Worker Absenteeism in Search Equilibrium*

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Abstract

The paper presents a tractable general equilibrium model of search unemployment that incorporates absence from work as a distinct labor force state. Absenteeism is driven by random shocks to the value of leisure that are private information to the workers. Firms offer wages, and possibly sick pay, so as to maximize expected profits, recognizing that the compensation package affects the queue of job applicants and possibly the absence rate as well. Shocks to the value of leisure among nonemployed individuals interact with their search decisions and trigger movements into and out of the labor force. The analysis provides a number of results concerning the impact of social insurance benefits and other determinants of workers' and firms' behavior. For example, higher nonemployment benefits are shown to increase absenteeism among employed workers. The normative anlysis identifies externalities associated with firm-provided sick pay and examines the welfare implications of alternative policies. Conditions are given under which welfare equivalence holds between publicly provided and firm-provided sick pay. Benefit differentiation across states of non-work are found to be associated with non-trival welfare gains.

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1 Introduction

Worker absenteeism is a pervasive feature of employment relationships. In many countries, sickness absence represents an underutilization of the labor force of a magnitude comparable to unemployment. Data from Sweden and Norway over the period 2000-2004 show that sickness absence amounted to 7-8 percent of contractual work hours. The Netherlands is another country where sickness absence appears to be high relative to other countries.[1]

Absence from work has many sources, some predictable by both the worker and the firm, and some predictable by neither the firm, nor the worker. In the present paper we present a general equilibrium analysis of employment and nonemployment where sickness absence, or absence for short, is incorporated as a distinct labor force state. Absenteeism in our model is triggered by random shocks to the worker's utility function that are private information to the worker. Although there are institutions in place whereby employers and insurance providers try to verify health conditions, perfect monitoring is bound to be prohibitively costly.

Previous research on sickness absence has almost exclusively been empirical and typically focused on how the individual worker responds to changes in sick pay or other plausible determinants of absence. Brown and Sessions (1996) provide a survey of the literature. There is by now considerable evidence that increased generosity of sickness benefits tends to increase absence rates; see, for example, Allen (1981), Johansson and Palme (1996, 2002) and Henrekson and Persson (2004). Time series data from some countries, notably Norway and Sweden, reveal markedly pro-cyclical absence rates. Arai and Skogman Thoursie (2005) as well as Askildsen et al (2002) provide evidence and interpretations of pro-cyclical absenteeism in those countries. There is not much evidence on the prevalence and determinants of sickness reporting among unemployed individuals, however. The scanty evidence there is indicates higher prevalence of reported sickness among unemployed individuals than among employed workers (see Larsson, 2004, for evidence on Swedish data).

Theoretical work on sickness absence is rare and has typically elaborated on the static neoclassical model of labor supply. Ehrenberg (1970) is a seminal paper where labor demand considerations are also taken into account. The paper by Barmby et al (1994) proposes an efficiency wage model. Other theoretical contributions include Coles and Treble (1996) and Chatterji and Tilley (2002), who emphasize the interactions between absenteeism and pro-

[1] Nyman et al (2002) contain international comparisons of sickness absence based on data from the labor force surveys. Se also Barmby et al (2002).

ductivity.

Our analysis of absenteeism in a search equilibrium framework is new in the literature. It derives from the notion that absence from work in a frictional labor market is fundamentally different from being "absent" from the labor force. A worker on sick leave has typically unrestricted access to his or her job. That is, the worker can return to work more or less instantaneously without having to engage in costly search. By contrast, a nonparticipant is restricted by labor market frictions and must compare the benefits of entry to the costs of search, recognizing the randomness of job offers.

The supply side of our model relates to some existing multistate models of labor force dynamics. Toikka (1976) is a seminal paper and other contributions include Flinn and Heckman (1982) as well as Burdett et al (1984). Those papers provide partial equilibrium analyses in the sense that wages are taken as given. Individual search and labor supply decisions are examined in stochastic environments, allowing for nonparticipation as a distinct state in addition to employment and unemployment. The value of nonmarket activity is taken as a random variable and individuals choose nonparticipation for sufficiently favorable realizations of nonmarket productivity. The more recent contribution by Garibaldi and Wasmer (2005) takes this approach into a general equilibrium setting by incorporating endogenous wage determination.[2]

The framework we propose can be used to shed light on a number of issues. For example, we can show how changes in sickness benefits affect employed workers' absence decisions as well as nonemployed workers' search decisions. We can also illuminate how those changes impact on firms' wage and recruitment decisions. Analogously, we can show how nonemployment benefits affect not only behavior among the nonemployed but also absence behavior among employees. Welfare policy interdependencies can thus be analyzed in a coherent general equilibrium framework. As noted by Krueger and Meyer (2002), not much research has been devoted to interactions between social insurance programs.[3]

Our model also relates to recent empirical work on how absenteeism re-

[2] The model by Garibaldi and Wasmer (G & W) has some technical similarities with our model but there are also important differences. G & W focus on risk neutral workers, whereas we assume risk aversion and thus have a motive for income insurance. G & W consider bargaining over wages whereas we have wage posting by firms. G & W do not allow for absence from work as a distinct labor force state as we do.

[3] See Larsson (2002) for an empirical study that focuses on interactions between unemployment insurance and sickness insurance.

sponds to employment protection rules. Ichino and Riphahn (2004, 2005) report that transitions from (insecure) temporary jobs to (secure) "permanent" jobs are associated with an increase in absenteeism. This pattern is consistent with the hypothesis that workers perceive the risk of job loss as positively correlated with absence from work, an hypothesis supported also by the analysis in Hesselius (2002). Our framework allows for the possibility that the probability of job loss depends on whether the employee is present or absent from work.

The analysis offers a number of results regarding the impact of social insurance benefits and other determinants of workers' and firms' behavior. For example, higher statutory sick pay is shown to increase absenteeism but also to reduce wage costs; the effect on employment is ambiguous. Higher nonemployment benefits lead to lower employment but also higher absenteeism among employed workers. Our normative analysis identifies externalities associated with firm-provided sick pay and examines the welfare implications of alternative policies. We provide conditions under which publicly provided and firm-provided sick pay are equivalent in welfare terms. We also show that there can be non-trivial welfare gains associated with benefit differentiation across states of non-work, i.e., sickness absence, unemployment, and nonparticipation.

The model is described in section 2 of the paper. We begin by a brief overview before proceeding to the details, i.e., workers' optimization, firms' optimization and the general equilibrium of the economy. We also present a numerical version of the model. Section 3 presents analytical as well as numerical comparative statics results. Section 4 turns to welfare analyses where we compare the welfare properties of government-provided and firm-provided sick pay and examine the effects of benefit differentiation across states of non-work. Section 5 concludes the paper.

2 The Model

2.1 Overview

A brief overview of the model runs as follows. There is a fixed number of infinitely lived and risk averse individuals who can occupy one of four states, namely work, sickness absence, unemployment and nonparticipation. Work and absence represent employment, whereas unemployment and nonparticipation represent nonemployment. Each state is associated with a present discounted value of utility. This value depends on income in the current state as well as incomes in the other potential states, since choice and chance trigger movements across states.

Employed workers are subject to a risk of job loss that may differ depending on whether the worker is present at work or absent from work. The state-specific firing risks are exogenous to the worker but the average firing probability is endogenous as a result of the worker's absence decision. The average firing probability corresponds to the fraction of employed workers that enter nonemployment in each period. A nonemployed worker must engage in active and costly search in order to obtain a job offer. The probability of job finding depends on labor market tightness, i.e., the ratio between vacancies and unemployment; the tighter the labor market, the easier to match with a firm.

Individuals are exposed to random shocks that affect the disutility of work and search and the optimal decision rules involve cut-off values for sickness. Sufficiently severe sickness induces the employee to choose absence rather than work; analogously, the nonemployed individual prefers nonparticipation to costly search for sufficiently severe sickness. These reservation values of sickness, which may differ between employed and nonemployed individuals, depend on benefits and other parameters of the model.

Firms offer wage and employment opportunities, and possibly sick pay as well, in order to maximize expected profits. When a firm announces its compensation package, it realizes that a more attractive package will bring about a longer queue of job applicants. There is free entry of firms and zero profits hold in equilibrium. The general equilibrium of the economy involves the simultaneous determination of labor market tightness, wages and a host of other variables, including employment, absenteeism, unemployment and nonparticipation.

2.2 Workers' Behavior[4]

The number of individuals is normalized to unity. Individuals are homogenous ex ante, i.e., before they have been hit by shocks to their utility functions and ended up in particular labor market states. The four states are as follows: p is present at work (or simply work), s is sickness absence (sick leave), u is unemployment, and n is nonparticipation. Work and sickness absence represent employment (e), whereas unemployment and nonparticipation are referred to as nonemployment (o). We think of nonparticipants as "inactive" nonemployed individuals who belong the potential labor force

[4] The supply side of the model is described in more detail in Appendix A and Holmlund (2005).

but do not actively pursue job search.[5] Let j indicate the labor force state, $j \in \{p, s, u, n\}$.

The worker's utility is taken to be quasi-linear of the form

$$\upsilon^j = \ln C^j - a^j \xi \tag{1}$$

where C^j is consumption, a^j a positive parameter, and ξ a utility shifter that is increasing in sickness. Successive ξ are independently and identically distributed random variables drawn from a known distribution $F(\xi)$ with support $(0, \infty)$ and density $f(\xi)$. Consumption is equal to after-tax income in every period.[6] Consumption while at work (wage income) is given as $C^p = w$, and work-hours are taken as fixed. The individual is entitled to non-work benefits when he does not work; the levels of these benefits may differ across the three states of non-work. An employed worker who is absent from work receives sickness benefits (sick pay), $C^s = \rho^s w$, where ρ^s is the replacement rate that applies to the wage in the firm where the worker is employed. The replacement rate may be exogenously given by law or determined by the firm as part of its optimal compensation package.

