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Harsh occupations, health status and social security

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Abstract

We study the optimal design of a social security system when individuals differ in health status and occupation. Health status is private information but is imperfectly correlated with occupation: individuals in harsh occupations are more likely to be in poor health. We explore the desirability of letting the social security policy differ by occupation and compare the results with those obtained when disability tests are used instead. We show that tagging by occupation is preferable to testing when the audit technology is relatively expensive and/or the proportion of disabled workers differs markedly across occupations. We also study the implications of imposing horizontal equity among disabled workers and show that those in the harsh occupation may be induced to retire later.

Keywords: health status, retirement age, tagging, disability tests.

JEL classification: H21, H55

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1 Introduction

Social security systems are under increased fiscal pressure, in particular due to the impact of population ageing on pension systems. Some authors have also highlighted the trend to earlier retirement, which is particularly striking in many developed countries. As pointed in Cremer et al. (2004), around 70% of men aged 60-64 remained in the workforce in the 1960s while nowadays in many countries, such as Belgium, France, Italy and the Netherlands, the percentage of men aged 60-64 still working is about 20%.

Individuals may have genuine reasons to retire early. A poor health status is an obvious one. Indeed, according to Lumsdaine and Mitchell (1999), the empirical literature has shown that poor health plays an important role in older workers' labor supply decisions. In this paper we explore the role of health status in the context of an on-going public debate on whether special pension provisions, such as early retirement, should be offered to workers in hazardous or arduous jobs. Such provisions are historically rooted in the idea that people who work in hazardous or arduous jobs deserve special treatment because this type of work is likely to impact negatively on the health of workers, and may even lead to premature mortality. Zaidi and Whitehouse (2009) discusses the incidence, structure and justification of these special pension schemes in OECD countries. They argue that, with the exception of some narrowly defined jobs that would still qualify for a special treatment, in general there is a weak case for either maintaining or introducing these special pension schemes. They contend that in cases where such work-related health risks can be recognised, they can be better dealt with some alternative, better targeted, social policies. For instance, they suggest that those whose health is compromised due to work experiences of the past can continue to receive a special treatment, but on individualised bases, with the help of more conventional disability pensions policies, through work-related sickness benefits or, preferably, some combination of work and benefits.

If it was possible to perfectly observe the individual's health status early retirement could be targeted to workers in poor health. Unfortunately, it is not always possible to perfectly observe the health status. Governments often rely on disability tests before allowing a worker to retire early. However, even ignoring possible errors, performing these disability tests is costly. Alternatively governments can use existing statistical information about the relationship between health status and occupation and provide special benefits to workers in occupations that are considered harsh, on the basis that working in these occupations leads on average to poorer health status (i.e. the special pension provisions mentioned above). Granting early retirement to an array of hazardous occupations is however not without cost, particularly in a dynamic setting as it may be politically delicate to abandon special treatments when formerly harsh occupations turn to be less demanding.[1] Special pension provisions can also be considered inequitable, particularly when there are workers in poor and good health in both occupations: two workers with the same underlying health status are likely to be treated differently just because they have different occupations.

In this paper we explore in some detail the choice between special pension provisions and disability tests. To analyze this issue we adopt a simple setting with two occupations and two levels of health status. All individuals have the same productivity but those in the harsh occupation face a higher probability of being in poor health than those who have a safe occupation. The health status is private information but the occupation is observable and can be used as a tag (i.e. the social security system is allowed to differ by occupation). We characterize the optimal social security policy by occupation and compare the results with those obtained using disability tests instead. We perform numerical simulations to identify the circumstances under which tagging outperforms testing: when the audit technology is particularly expensive and/or the distributions of healthy and unhealthy individuals in the two occupations differ markedly. We also explore the implications of imposing horizontal equity among disabled workers to ensure that the disabled workers in the safe occupation are not made worse-off by tagging than the disabled workers in the harsh occupation.

The paper is organised as follows. In Section 2 we present the model and obtain the laissez-faire solution. In section 3 we derive the first-best benchmark solution. In section 4 we analyze the second-best asymmetric information problem without tagging (i.e. when the policy does not differ by occupation), without and with disability tests. We also explore the second-best asymmetric

[1] Debrand and Lengagne (2008) point out that primary sector jobs - which are often associated with heavy physical workloads - are becoming rarer. Despite this, physical risks at work, as well as psychological problems, are increasing. Stressful work appears to be responsible for a growing number of work-related health problems. They argue that this may be linked to new forms of work organization and study the links between quality of employment and the health of older workers, using the Share 2004 survey. Their results suggest that lack of support at work and feeling of job insecurity are two key factors afecting the health status of older workers.

information problem with tagging (i.e. when the social security policy is allowed to differ by occupation). We perform numerical simulations in section 5 to shed more light on the results. We conclude in section 6.

2 The model

We consider a society in which individuals differ in health status and occupation. The health status, represented by h_i, is private information.[2] We assume that individuals can be either in good or in poor health: $h_H > h_D$, where H and D stand for healthy and disabled, respectively.[3] The occupation, represented by subscript $j = 1, 2$, is observable. n_j stands for the proportion of workers in occupation j and p_j for the proportion of workers in occupation j that are disabled. We assume that $p_1 > p_2$. Accordingly, we refer to occupation 1 as harsh and occupation 2 as safe. We assume that both occupations yield the same wage w.[4]

We have hence four types of individuals ij with preferences represented by the following utility function:[5]

$$U_{ij} = u(c_{ij}) - v(z_{ij}; h_i) \tag{1}$$

where c represents lifetime consumption and z represents the retirement age. The utility of consumption function $u(.)$ is assumed to be strictly increasing and concave (i.e. $u'(.) > 0$ and

[2] We assume that the individual learns her health status in the first years of employment.

