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Abstract: The study consists of four essays, which analyse the implications of labour taxation and unemployment insurance (UI) in the models of imperfectly competitive labour markets. The first essay studies the effects of labour taxation on unemployment and efficiency in a search equilibrium model with endogenous job destruction. It is shown that the adverse employment effect of labour taxes is mainly due to the prolonged spells of unemployment. A pure increase in the tax progression may reduce unemployment and facilitate the emergence of low-productivity jobs. In the second essay, the link between taxes and the public benefits is perceived owing to the centralised wage setting institutions. This is shown to promote wage moderation, make wages and employment less sensitive to wage taxation and reduce hours worked. The third essay considers alternative ways to organize the government subsidies in a model, where tax-alike payments are collected by the industry level funds in order to finance unemployment benefits. It is shown that equilibrium unemployment is decreasing in the share of UI financed by the employed union members. The fourth essay analyses the effects of UI in a job search model with endogenous search effort. It is shown that UI with a limited potential duration induces more search effort among the long-term unemployed who have exhausted a considerable amount of the current benefits.

Key words: Labour taxation, unemployment insurance, trade union model, search model

Tiivistelmä: Tutkimuksen neljässä artikkelissa tarkastellaan työtulojen verotuksen ja työttömyysturvan vaikutuksia epätäydellisen kilpailun työmarkkinoita kuvaavissa analyyttisissa malleissa. Ensimmäinen artikkeli käsittelee työtulojen verotuksen ja veroprogression vaikutusta työllisyyteen ja tehokkuuteen etsintämallissa, jossa työsuhteen päättyminen on endogeeninen. Osoittautuu, että verot pidentävät työttömyysjaksoja, mutta veroprogression kasvattaminen voi alentaa työttömyyttä ja edistää matalan tuottavuuden työpaikkojen syntymistä. Toinen artikkeli tarkastelee työverojen vaikutusta mallissa, jossa keskitetyn palkanmuodostuksen ansiosta otetaan huomioon verojen ja julkisten hyödykkeiden välinen yhteys. Osoittautuu, että keskitetty palkanmuodostus edistää maltillista palkkakehitystä, vähentää tehtyjä työtunteja ja pienentää verojen negatiivista vaikutusta työllisyyteen. Kolmannessa artikkelissa vertaillaan erilaisia julkisen subvention muotoja mallissa, jossa ammattiliittojen ylläpitämät työttömyysturvarahastot keräävät jäseniltään veroluonteisia maksuja. Osoittautuu, että tasapainossa työttömyys on sitä alhaisempi, mitä korkeampi on työssäkäyvien jäsenten rahoitusosuus. Neljäs artikkeli käsittelee työttömyysturvan vaikutuksia mallissa, jossa työnhaun intensiteetti määräytyy endogeenisesti. Osoittautuu, että enimmäiskestoltaan rajoitettu työttömyysturva lisää pitkään työttömänä olleiden etsintäintensiteettiä.

Asiasanat: Työtulojen verotus, työttömyysturva, ammattiliittomallit, etsintämallit

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Pekka Sinko

Summary

The study consists of four essays that analyse the implications of labour taxation and unemployment insurance (UI) in the models of imperfectly competitive labour markets.

The first essay studies the effects of labour taxation on wages, unemployment and efficiency in a search equilibrium model with endogenous job destruction. Three alternative hypothesis of wage formation is considered: Nash bargain, monopoly union and efficiency wages. It is shown that the adverse employment effect of labour taxes is mainly due to the prolonged spells of unemployment and less so due to the increased job destruction. If wage setting is based on bargaining, a pure increase in the tax progression reduces unemployment, improves the relative position of the low-income workers and facilitates the emergence of low-productivity jobs.

The second essay introduces a model, where the agents responsible for the wage formation perceive the link between taxes and the public benefits owing to the centralised wage setting institutions. It is shown that centralisation promotes wage moderation, makes wages and employment less sensitive to changes in the wage taxation and reduces hours worked. If individuals decide upon working hours, a wage tax can even improve employment, given that the marginal utility of public expenditure is sufficiently high. Moreover, if a profit tax is used to finance public expenditure, a higher tax reduces wages and improves employment.

The third essay considers the set up where tax-alike payments are used to finance the unemployment benefits. Then alternative ways to organize government subsidies for the UI funds run by the industry level unions are compared in a right-to-manage model. It is shown that equilibrium unemployment is decreasing in the share of UI financed by the employed union members. A reduction in the proportional subsidies matched by an increase in the lump sum grant is shown to bring about wage moderation and improve employment. If labour market parties can influence the level of benefits, a subsidy scheme with a fixed assistance per unemployed is preferable to the one covering a fixed share of the total UI costs.

The fourth essay analyses the effects of unemployment insurance in a job search model with endogenous search effort. The model is simulated numerically with the parameters fitted to the stylised facts of the Finnish labour market. It is shown that UI with limited potential duration induces more search effort among the long-term unemployed, who have exhausted a considerable amount of the current benefits. The positive effect starts to dominate the earlier, the steeper is the decline in the replacement ratio and the more insecure are the job contracts. A reform that combines a declining replacement ratio with a higher initial level of

benefits so as to leave the expected present value of the UI payments intact, is likely to increase search effort throughout the benefit period.

Contents

[1] This essay is joint work with Juha Kilponen.

Chapter 1

Introduction

Taxes on wages and labour income make up a major part of the tax revenues collected in today's developed economies. The increase in the importance of labour taxation during the last decades has been accompanied by the growth in the public spending, in particular on unemployment benefits and other social security. While the average effective tax rate on labour income in the OECD area during the first half of the 1970s was less than 29 per cent, it had reached the average of 39 per cent by the last half of the 1990s. At the same time, the average rate of unemployment ascended from the level of 2.5 per cent up to the level of 8.5 per cent (Kiander, Kilponen and Vilmunen, 2004). In the light of this development, it is not surprising that the economic effects of labour taxation has gained attention and become the subject of numerous economic studies.

The adverse effects of labour taxation on employment are well known from the traditional analysis based on the assumption of competitive labour markets. Since the 1990s, a growing number of studies has analysed labour taxation in the framework allowing for imperfect competition: models with trade unions, efficiency wages and unemployment search have been employed - in most cases - to confirm the harmful employment effects found in the competitive set-up. Pissarides (1998) provides a compact overview of the theoretical underpinnings of this approach with the help of stylized models. A recent survey of the theoretical results derived within the trade union set-up and the related empirical evidence is provided by Koskela (2002). In this literature, perhaps the most important difference to the competitive framework is the finding that an increase in tax progression may, under reasonable assumptions, improve employment in the non-competitive labour markets.

The early reference for this result in the trade union set-up include Herzoug (1984) and Koskela and Vilmunen (1996). The findings of Hoel (1990) and Pisauro (1991) suggest that a similar result can arise in the efficiency wage framework[1].

The analysis of the effects of tax progression is an important example of an attempt to show that the structure of taxation may matter if labour markets are not perfectly competitive. A closely related topic that has received some attention in the literature is the question of whether the nominal incidence of taxes makes any difference to the employment effects (e.g. Holm and Koskela, 1996, Koskela and Schöb, 1999). The "tax wedge" argument implied by the competitive framework asserts that the effects of labour taxes are independent of whether they are levied on employees or employers (e.g. Layard, Nickell and Jackman, 1991). This basic irrelevance result holds to a large extent even in the models with imperfect competition. These questions - the employment effects of taxation, tax incidence and tax progression - are the topics of the first essay of this study. The analysis, however, is cast in a dynamic framework of search equilibrium allowing for endogenous job destruction.

Apart from how taxation itself is organised, the effects of taxation on labour market are generally dependent on how the revenues are used. To the extent that the taxpayer receives some benefits financed with the taxes (and recognises this) the harmful side effects of taxation should be mitigated. This notion brings in another important extension to the traditional view on labour taxes: the employment effects of general income taxation and tax-alike social security contributions may differ significantly and thus cause the tax wedge argument to fail. Traditionally, the link between the taxes paid and the benefits received has been neglected in the analysis of labour taxation. The negligence is readily acceptable in the competitive set-up where individuals (and firms) are "small" relative to the market and the effect of individual decisions on public finance is insignificant. However, it is less suitable for the case of imperfectly competitive labour markets, in particular in the models involving union wage setting. An early analysis of the tax-benefit link in a trade union model is provided by Oswald (1982), who shows that UI benefits put an upward pressure on wages even if the general equilibrium

[1] This view has recently been challenged by papers suggesting that the positive employment effect may not be robust to a more versatile framework allowing for endogenous working hours (Hansen et al. 2000, Fuest and Huber, 2000) or long-run adjustment in the number of firms (Rasmussen, 2002).

effects through the public budget are allowed for. The perception of the tax-benefit link is explicitly connected to the degree of centralisation of the labour market in the seminal contribution of Summers, Gruber and Vergara (1993). They employ a model with efficient bargaining to argue that if wage setting is centralised or sufficiently co-ordinated, the institutions involved in wage negotiations recognize the linkage between labour taxes and the public provision of goods. This leads to a more moderate response of wages to taxes and better employment performance in countries with centralised wage setting. The findings of Summers et al. (1993) are the starting point of the second essay of this study, which extends their analysis to the case of endogenous working hours.

One important example of the benefits financed by general taxation or tax-alike contributions is unemployment insurance (UI). Similar to taxation, unemployment insurance is traditionally viewed as being harmful for employment. The adverse effect on employment is found in the models of both competitive and imperfectly competitive labour markets. In competitive labour markets, unemployment benefits will generally increase the opportunity cost of leisure and hence deter labour supply. In unionised labour markets, unemployment benefits serve to improve the fall back position of the union members and therefore increase wages. Again, the perception of the link between taxes and benefits potentially change the standard results: if the wage setters realise the increased tax pressures related to higher benefits, the adverse effects of unemployment insurance are mitigated. The working of such a mechanism is explicitly demonstrated by Holmlund and Lundborg (1988) in their analysis of the so-called Gent model of unemployment insurance that is widely applied in the Nordic countries. In their set-up, monopolistic unions run UI funds of their own, which are subsidised by the government. The third essay of this study extends their analysis by employing a right-to-manage model and considering some alternative means of public intervention in financing unemployment insurance.

In addition to financial aspects, the harmful effects of unemployment benefits may depend on how the benefits are actually paid out. Instead of a constant per head benefit paid indefinitely, the real-world UI programmes usually define a maximum duration for the benefit payments. Also, the replacement ratio can - at least in principle - vary over time. Analysis of these aspects is outside the scope of the traditional static models and inherently calls for a dynamic framework. A key question of interest is, whether altering the time profile of benefit payments can reduce the adverse effects of unemployment insurance. The seminal work in this field includes papers by Mortensen (1977) and Shawell and Weiss (1979). The central argument of Shawell and Weiss is that if unemployed workers can affect the probability of getting a job, the optimal sequence of benefits should decline over time. Mortensen (1977) focuses on the re-employment incentives and accommodates institutional features such as eligibility conditions and limited potential duration of benefits. His key notion is that, once these features are taken into account, the effect of unemployment insurance on employment is ambiguous. The recent upsurge of search model applications has brought in a number of studies where the dynamic effects of UI are inspected from different angles (e.g. Davidson and Woodbury, 1997, Hopenhayn and Nicolini, 1997, Fredriksson and Holmlund, 1999, Cahuc and Lehmann, 2000). The fourth essay of this study aims to contribute to this literature by considering the effects on optimal search behaviour of the limited duration and declining time sequence of UI benefits.

The introductory essay is organised as follows: We first briefly consider the effects of labour taxes in isolation, altering the underlying model of the labour market and paying particular interest to the tax progression. At the same time, we introduce the two modelling frameworks employed in the rest of the study: the trade union model and the search model. We then proceed to discuss the analysis of the tax-benefit link with applications to the centralisation of wage setting and to the financing of unemployment insurance by the premiums paid by unionised workers. Finally, we discuss the effects of limited potential duration and declining time profile of unemployment benefits in a dynamic framework of the unemployment search. A summary of the four essays is presented at the end of the introductory essay.

1.1 Labour Taxation and Employment

In this section we consider the effects of labour taxes in isolation and under the alternative assumptions made on the workings of the labour market. In particular, we review the results of the employment effects of labour taxation in three model categories: the competitive model, the trade union model and the search model. Throughout, we pay special attention to the effects of increased tax progression.

1.1.1 Effects of Taxation in the Competitive Model

To start with, it is instructive to review the effects of labour taxation in the competitive framework. With reference to the well known result of irrelevance of the nominal incidence, we concentrate on the case where taxes are levied on the worker. Consider a slightly modified consumer problem where a worker has well defined utility over disposable income y_d and working hours l as follows:

$$\begin{aligned} & \max_l u(y_d, l) \\ & s.t. \\ y_d &= wl - T(wl; \tau) \end{aligned} \tag{1.1}$$

where w refers to the before-tax wage rate and $T(wl;\tau)$ is a tax function defined over before-tax income wl and some (vector of) tax parameter(s) τ taken as given by the individual (e.g. nominal tax rate, per head subsidy etc.). Solving the problem yields the first order condition for the utility maximising supply of labour:

$$-u_l = u_y w (1 - T') \tag{1.2}$$

where $u_l < 0$ and $u_y > 0$ refer to the marginal utilities of working hours and income, respectively and $T' \equiv \partial T / \partial y$ is the marginal tax rate, which is not necessarily constant. What (1.2) effectively states is that, at the worker's optimum, the marginal disutility of labour is set equal to the marginal increase in utility resulting from supplying an extra unit of labour. Under the usual assumption of the decreasing marginal utility of leisure, (1.2) constitutes an upward sloping labour supply schedule in the (l, w) -space. Assuming the profit maximising behaviour of competitive firms with labour as a single input, labour demand can be derived from the problem

$$\max_l f(l) - wl \tag{1.3}$$

where $f(l)$ is the production function with $f' > 0$, $f'' < 0$. The first order condition for optimality then becomes

$$f_l = w \tag{1.4}$$

requiring the firm to set the marginal product of labour equal to the cost of an extra unit of labour. In the absence of employer taxes, the latter is simply the wage rate. With $f'' < 0$, (1.4) constitutes a downward sloping labour demand schedule in the (l, w)-space.

The competitive labour market equilibrium is found at the intersection of the supply and demand curves defined by (1.2) and (1.4), respectively. The equilibrium level of employment is affected by a change in the tax policy to the extent that it causes a shift in the labour supply curve. To consider the effect of a marginal change in the tax policy, let us differentiate (1.2) with respect to τ for given l to get

$$\frac{\partial w}{\partial \tau} = -\frac{u_{ly}}{u_y (1 - T')} \frac{\partial y_d}{\partial \tau} - u_l \left[\frac{1}{u_y (1 - T')^2} \frac{\partial T'}{\partial \tau} - \frac{u_{yy}}{u_y^2} \frac{\partial y_d}{\partial \tau} \right] \tag{1.5}$$

where $u_{ly} = \partial u_l / \partial y_d$ and $u_{yy} = \partial u_y / \partial y_d$ are the second derivatives of the utility function with respect to the disposable income. Expression (1.5) can be used to provide some insight into the dependency of tax policy effects on the structure of individual preferences in the competitive model.

For that purpose, consider first the following specification of individual utility $u = x(y_d) - v(l)$, where x denotes the subutility defined over disposable income and v the disutility over working hours. The utility function is *additively separable* between income and working hours, implying $u_{ly} = 0$. With $x' > 0$, $x'' < 0$ the subutility over disposable income is concave and individuals are said to be *risk averse*. Then $u_{yy} = x'' < 0$ and (1.5) takes the following simpler form

$$\frac{\partial w}{\partial \tau} = -u_l \left[\frac{1}{u_y (1 - T')^2} \frac{\partial T'}{\partial \tau} - \frac{u_{yy}}{u_y^2} \frac{\partial y_d}{\partial \tau} \right] \tag{1.6}$$

Expression (1.6) shows that for risk averse individuals, taxation affects labour supply through two separate channels. In addition to the effect through the marginal tax rate - captured by the first term within the square brackets - the tax policy influences labour supply and employment through the induced change in the disposable income. The latter effect is captured by the second term within the square brackets. Notably, the tax policy has an influence on labour supply, even when the marginal tax rate is not affected. For example, a fixed per head tax a reduces disposable income ($\frac{\partial y_d}{\partial a} < 0$) and according to (1.6) shifts labour supply down with a consequent increase in the equilibrium employment. The effect of a proportional wage tax t is a priori ambiguous with the two effects driving in opposite directions. The condition for increased wages and a negative effect on employment of a higher proportional tax rate can be derived from (1.6) as follows:

$$\frac{-u_{yy}}{u_y}(1-t)\,wl < 1 \tag{1.7}$$

where the left hand side is nothing but the *coefficient of relative risk aversion* (see e.g. Takayama, 1993). Intuitively, higher proportional tax reduces employment if individuals are not too risk averse.

An important special case satisfying (1.7) is the *quasi linear utility*, a formulation widely used in the tax literature (see e.g. Hansen et al, 2000). In this case, the individual utility takes the form $u = y_d - v(l)$ with $v' > 0$, $v'' < 0$. Utility is still additively separable between disposable income and working hours, but individuals are risk neutral in the sense that the disposable income enters utility in a linear fashion. Formally, these assumptions imply $u_{ly} = u_{yy} = 0$. Thus, equation (1.5) can be rewritten as

$$\frac{\partial w}{\partial \tau} = \frac{-u_l}{u_y\,(1-T')^2}\frac{\partial T'}{\partial \tau} \tag{1.8}$$

which shows that tax policy affects employment only to the extent that the marginal tax rate is changed. With $u_l < 0$, it is clear from (1.8) that a higher marginal rate implies an upward shift in the labour supply and a reduction in the equilibrium level of employment. This result has the important implication that a per head tax or subsidy has no employment effects in the competitive model if quasi linear utility is applied.

Finally, to consider the effects of tax progression in this set-up, let us specify the following widely used linear tax function

$$T(wl; a, t) = twl + a \tag{1.9}$$

with the marginal tax rate equal to $T'(wl) = t$ and the average tax rate equal to $\frac{T(wl)}{wl} = t + \frac{a}{wl}$. Then consider the effects of a policy that involves an increase in the proportional rate and a simultaneous reduction in the per head tax a so as to leave the average tax rate intact. Assuming that (1.7) holds, it is immediately clear by the results derived above that employment will deteriorate after such a policy change. This is especially the case if individual utility is quasi linear and the only influential effect is the increase in the marginal tax rate due to higher t. Thus, we can conclude that "a pure increase in progression" is likely to reduce employment in the competitive set-up with the commonly used restrictions imposed on the structure of individual preferences[2].

1.1.2 Effects of Taxation in the Trade Union Model

In the previous section we briefly reviewed the effects of labour taxation in the traditional competitive framework. We now reject the hypothesis of market clearing and consider the effect of labour taxation in the models involving imperfect competition. Keeping to the static framework, the main candidates for describing labour markets with involuntary unemployment are trade union models and efficiency wage models. While both come with numerous variants, the skeleton model can be described as one where the labour supply schedule of the competitive model has been replaced by an upward sloping *wage setting curve* (see e.g. Stiglitz, 1999). In the basic set-up with competitive firms, the labour demand is derived analogous to the competitive model. In the most widely applied variants, the right to manage and the monopoly union models, equilibrium is found on the labour demand curve (see e.g. Booth, 1995). In what follows we mainly confine ourselves to the trade union framework, but at least some of the results are equally applicable to the standard efficiency wage models.

In the above we saw that assumptions concerning the structure of individual utilities play a crucial role in the analysis of labour taxation in the competitive markets. In the trade union models, the standard assumptions include a fixed labour supply and union's objective that is linear with respect to disposable income. In the following, we consider a slightly generalised version of the monopoly union model. We retain the assumption of a fixed labour supply, but allow for risk aversion and the consequent concavity of the union's objective over disposable income[3].

[2] The restrictions in the utility structure are, in the first place, used for analytical tractability. In particular, the quasi linear formulation tends to be too restrictive in empirical work.

[3] The second essay of this study extends the standard framework in an alternative direction by assuming risk neutrality, but allowing for the endogenous supply of working hours.

Following the standard approach, we assume a utilitarian union that cares for the wellbeing of both employed and unemployed union members. The weights of the two groups in the union's objective are directly proportional to their numbers, in other words to employment and unemployment, respectively. Thus, the union's objective may be written as

$$V = nu\left(w - T\left(w\right)\right) + \left(1 - n\right)u\left(b\right) \tag{1.10}$$

where n is the employment rate and u is the individual utility function with $u' > 0$ and $u'' \leq 0$, reflecting the individual attitude to risk. The employed member receives the after tax wage equal to $w - T\left(w\right)$. With the individual labour supply fixed at unity, this is also the disposable income. The unemployed member receives a fixed benefit, b.

The problem of the monopoly union is to maximize (1.10) subject to the labour demand function such as defined in (1.4). Differentiating (1.10) with respect to the wage rate and manipulating to derive the elasticity form, the first order condition of optimality becomes

$$-\varepsilon\left[u\left(w\left(1 - \tau_a\right)\right) - u\left(b\right)\right] + w\left(1 - \tau_m\right)u' = 0 \tag{1.11}$$

where $\varepsilon = -\frac{\partial \log n}{\partial low} > 1$ is the own price elasticity of labour demand, which is assumed to be constant in the standard model[4], $\tau_a \equiv \frac{T(w)}{w}$ is the average tax rate and $\tau_m \equiv \frac{\partial T(w)}{\partial w}$ is the marginal tax rate. Equation (1.11) implicitly defines the optimal wage rate set by the union.

Now assuming that the wage setters take the marginal and average tax rates given, we may use (1.11) to derive the effects of tax policies on the equilibrium wage. For that purpose, we first differentiate the left hand side of (1.11) with respect to wage and the relevant tax parameters and then utilise the implicit rule to derive the wage response to taxation. Denoting the left hand side of (1.11) by $\Omega\left(.\right)$ we have

$$\frac{\partial \Omega}{\partial w} = -\varepsilon u'\left(1 - \tau_a\right) + \left(1 - \tau_m\right)\left[u' + wu''\left(1 - \tau_a\right)\right] < 0 \tag{1.12}$$

which can be shown to be negative under some plausible restrictions on the parameters (see Appendix A). Noteworthy, $\frac{\partial \Omega}{\partial w} < 0$ is also needed for the stationary point to be a maximum of the union's objective. Similarly,

[4] The constancy of $\frac{\partial \log n}{\partial low}$ can be shown to follow assumption of Cobb-Douglas technology (see e.g. Holmlund et al. 1989).

differentiating with respect to the average tax rate and marginal tax rates yields

$$\frac{\partial \Omega}{\partial \left(1-\tau_a\right)} = -\varepsilon u' w + w^2 u'' \left(1-\tau_m\right) < 0 \tag{1.13}$$

and

$$\frac{\partial \Omega}{\partial \left(1-\tau_m\right)} = u' w > 0 \tag{1.14}$$

Applying the implicit rule, we have from (1.12) and (1.13)

$$\frac{\partial w}{\partial \tau_a} > 0 \tag{1.15}$$

in other words, an increase in the average tax rate, with fixed marginal rates, puts an upward pressure on union wages. Similarly, from (1.12) and (1.14)

$$\frac{\partial w}{\partial \tau_m} < 0 \tag{1.16}$$

which states that if marginal rates are increased without affecting the average tax rate, the union will respond by lowering wages. Expression (1.16) restates the well known result of wage moderation and the positive employment effects of tax progression in trade union models (Herzoug 1984, Koskela and Vilmunen, 1996). Noteworthy, both (1.15) and (1.16) hold for risk neutral ($u'' = 0$) as well as risk averse ($u'' < 0$) individuals. This result concludes our discussion of employment effects of labour taxation in a trade union model. We have demonstrated that in the generic model of union behaviour labour taxation harms employment, but a pure increase in the tax progression is likely to have the opposite effect[5].

[5] In our analysis tax progression is taken to mean higher marginal rates for a given average tax rate. A somewhat broader definition widely used in the literature (e.g. Holmlund and Kolm (1995), Sörensen (1999), Schneider (2002)) is based on the *coefficient of residual income progression* (CRIP) defined as $v \equiv \frac{1-\tau_m}{1-\tau_a}$. The tax schedule is said to be progressive (regressive) if $v < 1$ ($v > 1$). It can be shown that in a comparison of any two tax schedules, the one with lower v is more redistributive in the sense that the implied after-tax Lorenz curve lies everywhere inside the corresponding curve implied by the less redistributive tax schedule (Jakobsson, 1976). Noteworthy, under this definition, tax progression may increase even if the marginal rate stays unchanged (or even decreases) given that the average rate is reduced strongly enough. Nevertheless, it is straightforward to show that $\partial w / \partial v > 0$ in our set-up and increased progression induces lower wages even when the CRIP definition is used.

1.1.3 Effects of Taxation in a Search Model

In addition to the trade union and efficiency wage models, a third widely used modelling approach to imperfectly competitive labour markets is the so-called search models[6]. In these inherently dynamic models, the focus is on the mismatch problem caused by the implicit frictions and heterogeneity among workers and firms. The potential mismatch induces a costly two-sided search for a suitable partner causing a delay and preventing instantaneous clearing. The search friction is usually modelled with the help of a *matching function*, which relates the stream of new jobs to the ratio of vacancies to unemployed workers, the *labour market tightness*. Combined with (exogenous) destruction of the existing jobs, this structure gives rise to equilibrium unemployment in the steady state. The foregone costs of search are reflected in a surplus associated with the filled jobs. Therefore, when an acceptable partner is found, a wage setting rule must be applied to share this surplus between the worker and the firm. The standard assumption is that the division of surplus is determined in a Nash bargain between the two parties.

A particularly prominent and widely used formulation of the equilibrium search model is presented in Pissarides (2000). The model builds on the Bellman type value functions of forward looking firms and workers in a stationary environment. Workers can be either employed or unemployed, whereas firms can hold either open or filled vacancies. Once free entry is assumed to bring the value of an open vacancy to zero, a job creation condition can be derived that is the counterpart of the labour demand schedule of the static models. Since the value of a filled job decreases in the wage rate and increases in the labour market tightness, the job creation schedule slopes down in the space of these two variables. Further assuming that wages are determined so as to return a fixed share of the match surplus to both parties, a wage setting equation can be derived that constitutes an upward sloping curve in the (wage, tightness) space. This is because the value of a filled job - and therefore the wage rate - increases with the difficulty to find a new worker in the case of separation. The equilibrium solution is the (wage, tightness) pair that satisfies these two conditions. The equilibrium rate of unemployment can then be solved from the steady state condition that equates the flow into and out of the pool of unemployment[7].

[6] See Mortensen (1986) and Mortensen and Pissarides (1999) for reviews of the early and the more recent research within this tradition.

[7] With a matching function exhibiting constant returns to scale, the steady state condi-

In what follows, we employ this model to consider the effects of wage taxation similar to the sections above, where the competitive and union models were used. Following Pissarides (2000), consider a model where firms post vacancies at cost c for a job producing output x. At the same time, filled jobs are destroyed at an exogenous rate, δ. Unemployed workers, entitled to benefit b, search for a job and find one with an endogenous probability $m(\theta)$. The probability of finding a job increases in the labour market tightness $\theta = v/u$, which is defined as the ratio of vacancies to the unemployed. Wages are determined in a standard Nash bargain between the firm and the worker after a match has been formed. Upon introduction of a general tax function $T = T(w)$, the equations for job creation, wage setting and the Beveridge curve can be written as follows (see Appendix B for the detailed derivation)

$$x - w - \frac{c(r+\delta)}{q(\theta)} = 0 \tag{1.17}$$

$$w = \frac{\beta(1-T')(x+\theta c) + (1-\beta)(T+b)}{1-\beta T'} \tag{1.18}$$

$$u = \frac{\delta}{\delta + m(\theta)} \tag{1.19}$$

where $q(\theta) = \theta^{-1} m(\theta)$ is the probability of filling a vacancy, β is the parameter reflecting the worker share of the surplus and r is the discount rate. The three unknowns of the model are wages w, labour market tightness θ and unemployment rate u. It is noticeable that the tax parameters enter the model only through the wage setting equation (1.18). Now, consider the effect of tax policy change that involves an increase in the marginal tax rate T' and leaves the per head tax burden T intact. Differentiating (1.18) for a given labour market tightness yields

$$\frac{\partial w}{\partial T'} = -\beta \frac{(1-\beta)(x + c\theta - b - T)}{(1-\beta T')^2} < 0 \tag{1.20}$$

which is negative under the plausible condition $x + c\theta - T > b$ i.e. that unemployment benefits are less than the sum of per head productivity and recruiting costs minus the per head tax burden. Then an increase in the

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tion stretches a downward sloping, convex-to-origin "Beveridge curve" in the (unemployment, vacancy) space as shown by Pissarides (2000).

marginal rate causes a downward shift in the wage setting schedule in (θ, w) space. While the job creation curve (1.17) remains stable, this indicates a drop in the equilibrium wage and an increase in the labour market tightness. Increased labour market tightness reduces the expected length of unemployment spells and reduces equilibrium rate of unemployment, as can be seen from the Beveridge curve relation (1.19). Consequently, we conclude that the employment enhancing effect of the increased tax progression carries over to the standard search equilibrium, as demonstrated by Pissarides (1998). We return to this issue in the first essay, which employs a more versatile framework with endogenous job destruction and compares alternative wage setting models within the search equilibrium.

1.2 The Link Between Taxes and Benefits

In the above we discussed the effects of labour taxation under alternative assumptions concerning individual preferences, structure of taxation and the functioning of the labour markets. Throughout, we ignored the use of revenues. This widely used simplification can be justified in the competitive labour markets, but is less suitable for the markets with imperfect competition. In particular, with unionised labour markets, the wage setting institutions may be large relative to the market and therefore should - to some extent - internalise the government budget in their decisions.

In this section we consider two cases where the link from taxes to benefits is explicitly taken into account in the wage setting. In the first case the perception of the tax-benefit link arises because wage setting is highly centralised or co-ordinated. In the second case, wage setting is decentralised, but the wage setting institutions are involved in financing the unemployment insurance.

1.2.1 Internalising Government Budget under Centralised Wage Setting

Some form of unionisation characterises the majority of labour markets within the OECD area. In most of the countries unions operate mainly at the industry level and the majority of workers are covered by industry level agreements[8]. In those countries there is not necessarily any remarkable co-operation among the unions. In another smaller group of countries, including the Nordic countries and the Netherlands, unionised wage setting is less decentralised, owing to either more centralised institutions or a higher level of co-ordination among industry level unions. In those countries centralised wage contracts extend to several industrial sectors and cover almost the entire private sector (see e.g. Wallerstein and Western, 2000).

After the peak of some 45 per cent in the mid 1980s the average union density rate in the OECD area has been declining and is now closer to 40 per cent. A probably more important measure of union influence, the coverage rate, is still close to 70 per cent on average. At the same time, the indices measuring centralisation and co-operation within union wage setting have shown a declining trend (see e.g. Kiander et al., 2004). It is interesting that this reduction in union influence and co-ordination has coincided with worsening of the labour market performance and the increase in the average rate of unemployment.

A key finding in the trade union models of imperfectly competitive labour markets is that the degree of centralisation or the co-ordination in the wage setting plays an important role in determining the effects of policy measures on wages and employment. The well known result of Calmfors and Driffill (1988) suggests that the equilibrium wage is hump-shaped in the degree of centralisation of the wage setting institutions. Intuitively, moving from the competitive wage setting to a relatively decentralised corporatism tends to increase wages with unions exploiting their monopoly power. However, a step further to a highly centralised corporatism forces the wage setting institutions to take into account the effect of their action on the economy wide variables such as the general price level. This brings about wage moderation and produces the hump-shaped pattern of equilibrium wages.

An important application of the same principle has been developed by Summers, Gruber and Vergara (1993). In their model, the degree of centralisation is reflected in the wage setting institutions' ability to internalise the government budget constraint and thereby perceive the link from taxes paid to publicly provided goods and services. Using an efficient bargaining model, Summers et al. conjecture that perception of the government budget constraint leads to more moderate responses of wages to taxes and therefore

[8] Remarkable exceptions are the United States, Canada and Great Britain where unionised workers make up only a minor share of the total labour force.

better employment performance in countries with centralised wage setting.

The approach of Summers et al. (1993) seems to be a particularly relevant description of the real-world case where the government is either implicitly or explicitly involved in the wage setting process through so-called tripartite co-operation. In such a regime, applied frequently for instance in Finland, the government typically provides incentives for wage moderation using tax and social policy instruments (Vartiainen (1998)).

The predictions of Summers et al. (1993) also find some support in empirical studies with international data. The results of Daveri and Tabellini (2000) suggest that labour taxes are considerably more harmful for employment in the countries with an industry level bargaining structure. Kiander, Kilponen and Vilmunen (2000) find similar evidence with a data set of 17 OECD countries. Their empirical results suggest that a 10 percentage point reduction in the effective tax rate on labour income would imply a 2-3 percentage points decrease in the unemployment rate in the countries with industry level bargaining system during the period of 1973 - 1996, but no statistically significant effect in the countries with centralized or competitive wage bargaining systems. Similar results have recently been reported by Everaert and Heylen (2002).