An unemployed person receives unemployment benefits, $C^u = b^u$, and nonparticipants receive what is referred to as sickness assistance, $C^n = b^n$. Each firm takes b^u and b^n as exogenous to its wage decisions, although these benefit levels are in fact indexed to the *average* wage in the economy through exogenously given replacement rates, ρ^u and ρ^n. The general equilibrium features a common economy-wide wage. Benefit differentiation between the unemployed and the nonparticipants is feasible only if search effort can be monitored by the labor market authorities. If monitoring is impossible, there is only room for a uniform replacement rate for nonemployed workers, i.e., $\rho^u = \rho^n \equiv \rho^o$.

We set $a^j = 1$ as normalization for $j \in \{s, n\}$, i.e., for "inactive" individuals who don't work or don't search. We set $a^j > 1$ for $j \in \{p, u\}$, i.e., for "active" individuals who are present at work or who are unemployed. Superscript j is dropped in the subsequent exposition, thus assuming $a^p = a^u = a > 1$. The assumptions concerning a^j capture the idea that the disutility of work or search is increasing in sickness. To illustrate this

[5] Our nonparticipants are close to a category often referred to as "latent" job searchers in labor force surveys, i.e., nonparticipants that report that they wish to work but fail to meet the search criteria for being classified as unemployed.

[6] We thus rule out the possibility of smoothing consumption through borrowing and saving, a simplification done for tractability. Analytical treatments of equilibrium search models with risk aversion and precautionary savings have proved to be highly complex and few results are available. See Costain (1997) for a numerical analysis.

idea, suppose that the utility function takes the form $\upsilon^j = \ln C^j - (1+\zeta^j)\xi$, where ζ^j represents effort devoted to work or to search. We thus have $\zeta^j = 0$ $(a = 1)$ for $j = s,\ n$ and $\zeta^j > 0$ $(a > 1)$ for $j = p,\ u$.

The probability of job loss may differ between workers who are present at work and workers on sick leave. Let ϕ^p denote the job loss probability for a person at work and ϕ^s the corresponding probability for a person on sick leave. Assume that work can never be more risky than sick leave, i.e., $\phi^p \leq \phi^s$. Equal separation risks, i.e., $\phi^p = \phi^s = \phi$, may correspond to a stringent employment protection legislation.[7]

We assume that job finding requires active search and let α denote the probability of job finding when searching. Job finding depends on labor market conditions and we make the usual assumption that it is increasing in the ratio between vacancies, v, and unemployment, u, i.e., $\alpha = \alpha(v/u) = \alpha(\theta)$ where $\theta \equiv v/u$. The probability that a firm with a vacancy finds a worker is given as $q(\theta) = \alpha(\theta)/\theta$ by virtue of a constant returns to scale matching function.

Individual optimization involves choosing reservation values of sickness. Let Q denote the value of ξ that equalizes the value to the employed worker of being present and absent at work. Analogously, let R denote the value of ξ that equalizes the value to the nonemployed worker of being an unemployed job seeker and a nonparticipant. The probability of being present at work is thus $F(Q)$ whereas the probability of being searching when nonemployed is $F(R)$.

Let M^e and M^o denote the expected present values of employment (e) and nonemployment (o) given that optimal decision rules are adhered to in the future. These values can be written as asset equations of the form:

$$rM^e = \tilde{\upsilon}^e + \tilde{\phi}\,(M^o - M^e) \tag{2}$$

$$rM^o = \tilde{\upsilon}^o + \tilde{\alpha}\,(M^e - M^o) \tag{3}$$

where $\tilde{\phi} \equiv \phi^p F(Q) + \phi^s\,[1 - F(Q)] = \tilde{\phi}(Q)$ is the average firing rate, $\tilde{\alpha} \equiv F(R)\alpha(\theta) = \tilde{\alpha}(R,\theta)$ the average hiring rate, and $\tilde{\upsilon}^e$ $(\tilde{\upsilon}^o)$ the expected per-period utility if employed (nonemployed). Per-period utilities are given as

$$\tilde{\upsilon}^e \equiv F(Q)\,[\ln w - aE(\xi \mid \xi \leq Q)] + [1 - F(Q)]\,[\ln \rho^s w - E(\xi \mid \xi > Q)]$$

$$\tilde{\upsilon}^o \equiv F(R)\,[\ln \rho^u w - aE(\xi \mid \xi \leq R)] + [1 - F(R)]\,[\ln \rho^n w - E(\xi \mid \xi > R)]$$

[7] A somewhat similar idea is contained in Wang and Williamson (1996), who assume that a worker's probability of job retention depends on effort supplied on the job.

where E stands for the expectations operator and where we have imposed the replacement rate conditions also for the nonemployed workers, i.e., $b^u = \rho^u w$ and $b^n = \rho^n w$; recall that the latter replacement rates apply to the common aggregate wage. The difference in present values is

$$M^e - M^o = \frac{\tilde{v}^e(\rho^s) - \tilde{v}^o(\rho^u, \rho^n)}{\tilde{\alpha}(R, \theta) + \tilde{\phi}(Q) + r} \tag{5}$$

The reservation values of sickness, Q and R, are obtained from equations of the form:

$$(a-1)\,Q = -\ln \rho^s + (\phi^s - \phi^p)\left[\frac{\tilde{v}^e(\rho^s) - \tilde{v}^o(\rho^u, \rho^n)}{\tilde{\alpha}(R, \theta) + \tilde{\phi}(Q) + r}\right] \tag{6}$$

$$(a-1)\,R = \ln \rho^u - \ln \rho^n + \alpha(\theta)\left[\frac{\tilde{v}^e(\rho^s) - \tilde{v}^o(\rho^u, \rho^n)}{\tilde{\alpha}(R, \theta) + \tilde{\phi}(Q) + r}\right] \tag{7}$$

Individual optimization implies that M^e and M^o are locally independent of the relevant reservation values of sickness. Note also that $M^e - M^o$ is independent of the wage, an implication of constant replacement rates.

Eqs. (6) and (7) have several interesting implications. Both Q and R depend in general on compensation while nonemployed as well as labor market conditions. Non-work benefits have direct effects, holding $M^e - M^o$ constant; they have also indirect "wealth effects" through $M^e - M^o$. The indirect effects sometimes tend to offset and sometimes tend to reinforce the direct effects. For example, a rise in ρ^s has a direct negative effect on Q, whereas the indirect effects works in the opposite direction (since higher sick pay increases the value of employment relative to the value of nonemployment). The direct effect dominates the indirect effect.[8] A rise in ρ^u has a direct positive effect on R, whereas the indirect effect tends to reduce R (since the value of employment falls relative to the value of nonemployment). The direct effect dominates the indirect effect also in this case.[9] The following partial equilibrium results are obtained:

Lemma 1: *Higher replacement rates affect Q and R as given by*

$$\begin{array}{llll} \dfrac{\partial Q}{\partial \rho^s} < 0, & \dfrac{\partial Q}{\partial \rho^u} \leq 0, & \dfrac{\partial Q}{\partial \rho^n} \leq 0, & \dfrac{\partial Q}{\partial \rho^o} \leq 0 \\ \dfrac{\partial R}{\partial \rho^s} > 0, & \dfrac{\partial R}{\partial \rho^u} > 0, & \dfrac{\partial R}{\partial \rho^n} < 0, & \dfrac{\partial R}{\partial \rho^o} < 0 \end{array}$$

[8] The employed worker spends only a fraction, $1 - F(Q)$, of his time as absent from work, a fact that attenuates the wealth effect. The wealth effect is also smaller, the smaller the excess firing risk associated with absence. We have $sign\,(\partial Q/\partial \rho^s) = sign\left[-1 + \left(\tilde{\phi} - \phi^p\right)/(\tilde{\alpha} + \tilde{\phi} + r)\right] < 0$.

[9] The worker spends a only fraction, $F(R)$, of his time as nonemployed as active job searcher, something that attenuates the wealth effect of higher unemployment benefits. We have $sign\,(\partial R/\partial \rho^u) = sign\left[1 - \tilde{\alpha}/(\tilde{\alpha} + \tilde{\phi} + r)\right] > 0$.

where $\partial Q/\partial\rho^o$ and $\partial R/\partial\rho^o$ denote the effects of simultaneous increases of ρ^u and ρ^n. The weak inequalities hold as equalities when $\phi^p = \phi^s$.

Lemma 2: *An increase in labor market tightness affect Q and R as given by $\partial Q/\partial\theta \leq 0$ for $\phi^p \leq \phi^s$, and $\partial R/\partial\theta > 0$.*

It is also clear from (6) that Q is increasing in $(\phi^s - \phi^p)$; the larger the excess firing risk associated with absence, the larger is Q, i.e., the lower is the probability of being absent from work. Empirical evidence suggests that absenteeism increases in labor market tightness, an observation consistent with $\partial Q/\partial\theta < 0$ (implied by $\phi^s > \phi^p$). Pro-cyclical labor force participation, for which there is ample evidence, is consistent with $\partial R/\partial\theta > 0$.

This completes the description of the supply side where labor market tightness is taken as given. We now turn to the behavior of firms and the determination of wages and tightness.

2.3 Zero Profits

From now on we ignore discounting ($r = 0$) and consider a firm with potentially many workers. The fraction of workers present at work is given by $F(Q)$ whereas the fraction absent is $1 - F(Q)$. The firm is operating under constant returns to labor and y denotes the constant marginal product. The wage cost per employee at work, inclusive of the payroll tax t, is $w_c = w(1+t)$. There is a cost k of holding a vacancy open. The firm maximizes profit per employed worker and free entry drives profits to zero. Because of constant returns, the level of employment at the firm level is indeterminate.

