agents' search costs $\gamma(X)$ are given by

$$\gamma(X) = \begin{cases} \gamma X & \text{if} \quad X \in [0, \bar{X}] \\ +\infty & \text{otherwise,} \end{cases}$$

where $\gamma \geq 0$ is a parameter representing the magnitude of the search costs. $\bar{X} < 1$ captures the idea that agents may fail to find a job, even if they search at full capacity. By modelling the costs and effectiveness of search, the parameters γ and $(1- \bar{X})$ represent labor-market imperfections that give rise to unemployment. Agents thus differ in both ability n and employment status and face two types of risks: being born with low ability n and being involuntarily unemployed.

If an agent does not succeed in finding a job, (s)he receives a welfare (or social assistance) benefit $B \geq 0$.[67] An agent who does not search for a job, while (s)he is expected to look for a job by the government has a probability $p_c \in \langle 0, 1 \rangle$ of receiving a penalty $\pi \geq 0$. This penalty is in the form of lost leisure time.

An agent of ability n who is expected to search by the government searches at full capacity if and only if

$$-\gamma \bar{X} + \bar{X} U(n) + \left(1 - \bar{X}\right) v(B) \geq v(B) - p_c \pi \tag{20}$$

The linear specification of the search cost function implies that a worker either does not search at all (and is voluntarily unemployed) or searches at the level $\bar{X}$ (and faces a probability of $(1 - \bar{X})$ of involuntary unemployment).

After a worker has found a job, (s)he has to determine her work effort. Ex-post utility of a type n agent who finds a job is determined by type n's choice of gross income Z:

$$U(n) = \max_{Z} \left\{ v\left(Z - \tilde{T}(Z)\right) - \frac{Z}{n} \right\}, \tag{21}$$

[67] An alternative interpretation of B is a categorial unemployment insurance benefit. Indeed, the benefit is paid only to those who have not found a job. In most countries, however, unemployment benefits depend on the previously earned wage and are thus likely to increase with ability n. This is the main reason why we interpret B as a social assistance benefit, i.e. the minimum income level provided by the government. Another interpretation of B is an early retirement or disability benefit that is paid if an agent does not work.

where $\tilde{T}(Z)$ denotes the tax schedule as a function of gross income Z. We can write $\tilde{T}(n) = T(Z(n))$, since type n chooses gross income $Z(n)$ in equilibrium. The envelope theorem yields the first-order incentive compatibility constraint[68]

$$U'(n) = \frac{Z(n)}{n^2}. \tag{22}$$

The utilitarian government maximizes ex-ante expected utility (i.e. expected utility before ability and labor market status have been revealed)

$$\Omega \equiv \int_{n_0}^{n_1} -\gamma X(n) + X(n)[U(n) + \xi] + (1 - X(n))[v(B) - \kappa^e(n)] f(n) dn,$$

where $\kappa^e(n)$ represents the expected penalty for type n with $d\kappa^e(n)/dn \geq 0$. We allow for positive employment externalities $\xi > 0$. If these externalities are positive, the government attaches more value to work than individual agents.

The government faces the following budget constraint

$$\int_{n_0}^{n_1} f(n) X(n) [B + T(n)] dn = G + B, \tag{23}$$

where G represents exogenously given exhaustive government expenditure, and $T(n) \equiv Z(n) - C(n)$ denotes the tax paid by type n. The government employs the non-linear income tax and welfare benefits to optimize social welfare and takes public spending G and the search monitoring and penalty system as given.

6.2 The optimal tax problem

In optimizing social welfare, the government faces three constraints: the incentive compatibility constraint (22), the participation constraint (20), and the government budget constraint (23). Since $Z(n) \geq 0$, incentive compatibility (22) implies that utilities do not decline with skill (i.e. $U'(n) \geq 0$). Accordingly, if the participation constraint $U(n) \geq \gamma + v(B) - \kappa^e(n)$ is met for skill $\bar{n}$, it is met also for higher skills $n > \bar{n}$. Defining n_w as the lowest skill that looks for work, we thus have $X(n) = 0$ for $n < n_w$ and $X(n) = \bar{X}$ for $n \geq n_w$. The agents with skill $n < n_w$ can be viewed as being voluntarily unemployed. The higher skills $n > n_w$ look for work but may be involuntarily unemployed (if $\bar{X} < 1$). The productivity level n_w is called the minimum productivity level. It is in fact the minimum gross wage implied by the welfare and tax systems.