The second essay contributes to this discussion by analytically studying the relationship between taxation, wages and employment when allowing for the different degree of centralisation within the wage setting institutions. It extends the earlier literature by developing a model with an endogenous supply of working hours and by analysing both wage and profit taxation. The key findings are that the main results of Summers et al. (1993) carry over to a framework with an endogenous labour supply. Furthermore, it is shown that centralised wage setting is likely to reduce the hours worked per employee.

1.2.2 Experience Rating of Unemployment Insurance

In the previous section we saw that internalising the government budget leads to wage moderation and less distortive labour taxation. If the wage setting is relatively decentralised, e.g. takes place at the level of individual industries, we cannot assume that the wage setting institutions take full account of the effects of wage policy on public finance. However, even with decentralised wage setting it is possible to design mechanisms that promote moderate wage policies and reduce the adverse effects of taxes or tax-alike social security payments.

One example of such arrangements is the so-called "Gent model" of unemployment insurance (UI) applied in the four Nordic countries of Denmark, Finland, Sweden and Iceland, where UI premiums are paid on the basis of a voluntary membership in funds that are closely connected with trade unions (see e.g. Holmlund, 1998). The unemployment insurance - although heavily subsidised by the government - has some fraction of the costs borne by the insured employees.

For example, in Finland the earnings-related UI is administrated and run by around 70 separate funds. The total number of workers belonging to a fund is around 1.75 million, which makes roughly three quarters of the total labour force. The funds collect premiums from their members, and the premiums are used to finance a part of the benefits paid out from the fund. The size of the premium varies between funds, reflecting - among others - the prevailing employment conditions (Kiander, 1996).

The fact that the premium size becomes dependent on the industry level unemployment makes the arrangement somewhat similar to the systems where employers' UI contributions are tied to their history of worker dismissals. Such a system, known as the *experience rating* of unemployment insurance, is applied mainly in the United States and has received much attention in the literature (see e.g. Feldstein, 1978, Burdett and Wright, 1989 and Fath and Fuest, 2002). Differently from the U.S. system, in the Gent model the own financial risk is introduced on the worker's rather than the employer's side.

A seminal article exploring this type of semi-private unemployment insurance is Holmlund and Lundborg (1988). They employ a monopoly union framework to show how alternative government subsidy measures directed to UI funds affect the wage setting behaviour of the unions. They find -among other thing - that a lump sum grant to the union's UI fund increases employment, whereas higher marginal subsidies have an ambiguous effect on wages and employment.

The third essay of this study builds on the work of Holmlund and Lundborg (1988) and provides an extension of their model by considering the effects of government subsidies for the UI funds in a right-to-manage framework. Mimicking the Finnish system, we derive a model where wages are determined in a Nash bargain between firms and industry level unions that run UI funds of their own. We show that the results derived by Holmlund and Lundborg hold, to a large extent, even in the more general set-up. In addition, we consider a subsidy regime where the government pays a fixed per head assistance to each unemployed member in the UI fund and show that under certain conditions this arrangement is preferable to the proportional subsidies. This is particularly so if the labour market parties can influence the level of UI benefits.

1.3 Dynamic Structure of the Benefits

In the previous section we saw how the method of financing may influence the effects of unemployment benefits in the labour market. In addition to this, the effects of UI may crucially depend on the way in which benefits are actually paid out to the recipients. Instead of a constant per head benefit paid indefinitely, the real-world UI systems usually define a maximum duration for benefit payments. Also, in some cases, the replacement ratio is not constant over time. This raises the question of whether altering the time profile of benefit payments can reduce the adverse effects of unemployment insurance. Answering this question is outside the scope of the traditional static analysis and inherently calls for a dynamic framework.

The seminal studies in this field include Shawell and Weiss (1979). They conjecture that if unemployed workers can affect the probability of getting a job, the optimal time sequence of benefits declines. The intuition behind the result is that declining benefits reduce the expected marginal cost of the search effort by reducing the loss in the event of a match. We refer to this as the *marginal cost effect*. In the Shawell and Weiss model, benefits are assumed to be paid indefinitely conditional on unemployment. Similar results are derived in a two-period model by Baily (1978).

Mortensen (1977) brings in an important aspect of real-world benefit programmes by considering the case where the maximum duration of benefits is limited and a spell of employment is necessary to qualify for a renewed benefit period. He then argues that the marginal cost effect that drives the results in the Shawell and Weiss analysis is accompanied by a partly offsetting *entitlement effect*: increased benefits will actually increase the search effort among those who are not currently entitled to benefits. This is because more generous benefits increase the present value of a job match. The entitlement effect is likely to dominate the marginal cost effect also for those unemployed who are close to exhausting their current benefit period.

More recent papers, cast in the job search framework, have presented somewhat mixed results. Wang and Williamson (1996) suggest a non-monotonic profile of the benefits in a model where endogenous work effort is incorporated. According to Hopenhayn and Nicolini (1997) benefits should decline monotonically and be accompanied by a re-employment tax that is increasing in the length of unemployment spell. Davidson and Woodbury (1997) argue that optimal insurance pays a positive benefit indefinitely. Fredriksson and Holmlund (1998) find that a two-tier system dominates a system with indefinite payments and a constant replacement ratio. Cahuc and Lehmann (2000) point out that a declining time sequence of benefits may lead to wage pressures that counteract the positive response of job search intensity. This is because a declining benefit profile improves the position of the short-term unemployed relative to the long-term unemployed. In Coles and Masters (2000) search effort plays no explicit role, but the negotiated wage rate depends on the expected duration of unemployment spells. Then UI distorts the wage formation and therefore equilibrium employment. Coles and Masters find that shortening of the benefit period improves employment, even when compensated by a higher benefit level.

The fourth essay of this study contributes to this discussion by analysing the incentive effects of unemployment insurance in a job search framework. Our special interest is to examine the consequences of introducing UI with a limited potential duration and possibly declining time sequence of benefits. We calibrate our model to mimic the stylized facts of the Finnish labour market and the earnings-related UI in Finland. Our findings suggest that introduction of the benefit system reduces the search effort of the short-term unemployed, but increases the effort of those who have been unemployed for a while and have already exhausted a considerable part of their current benefit spell. We also argue that faster depreciation of the replacement ratio combined with an increase in the initial benefit level could serve as a way to diminish unemployment without reducing the overall generosity of the benefit system.

1.4 Summary of the Essays

1.4.1 Essay I: Labour Taxation, Tax Progression and Job Matching - Comparing Alternative Models of Wage Setting

The aim of the first essay is to contribute to the discussion on the employment effects of labour taxation by considering the effects of labour taxation and increased tax progression in a search equilibrium model with endogenous job creation and job destruction. As for the tax instruments, proportional and progressive tax on labour income as well as a proportional payroll tax are covered. To emphasise the role of wage setting, we consider three alternative hypotheses of wage determination: Nash bargain, monopoly union and efficiency wages. This set-up facilitates an interesting comparison between the widely used models of non-competitive wage setting. In particular, we want to find out how alternative assumptions of wage setting affect the response to tax policy shocks and to what extent the results derived in static models carry over to the search equilibrium framework. Also, as suggested by Pissarides (1998), the inclusion of alternative wage setting mechanisms in tax policy analysis is justified by the lack of a definitive model for the European labour market. For instance, a recent study by Rocheteau (2001) argues that both bargain and efficiency wage mechanisms may coexist; which of the two is binding depends on the prevailing tightness of the labour market.

We find that labour taxes have a harmful effect on steady state employment, irrespective of the wage formation mechanism. The adverse effect is mainly due to reduced labour market tightness and the consequent increase in unemployment duration. However, the magnitude of the effect varies depending on the wage setting specification. In particular, employment turns out to be much less sensitive to taxation in the models involving wage bargaining. Our results also suggest that an increased progression of labour taxation may improve employment with low or even non-existent efficiency costs if wages are set in a bargaining framework. Moreover, we argue that in these models increased progression increases the take-home pay of the low-productivity workers and promotes the emergence of less productive jobs.

1.4.2 Essay II: Taxation and Centralised Wage Setting - the Case of Endogenous Labour Supply

The second essay contributes to discussion about the tax-benefit link by studying the relationship between taxation, wages and employment in a theoretical model that allows for a different degree of centralisation with respect to the wage setting institutions. In particular, we extend the earlier literature by utilising a framework with an endogenous supply of work hours and by analysing both wage and profit taxation.

In our set-up, monopolistic unions decide upon wages and profit maximising firms decide upon employment. The government collects taxes to finance unemployment benefits and provision of a public good. Regarding the determination of the labour supply, we consider two alternative approaches that have received attention in the literature: In the first, working hours are determined by the utility maximising individuals. In the second approach, we let both working hours and the wages be determined by the union. Throughout the paper, we retain the Summers et al. (1993) approach and define centralised wage setting as unions' ability to perceive the government budget constraint. We believe that this is a particularly relevant description of centralisation for the countries where a large part of the services are publicly provided.

We show that the key results of Summers et al. (1993) carry over to the case with endogenous working hours: centralised wage determination exhibits a wage moderation effect and supports higher employment. In addition, our model predicts that hours worked will be lower under centralised wage setting. With endogenous working hours, a tax on earned income increases wages and reduces employment even if unemployment benefits are taxed equally with the wage income. This contradicts the findings in the models with fixed hours. Also, centralised wage setting is shown to reduce the sensitivity of wages and employment to the increases in the wage tax. In fact, when individuals decide upon working hours and marginal utility of the publicly provided good is sufficiently high, a wage tax may even improve employment.

Finally, when a profit tax is used to finance public expenditure, the standard neutrality result of a pure profit tax breaks down: if wage setting is centralised, a profit tax is shown to reduce wages and improve employment. This result is equally valid whether the supply of hours is based on individual decisions or the union is allowed to decide upon both wages and hours worked.

1.4.3 Essay III: Subsidising vs. Experience Rating of Unemployment Insurance in Unionised Labour Markets

In the third essay we analyse the effects on wage determination and employment of the alternative government UI subsidy schemes within the so-called Gent model. The framework of the analysis is a "right to manage" model of unionised labour markets (see e.g. Booth, 1995) where the wage negotiations take place at the industry level. Public authorities subsidise unions in financing the UI. We consider four alternative types of government subsidy schemes: i) UI is financed entirely by the government ii) the government covers a fixed share of the total costs iii) the government pays a lump sum grant to the UI fund and iv) the government pays a fixed per head assistance for each unemployed member. To allow for a part of the UI costs to be borne by the union members, we endogenize the premium paid by the employed union members. The actual size of the members' contribution then depends, among others, on the unemployment rate prevailing at the industry level.

The study builds on Holmlund and Lundborg (1988), who utilise a monopoly union framework to study the case where part of the UI is financed by the government. We extend their analysis by employing a right-to-manage set-up that embeds the monopoly union model as a special case. In addition, we study the case not considered by Holmlund and Lundborg where the government pays a fixed per head subsidy for each unemployed member, that is of special interest from the Finnish viewpoint. Different from them - and perhaps more realistically - we assume that optimal premium differentiation between employed and unemployed union members is not possible and restrict the analysis to the case where the unemployed members pay no UI premium. We also compare the performance of subsidy schemes in equilibrium where the level of benefits is negotiated along with wages.

We show that the introduction of "experience rating" on the workers' side makes the wage setting curve downward sloping as the employed union members have to be offered compensation for the premium. In equilibrium, a ceteris paribus lower wage rate and higher employment will prevail than in the case where unemployment benefits are entirely financed by the government. In line with Holmlund and Lundborg (1988) we find that a lump sum subsidy to the UI fund reduces wage demands and improves employment. However, in our set-up this result is not conditional on risk aversion by the unions. Whether the government subsidy is a fixed share of the total cost or a fixed assistance per head makes no difference to wages or employment as long as the government spending per head is equal in the two regimes. However, it can be shown that the sensitivity of wages to improvement in benefits is smaller in the case of a fixed per head subsidy. Also, if the wage setting institutions can influence the level of UI benefits, the per head subsidy is likely to induce a more moderate wage policy.

1.4.4 Essay IV: Unemployment Insurance with Limited Duration and Variable Replacement Ratio - Effects on Optimal Search

The purpose of the fourth essay is to analyse the incentive effects of unemployment insurance in a job search model with endogenous search effort. Following closely the analysis of Pissarides (2000), we first review the effects of UI with a fixed benefit paid indefinitely. We then proceed to consider the implications of a limited potential duration of benefits and a declining time sequence for the replacement ratio. Similar to Mortensen (1977, 1990), we do not aim at determining the optimal UI system, but rather focus on the effects of the UI on search intensity and thereby on employment. Unlike Mortensen, we also allow for a declining time sequence of the benefits. The introduction of a duration limit for the benefits basically makes the model non-stationary and greatly increases the complexity of the model. For this reason we make a number of simplifying assumptions and mostly rely on numerical simulations. We parametrise the model to mimic the stylized facts of the Finnish labour markets, which allows us to draw some conclusions about the unemployment insurance system in Finland. In this respect our analysis is close to that of Kettunen (1991), who assesses the Finnish UI system in a search theoretic framework. However, unlike ours, their model does not allow for the limited potential duration of benefits and the anticipation of future layoffs by the workers.

Our central finding is that the introduction of a limited potential duration of benefits importantly shapes the effects of UI on search behaviour. While a constant benefit paid indefinitely unambiguously reduces the search effort, a benefit system with limited potential duration increases the search effort of those who have been unemployed for some time and have already exhausted a considerable part of their benefits. Concerning the declining time sequence of benefits, we find that if a faster depreciation of the replacement ratio is accompanied by an increase in the initial benefit level so as to keep the present value of the programme intact, the search effort is increased throughout the benefit period. We argue that such a policy is likely to be neutral in terms of the wage pressure and should therefore also lead to higher equilibrium employment.

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1.A Derivation of the Tax Effects in the Union Model

Develop the derivative (1.12) as follows

$$\begin{aligned}
\frac{\partial \Omega}{\partial w} &= -\varepsilon u' (1-\tau_a) + (1-\tau_m)(u' + wu''(1-\tau_a)) \\
&= -(1-\tau_a) u' \left(-\frac{wu''(1-\tau_m)}{u'} - \frac{(1-\tau_m)}{(1-\tau_a)} + \varepsilon \right) \\
&= -(1-\tau_a) u' \left(\frac{(1-\tau_m)}{(1-\tau_a)} (\delta_R - 1) + \varepsilon \right) \qquad (1.21)
\end{aligned}$$

where $\delta_R = \frac{-u''}{u'}(1-t) w \geq 0$ is the coefficient of relative risk aversion. The left hand side of (1.21) is negative if and only if

$$\frac{(1-\tau_a)}{(1-\tau_m)} \varepsilon + \delta_R > 1 \qquad (1.22)$$

with $\delta_R \geq 0$, a sufficient condition for this to hold is that

$$\frac{1-\tau_m}{1-\tau_a} \leq \varepsilon \qquad (1.23)$$

with $\varepsilon > 1$ this clearly holds as long as the tax system is not very regressive in the sense that $\tau_a >> \tau_m$. In particular, (1.23) holds for any proportional on progressive tax function.

1.B Derivation of the Equilibrium with Taxes in the Search Model

The model employed in section 1.1.3 introduces an income tax function on the basic model of Pissarides (2000). With the individual's search cost set to zero, the standard value functions can be written as

$$rU = b + m(\theta)(W - U) \qquad (1.24)$$

$$rW = w - T + \delta (U - W) \qquad (1.25)$$

$$rV = -c + q(\theta)(J - V) \qquad (1.26)$$

$$rJ = x - w + \delta (V - J) \tag{1.27}$$

where W is of being employed and U is the value of being unemployed for a worker, whereas J denotes the value of a filled vacancy and V the value of an open vacancy for the firm. Functions $m(\theta)$ and $q(\theta) = \theta^{-1} m(\theta)$ represent the transition probabilities between employment and unemployment that are dependent on the labour market tightness θ. Imposing the condition for free entry, $V = 0$ and utilising (1.26) and (1.27) produces the job creation equation (1.17) in the main text.

The standard assumption in the search models is that the wage rate is determined in a Nash bargain between workers and firms by the problem

$$w = \arg\max (W - U)^{\beta} (J - V)^{1-\beta} \tag{1.28}$$

where parameter β reflects the bargaining power of the workers. To derive the first order condition, we differentiate the right hand side of (1.28) with respect to w and set equal to zero to get

$$\beta (J - V) \Omega_W + (1 - \beta)(W - U) \Omega_J = 0 \tag{1.29}$$

where $\Omega_W = \frac{\partial (W-U)}{\partial w}$ and $\Omega_J = \frac{\partial (J-V)}{\partial w}$ and both $W - U$ and $J - V$ are assumed strictly positive. Equations (1.24)-(1.27) can be utilised to derive

$$\begin{aligned} W - U &= \frac{w - T + \delta (U - W)}{r} - \frac{b + m(\theta)(W - U)}{r} \\ J - V &= \frac{x - w + \delta (V - J)}{r} - \frac{-c + q(\theta)(J - V)}{r} \end{aligned}$$

Then, differentiating with respect to the wage rate then yields

$$\begin{aligned} \Omega_W &\equiv \frac{\partial (W - U)}{\partial w} = \frac{1 - T'}{r} \\ \Omega_J &\equiv \frac{\partial (J - V)}{\partial w} = -\frac{1}{r} \end{aligned}$$

Substituting these in (1.29) and some manipulation then yields

$$W - U = \left(1 + \frac{(1 - \beta)}{\beta (1 - T')}\right)^{-1} (J - V + W - U) \tag{1.30}$$

Substitution of (1.25) and (1.27) into the wage rule (1.29) gives

$$(1-\beta)\left(\frac{w-T+\delta(U-W)}{r}-U\right)=\beta\left(\frac{x-w+\delta(V-J)}{r}-V\right)(1-T')$$

which can be solved for the wage rate w to yield

$$w=\frac{\beta(1-T')(x-rV)+(1-\beta)(T+rU)}{1-\beta T'}$$

where we utilised $(1-\beta)(W-U)=\beta(1-T')(J-V)$. In equilibrium with $V=0$ we have then

$$w=\frac{\beta(1-T')x+(1-\beta)(T+rU)}{1-\beta T'} \tag{1.31}$$

Next, notice that under $V=0$ (1.30) implies $W-U=\frac{\beta(1-T')}{1-\beta}J$ and (1.26) reduces to $J=c/q(\theta)$. Substitute these into (1.24) to get

$$rU=b+\frac{\beta}{1-\beta}c\theta(1-T')$$

which can be substituted into (1.31) and rearranged to get the wage setting relation (1.18) in the main text. Finally, normalising the total labour force to unity and equating the flows into and out of unemployment yields

$$\delta(1-u)=m(\theta)u$$

which can be rearranged to yield the the Beveridge curve equation (1.19) in the main text.

Chapter 2

Labour Taxation, Tax Progression and Job Matching - Comparing Alternative Models of Wage Setting

Abstract: *We study the effects of labour taxation on wages, unemployment and efficiency in a search equilibrium model with endogenous job destruction Three alternative hypotheses of wage formation are considered: Nash bargain, monopoly union and efficiency wages. The adverse employment effect of labour taxes is mainly due to prolonged unemployment spells and less so due to increased job destruction. Higher taxes may improve efficiency if the initial equilibrium is suboptimal. If wage setting is based on bargaining, a pure increase in tax progression reduces unemployment, improves the relative position of low-income workers and facilitates the emergence of low-productivity jobs.*

2.1 Introduction

High and persistent European unemployment has given rise to numerous national and international policy advice programmes directed to reduce the structural causes of joblessness. Most of these programmes include suggestions in purpose to mitigate the tax burden on labour, in particular for low-paid wage earners. The European Union Employment Guidelines, for instance, specify the target of "reducing fiscal pressure on labour as well as non-wage labour costs". When appropriate, the measures should be targeted at relatively unskilled and low-paid labour (EU, 2000). Similar targets have been adopted by national governments as, for example, a recent evaluation study shows in the case of Finland (Ministry of Labour, 2002). A typical policy package along these lines would include increased tax allowances on earned income and would thereby mitigate the taxation of low incomes. Introduction of such policies would not only reduce the tax burden on low-productivity workers, but also make the taxation of labour income more progressive[1].

In most of the advice programmes, the recommendation for cutting taxes especially among low-paid workers, is justified by their presumably higher labour supply and demand elasticities (see e.g. CEPR, 1995). Directing tax cuts in this group should thus provide the best results in terms of increased employment. At the same time, much less attention has been paid to the potentially positive employment effects of the implied increase in progressivity of labour taxation. This is despite the fact that tax allowances already constitute a remarkable source of progressivity in personal income taxation in the OECD countries (Wagstaff and van Doorslaer, 2001). Also, there is a considerable amount of both theoretical and empirical evidence suggesting that a pure increase in the tax progression may bring about wage moderation and improve employment (e.g. Lockwood and Manning, 1993, Holmlund and Kolm, 1995, Pissarides, 1998.)

The aim of this paper is to contribute to this discussion by considering the effects of labour taxation and increased tax progression in a search equilibrium model with endogenous job creation and job destruction originating from Mortensen and Pissarides (1994). As for the tax instruments, our analysis covers proportional and progressive tax on labour income as well as a proportional payroll tax. To emphasise the role of wage setting, we consider three alternative hypotheses of wage determination: the Nash bargain, "monopoly union" and efficiency wages[2]. This set-up facilitates an

[1]By progression we mean the poperty that the average tax rate increases with income. A simple way of increasing the overall tax progression is to increase the lower limit of taxable income in a tax schedule that is otherwise proportional. For alternative interpretations of progression see e.g. Atkinson and Stiglitz (1987).

[2]We put "monopoly union" in quotation marks because - as discussed in more detail below - our specification due to Mortensen and Pissarides (1999) differs from the standard definition used in the static models.

interesting comparison between the widely used models of non-competitive wage setting. In particular, we want to find out how alternative assumptions of wage setting affect the employment response to tax policy shocks and to what extent the well known results derived in the static models carry over to the search equilibrium framework. Also, as noted by Pissarides (1998), the inclusion of alternative wage setting mechanisms in the tax policy analysis can be justified by the lack of a definitive model for the European labour market. For instance, a recent study by Rocheteau (2001) argues that both bargain and efficiency wage mechanisms may coexist: which one of the two is binding depends on the prevailing tightness of the labour market.

We find, not surprisingly, that labour taxes have a harmful effect on the steady state employment, irrespective of the wage formation mechanism[3]. The adverse effect is mainly due to reduced labour market tightness and the consequent increase in unemployment duration. However, the magnitude of the effect varies, depending on the wage setting specification. In particular, employment turns out to be much less sensitive to taxation in the models involving wage bargaining. Our results also suggest that increased progression of labour taxes may improve employment with low or even non-existent efficiency cost if wages are set in a bargaining framework. Moreover, we argue that in these models increased progression increases the take-home pay of low-productivity workers and promotes the emergence of less productive jobs.

Our approach is closely related to Pissarides (1998), which compares the effects of labour taxes and tax progression within alternative models of the labour market including a stylized search model. Unlike his, however, our analysis is cast in a search equilibrium with endogenous job destruction and is thereby more general[4]. Mortensen and Pissarides (1999) provide an analysis of labour taxation in a model with endogenous job destruction and Nash bargain over wages, but do not consider the effects of tax progression. They

[3]There are some recent studies with opposite results: Altenburg and Straub (2002) show that proportional labour taxes can actually improve employment in a combined efficiency wage and union bargaining framework. They result stems from decomposing the effective labour input into (endogenous) effort and employment. Kilponen and Sinko (2001) find a positive employment effect of proportinal labour income tax in a monopoly union model with an individual supply of working hours. Their finding is conditional on centralised wage setting and high marginal utility of publicly provided goods.

[4]On the other hand, we do not explicitly consider the role of unemployment benefits and their indexation as Pissarides does, but implicitly confine ourselves to the case where unemployment benefits are fixed in real terms.

also discuss alternative models of wage formation, but do not analyse their implications for the effects of tax policies.

The effects of labour taxes and tax progression in the union models with no explicit modelling of search behaviour has been studied by, for example, Hersoug (1984) and Koskela and Vilmunen (1996) as well as Hansen et al. (2000). Studies by Hoel (1990), Pisauro (1991) and Rasmussen (1998) provide corresponding analysis in the efficiency wage framework.

The structure of the paper is as follows. Section 2.2 introduces the basic model and the alternative models of wage determination. Section 2.3 presents simulations of tax policy effects in alternative model specifications. A summary of the results and some concluding remarks are presented in Section 2.4. Some of the technical details are presented in the Appendices 2.A-2.C.

2.2 The Model

The framework of our analysis is a model of equilibrium unemployment with endogenous job creation and job destruction originally presented in Mortensen and Pissarides (1994). In the standard equilibrium search model the rate of job destruction is exogenously fixed and the effects of , for example, policy shocks on the unemployment rate are dictated by changes in the job creation rate. In reality, even job destruction is affected by policy. In Mortensen and Pissarides' (1994) model the job destruction decision is made endogenous by assuming a distribution for the idiosyncratic productivity shock that faces the filled vacancies. The shocks arrive at a fixed Poisson rate. The firm then chooses an endogenous *reservation productivity* and destroys the jobs whose productivity falls below that threshold. Job destruction generates an endogenous flow of workers into unemployment that is equal with the flow out of unemployment through the matching of open vacancies and unemployed workers. The matching process is described by a standard constant returns to scale matching function.

A noticeable difference to the model exogenous job destruction is that now jobs are heterogeneous in terms of productivity. At any point of time there is a continuum of filled vacancies whose productivity is in the range between the reservation productivity and the highest attainable productivity. This is reflected in the notation where the value functions for employment $W(x)$ and filled vacancy $J(x)$ become dependent on the present productivity of the job x. It is assumed, consistently with free entry and profit maximising behaviour, that a new match always has the highest productivity, which is normalised to unity. The wage rate of a job is determined in Nash bargain once the match is formed and renegotiated after each productivity shock.

In what follows, we use this model as the starting point[5]. We first introduce taxation to the basic model with the Nash bargain on wages. We then proceed to consider the effects of taxation under two alternative hypothes is of wage determination: the monopoly union and the efficiency wage settings.

2.2.1 Individuals

Since jobs are only created at the highest productivity level ($x = 1$) the expected present value of unemployment search U is defined by

$$rU = b - a + \lambda \left(W\left(1\right) - U \right) \tag{2.1}$$

where b is the value of leisure or "home production", a is the net cost of search per period and W is the expected present value of a work offer. Furthermore, r is the discount rate of interest and λ is the endogenous probability of encountering a vacancy. For a worker employed in a job with productivity x we have

$$rW\left(x\right) = \left(1-t\right)w\left(x\right) - g + \delta \left[\int_0^1 \max \left(W\left(z\right), U \right) dF\left(z\right) - W\left(x\right) \right] \tag{2.2}$$

where w is the wage rate and δ is the exogenous probability of an idiosyncratic productivity shock. The distribution of the shock described by a cumulative density function $F(x)$, $F'(x) > 0$ within the interval $[0, 1]$. After a shock, the job either continues to exist with new productivity or is "destructed" if the value of the job falls below that of unemployment search i.e. $W\left(x\right) < U$. Furthermore, g and t are income tax parameters such that the income tax paid by an employed worker per period is

$$T = g + tw(x) \tag{2.3}$$

Notice that with $g = 0$ the tax schedule is purely proportional. With $g < 0$, the tax schedule is progressive and with $g > 0$, regressive. The *after tax wage*

[5] We apply some simplifications relative to Mortensen and Pissarides (1994). For example, we do not allow for a general productivity shock, bacause it is less interesting for the issue at hand. The notation used follows closely that of Pissarides (2000).

or take-home pay of a job with productivity x is then given by $(1-t)\,w(x)-g$. For later purposes, notice that (2.2) can be written as

$$W(x) = \frac{(1-t)\,w\,(x) - g + \delta\,(UF\,(R) + S_W)}{r+\delta} \tag{2.4}$$

where R is the endogenous reservation productivity to be determined below and $S_W = \int_R^1 W\,(z)\,F\,(z)$ is the average value for a worker of a filled job.

2.2.2 Firms

Since jobs are created at the highest productivity level, the value of a vacancy V is given by

$$rV = -c + \eta\,(J\,(1) - V) \tag{2.5}$$

where c is the cost of a vacancy per period, η is the probability of encountering an unemployed worker [6]and $J\,(1)$ is the value of a filled vacancy. The value of a filled vacancy with productivity x is given by

$$rJ\,(x) = x - (1+s)\,w\,(x) + \delta\left[\int_0^1 \max\left(J\,(z)\,,V\right)dF\,(z) - J(x)\right] \tag{2.6}$$

where s is the proportional payroll tax levied on the employer. Again, we find it useful to rewrite (2.6) in the form

$$J\,(x) = \frac{x - (1+s)\,w\,(x) + \delta\,(VF\,(R) + S_J)}{r+\delta} \tag{2.7}$$

where $S_J = \int_R^1 J\,(z)\,F\,(z)$ is the average value for the firm of a filled job.

2.2.3 Matching

Following the standard assumption in this type of models, the friction related to finding a suitable partner is summarised by a modelling device known as the matching function[7]. The matching function is defined over unemployed

[6] η is necessarily linked to λ, which is made explicit below.

[7] Pissarides (2000) provides more discussion on the general underpinnings of matching functions. Matching functions have also been estimated empirically for a number of countries with somewhat mixed results with respect to, for example, the returns to scale. A compact review of empirical results can be found in Broersma and van Ours (1999).

workers and vacancies and exhibits constant returns to scale. Then the probability of an unemployed worker receiving a work offer can be defined as

$$\lambda = m(\theta) \tag{2.8}$$

where m is the matching function divided by the number of unemployed workers and θ is the ratio of vacancies to the unemployed referred to as the labour market tightness. Consequently, the probability of a firm with a vacancy encountering an unemployed worker is given by

$$\eta = \theta^{-1} m(\theta) \tag{2.9}$$

Below, we specify a Cobb-Douglas matching technology with

$$m(\theta) = \theta^{\rho} \tag{2.10}$$

where $0 < \rho < 1$. With this specification and the notion that the expected duration of a job vacancy is the inverse of (2.9), we notice that the elasticity of the expected duration of a vacancy with respect to the number of vacancies is $(1 - \rho)$.

2.2.4 Nash Bargain on Wages

The standard assumption in this class of models is that the surplus associated with a job match is shared between workers and firms in a Nash bargain over wages. Importantly, given the transferable utility between the two parties, the Nash bargain guarantees the individual rationality of job destruction decisions (Mortensen and Pissarides, 1999). In our notation, the match specific Nash wage is determined by

$$w(x) = \arg\max (W(x) - U)^{\beta} (J(x) - V)^{1-\beta} \tag{2.11}$$

where $0 < \beta < 1$ is an exogenous parameter reflecting the relative "bargaining power" of workers. In the symmetric case β equals one half. It can be shown (see e.g. Pissarides, 2000) that if β is equal to the elasticity of the expected duration of a vacancy with respect to the number of vacancies, the equilibrium produced by the model with no taxes is socially efficient. This result generally holds for homogenous of degree one matching functions and is referred to as the Hosios condition (Hosios, 1990)[8].

[8] Satisfaction of the Hosios condition implies that the externalities related to search are internalised in the wage setting. Generally, this is not the case under the Nash bargain (see

The first order condition related to (2.11) can be written in the form (see Appendix A for details)

$$\frac{W(x) - U}{J(x) - V + W(x) - U} = \frac{\beta(1-t)}{(1+s) - \beta(s+t)} \tag{2.12}$$

where the numerator of the left hand side, $W(x) - U$ is the surplus of a worker and the denominator $J(x) - V + W(x) - U$ is the total surplus of a match. Expression (2.12) thus conveniently shows the effect of taxes on the worker's relative share of the surplus from a job. Differentiating the right hand side shows that an increase in either of the proportional tax rates, s or t, reduces the worker's relative share of the surplus. Intuitively, this is because taxes that are proportional to wages induce a common incentive to wage moderation for the worker and the firm, as noticed by Pissarides (2000). The per head tax g does not have this property and only affects the total surplus leaving the relative shares unaffected. Therefore, g is absent from the right hand side of (2.12).

For later purposes, we substitute (2.4) and (2.7) in (2.12) and solve for $w(x)$ (see Appendix A for details) to get

$$w(x) = \beta\frac{(x - rV)}{1+s} + (1-\beta)\frac{rU + g}{1-t} \tag{2.13}$$

which is the wage equation in flow form. Equation (2.13) shows that the resulting wage rate is a weighted average of the fall back position of the worker, rU, and the productivity of a match net of the flow return of holding a vacancy $(x - rV)$, both of which are corrected for the relevant taxes. It is worth noting that we cannot determine the effect of tax parameters on wages owing to the endogeneity of U and V.

2.2.5 Equilibrium with Taxes

The labour market equilibrium is defined by imposing the conditions for free entry and mutual acceptance of job destruction. Free entry for firms is assumed to bring the value of a vacancy to zero

$$V = 0 \tag{2.14}$$

Pissarides, 2000). In the present set-up, with (2.10) applying, satisfaction of the Hosios condition would require $\beta = 1 - \rho$.