The firm's profits per employed worker can be written as

$$\pi = F(Q)(y - w_c) - \tau\left[1 - F(Q)\right]\rho^s w_c - \frac{k\tilde{\phi}}{q(\theta)} \tag{8}$$

where $k\tilde{\phi}/q(\theta)$ is the cost of holding vacancies open; note that $\tilde{\phi}/q(\theta)$ is the vacancy/employment ratio in the firm that holds in a steady state with constant employment. We assume in general that the cost of holding a vacancy open is proportional to output per worker, i.e., $k = \kappa y$. The parameter τ is referred to as the degree of experience rating of sickness insurance, thus borrowing from the US terminology regarding the financing of unemployment insurance. With $\tau = 1$, the firm fully finances sick pay for its workers; with $\tau = 0$, the firm finances nothing (directly) of its workers' sick pay. It is assumed that firm-provided sick pay is taxed at the same rate as wages. We will generally consider two polar cases, viz. $\tau = 1$ and $\tau = 0$.

Free entry with zero profits implies:

$$Z(w_c, \rho^s, \theta) \equiv F(Q)\,(y - w_c) - \tau\,[1 - F(Q)]\,\rho^s w_c - \frac{\kappa y \tilde{\phi}}{q(\theta)} = 0 \qquad (9)$$

We will typically focus on two alternative versions of this zero profit condition:

(i) Sick pay (ρ^s) is provided by the government and exogenous to the firm. The natural benchmark regarding financing is $\tau = 0$, i.e., financing exclusively by taxes. We allow absence dependent firing risks, i.e., $\phi^s \geq \phi^p$ and thus $\tilde{\phi} = \tilde{\phi}(Q)$.

(ii) Sick pay is provided exclusively by firms and financed by them directly, i.e., $\tau = 1$. To simplify this analysis, we assume $\phi^p = \phi^s = \phi$ and thus $\tilde{\phi} = \phi$. Absence from work has thus no consequences for the risk of job loss in this case.[10]

The zero profit condition involves Q as obtained from (6). By making use of (6) and differentiate the zero profit condition we can state a useful lemma:

Lemma 3: *If ρ^s is exogenous to the firm, the zero profit condition implies a negative relationship between the wage cost, w_c, and labor market tightness, θ,* i.e., $\partial w_c / \partial \theta < 0$.

Eq. (9) is a Pissarides-type zero profit condition, slightly modified so as to incorporate absence behavior (see Pissarides, 2000). The zero profit relationship is downward sloping because a tighter labor market is associated with higher vacancy costs which has to be offset by lower wage costs so as to maintain zero profits. Absence appears in this relationship because it affects the surplus associated with more employed workers, and possibly the direct costs of having more workers absent from work (if $\tau > 0$).

2.4 Wage Posting

Our model of wage setting involves directed search with wage posting by firms. Firms post wages so as to attract job applicants, recognizing that higher wages attract a longer "queue" of applicants. The inverse of tightness, i.e., $\theta^{-1} = u/v$, can be thought of as the length of the queue. Unemployed workers allocate themselves to firms, recognizing wage offers as well as job offer probabilities. Worker mobility across job queues (or submarkets) equalizes the expected values across those queues and firms take as given

[10] Sickness insurance schemes exhibit marked variations across countries. Most countries outside the United States have publicly provided sickness insurance. The level of statutory sick pay relative to average earnings is very low in some countries (such as the United Kingdom), but very high in other countries (such as Scandinavia).

the common expected value of being unemployed. The model is thus of the competitive search variety; see Moen (1997) for a seminal contribution and Rogerson et al (2005) for a recent survey.[11]

Does a worker's sickness status, as measured by ξ, affect his preferences over job queues? Given our assumptions, the answer is no. At the beginning of each period, the worker draws a fresh value of ξ from the distribution $F(\xi)$. The instantaneous utility implied by a particular realization of ξ is given by $\upsilon^u(b^u, \xi) = \ln b^u - a\xi$. The worker directs his search to a firm (submarket) after ξ is realized. The value function for an unemployed worker who considers a submarket offering a particular w, θ-pair can be written as:

$$(1+r)U(\xi,\theta,w) = \upsilon^u(b^u,\xi) + \alpha(\theta)M^e(w) + [1-\alpha(\theta)]\,M^o \qquad (10)$$

where $U(\xi, \theta, w)$ is the present value of being unemployed given sickness status ξ (see Appendix A). $U(.)$ depends on ξ only through $\upsilon^u(b^u, \xi)$ since the worker draws a new value of ξ in the next period. It follows that the worker's preferences over job queues is independent of the current sickness status since ξ is analogous to a sunk cost. What matters for the choice of job queue is the value of the w, θ-pair on offer, as given by $\tilde{U} \equiv \alpha(\theta)M^e(w) + [1-\alpha(\theta)]\,M^o$. This is the value of being unemployed before the veil of ignorance regarding ξ has been lifted.

A firm that wants to stay competitive in the labor market must offer its workers a w, θ-pair that is no less attractive than the best alternative available in the market. Let $\bar{U}$ denote the value of the most attractive offer. A competitive w, θ-pair must respect the inequality $\tilde{U} \geq \bar{U}$. Note that this market restriction, written as an equality, is equivalent to $\bar{U} = M^o + \tilde{\alpha}(\theta)\,[\tilde{\upsilon}^e(w) - rM^o]\,/\tilde{\phi}$. The Lagrangian for the firm's problem can then be written as

$$L = \pi(.) + \mu\left[\bar{U} - M^o - \frac{\tilde{\alpha}(\theta)\,[\tilde{\upsilon}^e(w) - rM^o]}{\tilde{\phi}}\right]$$

where μ is the Lagrange multiplier. The firm takes $\bar{U} - M^o$ as exogenous and maximizes with respect to w and θ. The first-order conditions take the form:

$$\pi_w = \mu\tilde{\alpha}(\theta)\tilde{\upsilon}^e_w/\tilde{\phi} \qquad (11)$$

$$\pi_\theta = \mu\,[\tilde{\upsilon}^e(w) - rM^o]\,\tilde{\alpha}_\theta/\tilde{\phi} \qquad (12)$$

which imply that the marginal rates of substitution between w and θ are equal for firms and workers. The two first-order conditions can be combined

[11] For ease of exposition, we suppress submarket subscripts on w and θ.

with (9) to yield:

$$\tilde{v}^e - rM^o = \left(\frac{\eta}{1-\eta}\right)\left(-\frac{\partial \ln \pi^g}{\partial \ln w_c}\right)^{-1} \tag{13}$$

where $\pi^g \equiv \pi + \kappa y \tilde{\phi}/q(\theta)$ is gross profits per employee and $\eta \equiv -\theta q'(\theta)/q(\theta)$ is the elasticity of matching with respect to unemployment, $\eta \in (0,1)$. The absolute value of the elasticity of gross profits with respect to the wage cost takes the form:

$$-\frac{\partial \ln \pi^g}{\partial \ln w_c} = \frac{F(Q) + \tau\left[1 - F(Q)\right]\rho^s}{F(Q)\left(\frac{y}{w_c} - 1\right) - \tau\left[1 - F(Q)\right]\rho^s} \tag{14}$$

The more elastic profits are with respect to the wage, the lower compensation given to the worker and the lower the worker's utility while employed, $\tilde{v}^e$. Inspection of (14) reveals that this elasticity is nondecreasing in ρ^s, recognizing also that $Q = Q(\rho^s)$:

Lemma 4: *The absolute value of the elasticity of gross profits with respect to the wage cost is nondecreasing in* ρ^s*, i.e.,*

$$\partial\left[-\frac{\partial \ln \pi^g}{\partial \ln w_c}\right]/\partial \rho^s \geq 0 \text{ as } \tau \geq 0$$

The following partial equilibrium result is then immediate from (13) and (14) in conjunction with Lemma 4:

Lemma 5: *Higher sick pay reduces the wage, i.e.,* $\partial w/\partial \rho^s < 0$.

Higher sick pay allows the firm to reduce the wage without violating the market restriction as given by $\tilde{U} \geq \bar{U}$. To arrive at a general equilibrium relationship we must recognize that rM^o is endogenous and influenced by sick pay and labor market conditions. We use the fact that

$$\tilde{v}^e - rM^o = \left[\frac{\tilde{v}^e - \tilde{v}^o}{\tilde{\phi}(Q) + \tilde{\alpha}(\theta, R)}\right]\tilde{\phi}(Q) \tag{15}$$

and obtain:

$$W(w_c, \rho^s, R, \theta) \equiv \tag{16}$$

$$\frac{\tilde{v}^e - \tilde{v}^o}{\tilde{\phi}(Q) + \tilde{\alpha}(\theta, R)} - \left(\frac{\eta}{1-\eta}\right)\left(-\frac{\partial \ln \pi^g}{\partial \ln w_c}\right)^{-1}\frac{1}{\tilde{\phi}(Q)} = 0$$

The equation involves four endogenous variables: w_c, θ, Q and R; and possibly ρ^s as well. We can use (6) and (7) to substitute out Q and R, recognizing $Q = Q(\theta)$ and $R = R(\theta)$, with $Q'(\theta) \leq 0$ and $R'(\theta) > 0$. By differentiating (16), we obtain a positive relationship between w_c and θ, for given ρ^s. Eq. (16) can be thought of as a positively sloped "wage curve" in the w_c, θ-space.

An alternative useful representation of this relationship is obtained by invoking (9) to substitute out w_c:

$$\hat{W}\left(\rho^s, \theta\right) \equiv \frac{\tilde{v}^e - \tilde{v}^o}{\tilde{\phi}\left(Q\right) + \tilde{\alpha}(\theta, R)} - \left(\frac{\eta}{1-\eta}\right)\left[\frac{\kappa}{F(Q)q(\theta) - \kappa\tilde{\phi}(Q)}\right] = 0 \quad (17)$$

where $F(Q)q(\theta) - \kappa\tilde{\phi}(Q) > 0$ from (9). This equation determines θ as a function of parameters when ρ^s is exogenous; recall $Q'(\theta) \leq 0$ and $R'(\theta) > 0$. Existence requires $\tilde{v}^e - \tilde{v}^o > 0$, i.e., $M^e > M^o$; this restriction puts some restrictions on the parameters that are assumed to be fulfilled. Uniqueness is guaranteed by the fact that $\hat{W}_\theta < 0$. The wage cost is obtained by invoking the zero profit condition, i.e., (9). In summary:

Lemma 6: *Free entry and zero profits together with wage posting yield – for a given ρ^s – a vertical w_c, θ-locus that determines tightness independently of the wage cost, i.e., eq. (17). The wage cost is obtained recursively from the zero profit condition, i.e., eq. (9).*

We note that the tax rate and the degree of experience rating do not appear in (17) and thus do not affect the equilibrium level of tightness. The level of labor productivity is also neutral with respect to tightness, an implication of the assumption that vacancy costs are proportional to labor productivity, $k = \kappa y$.