These observations allow us to formulate the social planner's problem as[69]

$$\begin{aligned}
&\max_{\substack{n_w, U(.), Z(.), \\ B}} F(n_w) v(B) + [1 - F(n_w)] - \gamma_X \bar{X} + \left(1 - \bar{X}\right) v(B) \\
&+ \int_{n_w}^{n_1} \left\{ \bar{X} U(n) f(n) - \lambda_U(n) \left[U'(n) - \frac{Z(n)}{n^2} \right] + \lambda_E \left[f(n) \bar{X} T(n) \right] \right\} dn \\
&- \lambda_E \left\{ B \left[F(n_w) + (1 - F(n_w)) \left(1 - \bar{X}\right) \right] + G \right\} \\
&- \eta_w \left(\gamma - U(n_w) + v(B) - \frac{p_c}{\bar{X}} \pi \right),
\end{aligned} \tag{24}$$

[68] The second-order condition for the agents' optimal choice of consumption and gross income implies that consumption and gross income are non-decreasing in type n. Boone and Bovenberg (2003a) analyze these constraints (and the associated bunching implications) in depth and argue that they are not relevant for understanding optimal taxation and welfare benefits at the bottom of the labor market. We therefore ignore these constraints here and refer the interested reader to Boone and Bovenberg (2003a).

[69] Instead of $C(n)$, we employ $U(n)$ as a control variable in order to facilitate the inclusion of first-order incentive compatibility (22) into the optimization problem.

where $T(n) \equiv Z(n) - C(n) = Z(n) - v^{-1}\left(U(n) + \frac{Z(n)}{n}\right)$. $\lambda_U(n)$ represents the Lagrange multiplier of the incentive compatibility constraint, and λ_E stands for the multiplier of the government budget constraint. η_w denotes the Lagrange multiplier on the participation constraint for type n_w. It measures the social value of increasing employment by forcing more people to search, and can therefore be interpreted as the value of a work test (and the required information on search intensity) inducing more skills to look for work.

Boone and Bovenberg (2003b) derive the first-order conditions for the optimal tax problem and establish the following proposition.

Proposition 1 *If $\gamma\bar{X} > p_c\pi$, employed agents of type $n > n_0$ face positive marginal tax rates. If in addition $\bar{X} < 1 - n_0 f(n_0)$, there is voluntary unemployment (i.e. $n_w > n_0$), marginal taxes are positive at the bottom (i.e. $\tau(n_w) > 0$), and the following relationship holds at the minimum productivity level*[70]

$$\tau(n_w)Z(n_w) = (B + T(n_w)) + \frac{\xi - \pi\frac{p_c}{\bar{X}}}{\lambda_E}. \tag{25}$$

The inequality $\gamma\bar{X} > p_c\pi$ implies that search costs are so high that agents can be induced to search only if they can expect higher consumption levels in work than in unemployment. Since the unemployed enjoy less consumption than workers, the government wants to redistribute resources away from the employed skills $n > n_w$ to the unemployed skills $n < n_w$. This desire to redistribute towards the unemployed results in positive marginal tax rates for all workers, including the marginal workers with skill n_w.

The left-hand side of inequality $1 - \bar{X} > n_0 f(n_0)$ stands for involuntary unemployment among the skills that are actively searching for a job. Hence, if these labor-market imperfections as measured by this involuntary unemployment $1 - \bar{X}$ are substantial, voluntary unemployment (i.e. $n_w > n_0$ so that the least skilled do not look for a job) becomes optimal. Intuitively, to avoid poverty among the substantial numbers of involuntarily unemployed, the welfare level B is set at such high levels that the participation constraint becomes binding and the least skilled workers no longer search for work, especially if these workers feature only low labor productivity (i.e. n_0 is small). The desire to combat poverty among the low skilled and the involuntarily unemployed agents without imposing excessive distortions on the work effort of high-skilled agents thus optimally creates additional, voluntary unemployment.

To interpret expression (25), we first consider the case without employment externalities and penalties (i.e. $\xi = \pi = 0$). In that case, the right-hand side of (25) represents the direct budgetary implications of raising employment by reducing n_w: by bringing a marginal worker into work, the government saves a welfare benefit B and collects additional tax revenue $T(n_w)$. The indirect implications, namely the effects on other workers, are captured by the left-hand side of (25). Bringing a marginal type n_w into work encourages workers who are marginally more skilled to work less hard – as they can now mimic type n_w. An optimal tax system balances the welfare implications of this latter behavioral response on the intensive margin of the more productive workers (represented by the left-hand side of (25)) with the budgetary implications of the behavioral response on the extensive margin of the marginal workers. The government thus faces a trade-off between obtaining revenues from either inducing more agents to search or encouraging a smaller group of agents to work harder. As a result, the distortion on the extensive margin (i.e. the right-hand side of (25)) should equal the distortion on the intensive margin (i.e. the left-hand side of (25)).