With (2.14) holding, the mutual acceptance of job destruction implies[9]

$$W(R) - U = J(R) = 0 \tag{2.15}$$

Utilising (2.14), we may also rewrite (2.13) as

$$w(x) = \frac{\beta x}{1+s} + \frac{1-\beta}{1-t}(rU + g) \tag{2.16}$$

Substituting this in (2.7), under (2.14) and rearranging then gives

$$(r+\delta) J(x) = (1-\beta) x - \frac{1+s}{1-t}(1-\beta)(rU+g) + \delta S_J \tag{2.17}$$

To get a more convenient expression for the value of a filled job, we notice that $J(x)$ is linear in x and develop the Taylor series around $J(R) = 0$ to get

$$J(x) = \frac{1-\beta}{r+\delta}(x - R) \tag{2.18}$$

Applying (2.17) at the level of reservation productivity ($x = R$) and further substituting (2.18) for $J(z)$ yields

$$rU + g = \frac{(1-t) R}{(1+s)} + \frac{(1-t)\delta}{(1+s)(r+\delta)} \int_R^1 (z - R)\, dF(z) \tag{2.19}$$

To express the left hand side more conveniently, apply the wage equation (2.12) to $x = 1$ with (2.14) binding to get

$$W(1) = U + \frac{(1-t)\beta}{(1+s)(1-\beta)} J(1) \tag{2.20}$$

Then notice that with (2.14) binding, (2.5) implies

$$J(1) = \frac{c}{\eta(\theta)} \tag{2.21}$$

which shows that for a given labour market tightness, the value of a new match increases in the recruiting cost, c. Next, substituting (2.20) and (2.21) in (2.1) yields

[9] Alternatively, (2.15) follows from (2.12) and (2.14) and the condition that total surplus from a match is zero at the reservation productivity i.e. $J(R) - V + W(R) - U = 0$.

$$rU = b - a + \frac{(1-t)\,\beta c\theta}{(1-\beta)\,(1+s)} \tag{2.22}$$

where we utilised for $\lambda = m(\theta)$ and $\eta = \theta^{-1}m(\theta)$ as defined in (2.8) and (2.9). Notice that substituting (2.22) in (2.16) yields yet another useful form of the wage equation

$$w(x) = (1-\beta)\,\frac{b-a+g}{1-t} + \beta\frac{x+c\theta}{1+s} \tag{2.23}$$

which shows the dependency of wages (for given labour market tightness) on the value of leisure b search cost a and the cost of holding a vacancy c. Wages depend positively on the labour market tightness, because the expected cost for the firm to find another match increases. This is reflected by the term $c\theta$ in the right hand side of (2.23). Similarly, wages depend positively on vacancy cost c for given labour market tightness. Then, substituting (2.22) in (2.19) gives

$$\frac{(1+s)}{(1-t)}\,(b-a+g) + \frac{\beta c\theta}{(1-\beta)} = R + \frac{\delta}{(r+\delta)}\int_R^1 (z-R)\,dF(z) \tag{2.24}$$

which is the *job destruction condition in the presence of taxation* and constitutes an upward sloping curve in (θ, R) space. For given labour market tightness, (2.24) implies a positive relationship between the tax parameters and the reservation productivity. Thus, an increase in any of the tax parameters implies an upward shift of the curve.

Finally, to derive another independent equation in the two unknowns, apply (2.18) to $x = 1$ and substitute (2.21) for the value of a job to get

$$c = \frac{1-\beta}{r+\delta}\eta(\theta)\,(1-R) \tag{2.25}$$

which is the *job creation condition* and constitutes a downward sloping curve in (θ, R) space. The labour market equilibrium in the presence of taxation is the tuple (θ, R) defined by (2.24) and (2.25). It is worth noting that the tax instruments do not enter the job creation condition (2.25). Intuitively, with given labour market tightness, the reservation productivity is sufficient to transmit the effects of the tax changes to a job creation decision based on the free entry condition (2.14).

Having derived the two endogenous variables, labour market tightness and reservation productivity, the dynamics of the unemployment rate can be described simply by

$$\frac{du}{dt} = \delta F(R)(1-u) - m(\theta)u \tag{2.26}$$

where the first term on the right hand side is the flow into unemployment and the second term is the flow out of unemployment. Setting the left hand side equal to zero, the *steady state unemployment rate* can be derived as

$$u = \left(1 + \frac{m(\theta)}{\delta F(R)}\right)^{-1} \tag{2.27}$$

With $m'(\theta), F'(R) > 0$, equation (2.27) shows that the equilibrium rate of unemployment decreases in the labour market tightness and increases in the reservation productivity.

Turning to the effects of taxation, the job destruction condition (2.24) immediately reveals that the introduction of either a proportional tax on income or a payroll tax has identical effects on the equilibrium if the rates are chosen such that

$$(1+s) = (1-t)^{-1} \tag{2.28}$$

With the help of (2.23) it is then easy to see that the gross labour cost $(1+s)w(x)$ is also identical for the two cases under (2.28). The net wage $w(x)$ is lower in proportion to $(1+s)$ if a payroll tax is used, which guarantees that revenues in the two cases are equal. Thus, the so-called wedge argument applies and the real effects of a proportional income and a proportional payroll tax are identical in the model[10]. In what follows, we therefore mainly concentrate on the former.

Following Pissarides (2000), it is straightforward to show that the equilibrium with taxes is socially efficient if the matching elasticity parameter ρ satisfies the Hosios condition $\beta = 1 - \rho$ already discussed above, and the tax parameters are chosen to satisfy the following condition

$$g = \frac{-(b-a)(s+t)}{1+s} \tag{2.29}$$

[10] With the tax wedge we refer to the situation where the effects of the tax are independent of the nominal incidence and the wedge $\frac{(1+s)}{(1-t)}$ is a sufficient statistic to describe the level of taxation (see e.g. Layard et al.,1991).

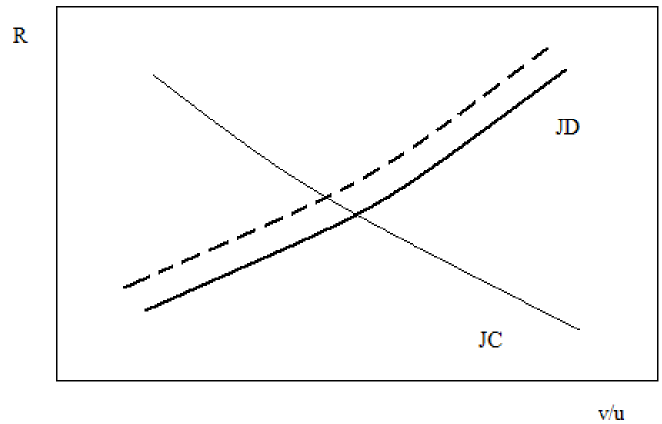

Figure 2.1: Effect of higher labour taxes in the model with the Nash bargain on wages: the upward sloping job destruction schedule shifts up and to the left with a consequent drop in the labour market tightness (v/u) and an increase in the reservation productivity R.

which in effect makes (2.24) equal to the case with no taxes. For an interpretation of (2.29), it is helpful to notice that the per head tax g essentially corresponds to a subsidy to leisure or home production. What (2.29) then states is that if the value of home production net of search cost $(b - a)$ is subsidised at a rate equal to the effective tax rate on wages, the overall tax system is neutral with respect to job creation and destruction. However, if $\beta \neq 1 - \rho$ the no tax equilibrium is inefficient and "full efficiency" cannot be restored with the available tax instruments[11].

The effects of exogenous changes in the tax rates can be presented diagrammatically in the (θ, R) space: An increase in either of the tax parameters shifts the job destruction schedule to the left, whereas the job creation schedule remains stable. Consequently, labour market tightness reduces and reservation productivity increases in response to higher taxation (Figure2.1). With the help of equations (2.12) and (2.18) it is then straightforward to

[11] If $\beta \neq 1 - \rho$, an approriate combination of the tax instruments can, however, improve efficiency over the no tax equilibrium, as we will show below in one of the simulations.

show that the value of a filled vacancy $J(x)$ as well as the worker's surplus $(W(x) - U)$ drops owing to higher taxes. Consequently, the total surplus of a match with productivity x is reduced. As for the wage rate, rearranging equation (2.23) reveals that an increase in any of the three tax parameters unambiguously reduces the after tax wage $(1 - t)\, w(x) - g$. With reference to (2.26) and (2.27) it is clear that an increase in any of the tax parameters leads to increased flow into unemployment and reduced flow out of unemployment at the initial level of employment and consequently into higher a rate of unemployment in the steady state. These findings can be summarised by the following proposition:

Proposition 2.1 *In the model where wages are determined in a standard Nash Bargain between firms and workers, an increase in proportional or per head labour tax causes an increase in the reservation productivity R and a decline in the labour market tightness θ. Consequently, equilibrium unemployment increases and the after tax wage of employed workers drops.*

The results stated in proposition 2.1 are in line with the findings of Mortensen and Pissarides (1999), who show that an increase in the proportional payroll tax increases reservation productivity and reduces labour market tightness[12].

2.2.6 Monopoly Union Wage Setting

Above, we employed the standard assumption in search models that wages are an outcome of a Nash bargain between firms and workers. When setting the wage, firms and workers took the action of other agents, and therefore the aggregate variables, as given. Also, the parameter β reflecting worker's bargaining power and relative share of the surplus was exogenously fixed.

In this section, we consider an alternative model of wage setting that involves the endogenous determination of β. In particular, we employ the "monopoly union" formulation suggested by Mortensen and Pissarides (1999). In this set-up - in order to preserve the individual rationality of job destruction - the monopolistic position of a trade union is captured by allowing the union to decide upon the value of β rather than directly dictate the wage rate. When setting β, the union takes full account of the implications of its

[12] It was pointed out by my examiners that Mortensen and Pissarides (2002) have also shown that the per head labour income tax has similar effects.

act for the decisions made by the individual agents. After β has been set, the Nash wage rule applies and firms and workers respond by making the appropriate job creation and destruction decisions[13].

Having stated the basic structure of the problem, we are left with the determination of the union's objective. Importantly, Pissarides (2000) shows that if the union were to maximise the expected utility of an unemployed worker, it would set the worker's share parameter equal to the elasticity of the expected duration of a vacancy with respect to the number of vacancies. This would guarantee the satisfaction of the Hosios condition and the equilibrium would be efficient. We employ, instead, the approach suggested by Mortensen and Pissarides (1999), where the objective of the union is to maximise the expected utility of a median member (see also Booth, 1995). With more than half of the members working, the median member will be employed. With the notation introduced in the previous section, with the use of (2.12), (2.14) and (2.18) the value function of the median worker can be written as

$$W(x_m) = U + \frac{(1-t)\,\beta\,(x_m - R)}{(r+\delta)\,(1+s)} \tag{2.30}$$

where $x_m > R$ is the productivity of the job held by the median member. According to (2.30), the value of a job held by the median member is a mark-up over the value of unemployment search U. The size of the mark-up increases in the job productivity x_m as well as in the worker's share parameter β, and decreases in the reservation productivity R.

The problem of the union is then to maximise the right hand side of (2.30) with respect to β, allowing for the fact that U and R are endogenous. Differentiating (2.30) with respect to β and setting equal to zero yields the first order condition for the union optimum

$$\frac{\partial W(x_m)}{\partial \beta} = \frac{\partial U}{\partial \beta} + \frac{(1-t)}{(r+\delta)\,(1+s)}\left((x_m - R) - \beta\frac{\partial R}{\partial \beta}\right) = 0 \tag{2.31}$$

To develop (2.31) further, we need to derive suitable expressions for U and R, respectively. Starting with U, we assume that the productivity shock is

[13] It is worth noting that this formulation is somewhat different from the standard meaning of the monopoly union in the static models. Rather than just altering the bargaining power of the union, this formulation clearly adds some features of centralised wage setting to the model (e.g. Calmfors & Driffill, 1988).

evenly distributed in the interval $]0,1[$ (see Appendix B) and apply equation (2.19) to get

$$rU = \frac{(1-t)}{(1+s)} \frac{2Rr + \delta R^2 + \delta}{2(r+\delta)} - g \tag{2.32}$$

As for the reservation productivity R, we solve the job destruction condition (2.24) for θ and substitute this in the job creation condition (2.25) to get

$$\frac{(1-\beta)^{\rho}(1-R)}{r+\delta}\left(\frac{R(2r+R\delta)+\Theta(s,t,g)}{2\beta(r+\delta)c}\right)^{-(1-\rho)} = c \tag{2.33}$$

where $\Theta(s,t,g) \equiv \delta - 2(1+s)(1-t)^{-1}(r+\delta)(b-a+g)$ is a constant incorporating the tax parameters. Equation (2.33) thus implicitly defines R as a function of β. Applying the implicit rule to (2.33) we then have

$$\frac{\partial R}{\partial \beta} = \frac{(1-\beta-\rho)(1-R)}{\beta(1-\beta)\left(1+2\left(2Rr+R^2\delta+\Theta(s,t,g)\right)^{-1}(1-\rho)(1-R)(R\delta+r)\right)} \tag{2.34}$$

Notice that setting the right hand side equal to zero implies $\beta = 1-\rho$, which is the Hosios condition in our set-up. This finding reflects the property of the basic model that the reservation productivity achieves its maximum at the social optimum, as shown by Mortensen and Pissarides (1999).

Differentiating (2.32) with respect to β and substituting into (2.31) for $\partial U/\partial\beta$ we can rewrite the first order condition as

$$\frac{(1-t)(x_m-R)}{(r+\delta)(1+s)} + \frac{(1-t)(r+R\delta-\beta r)}{r(r+\delta)(1+s)}\frac{\partial R}{\partial \beta} = 0 \tag{2.35}$$

Rearranging (2.35) to solve for $\partial R/\partial\beta$ then yields

$$\frac{\partial R}{\partial \beta} = -\frac{r(x_m-R)}{R\delta + r(1-\beta)} < 0 \tag{2.36}$$

which shows that at the union's optimum $\frac{\partial R}{\partial \beta} < 0$ and thus $\beta > 1-\rho$ implying that the union sets β higher than would be socially optimal. Consequently, the reservation productivity R will be lower than at the social optimum. Finally, substituting (2.34) for $\frac{\partial R}{\partial \beta}$ in (2.36) and some manipulation yields

$$\frac{2(1-\rho)(1-R)(R\delta+r)}{2Rr+\delta R^2+\Theta(s,t,g)} = \frac{R(1-\rho)-\beta x_m+(1-\beta-\rho)\left(\frac{\delta R(R-1)}{r(1-\beta)}-1\right)}{\beta(x_m-R)} \tag{2.37}$$

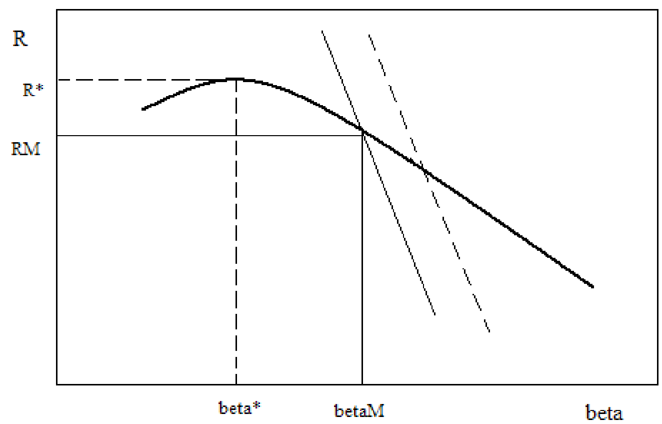

Figure 2.2: The equilibrium of the monopoly union case depicted in the (β, R) space. The reservation productivity R_M is lower and the workers share β_M is higher than in the efficient outcome (β^*, R^*). An increase in the median voter's productivity induces a rightward shift in the locus defined by (2.37) and increases the deviation from efficiency.

where $\Theta(s, t, g)$ is as defined above in (2.33). Equation (2.37) defines a locus in (β, R) space that satisfies the monopoly union condition. It is worth noting that all three tax rates enter the equation. Assuming that the second order condition holds, it can be shown that the locus is downward sloping. The labour market equilibrium with monopoly union wage determination is the three tuple (β, R, θ) defined by (2.24), (2.25) and (2.37). The wage rate is then determined by (2.23). Notice that by differentiating (2.37) with respect to x_m and β it is possible to show that an increase in the median voter's productivity induces a rightward shift of the locus, causing an increase in β and a further reduction in R (Figure 2.2). These findings (for the no-tax case) can be summarised as follows:

Lemma 2.2 *In the model where a monopoly union maximises the utility of a median member, the parameter β reflecting the worker's share in the Nash bargain is set above the socially efficient level. This implies lower reservation productivity and insufficient job destruction in the equilibrium. The deviation* *from efficiency increases with the productivity of the median member.*

Lemma 2.2 is in line with the findings of Mortensen and Pissarides (1999), who argue that, in general, the monopoly union formulation leads to a higher worker's share and a lower reservation productivity than would be socially optimal.

As for the effects of taxation, it is useful to consider the equilibrium in (β, R) space defined by the intersection of the two loci defined by (2.33) and (2.37). Differentiating (2.33) with respect to the tax parameters for given β shows that higher taxes cause an upward shift in the curve. Similarly, differentiation of (2.37) shows that an increase in one of the tax parameters causes a shift to the right. Consequently, we cannot infer the effect of higher taxation on reservation productivity and the worker's share parameter β. Consequently, the effect of taxes on the labour market tightness θ as well as on wages and employment are a priori ambiguous under the monopoly union specification.

Notice that the sharing rule (2.12) defining the worker's share of the surplus still holds, i.e.

$$\frac{W(x) - U}{J(x) - V + W(x) - U} = \frac{\beta(1-t)}{(1+s) - \beta(s+t)}$$

The difference to the basic model is that β is no longer constant in the equilibrium. By (2.37), the value of β will depend on the tax parameters as well as on the reservation productivity. In addition to the negative direct effect, the proportional tax rates s and t now have an indirect effect through β, which may either mitigate or reinforce the direct effect. As noticed above, the sign of this effect is ambiguous. Our numerical simulations show that, with plausible parameter values, the indirect effect is negative and thus reinforces the drop in the worker's share due to higher proportional taxes.

As for the per head tax g, there is still no direct effect, but now a change in g will affect the worker's share indirectly through β. Thus, the "neutrality" result of the per head tax of the previous section does not hold in the monopoly union framework. With plausible parameter values, the effect of g on the worker's relative share is negative. Therefore, the effects of proportional and per head income taxes are closer to each other in the monopoly union model when compared to the basic model with fixed weights in the Nash bargain on wages. The findings for the monopoly union case can be summarised as follows:

Proposition 2.3 *In the model where a monopoly union maximises the utility of a median member, the effects of either a proportional or per head labour tax on reservation productivity R, labour market tightness θ and the worker's share parameter β are a priori ambiguous.*

2.2.7 Efficiency Wage Setting

As another alternative mechanism of wage determination we consider an "efficiency wage" model based on the well known model of Shapiro and Stiglitz (1984). We utilise the specification by Mortensen and Pissarides (1999) and extend it by the introduction of taxation. In this framework, those who are employed can either exert effort or "shirk"[14]. For the workers, exerting effort is costly, so they need some incentives to do so. Because the productivity of those supplying effort is higher, it is in the interest of the firms that their employees exert effort. If a firm finds someone shirking, he or she will be dismissed and will end up searching for a new job. However, monitoring is imperfect and there is only a positive probability of detecting a less productive worker. The solution to the problem is that firms end up paying a wage rate that makes the workers indifferent between exerting effort and "shirking". This wage level is referred to as the "efficiency wage".

In this set-up, utilising the notation introduced above and allowing for the tax instruments as defined in (2.3), the valuation of a job by an employed worker exerting effort can be written as

$$rW_e(x) = (1-t)\,w - g + \delta\left[UF(R) + S_e(x) - W_e(x)\right] \tag{2.38}$$

where $S_i = \int_R^1 W_i(x)\,dF(x)$, $i = e, s$ is the average value of a filled job for a worker exerting effort e and for a shirker s, respectively. Similarly, for an employed worker not exerting effort (shirker) we have

$$\begin{aligned} rW_s(x) &= (1-t)\,w - g + e + \delta\left[UF(R) + S_s(x) - W_s(x)\right] \\ &\quad + q\left(U - W_s(x)\right) \end{aligned} \tag{2.39}$$

where e is the value of the extra leisure from exerting no effort and q is the monitoring frequency. Notice that the wage rate based on efficiency

[14] The dichotomy in the level of effort is a simplifying assumption that can be relaxed for a continuous level of effort. For risk-neutral workers, the results will not be affected as shown by Pisauro (1991).

consideration is independent of job productivity, as will be shown below. The valuation of a job for a worker only depends on whether he or she exerts effort. Thus we have

$$W_i(x) = W_i, \forall x, i = e, s \tag{2.40}$$

which implies

$$S_i = W_i \int_R^1 dF(x) = W_i (1 - F(R)) \tag{2.41}$$

Imposing indifference between exerting effort and "shirking" $W_e = W_s = W$ into (2.38) and (2.39) then yields the *no-shirking condition*

$$e = q(W - U) \tag{2.42}$$

Intuitively, the worker is indifferent between working and shirking if the disutility of effort is just equal to the expected loss from shirking. Notice that (2.38) can now be rewritten as

$$rW = (1 - t) w - g + \delta F(R)(U - W) \tag{2.43}$$

For the unemployed, recall (2.1) and apply (2.40) to get

$$rU = b + \lambda (W - U) \tag{2.44}$$

where, for simplicity, we have set $a = 0$ i.e. abstracted from a separate search cost. The efficiency wage can then be solved from (2.42), (2.43) and (2.44) to get

$$w = \frac{b + g}{1 - t} + \frac{e(r + \lambda(\theta) + \delta F(R))}{q(1 - t)} \tag{2.45}$$

According to (2.45), wages depend positively on both labour market tightness θ and reservation productivity R. Intuitively, labour market tightness puts an upward pressure on wages because finding another job becomes easier for a potential shirker. Wages increase in reservation productivity because jobs became more insecure with higher R. Furthermore, for given labour market tightness and reservation productivity, wages decrease in the monitoring frequency q and increase in the value of extra leisure to a shirker e as well as in the proportional and per head income taxes, t and g. However, slightly rearranging (2.45) shows that for given labour market tightness and reservation productivity, the after tax wage $(1 - t) w - g$ is independent of taxes. Intuitively, as long as the threat point of a potential shirker has not changed, the after tax remuneration needed to attract effort is invariable. Whether after tax wages increase or decrease after a tax hike thus depends on the indirect effects through θ and R.

To determine the labour market equilibrium in the efficiency wage case, we note that the reservation productivity is now determined by (with (2.14) binding)

$$J(R) = 0 \tag{2.46}$$

Substituting wage equation (2.45) in (2.7) under (2.14) and rearranging gives

$$(r+\delta) J(x) = x - (1+s)\left(\frac{b+g}{1-t} + \frac{e(r+\lambda(\theta)+\delta F(R))}{q(1-t)}\right) + \delta S_J \tag{2.47}$$

which corresponds to (2.17) in the basic model. Again, developing a Taylor series around $J(R) = 0$ yields

$$J(x) = \frac{1}{r+\delta}(x-R) \tag{2.48}$$

Applying (2.47) to $x = R$ (and (2.46)) and further substituting (2.48) for $J(z)$ gives

$$\frac{(1+s)}{1-t}\left(b+g+\frac{e}{q}(r+\lambda(\theta)+\delta F(R))\right) = \frac{\delta}{r+\delta}\int_R^1 (z-R)\,dF(z) + R \tag{2.49}$$

which is the *job destruction condition in the efficiency wage model* and constitutes an upward sloping schedule in the (θ, R)-space by an appropriate choice of the exogenous parameters [15]. To derive another independent equation in the two unknowns, first notice that with (2.14) binding, (2.5) still implies

$$J(1) = \frac{c}{\eta(\theta)} \tag{2.50}$$

which is (2.21). Next, apply (2.48) to $x = 1$ and substitute (2.21) for the value of a job to get

$$c = \frac{(1-R)}{r+\delta}\eta(\theta) \tag{2.51}$$

[15] Mortensen and Pissarides (1999) have shown that generally the job destruction schedule may be non-monotonic in the case of efficency wages and therefore multiple equilibria may arise.

which is the *job creation condition in the efficiency wage model* and constitutes a downward sloping curve in (R, θ) space.

By inspecting the equilibrium conditions, it is easy to see that the equivalence of proportional income tax and the payroll tax still holds under the condition (2.28). Furthermore, in the efficiency wage set-up, the proportional income tax is equivalent to the per head tax as long as rates are chosen such that $g = tw$. This can be verified by imposing $t = 0$ and $g = t_0 w$ into (2.45) and (2.49); the resulting equilibrium will be identical to the case where $t = t_0$ and $g = 0$[16].

The efficiency wage equilibrium with taxes is the tuple (R, θ) defined by the intersection of curves (2.49) and (2.51). Similar to the basic model with the Nash bargain over wages, tax parameters only enter the job destruction condition (2.49). Differentiating (2.49) shows that an increase in any of the tax parameters causes a shift up and to the left for the job destruction curve. Since the job creation schedule remains stable, higher taxes unambiguously cause an increase in the reservation productivity and a decline in the labour market tightness. By (2.27), this implies a higher steady state rate of unemployment.

It is worth noting that combining (2.42), (2.14) and (2.18) we can derive the following expression for the worker's share of the surplus in the efficiency wage equilibrium

$$\frac{W - U}{J(x) - V + W - U} = \left(1 + \frac{q(x - R)}{e(r + \delta)}\right)^{-1} \tag{2.52}$$

Expression (2.52) reveals that the tax rates affect the worker's relative share only indirectly through the reservation productivity R, which - as argued above - increases with any one of the three tax parameters. Since by (2.52) the worker's share increases in R, we can conclude that higher taxes increase the worker's relative share of the surplus in the efficiency wage specification. This is a clear contrast to the models with wage bargaining presented in the previous sections. As for the wages, equation (2.45) reveals that the induced changes in the endogenous variables by a tax hike (higher R and lower θ) cause two opposite effects on the after tax wage. Consequently, the overall

[16] It has been shown in models not allowing for search behaviour that the equivalence of proportional and per head taxes is a special feature of the Shapiro-Stiglitz model, which does not necessarily hold in more versatile extensions of the efficiency wage models (e.g. Pisauro, 1991 and Rasmussen, 1998).

effect of taxation on take-home pay is ambiguous[17]. The findings for the efficiency wage model can be summarised as follows:

Proposition 2.4 *In the model where wages are determined according to a standard efficiency wage rule, an increase in proportional or per head labour tax causes an increase in the reservation productivity R and a decline in the labour market tightness θ. Consequently, equilibrium unemployment increases, but the effect on the after tax wage is ambiguous.*

2.3 Simulations

In the previous section we derived the equilibrium of the labour market under alternative assumptions concerning the process of wage determination. We already noticed that the effects of tax parameters differ, depending on the prevailing wage setting mechanism. In this section we put the formulas to work to find more specific quantitative responses to changes in the tax policy. For that purpose, we specify the functional form of the matching function and the distribution of the productivity shock. We then choose some plausible numerical values for the exogenous parameters of the model.

Before turning to the simulations, we derive formulas for a few aggregate variables that will be used in reporting the simulation results. Let us first define the *unemployment incidence* as

$$I \equiv \delta F(R) \tag{2.53}$$

and the *expected duration of an unemployment spell* as

$$D \equiv \theta^{-\rho} \tag{2.54}$$

which is simply the inverse of the matching probability. According to (2.27) the steady state unemployment depends positively on the unemployment incidence and on the expected duration of an unemployment spell. It is worth noting that (2.27) can also be interpreted as the equation of the Beveridge curve, as shown in Pissarides (2000). To develop a measure of overall welfare,

[17] It turns out in the numerical simulations that the effect through lower labour market tightness dominates and after the tax wage drops if taxes are increased in the efficiency wage set-up.

notice that the steady state aggregate income net of search and recruiting costs y can be defined as

$$y = \left(F\left(R\right) + \int_R^1 x dF\left(x\right) \right) \left(1 - u\right) + \left(b - a - c\theta\right) u \tag{2.55}$$

where the first term on the right hand side defines the total product in steady state with $F\left(R\right)$ representing the fraction of matches of type $x = 1$ (see Appendix C for details). Notice that the value of leisure is taken as exogenous income and the incomes are defined gross of taxes. Finally, the total tax revenue collected by the three tax rates is given by (see Appendix C for details)

$$\begin{aligned} T &= \left[\left(\frac{(1-\beta)}{1-t} \left(b - a + g\right) + \frac{\beta}{1+s} \left(c\theta + 1 - \frac{1}{2} \left(1 - R\right)^2 \right) \right) \left(t + s\right) + g \right] \\ &\quad \times \left(1 - u\right) \end{aligned} \tag{2.56}$$

To facilitate the simulations, we have to specify a distribution for the productivity shock. For simplicity, we employ the assumption already utilised above in the monopoly union set-up that x is evenly distributed in the interval $[0, 1]$. With this assumption and after substituting (2.10) in (2.24) and (2.25), the aggregate income, the job destruction condition and the job creation condition for the Nash bargain model can be rewritten as follows (see Appendix B for details):

$$y = \left(1 - \frac{1}{2} \left(1 - R\right)^2 \right) \left(1 - u\right) + \left(b - a - c\theta\right) u \tag{2.57}$$

$$\frac{(1+s)}{(1-t)} \left(b - a + g\right) + \frac{\beta c\theta}{(1-\beta)} = R + \frac{\delta \left(1 - R\right)^2}{2 \left(r + \delta\right)} \tag{2.58}$$

$$c = \frac{1-\beta}{r+\delta} \theta^{\rho - 1} \left(1 - R\right) \tag{2.59}$$

The endogenous worker's share parameter is determined by equation (2.37), which has to be added to (2.57)-(2.59) to form the monopoly union model. As for the efficiency wage model, the job destruction condition (2.49), job creation condition (2.51) and the wage equation (2.45) simplify to

$$\frac{1+s}{1-t} \left(b + g + \frac{e}{q} \left(r + \theta^{\rho} + \delta \left(R - \gamma\right)\right) \right) = \frac{\delta \left(1 - R\right)^2}{2 \left(r + \delta\right)} + R \tag{2.60}$$

$$c = \frac{1-R}{r+\delta}\theta^{\rho-1} \tag{2.61}$$

$$w = (1-t)^{-1}\left(b + g + \frac{e\left(r+\theta^{\rho}+\delta R\right)}{q}\right) \tag{2.62}$$

At this stage, we could choose the exogenous parameters of the model to reflect the stylized facts of some particular economy (see e.g. Millard and Mortensen, 1997, Holm et al., 1999). However, we prefer to rely on the values that roughly correspond to the ones used in earlier studies on policy impact (Pissarides,1998 and Mortensen and Pissarides, 1999). Following common practice, the matching function elasticity parameter ρ is chosen so as to satisfy the Hosios condition in the case of a symmetric Nash bargain ($\beta = 0.5$). The quarterly discount rate r is set at 1 per cent. The value of leisure b is set at 0.6 to reflect the average replacement ratio provided by the unemployment insurance. The remaining parameter values are adjusted so as to produce a reasonably low unemployment rate (1.5 per cent) at the no-tax benchmark of the Nash bargain model. The extra parameters of the monopoly union model (median worker productivity x_m) and efficiency wage model (value of extra leisure e and monitoring frequency q) are then chosen so that the unemployment rate with no taxes in these models is close to that in the Nash bargain model. The exact parameter values used in the simulations are presented in Table 2.1.

a	b	c	r	s	ρ	δ	x_m	e	q
0.2	0.6	0.2	0.01	0.0	0.5	0.03	0.98	0.1	0.5

Table 2.1: The parameter values used in the model simulations. a is the search cost per period, b is the value of leisure gross of search cost, c is the per period cost of holding a vacancy, r is the (quarterly) rate of discount, s is the payroll tax, ρ is the matching elasticity parameter, δ is frequency of a productivity shock, $x_m$is the productivity of the median worker, e is the value of extra leisure for a shirker and q is the monitoring frequency of the firm.

2.3.1 Effects of Labour Taxes

Let us first consider the effect of an exogenous increase in the proportional tax rate on labour income, t. The results of a simulation where t was increased from zero to 0.1 are presented in Table 2.2. The effect on equilibrium job creation and job destruction rates are, as expected, of equal sign irrespective of the wage setting mechanism. The job creation rate is reduced, owing to introduction of the tax leading to longer unemployment spells ($\Delta D > 0$). Reservation productivity increases, causing more job destruction at the given level of employment. This is reflected by the higher unemployment incidence ($\Delta I > 0$)

The main difference between the models is the magnitude of the employment effects. In the efficiency wage models the effects are much larger than in the models with wage bargaining. This reflects the fact derived above in Section 2.2.7 that labour taxes increase the worker's share of the surplus in the efficiency wage model. This is reflected in the much stronger response of wages to a tax hike. In terms of the equilibrium condition, while the job creation condition of efficiency wage model (2.51) is identical to the Nash bargain model, the job destruction schedule (2.49) is much flatter than its counterpart in the bargaining framework.

	t	g	ΔD	ΔI	Δu	Δy
Efficiency wage	0.1	0.0	33.2	0.4	33.5	0.08
Monopoly union	0.1	0.0	3.6	0.1	3.5	−0.004
Nash bargain $\beta = 0.5$	0.1	0.0	4.0	0.1	4.1	−0.002

Table 2.2: Results from the simulations where proportional income taxation was introduced at rate $t = 0.1$. D is the average duration of unemployment spells, I is unemployment incidence, u is unemployment rate and y aggregate income, measuring overall efficiency. The symbol Δ refers to percentage change.