[3] In the following we denote the individuals in good and poor health as healthy and disabled, respectively, for convenience.

[4] By assuming equal wages we do not focus on the standard redistribution one expects from healthy well-paid individuals to disabled poor ones. Note also that we do not endogeneize in this paper the choice of occupation. We take it as given, which is consistent with e.g. assuming a segmented labour market. Endogenous occupational choice and differential wages will be considered in further research.

[5] This reduced-form utility function can be derived from an individual intertemporal problem as in Cremer et al. (2004, 2007). Consider an individual with wage w and health status h dividing his lifetime with duration normalized to one into a period of full activity and a period of retirement. Assume that utility is additively separable between consumption and effort, that there are no liquidity constraints and that both the interest rate and the time discount rate are zero. Lifetime utility can be written as $U = \int_0^1 u(c(t))\,dt - \int_0^z v(t;h)\,dt$ where $c(t)$ is instantaneous consumption, $u(.)$ is a strictly increasing and concave instantaneous utility function, z ($z \leq 1$) is the age of retirement and $v(t)$ denotes an increasing function effort disutility, which is assumed to depend on the health status of the individual. The budget constraint in the absence of a social security policy is given by $\int_0^1 c(t)\,dt = \int_0^z w dt$. Separability, concavity of the instantaneous utility functions, perfect capital markets and certain lifetimes imply that consumption is perfectly smoothed. If c represents lifetime consumption (also instantaneous consumption since lifetime duration is normalized to one) the lifetime utility can be rewritten as $U = u(c) - v(z;h)$ where $v(z;h) = \int_0^z v(t;h)\,dt$ represents the disutility of prolonging activity, which is an increasing and convex function of retirement age z and depends on the health status of the individual We use this reduced form for utility throughout the paper.

$u''(.) < 0$). The disutility of prolonging activity function $v(.)$ is assumed to be increasing and convex (i.e. $v'(.) > 0$ and $v''(.) > 0$). We also assume that the disutility of prolonging activity depends on the health status of individuals h_i and, in particular, that the marginal disutility of working longer is higher for disable individuals: $v'(z; h_D) > v'(z; h_H)$ for all z.[6] The marginal rate of substitution is given by

$$MRS_{zc}^{ij} = \frac{v'(z_{ij}; h_i)}{u'(c_{ij})}. \tag{2}$$

At a given allocation in the $(z, c)-$space the indifference curve of the disabled individuals are steeper.

The disability/retirement social security policy is a combination of consumption and retirement age (c_{ij}, z_{ij}). This social security policy can be implemented by a payroll tax, τ, and pension benefits that depend on retirement age, $b(z_{ij})$, and can be represented by a non-linear tax function:

$$T(z_{ij}) = \tau w z_{ij} - (1 - z_{ij}) b(z_{ij}). \tag{3}$$

Differentiating $T(z_{ij})$ with respect to z_{ij} yields the marginal tax on prolonging work (i.e. postponing retirement):

$$T'(z_{ij}) = \tau w + b(z_{ij}) - (1 - z_{ij}) b'(z_{ij}). \tag{4}$$

This expression shows a trade-off between the cost of delaying retirement, given by the extra contributions τw and the foregone pension $b(z_{ij})$, and the increase in benefits $b'(z_{ij})$ during the period of retirement z_{ij}.

The consumer ij's problem under a non-linear function $T(z_{ij})$ can be written as

$$\max_{z_{ij}} u[w z_{ij} - T(z_{ij})] - v(z_{ij}; h_i).$$

The first-order condition (hereafter FOC) yields

$$T'(z_{ij}) = w - \frac{v'(z_{ij}; h_i)}{u'(c_{ij})}. \tag{5}$$

A non-zero marginal tax implies a wedge between the marginal rate of substitution between work and consumption and the marginal productivity of labour. When the marginal tax is non-zero

[6] Note that the utility for consumption is independent of health status.

the pension system is hence not actuarially neutral at the margin, following the terminology from Cremer et al. (2007).[7]

In a market economy, each individual chooses c_{ij} and z_{ij} to maximize (1) subject to the budget constraint $c_{ij} = wz_{ij}$. The FOC for each individual ij, with $i = D, H; j = 1, 2$, is $u'(c_{ij})w = v'(z_{ij}; h)$ with $c_{ij} = wz_{ij}$. Accordingly, in the laissez-faire the indifference curves of individuals with health status h_i are tangent to w in the (z, c) −space:

$$MRS_{zc}^{ij} = \frac{v'(z_{ij}; h_i)}{u'(c_{ij})} = w. \tag{6}$$

Since $v'(z; h_D) > v'(z; h_H)$ individuals with different health status achieve different combinations of lifetime consumption and retirement age. In particular, disabled individuals work and consume less than healthy ones.

3 The first best

If the social planner was able to observe the health status of individuals it would maximize the social objective subject only to the resource constraint. With a utilitarian social objective the first-best problem can be represented by the following Lagrangian:

$$\begin{aligned} L &= \sum_{j=1,2} n_j \left[(1-p_j) \left(u(c_{Hj}) - v(z_{Hj}; h_H) \right) + p_j \left(u(c_{Dj}) - v(z_{Dj}; h_D) \right) \right] + \\ &\quad + \mu \sum_{j=1,2} n_j \left[w \left((1-p_j) z_{Hj} + p_j z_{Di} \right) - \left((1-p_j) c_{Hj} + p_j c_{Dj} \right) \right] \end{aligned}$$

where μ is the Langrange multiplier associated with the resource constraint.