The general equilibrium is illustrated in Figure 1. Eqs. (16) and (17) are alternative representations of the "wage curve". For some comparative statics purposes, one representation may be more useful than the other; of course, the results do not depend on which curve that is invoked.

2.4.1 Firm-Provided Sick Pay

Consider now the case where sickness benefits are provided by the firm as part of the optimal compensation package. When the firm chooses ρ^s, it recognizes that absence responds to sick pay. That is, the firm takes into account (6). As noted above, we simplify this analysis by assuming $\phi^p = \phi^s$ and thus have $(a-1)\,Q = -\ln \rho^s$. Maximization of the Lagrangian with respect to ρ^s yields a first-order condition analogous to (11) of the form:

$$\pi_{\rho^s} = \mu\tilde{\alpha}(\theta)\tilde{v}^e_{\rho^s}/\tilde{\phi} \quad (18)$$

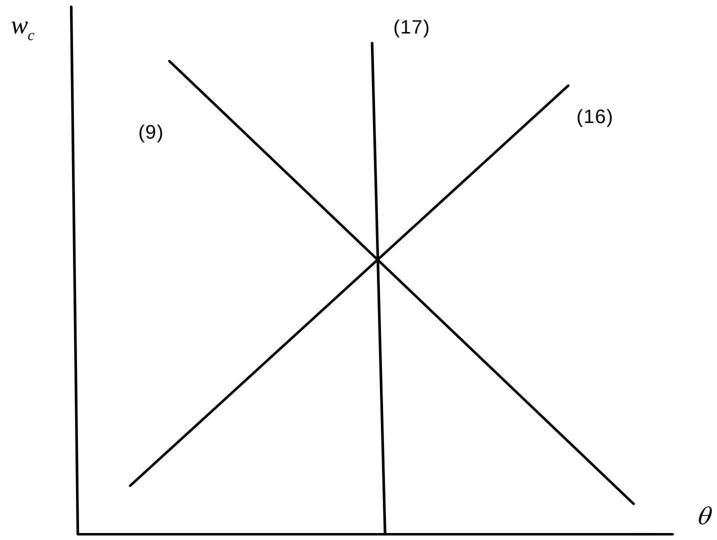

Figure 1: General equilibrium

The optimal compensation package thus involves the efficiency condition

$$\frac{\pi_w}{\pi_{\rho^s}} = \frac{\tilde{\upsilon}^e_w}{\tilde{\upsilon}^e_{\rho^s}} \tag{19}$$

which equalizes the marginal rates of substitution between wages and sick pay for the firm and the worker. The former rate is affected by the degree of experience rating; the latter is not. The efficiency condition given by (19) traces out a positively sloped "contract curve" in the w, ρ^s-space. The contract curve is affected by taxes and experience rating and can be written as an equation of the form:

$$\Gamma(\rho^s, w_c) \equiv \tau\rho^s - \frac{F(Q) - \left(\frac{y}{w_c} - 1\right)\varepsilon^s}{F(Q) + \varepsilon^s} = 0 \tag{20}$$

where $Q = Q(\rho^s)$ and

$$\varepsilon^s \equiv \frac{d\ln s^r}{d\ln \rho^s} = \frac{d\ln(1 - F(Q))}{d\ln \rho^s} \tag{21}$$

is the elasticity of the absence rate, s^r, with respect to the replacement rate. Absent moral hazard we have $\varepsilon^s = 0$ and full insurance, i.e., $\rho^s = 1$, under full experience rating, i.e., $\tau = 1$; this is of course a natural outcome with risk averse workers and risk neutral firms.

We assume that the elasticity ε^s is locally constant. In fact, ε^s is everywhere constant if $f(\xi)$ is exponential, $f(\xi) = \lambda \exp(-\lambda\xi)$, $\lambda > 0$:

$$\varepsilon^s = \frac{\lambda}{a-1} \tag{22}$$

To determine the general equilibrium configuration of θ, w_c and ρ^s, we need to invoke (20) together with (9) and (17), i.e., $Z(w_c, \rho^s, \theta) = 0$ and $\hat{W}(\rho^s, \theta) = 0$. Existence can be shown to hold for some parameter configurations but we have not been able to derive simple and transparent conditions for existence. However, provided that an equilibrium exists, it will be unique. Hence:

Lemma 7: *The general equilibrium of an economy where firms post both wages and sick pay will be unique and determine θ, w_c and ρ^s.*

Proof: (*Sketch - see Appendix B for more details.) Combine (20) and (9) to obtain a relationship $\tilde{\Gamma}(\theta, \rho^s) = 0$, where $(\partial\theta/\partial\rho^s)_{\tilde{\Gamma}} < 0$. Combine also $\tilde{\Gamma}(\theta, \rho^s) = 0$ and (17) to obtain a relationship $\tilde{W}(\theta, \rho^s) = 0$, where $(\partial\theta/\partial\rho^s)_{\tilde{W}} \gtreqless 0$. It can be shown that $(\partial\theta/\partial\rho^s)_{\tilde{\Gamma}} < (\partial\theta/\partial\rho^s)_{\tilde{W}}$. The two relationships between θ and ρ^s can cross only once and an equilibrium that determines θ* and *ρ^s is therefore unique. The wage cost, w_c, follows from (9) once θ and ρ^s are determined.* ■

The degree of experience rating, τ, may affect the level of tightness when sick pay is provided by firms. Experience rating is effectively a tax on sick pay and the firm's optimal compensation package responds to this tax.

2.5 Flow Equilibrium and Balanced Budget

Having determined w_c, θ, Q and R, and possibly ρ^s as well, it is straightforward to determine average hiring and firing rates, i.e., $\tilde{\alpha}(R, \theta)$ and $\tilde{\phi}(Q)$, as well as the sickness absence rate, $s^r(Q)$. The stocks of employment, sickness absentees, unemployed and nonparticants are obtained by imposing flow equilibrium in the labor market. Flow equilibrium implies the following relationships:

$$\begin{aligned}
e &= \tilde{\alpha}/\left(\tilde{\alpha}+\tilde{\phi}\right) \\
p &= \tilde{\alpha}F(Q)/\left(\tilde{\alpha}+\tilde{\phi}\right) = F(Q)e \\
s &= \tilde{\alpha}\left[1-F(Q)\right]/\left(\tilde{\alpha}+\tilde{\phi}\right) = \left[1-F(Q)\right]e \\
u &= \tilde{\phi}F(R)/\left(\tilde{\alpha}+\tilde{\phi}\right) = F(R)(1-e) \\
n &= \tilde{\phi}\left[1-F(R)\right]/\left(\tilde{\alpha}+\tilde{\phi}\right) = \left[1-F(R)\right](1-e)
\end{aligned}$$

$$\begin{aligned} u^r &= \tilde{\phi}F(R)/\left[\tilde{\alpha}+\tilde{\phi}F(R)\right] \\ s^r &= 1-F(Q) \end{aligned}$$

where $u^r = u/(u+e)$ is the unemployment rate as conventionally measured.

The tax rate, t, is determined recursively to balance the government's budget, assuming a given degree of experience rating, τ:

$$t\,(p+\tau\rho^s s) = (1-\tau)\rho^s s + \rho^u u + \rho^n n \tag{24}$$

2.6 Calibration of the Model

We have calibrated the model assuming that the density $f(\xi)$ is exponential, i.e., $f(\xi) = \lambda\exp(-\lambda\xi)$, $\lambda > 0$. The absence rate is then given as $s^r = \exp(-\lambda Q)$. Since $Q = -\ln\rho^s/(a-1)$ when $\phi^p = \phi^s$, we have $\ln s^r = [\lambda/(a-1)]\ln\rho^s$ in this case. The parameters λ and a enter into the model through the ratio $\lambda/(a-1)$, i.e., the elasticity of s^r with respect to ρ^s. When $\phi^p < \phi^s$, the elasticity expression takes the form

$$\frac{d\ln s^r}{d\ln\rho^s} = \left(\frac{\lambda}{a-1}\right)\left(\frac{\tilde{\alpha}+\phi^p}{\tilde{\alpha}+\tilde{\phi}}\right)$$

which is smaller than $\lambda/(a-1)$ since $\phi^p < \tilde{\phi}$. However, the difference between ϕ^p and $\tilde{\phi}$ is negligible for realistic values of the absence rate ($s^r \leq 0.1$, say) and $\lambda/(a-1)$ is therefore generally a good approximation of the elasticity. We have set $a = 2$ and the choice of λ is then equivalent to choosing the elasticity of s^r with respect to ρ^s.

The exponential distribution is attractive because of its simplicity and its apparent plausibility in this context: most sickness shocks are presumably of a relatively small magnitude. We have chosen parameters so as to get $s^r = 0.10$, which corresponds to work hours lost due to absence as a fraction of contractual hours among Swedish employees in 2004, excluding absence due to holidays and similar "predetermined" causes of absence.[12] We set $\lambda = 2$, arguably on the high side of estimates of $d\ln s^r/d\ln\rho^s$, and require a rather low value for ρ^s to get $s^r = 0.10$. (Note that s^r is decreasing in ε^s for given ρ^s.) We have set $\rho^s = \rho^u = \rho^n = 0.325$, which yields an absence rate around 10 percent.[13]

[12] Sickness absence accounts for over 90 percent of this measure of absence. Source: Labor force surveys, Statistics Sweden.