In the monopoly union and Nash bargaining models, the wage and employment responses are much more modest, owing to the wage moderation effect inherent in wage bargaining already discussed above in Section 2.2.4. A higher proportional tax rate reduces the worker's share of the surplus supporting a moderate wage response. Somewhat surprisingly though, the monopoly union does not try to counteract, but rather fortifies wage moderation by reducing β. Thus, the negative employment effect is smallest in the monopoly union model.

The effects of tax changes on the overall efficiency y mainly reflect the efficiency of the selected benchmark in the models. In the efficiency wage model, unemployment is below the efficient level in the no tax equilibrium and efficiency slightly improves after a tax hike. In the monopoly union model, the opposite is true. In the Nash bargain model the no tax equilibrium is efficient and cannot be improved with tax policy, as discussed above in Section 2.2.5. Therefore, efficiency necessarily drops when taxes are increased.

The effects on key endogenous variables of an increase in the per head tax g is presented in Table 2.3. The results are relatively similar to those of the proportional tax. In fact, for the efficiency wage model, the effects of the two taxes would be identical, if the rates were chosen in such a way that $g = tw$ and, with our choice of parameters, the equilibrium wage is close to unity. The main difference to the proportional tax is that now the wage and employment response in the bargaining models is not so much apart from the efficiency wage model. As noticed in Sections 2.2.4 and 2.2.6, the fixed component of income tax does not reduce the worker's share of the surplus. It does so, however, indirectly in the monopoly union model through lower β. These facts help to explain why the per head tax has a relatively strong effect (in comparison to proportional tax) on unemployment in the Nash bargaining model and a somewhat weaker effect in the monopoly union model.

	t	g	ΔD	ΔI	Δu	Δy
Efficiency wage	0.0	0.1	34.1	0.3	34.3	0.08
Monopoly union	0.0	0.1	8.5	0.25	8.6	-0.01
Nash bargain $\beta = 0.5$	0.0	0.1	9.8	0.25	9.9	-0.009

Table 2.3: Results from the simulations where per head income taxation was introduced at rate $g = 0.1$. D is the average duration of unemployment spells, I is unemployment incidence, u is unemployment rate and y aggregate income, measuring overall efficiency. The symbol Δ refers to percentage change.

2.3.2 Revenue Neutral Progressive Taxation

To compare the response of the alternative wage determination models to a progressive labour taxation, we simulated a simultaneous introduction of proportional wage tax ($t = 0.1$) and a per head tax allowance or subsidy, $g < 0$. The size of the subsidy was adjusted to just exhaust the revenue raised by the proportional tax. Thus, the net revenue raised by the tax system was zero, implying $dT = 0$. This set-up enables us to focus on the effects of pure progression of the tax system. For simplicity, our starting point is the no tax equilibrium of each model, but the results should be applicable to cases with pre-existing (proportional) taxes as well.

	t	g	ΔD	ΔI	Δu	Δy
Efficiency wage	0.1	-0.0985	–	–	–	–
Monopoly union	0.1	-0.0986	-4.5	-0.15	-4.59	–
Nash bargain $\beta = 0.5$	0.1	-0.0986	-5.13	-0.15	-5.18	-0.004
Nash bargain $\beta = 0.55$	0.1	-0.0987	-5.14	-0.15	-5.19	0.008

Table 2.4: Results from the simulations where progressive income taxation was introduced in a revenue neutral manner. D is the average duration of unemployment spells, I is unemployment incidence, u is unemployment rate and y aggregate income, measuring overall efficiency. The symbol Δ refers to percentage change.

The results from the balanced budget simulations are presented in Table 2.4. The results for the efficiency wage model are close to those expected in the case of competitive labour markets. The two taxes are essentially equivalent as long as the rates are chosen in such a way that $g = tw$, which indeed results from the balanced budget constraint. Consequently, higher progression, involving no change in the total tax burden, has no effect on the labour market equilibrium in this case.

In the Nash bargaining and monopoly union models, a revenue neutral introduction of progressive taxation evokes wage moderation and reduces unemployment. The mechanisms behind the result are essentially those discussed above with reference to the isolated increases in the two tax instruments. The only difference is that g now works in the opposite direction. As for the monopoly union case, the adjustment of β (upwards) again mitigates the (this time negative) wage response and leaves the improvement of employment somewhat smaller than in the Nash bargain model. These findings give rise to the following conclusion:

In the models where wages are set in a bargaining framework, a revenue neutral introduction of the tax progression reduces unemployment. In the model where wages are determined according to a standard efficiency wage rule, such a reform is neutral with respect to employment.

As for the effect on aggregate output, it is noteworthy that despite improved employment, efficiency drops in the Nash bargain model (with $\beta = 0.5$). This is a reflection of the fact discussed above in Section 2.2.4 that if the "no tax equilibrium" satisfies the Hosios condition, the efficiency cannot be improved. This is exactly the case in our model when $\beta = 0.5$ (and $\rho = 0.5$ as reported in Table 2.1). Then, introduction of any distortionary policy cannot improve efficiency. To put it differently, the unemployment rate in the no tax equilibrium is exactly at the right level for efficient functioning of the labour market. This does not necessarily hold in a "second best" situation where $\beta \neq 1 - \rho$, as demonstrated by the entries in the last row of Table 2.4. The final row shows the results for the Nash bargaining model where β was fixed to the value of 0.55. The employment effects are close to those of the $\beta = 0.5$ case, but efficiency improves, because unemployment is too high in the initial equilibrium. In the monopoly union case, efficiency remains unchanged, but this result is sensitive to the magnitude of the tax changes.

Finally, we notice that the policy package involving an increase in both the proportional tax and in the per head subsidy affects workers differently depending on their productivity. In the take-home pay of the workers, $(1 - t)\, w(x) - g$, the wage related part declines and the per head part increases (notice that $g < 0$ in the present set-up) for any level of productivity. Because of revenue neutrality, the two effects break even, on average. Consequently, there has to be a threshold level of job productivity at which the take-home pay remains unchanged after the introduction of taxation. For workers in jobs with productivity lower than that, the after tax wage will increase. For workers with productivity higher than the threshold, the after tax income will decline. Thus, the revenue neutral introduction of progressive taxation serves to improve the relative position of workers in the low productivity jobs. Moreover, the induced reduction in the reservation productivity R implies that less productive jobs will become profitable. Thus, the specific tax policy serves to widen the range of active jobs towards less productive occupations. To sum up:

In the models where wages are set in a bargaining framework, a revenue neutral introduction of tax progression increases (decreases) the after tax wage of workers with low (high) productivity and facilitates the emergence of less productive jobs.

2.4 Concluding Remarks

We have considered the effects of labour taxation and tax progression in an equilibrium model of the labour market with endogenous job creation and job destruction. To emphasize the role of wage setting, we applied three alternative hypotheses of wage determination: the standard Nash bargain as well as the monopoly union and efficiency wage specifications suggested by

Mortensen and Pissarides (1999). After deriving the equilibrium with proportional and specific taxes on labour under the alternative wage determination processes, we discussed the key features of the resulting three distinct models.

In all model specifications, the effects of a proportional income tax is equivalent to a proportional payroll tax. Thus, the nominal incidence does not make a difference. Increases in either proportional or per head taxation have an adverse effect on employment at two margins: less vacancies are posted and more jobs are terminated. Our numerical simulations suggest that the former effect is stronger and labour taxation is reflected mainly in prolonged spells of unemployment. At the same time, the magnitude of the negative employment effects are smaller in the models with wage bargaining in comparison to the efficiency wage specification. This can be explained by the finding that higher taxes tend to reduce a worker's share of the match surplus in the bargaining models, but to increase that share in the efficiency wage specification.

Finally, we combine the two tax instruments in a revenue neutral manner to enable a pure increase in the tax progression. We find that the increased progression of labour taxes may improve employment with low or even non-existent efficiency cost if wages are set in a bargaining framework. Moreover, we argue that in these models increased progression increases the take-home pay of low-productivity workers and promotes the emergence of less productive jobs. In the efficiency wage set-up a pure increase in progression is neutral in terms of employment.

Despite the somewhat different framework, our results are broadly in line with those of Pissarides (1998), who suggests that a revenue- neutral increase in the tax progression comes close to a "free lunch". From a policy point of view, these findings might provide another justification for the tax reforms that aim to mitigate the tax burden of the low-income workers by introducing tax exemptions and increasing the lower limit for taxable income. Also, to the extent that formulation of the "monopoly union" case can be interpreted as representing more centralised wage bargaining, the results may help to explain the recent empirical findings that suggest that the employment effects of labour taxes tend to be smaller in the corporatist economies (Daveri and Tabellini, 2000, Kiander et al, 2000).

As for future research, it would be interesting to try to fit the models with more realistic parameter values. As this may prove relatively difficult, the sensitivity of the results to changes in the parameter values should be more rigorously considered. A characteristic feature of the models employed in this study is that the tax policy effect on employment comes mainly through the implied changes in job creation and therefore in unemployment duration. The effects through job destruction seem to be of minor importance. Though this feature may not be all that unrealistic, it might need to be elaborated in future work.

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2.A Derivation of the Nash Wage Rule with Taxes

When wage setting is assumed to be based on a Nash bargain between workers and firms, the wage rate is determined as a solution to the problem (2.11) in the main text. Workers and firms are assumed to be "small" in the sense that they do not consider the effects of their action on aggregate variables, in particular on the value of unemployment search and the value of a vacancy.

To derive the first order condition of the problem, we differentiate the right hand side of (2.11) with respect to $w(x)$ and set equal to zero to get

$$\beta (J(x) - V) \Omega_W + (1-\beta)(W(x) - U)\Omega_J = 0 \tag{2.63}$$

where $\Omega_W = \frac{\partial (W(x)-U)}{\partial w(x)}$ and $\Omega_J = \frac{\partial (J(x)-V)}{\partial w(x)}$ and both $W(x) - U$ and $J(x) - V$ are assumed to be strictly positive. Utilising the formulas (2.1), (2.4), (2.5) and (2.7) we can derive expressions for the two derivatives as follows

$$\Omega_W = \frac{1-t}{r+\delta}$$

$$\Omega_J = -\frac{1+s}{r+\delta}$$

Substituting these in (2.63) and some manipulation then yields

$$W(x) - U = \left(1 + \frac{(1-\beta)(1+s)}{\beta(1-t)}\right)^{-1} (J(x) - V + W(x) - U) \tag{2.64}$$

which yields (2.12) after some rearranging. Notice that the derivatives with respect to the proportional tax rates of the first term on the right hand side of (2.64) are given by

$$\frac{\partial}{\partial t}\left(\frac{\beta(1-t)}{(1+s) - \beta(s+t)}\right) = -\frac{\beta(1-\beta)(1+s)}{(-1-s+\beta s+\beta t)^2} < 0$$

and

$$\frac{\partial}{\partial s}\left(\frac{\beta(1-t)}{(1+s) - \beta(s+t)}\right) = -\frac{\beta(1-t)(1-\beta)}{(-1-s+\beta s+\beta t)^2} < 0$$

Substitution of (2.4) and (2.7) in the wage rule (2.12) gives

$$\begin{aligned} & (1-\beta)\left(\frac{(1-t)w(x) - g + \delta(UF(R) + S_W)}{r+\delta} - U\right)(1+s) \\ = \; & \beta\left(\frac{x - (1+s)w(x) + \delta(VF(R) + S_J)}{r+\delta} - V\right)(1-t) \end{aligned}$$

which can be solved explicitly for the wage rate to get

$$w(x)(1+s) = \beta x + (1-\beta)\frac{1+s}{1-t}(rU+g) - \beta r V$$

which is (2.13) in the main text.

2.B Distribution for the Productivity Shock

Assume productivity shock is uniformly distributed in the interval $[0, 1]$. Then $f(z) = 1$ and we have

$$\int_R^1 (z - R)\, dF(z) = \int_R^1 (z - R)\, dz = \frac{1}{2}(1 - R)^2$$

and

$$F(R) = \int_0^R dz = R$$

Also notice that

$$\int_R^1 z dF(z) = \int_R^1 z dz = \frac{1 - R^2}{2}$$

2.C Tax Revenues at the Steady State

Derive the steady state shares of different type of matches. The stock of matches with productivity $x = 1$, n_1 evolves according to

$$\frac{dn_1}{dt} = m(\theta)\, u - \alpha_1 \delta (1 - u)(1 - F(R)) - \alpha_1 \delta (1 - u) F(R)$$

where α_1 is the share of matches with productivity $x = 1$ of all matches. The three terms on the right hand side represent creation of new jobs, revaluation of jobs with $x = 1$ and destruction of jobs with $x = 1$, respectively. Setting the right hand side equal to zero and solving for α_1 yields

$$\alpha_1 = \frac{m(\theta)\, u}{\delta (1 - u)} = F(R)$$

where the second equality follows from the right hand side of (2.26) being equal to zero in the steady state. Consider the revenue from the labour income tax at the steady state. For the proportional part, the revenue is given by

$$T_t = \left(w(1) F(R) + \int_R^1 w(z) dF(z) \right) (1 - u)\, t \tag{2.65}$$

For the constant part the revenue is simply

$$T_g = (1 - u)\, g \tag{2.66}$$

Substituting (2.23) for $w(x)$ and utilising $f(x) = 1$ and $F(R) = R$ we get

$$\begin{aligned}
\int_R^1 w(x)dF(x) &= \int_R^1 \left((1-\beta)\frac{b-a+g}{1-t} + \beta\frac{x+c\theta}{1+s} \right) dF(x) \\
&= (1-R)\left(\frac{1-\beta}{1-t}(b-a+g) + \frac{\beta}{1+s}\left(c\theta + \frac{1+R}{2} \right) \right)
\end{aligned}$$

Substituting this in (2.65) and applying (2.23) for $w(1)$ then yields

$$T_t = \left(\frac{1-\beta}{1-t}(b-a+g) + \frac{\beta}{1+s}\left(c\theta + 1 - \frac{1}{2}(1-R)^2 \right) \right)(1-u)\,t \quad (2.67)$$

Repeating similar procedure for the payroll tax yields

$$T_s = \left(\frac{1-\beta}{1-t}(b-a+g) + \frac{\beta}{1+s}\left(c\theta + 1 - \frac{1}{2}(1-R)^2 \right) \right)(1-u)\,s \quad (2.68)$$

Combining (2.66), (2.67) and (2.68), the total revenue can be expressed as follows

$$\begin{aligned}
T &= T_t + T_g + T_s \\
&= \left(\left(\frac{(1-\beta)}{1-t}(b-a+g) + \frac{\beta}{1+s}\left(c\theta + 1 - \frac{1}{2}(1-R)^2 \right) \right)(t+s) + g \right) \\
&\quad \times (1-u)
\end{aligned}$$

which is (2.56) in the main text.

Chapter 3

Taxation and Centralised Wage Setting - the Case of Endogenous Labour Supply[1]

Abstract: *The implications of centralised wage setting for the relationship between taxation, wages and employment is studied allowing for endogenous adjustment in work hours. We show that centralisation promotes wage moderation, makes wages and employment less sensitive to changes in the wage taxation and reduces hours worked. With individual supply of working hours, a wage tax can even improve employment if wage setting is centralised and marginal utility of the public expenditure is sufficiently high. Moreover, if a profit tax is used to finance public expenditure, a higher tax reduces wages and improves employment.*

3.1 Introduction

Imperfect competition in labour markets - caused for instance by monopolistic trade unions - tends to bring wages above the market clearing level and give rise to involuntary unemployment. Since the pioneering work by Calmfors and Driffill (1988) it has become widely acknowledged that centralised wage setting can potentially mitigate these adverse effects of imperfect competition through internalisation of various externalities such as the effect of wages on general price level.

[1]This essay is joint work with Juha Kilponen.

A particularly prominent application of this idea is provided in the seminal paper by Summers Gruber and Vergara (1993). The authors utilise a model with efficient bargaining to argue that if wage setting is centralised or sufficiently co-ordinated, the institutions involved in wage negotiations recognize the linkage between labour taxes and public provision of goods. This leads into more moderate response of wages to taxes and better employment performance in countries with centralised wage setting. These findings have found support in recent empirical studies of OECD economies (see e.g. Daveri and Tabellini, 2000).

Building on the work of Summers et al (1993), this paper extends the existing literature in two dimensions. First, we employ a model with endogenous determination of working hours thereby incorporating an important adjustment mechanism neglected in the previous studies. Second, in addition to labour taxation we consider the implications of centralised wage setting for labour market response to capital income taxation.

Recent years have witnessed a renewed interest in the issue of centralised wage bargaining in the form of empirical studies on the relationship between labour taxation and employment. Daveri and Tabellini (2000) suggest that labour taxes are considerably more harmful for employment in the countries with industry level bargaining structure. Kiander, Kilponen and Vilmunen (2000) find similar evidence based on a data set of 17 OECD countries. Their results suggest that 10 percentage point reduction in the effective tax rate on labour income would imply around 2-3 percentage points decrease in unemployment rate in the countries with industry level bargaining system during the period of 1973 - 1996, but have no statistically significant effect in the countries with centralized or competitive wage bargaining systems. Results along these lines have also been reported by Everaert and Heylen (2002).

So far, the empirical and theoretical analyses have not considered the implications of centralisation to hours worked. Reflecting the substitutability between "heads and hours", the variations in labour input after a policy shock normally involve changes in both the number of workers employed and hours worked per employee. For example, a recent study by OECD shows that labour income tax creates incentives to reduce work effort especially through shorter working time (OECD, 2002). With this respect, abstracting from determination of work hours may provide an incomplete account of the labour market adjustment to taxation. Furthermore, there is some evidence suggesting that structure of collective bargaining may be important in explaining differences in hours worked across countries. In particular, union density and centralisation tend to be negatively correlated with changes in working hours (OECD, 1998).

As the earlier studies have focused on the effects on labour taxation, capital income taxation has received much less attention in this context. Also, the empirical evidence on the effects of capital taxes on economic performance is fairly inconclusive. For example, Daveri and Tabellini (2000) provide some evidence that capital taxes slow down investments, but they find no clear evidence that capital taxation would directly distort economic growth or employment. Kiander, Kilponen and Vilmunen (2000) find no statistical relationship between capital taxation and unemployment in a selection of OECD countries, but do find evidence that high capital taxes are harmful to economic growth. Their findings also suggest that effective capital tax rates tend to be higher in the countries where the union density is higher. The latter result is of particular interest to us, because it suggests that there might be a link between labour market institutions and use of capital taxation.

In order to incorporate these additional features, we set-up the model where monopolistic unions decide upon wages and profit maximising firms decide upon employment. Government then collects taxes to finance unemployment benefits and provision of public goods**.** Regarding the determination of labour supply, we consider two alternative approaches that has received attention in the literature: In the first, determination of working hours is based on individual labour supply. In the second approach, both working hours and the wages are determined by the trade unions. Throughout the paper, we retain the Summers *et al* (1993) approach and define centralised wage setting as unions' ability to perceive the government budget constraint.[2] We believe that this is particularly relevant formulation in the countries where a large part of the services are publicly provided.

We show that the results of Summers *et al* (1993) to large extent carry over to the case with endogenous working hours: centralised wage determination exhibits a wage moderation effect and supports higher employment. In addition, our model predicts that hours worked will be lower under centralised wage setting.

When determination of working hours is endogenous, tax on earned in-

[2] For an alternative approach where a centralised union takes account of the link between wages and general price level see Calmfors & Driffill (1988) and Driffill & van der Ploeg (1993).

come increases wages and reduces employment even if unemployment benefits are taxed equally with wage income. Similar to the case of fixed hours, centralised wage setting is shown to reduce the sensitivity of wages and employment to increases in the wage tax. In fact, when individuals decide upon working hours, a wage tax may even improve employment, if the marginal utility from the public provision of goods is sufficiently high.

Finally, when a profit tax is used to finance public expenditure, the standard neutrality result breaks down in centralized case: a profit tax reduces wages and consequently improves employment. This result is equally valid whether the supply of hours is based on individual decision or the union decides upon both wages and hours worked.

The rest of the paper is organised as follows: Section 2 introduces the preliminaries of the model. Section 3 describes the problem and results from the model with decentralised monopoly union. Section 4 does the same in centralised union framework. Section 5 extends the discussion and considers the case of working hours determined by the union and the profit tax. Section 6 concludes

3.2 Preliminaries

Our basic model of the labour markets is as follows: Individuals choose working hours taking the wage as given, firms choose employment, taking wages and working hours as given, and a monopoly union sets wages allowing for the response of both workers and firms.

Following Summers *et al* (1993), if the wage setting is relatively decentralised, it is plausible to assume that unions ignore the connection between taxes paid and the amount of public goods provided. If, instead, the wage setting is centralised, the unions find it necessary to pay attention to the consequences of its wage policy on government budget, in particular on the provision of public goods[3].

[3] Sometimes it may not be the actual degree of centralisation that is relevant for perception of the tax-benefit link, but the degree of co-ordination among the unions in the wage setting process (see e.g. Nickell, 1997).

3.2.1 Firm Behaviour

The level of employment is determined by competitive profit maximising firms, which solve the following problem

$$\max_N \Pi = f(N,h) - whN \tag{3.1}$$

For analytical simplicity, we assume that number of workers N and working hours per employee h are perfect substitutes in production so that production function takes the following simple form

$$f(N,h) = (Nh)^{\gamma} \ \ , \gamma < 1 \tag{3.2}$$

The production technology exhibits decreasing returns for the labour input, which gives rise to profits in the equilibrium. These profits can be interpreted as return to a fixed capital input. Under this structure, the first order condition for optimality can be solved for the number of workers to yield

$$N(w,h) = \left(\frac{\gamma}{w}\right)^{\frac{1}{1-\gamma}} h^{-1} \tag{3.3}$$

which is the demand for labour with $N_w < 0$, $N_h < 0$. In what follows we assume that the firms are not rationed in the labour market and employment always equals labour demand. Utilising (3.3) we can define the *wage elasticity of employment with fixed working hours*, $\epsilon^d \equiv -\frac{\partial \log N}{\partial \log w} = \frac{1}{1-\gamma}$ which is greater than unity. Also notice that the elasticity of employment with respect to working hours equals unity. [4]

For further purposes, we notice that substituting (3.3) into (3.1) and (3.2) yields

$$\Pi = (1-\gamma)\left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\gamma}} \tag{3.4}$$

which expresses the maximum attainable profits as a function of wages. Furthermore, dividing (3.4) by (3.3), we find that profits per employee can be expressed as simply as .

$$\frac{\Pi}{N} = wh\frac{1-\gamma}{\gamma} \tag{3.5}$$

[4] Although assumption of perfect substitutability between work hours and number of workers can in some cases be an overstatement, it is within the limits of empirical estimates. For example, on the basis of various empirical studies, Hunt (1996) suggests that 1 per cent reduction in standard hours raises employment by 0.2-1 per cent. See also Hart & McGregor (1998) and Crepon & Kramarz (2000).

3.2.2 Individual Behaviour and Labour Supply

As for the individuals, we normalise their total number to unity, out of which N are employed and $1 - N$ are unemployed. The utility of employed individuals is given by

$$U_e = y_e - v(h) + z(G) \tag{3.6}$$

where y_e denotes after tax income to be defined below and $v(h)$ is some convex function denoting disutility from work with $v_h > 0, v_{hh} > 0, v(0) = 0$ and $v(1) < \infty$. We normalise total time endowment to unity, so that $(1 - h)$ is the time spent on other non-productive activities, such as leisure. $z(G)$, in turn, is some concave function, denoting the utility from the public provision of goods, G. Throughout the paper we assume that the publicly provided goods have a constant positive marginal utility less than one $0 < z_G < 1$. The utility of unemployed individuals is then given by

$$U_u = y_u + z(G) \tag{3.7}$$

After tax income for employed, y_e and unemployed, y_u, are defined as

$$y_e \equiv wh(1 - \tau) \tag{3.8}$$

$$y_u \equiv w_u(1 - \tau_u) \tag{3.9}$$

where w is wage set by the union, w_u is an exogenous unemployment benefit and h denotes work hours. Finally, τ and τ_u are the proportional tax rates on wages and unemployment benefits, respectively.[5] Once employed, individual worker chooses working hours to maximise utility (3.6) subject to the budget constraint (3.8). Assuming that disutility from labour takes the following convenient functional form

$$v(h) = \frac{1}{\delta} h^{\delta}, \ \delta > 1 \tag{3.10}$$

we can derive the individual's supply of working hours as follows

$$h = ((1 - \tau)w)^{\frac{1}{\delta - 1}} \tag{3.11}$$

[5] We assume throughout the paper that $U_e - U_u$ is positive i.e. employed are better off than the unemployed and unemployment is thus involuntary.

Under this formulation, our model encompasses the model with fixed working hours when $\delta \to \infty$. As $\delta \to \infty$, individual workers disutility from labour approaches zero and workers supply a fixed amount of labour ($h = 1$) as implied by (3.10) and (3.11). Finally, notice that (uncompensated) wage elasticity of labour supply is given by $\epsilon^s \equiv \frac{\partial \log h}{\partial \log w} = \frac{1}{\delta - 1}$.

3.2.3 Government Budget

We first concentrate on the simpler case where profit tax is zero. However, we allow for unemployment benefits being taxed at the rate τ_u which is not necessarily equal to the rate of wage tax τ. Tax revenues are used to finance the costs of the unemployment benefits w_u and the public provision of goods and services, G. Consequently, the government budget constraint takes the following form

$$\tau whN = G + (1 - \tau_u)w_u(1 - N) \tag{3.12}$$

For simplicity, we do not allow the government balance its budget by debt. With fixed per head unemployment benefit, the level of public provision is endogenous and adjusts so as to satisfy the budget constraint.

3.3 Decentralised Union

Let us first consider the case of decentralised wage setting, where the unions are "small" in the sense that they do not internalise the effect of wages on the government budget. In other words, the unions treat the provision of public goods as given. The unions have been granted a right to negotiate the wages of their members, but not working hours. Unions operate for instance at industry level and there is no explicit or even de facto co-operation among the unions of different industries. Unions, act as Stackelberg leaders, setting the wage of their members and letting the firms and individuals decide over employment and hours, respectively. In most of the advanced economies, except US, Canada and Great Britain, a majority of workers are covered by this kind of industrial agreements (see for instance Golden et al, 2002).

Formally, a utilitarian union then solves the following maximisation problem

$$\underset{w}{max} V = NU_e + (1 - N)\, U_u \tag{3.13}$$

subject to the constraints defined in (3.3), (3.6)-(3.9) and (3.11) respectively. Notice that unions perceive the effect of wages on both supply of working hours by the individuals and demand for labour by the firms. Differentiating (3.13) with respect to wage rate and expressing it conveniently in the elasticity form delivers the following first order condition for optimal union wage

$$-(U_e - U_u)\left(\epsilon^d + \epsilon^s\right) + h(1-\tau)w = 0 \tag{3.14}$$

Noteworthy, $\frac{dU_u}{dw}$ does not enter into the first order condition of the union, because U_u is unaffected by the changes in w, when the union takes the level of public provision G as given. Also, when the working hours are determined optimally by the workers, small changes in working hours do not change the utility of the workers. That is, $\frac{\partial U_e}{\partial h} = 0$. Finally, the total elasticity of labour demand with respect to wage constitutes of both the direct effect (ϵ^d) and the indirect effect through working hours (ϵ^s).

Using (3.6)-(3.9) to substitute for the utility difference and solving the first order condition for the wage rate yields

$$w(h) = \frac{1}{1-1/\epsilon}\left[\frac{(1-\tau_u)w_u}{(1-\tau)\,h} + \frac{v\,(h)}{(1-\tau)\,h}\right] \tag{3.15}$$

Equation (3.15) defines the union wage for given working hours. The wage rate has been decomposed into the wage rate prevailing in the conventional monopoly union model with perfectly inelastic labour supply ($h = 1$) and into an additional term allowing for the disutility of labour, $v\,(h)$. The additional term is positive i.e. the wage rate is higher when the disutility of labour is allowed for. Furthermore, (3.15) suggests that the monopoly union's wage is a mark-up over the fall back position of its members. The size of the mark up, determined by the first term in the right hand side of (3.15) is inversely related to the elasticity of labour demand, $\epsilon = \epsilon^s + \epsilon^d$. With endogenous labour supply the fall back position, captured by the term within square brackets, consists of unemployment pay per hour and the value of lost leisure "gross of tax".

3.3.1 Labour Market Equilibrium in the Decentralised Case

Given the decision rules for wages (3.15), hours supplied (3.11) and employment (3.3) we can now determine the labour market equilibrium. Substituting for $v(h) = \frac{1}{\delta}h^{\delta}$ and using the definition of after tax income (3.8), solution to the set of two equations (3.15) and (3.11) yields

$$\begin{aligned} w &= (1-\tau)^{-1} y_e^{\frac{\delta-1}{\delta}} && (3.16) \\ h &= y_e^{\frac{1}{\delta}} && (3.17) \\ N &= ((1-\tau)\gamma)^{\frac{1}{1-\gamma}} y_e^{-\frac{\delta-\gamma}{\delta(1-\gamma)}} && (3.18) \end{aligned}$$

where

$$y_e = \frac{(1-\tau_u) w_u}{1 - 1/\delta - 1/\epsilon} \tag{3.19}$$

The above formulas provide a convenient way to characterise the effects of taxation in the equilibrium. In section 4 we show that equations (3.16) - (3.18) hold even in the case of centralised wage setting with the exception that the formula for the after tax income (3.19) is altered.

Noticing from (3.19) that $\partial y_e/\partial \tau = 0$, (3.16) - (3.18) immediately imply the following response of wages, employment and hours to the wage tax

$$\frac{\partial w}{\partial \tau} > 0, \frac{\partial N}{\partial \tau} < 0, \frac{\partial h}{\partial \tau} = 0 \tag{3.20}$$

Decentralised union keeps the after tax wage $w(1-\tau)$ constant, as can be seen from (3.16). Thus, there is a complete after tax wage resistance, such that tax changes are completely borne by the employer. This is the conventional result of the monopoly union model (e.g. Holmlund *et al*, 1989). Moreover, since the after tax wage determines supply of hours, the equilibrium value of the latter is unaffected by changes in the tax rates. Furthermore, we can express (3.16) alternatively as

$$w = (1-\tau)^{-\frac{1}{\delta}} \left(\frac{T w_u}{1 - 1/\delta - 1/\epsilon} \right)^{\frac{\delta-1}{\delta}} \tag{3.21}$$

where $T \equiv \left(\frac{1-\tau_u}{1-\tau}\right)$ reflects the ratio of the tax rates on unemployment benefits and wages, respectively. This formulation suggests that the wage tax affects the wage rate through two separate channels. The first is related to the individual supply of labour hours, as captured by the first term in the right hand side of (3.21): higher wage tax makes leisure more valuable. The second effect is related to the union's incentive to adjust wage level relative to the unemployment benefits: higher wage tax increases the after tax value of unemployment benefits relative to wages ($\partial T/\partial\tau > 0$). If the tax rate on unemployment benefits is equal to that on wages, the latter effect disappears[6]. This is why in the standard union models with exogenous labour supply, the labour income tax affects wages and employment only when $\tau_u \neq \tau$ i.e. unemployment benefits are treated differently from wage income (see e.g. Koskela and Schöb, 1999). In the present set-up, however, higher tax rate increases wages and depresses employment *even if* $\tau_u = \tau$. However, in the case of fixed hours ($\delta \to \infty$), this effect disappears. We summarise this finding by the following proposition

Proposition 3.1 *If supply of labour hours is determined by the utility maximising individuals and wages are set by the decentralised monopoly union, higher income tax will increase wages even if unemployment benefits are taxed equally with wages.*

In the rest of the paper we concentrate on the case where tax treatment of wages and benefits are separated in the sense that changes in the tax rate on wages τ do not imply changes in the taxation of benefits, i.e. $\tau_u \neq \tau$. Thus, τ should be interpreted as *wage* tax rather than *income* tax. In this set-up we can set τ_u to zero without loss of generality.

3.4 Centralised Union and the Role of Public Expenditure

The previous case of decentralised wage setting characterises the labour market situation where wage setting takes place without explicit co-ordination among the unions. Let us next turn to the alternative case, where an exclusive control over wages has been granted to a confederation of unions, representing several industrial sectors or alternatively, wage setting is well co-ordinated between individual trade unions. Despite the recent declining trend in unionisation, the Scandinavian countries and the Netherlands are examples of economies where the centralised contracts have extended to several industrial sectors and covered almost entire private sector for substantial

[6] To be exact, taxation of benefits must be adjusted so that $\frac{1-\tau_u}{1-\tau}$ remains constant. This holds naturally in the special case where the two tax rates are identical by definition, $\tau_u \equiv \tau$.

periods of time[7]. In such countries, it is reasonable to assume that unions "see beyond the budget constraint of the government" and thus take account of the effects of wages on public finances, in particular on the public provision of goods and services.

This is particularly plausible if the government is either implicitly or explicitly involved in the wage setting process through the so-called tripartite co-operation[8].