The FOCs with respect to c_{ij} and z_{ij} are $u'(c_{ij}) = \mu$ and $v'(z_{ij}; h_i) = \mu w, \forall i, j$, respectively. Lifetime consumption is the same for all individuals regardless of occupation or health status: $c_H = c_D = c$. The retirement age does not depend on occupation but depends on health status with $z_D < z_H$: disabled individuals retire earlier. To decentralize the full information solution lump-sum transfers from healthy to disabled individuals are sufficient and it is not necessary to distort the retirement choice of any individual since, rearranging the FOCs:

$$\frac{v'(z_{ij}; h_i)}{u'(c_{ij})} = w, \tag{7}$$

[7] Cremer et al. (2007) use the term "actuarial neutrality" regarding retirement to draw a distinction from marginal or average fairness regarding the relation between contribution and benefit.

which implies $T'(z_{ij}) = 0$ for all ij (i.e. the pension system is actuarially neutral at the margin).

If health status is otherwise not observable the first-best solution described above is not feasible. This is so because healthy individuals would be better off by retiring at the lower retirement age designed for disabled ones:

$$u(c_D) - v(z_D; h_H) > u(c_H) - v(z_H; h_H) \text{ since } z_D < z_H.$$

4 The second best

When health status is not observable the social planner has to take into consideration the incentives provided by the policy to induce individuals to reveal their true health status. In this section we compare alternative second-best policies. We present first the second-best benchmark solution in which the social security policy is not allowed to differ by occupation. We then explore the alternative approaches of using disability tests or allowing the social security policy to differ by occupation instead.

4.1 Same social security policy across occupations

When health status is private information, the social planner needs to ensure that healthy individuals do not have incentives to mimic disabled ones. The second best problem is represented by the following Lagrangian:

$$\begin{aligned}\pounds &= \sum_{j=1,2} n_j \left[(1-p_j)\left(u(c_H) - v(z_H; h_H)\right) + p_j\left(u(c_D) - v(z_D; h_D)\right)\right] \\ &\quad + \mu \sum_{j=1,2} n_j \left[w\left((1-p_j) z_H + p_j z_D\right) - \left((1-p_j) c_H + p_j c_D\right)\right] \\ &\quad + \lambda \left[u(c_H) - v(z_H; h_H) - u(c_D) + v(z_D; h_H)\right]\end{aligned}$$

where λ represents the Lagrangian multiplier associated with the self-selection constraint that is incorporated to ensure that healthy individuals do not have incentives to mimic disabled ones.

Rearranging the FOCs from the above problem we obtain:

$$u'(c_H) = \frac{\mu}{1 + \frac{\lambda}{n_1(1-p_1)+n_2(1-p_2)}}, \tag{8}$$

$$\frac{v'(z_H; h_H)}{u'(c_H)} = w, \tag{9}$$

for the healthy workers, and

$$u'(c_D) = \frac{\mu}{1 - \frac{\lambda}{n_1 p_1 + n_2 p_2}}, \tag{10}$$

$$\frac{v'(z_D; h_D)}{u'(c_D)} = w - \frac{\lambda}{n_1 p_1 + n_2 p_2} \left[w - \frac{v'(z_D; h_H)}{u'(c_D)} \right] < w, \tag{11}$$

for the disabled workers. Hence, $c_H > c_D$, $T'(z_H) = 0$ and $T'(z_D) > 0$. The pension policy is actuarially neutral for healthy workers. Disabled individuals obtain a lower lifetime consumption than healthy ones and their decision to retire is distorted at the margin, towards earlier retirement. The downward distortion in z_D is justified by incentive arguments. Healthy individuals have flatter indifference curves at any given point in the (z, c) −space than disabled ones because the marginal disutility of prolonging activity is smaller. By inducing disabled individuals to retire earlier it is possible to relax an otherwise binding self-selection constraint and extend the amount of redistribution that takes place from healthy to disabled individuals.

4.2 Disability tests

The implicit tax on prolonging activity imposed on disabled individuals in the second best problem above stems from the asymmetry of information regarding the health status. A way to address up to some extent the lack of information on health status is to introduce audits. If bad health is considered a form of disability, disability tests can be conducted to prevent healthy workers from claiming undeserved benefits. Cremer et al. (2007) explores the use of disability tests designed to discourage healthy individuals from claiming to be disabled. They incorporate a particular type of audit that is costly but error-proof. Any individual claiming to be disabled is audited with probability π. This audit is perfect and has a total cost $k(n_D \pi)$, where n_D stands for the proportion of disabled individuals in the society ($n_1 p_1 + n_2 p_2$ in our case). If it is found that the individual is healthy rather than disabled, the individual is allocated a minimum utility $\underline{u}$.

Audits affect both the resource constraint and the self-selection constraint:

$$\sum_{j=1,2} n_j \left[w\left((1 - p_j) z_H + p_j z_D \right) - \left((1 - p_j) c_H + p_j c_D \right) \right] - k\left((n_1 p_1 + n_2 p_2) \pi \right) \geq 0, \tag{12}$$

$$u(c_H) - v(z_H; h_H) > (1 - \pi) \left[u(c_D) - v(z_D; h_H) \right] + \pi \underline{u}. \tag{13}$$

Increasing the audit probability is costly but it enables to relax the incentive constraint by reducing the level of utility achievable by the mimicker. In the optimal solution a compromise is found between these two considerations. It is worth noting that if the audit was costless the central planner would use an audit probability that would make the self-selection constraint non binding and the first-best solution would be achieved without any distortion. When the cost of audit k increases, the audit has to be restricted to a decreasing number of individuals who claim to be disabled. The distortion on the choice of the retirement age increases with the cost of the audit. If the audit was too costly we would then approach the second-best problem studied above.