[13] Replacement rates around 30 percent may seem implausibly low. However, these

The other parameters were chosen so as to get an unemployment rate of 6.5 percent and an average annual job separation rate of roughly 25 percent. Consistency with empirical observations also requires that the expected duration of unemployment, $1/\alpha(\theta)$, should be substantially higher than the expected duration of vacancies, $1/q(\theta)$. Moreover, some (scanty) empirical evidence suggests $Q > R$, implying less sickness reporting among employees than among nonemployed workers.

Taking a day as the time unit, we set $\phi^p = 0.25/365$, $\phi^s = 0.35/365$, $y = 1$, $\eta = 0.5$, $\kappa = 1.85$ and $m = 0.015$. The rate of time preference is set to zero throughout. The implications of these choices are set out in the first column of Table 1. Sickness absence is 10 percent and unemployment is 6.5 percent of the labor force. The expected duration of unemployment is close to 14 weeks whereas the expected duration of vacancies is 6.6 weeks. The average (annual) separation rate is 26 percent. The inactivity rate, $n/(n + u)$, is 0.12, thus slightly higher than s^r (so we have $Q > R$).

We have also repeated the exercise under the assumption that there is no excess firing risk associated with absence. That is, we set $\phi^p = \phi^s = 0.26/365$, which corresponds to the average separation risk in the previous specification. All other parameters are the same. As is clear from Table 1, the results are very similar.

The third column of Table 1 shows the outcomes when sick pay is endogenously provided by firms (and $\tau = 1$). All relevant parameters are those that apply in the second column of the table. It turns out that the optimal sick pay chosen by firms is somewhat lower than the benchmark case (0.257 as opposed to 0.325). Workers are compensated for the lower level of sick pay by higher wages. The lower level of sick pay implies lower sickness absence than in the previous cases. The other outcomes are close to those given in the first two columns.

rates pertain to systems without time limits, whereas existing systems generally involve time limits on benefit receipt. Existing systems also involve some degree of monitoring of sickness status and job search, something that will tend to make higher replacement rates feasible.

Table 1. Calibration of the model.

	Exogenous ρ^s		Endogenous ρ^s
	$\phi^s > \phi^p$	$\phi^s = \phi^p$	$\phi^s = \phi^p$
ρ^s	–	–	.257
w_c	.933	.933	.918
w	.876	.874	.894
θ	.473	.470	.482
e	.927	.927	.927
p	.834	.829	.866
s	.093	.098	.061
u	.064	.064	.063
n	.009	.009	.009
u^r	.065	.064	.064
s^r	.100	.106	.066
$1/\alpha(\theta)$ (in weeks)	13.8	13.9	13.7
$1/q(\theta)$ (in weeks)	6.6	6.5	6.6
$\tilde{\phi}$ (annualized)	.260	.260	.260

3 Comparative Statics

The parameters of the model have their origins in preferences and shocks to preferences, vacancy costs, matching technologies, job separation rates and benefit policies. Changes in parameters impact on the economy by influencing workers' decisions on absence and search and by influencing firms' decisions on wages and recruitments. Some disturbances may affect hirings and firings in opposite directions. Some will affect both the wage setting and zero profit relationships; it may be possible to predict the wage outcome but not the effect on labor market tightness, or vice versa.

Table 2 presents comparative statics results, some of them analytical and the remaining ones numerical. We confine the discussion to a subset of parameters, beginning with benefit policies when sick pay is exogenous. To provide some feel for how the model works, the discussion of the effects of higher sick pay is more detailed than the discussions of other experiments.

Table 2. Comparative statics results.

	ρ^s	ρ^u	ρ^n	ρ^o	κ	τ (i)	τ (ii)
R	+	+	−	−	−	0	−
Q $(\phi^s > \phi^p)$	−	−	−	−	+	0	
Q $(\phi^s = \phi^p)$	−	0	0	0	0	0	+
θ	−	−	−	−	−	0	+
w_c	−	+	+	+	−	−	+
t	+	+	+	+	+	−	−
w	−	−	−	−	−	0	+
e	−	−	−	−	−	0	+
p	−	−	−	−	−	0	+
s exog. ρ^s	+	−	−	−	−	0	
s endog. ρ^s		+	−	+	−		−
u	+	+	+	+	+	0	−
n	−	+	+	+	+	0	+
u^r	+	+	+	+	+	0	−
s^r $(\phi^s > \phi^p)$	+	+	+	+	−	0	
s^r $(\phi^s = \phi^p)$	+	0	0	0	0	0	−
ρ^s		+	+	+	−		−

Notes: ρ^o involves a simultaneous increase in ρ^u and ρ^n. (i) corresponds to exogenous ρ^s, (ii) to endogenous ρ^s.

3.1 Exogenous Sick Pay

Higher Sick Pay Consider how the economy responds to an exogenous increase in sick pay, ρ^s, that is financed by taxes. Holding labor market tightness constant, the effect on Q, and thus on absence, is given by (6). The direct effect on Q is obviously negative. However, there is also a "wealth effect" involved since higher sick pay increases the value of employment relative to nonemployment, $M^e - M^o$. The direct effect dominates the indirect effect so Q does indeed fall; cf. Lemma 1 and footnote 8. The increase in absence triggers an increase in firings (if $\phi^s > \phi^p$) and thus contributes to a decline in employment.

The fact that higher sick pay increases the value of employment relative to nonemployment strengthens the incentives for job search among nonemployed individuals, as is clear from (7). By raising R, nonemployed individuals substitute job search as unemployed for inactivity, thereby contributing to a rise in hirings and an increase in employment. The net effect on employment is generally unclear but positive when $\phi^s = \phi^p$; in this case there is no increase in firings associated with higher sick pay.

So far we have taken labor market tightness as given. As is clear from (6) and (7), both absence and search decisions depend in general on tightness. Higher tightness reduces the value of employment relative to nonemployment and makes the employed worker less reluctant to call in sick (Q falls). For the nonemployed worker, a stronger labor market makes it more attractive to engage in search and R thus increases; this follows from eq. (7). To determine the effect on labor market tightness, we need to consider firms' wage and recruitment decisions.

A rise in ρ^s that increases absence reduces the firm's surplus per worker; cf. (9). To maintain zero profits, firms offer fewer jobs thereby reducing expected vacancy costs. The process can be illustrated as a shift to the left of the zero profit condition in the w_c, θ-space. However, the higher level of sick pay also affects wage setting via the associated increase in the value of employment relative to nonemployment. In that respect, higher sick pay is equivalent to a subsidy to employment and firms can sustain recruitments with lower wages. The wage curve as given by (16) shifts to the right. The wage cost falls unambiguously and the worker's real consumer wage also falls as long as the tax rate does not decrease.

The effect on tightness is ambiguous. The wage moderation effect is counteracted by the adverse labor demand effect as higher absence reduces the firm's surplus per worker. Recall that we obtained an unambiguously positive employment response to higher sick pay when $\phi^s = \phi^p$ and tightness was taken as given. This prediction does not carry over the case with endogenous tightness: higher sick pay may reduce tightness which weakens search incentives and reduces the average hiring rate, $\tilde{\alpha}(R, \theta)$.[14] The numerical analysis suggests that tightness as well as employment would decline.

How does then sickness absence respond to higher sick pay? From Lemma 1 we have $\partial Q/\partial \rho^s < 0$, holding tightness constant. This effect, implying higher absenteeism, may conceivably be offset by changes in tightness; recall $\partial Q/\partial \theta \leq 0$ from Lemma 2. However, by invoking (6) and (17), we can establish an unambiguous increase in absenteeism, regardless of how tightness is affected. In summary:

Proposition 1 *Higher sick pay increases absenteeism,* $\partial s^r/\partial \rho^s > 0$*, and*

[14] The sign of the derivative of interest can be written as

$$sign \frac{d\theta}{d\rho^s} = sign \left[1 - \frac{(\tilde{v}^e - \tilde{v}^o)\, \varepsilon^s}{F(Q)q(\theta) - \kappa\tilde{\phi}} \right] \gtreqless 0.$$

reduces the wage cost, $\partial w_c/\partial \rho^s < 0$.

Higher Nonemployment Benefits A uniform increase in nonemployment benefits, ρ^o, causes an unambiguous decline in tightness; the prediction follows immediately from (17). Search activity among nonemployed workers falls unambiguously since eq. (7) implies $\partial R/\partial \rho^o < 0$ and $\partial R/\partial \theta > 0$. Sickness absence among employees is not affected as long as $\phi^p = \phi^s$, but will unambiguously increase when $\phi^s > \phi^p$. Note from (6) that the rise in nonemployment benefits tend to increase absenteeism (reduce Q) as the per-period utility difference between employment and nonemployment increases. However, the fall in tightness reduces job finding which makes nonemployment less attractive, which in turn makes absenteeism more costly. By invoking (6) and (17), it is straightforward to establish that absenteeism does indeed increase (Q falls when $\phi^s > \phi^p$); the indirect effect through adjustments in tightness can never offset the direct effect.