Assuming that individuals and firms behave as above [9], the union's problem can be expressed as above in (3.13). However, since we now allow the effects through public spending, the government budget balance (3.12) has to be explicitly included among the constraints. Recalling that the union's objective is as defined in (3.13), we can express the first order condition as follows

$$(U_e - U_u)\frac{dN}{dw} + N(\frac{dU_e}{dw} - \frac{dU_u}{dw}) + \frac{dU_u}{dw} = 0 \tag{3.22}$$

In contrast to the decentralised case analysed previously, $\frac{dU_u}{dw}$ enters into the first order condition because the utility of unemployed workers is affected by changes in the wage rate through the provision of public goods. In particular,

$$\frac{dU_u}{dw} = z_G \frac{dG}{dw} \tag{3.23}$$

where z_G denotes the marginal utility of public provision as defined above. The total derivative $\frac{dU_e}{dw}$ in (3.22), in turn, can be written as

$$\frac{dU_e}{dw} = \frac{\partial U_e}{\partial w} + z_G \frac{dG}{dw} \tag{3.24}$$

where we again utilised the fact that $\frac{\partial U_e}{\partial h} = 0$. Notice that for $z_G = 0$, individuals would not gain any utility from the public provision and therefore (3.24) and (3.23) would actually reproduce the decentralised union case. On

[7]See for instance, Checchi and Lucifora (2002), Golden et al (2002) and Wallerstein and Western (2000).

[8]In tripartite co-operation government typically provides incentives for wage moderation using tax and social policy instruments. For a description of such arrangement in the case of Finland see Vartiainen (1998).

[9]Calmfors and Driffill (1988) argue that labour demand elasticity is likely to change when wage setting becomes more centralised. Since our focus is on the wage formation mechanism, we assume that the external conditions are invariable with respect to centralisation.

the other hand, for $z_G > 1$, a centralized union would have incentive to "overcompensate" the effect of its wage policy on the provision of public goods. Our assumption of $0 < z_G < 1$ effectively rules out these extreme cases.

Next, totally differentiating the government's budget constraint (3.12) under $\tau_u = 0$ and multiplying both sides by $\frac{w}{N}$ yields

$$\frac{dG}{dw}\frac{w}{N} = \frac{\partial G}{\partial w}\frac{w}{N} + \frac{\partial G}{\partial h}\frac{h}{N}\epsilon^s - \frac{\partial G}{\partial N}(\epsilon^d + \epsilon^s) \tag{3.25}$$

Equation (3.25) decomposes the effects of wage hike on the public provision from the centralised union's point of view. At given working hours and employment, higher wages increase the tax revenue and thus the public provision of goods. Higher wages also increase individuals' supply of working hours. This generates an additional upward pressure on revenue from the wage tax and on the level of public provision. At the same time, however, higher wage tends to reduce labour demand directly (ϵ^d) and also indirectly through increased individual hours (ϵ^s). This effect, in turn, reduces the tax revenue and increases the spending on unemployment benefits.

Utilising the government budget constraint we can develop the expression (3.25) into a more convenient form

$$\frac{dG}{dw}\frac{w}{N} = \tau hw\left(1 - \epsilon^d\right) - w_u\epsilon \tag{3.26}$$

By substituting (3.22)-(3.24) and (3.26) in the first order condition (3.22) and solving for the wage rate yields the following wage rule

$$w_c(h) = \frac{v(h) + w_u(1 - z_G)}{h\left((1 - 1/\epsilon)(1 - \tau) + z_G\tau\left(\epsilon^d - 1\right)/\epsilon\right)} \tag{3.27}$$

First, notice that (3.27) collapses to (3.15) when $z_G = 0$. When the public provision has a positive marginal utility, $z_G > 0$, and $\epsilon^d > 1$, it easy to see that $w_c(h)$ is unambiguously decreasing in z_G. This represents a pure wage moderation effect of public good. The centralised union realises that higher wages and the consequent drop in employment implies lower supply of the public goods. This is so because of two reasons: First, with $\epsilon^d > 1$ tax revenues decrease. Second, spending on unemployment benefits increase. This is evident from the government's budget constraint (3.12).

3.4.1 Labour Market Equilibrium in the Centralised Case

Using the wage rule (3.27), supply of hours (3.11) and employment (3.3), the equilibrium wage, working hours and employment can be solved analogously with the decentralised case. With subscript c denoting the centralised case, we find that

$$\begin{aligned} w_c &= (1-\tau)^{-1}(y_{ec})^{\frac{\delta-1}{\delta}} && (3.28)\\ h_c &= (y_{ec})^{\frac{1}{\delta}} && (3.29)\\ N_c &= (\gamma(1-\tau))^{\frac{1}{1-\gamma}}(y_{ec})^{-\frac{\delta-\gamma}{\delta(1-\gamma)}} && (3.30)\end{aligned}$$

The difference to the decentralised case can be neatly expressed in terms of the after tax income of an employed member, which now reads as

$$y_{ec} = \frac{w_u(1-z_G)}{(1-1/\epsilon-1/\delta)+z_G\frac{\tau}{1-\tau}\frac{\epsilon^d-1}{\epsilon}} \qquad (3.31)$$

Notably, (3.31) collapses into gross labour income in the decentralised case when $z_G = 0$ and $\tau_u = 0$. Then, it is immediately clear that with $0 < z_G < 1$

$$y_{ec} < y_e \qquad (3.32)$$

i.e. at any given positive tax rate, the after tax income is lower in the centralised union case[10]. The wage moderation effect implied by (3.31) is larger the higher is the marginal utility of the public goods since w_c in (3.28) is decreasing in z_G.

Given the above formulas, the following proposition can be stated:

Proposition 3.2 *If wage setting is centralised, gross wage will be lower, employment will be higher and the working hours lower than in the decentralized case i.e.*

$w_c < w$, $N_c > N$ *and* $h_c < h$

[10] To see this, it is enough to realize that (3.31) collapses into (3.19) when $z_G = 0$ and that (3.31) is decreasing in z_G. Therefore for all $0 < z_G < 1$, $y_{ec} < y_e$.

Proof. Follows directly from (3.32) combined with (3.16-3.18) and (3.28-3.30). ■

As for the wages and employment, proposition (3.2) establishes the results of Summers et al (1993) in the present framework. In addition, our model predicts that working hours will be lower when wage setting is centralised.

Let us now turn to the effects of tax policy in the centralised case. Differentiating (3.31) with respect to the tax rate yields (see Appendix A for details)

$$\frac{\partial y_{ec}}{\partial \tau} < 0 \tag{3.33}$$

Accordingly, the after tax income of the employed workers is no longer immune to tax changes. On the contrary, higher tax leads to a lower take-home-pay for an individual worker. Therefore, as opposed to the decentralized case, after tax wage resistance is incomplete. The union now internalises the increase in the public provision of goods and does not fully compensate the tax increase by higher wages as was the case with the decentralized union.

With the help of (3.33) comparative statistic results of tax policy can now be derived. For technical convenience we define $\mu \equiv (1-\tau)$ and differentiate with respect to μ rather than τ. With this notation and using (3.28) we can derive elasticity of wage with respect to the wage tax as follows

$$\frac{\partial w_c}{\partial \mu}\frac{\mu}{w_c} = \frac{(\delta-1)\,\varepsilon_{y\mu}^{c}}{\delta} - 1 \tag{3.34}$$

where $\varepsilon_{y\mu}^{c} \equiv \frac{\partial y_{ec}}{\partial \mu}\frac{\mu}{y_{ec}} > 0$ is the corresponding elasticity of after tax income. It is evident from (3.34) that

$$\frac{\partial w_c}{\partial \mu}\frac{\mu}{w_c} > -1 \tag{3.35}$$

whereas in the decentralised case the very same elasticity is equal to -1 as can be easily derived from (3.16). This leads to the following proposition

Proposition 3.3 *Wages react less to tax changes if wage setting is centralised than in the decentralised case.*

Proof. Follows from (3.35) and (3.16) which imply $\frac{\partial w_c}{\partial \mu}\frac{\mu}{w_c} > \frac{\partial w}{\partial \mu}\frac{\mu}{w}$. ■

Although the sign of wage response to the tax is *a priori* ambiguous, we show in Appendix B that within a plausible range of parameter values

$\frac{\partial w_c}{\partial \tau} > 0$. In other words, higher tax leads to an increase in the gross wage. What comes to the working hours, it follows directly from (3.29) and (3.33) that hours supplied decline in response to higher taxes, $\frac{\partial h}{\partial \tau} < 0$. This outcome is evident also by (3.35). The drop in the after tax wage due to higher tax rate is not offset by a corresponding increase in the gross wage and supply of hours decline.

Finally, and perhaps more importantly, we analyse the response of equilibrium employment on the wage tax. Utilizing (3.30), we can express the elasticity of employment with respect to the wage tax as

$$\frac{\partial N^c}{\partial \mu}\frac{\mu}{N^c} = \epsilon^d \left(1 - \frac{\delta - \gamma}{\delta}\varepsilon^c_{y\mu}\right) \tag{3.36}$$

where the term within the brackets is less than one with the parameter restrictions of the model. Recalling that by (3.18) the very same elasticity for the decentralized case is simply $\frac{\partial N}{\partial \mu}\frac{\mu}{N} = \frac{1}{1-\gamma} \equiv \epsilon^d$, we can conclude that the following proposition holds

Proposition 3.4 *Higher wage taxes are less harmful for employment in the centralized case.*

Proof. It follows from (3.18) and (3.36) that $\frac{\partial N^c}{\partial \mu}\frac{\mu}{N^c} < \frac{\partial N}{\partial \mu}\frac{\mu}{N}$. ∎

In other words, an equal proportional increase in the tax rate causes a smaller drop in employment in the centralised case. Closer inspection of (3.36) reveals that the sign of $\frac{\partial N^c}{\partial \tau}\frac{\tau}{N^c}$ is ambiguous so that *employment may even improve in the centralised case.* It turns out that marginal utility of public provision plays an important role here: In Appendix C we derive the following condition

$$\frac{\partial N^c}{\partial \tau}\frac{\tau}{N^c} \lesseqqgtr 0 \Leftrightarrow z_G \lesseqqgtr \frac{(1-\tau)(\delta-1)}{\delta(1-\tau)-\gamma} \equiv z_G^* \tag{3.37}$$

This result implies the following proposition

Proposition 3.5 *If the marginal utility of the publicly provided good is sufficiently high, precisely $z_G > z_G^*$, a higher wage tax will lead into higher employment in the centralized case.*

Proof. See Appendix C. ∎

This surprising effect is due to endogenous working hours. In the centralised case the union is giving up some after tax wage when facing an increased wage tax. Increase in gross wage is not enough to compensate for higher taxes and consequently, employed workers cut their labour supply. The employers encounter increased wages, but lower supply of working hours. Whether employment decreases or increases depends on the relative magnitude of these effects. High values z_G leads to a more moderate gross wage increase and correspondingly to a larger decline in the hours due to deteriorated net wage. With high enough valuation of the public goods, the supply effect dominates and employment improves. It is shown in the Appendix C that z_G^* may be lower than unity under the parameter restrictions of the model. Positive employment response to wage tax ($z_G > z_G^*$) is more likely when the initial tax rate and labour demand elasticity are low and labour supply elasticity is high. If supply of hours is exogenously fixed ($\delta \to \infty$), it is easy to see from (3.37) that $z_G^* = 1$, which z_G cannot exceed. Therefore, with fixed hours, an increase in the wage tax will lead into a drop in employment independently on the marginal utility of the publicly provided goods.

3.5 Extensions

In this section we extend the model in two directions. First, we consider an alternative hypothesis on determination of working hours by assuming that hours are set by the union. Second, since firms make pure profit in the equilibrium, it seems natural to consider profit tax as an alternative source of revenue. In both cases, we contrast between decentralised and centralised wage setting.

3.5.1 Working Hours Determined by the Union

The analysis in the previous sections assumed that the working hours are chosen by the employed individuals. While this may be realistic for some jobs, it is not necessarily the only relevant option for modelling the determination of working time. An alternative formulation that has received attention in the theoretic literature, and also seems to be in line with the casual observations, is that hours are determined simultaneously in the wage setting process.[11]

In our set-up this approach can be operationalised by assuming that the trade union, either centralised or decentralised, chooses both wages and hours so as to maximise its objective. This set-up can be characterised as a Stackelberg game where the union takes the role of a leader and the employer follows by adjusting employment along the labour demand schedule.

Since the decentralised case can be derived as a special case of a centralised case with $z_G = 0$, we proceed directly with the latter. Formally, the problem of a centralised union is now reformulated as

$$\underset{w,h}{max} V = NU_e + (1 - N)\, U_u \tag{3.38}$$

subject to (3.3), (3.6)-(3.9) and (3.12) under $\tau_u = 0$, respectively. Solving the problem delivers the following expression for the after tax income of the employed worker (see Appendix D for details)

$$y_{ec} \equiv w_c h_c (1 - \tau) = \frac{w_u\,(1 - z_G)}{(1 - 1/\delta)\,(1 - 1/\epsilon^d)\,\left(1 + z_G \frac{\tau}{1-\tau}\right)} \tag{3.39}$$

Setting $z_G = 0$ in (3.39) reproduces the decentralised case. Then, it is immediately clear that $y_{ec} < y_e$ i.e. the after tax income is lower in the centralised case even if union decides upon hours. Given this, it is straightforward to show that proposition (3.2) holds even when working hours are determined by the union. Similarly, the wage tax effects stated in the propositions (3.3)-(3.4) are equally valid. However, since working hours are not directly affected by the labour tax, proposition (3.5) no longer holds. Thus, if hours are set by the union, a wage tax has unambiguously an adverse effect on employment[12].

3.5.2 Profit Tax

In the previous section we have shown that labour taxes are less harmful for employment when the wage setting is centralised. This has been suggested

[11] See e.g. Holmlund et al (1989) for discussion on the alternative mechanisms for determination of working hours in union models.

[12] In this setup it can also be shown that if the marginal utilility from public good is sufficiently high (low) the centralised union has a tendency to set hours higher (lower) than what the individual worker would prefer at the prevailing wage rate. The decentralised union, in turn, would set the hours lower than preferred by individuals, irrespective of z_G. The latter finding is in line with the results of Holmlund et al (1989).

to explain why labour taxes are higher in the countries with centralised wage setting.

The relationship between wage setting and taxation of capital income has received much less attention in the literature. In order to shed some light on this issue in an analytical framework, we extend the model by introducing a proportional tax on profits, which can be interpreted as a tax on capital income[13]. Formally, denoting the profit tax by t, the government's budget constraint can be modified to

$$\tau whN + t\Pi = G + w_u(1 - N) \tag{3.40}$$

where Π is the profits as defined in (3.4). With this extension, the problem of a centralised union is as above in section 4 with the exception that the government budget constraint is replaced by (3.40) as the union internalises the effect of profits tax revenue on the public provision of goods. The derivation of the first order condition proceeds as in section 3.4, except for the total differentiation of the government's budget constraint, which now becomes

$$\frac{dG}{dw}\frac{w}{N} = \frac{\partial G}{\partial w}\frac{w}{N} + \frac{\partial G}{\partial h}\frac{h}{N}\epsilon^s - \frac{\partial G}{\partial N}\left(\epsilon^d + \epsilon^s\right) + \frac{\partial G}{\partial \Pi}\frac{\partial \Pi}{\partial w}\frac{w}{N} \tag{3.41}$$

Compared to (3.25), there is an additional term in the right hand side of (3.41). This term shows that higher wages reduce profits and therefore revenue from the profit tax. Noticing that government budget constraint (3.40) implies that $\frac{\partial G}{\partial \Pi} = t$ and making use of equations (3.4) and (3.5), the additional term can be developed to yield $\frac{\partial G}{\partial \Pi}\frac{\partial \Pi}{\partial w}\frac{w}{N} = -thw$. Utilising (3.40) to substitute for the appropriate partial derivatives, (3.41) can be developed to

$$\frac{dG}{dw}\frac{w}{N} = [-\left(\epsilon^d - 1\right)\tau - t]hw - w_u\epsilon < 0 \tag{3.42}$$

Since the right hand side of (3.42) is negative, any increase in wages leads into a lower provision of public goods. Finally, substituting (3.42) into the union's first order condition (3.22), we can solve for the after tax income of the employed worker as follows

$$y_{ec} = \frac{w_u\left(1 - z_G\right)}{(1 - 1/\epsilon - 1/\delta) + \frac{z_G}{\epsilon(1-\tau)}\left(\tau\left(\epsilon^d - 1\right) + t\right)} \tag{3.43}$$

[13]Noteworthy, we have implicitly assumed that profits accrue to "capitalists" that are not union members, which is standard in the trade union models.

Noteworthy, profit tax rate t enters into the formula for after tax income only if wage setting is centralised. More precisely, $\frac{\partial y_{ec}}{\partial t} < 0 \Leftrightarrow z_G > 0$. Since equations (3.28)-(3.30) still apply, with y_{ec} replaced by (3.43), we can readily prove the following proposition

Proposition 3.6 *If wage setting is centralised, a profit tax lowers gross wages, improves employment and reduces hours worked, i.e.*
$\frac{\partial w_c}{\partial t} < 0, \frac{\partial N_c}{\partial t} > 0, \frac{\partial h_c}{\partial t} < 0,$

Proof. Follows from substituting (3.43) for y_{ec} in equations (3.28)-(3.30) and differentiating with respect to t. ■

The fact that an increase in profit tax leads into lower wages and therefore enhances employment in the equilibrium is somewhat surprising. Intuitively, a wage hike reduces profits and thereby tax revenue and the public provision. This lowers the utility of an unemployed member, which serves as a fall back position of the union. This effect is the stronger the higher the tax rate on profits, t. Consequently, a higher profit tax reduces the effectiveness of a wage hike in improving union objective and calls for a lower optimal wage. The result holds independently of how working hours are determined.

In conclusion, the level of wage determination crucially shapes the relationship between the model's equilibrium variables and profit taxes. Our results suggest that parallel to labour taxation, centralised bargaining makes the use of profit taxation more attractive from employment viewpoint: while the profit tax is neutral in the decentralised case, it appears to improve employment in the centralised case. This idea finds some support in the empirical evidence provided by Kiander *et al* (2000) that while capital income tax has no significant effect on unemployment in a selection of OECD countries, the effective capital tax rates tend to be higher where union density is higher. Bearing in mind that union density and the degree of centralisation are positively correlated, this finding could reflect the fact that minor distortionary costs of profit taxation have facilitated their more extensive use in the countries with centralised wage bargaining.[14]

[14] At this point it is important to note that the present framework is far too simplistic to capture all the relevant aspects of capital income taxation such as the effects on investment and growth. Nevertheless, our partial analysis suggests that the employment effects of capital income taxation are more favourable if wage setting is centralised. Therefore, ceteris paribus, one could expect to see higher tax rates in countries with more centralised labour markets.

3.6 Concluding Remarks

This paper has studied the relationship between labour taxation and the degree of centralisation in a monopoly union model with endogenous labour supply. In the model with decentralised wage formation and endogenous labour supply, we have shown that higher taxes increase wages and reduce employment even if unemployment benefits are taxed equally with labour income. When compared to the decentralised case, centralised wage setting exhibits a wage moderation effect, which arises from internalisation of the government's budget constraint. Hours worked will be lower and employment higher in the centralised union case. Moreover, both wages and employment are less sensitive to changes in the wage tax when wage setting is centralised. These results are not sensitive to the alternative assumptions concerning the determination of working hours.

Furthermore, we have demonstrated that when marginal utility from the publicly provided goods is sufficiently high and individual workers decide upon hours worked, the wage tax can even improve employment in the centralised union case. This is a consequence of the moderate wage policy, due to which the labour supply effect through a decline in working hours dominates the labour demand effect.

Somewhat surprisingly, we find that when public provision of goods is financed by a profit tax, the centralised union's optimal response to increasing profit tax is to set wage lower. This leads into consequent increase in employment even if working hours were exogenously fixed. This result is in sharp contrast to the standard monopoly union model with decentralised wage setting where a tax on profits has no distorting effects at all.

Although very simplified the model provides some interesting insights into the interactions between labour market institutions, working hours and effects of taxation. For example it suggests that profit taxation may serve as a device to improve employment performance in an economy with highly centralised wage setting. This might be a relevant policy option if the ability to direct regulation of labour market outcomes is limited. Also, the model predicts that working hours correlate negatively with the degree of centralisation. This result finds some support in country data (OECD, 1998), but would also provide an interesting topic for further empirical work.

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3.A Proof of Result (3.33)

With the definition of after tax income (3.31) at hand we show that it depends negatively on the wage tax in the equilibrium.

Proof. Using the notation $\mu \equiv 1 - \tau$ we have

$$\varepsilon_{y\mu} \equiv \frac{\partial y_{ec}}{\partial \mu} \frac{\mu}{y_{ec}} = \frac{1}{\frac{\epsilon\mu((1-1/\epsilon-1/\delta)}{z_G\left(\epsilon^d-1\right)} + (1-\mu)}$$

Substitute for $\epsilon^d = \frac{1}{1-\gamma}$ and $\epsilon = \epsilon^d + \epsilon^s = \frac{\delta-\gamma}{(1-\gamma)(\delta-1)}$ to get

$$\varepsilon_{y\mu} = \frac{1}{\tau + \frac{(1-\tau)(\delta-1)}{z_G \delta}} > 0$$

Also notice that this implies

$$\frac{\partial y_{ec}}{\partial \tau}\frac{\tau}{y_{ec}} = -\frac{\tau}{(1-\tau)}\frac{1}{\tau + \frac{(1-\tau)(\delta-1)}{z_G \delta}} < 0$$

which establishes result (3.33) in the main text. ■

3.B Proof of Result $\partial w_c / \partial \tau > 0$

In section 3.4.1 we argue that in the centralised case, higher wage tax leads to higher wages.
Proof. Using (3.31) we can derive

$$\frac{\partial w}{\partial \mu}\frac{\mu}{w} = (1 - 1/\delta)\,\varepsilon_{y\mu} - 1$$

which has to be less than zero for wages to increase when tax rate is increased. Substituting the formula for $\varepsilon_{y\mu} \equiv \frac{\partial y_{ec}}{\partial \mu}\frac{\mu}{y_{ec}} = \left(\frac{\epsilon\mu((1-1/\epsilon-1/\delta)}{z_G\left(\epsilon^d-1\right)} + 1 - \mu\right)^{-1} > 0$ (see Appendix A) then yields

$$\frac{\partial w}{\partial \mu}\frac{\mu}{w} = \frac{\delta - 1}{\delta\tau + \frac{(1-\tau)(\delta-1)}{z_G}} - 1$$

Setting the right hand side to be less than zero implies

$$z_G < \frac{(1-\tau)(\delta-1)}{\delta(1-\tau)-1}$$

With $0 < z_G < 1$, the sufficient condition for this to hold is $0 < \tau < 1 - 1/\delta$. Thus, we conclude that with plausible tax rates on wages (we expect δ to take values clearly above unity), a tax increase leads to higher wages. ■

3.C Proof of Result (3.37)

In result (3.37) we argue that employment can improve in response to higher taxes if the marginal utility of the public goods is high enough.
Proof. Using (3.30) in the main text, the elasticity can be written

$$\frac{\partial N^c}{\partial \tau}\frac{\tau}{N^c} = -\frac{1}{1-\gamma}\frac{\tau}{1-\tau} - \frac{\delta-\gamma}{\delta(1-\gamma)}\frac{\partial y_{ec}}{\partial \tau}\frac{\tau}{y_{ec}}$$

Recalling (3.44) we can express the elasticity as

$$\frac{\partial N^c}{\partial \tau}\frac{\tau}{N^c} = \frac{1}{1-\gamma}\left(\left(\frac{(\delta-\gamma)\, z_G \tau}{((\delta-1)(1-\tau)+z_G\tau\delta)(1-\tau)}\right) - \frac{\tau}{1-\tau}\right)$$

Consequently,

$$\begin{aligned} \frac{\partial N^c}{\partial \tau}\frac{\tau}{N^c} &> 0 \\ &\Leftrightarrow \\ z_G &> \frac{(1-\tau)(\delta-1)}{\delta(1-\tau)-\gamma} \equiv z_G^* \end{aligned}$$

Notice then that

$$\frac{\partial z_G^*}{\partial \tau} = \frac{(\delta-1)\gamma}{(\gamma-\delta(1-\tau))^2} > 0$$

In other words, the level of marginal utility of the public goods needed for a tax increase to boost employment, z_G^*, is the higher, the higher the initial level of taxation. Noteworthy, with plausible parameter values such that $0 < \tau < 1-\gamma$, z_G^* indeed lies in the interval $]0,1[$ and is within the defined range for z_G in the model. ■

3.D Hours Set by the Union

Assume that the monopoly union chooses both wages and hours so as to maximise its objective as expressed by (3.38). The first order conditions for optimal wage rate and work hours then becomes

$$(U_e - U_u)\frac{\partial N}{\partial w} + N(\frac{dU_e}{dw} - \frac{dU_u}{dw}) + \frac{dU_u}{dw} = 0$$

$$(U_e - U_u)\frac{\partial N}{\partial h} + N(\frac{dU_e}{dh} - \frac{dU_u}{dh}) + \frac{dU_u}{dh} = 0$$

These can be developed further to give

$$\begin{aligned}(v(h) + w_u - z_G w_u)\epsilon^d - wh\,(1 - \tau + z_G\tau)\left(\epsilon^d - 1\right) &= 0\\ v(h) + w_u - hv' - z_G w_u &= 0\end{aligned}$$

Solving for wage and hours then yields

$$\begin{aligned}w_c &= \frac{1}{(1 - 1/\epsilon^d)\,((1-\tau) + z_G\tau)}\left(\frac{(1 - z_G)\,w_u}{1 - \frac{1}{\delta}}\right)^{1-1/\delta}\\ h_c &= \left(\frac{(1 - z_G)\,w_u}{1 - \frac{1}{\delta}}\right)^{1/\delta}\end{aligned}$$

which in turn implies (3.39) in the main text.

Chapter 4

Subsidising vs. Experience Rating of Unemployment Insurance in Unionised Labour Markets

Abstract: *Alternative ways to organize government subsidies to unemployment insurance (UI) are analysed in a right-to-manage model where industry level unions run UI funds of their own. It is shown that equilibrium unemployment decreases in the share of UI financed by the employed union members. A reduction in the proportional subsidies matched by an increase in the lump sum grant is shown to bring about wage moderation and improve employment. If labour market parties can influence the level of benefits, a subsidy scheme with a fixed assistance per unemployed member is preferable to one covering a fixed share of the total UI costs.*

4.1 Introduction

Unemployment insurance (UI) of some type or other is an essential part of the labour market policy in practically all developed countries. At the same time, unemployment insurance is commonly regarded as one of the key factors behind the high structural rates of unemployment. In unionized labour markets, unemployment benefits serve to improve the fall back position of the union members and therefore lead to higher wages. This basic result incorporates the assumption that unemployment benefits are entirely financed by the government and therefore impose no direct cost on the labour market parties.

From this viewpoint it seems plausible that the adverse effects of UI could be mitigated if some part of the cost were borne by the agents directly responsible for the wage setting and the employment decisions. A working example of such an arrangement that has gained attention lately is the experience rating of employers' UI payments in the United States. The experience rated system - largely absent from other OECD countries - has been seen as one of the structural explanations for the lower unemployment rate in the U.S. in comparison to Europe (see e.g. Fath and Fuest, 2002, L'Haridon and Malherbet, 2002).

Within Europe, the Nordic countries have traditionally shown lower unemployment rates than Europe on average[1]. In many views, the success of the Nordic labour markets has been explained by their corporatist structure and the relatively coordinated wage bargaining in those countries (e.g. Koskela and Uusitalo, 2003). In the light of the fact that coordination of the wage setting has become less predominant since the 1980s (see e.g. Nickell, 2003), one might want to look for some alternative institutional features that could explain the sound performance of the Nordic labour markets. One such a feature not present in the rest of the Europe is the organization of UI through voluntary membership in funds that are closely connected with the trade unions. This so-called "Gent model" applied in the four Nordic countries of Denmark, Finland, Sweden and Iceland - though heavily subsidized by the government - has some fraction of the costs borne by the insured employees and can therefore be seen as an alternative way to introduce experience rating into the UI system[2].

Even within the Gent model, the government still covers a major part of the costs of the UI. However, the exact form of government intervention is not settled. The government can, for example, bear a predetermined share of the total costs of the scheme. Another possibility is that the government finances a fixed per head assistance for each unemployed person. Recently, a change from the former practice to the latter took place within the Finnish

[1] The upsurge of Finnish unemployment during the recession in the early '90s and its sluggish recovery is an exception to the rule. Despite this, the average unemployment rate in the Nordic countries in 2002 was at the same level as in the U.S.

[2] A more detailed description of the UI systems can be found in Björklund and Holmlund (1991) for Sweden, Sinko (2001) for Finland and Parsons et al. (2003) for Denmark.

earnings-related UI system (Sinko, 2001). Also, the systems differ with respect to whether the premiums are collected from only the employed members or both employed and unemployed fund members. Faced with these several alternatives, the question arises about whether the type of government intervention makes any difference in terms of wages, employment and distribution of income between the employed and unemployed workers.

In this paper we analyse the effects of the alternative government UI subsidy schemes on wage determination and employment. The framework of the analysis is a right-to-manage model of unionized labour markets (e.g. Booth, 1995) where wage negotiations take place at the industry level. Public authorities subsidize unions in financing the UI. We consider four alternative types of government subsidy schemes: i) UI is financed entirely by the government ii) the government covers a fixed share of the total costs iii) the government pays a lump sum grant to the UI fund and iv) the government pays a fixed per head assistance for each unemployed. To allow for a part of the UI costs to be borne by the union members, we extend the standard model by endogenizing the premium paid by the employed union members. The actual size of the members' contribution then depends, among others, on the unemployment rate prevailing at the industry level[3].

The fact that the premium size becomes dependent on the unemployment rate relates our analysis to the studies on the experience rating of employers' payments. These studies, inspired by the U.S. system, include among others Feldstein (1978), Burdett and Wright (1989) and Fath and Fuest (2002). Unlike theirs, however, in our set-up one's own financial risk is introduced on the worker's rather than the employer's side.

The study most closely connected to ours is Holmlund and Lundborg (1988), who utilize a monopoly union framework to study the implications of the Gent model[4]. They find that lump sum government subsidies improve employment, whereas the effects of marginal subsidies are ambiguous. We extend the analysis of Holmlund and Lundborg by employing the right-to-manage set-up that embeds the monopoly union model as a special case. In

[3] This is in line with the observations from the Finnish earnings-related UI system where the premium varies from 0.1 to 2.2 per cent of wages between the industry level funds (Kiander, 1996).

[4] The effects of an endogenous UI premium are also studied by Kiander (1993), who allows for endogenous search intensity among the unemployed members and by Holmlund and Lundborg (1999), who focus on the endogenous decision to join the union. A recent contribution in a similar set-up is provided by Halko (2003).

addition, we study the case not considered by them where the government pays a fixed per head subsidy for each unemployed, that is of special interest in the light of the Finnish reform mentioned above. Unlike Holmlund and Lundborg we assume - perhaps more realistically - that unions are interested in the disposable incomes of their members and unemployed members pay no UI premium[5]. Finally, we compare the performance of the alternative subsidy schemes in the equilibrium when the level of benefits is negotiated along with wages.

We show that introduction of experience rating on the workers' side makes the wage setting curve downward sloping, as the employed union members have to be offered compensation for the premium. In equilibrium, a ceteris paribus lower wage rate and higher employment will prevail than in the case where unemployment benefits are entirely financed by the government. In line with Holmlund and Lundborg (1988) we find that a lump sum subsidy to the UI fund reduces wage demands and improves employment. However, in our set-up this result is not conditional on risk aversion by the unions. Whether the government subsidy is a fixed share of the total cost or a fixed assistance per head makes no difference to wages or employment as long as the government spending per head is equal in the two regimes. However, it can be shown that the sensitivity of wages to improvement in the benefit level is smaller in the case of the fixed per head subsidy. Also, if wage setting institutions can influence the level of UI benefits, the per head subsidy is likely to induce a more moderate wage policy.

The structure of the paper is as follows. Section 4.2 introduces the model and considers the case where the government finances a fixed share of the total costs of UI. In addition, a subsidy in the form of a lump sum grant is assumed to be available. The standard model where the government alone stands for the UI costs then arises as a special case. We also briefly consider the special case where the premium is also paid by unemployed members. Section 4.3 presents some extensions to the basic set-up. We first consider an alternative subsidy regime where the government pays a fixed per head assistance for each unemployed worker. Finally, a stylized model for the endogenous determination of the UI benefit level is derived. Section 4.4 presents a summary of the findings and some discussion of the results. More

[5]In Finland, most of the UI funds exempt unemployed members from paying the premium. In Section 4.2.6 we briefly consider the case applying to Denmark where the premium is independent of labour market status. In the Swedish system the practice is mixed in this respect.

detailed derivation of selected results is presented in Appendices 4.A-4.C.

4.2 The Model

The broad structure of the model is as follows: Labour demand by competitive firms is based on profit maximisation, taking wages as given. Individuals are either employed or unemployed and belong to a trade union. Wages are determined in an industry level Nash bargain between firms' representatives (industry level confederations) and the unions. When negotiating the wage rate, the wage setters realize that the cost of unemployment insurance has to be financed from an industry specific UI fund. The level of benefits is mandatory. The government subsidizes these funds by financing a fixed share of their total outlays. The rest of the UI expenses is covered by the premiums collected from the employed union members.

