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Revisiting Hopenhayn and Nicolini 's optimal unemployment insurance with job search monitoring and sanctions

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Abstract

Unemployment insurance is commonly believed to adversely affect job search behavior and to lengthen the duration of unemployment. Given that job search is difficult to monitor, much literature has focused on the need for decreasing unemployment benefits according to the unemployment duration. A declining sequence should encourage to get jobs sooner as in Hopenhayn and Nicolini (1997). Some reforms are directly inspired by this result. In this paper, we characterize the optimal unemployment insurance contract in a more general framework. In a principal-agent model, we argue that monitoring individual behavior can undermine the need for a declining sequence. In particular, if the monitoring technology is almost perfect, proposing an increasing sequence of unemployment benefits with the unemployment duration is optimal in that it increases the opportunity cost of shirking.

Keywords: unemployment insurance, incentives, monitoring, sanctions, public expenditures

JEL: D82; H53; J65; J68

1 Introduction

The main goal of unemployment insurance is to provide a decent income in the event of a job loss. But this very narrow view of unemployment insurance has perverse effects if it does not encourage and provide incentives for job search, in particular because of the problem of moral hazard. This paper considers job-search monitoring and sanction in a model *à la* Hopenhayn and Nicolini (1997) and Shavell and Weiss (1979). These seminal papers suppose that the government cannot observe the workers' search effort[1]. The main result is that the optimal compensation scheme decreases monotonically with the unemployment spell. However, if job search is difficult to control, it does not means that there is no job search monitoring. In this paper we consider that public employment services can observe job-search

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[1] These authors consider that if the government monitors individual behavior, then because there is no problem of adverse incentives, the optimal time sequence of benefits is a constant sequence. But this could not be the case, because monitoring individual behavior is not perfect (type I and type II errors)

effort. This is the case in Denmark, for instance, where job search assistance programs are accompanied with a monitoring technology. In France, a policy has proposed a flat profile on the unemployment benefits since 2001. In return, the unemployed workers are controlled and have to search for a job actively. With a decreasing sum of unemployment benefits, individuals who have the bad luck to remain unemployed a long time collect lower benefits. But with a flat or even an increasing profile, only individuals who do not search for a job will collect lower benefits.

The role of unemployment insurance on the duration of unemployment have been extensively studied in the literature but often one component at a time: optimal time sequence on one hand, monitoring and sanctions on the other hand. We propose a model to design the optimal contract of UI by taking into account the variation of benefits with the duration of unemployment, monitoring job search activity and sanctions. In a more general framework than the papers quoted above, we characterize the optimal unemployment insurance contract between a risk-averse agent and a risk-neutral principal. We illustrate a trade-off between searching for a job and shirking. On the one hand, by searching for a job, the unemployed worker undergoes a loss of utility but increases his chances to escape unemployment. On the other hand, by shirking, an unemployed worker does not undergo too much disutility and almost no probability of finding a job. But, he is likely to be punished by a suspension of his unemployment benefits. We show that in the presence of monitoring, the unemployment benefits profile must be less degressive or even increasing. The intuition is simple: in the principal-agent models, the insurer must minimize his expenses by ensuring to the unemployed workers a keeping promised value. As the unemployed workers are risk-averse, the principal must therefore propose a consumption expectancy close to the workers'consumption while giving incentives to the exit from unemployment. In the model of Hopenhayn and Nicolini, this objective is assured by a decreasing profile. The unemployed workers have high benefits at the beginning of the unemployment period and the degressivity provides incentives for job search. By introducing the control, another incentive mechanism can be used. Indeed, the threat of a sanction in the future makes it possible to give incentives to search for a job in the present. In this case, the significance of the sanction corresponds to the difference between the value of the non-sanctioned unemployment and the sanctioned unemployment. This is why an increase in unemployment benefits can be incentive since it increases the gap between the (increasing) utility in the standard regime and the (decreasing or flat) utility in the sanction regime. Thus, when the frequency of monitoring increases, the optimal profile may become increasing. In other words, when all the unemployed workers are monitored, the increase in benefits can be seen as a bonus given to the unemployed who respect the requirements of the principal.