[70] This expression holds also if the welfare benefit is fixed exogenously.

In this particular case (i.e. $\xi = \pi = 0$), the progressiveness of the income tax is directly related to the level of welfare benefits. To see this, we rewrite (25) as $\tau(n_w) - \frac{T(n_w)}{Z(n_w)} = \frac{B}{Z(n_w)} = \frac{B}{C(n_w)}\left[1 - \frac{T(n_w)}{Z(n_w)}\right]$. For the least-skilled worker, the marginal tax rate $\tau(n_w)$ minus the average tax rate $\frac{T(n_w)}{Z(n_w)}$ is directly related to the replacement rate $\frac{B}{C(n_w)}$. In particular, the tax system is progressive at the minimum productivity level n_w if and only if the welfare benefit is positive. This result resembles the corresponding result on optimal progression in section 4. In particular, if the Hosios condition holds, this latter section establishes also that the income tax is progressive if and only if the welfare benefit is positive. An important difference is, however, that in section 4 the search margin is not distorted in the optimum (i.e. $\tau_a + B = 0$ so that at a wage level of B, workers collect a tax subsidy of $-\tau_a = B$). In the presence of an extensive labor-supply margin, in contrast, the distortions on the search margin have to be traded off against the distortions in work effort. Hence, the search margin remains distorted in equilibrium as the tax on search $B + T(n_w)$ is positive.

We now turn to the case with positive employment externalities $\xi > 0$. In that case, *ceteris paribus* the gross replacement rate $\frac{B}{Z(n_w)}$,[71] the gap between the marginal tax and average tax rates widens at the minimum productivity level. Intuitively, with positive employment externalities, the government wants to subsidize search of unskilled workers in order to have these workers internalize the positive externalities from search. These subsidies are financed by higher skilled agents so that marginal tax rates increase and the tax system becomes more progressive. An alternative way to understand why employment externalities tend to make the tax system more progressive and therefore reduce work effort of high-skilled workers is that positive employment externalities can be viewed as implicit taxes on search. With a larger overall tax on search, the optimal trade-off between distortions on the intensive and extensive margins demands that the explicit tax on search (i.e. the extensive margin) is reduced and that the tax on effort (i.e. the intensive margin) is raised. If the employment externalities are large enough and the revenue requirements are only small (so that the marginal tax rate $\tau(n_w)$ can be small), search may even be subsidized in equilibrium (i.e. $B + T(n_w) < 0$).

With penalties on inadequate search (i.e. $\pi p_c > 0$), the government reduces the search distortions originating in the welfare system and can rely less on explicit search subsidies for low-skilled labor. With less need to subsidize the low skilled, the income tax system has to be less progressive. Hence, compared to positive employment externalities, the penalty system exerts exactly the opposite effect on marginal tax rates facing workers. Indeed, whereas positive employment externalities can be viewed as an implicit tax on search, the penalty system works as an implicit subsidy on search. If the penalties are strong enough to internalize the employment externalities (i.e. $\pi\frac{p_c}{\bar{X}} > \xi$), the penalty effect dominates. Hence, (25) together with $\tau(n_w) > 0$ (see Proposition 1) implies that search is necessarily taxed (i.e. $B + T(n_w) > 0$). Intuitively, the net tax on search helps to redistribute resources away from workers to the unemployed, who are poorer than the workers.

The monitoring system allows the government to alleviate the distortions imposed by the welfare system on the search margin.[72] It thus alleviates the distortions

[71] Equation (25) holds also with an exogenous benefit level. If B is not optimally set, however, $\tau(n_w)$ may be negative (see Boone and Bovenberg (2003a)). With positive search externalities, the optimal welfare benefit B will typically be lower than without positive search externalities. Indeed, the search externalities will be internalized by reducing both B and $T(n_w)$. Indeed, redistribution away from workers towards the poorer unemployed becomes more problematic.