The second-best problem with disability tests is represented in our case by the following Lagrangian:

$$\begin{aligned} \pounds &= \sum_{j=1,2} n_j \left[(1-p_j)\left(u(c_H)-v(z_H;h_H)\right)+p_j\left(u(c_D)-v(z_D;h_D)\right)\right]+ \\ &\quad +\mu \sum_{j=1,2} n_j \left[w\left((1-p_j)\,z_H+p_j z_D\right)-\left((1-p_j)\,c_H+p_j c_D\right)\right]-k\left(\left(n_1p_1+n_2p_2\right)\pi\right)+ \\ &\quad +\lambda\left[u(c_H)-v(z_H;h_H)-(1-\pi)\left[u(c_D)-v(z_D;h_H)\right]-\pi\underline{u}\right] \end{aligned}$$

Rearranging the FOCs from the above problem we obtain:

$$u'(c_H)=\frac{\mu}{1+\frac{\lambda}{n_1(1-p_1)+n_2(1-p_2)}}, \tag{14}$$

$$\frac{v'(z_H;h_H)}{u'(c_H)}=w, \tag{15}$$

for the healthy workers, and

$$u'(c_D)=\frac{\mu}{1-\frac{\lambda}{n_1p_1+n_2p_2}(1-\pi)}, \tag{16}$$

$$\frac{v'(z_D;h_D)}{u'(c_D)}=w-\frac{\lambda}{n_1p_1+n_2p_2}(1-\pi)\left[w-\frac{v'(z_D;h_H)}{u'(c_D)}\right], \tag{17}$$

for the disabled workers. A higher π involves a smaller distortion at the margin on z_D.

To determine the optimal level of π we have to use the first-order condition with respect to π, which can be rewritten:

$$\lambda\left[u(c_D)-v(z_D;h_H)-\underline{u}\right]\leq\mu\left[n_1p_1+n_2p_2\right]k'\left(\left(n_1p_1+n_2p_2\right)\pi\right). \tag{18}$$

The determination of π depends on the trade-off between the costs of increasing the audit probability, given by $\mu [n_1 p_1 + n_2 p_2] k' ((n_1 p_1 + n_2 p_2) \pi)$, and the benefits derived from a relaxed incentive compatibility constraint. The latter depend on the utility gap between not being and being caught lying. The optimal π depends on the audit costs: higher costs involve lower π, and viceversa. Note, however, that auditing with probability 1 is never optimal, which is a standard result in auditing models. If $\pi = 1$, the self-selection constraint is satisfied with strict inequality and $\lambda = 0$, which would imply that the derivative is negative. If incentive constraints are satisfied with strict inequality, they continue to be satisfied when the audit probability is slightly reduced.

4.3 Tagging by occupation

We have just seen that the self-selection constraint that links healthy and disabled individuals can be relaxed at the expense of introducing costly audits. We explore now an alternative second-best solution that seeks to exploit the differences in distributions of healthy and disabled workers by occupation.[8] In particular we investigate whether, and if so how, the social security policy should differ by occupation. The main distinction with respect to the second-best benchmark in which the social planner employs a single social security policy regardless of occupation is that now there is one self-selection constraint for each occupation:

$$\begin{aligned}
\pounds \quad = \quad & \sum_{j=1,2} n_j \left[(1-p_j) \left(u(c_{Hj}) - v(z_{Hj}; h_H) \right) + p_j \left(u(c_{Dj}) - v(z_{Dj}; h_D) \right) \right] + \\
& + \mu \sum_{j=1,2} n_j \left[w \left((1-p_j) z_{Hj} + p_j z_{Di} \right) - \left((1-p_j) c_{Hj} + p_j c_{Dj} \right) \right] + \\
& + \lambda_1 \left[u(c_{H1}) - v(z_{H1}; h_H) - u(c_{D1}) + v(z_{D1}; h_H) \right] + \\
& + \lambda_2 \left[u(c_{H2}) - v(z_{H2}; h_H) - u(c_{D2}) + v(z_{D2}; h_H) \right]
\end{aligned}$$

where λ_j is the Lagrange multiplier associated the self-selection constraint that ensures that healthy individuals do not have incentives to mimic disabled ones in occupation j.

[8] We assume that the government uses existing statistical information about the relationship between health status and occupation, and that this information does not rely on disability tests being performed. Many households surveys contain information about occupation and health status. This is for instance the case of the Survey on Health Ageing and Retirement in Europe (Börsch-Supan et al., 2005), commonly known as *Share*. It would be worth considering in further research the possibility and implications of employing the outcomes from disability tests, if they are performed, to update the statistical relationship between health status and ocupation that is used for tagging purposes. We thank Kieron Meagher and Rohan Pitchford for this suggestion.

Rearranging the FOCs we obtain, for healthy workers in occupation j:

$$u'(c_{Hj}) = \frac{\mu}{1 + \dfrac{\lambda_j}{n_j(1-p_j)}}, \tag{19}$$

$$v'(z_{Hj}; h_H) = \frac{\mu w}{1 + \dfrac{\lambda_j}{n_j(1-p_j)}}. \tag{20}$$

There is hence no distortion at the margin for healthy individuals: $T'(z_{Hj}) = 0$ in all occupations j. However, this does not mean that healthy individuals in different occupations receive the same social security policy treatment, given by the combination of lifetime consumption and retirement age, nor achieve the same utility level. If there is a larger proportion of individuals in poor health in occupation 1 (hence, a smaller proportion of healthy individuals in the harsh occupation) there is a tendency to increase benefits and decrease retirement age for healthy individuals in the harsh occupation. Healthy workers in the harsh occupation would in those cases benefit from being mixed with a large proportion of disabled ones. The precise relationship between the social policy that applies to healthy individuals in different occupations depends on the value of the Lagrange multipliers for which we do not have closed-form solutions with the general functional forms assumed. However, in the cases where $c_{H1} > c_{H2}$ then $z_{H1} < z_{H2}$ and $U_{H1} > U_{H2}$.