In this paper, we propose an extension of the Hopenhayn and Nicolini's model in which the principal, the government, maximizes the welfare of an unemployed individual subject to a budget constraint (the payment of unemployment benefits and the cost of monitoring). Considering the possibility of monitoring the unemployed workers (even in an imperfect way) will modify the traditional reflexions on

Table 1: Variation of the replacement ratio with the unemployment duration

	Variation of the replacement ratio with the unemployment duration	Duration of benefits
Denmark	not declining	24 months
France	not declining	4 to 36 months
Germany	not declining	6 to 24 months
Great Britain	flat-rate	6 months
Netherlands	75%, 70% after 2 months	3 to 38 months
Sweden	80% 70% after 200 days	14 months

Source: UNEDIC, 2015

the unemployment insurance.

The paper is organized as follows. The next section presents an overview of the unemployment benefit schemes in some OECD countries with different mixes of rules, monitoring effort, sanctions and generosity. Section 3 relates the literature on unemployment insurance and monitoring and sanctions. Section 4 describes the model. Numerical results are presented in the section 5 and section 6 concludes.

2 Unemployment benefits, monitoring and sanctions: an overview

The aim of this section is to provide an overview of the unemployment benefit schemes in some OECD countries. The generosity of UI system differ from one country to another and can be designed in different ways. In this paper, we focus on the level of unemployment benefits according to the unemployment duration and on the duration of these benefits (see Table 1). There are three types of replacement rate ratio: proportional to the reference wage (as in Denmark, Germany, the Netherlands), proportional but with a redistributive system (as in France), lump sum (in Great Britain). Unemployment benefits could vary with the duration of unemployment. This is the case in the Netherlands and to a lesser extent in Sweden. But in the other countries of this Table, unemployment benefits remain constant during the insured unemployment duration. Such data are difficult to obtain for the United States because each state has its own specific rules for unemployment insurance programs. But according to Pallage, Scruggs and Zimmermann (2009), France is about three times more generous than the state of Ohio (this state was chosen because it is similar to France in terms of average wages and its manufacturing share). This greater generosity in the french system is explained by higher benefits after unemployment insurance eligibility and a longer unemployment duration.

Most unemployment benefit systems have basic eligibility requirements, such as being available for work, registering with the employment services, and accepting suitable job offers. But only since the mid-1990s, these requirements have been coupled with monitoring and sanctions which are now widely used in OEDC countries. These measures are considered as additional tools to counteract the disincentive effects of unemployment insurance. Job search monitoring is the process of checking wether unemployed workers

Table 2: Strictness of job-search monitoring and sanctions

	Score		
	Job-search monitoring	For refusing a job or ALMP	For repeated refusals
Denmark	2	1	5
France	4	1	2
Germany	2	1	2.5
Netherlands	4	1	1
Sweden	1	1	3
Switzerland	4	2.5	4
United Kingdom	5	2	3
United States	2	5	5

Source: Venn (2012)

are engaging in sufficient search activity to receive unemployment benefits. This can mean checking up on search methods, time spent searching, and employers contacts made. Monitoring usually goes along with the threat of withdrawing benefits (sanctions) for people who are not sufficiently active in their job search or who refuse a suitable job offer or for other administrative infractions. Again, the regularity of monitoring and the toughness of sanctions (duration, coverage, and severity) vary across countries and over time within countries making the comparison between countries difficult. Venn (2012) proposes an interesting indicator to evaluate the strictness of eligibility criteria. This indicator comprises nine items describing various aspects of eligibility criteria and sanctions. One of these item relates to job-search monitoring and describes if and how often benefit recipients must prove that they have been actively searching for work. Beneficit recipients may be asked to prove that they followed up on referrals given by the Public Employment Services or equivalent private-sector-job-placement providers. Venn (2012) uses two other items to describe the sanctions applied if unemployment benefit recipients infringe job-search requirements. Sanctions for refusing job offers or Active Labor Market Policies placements (ALMP) can take the form of reductions or suspensions of benefits. Sanctions can be stricter for multiple refusals of suitable job offers or ALMP participation. The Table 2 shows the score obtained by the countries presented above with regard to the strictness of their job-search monitoring and sanctions schemes. The score ranges from 1 (least strict) to 5 (most strict).