The fall in tightness reduces job finding and the fact that Q can never increase imply that firings can never fall. It is clear, then, that employment must fall. To obtain the effect on the wage cost, we need to invoke the zero profit condition, i.e., eq. (9). As long as $\phi^p = \phi^s$ holds, there is no effect on this relationship; the shift to the left of the vertical wage curve given by (17) implies an unambiguous increase in the wage cost. In general, the zero profit condition may shift in either direction and the effect on the wage cost is thus ambiguous. The numerical analysis suggests a positive effect on the wage cost. In summary:

Proposition 2 *A rise in nonemployment benefits reduces tightness, job finding and employment: $\partial \theta/\partial \rho^o < 0$, $\partial \tilde{\alpha}/\partial \rho^o < 0$ and $\partial e/\partial \rho^o < 0$. Sickness absence and the average firing rate increase if $\phi^s > \phi^p$: $\partial s^r/\partial \rho^o \geq 0$ and $\partial \tilde{\phi}/\partial \rho^o \geq 0$ as $\phi^s \geq \phi^p$. The wage cost increases as long as $\phi^s = \phi^p$: $\partial w_c/\partial \rho^o > 0$ if $\phi^s = \phi^p$.*

Higher Experience Rating It is clear from (17) that experience rating does not affect tightness, $\partial \theta/\partial \tau = 0$. It is therefore also neutral with respect to employment. Experience rating is in this respect similar to general taxes; recall that $\partial \theta/\partial t = 0$. The wage cost per labor input, i.e., $w_c = w(1+t)$, falls as τ increases but there is no effect on the expected total labor cost per employee, i.e., $w_c^T \equiv [F(Q) + \tau [1 - F(Q)] \rho^s] w_c$. The real consumer wage, w, remains unchanged; this result is obtained by using the zero profit condition and the government's budget restriction to obtain an equation that determines w independently of τ. Hence:

Proposition 3 *The degree of experience rating has no effect on tightness, employment and the real consumer wage:* $\partial\theta/\partial\tau = \partial e/\partial\tau = \partial w/\partial\tau = 0$.

Higher Vacancy Costs A rise in vacancy costs, κ, causes an unambiguous fall in tightness, an implication that is clear from eq. (17). Job findings therefore fall and employment falls as long as $\phi^p = \phi^s$. When $\phi^p < \phi^s$, the fall in tightness will reduce worker absenteeism and therefore reduce firings as well as hirings; the net effect on employment is then ambiguous. The numerical analysis suggests that employment would fall.

The effect on the wage cost depends also on how the zero profit condition is affected. The "direct" effect can be represented as a shift to the left in the w_c, θ-space; zero profits require lower wage costs at a given level of tightness when vacancy costs have increased. However, this effect is potentially counteracted by lower absenteeism among workers. However, it can be shown that the direct effect dominates the indirect effect.

Proposition 4 *Higher vacancy costs reduce tightness, job finding and the wage cost:* $\partial\theta/\partial\kappa < 0$, $\partial\tilde{\alpha}/\partial\kappa < 0$, *and* $\partial w_c/\partial\kappa < 0$. *Absenteeism and firings fall if* $\phi^s > \phi^p$: $\partial s^r/\partial\kappa \leq 0$ *and* $\partial\tilde{\phi}/\partial\kappa \leq 0$ *as* $\phi^s \geq \phi^p$. *Employment falls as long as* $\phi^p = \phi^s$: $\partial e/\partial\kappa < 0$ *if* $\phi^p = \phi^s$.

Cyclical Effects As noted in the introduction, time series data from several countries indicate pro-cyclical absenteeism. Our analysis involves comparisons of steady states and the model as it stands is not directly suitable for studies of business cycle effects. However, we have noted a positive partial equilibrium association between sickness absence and labor market tightness (Lemma 2), an association that it is tempting to interpret as a cyclical effect. But absenteeism and tightness are both endogenous variables and the covariations between the two generally depend on the origins of the exogenous disturbances. Higher vacancy costs lead to lower tightness as well as lower absenteeism, i.e., a positive covariation between tightness and absence. However, higher nonemployment benefits lead to lower tightness but higher absenteeism, i.e., a negative covariation between tightness and absence.

We have indexed vacancy costs to productivity, $k = \kappa y$, a relationship that may not hold in the short run. If we allow productivity to move without affecting k, it is clear that our model implies a positive covariation between output, tightness and absenteeism. Productivity changes are presumably more important for business cycle fluctuations than changes in nonemployment benefits. Pro-cyclical absenteeism would therefore seem to be the most plausible prediction from a suitably extended version of the model.

3.2 Firm-Provided Sick Pay

The firm's optimal compensation package is affected by all parameters of the problem. The general equilibrium features three key endogenous variables – θ, w_c and ρ^s – and we need to invoke eq. (20) in addition to the other relationships. We examine the labor market responses to exogenous changes in nonemployment benefits and in experience rating. Note that the firing probability is taken as independent of absence behavior in this case, an assumption implying that the sickness absence rate is exclusively determined by the level of sick pay relative to the wage, i.e., ρ^s.

Nonemployment Benefits Higher nonemployment benefits reduce tightness, job finding and employment. More interesting is that the level of sick pay also increases, which in turn leads to an increase in absenteeism. To understand this result, consider (20) which can be viewed as a positively sloped contract curve in the w, ρ^s-space. Higher nonemployment benefits reduce tightness and thereby the costs of holding vacancies open; this in turn allows firms to pay higher wages as well as higher sick pay without violating the zero profit constraint. The optimal adjustment can be thought of as a movement along the positively sloped contract curve in the w, ρ^s-space. The rise in nonemployment benefits has made it more expensive for firms to offer job opportunities and they respond by offering higher wages and sick pay. In conclusion:

Proposition 5 *A rise in nonemployment benefits reduces tightness, job finding and employment: $\partial\theta/\partial\rho^o < 0$, $\partial\tilde{\alpha}/\partial\rho^o < 0$ and $\partial e/\partial\rho^o < 0$. The level of sick pay provided by firms increases, $\partial\rho^s/\partial\rho^o > 0$, which triggers an increase in absenteeism, $\partial s^r/\partial\rho^o > 0$. The wage cost also increases: $\partial w_c/\partial\rho^o > 0$.*

Proof (*Sketch.*) *Combine (20) and (9) to obtain a relationship $\tilde{\Gamma}(\theta, \rho^s) = 0$, where $(\partial\theta/\partial\rho^s)_{\tilde{\Gamma}} < 0$; combine also $\tilde{\Gamma}(\theta, \rho^s) = 0$ and (17) to obtain a second relationship $\tilde{W}(\theta, \rho^s) = 0$, where $(\partial\theta/\partial\rho^s)_{\tilde{W}} \gtreqless 0$. Note that $(\partial\theta/\partial\rho^s)_{\tilde{\Gamma}} < (\partial\theta/\partial\rho^s)_{\tilde{W}}$ (see Appendix B) and that ρ^o features only in the second relationship. Differentiate with respect to ρ^o and obtain $\partial\rho^s/\partial\rho^o > 0$* and $\partial\theta/\partial\rho^o < 0$. *The other results follow by noting that job finding as well as employment depends on tightness, that absence depends on sick pay, and that (20) implies a positive relationship between ρ^s and w_c.* ■

Experience Rating Consider next how the firm's choice of sick pay responds to higher experience rating. Obviously, a reduction of τ below one would imply a subsidy to firm-provided sick pay. The following result is obtained by using a proof analogous to the proof of Proposition 5:

Proposition 6 *Higher experience rating reduces sick pay, i.e.,* $\partial \rho^s / \partial \tau < 0$.

Since experience rating from the firm's perspective is a tax on sick pay, it is not surprising that firms respond by reducing sick pay. The effects on tightness and employment work through the induced effects on sick pay; the direction of these effects are generally ambiguous. Recall that the effects on tightness and employment from exogenously imposed increases in sick pay were also ambiguous. However, the numerical analysis suggested that tightness as well as employment would fall. Analogously, the numerical analysis suggests that higher experience rating, via the induced fall in sick pay, leads to an increase in tightness and employment.

4 Welfare Analysis

Competitive search equilibria have been shown to be socially optimal under some conditions; see Moen (1997) and Rogerson et al (2005). These results do not obtain in our case where individuals are risk averse, credit markets are imperfect and the government finances social insurance benefits by means of taxes. The presence of a social insurance system creates externalities that operate through the government's budget constraint. This section offers an analysis of these externalities and provides a quantitative comparison of the welfare implications of alternative social insurance policies.

4.1 Private versus Public Provision of Sick Pay

Does firm-provided sick pay yield higher or lower compensation compared to what a benevolent government would choose? We approach this issue by asking whether a social planner can improve welfare by implementing a small (infinitesimal) change of sick pay at the privately optimal solution. To facilitate this exercise, it is useful to reformulate the private solution so that it mimics the decision problem facing the planner. This is accomplished by means of a "dual" approach where the private equilibrium is viewed as the result of a maximization of the worker's expected utility against a zero profit constraint. This approach yields outcomes that are identical to those obtained from the "primal" approach where profits are maximized against an expected utility constraint for the worker. We assume complete experience rating, i.e., $\tau = 1$. Discounting is ignored so the relevant welfare objective can be stated as the worker's expected utility, i.e., $\Lambda = e\tilde{v}^e + (1-e)\tilde{v}^o$.

It is useful to begin by invoking the zero profit constraint, eq. (9), and obtain tightness as a function of the wage cost and sick pay:

$$\theta = \theta(w_c, \rho^s), \qquad \theta_{w_c} < 0,\ \theta_{\rho^s} < 0 \tag{25}$$

which can be substituted into the worker's objective function:

$$\Lambda = e\left[\theta(w_c, \rho^s), R\right]\left[\tilde{v}^e(w, \rho^s) - \tilde{v}^o(w, \rho^o)\right] + \tilde{v}^o(w, \rho^o) \tag{26}$$

where $e(.) = \tilde{\alpha}(\theta)/\left[\tilde{\alpha}(\theta) + \phi\right]$. Employment generally depends on search effort on the extensive margin, i.e., R, which in turns depends on tightness, $R = R(\theta)$. However, this relationship can be ignored as long as we focus on small (infinitesimal) deviations from the privately optimal solution. The worker's expected utility is invariant to derivative changes of R, by the envelope theorem.

The first-order conditions pertaining to the private solution can now be written as:

$$\Lambda_w \equiv A = \left(\tilde{v}^e - \tilde{v}^o\right) e_\theta \theta_w + e\tilde{v}^e_w = 0 \tag{27}$$

$$\Lambda_{\rho^s} \equiv B = \left(\tilde{v}^e - \tilde{v}^o\right) e_\theta \theta_{\rho^s} + e\tilde{v}^e_{\rho^s} = 0 \tag{28}$$

which, as in the previous primal approach, imply equality between the firm's and the worker's marginal rate of substitution between wages and sick pay.