[72] Whereas we thus model the benefits of monitoring, we do not specify the costs of monitoring. We thus can not compute optimal monitoring levels.

from redistribution resources away from workers to poorer unemployed. In particular, the agents who are required to search collect $B - \pi \frac{p_c}{\overline{X}} / \lambda_E$ rather than B in unemployment. As long as $B - [\pi \frac{p_c}{\overline{X}} / \lambda_E] > 0$, the welfare system distorts search and the tax system is progressive at the minimum productivity level.

7 Conclusions

The link between taxes and labor-market performance depends crucially on non-tax institutions. In particular, the impact of taxes on wages and unemployment depend on how wages are set and on welfare and unemployment benefits. Indeed, a key channel through which taxes affect unemployment is the effective replacement rate. The highest effective tax rates on work typically originate in welfare and unemployment benefits that are withdrawn if work is found.

Changes in the tax structure can cut unemployment if they succeed in shifting the tax burden unto the unemployed, thereby reducing the effective replacement rate. Moreover, whether a higher tax burden raises unemployment depends crucially on whether the unemployed share in the higher tax burden or not. These two insights explain how revenue neutral environmental tax reforms can create a double dividend by producing not only a cleaner environment but also a lower level of unemployment. How unemployment benefits are indexed is crucial in determining whether a change in the tax structure can affect the effective after-tax replacement rate and whether a higher tax burden is shared by the unemployed.[73] In particular, an environmental tax reform can shift the tax burden onto the unemployed by taxes on dirty consumption replacing labor income taxes if unemployment benefits are linked to producer prices and not subject to personal income tax. Alternatively, this can be accomplished by taxes on dirty inputs into production replacing consumption taxes if unemployment benefits are linked to wages. In all these cases, environmental tax reform in effect succeeds in cutting the effective after-tax replacement rate.[74] With revenue-neutral reforms, the employment impact also depends on the additional implicit tax burden associated with a better quality of the public good of the environment. A double dividend is feasible only if the benefit recipients pay a more than proportional share of the larger supply of the environmental public good (see Bovenberg and van der Ploeg (1998)).

The tax system may impact unemployment also through rigid market wages. If statutory minimum wages prevent market wages from falling, tax policy can then in effect offsets the implicit tax on employers imposed by workers by reducing payroll taxes paid by employers. The question also applies here why these non-tax institutions cannot be reformed directly but have to be changed indirectly through tax policy.

Another channel through which the tax system impacts unemployment is the progressiveness of the tax system. In particular, by taxing wage rises, progressive taxes moderate wages, thereby reducing unemployment. However, progression may also increase the effective net replacement rate if unemployment benefits are subject to tax.

[73] We demonstrated that higher income or payroll tax rates can raise unemployment even though productivity growth does not affect the unemployment rate. This may happen if the 'outside wage' is indexed to labour productivity in the formal sector. This case seems particularly relevant if the outside option is employment in the untaxed, informal economy.

[74] This raises the question why the government cannot cut the replacement rate directly but has to rely on an environmental tax reform to do so. One reason may be that benefit recipients reap the largest gains from the improvement in environmental quality. With environmental benefits offsetting the decline in after-tax unemployment benefits, benefit recipients may favor an environmental tax reform that cuts their after-tax incomes while they would not support a direct cut in the replacement rate (see Bovenberg (1999)).

This latter effect may in fact be stronger than the first one if gross replacement rates and non-taxable incomes in unemployment are substantial. Moreover, even though progressive taxes combat unemployment, they typically imply other costs, for example reducing labor supply, work effort, human capital accumulation and labor mobility while stimulating tax avoidance, tax evasion, jobs with substantial nontaxable non-pecuniary benefits, and the informal and black economies.

Tax policy impacts the labor market not only through wage setting but also through labor supply. The labor-supply effects of tax policy require microeconomic analysis of specific, disaggregated groups (such as secondary part-time workers, low-skilled agents and older employees close to retirement) in order to do justice to substantial variation in effective marginal tax rates and labor supply elasticities. The general equilibrium model MIMIC incorporates a disaggregated household model in a general equilibrium setting. In addition to labor supply and wage determination, various other ways through which taxes and benefits affect the labor market are incorporated, namely the black economy, human capital accumulation, efficiency wages, costly job matching, and search behavior of the unemployed.