Job-search monitoring seems to be stricter in United Kingdom, France, Switzerland and the Netherlands (the unemployed workers must provide evidence of job search at interviews with an employment counsellor once a month or fortnightly). Whereas in Germany, Sweden and United States, unemployed are not clearly required to regularly prove job-search activity. Sanctions are stricter in the United States where refusing job offers results in a suspension of unemployment benefits and in Switzerland benefits are suspended between 6 and 12 weeks. In France, the Netherlands or Sweden, benefits are reduced for a fixed period rather than suspended. But for unemployed who repeatedly refuse suitable job offers, growing sanctions are imposed in most countries. For instance, in France, the refusal of two suitable job offers implies a suspension of two months of unemployment benefits. This suspension can be permanent in case of repeated refusals. In Denmark, the second refusal implies an exclusion from unemployment insurance.

To counteract the disincentive effects of UI, we argue that the generosity of unemployment benefits, monitoring job-search activity and sanctions in case of non-compliance with the rules have to be designed together and not one component at a time. In fact, the impact of the sanctions will depend on the generosity of UI. Indeed, temporary suspensions of benefits will have a greater cost in term of income loss in countries where replacement rates are higher. And a full suspension is more costly in countries where benefits normally have a long duration of unemployment benefits. Furthermore, the efficiency of monitoring job search activity will depend on the severity of the sanctions. Actually, job search requirements will not be considered as a real threat if the sanction is not too severe or if the rules are interpreted generously by job counsellors. Venn (2012) and Langenbucher (2015) explain that the strictness of rules as they are outlined in legislation are different from how they operate on the ground (however the frequency of job-search monitoring may capture this to some extent). Stricter criteria need not necessarily have an impact on the sanction rates because PES have some scope to interpret the rules. Hence, stricter legislation will lose touch in reality. Conversely, less strict criteria may result in more effective enforcement on the ground level.

3 Related literature

We present now the different results on the optimal time sequence of benefits and on monitoring and sanctions. Several studies show that unemployment insurance enables a high degree of consumption smoothing (Gruber (1997), Browning and Crossley (2001)). But at the same time, unemployment insurance has adverse effects on incentives to work and is often accused of increasing unemployment spells and the unemployment rate. To limit these negative effects, theoretical and empirical studies have pointed out several incentive mechanisms: sequencing of unemployment benefits, monitoring and benefit sanctions and workfare. Our paper relates to the two first mechanisms.

It is now well-known that more generous unemployment benefits increase the reservation wage and lead to a lower search effort which affect negatively the job-finding rate. In the presence of moral hazard (because the search effort of unemployed worker is not perfectly observable), the trade-off between insurance and incentives to search for a job should be taken into account to design the optimal unemployment insurance contract. A first mechanism analyzed in the literature is the optimal time sequence of unemployment benefits (for a complete survey, see Tatsiramos and van Ours (2012) and Fredriksson and Holmlund (2006)). In their seminal paper Shavell and Weiss (1979) analyze the optimal time profile of benefits. They consider a job-search model in which the unemployment insurance agency maximizes the expected utility of an unemployed worker subject to a fix budget. They find that the benefit level should decline monotonically over the spell. The explanation of their result is the following: a declining profile of unemployment benefits leads to a reduction in the value of unemployment which implies a drop in the reservation wage and a higher search effort. These two effects result in a higher exit rate from unemployment. The literature suggesting that a declining profile provides better incentives than a flat (or an increasing) profile is now well developed (Wang and Williamson (1996), Cahuc and Lehmann (2000), Fredriksson and Holmlund (2001), Pavoni and Violante (2007)). In the same strand, Hopenhayn and Nicolini (1997) enlarge the set of policy instruments by considering a tax on the wage received by the worker once he finds a job, which should increase with the unemployment duration. This wage tax provides a smoother consumption profile, while retaining job-search incentives. The declining benefit profile and the rising tax profile encourage job finding by making prolonged job-search more expensive. The numerical simulations (calibrated on the US economy) presented in their work suggest that the welfare gain can be substantial and the cost savings relative to the current system amount to almost 30%. Most of these works have ignored borrowings and savings. Recent research considers that private savings can be substituted to unemployment insurance for very short spells of unemployment (Pavoni (2007), Chetty (2008), Shimer and Werning 2008). Shimer and Werning (2008) show that a constant benefit level over time insures workers against unemployment risk and their ability to dissave and borrow allow them a consumption smoothing. Rendahl (2012) finds that the level of assets is decreasing over time during unemployment spell while unemployment benefits should be increasing.