4.2.1 Preliminaries

More specifically, we assume that firms use labour N as a single input and solve the problem

$$\max_{N} \Pi = f(N) - wN \tag{4.1}$$

The corresponding first order condition for optimality determines the labour demand as a function of the wage rate

$$N = w^{-\epsilon} \tag{4.2}$$

where $\epsilon \equiv -\frac{\partial \log N}{\partial \log w}$ is the labour demand elasticity. To facilitate a closed form solution of the model we assume that the production function takes the simple form of $f(N) = \frac{1}{\gamma} N^{\gamma}$. The parameter $0 < \gamma < 1$ reflects the technology with decreasing returns to labour that can be interpreted as a Cobb-Douglas type with fixed capital input. With this technology, the labour demand elasticity is given by $\epsilon = (1-\gamma)^{-1} > 1$ [6].

As for the individuals, we assume that their total number is M, N of which are employed and $(M - N)$ unemployed. All individuals are members

[6] The implied constancy of labour demand elasticity greatly improves the analytical tractability of the model. However, the main results derived should be valid even with more flexible technology.

in an industry level worker's union. The employed individuals supply one unit of labour each. They are paid a wage determined in a bargain between firms and unions. Salaries w are subject to a premium z paid to an industry level UI fund. Thus, the disposable income of an employed individual is given by $y_e = w - z$. The size of the premium is endogenous and will depend on wages and employment as defined below. The unemployed individuals receive unemployment benefit and pay no premium to the UI fund. The income of an unemployed individual is thus determined simply by the unemployment benefit, $y_u = w_u$. We assume throughout that workers are better off than non-workers and unemployment is hence involuntary. Notably, we do not exclude the possibility of risk aversion in the form of a concave individual utility over disposable income. However, as long as the union is only interested in the disposable income of its members - which seems a rather realistic assumption - allowing for individual risk aversion would not affect the results derived below that are driven by the wage setting response to policy[7].

4.2.2 Financing of UI

Assume that unemployment benefits are financed by an industry level UI fund that collects premiums from employed union members and receives subsidies from the government. The budget constraint of such a fund can be written as

$$zN + g = (1 - p)\, w_u\, (M - N) \tag{4.3}$$

where z is the endogenous rate of individual contribution, p is the proportional government subsidy rate, g is the government lump sum grant for the fund and M is the total number of union members. Expression (4.3) effectively defines the premium as a function of employment of the union members. For a given wage rate, the premium increases in the benefit level as well as in union membership and decreases in both the proportional and lump sum government subsidies. Differentiating with respect to the wage rate gives

$$\frac{\partial z}{\partial w} = [(1 - p)\, w_u M - g]\, N^{-1} w^{-1} \epsilon > 0 \tag{4.4}$$

[7]It can be shown that the wage moderation effect derived below is robust to concavity of the union objective over the disposable income of its members as long as the risk aversive attitude of the union is not too strong.

Expression (4.4) shows that the contribution rate of employed members increases in the wage rate as long as $g < (1-p)\, w_u M$ i.e. the lump sum subsidy is less than the total private liabilities in the UI financing, which we readily assume. Thus, from the employed members' viewpoint, a positive effect of a wage hike is partly offset by the higher contribution rate. The strength of this effect is increasing in the union membership, M. Also notice that the effect of a wage increase on the take-home pay of an employed member is given by

$$\frac{dy_e}{dw} = 1 - \frac{\partial z}{\partial w} \tag{4.5}$$

In what follows we make the natural assumption that the implied increase in the premium never dominates the direct effect of a wage hike. That is, a wage hike does not deteriorate the position of an employed worker and the right hand side of (4.5) is non-negative[8].

4.2.3 Wage Bargaining

The wage rate is determined in a Nash Bargain between decentralized, industry level unions and firm representatives. When setting the wage, the two parties take account of the effect of wages on labour demand, profits and individual incomes as defined above. In particular, they perceive the link from wages to unemployment and to the resulting outlays of the UI fund. The wage bargaining problem can then be written as follows:

$$\max_w \left(V - V_0\right)^{\beta} \left(\Pi - \Pi_0\right)^{1-\beta}$$

where $V - V_0$ is the maximand of the union and $\Pi - \Pi_0$ is the maximand of the firms. Differentiating with respect to the wage rate and setting the right hand side equal to zero yields the first order condition for optimality

$$\beta \left(\Pi - \Pi_0\right) \frac{\partial \left(V - V_0\right)}{\partial w} + (1-\beta)\left(V - V_0\right) \frac{\partial \left(\Pi - \Pi_0\right)}{\partial w} = 0 \tag{4.6}$$

To define the maximands of the two parties, we assume that without a contract the firms get no labour ($N = 0$). In that case, their output and profits are zero and their fall back position is $\Pi_0 = 0$. Substituting labour

[8] This is a prerequisite for the first order condition of the wage setting problem to be feasible and can be shown to hold as long as the government subsidy rate p is high enough to exceed some threshold p^*, $0 < p^* < 1$.

demand (4.2) in (4.1), we can express firms' profits as a function of the wage rate and differentiate to get

$$\frac{\partial \log (\Pi - \Pi_0)}{\partial \log w} = -(\epsilon - 1) < 0 \tag{4.7}$$

which determines the relative change in profits due to a wage hike. For a union aiming to maximize the disposable income of its members, the objective can be written as $V = Ny_e + (M - N)\, y_u$. The fall back position of the union is the case where $N = 0$, implying $V_0 = My_u$. Consequently, the union Nash maximand becomes $V - V_0 = N(y_e - y_u)$. Differentiating this with respect to the wage rate yields

$$\frac{\partial (V - V_0)}{\partial w} = (y_e - y_u) \frac{\partial N}{\partial w} + N \left(1 - \frac{\partial z}{\partial w}\right) \tag{4.8}$$

As already noted above, the effect of wages on the disposable income of the employed workers comes from two separate channels: in addition to the direct effect there is an indirect effect through an implied change in the premium, z. Utilizing (4.7) and (4.8) and substituting for the relevant formulas we can rewrite the first order condition (4.6) as follows

$$\beta \left((1 - p)\, w_u M - g\right) N^{-1} \epsilon - (z + w_u)(\epsilon - 1 + \beta) + w(\epsilon - 1) = 0 \tag{4.9}$$

where w, z and N are the endogenous variables to be determined below[9]. The formula (4.9) nests several simpler models as special cases. In particular, setting $p = 1$ and $g = z = 0$ and solving for w yields

$$w = \left(1 + \frac{\beta}{\epsilon - 1}\right) w_u \tag{4.10}$$

which is the wage setting schedule of the standard Nash bargain model (with $0 < \beta < 1$) where the government fully finances the unemployment insurance. Similarly, setting $\beta = 1$ produces the monopoly union framework, with the government either fully financing UI ($p = 1$) or with some experience rating involved ($0 < p < 1$).

[9] We show in Appendix A that the second order condition for a maximum is satisfied under certain parameter restrictions.

4.2.4 Labour Market Equilibrium

Let us turn back to the general case where $0 < \beta, p < 1$ and $g > 0$. Following the right-to-manage approach, we assume that after the wage has been set, the firms unilaterally determine the level of employment. The industry level labour market equilibrium is then characterized by the set of three equations (4.2), (4.3) and (4.9) that determine the wage rate w, employment N and the premium paid by the employed members, z. There are several industries in the economy, the total number of which is normalized to unity. Then, in a symmetric equilibrium, the general wage rate and total employment coincide with the industry level outcomes. Substituting (4.3) in (4.9) and solving for w yields

$$w = \frac{\beta + \epsilon - 1}{\epsilon - 1} p w_u + \frac{(1-\beta)\left((1-p)\, w_u M - g\right)}{N} \tag{4.11}$$

which constitutes a downward sloping wage setting schedule in (N, w)-space under the assumption stated in connection with equation (4.4). According to (4.11) the industry level optimal wage rate consists of a "base wage" $\frac{p w_u(\epsilon - 1 + \beta)}{\epsilon - 1}$ plus an additional term that is negatively dependent on the employment rate N/M. Intuitively, when part of the UI is financed by the employees, the optimal wage has to compensate for the premium paid to cover the costs of the UI fund. The size of the premium is inversely related to the employment rate and so is the optimal wage. In the case where the government fully finances UI ($p = 1$, $g = 0$) the additional term disappears and the wage setting curve becomes horizontal, as can be seen from equation (4.10)[10].

Let us first consider the case where the government finances a fixed share of the total costs of UI, i.e. $0 < p < 1$ and $g = 0$. It can be shown, by comparison of (4.11) and (4.10), that the wage setting schedule allowing for an individual contribution to UI costs lies below the wage setting schedule implied by the regime where the government fully finances the UI as long as

$$\frac{N}{M} > \frac{(1-\beta)(\epsilon - 1)}{(\epsilon - 1 + \beta)} \tag{4.12}$$

i.e. when the employment rate is not too low. Condition (4.12) is quite likely to hold with plausible parameter values. For example, with $\beta = 0.5$ and $\epsilon =$

[10] Also, it can be shown that in contrast to the standard model, the net replacement ratio $\rho_n \equiv w_u / (w - z)$ implied by (4.11) is declines with employment. Increased unemployment thus serves to reduce income inequality in the model.

1.5 the right hand side is equal to 0.25. In what follows we limit the analysis to the case where the employment rate is reasonably high and condition (4.12) is satisfied. Allowing for the downward sloping labour demand curve (4.2), we can then conclude that introduction of the own risk into the financing of UI leads to a lower equilibrium wage rate and higher employment. More formally:

Proposition 4.1 *If a fixed share of the UI related costs is covered by a premium paid by the employees ($p < 1$), wages will be lower and employment will be higher than in the case where UI is entirely financed by the government ($p = 1$).*

Proof. The right hand side of (4.11) is less than the right hand side of (4.10) as long as (4.12) holds. ■

Also notice that (4.11) can be presented in the form

$$w = \frac{\beta p w_u}{1 - 1/\epsilon} + (1 - \beta)(w_u + z) \tag{4.13}$$

which conveniently decomposes the Nash bargain wage into the monopoly union wage $\frac{p w_u}{1-1/\epsilon}$ and the reservation wage $(w_u + z)$. The former is the limiting outcome as β approaches unity, reflecting a strong bargaining position of the union. As β approaches zero, the firms are in a position to drive wages down to the reservation level. It is noteworthy that the reservation wage depends on the premium z and is therefore endogenous in the model.

Recognizing that the labour demand defined by (4.2) is downward sloping, it is straightforward to determine the sign of the effects on equilibrium wages and employment of changes in the exogenous parameters implied by the wage setting equation (4.11). Furthermore, utilizing (4.3) we can derive the following comparative statics results (see Appendix B for the detailed derivation)

$$\begin{aligned} \frac{\partial w}{\partial M} &> 0, \frac{\partial N}{\partial M} < 0, \frac{\partial z}{\partial M} > 0 \\ \frac{\partial w}{\partial w_u} &> 0, \frac{\partial N}{\partial w_u} < 0, \frac{\partial z}{\partial w_u} > 0 \\ \frac{\partial w}{\partial p} &> 0, \frac{\partial N}{\partial p} < 0, \frac{\partial z}{\partial p} \gtreqless 0 \end{aligned} \tag{4.14}$$

An increase in either the union membership M or the benefit level w_u increases wages, reduces employment and increases the premium paid by the employed workers. These effects become understandable through the inspection of (4.13): higher membership puts an upward pressure on the premium z and therefore increases the reservation wage and thus the optimal wage in the Nash bargain. The higher wage rate, in turn, reduces labour demand and employment. According to (4.3), an increase in the membership causes a direct and an indirect effect (through N), both of which tend to increase the premium. A similar argument holds for an increase in the mandatory level of benefit w_u.

As for the public share of the UI costs, p, things are somewhat more complex: On the one hand, a higher public share increases the marginal gain of a wage hike to the employed workers. On the other hand, a higher public share puts a downward pressure on the premium and thus reduces the reservation wage. These two effects tend to move the wage rate in opposite directions. However, the magnitude of the latter effect is inversely related to the level of employment. Therefore, given that the employment rate is reasonably high, i.e. condition (4.12) holds, a higher public share increases wages and reduces employment. The effect of the public share on the premium z is a priori ambiguous as can be seen from (4.3). A closer inspection (see Appendix B) reveals that a higher public share reduces the premium if employment is not too elastic with respect to changes in the public share.

4.2.5 Lump Sum Subsidy for the Fund

So far we have assumed that the government finances a fixed share of unemployment expenditures. Let us now briefly consider the effects of a lump sum (annual) subsidy $g > 0$ paid for the UI fund on top of the proportional subsidy. Differentiating (4.11) shows that

$$\frac{\partial w}{\partial g} < 0, \frac{\partial N}{\partial g} > 0, \frac{\partial z}{\partial g} < 0 \tag{4.15}$$

in other words, a marginal increase in the lump sum subsidy brings about wage moderation and improves employment. Intuitively, at a given wage (and employment) an increase in the lump sum subsidy serves to reduce the premium which, in turn, lowers the reservation wage as reflected in (4.13) and triggers the wage moderation. Lower wages then improve employment which further reduces the premium. Notably, this effect disappears when the bargaining power of the union approaches unity[11].

Result (4.15) suggests that government can "buy" wage moderation and improve employment by providing the UI funds with lump sum subsidies. This would, of course, be costly and necessitate either tax increases or cuts in other public spending. Since the results stated in (4.14) suggest that the proportional UI subsidies are harmful for employment, they are a natural candidate for the retrenchments. This reasoning leads to the following proposition:

Proposition 4.2 *A (budget neutral) switch where the subsidies proportional to UI spending are reduced and the lump sum subsidies are simultaneously increased will reduce wages and improve employment in the model.*
Proof. *Follows directly from the results (4.14) and (4.15).* ■

The results stated in propositions 4.1 and 4.2 are broadly in line with the findings of Holmlund and Lundborg (1988), but are based partly on a different reasoning. In particular, in their set-up, the ambiguity of the wage effect of the proportional subsidy p and the negative wage effect of the lump sum subsidy g is due to the assumed concavity of the union's objective. In the present model, qualitatively similar results arise without explicit modelling of risk aversion by the union. Furthermore, the effect of proportional subsidy on wages is unambiguously positive.

4.2.6 Premium Collected from the Unemployed

So far we have assumed that the UI premium was only paid by the employed workers, which is mostly the case in Finland. Let us now consider a setting more close to the Danish system, where the size of the premium is independent of employment status. In this case the UI fund's budget becomes

$$zM = (1 - p)\, w_u\, (M - N) - g \tag{4.16}$$

Following the procedure similar to that in Section 2.4 it is straightforward to show that the wage equation now reduces to (4.10) and the wage moderation

[11] Holmlund and Lundborg (1988) derive a negative relationship between a lump sum UI subsidy and the wage rate in the monopoly union set up. However, their result necessitates risk aversion by the unions.

effect disappears. Intuitively, introduction of own financial risk at rate $(1-p)$ on both employed and unemployed members leaves the marginal effect of a wage hike on the income difference unchanged. Therefore, the effectiveness of wages in improving the income of the employed relative to the unemployed is not reduced and wages remain unchanged in comparison to the standard model with $p = 1$[12].

4.3 Extensions

4.3.1 Fixed per Head Assistance

Next consider an alternative financial scheme where - instead of covering a fixed share of the total costs - the government pays a fixed per head assistance b for each unemployed member [13]. In this case the UI fund's budget constraint becomes

$$zN = (w_u - b)(M - N) \tag{4.17}$$

The wage setting problem is as before except for determination of the premium given by (4.17), which now enters the union maximand in (4.8). In this case the wage equation becomes (see Appendix C for the detailed derivation)

$$w = \frac{b(\epsilon - 1 + \beta)}{(\epsilon - 1)} + (w_u - b)(1 - \beta) M N^{-1} \tag{4.18}$$

which defines a downward sloping wage setting curve in (N, w)-space. The equilibrium is characterized by the set of three equations (4.2), (4.17) and (4.18). Following a procedure similar to that in Section 2.4 above, we can utilize (4.18), (4.2) and (4.17) to derive some comparative statics results concerning the effects of the key parameters on the equilibrium values of wages, employment and the premium. As for the union membership M and the benefit level w_u, the effects are qualitatively similar to those derived in (4.14) above. As for the per head subsidy b, we get

$$\frac{\partial w}{\partial b} > 0, \frac{\partial N}{\partial b} < 0, \frac{dz}{db} \gtreqless 0 \tag{4.19}$$

[12] I thank Peter Birch Sörensen for directing my attention to the "Danish case". Actually, in the Danish system, the size of the premium is also only loosely linked to the fund outlays (Parsons et al., 2003).

[13] This corresponds closely to the current Finnish system, where the government covers an amount equal to the basic unemployment assistance of each unemployment benefit paid out by the funds.

Higher per head assistance increases wages and reduces employment conditional on (4.12). Similar to (4.14) above, the effect of increased subsidy on the premium is a priori ambiguous. It is noteworthy that imposing $b = pw_u$ in (4.18) makes it identical to (4.11) with the consequence that equilibrium wage and employment will be equal under the two regimes. Intuitively, if the government assistance per head were designed so as to make up share p of the total benefit, the outcome would be equivalent to the one with the government covering share p of the total outlays. However, the sensitivity of wages to exogenous changes in the benefit level w_u would differ between the two regimes. In particular, it can be shown that (see Appendix C)

$$\left(\frac{\partial w}{\partial w_u}\frac{w_u}{w}\right)_b < \left(\frac{\partial w}{\partial w_u}\frac{w_u}{w}\right)_p \tag{4.20}$$

i.e. that the elasticity of the wage rate with respect to UI benefits is smaller in the "b-regime" than in the "p-regime". This finding is conditional on (4.12) and can be summarized by the following proposition:

Proposition 4.3 *A switch to an UI subsidy regime with the government paying the fund a fixed assistance per unemployed member makes wages less sensitive to increases in the UI benefit level.*

Proof. see Appendix C. ■

The result can be interpreted with the help of formula (4.13): Under the "p-regime" with the government covering share p of the total costs, a mandatory improvement in the benefit level w_u puts an upward pressure on wages through both the monopoly union wage and the reservation wage. In the "b-regime" with the government paying the fund a fixed assistance per unemployed member, only the latter channel is active. Intuitively, under the "b-regime", an improvement in the benefit level w_u implies no income transfer from the government to the labour market parties unless the per head assistance b is simultaneously increased.

4.3.2 Endogenous Determination of the Benefit Level

In the above, the level of unemployment benefit w_u was mandatory and taken as an exogenous parameter in the wage setting process. In this section we relax this assumption and derive an equilibrium where the wage setting institutions can affect the benefit level and w_u becomes endogenous. For that purpose we now assume that the level of UI benefits is decided in a Nash bargain between the workers' and the firms' representatives simultaneously with the wages[14]. The bargaining problem then becomes

$$\max_{w,w_u} \Omega = (V - V_0)^{\beta} (\Pi - \Pi_0)^{1-\beta} \tag{4.21}$$

With the notion that the unemployment benefit affects the disposable income of the unemployed directly and the disposable income of the employed indirectly through the premium, it is straightforward to derive the following first order condition for the optimal benefit level

$$N \left(\frac{dy_e}{dz} \frac{dz}{dw_u} + \frac{dy_u}{dw_u} \right) = 0 \tag{4.22}$$

According to (4.22) the benefit level is chosen so as to equalize the marginal benefit accruing to the unemployed members with the marginal loss caused among the employed members due to higher premiums. With a constant marginal utility of income, the optimality condition is dictated by the term $\frac{dz}{dw_u}$ that reflects the magnitude of a negative effect on the take-home pay of the employed. Substituting for the formulas of the relevant derivatives into (4.22) then yields the condition

$$(1 - p) \left(MN^{-1} - 1 \right) = 1 \tag{4.23}$$

which can be explicitly solved for employment. Combining (4.23) with equations (4.2), (4.3) and (4.11) we can then solve the equilibrium with w_u endogenously determined under the "p-regime", i.e. with the government covering a fixed share of the total costs. This yields the following equilibrium values for wages, the premium and the unemployment benefit

$$\begin{aligned} w &= \left(\frac{2-p}{1-p} \right)^{1/\epsilon} M^{-1/\epsilon} \\ z &= w_u = \frac{1}{2(1-\beta) + \frac{p\beta\epsilon}{\epsilon - 1}} w \end{aligned} \tag{4.24}$$

[14]This set-up should be understood as a stylised descpriction of a situation where wage setting institutions have an influence on UI benefits as well as wages. It may therefore be more realistic to think about relatively centralised, economy wide wage setting institutions here.

where we have assumed $g = 0$, for simplicity. Notably, the equilibrium wage is increasing in the government subsidy rate p and decreasing in the union membership M. Next, we derive the corresponding formulas under the "b-regime" where the government provides a fixed assistance b per each unemployed member, as described in the previous section. Following a procedure similar to that above yields

$$\begin{aligned} w &= 2^{1/\epsilon} M^{-1/\epsilon} \\ z &= w_u - b = \frac{(\epsilon - 1)(w - b) - b\beta}{2(1-\beta)(\epsilon - 1)} \end{aligned} \tag{4.25}$$

In this case the equilibrium wage rate is independent of the per head assistance b. Also, for any $0 < p < 1$ the wage rate is lower than in the case of the proportional subsidy p. Furthermore, by imposing the restriction $b = pw_u$ on (4.25) it is possible to show that for a high enough public share, the benefit level w_u will be lower than under the "p-regime". These findings can be summarized by the following proposition:

Proposition 4.4 *If the level of unemployment benefits is negotiated simultaneously with the wages, a fixed government assistance per unemployed member leads to lower wages and higher employment than a subsidy that is proportional to unemployment outlays of the UI fund.*

Proof. Follows from comparison of (4.24) and (4.25) and the fact that employment is determined by (4.2). ■

Intuitively, under the regime with a per head assistance b, the marginal cost of an increase in the benefit level accruing to labour market parties is higher for a given level of employment . This is because government subsidies increase only to the extent that unemployment increases. This leads to a lower level of benefits and lower wages relative to the "p-regime" where the subsidies serve to reduce the marginal cost of higher benefits even for a given level of employment.

4.4 Concluding Remarks

We have analysed alternative ways to organize the government subsidies for unemployment insurance in a right-to-manage model of unionized labour markets where wage negotiations take place at the industry level. We considered four alternative types of government subsidy schemes: i) UI is financed entirely by the government ii) the government covers a fixed share of the total costs iii) the government pays a lump sum grant to the UI fund and iv) the government pays a fixed per head assistance for each unemployed. Employed union members pay an endogenous premium to cover the private share of the UI costs. The size of the premium depends, among other things, on the unemployment rate prevailing at the industry level.

We showed that introduction of "experience rating" on the workers' side in the financing of the UI makes the wage setting curve downward sloping as the employed union members have to be offered compensation for the premium they pay. If part of the unemployment benefits is financed by the employed union members, a ceteris paribus lower wage rate and higher employment will prevail than in the case where unemployment benefits are entirely financed by the government.

In this set-up, a lump sum subsidy to the UI fund serves to reduce wage demands and improves employment. Therefore, a budget neutral switch that reduces the proportional subsidy rate and correspondingly increases the lump sum grant is suggested to bring about wage moderation and to reduce unemployment.

Whether the government subsidy is a fixed share of the total UI costs or a fixed assistance per head makes no difference to wages or employment as long as the government spending per head is equal in the two regimes. However, it can be shown that the sensitivity of wages to improvement in the benefits is smaller in the case of fixed per head subsidy. Also, if wage setting institutions can influence the level of UI benefits, the per head subsidy is likely to induce a more moderate wage policy.

As for the policy implications, our analysis suggests that, with some part of the UI costs borne by the union members, the "Gent model" may improve employment in unionized labour markets. It therefore has potential - along with other institutional features - in explaining the relatively low unemployment rates in the Nordic countries in comparison to the rest of Europe. However, assessment of the quantitative importance of this effect would necessitate a careful empirical analysis that lies outside the scope of this study.

The model also gives some support for the recent reform in the Finnish earnings-related UI system: Paying a fixed per head assistance for each unemployed union member seems to do better - at least in certain respect - than covering a fixed share of the total UI costs when measured by employment performance. At the same time, the importance of premium differentiation between employed and unemployed members is stressed; in the "Danish model" where premium is independent of the labour market status, the wage moderation effect does not arise. This notion may help to explain the empirical results suggesting that the wages in Denmark are more sensitive to changes in the UI benefits than in Finland and Sweden (Nymoen and Rödseth, 2003).

Finally, it should be noted that the modelling framework used is insufficient to deal with some important aspects of UI. In particular, we do not explicitly allow for income uncertainty that, on the one hand, forms the justification for UI in the first place. Also, the inherently dynamic aspects such as the length and time profile of benefits are outside the scope of the present study. We have deliberately focused solely on the differences in the wage and employment response under alternative financial arrangements of UI while keeping the framework as simple as possible. While most of the results derived are not qualitatively sensitive to allowing, for example, risk aversion in the union objective, assessing the welfare or efficiency aspects of different UI related policies would certainly call for a more versatile framework.

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4.A Second Order Condition

Differentiating the left hand side of (4.9) with respect to the wage rate yields

$$\beta\epsilon\left(\left(1-p\right)w_u M - g\right)N^{-2}\frac{\partial N}{\partial w} - \left(\epsilon - 1\right) + \left(\epsilon - 1 + \beta\right)\frac{\partial z}{\partial w} \tag{4.26}$$

Substituting (4.4) for $\frac{\partial z}{\partial w}$ and utilizing $\epsilon \equiv -\frac{\partial N}{\partial w}\frac{w}{N}$ we can rewrite (4.26) as

$$\left(\epsilon - 1\right)\left[\epsilon\left(1-\beta\right)\left(\left(1-p\right)w_u M - g\right)w^{-1}N^{-1} - 1\right]$$

which is negative iff

$$g > Mw_u (1-p) - \frac{Nw}{\epsilon (1-\beta)}$$

We have already assumed in connection with (4.4) that $g < Mw_u (1-p)$. Consequently, we restrict the analysis to the range of parameter values such that

$$Mw_u (1-p) - \frac{Nw}{\epsilon (1-\beta)} < g < (1-p) Mw_u$$

4.B Comparative Statics of the Basic Model

Substitute (4.2) for N and rearrange (4.11) (under $g = 0$) to get

$$w - (1-p)(1-\beta) w_u M w^{\epsilon} - \frac{p(\epsilon - 1 + \beta)}{\epsilon - 1} w_u = 0 \tag{4.27}$$

which implicitly defines the equilibrium wage rate as a function of the exogenous parameters $\alpha = (w_u, M, p)$. Denoting the left hand side of (4.27) by $\Theta(w; \boldsymbol{\alpha})$, differentiate with respect to w and utilize (4.4) to get

$$\frac{\partial \Theta (w; \boldsymbol{\alpha})}{\partial w} = 1 - (1-\beta) \frac{\partial z}{\partial w} > 0$$

where the inequality follows from $\frac{\partial z}{\partial w} < 1$ implied by (4.5). Differentiating the left hand side of (4.27) with respect to M, w_u and p yields

$$\frac{\partial \Theta (w; \boldsymbol{\alpha})}{\partial M} = -(1-p)(1-\beta) w_u w^{\epsilon} < 0$$

$$\frac{\partial \Theta (w; \boldsymbol{\alpha})}{\partial w_u} = -(1-p)(1-\beta) MN^{-1} - \frac{p(\epsilon - 1 + \beta)}{\epsilon - 1} < 0$$

$$\frac{\partial \Theta (w; \boldsymbol{\alpha})}{\partial p} = w_u \left[(1-\beta) MN^{-1} - \frac{(\beta + \epsilon - 1)}{\epsilon - 1} \right] < 0$$

where the last inequality holds conditional on (4.12). Applying the implicit rule then yields $\frac{\partial w}{\partial M} > 0, \frac{\partial w}{\partial w_u} > 0$ and $\frac{\partial w}{\partial p} > 0$. Utilizing (4.2) we have consequently $\frac{\partial N}{\partial M} < 0, \frac{\partial N}{\partial w_u} < 0$ and $\frac{\partial N}{\partial p} < 0$. Then noticing that $\frac{dz}{d\alpha} = \frac{\partial z}{\partial \alpha} + \frac{\partial z}{\partial N}\frac{dN}{d\alpha}$ for any $\alpha = (w_u, M, p)$ allows us to derive

$$\begin{aligned}
\frac{dz}{dw_u} &= (1-p)\left[\left(MN^{-1}-1\right) - w_u MN^{-2}\frac{\partial N}{\partial w_u}\right] > 0 \\
\frac{dz}{dM} &= (1-p)\,w_u N^{-1}\left(1 - MN^{-2}\frac{\partial N}{\partial M}\right) > 0
\end{aligned}$$

As for the proportional subsidy p we similarly get

$$\begin{aligned}
\frac{dz}{dp} &= -w_u\left[MN^{-1} - 1 + (1-p)\,MN^{-2}\frac{\partial N}{\partial p}\right] \gtreqless 0 \\
&\Longleftrightarrow \\
\frac{\partial N}{\partial p}\frac{p}{N} &\lesseqgtr -\frac{p}{1-p}\left(1 - \frac{N}{M}\right)
\end{aligned}$$

where the second line follows from multiplying the first line by $\frac{p}{N}$ and some manipulation.

4.C Model with Fixed per Head Assistance

Substituting (4.17) for the premium in the union maximand in (4.8) and further to the first order condition (4.6) gives the following wage equation

$$w - \frac{(z+w_u)(\epsilon - 1 + \beta) - \beta\epsilon\,(w_u - b)\,MN^{-1}}{(\epsilon - 1)} = 0 \qquad (4.28)$$

The equilibrium is then determined by (4.2), (4.17) and (4.28). Substituting (4.17) in (4.28) gives equation (4.18) in the main text. Comparison of (4.18) with (4.10) shows that the "b-regime" leads to a lower wage rate than the standard model with the government financing UI entirely, as long as condition (4.12) holds.

Comparative statics results for the case of fixed per head assistance can be derived analogous to the basic model in Appendix B: Reorganizing (4.18) and denoting the left hand side by $\Lambda(w;\boldsymbol{\alpha})$ we can differentiate with respect to the wage rate to get

$$\frac{\partial \Lambda(w;\boldsymbol{\alpha})}{\partial w} = 1 - (1-\beta)\frac{\partial z}{\partial w} > 0$$

where the inequality follows from $\frac{\partial z}{\partial w} < 1$ implied by (4.5). Furthermore, for the membership M and the benefit level w_u we have

$$\begin{aligned} \frac{\partial \Lambda\left(w; \boldsymbol{\alpha}\right)}{\partial M} &= -\left(1-\beta\right)\left(w_u - b\right) N^{-1} < 0 \\ \frac{\partial \Lambda\left(w; \boldsymbol{\alpha}\right)}{\partial w_u} &= -\left(1-\beta\right) M N^{-1} < 0 \end{aligned}$$

Similarly, for the per head subsidy b

$$\frac{\partial \Lambda}{\partial b} = -\frac{\left(\epsilon - 1 + \beta\right)}{\left(\epsilon - 1\right)} + \left(1-\beta\right) M N^{-1} < 0$$

which holds conditional on (4.12). Applying the implicit rule then implies $\frac{\partial w}{\partial M} > 0$, $\frac{\partial w}{\partial w_u} > 0$ and $\frac{\partial w}{\partial b} > 0$. Using equation (4.2) we get $\frac{\partial N}{\partial M} < 0$, $\frac{\partial N}{\partial w_u} < 0$ and $\frac{\partial N}{\partial b} < 0$. Then utilize $z = \left(w_u - b\right)\left(M N^{-1} - 1\right)$ to derive

$$\begin{aligned} \frac{dz}{dM} &= \left(w_u - b\right) N^{-1} - \left(w_u - b\right) M N^{-2} \frac{\partial N}{\partial M} > 0 \\ \frac{dz}{dw_u} &= \left(M N^{-1} - 1\right) - \left(w_u - b\right) M N^{-2} \frac{\partial N}{\partial w_u} > 0 \\ \frac{dz}{db} &= -\left(M N^{-1} - 1\right) - \left(w_u - b\right) M N^{-2} \frac{\partial N}{\partial b} \gtreqless 0 \end{aligned}$$

Differentiating the equilibrium wage (4.18) with respect to w_u implies

$$\left(\frac{\partial w}{\partial w_u}\frac{w_u}{w}\right)_b = \left(\frac{wN}{\left(1-\beta\right) M w_u} - \epsilon\left(1 - \frac{b}{w_u}\right)\right)^{-1}$$

which is the elasticity of wages with respect to level of unemployment benefits under the regime with fixed per head assistance. Applying a similar procedure to (4.11) allows us to derive the corresponding elasticity in the case where the government covers a fixed share of the UI related costs ($0 < p < 1$, $g = 0$) as follows

$$\left(\frac{\partial w}{\partial w_u}\frac{w_u}{w}\right)_p = w_u \frac{p\left(\epsilon - 1\right)^{-1}\left(\beta + \epsilon - 1\right) + M N^{-1}\left(1-p\right)\left(1-\beta\right)}{w - M N^{-1} \epsilon w_u \left(1-p\right)\left(1-\beta\right)}$$

Setting the two elasticities equal under the assumption $b = p w_u$ and noticing that their difference is decreasing in the employment rate N/M, it is straightforward to show that (4.20) and, therefore, proposition 4.3 hold as long as condition (4.12) is satisfied.