For disabled workers in occupation j we obtain:

$$u'(c_{Dj}) = \frac{\mu}{1 - \frac{\lambda_j}{n_j p_j}}, \tag{21}$$

$$\frac{v'(z_{Dj}; h_D)}{u'(c_{Dj})} = w - \frac{\lambda_j}{n_j p_j}\left(w - \frac{v'(z_{Dj}; h_H)}{u'(c_{Dj})}\right) < w. \tag{22}$$

Disabled workers consume less than healthy workers with the same occupation - i.e. $c_{Dj} < c_{Hj}$ - and are distorted at the margin - i.e. $T'(z_{Dj}) > 0$ - in both occupations j. The extent to which the consumption of healthy and disabled workers differ, as well as the extent to which retirement of disabled workers is distorted at the margin, may however vary by occupation.

4.3.1 3-types societies

In order to shed more light on the results we concentrate next on 3-types societies, of the kind Akerlof (1978) first analyzed, in which one of the groups contains individuals of a single type.

Given that $p_1 > p_2$ there are only two possible 3-types societies to consider: either $p_2 = 0$ (i.e. all workers in the safe occupation are healthy - in this case there are both healthy and disabled workers in the harsh occupation) or $p_1 = 1$ (i.e. all workers in the harsh occupation are disabled - in this case there are both healthy and disabled workers in the safe occupation).

If all workers in the safe occupation are healthy the only relevant self-selection is the one linking healthy and disabled workers in the harsh occupation. We obtain:

$$u'(c_{D1}) = \frac{\mu}{1 - \frac{\lambda_1}{n_1 p_1}}, \tag{23}$$

$$u'(c_{H1}) = \frac{\mu}{1 + \frac{\lambda_1}{n_1(1-p_1)}}, \tag{24}$$

$$u'(c_{H2}) = \mu, \tag{25}$$

which implies $c_{D1} < c_{H2} < c_{H1}$. As before we obtain non-distortion on healthy workers in both occupations $T'(z_{H2}) = T'(z_{H1}) = 0$ and $T'(z_{D1}) > 0$. Also $c_{H1} > c_{H2}$ and $z_{H1} < z_{H2}$ imply that $U_{H1} > U_{H2}$.

If all workers in the harsh occupation are disabled the only relevant self-selection is the one linking healthy and disabled workers in the safe occupation. We obtain:

$$u'(c_{D1}) = \mu, \tag{26}$$

$$u'(c_{D2}) = \frac{\mu}{1 - \frac{\lambda_2}{n_2 p_2}}, \tag{27}$$

$$u'(c_{H2}) = \frac{\mu}{1 + \frac{\lambda_2}{n_2(1-p_2)}}, \tag{28}$$

which implies $c_{D2} < c_{D1} < c_{H2}$. No distortion is imposed on healthy workers in the safe occupation, $T'(z_{H2}) = 0$, or on workers in the harsh occupation, who are all disabled, $T'(z_{D1}) = 0$. On the other hand disabled individuals in the safe occupation are distorted at the margin $T'(z_{D2}) > 0$. $c_{D1} > c_{D2}$ and $z_{D1} < z_{D2}$ imply that $U_{D1} > U_{D2}$. The workers in the harsh occupation, who can be readily identified as disabled, are made better off than the disabled workers in the safe occupation, who are mixed with healthier workers.

4.3.2 Horizontal equity among disabled workers

If the distribution of health status by occupation differs conditioning the social security policy on occupation increases social welfare. This result from tagging literature is well known since the seminal paper by Akerlof (1978). However, Akerlof (1978) also noted that for certain social objectives tagging might violate the principle of horizontal equity. In our case, individuals with the same health status may achieve different utility levels because they belong to different occupations. We have just showed this is the case in the 3-types societies above. Other such examples may arise more generally when there are both healthy and disabled workers in both occupations but the ratio of disabled to healthy workers differs by occupation. This horizontal inequity result is one of the aspects of tagging that has received more criticism. We address this criticism below, up to some extent, by ensuring that the worse-off workers in the safe occupation are not made worse off by tagging than the worse-off workers in the harsh occupation.[9]

$$\begin{aligned}
\pounds &= \sum_{j=1,2} n_j \left[(1-p_j)\left(u(c_{Hj}) - v(z_{Hj};h_H)\right) + p_j\left(u(c_{Dj}) - v(z_{Dj};h_D)\right)\right] + \\
&+\mu \sum_{j=1,2} n_j \left[w\left((1-p_j)\, z_{Hj} + p_j z_{Di}\right) - \left((1-p_j)\, c_{Hj} + p_j c_{Dj}\right)\right] + \\
&+\lambda_1 \left[u(c_{H1}) - v(z_{H1};h_H) - u(c_{D1}) + v(z_{D1};h_H)\right] + \\
&+\lambda_2 \left[u(c_{H2}) - v(z_{H2};h_H) - u(c_{D2}) + v(z_{D2};h_H)\right] + \\
&+\gamma \left[u(c_{D2}) - v(z_{D2};h_D) - u(c_{D1}) + v(z_{D1};h_D)\right],
\end{aligned}$$

where γ represents the Lagrange multiplier associated the additional constraint that ensures that disabled workers in the safe occupation are not made worse than disabled workers in the harsh occupation.