Second, our paper relates to literature on monitoring and sanctions. In the studies discussed above, the receipt of unemployment benefits is not influenced by some requirements on search activity or availability for work. However, as explained in the previous section, most of unemployment insurance programs do not pay out unemployment benefits unconditionaly. In practice, unemployed workers have to report with some regularity at the employment agency, they have to give evidence of job applications. And the non-compliance with one of these criteria implies a sanction, *ie* a temporary or permanent reduction in benefits. As a consequence, unemployment insurance agency has to monitor unemployed workers behavior. The seminal paper on optimal law enforcement is Becker's paper on crime and punishment (Becker (1968)). He shows that the probability of detection and the severity of the sanction imposed by the government can influence individuals' incentives. The implications of this literature are that the more costly monitoring is, the less money should be spent on monitoring technology and the larger the sanction should be. The theoretical contributions on monitoring and sanctions point out an *ex ante* effect and an *ex post* effect (Ljungqvist and Sargent (1995), Abbring *et al* (2005), Boone and van Ours (2006), van den Berg and van der Klaauw (2001)). There is an *ex ante* effect when the perspective of a sanction encourages the unemployed workers to search harder to avoid the sanction. Once sanctioned, the drop in unemployment benefits forces the unemployed workers to get out fastly from the unemployment. This is called an *ex post* effect. The first effect captures deterrence: job-finding rate are higher even before the date at which sanctions are imposed. The latter captures the idea that search effort is higher among those who are actually sanctioned. The numerical results from calibrated search models indicate that the *ex ante* effect can be quite important. Monitoring activity is costly and it is difficult to quantify the costs of monitoring. However Boone *et al* (2007) finds that introducing monitoring and sanctions represents a welfare improvement for reasonable estimates of monitoring costs. Empirical evidence on monitoring and sanctions is growing (Abbring *et al* (2005), van den Berg *et al* (2004), Svarer (2011), van der Klaauw et van Ours (2011), Boockmann *et al* (2009)). These studies focus on the outflows from unemployment and not on the inflows into unemployment. Their results suggest that the *ex post* effect is substantial meaning that monitoring and benefit sanctions speed up job finding, *ie* they have a positive treatment effect regardless of the size of the penalty or the duration of the punishment. More specifically on the impact of monitoring only (without analysing the other aspects of unemployment insurance and benefit sanctions), most studies used experimental approaches. Klepinger *et al* (2002), McVicar (2008) as well as Cockx and Dejemeppe (2012) report positive and statistically significant effects of job-search monitoring on the unemployment rate and/or on job finding rate, which reduce the unemployment duration. On the contrary, Ashenfelter *et al* (2005) and Mickelwright and Nagy (2010) find no significant monitoring effects on unemployment exit rates. Concerning the impact of benefit sanctions, empirical studies mostly account for the selection effect (unemployed workers who receive a sanction have characteristics that would otherwise reduce their probability of unemployment exit or job entry). By using administrative data with a timing of events approach, these studies report that benefit sanctions significantly increases the exit rate from unemployment benefits and/or the job finding rate. These rates are more than doubled (van den Berg, van der Klaauw and van Ours (2004), Svarer (2011)). Using Swiss data, Arni, Lalive and van Ours (2013) and Lalive, van Ours and Zweimuller (2005) identify separately the effect of receiving a sanction from that of receiving a warning letter before a sanction is imposed and find similar effects in both cases on the unemployment exit rate and the job-finding rate. Some studies examine wether the effects of sanctions vary with the unemployment benefits period it is imposed. Their results are assorted. Svarer (2011) finds that the effect of sanctions decrease over the time after the sanction was imposed. Van der Klaauw and van Ours (2013) report that receiving a sanction during first year has larger effects than sanctions imposed later for women but the opposite for men. On the contrary, van den Berg and Vikstrom (2014) finds that the effect of receiving a sanction does not change over time. The effect of severity of sanctions has been studied in Svarer (2011) on Denmark: not surprinsingly, more severe sanctions may have larger effects on the exit rate from unemployment benefits.