Chapter 5

Unemployment Insurance with Limited Duration and Variable Replacement Ratio - Effects on Optimal Search

Abstract: *We analyse the effects of unemployment insurance (UI) in a job search model with endogenous search effort. The model is simulated numerically with the parameters fitted to the stylized facts of the Finnish labour market. We show that UI with a limited potential duration induces more search effort among the long-term unemployed that have exhausted a considerable amount of the current benefits. The positive search effect starts to dominate the earlier, the steeper is the decline in the replacement ratio and the more insecure the job contracts are. A reform that combines a declining replacement ratio with a higher initial level of benefits so as to leave the expected present value of the UI payments intact is likely to increase search effort throughout the benefit period. Such a reform is appealing for two reasons: it does not increase the expected public spending per head and is likely to be neutral in terms of the wage pressure.*

5.1 Introduction

Unemployment insurance (UI) is an important ingredient of the labour market policies of most developed economies. At the same time, it is commonly believed that high replacement ratios offered by the UI schemes constitute one of the causes of poor performance of the labour market in European economies. This view is broadly backed by economic theory: the negative employment effects of benefits, owing to increased reservation wages, are well known properties from the static models of competitive labour markets. In trade union models, unemployment benefits serve to improve the fall back position of the union and therefore lead to higher wage claims (e.g. Booth, 1995).

However, as pointed out in a recent OECD report, the replacement ratio is not the only relevant characteristic to consider when evaluating the employment effects of existing UI systems. Another, possibly equally important aspect is the maximum duration of the benefit payments. In most countries, benefit payments are limited to some finite period, ranging from five months in the UK to 60 months in Denmark, France and the Netherlands (OECD, 1999). It should be obvious that two systems with an equal replacement ratio may have totally different effects on employment incentives if the one provides benefits indefinitely and the other only for a short, predetermined period.

Yet another important issue neglected in the static analysis of UI is the eligibility for benefits. With few exceptions, the existing systems include an employment condition that defines a minimum length of employment prior to unemployment as a prerequisite for the reception of benefits. This arrangement has the important implication that for those who have already exhausted a period of benefits, employment provides an opportunity to renew the benefit period.

Turning back to the replacement ratio, a look at the data reveals that in most countries the replacement ratio provided by the UI is constant across the benefit period (OECD, 1999). However, this does not need to be case, but the replacement ratio could, in principle, vary over time. Indeed, a declining time sequence of the benefits has been proposed and even adopted in some European countries, for instance in Belgium. Recently, plans to introduce a step-wise declining benefit profile has also been taken up in Finland.

The analysis of these real-world aspects of UI systems inherently calls for a dynamic framework. A seminal contribution on the dynamic effects of unemployment insurance is Shawell and Weiss (1979). They, as well as most of the existing literature, focus on the optimal sequencing and duration of the benefit system, given some criterion for welfare. According to their results, if unemployed workers can affect the probability of getting a job, the optimal sequence declines over time.

A slightly different view is taken in a pioneering article by Mortensen (1977). They focus on the re-employment incentives and accommodate institutional features such as eligibility conditions and the limited potential duration of benefits. The key notion is that once these features are taken into account, the effect of unemployment insurance on employment is ambiguous. A more recent contribution along these lines is Mortensen (1990) that also allows for on-the-job search and endogenous layoff decisions. With exogenous search effort, Mortensen (1990) shows that the introduction of a duration limit for benefits causes the reservation wage to fall monotonically from that associated with no limit to that which obtains after benefits are exhausted. In both of Mortensen's models the replacement ratio is assumed to be constant over time.

More recent papers, cast in the job search framework, have presented somewhat mixed results. Davidson and Woodbury (1997) argue that optimal insurance pays a positive benefit indefinitely. Fredriksson and Holmlund (1998) find that a two-tier system dominates one with indefinite payments and a constant replacement ratio. Cahuc and Lehmann (2000) are somewhat more cautious and point out that a declining time sequence of benefits may lead to a wage increase that counteracts the positive response of job search intensity. These also use either utilitarian or Rawlsian criteria for judging the welfare implications of UI. The benefits are assumed be paid indefinitely and the decline in the replacement ratio is modelled as a stochastic shock.

The purpose of this paper is to analyse the incentive effects of unemployment insurance in a job search model with endogenous search effort. Following closely the analysis of Pissarides (2000), we first review the effects of UI with a fixed benefit paid indefinitely. We then proceed to consider the implications of a limited potential duration of benefits and a declining time sequence for the replacement ratio. Similar to Mortensen (1977, 1990) we do not aim at determining the optimal UI system, but rather focus on the effects of UI on search intensity and thereby on employment. Unlike Mortensen, we also allow for a declining time sequence of the benefits. The introduction of a duration limit for the benefits basically makes the model non-stationary and greatly increases the complexity of the model. For this reason we mostly rely on numerical simulations. For this purpose, we parametrise the model to mimic the stylized facts of the Finnish labour markets, which allows us to draw some conclusions on the unemployment insurance system in Finland. In this respect our analysis is close to that of Kettunen (1991), who assesses the Finnish UI system in a search theoretic framework. However, unlike ours„ his model does not allow for limited potential duration of benefits and anticipation of future layoffs by the workers.

Our central finding is that the introduction of a limited potential duration for benefits importantly shapes the effects of UI on search behaviour. While a constant benefit paid indefinitely unambiguously reduces the search effort, a benefit system with a limited potential duration increases the search effort of those who have been unemployed for some time and have already exhausted a considerable part of their benefits. Concerning the declining time sequence of benefits, we find that if a faster depreciation of the replacement ratio is accompanied by an increase in the initial benefit level so as to keep the present value of the programme intact, the search effort is increased throughout the benefit period. We argue that such a policy is likely to be neutral in terms of the wage pressure and therefore should lead to lower unemployment as well.

The structure of the paper is as follows. Section 5.2 introduces the basic model with no unemployment insurance. Section 5.3 introduces the UI programme and presents the related results, which are mostly based on numerical simulations. Section 5.4 sums up and presents some concluding remarks. Detailed derivation of the equations and results is presented in the Appendices 5.A-5.E.

5.2 The Basic Model

The modelling framework with endogenous search is based on Pissarides (2000). Unemployed workers are engaged in a costly search for a job. The probability of finding one is positively correlated with the individual effort devoted to search activity. Once a job is found, the worker becomes employed, but faces a positive probability of dismissal and becoming unemployed again. The problem of the worker is to choose the optimal search intensity allowing for the possible loss of unemployment benefits in the event of becoming employed. All jobs are identical and there is no on-the-job search. For simplicity, the wage formation and the determination of labour market tightness is assumed to be exogenous to the model.

Let us first consider the case where unemployment insurance is paid indefinitely at a constant rate b. Assuming that all job offers are accepted, the value function of an unemployed worker is given by (see Appendix A for the detailed derivation)

$$rS_i = b - a_i(\varepsilon_i) + \lambda_i(\varepsilon_i)(W - S_i) \tag{5.1}$$

where r is the discount rate, b is the fixed unemployment benefit paid until a job is found, a_i is the per period cost of search and λ_i is the unemployment hazard that depends on the individual search effort. S_i and W refer to the expected present values of unemployment search and employment, respectively. Since all jobs are identical, the value of employment is independent of individual characteristics. Assuming a quadratic cost function for the search effort[1]

$$a_i = \sigma\varepsilon_i^2 \tag{5.2}$$

and that the unemployment hazard or probability of finding a job is proportional to individual effort according to

$$\lambda_i = \varepsilon_i\lambda \tag{5.3}$$

where λ is the exogenous unemployment hazard per efficiency unit of unemployment (see Pissarides, 2000), we can rewrite (5.1) as follows

$$rS_i = b - \sigma\varepsilon_i^2 + \varepsilon_i\lambda(W - S_i) \tag{5.4}$$

Now consider the problem of an individual unemployed, who wishes to choose the optimal level of search effort so as to maximise the expected value of search S_i. Differentiating (5.4) with respect to the search effort ε_i under the standard assumption that the value of a job is taken as given by an individual yields the following first order condition for optimality

$$2\sigma\varepsilon_i r + \lambda\left(\varepsilon_i^2\sigma - rW + b\right) = 0 \tag{5.5}$$

which implicitly defines the optimal search effort ε_i for individual i. In what follows we consider the symmetric case where all workers are identical and therefore choose the same optimal search intensity $\varepsilon_i = \varepsilon\ \forall i$. Consequently, according to (5.1) the value of search is equal to all individuals $S_i = S\ \forall i$.

In this context, the value function for an employed worker (see Appendix A for detailed derivation) can be written as follows

[1] More generally, we must have $a_i' > 0$, $a_i'' > 0$ for the problem to be feasible (see Pissarides, 2000).

$$rW = w + \delta (S - W) \tag{5.6}$$

where w is the wage rate received while working and δ is the exogenous probability of being laid off. Utilising equations (5.1) and (5.6) to solve for the value of a job W in the symmetric case then yields

$$rW = \frac{\delta (b - \sigma\varepsilon^2) + w (r + \varepsilon\lambda)}{r + \delta + \varepsilon\lambda} \tag{5.7}$$

which can be further substituted for W in the first order condition (5.5) to get

$$2\sigma\varepsilon r + \sigma\varepsilon^2\lambda - \lambda\frac{\delta (b - \sigma\varepsilon^2) + w (r + \varepsilon\lambda)}{r + \delta + \varepsilon\lambda} + \lambda b = 0 \tag{5.8}$$

Solving explicitly for ε then yields

$$\varepsilon = \frac{1}{\sigma\lambda}\sqrt{\sigma^2 (r + \delta)^2 + \sigma\lambda^2 (w - b)} - \frac{r + \delta}{\lambda} \tag{5.9}$$

which defines the optimal search effort of a representative unemployed worker in the model with unemployment insurance paid indefinitely at a constant rate b. Differentiating (5.9) with respect to the exogenous variables yields the following comparative static results: Wages w and aggregate employment probability λ induce more search effort. Increases in either unemployment benefit b, search costs σ, interest rate r or lay off probability δ lead to less effort devoted to search (see Appendix A for the details). These findings are in line with those reported by Pissarides (2000, Chapter 5).

Finally, we notice that by assuming a fixed labour force, the equilibrium rate of unemployment implied by the model can be defined as

$$u = \left(1 + \frac{\varepsilon\lambda}{\delta}\right)^{-1} \tag{5.10}$$

which shows that unemployment is increasing in the lay off probability δ and decreasing in the unemployment hazard $\varepsilon\lambda$.

5.3 Unemployment Insurance with Limited Potential Duration

It was shown in the previous section that a UI system with a constant benefit and no limit for the potential duration of the payment will unambiguously reduce the search effort in the present framework. In this section we consider a somewhat more realistic UI system with a limited maximum duration of the benefits. After the exhaustion of benefits, a spell of employment is necessary to re-establish the right to UI. We also allow for the possibility that the benefits decline over time within the benefit period. For this purpose, we define an unemployment insurance programme that provides unemployed workers with benefits $\rho(t)\, w$ per period for a maximum number of periods τ according to

$$\rho(t) = \begin{cases} \rho_0 \exp(-\alpha t), t \leq \tau \\ 0, t > \tau \end{cases} \tag{5.11}$$

where ρ_0 is the replacement ratio at the beginning of the unemployment spell and α is the rate at which the replacement ratio declines as time passes. The higher α, the steeper the declining time profile of the benefits is. The special case of a fixed replacement ratio is captured by setting $\alpha = 0$. After τ periods the replacement ratio goes to zero, independently of the values of ρ_0 and α.

It can be shown (see Appendix B) that, for an unemployed individual, the expected present value of unemployment benefits at period t of unemployment is defined by

$$B(t) = \frac{\rho_0 w}{r + \alpha + \varepsilon\lambda} e^{-\alpha t} \left(1 - e^{-(r+\alpha+\varepsilon\lambda)(\tau - t)}\right) \tag{5.12}$$

where ε is the optimal level of search to be determined below[2]. We have suppressed the subscript i referring to an individual for the convenience of notation. With the unemployment insurance available, the total value of unemployment U can be decomposed into the value of search net of unemployment benefits and the value of unemployment benefits remaining at time period t as follows :

$$U(t) = S + B(t) \tag{5.13}$$

where S and $B(t)$ are as defined in (5.1) and (5.12) respectively (see Appendix B for the detailed derivation). The value of a job is now given by

$$rW = w + \delta (U(0) - W) \tag{5.14}$$

[2] We assume that workers are myopic in the sense that once choosing the effort they expect to stick to that level from now on. They therefore value the benefit programme under the assumption of constant unemployment hazard.

where $U(0)$ is the expected present value of unemployment at the beginning of the unemployment spell. Substituting (5.1) in (5.13) and applying to the initial period of the unemployment spell under symmetry ($S_i = S\ \forall i$) we get

$$rU(0) = -c + \varepsilon\lambda\left(W - U(0)\right) + \left(r + \varepsilon\lambda\right)B(0) \tag{5.15}$$

which implicitly defines the value of unemployment at the beginning of the unemployment spell as a function of the value of unemployment benefits $B(0)$ and the value of a job W. Utilising (5.14) and (5.15) we can derive the following expression for the value of a job

$$W = \frac{\left(r + \varepsilon\lambda\right)w - \delta c + \delta\left(r + \varepsilon\lambda\right)B(0)}{r\left(r + \delta + \varepsilon\lambda\right)} \tag{5.16}$$

The problem of the individual unemployed is now to choose the search effort so as to maximise his or her utility, taking account of the public insurance. For individual i, utilising (5.1), (5.12) and (5.13) yields

$$\begin{aligned} U_i\left(t\right) &= S_i + B_i\left(t\right) \\ &= \frac{-c + \varepsilon_i\lambda W}{r + \varepsilon_i\lambda} + \frac{\rho_0 w}{r + \alpha + \varepsilon_i\lambda}e^{-\alpha t}\left(1 - e^{-(r+\alpha+\varepsilon_i\lambda)(\tau-t)}\right) \end{aligned}$$

The problem of the individual unemployed is then to choose the search effort so as to maximise $U_i\left(t\right)$. The first order condition for optimality amounts to

$$\frac{\partial S_i}{\partial\varepsilon_i} + \frac{\partial B_i\left(t\right)}{\partial\varepsilon_i} \equiv S_\varepsilon + B_\varepsilon = 0 \tag{5.17}$$

where

$$S_\varepsilon = \frac{\lambda W r - \beta\varepsilon_i\left(2r + \varepsilon_i\lambda\right)}{\left(r + \varepsilon_i\lambda\right)^2} \tag{5.18}$$

is the partial derivative of the value of the search, assuming again that the value of a job W is taken as given by the individual worker and

$$B_\varepsilon = -\lambda\rho_0 w e^{-\alpha t}\frac{1 - \left(1 + \left(r + \alpha + \varepsilon_i\lambda\right)\left(\tau - t\right)\right)e^{-(r+\alpha+\varepsilon_i\lambda)(\tau-t)}}{\left(r + \alpha + \varepsilon_i\lambda\right)^2} < 0 \tag{5.19}$$

is the marginal gain from extra effort in terms of unemployment benefits. It is noteworthy that the marginal gain from extra effort in terms of unemployment benefits is negative, $B_\varepsilon < 0$. Therefore, in the optimum with unemployment insurance we must have $S_\varepsilon > 0$. In other words, there are positive marginal gains associated with an additional effort if the influence of the current benefit period is ignored.

Substituting (5.18), (5.19) and (5.16) in (5.17) and imposing the symmetry condition $\varepsilon_i = \varepsilon$ gives the first order condition that implicitly defines the optimal search effort under UI with limited potential duration and (possibly) declining time sequence of benefits.

$$h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t) = 0 \tag{5.20}$$

The exact form of the equation is presented in Appendix D. Equation (5.20) is too complicated to be solved analytically. However, it can be used to provide some useful insights by the numerical simulations that we now turn to.

5.3.1 Simulations with Constant Replacement Ratio

For the simulations we choose a plausible set of parameter values reported in Table 5.1, which also reflect the stylized facts of the Finnish labour market. In particular, we match the parameters to the earnings-related unemployment insurance system with a maximum payment period of 500 working days (8 quarters) and the average replacement ratio of 60 per cent[3]. The Finnish system also incorporates a lower basic allowance available to those not eligible for the earnings-related scheme and those who have exhausted their earnings-related benefits. Since the drop in benefits after the exhaustion is substantial, 50 per cent on average (Vartiainen, 1998), we abstract from the basic allowance here. In effect, we assume that there is some minimum social allowance that a person can obtain indefinitely irrespective of his/her position in the labour market. A detailed description of the selection of the parameter values is presented in Appendix C.

Using these parameter values we can characterise the optimal solution implied by (5.20) in some special cases. Let us first consider the case where both the probability of being laid off and the initial replacement ratio of the unemployment insurance programme are equal to zero, $\delta = \rho_0 = 0$. This

[3]Recently, a proposal to introduce a step-wise declining time sequence of the replacement ratio instead of the current constant stream of benefits was put forward by the Finnish Ministry of Finance.

r	δ	λ	β	τ	ρ_0	α	w
0.01	0.03	0.25	0.5	8	0.6	$0-2$	1

Table 5.1: Parameter values used in the numerical simulations.

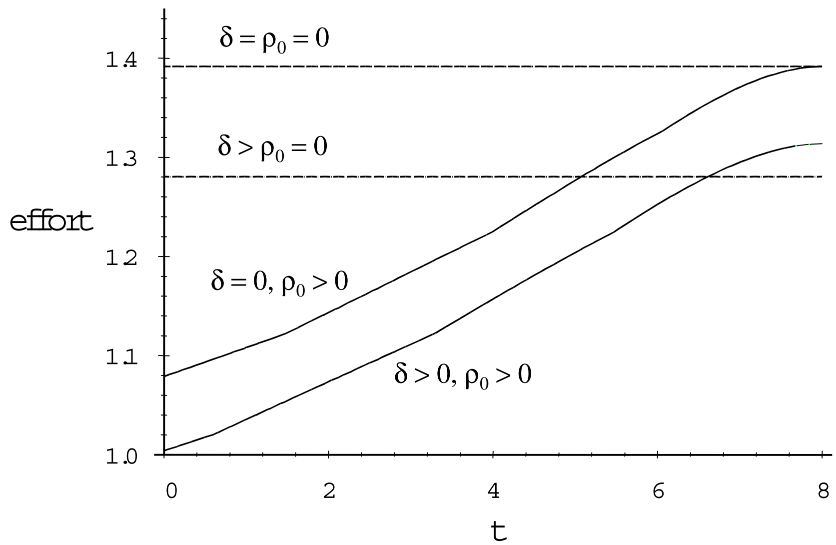

Figure 5.1: The time profile of search effort in the alternative model specifications ($\alpha = 0$).

can be interpreted as a model where the workers regard the job contracts as being permanent and no unemployment insurance exists. In this case the optimal search intensity depends on the exogenous variables such as wages w and search costs β, but, as depicted by the horizontal line in Figure 5.1, is constant over time.

Next, consider the case $\delta = 0, \rho_0 > 0$[4]. Depicted by the upper upward sloping line in Figure 5.1, this corresponds to the case where jobs are regarded as being permanent by the workers and an unemployment insurance programme exists. As we can see from the figure, the introduction of unemployment insurance under $\delta = 0$ causes a temporary drop in the search intensity of the unemployed who are eligible for the benefits. This is because

[4]For the time being, we assume that $\alpha = 0$, i.e. that the replacement rate is constant over time i.e. $\rho(t) = \rho_0$, $\forall t \in [0, \tau]$.

the existence of the benefit programme increases the marginal cost of extra search intensity, owing to the possible loss of the remaining benefits in the event of signing up for a job. However, this effect becomes weaker towards the end of the benefit period τ and the search intensity thus converges to the level that prevails when no insurance is available. It is noteworthy that in this case unemployment insurance unambiguously reduces the total search effort in the economy, which is likely to prolong unemployment spells and increase the equilibrium rate of unemployment according to equation (5.10).

The third special case $\delta > 0, \rho_0 = 0$ is depicted by the lower horizontal line in Figure 5.1. In this set-up, no unemployment insurance exists, but, when valuing a job, the unemployed take account of the possibility of being laid off later on. The fact that jobs are insecure reduces their value from the viewpoint of the unemployed. This is why the optimal search intensity, though constant over time, is lower than in the case where jobs were assumed to be permanent ($\delta = \rho_0 = 0$). The optimal search intensity corresponds to the one derived in equation (5.9) above and is depicted by the lower horizontal line in Figure 5.1.

Finally, let us consider the most general case $\delta > 0, \rho_0 > 0$. In this set-up the unemployed take account of the possibility of being laid off later on and a benefit programme exists. As depicted by the lower upward sloping line in Figure 5.1, the introduction of an insurance system now has a twofold effect on the optimal search intensity: It reduces the search intensity of those who have been unemployed for a relatively short time and increases the search intensity of those who have been unemployed for a relatively long time. Thus, the overall effect on search is ambiguous. This is because the unemployment insurance now has two opposite effects on the search intensity at any point of time during the benefit period. First, as in the above case, the existence of the benefit programme increases the marginal cost of extra search intensity, owing to the possible loss of remaining benefits in the event of signing up for a job. We refer to this as the *marginal cost effect*. Second, since the unemployed take account of the possibility of being laid off and of thus becoming unemployed in the future, the existence of the benefit program increases their valuation of employment relative to the case where no insurance is available. The latter effect, referred to as the *entitlement effect*, therefore increases the marginal benefits from additional effort[5]. The former negative effect dominates at the beginning of the unemployment spell, but becomes weaker as

[5] The existence of the entitlement effect was made explicit by Mortensen (1977).

the benefit period proceeds. After some time, the positive entitlement effect starts to dominate. It is noteworthy that the boost to search intensity carries over to the periods after the benefit exhaustion: even those who have been unemployed for more than τ periods will find it optimal to increase their effort when unemployment insurance is introduced.

The above results suggest that unlike UI with an indefinitely paid constant benefit, introduction of a system with fixed potential duration induces more search effort among some fraction of the unemployed. This is because for those who have already exhausted some of the current benefit period, the entitlement effect dominates. Furthermore, the findings suggest that the strength of the entitlement effect is positively correlated with the uncertainty related to job contracts. Ceteris paribus, the more insecure the jobs are (δ is high), the sooner the entitlement effect starts to dominate. At the other extreme, where jobs are regarded as permanent, the entitlement effect disappears. Thus, we can conjecture that the adverse search effects of UI are smaller in the circumstances characterised by a relatively low job security. This finding leads to the interesting prediction that if the job security is high due to, for example, mandatory measures to promote job retention, then the adverse incentive effects of UI are larger[6].

5.3.2 Declining Time Sequence of Benefits

So far we have considered the case where $\alpha = 0$, in other words, the replacement ratio remains constant over the benefit period. Let us now turn to the case where $\alpha > 0$, and consequently, the replacement ratio declines with the unemployment spell.

As noted above, if the probability of being laid off is taken account of ($\delta > 0$), unemployment insurance has a twofold effect on the search intensity. The positive entitlement effect starts to dominate as soon as the value of the remaining benefits becomes low enough. The introduction of a positive value for α allows us to control the speed of reduction in the replacement ratio over time. The higher α is, the faster the reduction in the replacement ratio during the benefit period is and, consequently, the sooner the entitlement effect starts to dominate. This principle is captured by the illustration in Figure 5.2 where the time profile of search effort with no benefits available is

[6] Notably, we have assumed an exogenous job destruction rate. In a more versatile framework, the job destruction rate could be endogenous and also affected by, among others, the UI system (see e.g. Wang and Williamson, 1996).

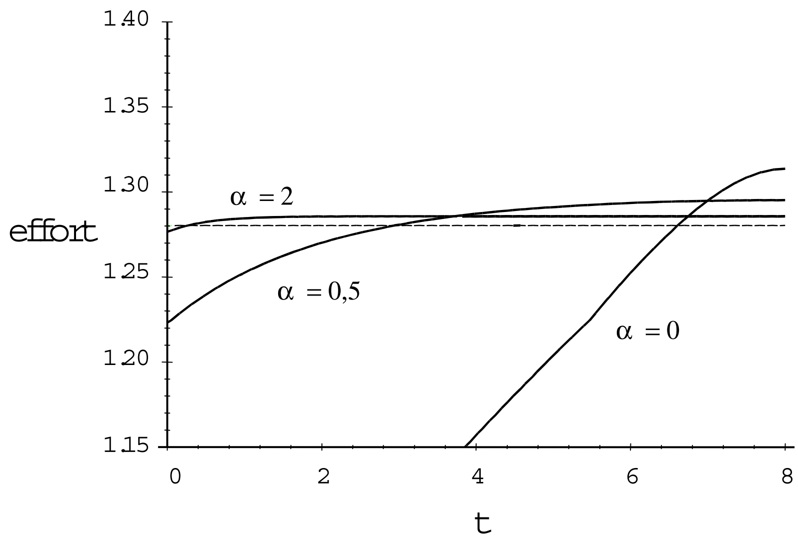

Figure 5.2: The search effort time profile with alternative values of α.

depicted by the horizontal dashed line corresponding to the case $\delta > 0, \rho_0 = 0$ of Figure 5.1. Case $\alpha = 0$ is depicted by the steeply upward sloping solid line and corresponds to the case $\delta > 0, \rho_0 > 0$ in Figure 5.1. With positive α, such as $\alpha = 0.5$ depicted by the less steeply upward sloping solid line in Figure 5.2, the threshold for increased effort is pushed to the left. At the same time, the effects become weaker throughout, reflecting the reduction of the present value of benefits. With high enough values of α the introduction of UI increases the search intensity irrespective of the length of the unemployment spell (except at the very beginning) as shown by the solid line ($\alpha = 2$) lying mostly above the horizontal line in Figure 5.2. Increased search effort should reduce the average length of unemployment spells and therefore create a downward pressure on equilibrium unemployment. However, in assessment of the effects on employment caution should be taken because we have assumed a fixed wage rate. It is likely that the introduction of a UI programme puts an upward pressure on wages, which tends to counteract the positive effects through search intensity in a more versatile modelling framework. We return to this issue in Section 5.4.

5.3.3 Comparative Statics

With the unemployment insurance system described above in (5.11), let us now derive some comparative static results concerning changes in the key parameters. For that purpose, we first differentiate the first order condition (5.20) with respect to the exogenous parameters (see Appendix D for the details) to get:

$$\frac{\partial h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t)}{\partial \varepsilon_i} = S_{\varepsilon\varepsilon} + B_{\varepsilon\varepsilon} < 0 \tag{5.21}$$

which is the second order condition for a maximum. Furthermore, we can derive

$$\frac{\partial h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t)}{\partial t} = B_{\varepsilon t} > 0 \tag{5.22}$$

which is the derivative of the first order condition with respect to time. Using the implicit function rule (5.21) and (5.22) imply

$$\frac{\partial \varepsilon_i}{\partial t} > 0 \tag{5.23}$$

According to (5.23), in the presence of the specified unemployment insurance, the search intensity of the unemployed increases over time during the benefit period. This finding is consistent with the optimal search profile in the case $\delta > 0$, $\rho_0 > 0$ depicted in Figure 5.1.

Next, consider the effects of the parameters of the unemployment insurance system. Differentiating the first order condition (5.20) with respect to the initial replacement ratio gives

$$\frac{\partial h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t)}{\partial \rho_0} = S_{\varepsilon\rho} + B_{\varepsilon\rho} \tag{5.24}$$

where $S_{\varepsilon\rho} > 0$ and $B_{\varepsilon\rho} < 0$ and the sign of the derivative depends on the parameter values. It can be shown (see Appendix D) that with plausible parameter values (5.24) is negative for $t \leq t_\rho$ and positive for $t \geq t_\rho$, where t_ρ is some point of time in the interval $[0, \tau]$. Together with (5.21) this implies

$$\frac{\partial \varepsilon_i}{\partial \rho_0} \gtreqless 0 \Longleftrightarrow t \gtreqless t_\rho \tag{5.25}$$

In other words, a higher initial level of the replacement ratio reduces the search effort of those who have been unemployed for less than some critical duration t_ρ and increases the effort of those who have been unemployed longer than that. The intuition behind (5.25) is that for the short term unemployed the marginal cost effect dominates, whereas for the long term unemployed it is the entitlement effect that drives the behaviour. It can be shown that the critical point t_ρ depends, among other things, on the speed of reduction in the benefit level, α: the higher α is, the lower the critical point is. This is because a higher speed of reduction makes the remaining benefits relatively less important and the entitlement effect starts to dominate earlier.

Finally, consider the effect of α, the rate of reduction in the replacement ratio. Differentiating the first order condition (5.20) gives

$$\frac{\partial h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t)}{\partial \alpha} = S_{\varepsilon\alpha} + B_{\varepsilon\alpha} \tag{5.26}$$

where $S_{\varepsilon\alpha} < 0$ and $B_{\varepsilon\alpha} \gtreqless 0$ and the sign of the derivative depends on the parameter values. It can be shown (see Appendix D) that with plausible parameter values (5.26) is positive for $t \leq t_\alpha$ and negative for $t \geq t_\alpha$, where t_α is some point of time in the interval $[0, \tau]$. Together with (5.21) this implies

$$\frac{\partial \varepsilon_i}{\partial \alpha} \gtreqless 0 \Longleftrightarrow t \lesseqgtr t_\alpha \tag{5.27}$$

Formula (5.27) states that a higher rate of reduction of the replacement ratio increases the search effort of those who have been unemployed for less than some critical duration t_α and reduces the effort of those who have been unemployed longer than that. This is again because the marginal cost effect dominates the decision of the short term unemployed, whereas the entitlement effect is dominant for the long term unemployed. The difference to the above case is that now the two effects are of exactly opposite signs. The position of the critical point t_α depends, among other things, on the initial speed of reduction in the benefit level, α: the higher α is to start with, the lower the critical point is. The intuition is as before: a higher speed of reduction makes the remaining benefits relatively less important and the entitlement effect starts to dominate earlier.

5.4 A "Pure Increase" in the Rate of Reduction of the Benefits

In the previous section we considered the effects on the search effort of isolated changes in the parameters of the UI with a limited potential duration of benefits. When assessing the results, we must keep in mind that in most of the cases the net present value of the unemployment benefits changes as we change one of the benefit system parameters. This has two important implications: First, the expected public expenditure on the benefit programme changes. In other words, we end up comparing two regimes that are not equally expensive from the government's viewpoint. Second, it is standard to assume that the net present value of the unemployment benefits has a positive influence on wages (see e.g. Millard and Mortensen, 1997) and therefore we are comparing two regimes under which the wage level is not likely to be equal. This, in turn, might have important general equilibrium effects in a more versatile framework allowing for endogenous wage determination as suggested by Cahuc and Lehmann (2000), for example.

From the public policy point of view it is of interest to analyse the effects of a "pure increase" in the rate of reduction of the replacement ratio. By this we mean a simultaneous increase in both the rate of reduction of the replacement ratio α and the initial level of the replacement ratio ρ_0 that leaves the expected present value of the unemployment benefits intact. We then essentially ask what the desirable structure of the benefit system is - from the viewpoint of search insentives - for a given expected amount of public expenditure on UI per head[7]. An additional attractive feature of this exercise is that since the net present value of the unemployment benefits is kept fixed, we can assume that the reform has no remarkable effects on the wage level[8].

Consider a simultaneous increase in α and ρ_0 such that the expected present value of unemployment benefits at the beginning of an unemployment

[7] The induced changes in the equilibrium employment obviously also affect, for example, the expected tax revenues and total amount of transfer payments. These effects, though crucial for the overall public balance, lie outside the scope of the partial framework used in the present study.

[8] Applying the standard Nash bargain on wages to the present model, it is possible to show that for given search effort, wages depend only on the expected present value of benefits at the beginning of unemployment, $B(0)$.

spell remains unchanged. Totally differentiating the net present value of the benefits allows us to write

$$B_{0\rho}d\rho_0 + B_{0\alpha}d\alpha = 0 \tag{5.28}$$

where $B_{0\rho} = \frac{\partial B(0)}{\partial \rho_0}$ and $B_{0\alpha} = \frac{\partial B(0)}{\partial \alpha}$ refer to the partial derivatives of the net present value of unemployment benefits at the beginning of an unemployment spell, $B(0)$[9]. Equation (5.28) implicitly defines the changes in α and ρ_0 that keep the net present value of benefits unchanged. The effect of a marginal increase in the reduction rate of the benefits α on the search intensity of the representative consumer is given by

$$d\varepsilon = \left(\frac{\partial \varepsilon}{\partial \alpha} + \frac{\partial \varepsilon}{\partial \rho_0} \frac{d\rho_0}{d\alpha} \right) d\alpha \tag{5.29}$$

where the term $\frac{\partial \varepsilon}{\partial \rho_0} \frac{d\rho_0}{d\alpha}$ allows for the induced effect through higher ρ_0. Substituting (5.28) for $\frac{d\rho_0}{d\alpha}$ and utilising the condition (5.20) for optimal search we can rewrite (5.29) as

$$d\varepsilon = \left(\frac{-h_\alpha B_{0\rho} + h_\rho B_{0\alpha}}{h_\varepsilon B_{0\rho}} \right) d\alpha \tag{5.30}$$

where $h_\alpha \equiv \frac{\partial h}{\partial \alpha}$ and $h_\rho \equiv \frac{\partial h}{\partial \rho_0}$ are the derivatives of the optimality condition with respect to α and ρ_0 as derived in (5.26) and (5.24), respectively. Consequently, since $h_\varepsilon B_{0\rho} < 0$, for the search effort to improve after the policy reform, we must have

$$h_\alpha B_{0\rho} - h_\rho B_{0\alpha} \geq 0 \tag{5.31}$$

The formula in (5.31) proves to be relatively complicated, but can be numerically assessed (see Appendix E). It turns out that with plausible parameter values (5.31) is indeed positive for all $0 \leq t \leq \tau$. In other words, the switch to a benefit structure with a higher initial replacement ratio and faster depreciation of the benefits over time will induce more search effort among the recipients.