For healthy workers in occupation j we obtain, as before:

$$u'(c_{Hj}) = \frac{\mu}{1 + \dfrac{\lambda_j}{n_j(1-p_j)}} \text{ and } v'(z_{Hj};h_H) = \frac{\mu w}{1 + \dfrac{\lambda_j}{n_j(1-p_j)}} \tag{29}$$

with $T'(z_{Hj}) = 0$. For disabled workers in occupation 1 we obtain:

$$u'(c_{D1}) = \frac{\mu}{1 - \frac{\lambda_1+\gamma}{n_1 p_1}} \text{ and } v'(z_{D1};h_D) = \frac{n_1 p_1 \mu w + \lambda_1 v'(z_{D1};h_H)}{n_1 p_1 - \gamma}, \tag{30}$$

[9] This is the simplest way of addressing the horizontal inequity that results at the bottom without fundamentally altering the social objective. By keeping the same social objective we are able to quantify in the numerical simulations the welfare loss that results from imposing horizontal equity among disabled. It is possible to show that the maximin objective also ensures horizontal equity among disabled individuals. Numerical solutions for the maximin objective are available from the authors upon request. When compared with the results in Table 4, distortions imposed on disabled individuals are larger, particularly for those in the safe occupation, all individuals consume less, healthy workers retire later (difference is more pronounced for those in the safe occupation) and are worse off, while disabled workers retire earlier (more so those in the safe occupation) and are better off.

whereas for disabled workers in occupation 2:

$$u'(c_{D2}) = \frac{\mu}{1 - \frac{\lambda_2 - \gamma}{n_2 p_2}} \text{ and } v'(z_{D2}; h_D) = \frac{n_2 p_2 \mu w + \lambda_2 v'(z_{D2}; h_H)}{n_2 p_2 - \gamma}, \tag{31}$$

with both disabled types being distorted at the margin, $T'(z_{Dj}) > 0$, albeit to different extents. It can be shown that all constraints bind. In particular, $\gamma > 0$ and $U_{D2} = U_{D1}$. This does not mean however that the disabled individuals in both occupations receive the same combination of lifetime consumption and retirement age. There may be cases in which the disabled workers in the safe occupation are allowed to retire earlier than disabled workers in the harsh occupation, but those working longer in the harsh occupation are compensated with extra consumption so as to achieve the same utility level as disabled workers in the safe occupation, who retire earlier.

Imposing horizontal equity at the bottom will however affect the level of social welfare that can be achieved, resulting in lower overall social welfare than that achieved when the utility levels of disabled individuals in different occupations are allowed to differ.

To better assess how the results differ for the different cases mentioned we perform some numerical simulations below. We show that the ratio of disabled to healthy workers by occupation plays a prominent role. We also quantify the welfare loss when horizontal equity among disabled is imposed.

5 Numerical illustration

The functional form we employ for the numerical simulation is:

$$U_{ij} = u(c_{ij}) - v(z_{ij}; h_i) = \ln c_{ij} - \frac{1}{h_i} \frac{z_{ij}^{\epsilon}}{\epsilon}. \tag{32}$$

We use $w = 100$ and $\varepsilon = 2$, as well as $h_H = 2/3$ and $h_D = 0.2$.[10] We assume $n_1 = n_2 = 1/2$ (i.e., the proportion of individuals working in each of the two occupations is the same) and focus on the role of varying the proportions p_i. We start from the benchmark case where $p_1 = p_2 = 1/2$ and

[10] These values are consistent with those employed for the disutility of prolonging activity in Cremer et al. (2007), which previously explored the role of disability tests. The setting is however slightly different. The purpose of their numerical illustration was to analyze the use of disability tests to separate leisure-prone from genuinely disabled individuals who display the same disutility of effort parameter. The aim of our illustration is however to compare the use of disability tests and tagging by occupation. Accordingly, the ratios of disabled to healthy workers in different occupations play a crucial role in our simulations. We vary these ratios to assess the role that alternative distributions play, whereas the proportions of individuals of different types was kept constant in their illustration.

	Second best	
Types	D	H
c	46.7991	75.9984
z	0.350761	0.877211
T'	0.179235	0
U	3.53828	3.75359
SW	3.64593	

Table 1: Second-best benchmark: same social security policy across occupations

$k(\pi)$	$2000\pi^2$		$1000\pi^2$		$100\pi^2$	
π	0.0129489		0.0244932		0.113179	
Types	D	H	D	H	D	H
c	47.960	75.191	49.027	74.4757	58.395	69.102
z	0.348	0.887	0.346	0.895	0.323	0.965
T'	0.165	0	0.152	0	0.0569	0
U	3.567	3.730	3.593	3.710	3.80638	3.5375
SW	3.64882		3.65140		3.67194	

Table 2: Second best with disability tests

explore the subsequently relevant cases where $p_1 > p_2$, when occupation 1 is effectively harsher than occupation 2, keeping the overall proportion of disabled individuals in the society however constant, so that the role of the different ratios of disabled to healthy workers by occupation is isolated from the role of the overall number of disabled individuals in the society.

We include in Table 1 the results for the second-best benchmark without tagging (i.e. when the planner is not allowed to differentiate the social security policy by occupation).[11]

We include in Table 2 the results for the second best with disability tests. As Cremer et al. (2007) we consider different audit technologies, from more expensive to cheaper ones. Not surprisingly the probability of audit, and the level of social welfare achieved, is larger for cheaper audit technologies. With cheaper audit technologies healthy individuals consume less and retire later than with more expensive technologies. Cheaper technologies allow the government to provide a higher utility level for disabled individuals, with a combination of higher lifetime consumption

[11] In the tables T' stands for the marginal tax rate on earnings from prolonging activity to enable relatively straightforward comparison, in terms of magnitude, with traditional optimal income taxes.

(p_1, p_2)	$(0.6, 0.4)$				$(0.7, 0.3)$			
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	50.180	78.679	43.650	73.532	53.783	81.573	40.743	71.281
z	0.344	0.847	0.356	0.907	0.335	0.817	0.359	0.935
T'	0.137	0	0.223	0	0.098	0	0.269	0
U	3.620	3.827	3.460	3.681	3.704	3.900	3.385	3.611
SW	3.64766				3.65281			
(p_1, p_2)	$(0.8, 0.2)$				$(0.9, 0.1)$			
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	57.600	84.675	38.085	69.248	61.620	87.981	35.685	67.430
z	0.3258	0.787	0.360	0.961	0.315	0.758	0.359	0.989
T'	0.062	0	0.314	0	0.029	0	0.359	0
U	3.788	3.974	3.316	3.543	3.873	4.047	3.252	3.478
SW	3.66124				3.67275			

Table 3: Tagging

and earlier retirement, with lower distortions at the margin, relative to allocations achieved when the technology is more expensive.