The *ex ante* effect is more difficult to measure. Only a few studies seem to suggest that increased monitoring has little or no effect on search behavior (van den Berg and van der Klaauw (2001), Jensen *et al* (2003)). But this weak effect could be explained by a susbtitution between different search channels, such as formal and informal search (van den Berg and van der Klaauw (2001)). Lalive, van Ours and Zweimuller (2005) on Switzerland finds that the threat of the sanctions increases the exit rate from unemployment benefits by 23%. In the same way, Arni, Lalive and van Ours (2005) reports that this threat increases the job-finding rate by 17% in Switzerland.

Obviously, the effectiveness of the monitoring depends on the credibility of monitoring and sanctions. In practice, the political cycle or time-inconsistent issues may lead a government not to apply sanctions. In Hopenhayn and Nicolini, there is no mechanism threatening the credibility of the principal. Thus, the degressivity is always applied. Similarly, the sanctions provided are always applied in our model. This hypothesis is intuitive: If the principal gives up the optimal contract for one unemployed worker, he can not offer it credibly anymore for all the following unemployed workers. This repeated game ensures that the principal never has an interest in not applying the proposed contract to agents.

Thus, in the literature, different ways have been explored one by one to provide incentives to search for a job: sequencing benefits with the unemployment duration as well as monitoring job-search activity or else sanctioning in case of non compliance with the rules. Our contribution to the literature is the following: we analyze the optimal time sequence of unemployment benefits in a real-world where unemployment insurance systems do not pay out benefits unconditionally. As far as we know, there are no other theoretical studies that analyze these combined effects in this way.

4 The model

In this section, we formulate a simple model which captures the incentive role of monitoring and sanctions as described above.

4.1 The environment

We consider a principal-agent model in which the unemployed workers are risk-averse and the principal (the unemployment insurance agency, UI agency thereafter) is risk neutral. The preferences of the workers are:

$$E \sum_{t=0}^{\infty} \beta^t [u(c_t) - e_t] \tag{1}$$

where c_t and e_t are consumption and job-search effort at time t, $\beta \in [0, 1]$ denotes the intertemporal discount factor and E the expectation operator. The instantaneous utility function $u(.)$ is strictly increasing, twice differentiable ans strictly concave. It is required that $c_t > 0$ and $e_t > 0$.

Workers have perfect foresights but cannot borrow or lend and hold no assets. At any time, a worker may be in one of the three following situations: employed, insured unemployed who searches for a job or sanctioned unemployed (that is an unemployed worker who has been detected with an insufficient level of search effort). An insured unemployed worker get an unemployment benefit b_t at each period t. His probability of finding a job depends on search intensity and is denoted $\pi(e_t)$, where π is an increasing and strictly concave and twice differentiable function of e, satisfying $\pi(e) \in [0,1]$ for $e \geq 0$, $\pi(0) = 0$. If the agent finds a job in period t, then he is employed in period $t+1$. All jobs are alike and pay a wage denoted by $w > 0$. Once a worker has found a job, he keeps it: we assume that jobs are not destructed. This hypothesis simplifies the analysis. Hopenhayn and Nicolini (2009) consider multiple unemployment spells. In their paper, unemployment benefits paid to unemployed workers are conditioned by their employment history. This is not what we do here. We assume a unique unemployment spell and one type of job as in Hopenhayn and Nicolini (1997)[2]. Therefore, we do not take into account the fact that monitoring can speed up the exit of unemployment into low quality jobs (see Acemoglu and Shimer (2000) and Acemoglu (2001)). We assume here that only search effort is controlled and job refusals are not. Then, if monitoring could encourage unemployed workers to accept jobs of bad quality in order to exit of unemployment quickly, on the other hand, the increase in search effort could be directed towards good quality jobs.