The simulations with MIMIC reveal several trade-offs between various objectives. These objectives include cutting unemployment in general and low-skilled unemployment in particular, stimulating the participation of women in the labor force, raising the quality and quantity of labor supply (both in hours and in persons), and establishing an equitable income distribution, including a reasonable income level for those dependent on social benefits. Indeed, these objectives imply different priorities for how tax cuts should be structured. In particular, cutting unemployment primarily requires widening the gap between labor incomes and transfer incomes in unemployment. Stimulating labor-force participation of women calls for widening the gap between, on the one hand, after-tax incomes of households with two partners who are active on the formal labor market and, on the other hand, after-tax incomes of households with a non-participating partner. Such a larger income gap encourages partners to start participating in the labor force so that the latter households turn into the former households. Raising the quantity and quality of labor supply in the formal economy calls for widening the income differentials between low formal labor incomes and high formal labor incomes.

The most effective way to fight economy-wide unemployment is through in-work benefits. These benefits widen the gap between after-tax income from work and net transfer income, thereby raising the reward to work compared to relying on social benefits. This moderates wage costs, reduces reservation wages and encourages job search. Wage moderation reduces social benefits if these benefits are linked to market wages.

Targeting in-work benefits at the low skilled is most effective in cutting economy-wide unemployment. This is because the gap between labor income and transfer income is smallest for low-skilled workers. Hence, widening this small gap produces the largest pay-off in terms of reducing unemployment. However, by decreasing the gap between low and high labor incomes through a more progressive tax system for workers, a targeted EITC reduces the hours of labor supplied. The cost of higher marginal tax rates in the phase-out range is particularly high in European countries, where marginal tax rates are already quite high. The trade-off between cutting unemployment and raising labor supply (in hours) can be mitigated by linking the EITC to hourly wages rather than annual incomes and by reducing the EITC proportionally for small part-time jobs. Doing so, however, raises the marginal tax burden on hourly wage increases, thereby discouraging the accumulation of human capital and stimulating the black

economy. Moreover, whereas the tax cuts are better targeted at benefit recipients, the lower benefits to small part-time jobs do not help to raise the labor-force participation of women. This points to a trade-off between targeting tax cuts at small part-time jobs of partners or at full-time jobs of breadwinners and singles earning low hourly wages.

Tax cuts in the higher tax brackets are most effective in raising the quantity and quality of formal labor supply (in hours). Indeed, these policies widen the after-tax income differentials between low and high labor incomes by reducing marginal tax rates. However, cuts in higher tax brackets are less effective in reducing unemployment (by widening the income gap between being in work and collecting unemployment benefits), raising low-skilled employment, and stimulating female labor supply. Indeed, the contrast between cuts in the highest tax brackets and a targeted EITC reveals a trade-off between raising the quality and quantity of labor supply and combatting unemployment.

We formalized the trade-off between high levels of labor supply and low unemployment rates in a model of optimal taxation with involuntary unemployment. In a model with homogeneous households without an intensive margin of labor supply, a progressive labor tax eliminates non-tax distortions on wage setting. In particular, a progressive tax allows workers to commit not to expropriate specific investments of firms. This is especially relevant if unions feature a short time horizon and thus set wages on the basis of low short-run labor-demand elasticities rather than higher long-run labor-supply elasticities. In other words, progressive taxes restore the efficient balance of power between workers and employers. A progressive tax also corrects for the impact of the welfare system on wage setting, thereby alleviating the adverse impact of the welfare benefit on job creation and the unemployment rate. The benefit system thus determines the optimal progressiveness of the labor tax: a higher welfare benefit is accompanied by a higher in-work benefit so that the improved outside option of workers as a result of the higher welfare benefit does not raise unemployment. The more progressive labor tax depresses labor supply, but it is more efficient to reduce labor supply through lower after-tax wages than through the discouraged-worker effect.

In the presence of an intensive labor-supply margin, the government faces a trade-off between obtaining revenues from either inducing more agents to search or encouraging a smaller group of agents to work harder. In that case, therefore, the government does not completely eliminate the impact of the welfare benefit on the unemployment rate. In particular, the government balances the distortions on job creation and the unemployment rate against those on hours worked and work effort.

The government can improve this trade off in various ways. First of all, agents may insure themselves against the risk of involuntary unemployment through precautionary saving and compulsory saving schemes so that the unemployment insurance benefits paid to the involuntarily unemployed can be cut.[75] Self insurance seems a particularly attractive instrument for high-skilled agents who face relatively short unemployment spells during their careers. In this connection, the government may want to relieve liquidity constraints by offering loans to the unemployed.[76] This combats the

[75] Indeed, the desire to provide income to involuntarily unemployed agents creates distortions on the extensive margin in the model laid out in section 7. If the government does not need to provide income to the involuntarily unemployed, even the least skilled workers can be offered sufficient incentives to look for jobs.