When we are interpreting the result, it is useful to note that the impact of the benefit parameters α and ρ_0 on the value of a job runs through changes

[9]We assume that when designing the policy, the government takes search intensity as given. This is in line with the common practice of not allowing for behavioural effects in policy design, but rather balancing the incomes and outlays *ex ante*.

in $B(0)$ only, which can be seen from (5.16) (for given w and ε). This is why the definition of the policy such that $dB(0) = 0$ effectively eliminates any changes in the entitlement effect. With the entitlement effect intact, the effect of higher α on the search effort comes solely from the reduced marginal cost effect: Within the benefit period, at each point of time the value of the remaining benefits is lowered when α increases. Consequently, the effect on search effort is positive throughout the benefit period (and zero thereafter) and employment improves as the steady state unemployment rate defined by (5.10) declines. With the fixed wage rate this is the end of the story. In the general equilibrium set-up, we could expect that the UI reform would have some effect on wages and thereby on labour market tightness and aggregate matching probability. However, as already argued above, by considering a policy such that $dB(0) = 0$ we, in effect, eliminate the wage effect and therefore can expect that the employment effect would be positive even if endogenous wages were allowed for.

5.4.1 Discussion on the Results

Owing to the differences in the approach, it seems warranted to compare our findings with some of the other studies, in particular with the results of Cahuc and Lehmann (2000) which at first sight seem to be more pessimistic than ours. In the Cahuc and Lehmann model, the benefits are paid indefinitely, but the replacement rate drops (stochastically) at some point. They then effectively compare a constant benefit paid indefinitely (Section 5.2 in this study) with a two-tier system where the lower benefit rate is paid indefinitely[10]. Their main point is that the positive incentive effects of "front loading" the benefits may be dominated by an opposite effect through the increased wage pressure that will cause labour market tightness to drop and reduce the aggregate matching probability. However, the increased wage pressure in their model is conditional on the assumption of insider wage setting, which is not standard in this type of models.

In the present set-up we avoid the caveat of general equilibrium wage effects by comparing two regimes with identical expected present values of benefits. Then, assuming the standard Nash bargain on wages, the reform would not cause an extra pressure on wages. Our findings are then more

[10] Cahuc and Lehmann do not explicitly discuss the entitlement effect although it should be working in their set up as well.

close to those of Fredriksson and Holmlund (1998), who explicitly allow for the entitlement effect and find that a declining time sequence of benefits improves employment if there is no discounting[11]. In their set-up, the zero discounting rate effectively rules out any wage effects of front loading the benefits. In our analysis a similar effect arises - with a positive discount rate - as we keep the expected present value of benefits intact.

5.5 Summary and Concluding Remarks

In this paper we have analysed the incentive effects of unemployment insurance in a job search model with an endogenous search effort. In particular, we wanted to consider the implications of a UI system with a limited potential duration and declining time sequence of benefits. Our central finding is that the introduction of a limited potential duration for benefits importantly shapes the effects of UI on search behaviour.

We first demonstrated - in line with Pissarides (2000) - that a constant benefit paid indefinitely unambiguously reduces the search effort. We then showed that the same result holds for UI with a limited potential duration if the workers do not anticipate job uncertainty and regard the job contracts as permanent. In a somewhat more realistic set-up allowing for the risk of being laid off in the future, the effect of UI with a limited potential duration on individual search intensity depends on the length of his or her unemployment spell: The introduction of UI reduces the effort of those who have been unemployed for a relatively short time, but increases the effort of those who have been unemployed for a sufficiently long time. The asymmetry arises because of the difference in the value of the remaining UI benefits. Consequently, in line with Mortensen (1977,1990) we find that the overall effect of UI with a limited potential duration on the search effort and employment is ambiguous.

We also considered the implications of the introduction of a time dependent replacement ratio. Generally, a faster depreciation of the replacement ratio induces more search effort among those unemployed for a relatively short time and less search effort among those unemployed for a longer time. However, if the higher degree of depreciation of the replacement ratio is ac-

[11] Similar to Cahuc and Lehmann, Fredriksson and Holmlund define "front loading of benefits" as an increase in the replacement ratio of the short term unemployed, holding the average UI expenditure per employed worker constant.

companied by an increase in the initial benefit level so as to keep the present value of the programme intact, the search effort is increased throughout the benefit period. Accordingly, there seems to be little reason to extend the benefit payments over time. On the contrary, the results seem to favour a rapid depreciation of the replacement ratio, which at the extreme would propose a fixed redundancy payment[12]. We argue that such a policy is likely to be neutral in terms of the wage pressure and therefore should lead to lower unemployment as well.

Calibrated to mimic the stylized facts of the Finnish labour market, our model can also be used to make some conjectures about the earnings-related UI in Finland. The simulations suggest that when the entitlement effect is taken into account, unemployment insurance may have some positive effects on the search intensity and therefore on employment. Our analysis thus challenges the more pessimistic view of Kettunen (1991), according to which the Finnish unemployment benefit system has an unambiguously negative effect on the employment probability. At the same time, the present analysis gives some support for the recent proposals to introduce a declining time sequence of the benefits. However, the effects of such a reform would depend on the exact specification, in particular on the implicated change in the expected present value of the benefits. To keep the present value of the benefits intact, a drop in the benefits after, say, 200 days, should be matched by an increase in the initial level of benefits.

From the viewpoint of policy proposals, the analysis presented has several qualifications. First, we have focused on the search effort and employment, leaving the welfare implications aside. Hence, the framework is insufficient for assessing some important aspects of UI such as the consumption smoothing of those facing a temporary loss of income (see e.g. Holmlund, 1998). Also, we do not allow for the possibly positive effects of UI on the allocation of resources due to reduced mismatch that has been found in models with either one or two-sided heterogeneity (e.g. Acemoglu, 1998, Marimon and Zilibotti, 1999). Maybe most importantly, a recent study by Albrecht and Vroman (2003) suggests that time-varying UI benefits can lead to inefficient job rejection in a model where wages are posted rather than bargained.

Second, to avoid unnecessary complications in the model, we have kept the analysis partial in the sense that the aggregate labour market variables,

[12] A fixed redundancy payment is suggested on a different reasoning by Baily's (1978) two period analysis in a case where there is no uncertainty of unemployment duration.

wages and labour market tightness, are exogenously determined. However, as argued above, we have designed the cases considered in a way that this shortcoming is unlikely to affect the main results. Nevertheless, extending the model to cover endogenous determination of these variables would facilitate a more thorough assessment of the employment effects and provide scope for a wider range of policy questions to be addressed.

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5.A The Basic Model

Our derivation of the basic model follows that of Pissarides (2000) with the exception that wages and labour market tightness are taken as predetermined. Let us consider the value of the unemployment search by an individual worker. Assuming infinite horizon and a constant probability λ of getting an offer per period, the expected present value of the unemployment search is given by

$$S(t)=\int_t^{\infty}\left[\int_t^{T} ae^{-r(s-t)}ds+e^{-r(T-t)}\int \max(W,S(T))dF(W)\right]\lambda e^{-\lambda(T-t)}dT \tag{5.32}$$

where a is the net cost of search per period, r is the discount rate, W is the expected present value of a work offer and T refers to the time period when the first offer arrives. Assuming that all jobs are equally productive and, therefore, that all offers are accepted, (5.32) simplifies to

$$\begin{aligned} S(t) &= \int_t^{\infty}\left[\frac{a}{r}\left(1-e^{-r(T-t)}\right)+We^{-r(T-t)}\right]\lambda e^{-\lambda(T-t)}dT \\ &= \frac{a}{r+\lambda}+\frac{\lambda W}{r+\lambda} \end{aligned} \tag{5.33}$$

It can been seen from (5.33) that the value of search does not depend on time and is thus stationary $S(t)=S\forall t$. For an individual worker the probability of getting a job offer and the search cost depend on the level of effort. Allowing for this and rearranging (5.33) produces (5.1) in the main text.

Next, consider the valuation of a job by an employed worker. Assuming the job pays a wage rate w and that the perceived probability of being laid off is δ per period, the expected present value of employment is given by

$$\begin{aligned} W(t) &= \int_t^{\infty}\left[\int_t^{T} we^{-r(s-t)}ds+e^{-r(T-t)}S(T)\right]\delta e^{-\delta(T-t)}dT \\ &= \int_t^{\infty}\left[\frac{w}{r}\left(1-e^{-(T-t)r}\right)+e^{-r(T-t)}S\right]\delta e^{-\delta(T-t)}dT \\ &= \frac{w}{r+\delta}+\frac{\delta S}{r+\delta} \end{aligned} \tag{5.34}$$

where the second equality utilises $\int_t^T we^{-r(s-t)}ds = \frac{w}{r}\left(1 - e^{-(T-t)r}\right)$ and the fact that the value of the search is stationary. It can be seen from (5.34) that the value of a job is stationary and we can write $W(t) \equiv W \forall t$. Allowing for this and rearranging then yields (5.6) in the main text.

Differentiating (5.4) with respect to the search effort ε_i with the usual assumption that the value of a job is taken as given by an individual unemployed, yields

$$\frac{\partial S_i}{\partial \varepsilon_i} = -\frac{2\sigma\varepsilon_i r + \sigma\varepsilon_i^2\lambda - r\lambda W}{(r + \varepsilon_i\lambda)^2}$$

Substituting (5.7) for W, imposing symmetry $\varepsilon_i = \varepsilon$ and setting the right hand side equal to zero then yields the first order condition

$$\begin{aligned} 2\sigma\varepsilon r + \sigma\varepsilon^2\lambda - r\lambda\left(\frac{rw - \sigma\varepsilon^2\delta + w\varepsilon\lambda}{r(r+\delta+\varepsilon\lambda)}\right) &= 0 \\ &\Longleftrightarrow \\ 2\sigma\varepsilon(r+\delta+\varepsilon\lambda) - \lambda w - \lambda\sigma\varepsilon^2 &= 0 \end{aligned}$$

Solving explicitly for the optimal search intensity and skipping the negative roots then yields (5.9) in the main text. To determine the effects of the exogenous parameters on the optimal search effort we differentiate (5.9) respectively to get

$$\frac{\partial\varepsilon}{\partial b} = -\frac{\partial\varepsilon}{\partial w} = -\frac{\lambda}{2\sqrt{\sigma\left(\sigma(r+\delta)^2 + \lambda^2(w-b)\right)}} < 0$$

$$\frac{\partial\varepsilon}{\partial\lambda} = \frac{r+\delta}{\lambda^2}\left(1 - \frac{r+\delta}{\sqrt{(r+\delta)^2 + \lambda^2\sigma^{-1}(w-b)}}\right) > 0$$

$$\frac{\partial\varepsilon}{\partial\sigma} = -\frac{\lambda(w-b)}{2\sigma\sqrt{\left(\sigma\left(\sigma(r+\delta)^2 + \lambda^2(w-b)\right)\right)}} < 0$$

$$\frac{\partial\varepsilon}{\partial\delta} = \frac{\partial\varepsilon}{\partial r} = \frac{1}{\lambda}\left(\frac{r+\delta}{\sqrt{(r+\delta)^2 + \lambda^2\sigma^{-1}(w-b)}} - 1\right) < 0$$

where we assumed that the wage rate exceeds the UI benefit, $w > b$.

5.B UI with Limited Potential Duration

Assume a publicly financed unemployment insurance programme that provides unemployed workers with benefits $\rho(t)\,w$ per period for some fixed number of periods τ. With the replacement ratio $\rho(t)$ being time dependent, the generosity of the programme may vary over time. The value of unemployment at time period t, $0 \leq t \leq \tau$, to a worker eligible for the programme is given by

$$\begin{aligned}
U(t) &= \int_t^{\tau}\left[\int_t^T (\rho(s)\,w - c)e^{-r(s-t)}ds + e^{-r(T-t)}\int \max(W, U(T))dF(W)\right] \\
&\quad \times\lambda e^{-\lambda(T-t)}dT \\
&\quad + \int_{\tau}^{\infty}\left[\begin{array}{c} \int_t^{\tau}(\rho(s)\,w)e^{-r(s-t)}ds - \int_t^T ce^{-r(s-t)}ds \\ +e^{-r(T-t)}\int \max(W, U(T))dF(W) \end{array}\right]\lambda e^{-\lambda(T-t)}dT \\
&= \int_t^{\infty}\left[-\int_t^T ce^{-r(s-t)}ds + We^{-r(T-t)}\right]\lambda e^{-\lambda(T-t)}dT \\
&\quad + \int_t^{\tau}\left[\int_t^T \rho(s)\,we^{-r(s-t)}ds\right]\lambda e^{-\lambda(T-t)}dT \\
&\quad + \int_{\tau}^{\infty}\left[\int_t^{\tau}(\rho(s)\,w)e^{-r(s-t)}ds\right]\lambda e^{-\lambda(T-t)}dT \\
&= B(t) + S
\end{aligned}$$

where S is the value of search with no unemployment insurance available as defined by ((5.33)) and

$$\begin{aligned}
B(t) &= \int_t^{\tau}\left[\int_t^T \rho(s)we^{-r(s-t)}ds\right]\lambda e^{-\lambda(T-t)}dT \\
&\quad + \int_{\tau}^{\infty}\left[\int_t^{\tau}\rho(s)we^{-r(s-t)}ds\right]\lambda e^{-\lambda(T-t)}dT
\end{aligned}$$

is the expected present value of unemployment insurance programme for an unemployed individual, who faces a constant unemployment hazard λ. For time periods $t \geq \tau$ (calculated from the beginning of the unemployment spell) $B(t) = 0.$ and $U(t) = S$. For more specific results, we assume that the replacement ratio of the UI takes the form defined by (5.11) in the main text. This formulation for the replacement ratio is chosen because it is analytically

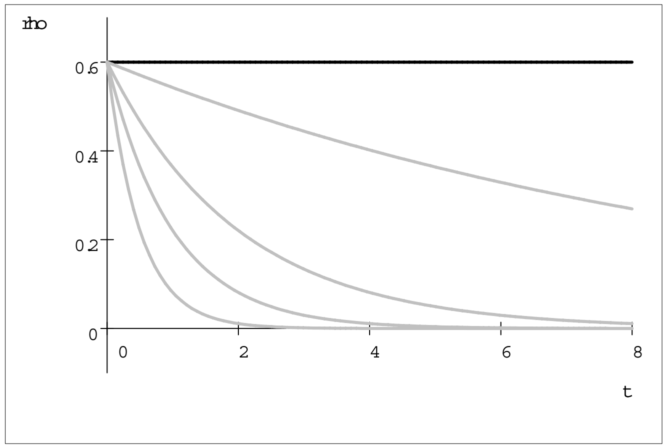

Figure 5.3: Time sequence of the replacement ratio for alternative values of α in the range between 0 (black line) and 2 (the lowest grey line). In all cases $\tau = 8$ and $\rho_0 = 0.6$.

tractable and nicely embeds the important special cases of a constant ($\alpha = 0$) and a declining ($\alpha > 0$) sequence of benefits. The alternative path of replacement ratios with different values of α are depicted in Figure 5.3. For this specification, the value of the UI programme is given by

$$\begin{aligned} B(t) &= \int_t^\tau \left[\int_t^T \rho_0 e^{-\alpha s} w e^{-r(s-t)} ds \right] \lambda e^{-\lambda(T-t)} dT \\ &\quad + \int_\tau^\infty \left[\int_t^\tau \rho_0 e^{-\alpha s} w e^{-r(s-t)} ds \right] \lambda e^{-\lambda(T-t)} dT \\ &= \frac{\rho_0 w}{r+\alpha+\lambda} e^{-\alpha t} \left(1 - e^{-(r+\alpha+\lambda)(\tau-t)} \right) \end{aligned}$$

which is (5.12) in the main text.

5.C Selection of the Parameter Values

In this appendix we describe in detail the selection of the parameter values used in the numerical simulations of the model. Following Millard and

Mortensen (1997) we divide the exogenous parameters into "policy parameters" and "structural parameters". The former are set to correspond to the observed values or stylized facts of Finnish labour markets. The latter are either set to match observations or chosen so that the model predictions are roughly in line with the observed features of the labour market.

As for the policy parameters, the maximum duration of unemployment benefits τ is 8 quarters and the initial replacement ratio ρ_0 is 60 per cent of the wage rate. These are roughly consistent with the features of the earnings-related unemployment insurance in Finland. Since the replacement ratio is constant over time, the rate of depreciation of the replacement ratio α is zero in the benchmark. As for the structural parameters, we assume one per cent discount rate r at the quarterly basis and normalise wage rate w to unity.

The average duration of an unemployment spell predicted by a search model is $1/\varepsilon\lambda$, where λ is the exogenous unemployment hazard per efficiency unit of unemployment and ε is the search effort of a representative unemployed. To match this with the observed average of 4 quarters in Finland in 1999 we must have

$$\frac{1}{\varepsilon\lambda} = 4 \tag{5.35}$$

The equilibrium rate of unemployment predicted by the model is $\frac{\delta}{\delta+\varepsilon\lambda}$, where δ is the probability of being laid off [13]. To support an unemployment rate of 10 per cent we thus must have

$$\frac{\delta}{\delta + \varepsilon\lambda} = 0.1 \tag{5.36}$$

Utilising (5.35) and (5.36) we get the following restrictions for the parameters

$$\begin{aligned} \lambda\varepsilon &= 0.25 \\ \delta &\simeq 0.03 \end{aligned}$$

Substituting these in the first order condition (5.20) of optimal search (at $t = 0$) and solving for parameter β reflecting the search costs yields

$$\beta = 0.491\varepsilon^{-2} \tag{5.37}$$

[13] This is exactly true for a constant search effort, which we, for simplicity, assume in the calibration.

Equation (5.37) suggests that fixing δ and $\varepsilon\lambda$ effectively determines the search cost of the representative worker, $c = \beta\varepsilon^2 = 0.491$, relative to the wage rate normalised to unity. Fixing β will fix the effort level in the benchmark. With the help of expression (5.35) it is easy to see that the higher β is, the lower ε and the higher λ are consistent with the data. Since we are interested in the changes rather than the level of effort, the latter can arbitrarily be normalised to unity for the representative worker in the benchmark. Then (5.37) implicates $\beta \simeq 0.5$ and from (5.35) we have $\lambda = 0.25$.

5.D Simulated Comparative Statics

Consider the model with unemployment insurance available. Differentiating the value of unemployment U_i with respect to search effort ε_i yields

$$\begin{aligned}
\frac{\partial U_i}{\partial \varepsilon_i} &= \frac{\partial S_i}{\partial \varepsilon_i} + \frac{\partial B_i(t)}{\partial \varepsilon_i} \\
&= \frac{r\lambda W(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta) - \beta\varepsilon_i(2r + \varepsilon_i\lambda)}{(r + \varepsilon_i\lambda)^2} - \lambda\rho_0 w e^{-\alpha t} \\
&\quad \times \frac{1 + (-1 - (r + \alpha + \varepsilon_i\lambda)(\tau - t))\exp(-(r + \alpha + \varepsilon_i\lambda)(\tau - t))}{(r + \alpha + \varepsilon_i\lambda)^2} \\
&\equiv h(w, \rho_0, \tau, \alpha, \lambda, r, \varepsilon_i, \delta, \beta, t) \qquad (5.38)
\end{aligned}$$

Setting the right hand side of (5.38) equal to zero constitutes the first order condition for the optimal search (5.20) in the main text. The comparative static results on the effects of the exogenous parameters can be derived from (5.20) with the help of the implicit function rule. For that purpose, we first derive the second derivative of the value of unemployment with respect to the individual effort

$$\begin{aligned}
\frac{\partial h}{\partial \varepsilon_i} &= S_{\varepsilon\varepsilon} + B_{\varepsilon\varepsilon} \\
&= -\frac{2r\left(\beta r + \lambda^2 W\right)}{(r + \varepsilon_i\lambda)^3} - \lambda\rho_0 w e^{-\alpha t} \\
&\quad \times \frac{\partial}{\partial \varepsilon_i}\left[\frac{1 - (1 + (r + \alpha + \varepsilon_i\lambda)(\tau - t))\, e^{-(r+\alpha+\varepsilon_i\lambda)(\tau - t)}}{(r + \alpha + \varepsilon_i\lambda)^2}\right] \\
&< 0 \qquad (5.39)
\end{aligned}$$

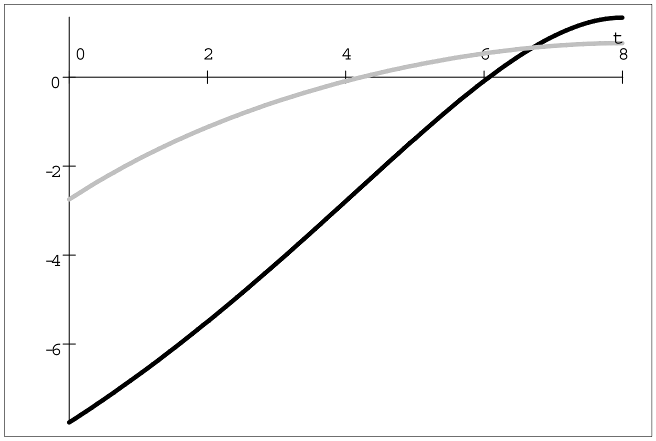

Figure 5.4: The derivative of the optimal search effort with respect to the initial level of replacement ratio ρ_0 for alternative values of α: $\alpha = 0$ (black line) and $\alpha = 0.25$ (grey line).

where we have utilised the property $\partial W / \partial \varepsilon_i = 0$. It takes some manipulation to show that (5.39) is indeed negative with plausible parameter values.

Since $\partial h / \partial \varepsilon_i < 0$, the sign of the effects on search intensity of the exogenous parameters are determined by the derivatives of the right hand side of (5.38) with respect to the parameters. The derivatives of the right hand side of (5.38) with respect to time t, initial level of replacement ratio ρ_0 and the rate of depreciation of the replacement rate α are as follows:

$$\begin{aligned}\frac{\partial h}{\partial t} &= \frac{\alpha + \left[-\alpha + \left(r + \varepsilon_i \lambda\right)\left(r + \alpha + \varepsilon_i \lambda\right)\left(\tau - t\right)\right] e^{-\left(r+\alpha+\varepsilon_i \lambda\right)\left(\tau - t\right)}}{\left(\lambda \rho_0 w e^{-\alpha t}\right)^{-1}\left(r + \alpha + \varepsilon_i \lambda\right)^2} \\ &\geq 0\end{aligned}$$

where the last inequality follows from some manipulation and substitution of plausible parameter values. Differentiating the right hand side of (5.38) with respect to the initial replacement ratio gives

$$\begin{aligned}\frac{\partial h}{\partial \rho_0} &= \lambda \delta w \frac{1 - \exp\left(-\left(r + \alpha + \varepsilon_i \lambda\right)\tau\right)}{\left(r + \varepsilon_i \lambda\right)\left(r + \alpha + \varepsilon_i \lambda\right)\left(r + \delta + \varepsilon_i \lambda\right)} \\ &\quad - \frac{1 + \left(-1 - \left(r + \alpha + \varepsilon_i \lambda\right)\left(\tau - t\right)\right)\exp\left(-\left(r + \alpha + \varepsilon_i \lambda\right)\left(\tau - t\right)\right)}{\left(\lambda w e^{-\alpha t}\right)^{-1}\left(r + \alpha + \varepsilon_i \lambda\right)^2}\end{aligned}$$

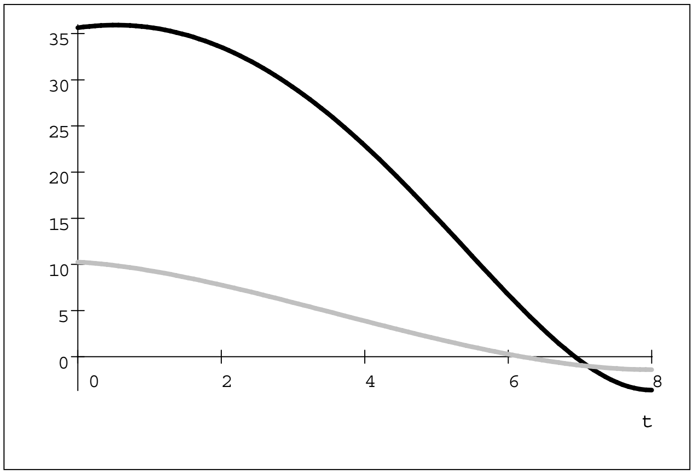

Figure 5.5: The derivative of the optimal search effort with respect to the rate of depreciation of the replacement ratio α for alternative initial values of α: $\alpha = 0$ (black line) and $\alpha = 0.25$ (grey line).

$$\begin{aligned}\frac{\partial h}{\partial \alpha} &= \lambda \rho_0 w \delta \frac{-1 + (1 + r\tau + \alpha\tau + \varepsilon_i \lambda \tau) \exp\left(-\left(r + \alpha + \varepsilon_i \lambda\right) \tau\right)}{\left(r + \varepsilon_i \lambda\right)\left(r + \delta + \varepsilon_i \lambda\right)\left(r + \alpha + \varepsilon_i \lambda\right)^2} \\ &+ \lambda \rho_0 w e^{-\alpha t} \frac{t\left(r + \alpha + \varepsilon_i \lambda\right) + 2}{\left(r + \alpha + \varepsilon_i \lambda\right)^3} \\ &\times \left[1 - \frac{2 + \left(r + \alpha + \varepsilon_i \lambda\right)\left[\tau + 1 + (\tau - t)\left(\tau\left(r + \alpha + \varepsilon_i \lambda\right)\right)\right]}{\left(2 + t\left(r + \alpha + \varepsilon_i \lambda\right)\right) e^{\left(r + \alpha + \varepsilon_i \lambda\right)(\tau - t)}}\right] \quad (5.40)\end{aligned}$$

In order to determine the signs of $\frac{\partial h}{\partial \rho_0}$ and $\frac{\partial h}{\partial \alpha}$ we plot the above formulas over time, using the parameter values defined in Table 5.1. The time path of $\frac{\partial h}{\partial \rho_0}$ is depicted in Figure 5.4 and the time path of $\frac{\partial h}{\partial \alpha}$ is depicted in Figure 5.5.It should be evident from Figures 5.4 and 5.5 that

$$\frac{\partial \varepsilon_i}{\partial \rho_0} \gtreqless 0 \Longleftrightarrow t \gtreqless t_\rho$$

and

$$\frac{\partial \varepsilon_i}{\partial \alpha} \gtreqless 0 \Longleftrightarrow t \lesseqgtr t_\alpha$$

where t_ρ, t_α are some points of time in the interval $[0, \tau]$ and $\tau = 8$ quarters.

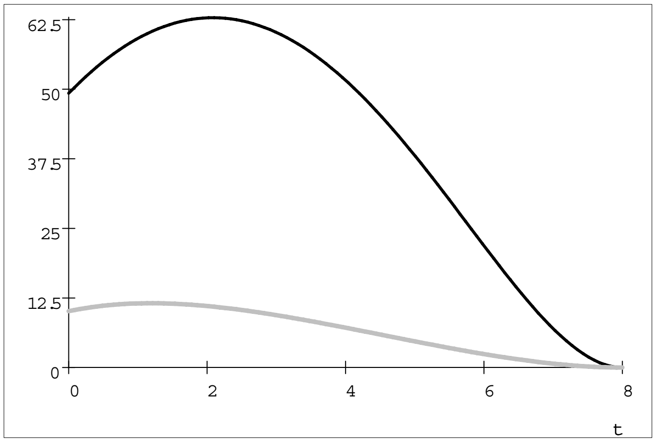

Figure 5.6: The sign of the effect on search intensity of a pure increase in the rate of reduction of the benefits. The horizontal axis is the length of the unemployment spell. The black line depicts the case where $\alpha = 0$ initially and the grey line the case where $\alpha = 0.25$ initially.

5.E A "Pure Increase" in the Rate of Reduction of the Benefits

Consider a simultaneous increase in α and ρ_0 such that the expected present value of unemployment benefits at the beginning of an unemployment spell $B(0)$ remains unchanged. As argued in the main text (Section 5.4) the condition for search intensity to increase after such a reform is

$$h_\alpha B_{0\rho} - h_\rho B_{0\alpha} \geq 0 \tag{5.41}$$

where $h_\alpha \equiv \frac{\partial h}{\partial \alpha}$ and $h_\rho \equiv \frac{\partial h}{\partial \rho_0}$ are partial derivatives of the first order condition for optimal search intensity. $B_{0\alpha}$ and $B_{0\rho}$ refer to the partial derivatives of the net present value of unemployment benefits at the beginning of the unemployment spell.

$$B_{0\rho} \equiv \frac{\partial B}{\partial \rho_0} = w \frac{1 - e^{-(r+\alpha+\varepsilon_i\lambda)\tau}}{r + \alpha + \varepsilon_i\lambda} \geq 0$$

$$B_{0\alpha} \equiv \frac{\partial B_0}{\partial \alpha} = \rho_0 w \frac{-1 + (1 + (r + \alpha + \varepsilon_i\lambda)\tau)\, e^{-(r+\alpha+\varepsilon_i\lambda)\tau}}{(r + \alpha + \varepsilon_i\lambda)^2} \leq 0$$

$$
\begin{aligned}
h_\rho &\equiv \frac{\partial h}{\partial \rho_0} \\
&= \lambda w \left(\begin{array}{c} \delta \frac{1-\exp(-(r+\alpha+\varepsilon_i\lambda)\tau)}{(r+\varepsilon_i\lambda)(r+\alpha+\varepsilon_i\lambda)(r+\delta+\varepsilon_i\lambda)} \\ -e^{-\alpha t} \frac{1+(-1-(r+\alpha+\varepsilon_i\lambda)(\tau-t))\exp(-(r+\alpha+\varepsilon_i\lambda)(\tau-t))}{(r+\alpha+\varepsilon_i\lambda)^2} \end{array} \right) \\
&\equiv \lambda w \psi\left(\tau,\alpha,\lambda,r,\varepsilon_i,\delta,t\right)
\end{aligned}
$$

$$
\begin{aligned}
h_\alpha &\equiv \frac{\partial h}{\partial \alpha} \\
&= \lambda \rho_0 w \left[\begin{array}{c} \delta \frac{-1+(1+r\tau+\alpha\tau+\varepsilon_i\lambda\tau)\exp(-(r+\alpha+\varepsilon_i\lambda)\tau)}{(r+\varepsilon_i\lambda)(r+\delta+\varepsilon_i\lambda)(r+\alpha+\varepsilon_i\lambda)^2} + \\ \left(1 - \frac{[2+\tau(r+\alpha+\varepsilon_i\lambda)+(\tau-t)(r+\alpha+\varepsilon_i\lambda)(\tau(r+\alpha+\varepsilon_i\lambda)+1)]}{[2+t(r+\alpha+\varepsilon_i\lambda)]e^{(r+\alpha+\varepsilon_i\lambda)(\tau-t)}}\right) \\ \times e^{-\alpha t} \frac{t(r+\alpha+\varepsilon_i\lambda)+2}{(r+\alpha+\varepsilon_i\lambda)^3} \end{array} \right] \\
&\equiv \lambda \rho_0 w \varphi(\tau,\alpha,\lambda,r,\varepsilon_i,\delta,t)
\end{aligned}
$$

Substituting the formulas of $h_\alpha, h_\rho, B_{0\alpha}$ and $B_{0\rho}$ into (5.41) yields

$$
h_\alpha B_{0\rho} - h_\rho B_{0\alpha} = \lambda \rho_0 w^2 \left[\begin{array}{c} \varphi(\tau,\alpha,\lambda,r,\varepsilon_i,\delta,t) \frac{1-e^{-(r+\alpha+\varepsilon_i\lambda)\tau}}{r+\alpha+\varepsilon_i\lambda} \\ -\psi\left(\tau,\alpha,\lambda,r,\varepsilon_i,\delta,t\right) \frac{-1+(1+(r+\alpha+\varepsilon_i\lambda)\tau)e^{-(r+\alpha+\varepsilon_i\lambda)\tau}}{(r+\alpha+\varepsilon_i\lambda)^2} \end{array} \right]
$$

the sign of which is determined by the term within the square brackets, which can be plotted over time using the parameter values reported in Table 5.1. The resulting plot is depicted in Figure 5.6. Its shows that the sign of the formula and therefore the change in the optimal search intensity is positive throughout the benefit period.

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