In the literature on unemployment insurance, the moral hazard problem arises from the difficulties in monitoring the unemployed worker's effort. It is then assumed that the principal is not able to monitor the search effort[3]. We consider here that the UI agency can observe but not perfectly job-search effort. Said otherwise, actions realized by the unemployed workers (such as the number of applications, participations in job-search workshops organized by the UI agency) are an indicator of their job-search intensity, of course an imperfect indicator. Then the unemployed worker has a probability of being detected not to search sufficiently. This probability depends on search intensity and denotes $\mu_t h(e_t)$ where $\mu_t \in [0,1]$ is the frequency of job-search monitoring by the UI agency and $h(e_t)$ is the probability that the observed level of search-effort is below the required level of search-effort defined by the UI agency e^*. h is a decreasing function of e, satisfying $h(e) \in [0,1]$ and $h''(e) = 0$. Then there are two components of monitoring: the frequency μ_t of monitoring and the probability to enter the sanction regime $h(e)$ if search effort is not enough ($e < e^*$).

If the unemployed worker is controlled not to search sufficiently at period t, he is sanctioned which means that he receives reduced unemployement benefits, denoted by $b^s_{t,j}$ during all the remaining duration in the unemployment and until his exit toward the employment. j is the duration as a sanctioned unemployed worker (whereas t is the duration as an insured unemployed worker). And his probability of finding a job depends on his search intensity $a_{t,j}$ and is denoted $\pi(a_{t,j})$. There is no more control from the UI agency. The probabilities of status change are represented in Figure 1.

Our model is in line with Hopenhayn and Nicolini. Thus, the status of an unemployed worker depends

[2]If we consider multiple unemployment spells, we would have monitoring rates conditioned on the unemployment history of the unemployed workers. But the optimal sequence of unemployment benefits would be close to what we have here : less declinging than in HN.

[3]Another source of informational asymmetry arises when the unemployment agency cannot observe the job offers received by the unemployed workers which implies that the agency cannot impose a reservation rule for job acceptance

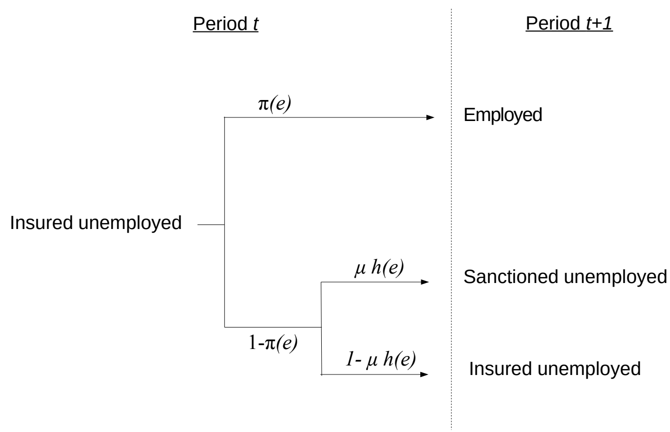

Figure 1: Probabilities of status change between t and $t+1$

only on his situation with regard to of the UI agency (the principal). There are 2 possible states: *(i)* The unemployed worker can depend on the non-sanctioned workers'UI agency. Then, he perceives an allocation b_t and chooses the level of effort e_t which maximizes his intertemporal value V_t^u. *(ii)* He depends on the sanctioned workers'UI agency. In this case, he receives $b_{t,j}^s$ and provides the effort $a_{t,j}$ which maximizes his intertemporal value $V_{t,j}^s$. Contrary to Shapiro and Stiglitz's model (1984), the level of effort for a shirker is not constrained to 0. We assume that the search effort is endogenous and always results from a maximization of the intertemporal utility of the unemployed worker. The probability of being sanctioned depends on a function $h(e_t)$ decreasing in e_t. This means that there is a non-zero probability that an unemployed worker providing a high level of effort is punished and that there is a non-zero probability that an unemployed worker providing a low level of effort is not sanctioned. Said otherwise, the monitoring technology does not allow to perfectly observe the search effort.