[76] Table 10 suggest that lowering unemployment benefits may actually benefit the unemployed if the unemployed do not face liquidity constraints. The reason is that lower unemployment benefits enhance the probability of finding a job, thereby improving expected incomes in the future.

capital-market distortions that may give rise to labor-market distortions. Compulsory saving schemes with liquidity insurance in effect provide a stronger link between contributions and insurance benefits on a micro level (see Sørensen (2003)). This protects incentives to search for work, work hard and moderate wages.

For agents with low life-time incomes, self insurance does not work well. To protect these agents against poverty, the government needs to transfer resources to these agents. For these agents, other ways need to be found to improve the trade-off between the extensive and the intensive margins. In particular, the government may collect more information by monitoring job search and imposing penalties on less active job search.[77] In this connection, workfare may also play a role, even though it may to some extent crowd out private employment. In particular, the mere threat of being put on workfare is likely to boost job search of able individuals and prevent nonworkers who highly value leisure[78] from claiming unemployment benefits (see Fredriksson and Holmlund (2003)). Workfare can thus be seen as a way to redistribute resources to low-skilled agents who are involuntarily unemployed.

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[77] The government can also collect more information regarding why workers lost their jobs. If they were laid off because of misconduct or if they quit voluntarily, the government may refuse unemployment benefits. This may reduce the wage pressure from higher unemployment benefits (see van der Ploeg (2003)). Higher categorical benefits for verifiable disabilities (so-called 'tagging') may also provide valuable insurance without inducing moral hazard. Indeed, the trade-off between efficiency and equity originates in assymetric information about the skills and behavior of agents. The agencies paying welfare and unemployment benefits typically collect much more information about the skills and health of benefit recipients than the tax office does about taxpayers.

[78] In terms of the model developed in section 3.2, workfare in effect reduces δ (i.e. the value of leisure in unemployment).

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9 Appendix

To establish (19), we linearize the following equations characterizing the decentralized equilibrium

$$\gamma'(X) = m(\theta)\left(Y - \Pi - \frac{G+B}{m(\theta)}\right), \tag{26}$$

$$\frac{c\theta}{m(\theta)} = \Pi. \tag{27}$$

To derive the first equation, we have substituted the government budget constraint $Xm(\theta)Y = Xm(\theta)[W + \Pi] + (1 - Xm(\theta))B + G$ to eliminate the after-tax wage W from (16). The second equation follows from (15) and (18).

Loglinearization yields

$$\begin{pmatrix} \tilde{X} \\ \tilde{\theta} \end{pmatrix} = \frac{1}{\frac{c\theta(1-\eta)}{m(\theta)}\left(X\gamma''(X) - \frac{G+B}{X}\right)} \begin{pmatrix} \frac{c\theta(1-\eta)}{m(\theta)} & m(\theta)\eta\left(Y-\Pi\right) \\ 0 & X\gamma''(X) - \frac{G+B}{X} \end{pmatrix} \begin{pmatrix} -m(\theta)\Pi\tilde{\Pi} - \frac{G}{X}\tilde{G} - \frac{B}{X}\tilde{B} \\ \Pi\tilde{\Pi} \end{pmatrix}. \tag{28}$$

We thus have (the second equality follows from (27))

$$\begin{aligned} \frac{\tilde{X}}{\tilde{\Pi}} &= \frac{\Pi m(\theta)}{\frac{c\theta(1-\eta)}{m(\theta)}\left(X\gamma''(X) - \frac{G+B}{X}\right)}\left[-\frac{c\theta}{m(\theta)}(1-\eta) + \eta(Y-\Pi)\right] \\ &= \frac{\Pi m(\theta)}{\frac{c\theta(1-\eta)}{m(\theta)}\left(X\gamma''(X) - \frac{G+B}{X}\right)}\left[-\Pi + \eta Y\right] \\ &= \begin{cases} \geq 0 & \text{if} \quad \Pi \leq \eta Y \\ < 0 & \text{if} \quad \Pi > \eta Y \end{cases}. \end{aligned} \tag{29}$$

Hence, X and thus welfare is maximized if $\Pi = \eta Y$. Using (15) to eliminate Π, we arrive at the expression for the optimal tax τ_a in (19). QED

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