The social planner contemplates a small increase in ρ^s at the prevailing equilibrium and recognizes the government's budget constraint

$$t = \frac{\rho^o(1-e)}{F(Q)e + \left[1 - F(Q)\right] e\rho^s} = t\left[\rho^s, Q(\rho^s), e(\theta, R), \rho^o\right] \tag{29}$$

in addition to the zero profit constraint; these two constraints together represent the aggregate resource constraint for the economy. The relevant expression is

$$\frac{d\Lambda}{d\rho^s} = \left(\tilde{v}^e - \tilde{v}^o\right) e_\theta \left(\theta_{w_c} \frac{dw_c}{d\rho^s} + \theta_{\rho^s}\right) + e\left(\tilde{v}^e_{\rho^s} + \tilde{v}^e_w \frac{dw}{d\rho^s}\right) + (1-e)\tilde{v}^o_w \frac{dw}{d\rho^s} \tag{30}$$

where $\theta_{w_c} = \theta_w/(1+t)$, and

$$\frac{dw_c}{d\rho^s} = (1+t)\frac{dw}{d\rho^s} + w\frac{dt}{d\rho^s} < 0 \tag{31}$$

where $dt/d\rho^s$ is the total derivative of the government's budget restriction. Now evaluate the welfare derivative at the privately optimal ρ^s and obtain:

$$\left(\frac{d\Lambda}{d\rho^s}\right)_{A=B=0} = (\tilde{v}^e - \tilde{v}^o)\, e_\theta \theta_{w_c} \left(w \frac{dt}{d\rho^s}\right) + (1-e)\tilde{v}^o_w \frac{dw}{d\rho^s} \qquad (32)$$

The two terms on the right-hand side of (32) capture externalities associated with the tax system and the unemployment insurance system. The first term involves the tax externality: private agents do not internalize the fact that their decisions affect tax rates via the government's budget constraint. The second term captures what may be referred to as a "wage externality": private agents do not internalize the linkage between their wage decisions, the aggregate wage, and the level of consumption during nonemployment. Nonemployment benefits are indexed to the aggregate wage, $\tilde{v}^o_w > 0$; absent this linkage, there would be no wage externality.

Is the privately chosen ρ^s too low or too high? Clearly, $d\Lambda/d\rho^s > 0$ would imply that the private system yields too low sick pay, and vice versa. There is a presumption that $dt/d\rho^s > 0$, although this cannot be analytically verified; this would pull in the direction of $d\Lambda/d\rho^s < 0$. This may be offset by the wage externality in so far as $dw/d\rho^s > 0$. However, we find $dw/d\rho^s < 0$ in our calibrated model; this result is also what we have obtained analytically in partial equilibrium (cf. Lemma 5). We obtain $d\Lambda/d\rho^s < 0$ when we evaluate the derivative at our calibrated equilibrium with firm-provided sick pay. This would suggest, then, that firm-provided sick pay would be too generous relative to what a social planner would prefer.

Instead of asking whether firm-provided sick pay is set too low or too high, we could ask if there are incentives for firms to offer sick pay in addition to the statutory benefits, if the latter were optimally chosen by the government. To answer this question, we evaluate the derivative of the firm's objective function at the socially optimal level of government-provided sick pay. We find, as should be expected, that the sign of this derivative is the negative of (32): if $d\Lambda/d\rho^s < 0$, the firm could thus increase its profit by topping up the statutory sick pay. Indeed, in countries where statutory sick pay involves relatively low replacement rates, as in the United Kingdom, many employers have their own schemes which top up statutory sick pay.

The exercises so far involve "local" changes in sick pay, taking other instruments as given. We proceed to an analysis of optimal policies that makes use of all available instruments.

4.2 Optimal Policies

The problem facing the social planner is to maximize social welfare, which involves maximization of the worker's expected utility subject to a zero profit constraint and the government's budget constraint. The social welfare function is given by (26), which incorporates the zero profit constraint. The government's budget constraint with an arbitrary τ is given by (24), recognizing that the chosen policies affect the allocation of workers across the four states, i.e., $p,\ s,\ u$ and n.

We use as benchmark a policy with publicly provided sick pay and uniform replacement rates, i.e., $\tau = 1$ and $\rho^s = \rho^u = \rho^n$. Column (1) in Table 3 shows the outcomes. The optimal uniform replacement rate is 0.31, which is close the benchmark solution in Table 2 where $\rho^s = 0.325$ was assumed. The other policies, displayed in columns (2) through (6), are as follows: (2): Publicly provided sick pay with optimal differentiation of ρ^s and ρ^o; (3): Publicly provided sick pay with optimal differentiation of $\rho^s,\ \rho^u$ and ρ^n; (4): Privately provided sick pay with optimal ρ^o and $\tau = 1$; (5): Privately provided sick pay with optimal ρ^o as well as optimal τ; (6): Privately provided sick pay with optimal ρ^u, ρ^n and τ.

The welfare effect of a specific policy is measured relative to case (1). It is expressed as the equivalent of a consumption tax that equalizes welfare across policy regimes. Let Λ^U represent welfare associated with reference case (1) with uniform benefits and Λ^A welfare associated with an alternative policy. The measure of the welfare gain of policy A relative to policy U is given by the value of the tax rate z that solves $\Lambda^A\left[(1-z)w; \cdot\right] = \Lambda^U$. With logarithmic utility functions we have $\Delta\Lambda \equiv \Lambda^A - \Lambda^U = -\ln(1-z) \approx z$.

Table 3 immediately reveals that privately and publicly provided sick pay are equivalent provided that the planner makes optimal use of experience rating; cf. the outcomes in columns (2) and (5), and those in columns (3) and (6). The planner can choose ρ^s directly, as in the public system; or ρ^s can be controlled indirectly by means of τ, as in the private system. The welfare implications are identical. The only variables that depend on private/public regime are w_c and t; however, these effects are uninteresting since they do not affect consumption possibilities (lower t is offset by higher τ so there will no effect on firms' total labor costs).

The equivalence result can be stated formally as follows:

Proposition 7 *Publicly provided optimal sick pay is welfare equivalent to privately provided sick pay provided that the degree of experience rating is chosen optimally.*

Proof Let $X(\rho^s, \tau)$ denote the solution vector of endogenous variables in the system with public provision of sick pay. The key variables are determined by eqs. (9) and (17). We have $\partial X/\partial\tau = 0$ by Proposition (3). Consider next a system with firm-provided sick pay, where the key variables are determined by eqs. (9), (17) and (20). We obtain $\rho^s = \rho^s(\tau)$, with $\partial\rho^s/\partial\tau < 0$ by Proposition (5). Substitution of $\rho^s = \rho^s(\tau)$ into $X(\rho^s, \tau)$ yields the vector $X(\rho^s(\tau), \tau)$. The social planner maximizes $\Lambda = \Lambda[X(\rho^s, \tau)]$ by choosing ρ^s directly, or indirectly via τ. The relevant first-order condition for the first case (public provision) is $\Lambda_X(\partial X/\partial\rho^s) = 0$; note that $\Lambda_X(\partial X/\partial\tau) = 0$ is always satisfied. The first-order condition for the second case (private provision) is $\Lambda_X(\partial X/\partial\rho^s)(\partial\rho^s/\partial\tau) + \Lambda_X(\partial X/\partial\tau) = 0$, which can be written as $\Lambda_X(\partial X/\partial\rho^s)(\partial\rho^s/\partial\tau) = 0$ since $(\partial X/\partial\tau) = 0$. It follows that the solution vector for the two systems is identical. ■

Table 3. Welfare comparisons, private and public sick pay.

	Publicly provided			Privately provided		
	Optimal uniform ρ^j	Optimal ρ^s, ρ^o	Optimal ρ^s, ρ^u, ρ^n	Optimal ρ^o $\tau = 1$	Optimal ρ^o, τ	Optimal ρ^u, ρ^n, τ
	(1)	(2)	(3)	(4)	(5)	(6)
ρ^s	.307	.228	.225	.262	.228	.225
ρ^o	.307	.398		.397	.398	
ρ^u	.307	.398	.534	.397	.398	.534
ρ^n	.307	.398	.170	.397	.398	.170
τ	1	1	1	1	1.181	1.226
w_c	.931	.943	.951	.924	.929	.937
θ	.501	.377	.285	.376	.377	.285
e	.930	.911	.915	.911	.911	.915
p	.842	.863	.869	.849	.863	.869
s	.088	.048	.047	.063	.048	.047
u	.062	.070	.081	.071	.070	.081
n	.008	.019	.003	.018	.019	.003
u^r	.063	.072	.082	.072	.072	.082
s^r	.094	.052	.051	.069	.052	.051
t	.058	.054	.063	.041	.038	.047
w	.881	.895	.895	.888	.895	.895
$\Delta\Lambda$ (%)		0.84	1.56	0.79	0.84	1.56

Notes: $\phi^p = \phi^s$ in all simulations. The welfare changes are measured relative to the optimal uniform public system.

The government can thus "delegate" the decision on sick pay to firms, provided that it exercises appropriate control over the degree of experience rating. By choosing experience rating optimally, the government induces the private agents to internalize all relevant externalities. As our numerical results in Table 3 indicate, the optimal degree of experience rating involves $\tau > 1$; firms should be charged with *more* than the full amount of their expenditure on sick pay.