Then, the expected discounted utility of an employed worker[4] is defined by:

$$V_t^e = u(w) + \beta V_{t+1}^e \tag{2}$$

Since V_t^u is the expected discounted utility offered to an unemployed worker and $V_{t,j}^s$ the expected discounted utility offered at each date j to an unemployed worker, sanctioned at date t, it follows that:

$$V_t^u = u(b_t) - e_t + \beta\Big(\pi(e_t)V_{t+1}^e + (1-\pi(e_t))\big[\mu_t h(e_t)V_{t+1,1}^s + (1-\mu_t h(e_t))V_{t+1}^u\big]\Big) \tag{3}$$

[4]We do not consider the disutility of work because we assume that the disutility of job search is higher when unemployed

From there, we can deduce the following approximation[5]:

$$V_t^u = u(b_t) - e_t + \beta\Big(\pi(e_t)V_{t+1}^e + \mu_t h(e_t)V_{t+1,1}^s + \big[1 - \pi(e_t) - \mu_t h(e_t)\big]V_{t+1}^u\Big) \tag{4}$$

And for a sanctioned unemployed, we have:

$$V_{t,j}^s = u(b_{t,j}^s) - a_{t,j} + \beta\Big(\pi(a_{t,j})V_{j+1}^e + \big[1 - \pi(a_{t,j})\big]V_{t,j+1}^s\Big) \tag{5}$$

The actions always take place over two periods t and $t+1$. Bellman's equation of a non-sanctioned unemployed indicates that the agent receives an income b_t and chooses his level of effort e_t at the period t. This level of effort allows him to obtain a job with a probability $\pi(e_t)$ at the period $t+1$. If he does not receive a job offer, the unemployed can be monitored and sanctioned with probability $\mu h(e_t)$ or retain its status with probability $1 - \mu h(e_t)$. In the case of a sanctioned unemployed, we must specify the time spent as an unemployed not sanctioned t and the duration spent as an unemployment sanctioned j. Thus, Bellman's equation of an unemployed worker who is sanctioned at date t indicates that he receives a benefits $b_{t,j}^s$ and provides an effort $a_{t,j}^s$ at date j. Then, at date $j+1$, the unemployed has a probability $\pi(a_{t,j}^s)$ to obtain an offer and $1 - \pi(a^s t, j)$ to remain unemployed. An individual can never be sanctioned twice.

4.2 The job search decision of an unemployed worker

If the unemployed worker's search effort was perfectly observable, the optimal program of unemployment insurance would give the agent a constant unemployment benefit per period (because of his risk aversion). But because job-search effort is not perfectly observable, it is not beneficial for the unemployment insurance system to compensate unemployed workers who have no chance of escaping unemployment. This is the well-known criticism of unemployment insurance schemes which strongly reduce the incentives to look for a job. From there, it seemed obvious to study the optimal contract problem assuming that the effort level is not observable by the principal, as done in the seminal papers of Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997). Given that the search effort is not observed by the principal, they include the restriction that the agent optimally chooses the effort level prescribed by the contract (the incentive constraint). They show that the unemployment benefit is decreasing over time while the worker remains unemployed.

But as already said, it would seem more realistic to study the optimal contract problem assuming that the effort level is *rather* observable by the principal but not in a perfect way. To encourage the

[5] For a weekly calibration, we have $\pi(e_t)\mu_t h(e_t) = 0$. This corresponds to the unemployed worker who is monitored and punished whereas he has just found a job. In this case, either the unemployed worker provides a low search level which implies a $\pi(e_t)$ close to zero, or his level of effort is high and his probability of being sanctioned $h(.)$ is close to zero. In other words, by definition, an individual who found a job provided a sufficiently high search effort and can not be penalized. This approximation does not modify our results, but allows us to enrich our modeling by endogenizing the risk of sanction.

unemployed to search, we assume that the UI agency can monitor the behaviour of the unemployed workers and can adapt the amount of the unemployment benefits (with the duration of unemployment and by reducing unemployment benefits when shirking is detected). If an unemployed is caught searching not sufficiently, he is sanctioned. If he finds a job, he becomes employed, with $V_t^e > V_t^u$.