We include in Table 3 the second best results when tagging by occupation is possible. Note that the results in Table 2 above, with policies that do not take into account differences in distributions of healthy and disabled across occupations, hold for different distributions of the healthy and disabled individuals by occupation as long as the overall proportion of healthy and disabled individuals in the population remains the same.

Several interesting conclusions can be drawn from the previous tables. When compared with the second best in which the planner employs the same social security policy across occupations, tagging by occupation increases overall social welfare. The gains in social welfare of allowing the social planner to tag are more pronounced when the distribution of disabled versus healthy workers differs significantly by occupation. The comparison with disability testing is ambiguous in general but some relatively intuitive observations can be highlighted: if the audit technology available is relatively cheap ($k(\pi) = 100\pi^2$) and the difference in distributions across occupations is small ($p_1 = 0.6$ and $p_2 = 0.4$) disability testing implies a higher overall social welfare. As the distribution of disabled workers across the two occupations becomes more unequal and/or the audit technology becomes more expensive tagging by occupation becomes preferable.

The increases in overall social welfare when the social planner employs different social security policies by occupation are however obtained at the expense of significant horizontal inequity among individuals with the same health status but different occupation. In the simulation results in Table 3 healthy and disabled workers in the harsh occupation obtain a higher level of consumption and retire earlier than their counterparts in the safe occupation. That is, $c_{i1} > c_{i2}$, $z_{i1} < z_{i2}$ with $U_{i1} > U_{i2}$ for both $i = H, D$, with the utility achieved by both healthy and disabled workers in the harsh occupation being higher than the utility they would achieve if tagging was not possible. The healthy workers in the harsh occupation benefit from being mixed with a large proportion of disabled workers, whereas the healthy workers in the safe occupation are harmed. This effect is stronger when the proportion of disabled workers is relatively small in the safe occupation and relatively large in the harsh occupation. It is worth noticing that when the proportion of disabled workers in the harsh occupation approaches 1 the marginal tax imposed on the disabled worker in the harsh occupation tends to 0. This is consistent with the analytical result presented above of non-distortion on disabled workers in the harsh occupation when all workers in the harsh occupation are disabled.

We present in Table 4 a numerical illustration for the second best with tagging when the social planner is constrained by ensuring that horizontal equity holds among disabled workers.

The horizontal equity among disabled workers is achieved at the expense of some aggregate loss in social welfare. This loss in overall social welfare tilts in some cases the balance making disability tests now preferable in situations where tagging by occupation was preferred before. For instance, for $p_1 = 0.8$ and $p_2 = 0.2$ tagging by occupation was preferred to a disability test with audit cost $k(\pi) = 1000\pi^2$, before the introduction of the horizontal equity constraint among disabled workers, but the disability test is preferred now. It is however still the case that tagging remains preferred to a test with such an audit technology if the distribution of disabled workers across occupations is more unequal (e.g. $p_1 = 0.9$ and $p_2 = 0.1$). Note that with the disability tests disabled workers receive the same treatment regardless of their occupation, and the same holds for healthy workers.

When tagging is allowed, horizontal equity at the bottom, with both disabled workers obtaining the same utility level, implies differential social security treatment of disabled workers, with different

(p_1, p_2)	(0.6, 0.4)				(0.7, 0.3)			
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	48.012	76.679	45.542	75.373	49.276	77.476	44.149	74.755
z	0.363	0.869	0.332	0.884	0.370	0.860	0.305	0.891802
T'	0.129	0	0.243	0	0.088	0	0.326	0
U	3.542	3.773	3.542	3.736	3.555	3.795	3.555	3.718
SW	3.64637				3.6478			
(p_1, p_2)	(0.8, 0.2)				(0.9, 0.1)			
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	50.718	78.488	42.515	74.101	52.532	79.876	40.551	73.388
z	0.373	0.849	0.262	0.900	0.371	0.835	0.185	0.908
T'	0.054	0	0.443	0	0.025	0	0.624	0
U	3.578	3.822	3.578	3.698	3.617	3.858	3.617	3.677
SW	3.65061				3.65589			

Table 4: Tagging with horizontal equity among disabled workers

combinations of lifetime consumption and retirement age. Somewhat surprisingly, in the numerical results reported horizontal equity at the bottom is achieved by inducing individuals in the harsh occupation to retire later but compensating them with more consumption than disabled workers in the safe occupation. The differences are more pronounced as the distribution of disabled workers across occupations becomes more unequal. Those allocations are achieved by imposing relatively large distortions on the disabled workers in the safe occupation and relatively small distortions on the disabled workers in the harsh occupation. The large distortions at the bottom imposed on the disabled workers in the safe occupation serve the purpose to relax the self-selection constraint on the relatively numerous healthy workers in the safe occupation. The healthy workers in the safe occupation retire later and consume less than the healthy workers in the harsh occupation with $U_{H1} > U_{H2}$. Healthy workers in the harsh occupation benefit from being mixed with a large proportion of disable ones.