In the simulations reported in Table 3, a private system with optimally chosen ρ^o and $\tau = 1$ dominates a public system with optimal uniform replacement rates; the welfare gain amounts to 0.8 percent of consumption. More substantial welfare gains are obtained by also differentiating between ρ^u and ρ^n. The increase in welfare relative to the reference case amounts to 1.6 percent of consumption. Note that the rankings of the optimal nonwork replacement rates are $\rho^u > \rho^s > \rho^n$. There is a case for a relatively generous unemployment compensation since it provides incentives to substitute active search for inactive nonparticipation Of course, this type of differentiation presumes that monitoring of job search is feasible, at least to some degree.[15]

5 Concluding Remarks

The paper has offered a general equilibrium framework suitable for analyzing absenteeism along with employment, unemployment and nonparticipation. Welfare policy interdependencies arises naturally in the model and can be analyzed in a unified and coherent fashion. It comes as no surprise that nonemployment benefits have adverse employment effects, but it is less obvious that the propensity to be present at work also declines. Higher sickness benefits for employed workers result in higher absenteeism, as should be expected. However, such policies will also generally affect labor market tightness, wages and employment. The details of the adjustments to policy changes can sometimes be determined analytically, but sometimes only numerically. The need for "complementary calibrations" is pertinent in our model as in other general equilibrium models of the labor market. However, the credibility of the numerical exercises could be much improved if we had access to better empirical knowledge about some key parameters.

In light of this, there is a need for more empirical work on the determinants of sickness absence at the individual level. Although such research has

[15] The optimality of $\rho^u > \rho^n$ can be shown to hold analytically in a simplified version of the model with exogenous tightness and wages; see Holmlund (2005).

been on the rise in recent years, the area is less well developed than research on transitions between unemployment and employment. Better empirical knowledge about individual responsiveness to changes of sick pay, or other parameters of the sickness insurance system, is crucial for the design of policy. We also need a better understanding of firms' behavior in this area, including knowledge of how firms respond to alternative financing schemes. In European policy discussions, experience rating of sickness insurance has sometimes been suggested as a means to encourage firms to offer better workplaces with lower absenteeism. Skeptics have noted that policies that make absenteeism more costly to firms are likely to induce them to discriminate against more sickness-prone individuals in their hiring decisions. To our knowledge, there is so far very little relevant knowledge available that can be used for policy evaluation and policy guidance in this area.

Appendix A. Value Functions

Time is discrete and future sickness status is uncertain. Tomorrow is another day and each morning involves a draw from the distribution $F(\xi)$. Let $P(\xi)$ denote the expected present value of being present at work, $S(\xi)$ the value of being on sick leave, $U(\xi)$ the value of being unemployed, and $N(\xi)$ the value of being a nonparticipant. These present values are computed after a particular realization of ξ and involves optimal behavior with respect to future shocks. The value functions are written as follows:

$$\begin{aligned} P(\xi) &= [\ln w - a\xi + \int_0^\infty \phi^p \{\max[U(x), N(x)]\} dF(x) \\ &\quad + \int_0^\infty (1-\phi^p)\{\max[P(x), S(x)]\} dF(x)] \frac{1}{1+r} \end{aligned} \tag{A1}$$

$$\begin{aligned} S(\xi) &= [\ln \rho^s w - \xi + \int_0^\infty \phi^s \{\max[U(x), N(x)]\} dF(x) \\ &\quad + \int_0^\infty (1-\phi^s)\{\max[P(x), S(x)]\} dF(x)] \frac{1}{1+r} \end{aligned} \tag{A2}$$

$$\begin{aligned} U(\xi) &= [\ln \rho^u w - a\xi + \int_0^\infty \alpha(\theta) \{\max[P(x), S(x)]\} dF(x) \\ &\quad + \int_0^\infty (1-\alpha(\theta))\{\max[U(x), N(x)]\} dF(x)] \frac{1}{1+r} \end{aligned} \tag{A3}$$

$$N(\xi) = [\ln \rho^n w - \xi + \int_0^\infty \{\max[U(x), N(x)]\} dF(x)] \frac{1}{1+r} \tag{A4}$$

The present value of being employed and working involves a flow return given by $\ln w - a\xi$ as well as changes in utility caused by sickness and labor market shocks. The probability of job loss is ϕ^p and the probability of retaining the job is $1 - \phi^p$. If the worker loses the job he decides whether to choose unemployment or nonparticipation, i.e., he takes $\max[U(x), N(x)]$. If the job is retained the choice is between work and sick leave and the worker thus takes $\max[P(x), S(x)]$. End-of-period discounting is applied at the rate $r > 0$. Analogous interpretations hold for the other value functions. Note from (A3) and (A4) that job finding takes place only when unemployed; we have thus ignored transitions from nonparticipation to employment.

The decision rules are such that sufficiently serious sickness makes the worker more inclined to prefer inactivity to activity, i.e., sick-leave is preferred to work and nonparticipation is preferred to unemployment. Consider an individual at work who observes a new value of ξ and decides to remain at work as long as ξ does not exceed a critical value, Q. That is, work is chosen for $\xi \leq Q$ and sickness absence for $\xi > Q$. Analogous rules apply to nonemployed individuals. Let R denote the critical value of sickness for a nonemployed person. Search unemployment is chosen for $\xi \leq R$ and nonparticipation for $\xi > R$. A reservation sickness strategy is optimal for the employed worker when $P(\xi) \geq S(\xi)$ for $\xi \leq Q$, and $P(\xi) < S(\xi)$ for $\xi > Q$. Note that both $P(\cdot)$ and $S(\cdot)$ are decreasing in ξ, with $P'(\xi) < S'(\xi)$:

$$P'(\xi) = -\frac{a}{1+r}, \qquad S'(\xi) = -\frac{1}{1+r}$$

which guarantees the optimality of the reservation sickness rule since $a > 1$. For a nonemployed person, the optimality of the reservation sickness rule requires that $U(\xi) \geq N(\xi)$ for $\xi \leq R$, and $U(\xi) < N(\xi)$ for $\xi > R$. $U(\cdot)$ and $N(\cdot)$ are both decreasing in ξ, with slopes:

$$U'(\xi) = -\frac{a}{1+r}, \qquad N'(\xi) = -\frac{1}{1+r}$$

so the inequality $U'(\xi) < N'(\xi)$ holds.

The reservation sickness conditions imply that we can define the following maximum value functions for employment and nonemployment:

$$M^e \equiv \int_0^Q P(x)dF(x) + \int_Q^\infty S(x)dF(x) \tag{A5}$$

$$M^o \equiv \int_0^R U(x)dF(x) + \int_R^\infty N(x)dF(x) \tag{A6}$$

where M^e pertains to employment (work and sick leave) and M^o to nonemployment (unemployment and nonparticipation). M^e and M^o are ex ante expected present values of employment and nonemployment in the sense that they correspond to present values before the veil of ignorance concerning ξ is lifted, given that optimal decision rules are followed in the future. The reservation sickness conditions, given by eqs. (6) and (7) in the main text, are obtained by imposing the indifference condition $P(Q) = S(Q)$ for the employed worker and the analogous condition $U(R) = N(R)$ for a worker who is not employed. The maximum value functions can be written as conventional asset value equations, as given by eqs. (2) and (3) in the text.

Appendix B: Uniqueness with Endogenous Sick Pay

The three equations that determine ρ^s, w_c and θ are:

$$\Gamma(\rho^s, w_c) \equiv \tau\rho^s - \frac{F(Q) - \left(\frac{y}{w_c} - 1\right)\varepsilon^s}{F(Q) + \varepsilon^s} = 0 \tag{B1}$$

$$Z(w_c, \rho^s, \theta) \equiv F(Q)(y - w_c) - \tau[1 - F(Q)]\rho^s w_c - \frac{\kappa y \phi}{q(\theta)} = 0 \tag{B2}$$

$$\hat{W}(\rho^s, \theta) \equiv \frac{\tilde{v}^e - \tilde{v}^o}{\phi + \tilde{\alpha}(\theta, R)} - \left(\frac{\eta}{1-\eta}\right)\left[\frac{\kappa}{F(Q)q(\theta) - \kappa\phi}\right] = 0 \tag{B3}$$

where $Q = Q(\rho^s)$. Our strategy is to substitute out w_c so as to get a system with two equations that determine ρ^s and θ. First, use (B1) and (B2) to get a "zero profit contract curve" of the form:

$$\tilde{\Gamma}(\theta, \rho^s) \equiv [F(Q) + \varepsilon^s](1 - \tau\rho^s) - \frac{F(Q) + \tau[1 - F(Q)]\rho^s}{F(Q) - \frac{\kappa\phi}{q(\theta)}}\varepsilon^s = 0 \tag{B4}$$

where $\tilde{\Gamma}_\theta < 0$ and $\tilde{\Gamma}_{\rho^s} < 0$. As a second step, use (B3) in conjunction with (B4) to get a "modified wage equation" of the form:

$$\tilde{W}(\theta, \rho^s) \equiv \frac{\tilde{v}^e - \tilde{v}^o}{\phi + \tilde{\alpha}(\theta, R)} - \left(\frac{\eta}{1-\eta}\right)\left[\frac{\kappa(F(Q) + \varepsilon^s)}{\left(F(Q) + \frac{\tau\rho^s}{1-\tau\rho^s}\right)\varepsilon^s q(\theta)}\right] = 0 \tag{B5}$$

where $\tilde{W}_\theta < 0$ and $\tilde{W}_{\rho^s} \gtreqless 0$.

Lemma 7 in the main text can be proved by establishing that the following inequality holds:

$$\left(\frac{\partial\theta}{\partial\rho^s}\right)_{\tilde{\Gamma}} < \left(\frac{\partial\theta}{\partial\rho^s}\right)_{\tilde{W}} \tag{B6}$$

where $(\partial\theta/\partial\rho^s)_{\tilde{\Gamma}} = -\left(\tilde{\Gamma}_{\rho^s}/\tilde{\Gamma}_\theta\right) < 0$ and $(\partial\theta/\partial\rho^s)_{\tilde{W}} = -\left(\tilde{W}_{\rho^s}/\tilde{W}_\theta\right) \gtreqless 0$. After some tedious calculations it can be shown that this inequality does indeed hold; the details are available on request. In graphical terms, the slope of $\tilde{\Gamma}(\theta, \rho^s)$ is more negative in the θ, ρ^s-space than the slope of $\tilde{W}(\theta, \rho^s)$; as noted, the slope of $\tilde{W}(\theta, \rho^s)$ can take either sign.

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