We have shown previously that each policy - disability tests and tagging - in isolation increases social welfare, although whether one outperforms the other depends notably on the relative cost of the audit technology and how different the distributions of healthy and disabled workers is across occupations. The social planner could consider combining them. We present in Table 5 the numerical results of combining disability tests and tagging for an intermediate audit technology

(p_1, p_2)	$(0.6, 0.4)$				$(0.7, 0.3)$			
π_i	0.0196985		0.0293188		0.014906		0.0341948	
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	51.759	77.080	46.585	72.191	54.788	80.023	44.434	70.198
z	0.340	0.865	0.350	0.923	0.333	0.833	0.351	0.950
T'	0.119	0	0.186	0	0.0874	0	0.219	0
U	3.657	3.784	3.536	3.640	3.726	3.862	3.485	3.575
SW	3.6529				3.65737			
(p_1, p_2)	$(0.8, 0.2)$				$(0.9, 0.1)$			
π_i	0.0100731		0.0391329		0.0051366		0.0441375	
Types	$D1$	$H1$	$D2$	$H2$	$D1$	$H1$	$D2$	$H2$
c	58.126	83.361	42.579	68.480	61.795	87.150	41.029	67.026
z	0.325	0.780	0.351	0.974	0.315	0.765	0.349	0.995
T'	0.0569	0	0.253	0	0.028	0	0.284	0
U	3.799	3.944	3.443	3.516	3.876	4.029	3.410	3.463
SW	3.66469				3.67467			

Table 5: Differential social security and audit policies

$k(\pi) = 1000\pi^2$.[12]

The combination of testing and tagging implies a higher social welfare than that achieved with either testing or tagging in isolation. When audit probabilities are allowed to differ by occupation it is optimal to test more often in the safe occupation, and the difference between the audit probabilities increases as the distribution of disabled workers across occupations differs more markedly. Compared with the situation in which only disability tests are employed and the same audit probability applies to both occupations (Table 2), the audit probability is smaller in the harsh occupation and larger in the safe occupation than the common audit probability.[13] Compared with the situation in which tagging is the only policy available (Table 3), disabled workers in both occupations are better off (consume more and work less), and healthy workers in both occupations are worse off (consume less and work more) when audits are used alongside tagging. Among the disabled workers those who benefit the most from the introduction of audits alongside tagging are the disabled workers in the safe occupation, even if their utility remains below that of the disabled workers in

[12] Note that we allow the audit probability to differ by occupation in this case, for consistency with the use of the occupation information for tagging purposes.

[13] This result also holds in an intermediate case, not reported here, in which the audit probabilities are allowed to differ by occupation, but there is a common social security policy.

the harsh occupation when horizontal equity among disabled workers is not explicitly imposed.

6 Conclusions

In this paper we have explored the possibility of differentiating the social security policy by occupation if there is evidence that the health status of workers is affected to some extent by their occupation. Previous contributions have illustrated that there is a trend towards early retirement in developed countries of otherwise healthy individuals that could remain in the labour force longer. Cremer et al. (2007) in particular explored the possibility of using disability tests. We perform numerical simulations to compare disability tests and tagging by occupation. The simulations suggest that disability tests outperform tagging if the audit technology is relatively cheap and the distribution of disabled workers across occupations is relatively similar. If the audit technology available is more expensive and/or there is a significant proportion of disabled workers in the harsh occupation (when compared with the proportion of disabled workers in the safe occupation) differentiating the social security policy - which is given by a combination of benefits and retirement age - is preferable. Both the healthy and disabled workers in the harsh occupation are better off in the tagging solution, consuming more and retiring earlier than their counterparts in the safe occupation. This horizontal inequity aspect is common to other tagging applications in the literature, particularly in income taxation, and is often criticised.

Accordingly we have explored the implications of addressing the horizontal inequities often linked to tagging up to some extent by ensuring that the disabled worker in the safe occupation is not made worse off than the disabled worker in harsh occupation by tagging. It is possible to show analytically that this constraint is binding. Hence the level of social welfare that can be achieved with tagging is reduced. In the numerical simulations we have shown that there are cases where disability testing may become preferable where tagging was preferable in the absence of the additional constraint. Nevertheless, if the audit technology is sufficiently expensive and/or the distribution of disabled workers significantly differs by occupation tagging remains preferable despite the decrease in the level of overall social welfare. We have also shown that, even though both types of disabled workers achieve the same level of utility, the social security policy, in terms of benefits and age of retirement, differs by occupation. The disabled workers in the harsh occupation are induced to retire later but are compensated with more benefits so as to achieve the same level of utility of their disabled counterparts in the safe occupation. This is achieved by imposing considerably larger distortions on the disabled workers in the safe occupation. The healthy workers in the harsh occupation continue to retire earlier and consume more than their healthy counterparts in the safe occupation.

Our results indicate that there is a case for special pension provisions for workers in harsh occupations when the individual's health status is private information, disability tests are relatively costly but there is statistical information available that suggests a significantly poorer average health status in those occupations. We have shown however that this does not necessarily mean that those who claim to be disabled in the harsh occupation should always be allowed to retire earlier than those who claim to be disabled in the safe occupation. If the social planner cares about possible horizontal inequity among disabled workers it can ensure that disabled workers achieve the same level of utility regardless of occupation by setting differentiated policies by occupation that induce later retirement for disabled workers in the harsh occupation but compensate them with more benefits.

Given that both policies - disability tests and tagging - are shown to increase social welfare, the social planner could consider combining them. If audits are used alongside tagging, and the probability of audit is allowed to differ by occupation, it is optimal to test more often in the safe occupation. Both disabled workers are better off when compared with the case in which tagging is the only policy available, but those who benefit the most from incorporating differential audits are the disabled workers in the safe occupation, even if their overall utility remains lower than that of the disabled workers in the harsh occupation when horizontal equity among disabled workers is not imposed.

In this paper we have taken the occupation as given, which may be a reasonable approximation if labour markets are relatively segmented. We plan to investigate the consequences of relaxing this assumption, by allowing the occupational choice to be endogenous, in further research.

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