Given that there is a probability of being controlled and sanctioned, the insured unemployed worker chooses the optimal search effort. The following incentive constraint is thus needed:

$$\underbrace{\beta\pi'(e_t)\big[V_{t+1}^e - V_{t+1}^u\big]}_{\text{Marginal gain to search for a job}} + \underbrace{\beta\mu_t h'(e_t)\big[V_{t+1,j}^s - V_{t+1}^u\big]}_{\text{Marginal cost of shirking}} \leq 1 \tag{6}$$

Optimal search effort depends on two elements: a bonus associated with being employed (marginal gain to search for a job) as in Hopenhayn and Nicolini and a penalty associated with being sanctioned (marginal cost of shirking). If an individual could obtain unemployment benefits after being controlled to shirk ($V_{t+1,j}^s = V_{t+1}^u$) and while employed ($V_{t+1}^e = V_{t+1}^u$), this incentive constraint could never be satisfied. The fact that the probability of sanction depends on search effort introduces an additionnal reward for search which is captured by the last term in (6): by searching harder, the worker reduces the probability of being sanctioned and thereby transferred to the sanctioned state. Even if the bonus associated with being employed ($V^e - V^u$) decreases, job-search effort still increases because of the penalty associated with being sanctioned ($V^u - V^s$).

The sanctioned unemployed worker chooses his optimal search effort given that he is not observed anymore by the agency:

$$\beta\pi'(a_{t,j})\big[V_{j+1}^e - V_{t,j+1}^s\big] \leq 1 \tag{7}$$

In this case, incentives to search for a job come only from the bonus associated with being employed.

4.3 The contract

We want to study the design of an optimal unemployment compensation along the lines of Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997). Setty (2016) proposes a principal-agent model taking into account the monitoring of the unemployed workers. He shows that the degree of precision of the monitoring has to follow an inverse U-shaped with respect to promised utility. We propose a framework close to Setty, but which differs by the technology of monitoring and the terms of the sanctions. Indeed, the principal can not choose the precision of our monitoring $h(e)$, but he can change over time the rate μ of unemployed workers controlled. The cost of the control is then a function of the number of unemployed workers controlled and is independent of the precision. Moreover, we assume that the sanctions are permanent, but that the principal has the possibility to propose a non-constant profile of benefits for the sanctioned unemployed workers.

In our model, the insurance agency can observe and control not in a perfect way the unemployed worker's search effort. The agency wants to design an unemployment insurance contract to give the unemployed worker discounted expected value V^u, and the sanctioned unemploymed worker discounted expected value V^s. The planner wants to deliver V^u and V^s in the most efficient way, meaning the way that minimizes discounted costs, using β as the discount factor. The agency has to enforce job search effort, because it is costly to pay unemployment benefits for unemployed worker who has no chance of finding a job (because of insufficient job-search). We formulate the optimal insurance problem recursively. Let $C[.]$ be the expected cost for the principal (the unemployment insurance agency). This function associates the minimum cost $C^u\left[V_t^u\right]$ for the UI agency to ensure the level of expected utility V_t^u to a new unemployed worker at each date t and the minimum cost $C^s\left[V_{t,j}^s\right]$ for the UI agency to ensure the level of expected utility $V_{t,j}^s$ to a new unemployed worker sanctioned at date t at each period j. The optimal unemployment insurance contracts consists of a sequence of unemployment benefits for insured unemployed workers (b_t), reduced unemployment benefits for sanctioned unemployed workers ($b_{t,j}^s$) and a sequence of monitoring rateμ_t. Monitoring the job-search activity allows to improve the accuracy of information about some performance criteria such as "actively searching for a job". There is a cost associated with improving the accuracy of information, *ie* reducing probabilities of Type I (individuals may be falsely sanctionned) and Type II errors (individuals may escape sanctions even if they have not actively search for work). The monitoring costs are represented by the function $f(\mu_t)$ with the following properties: $f'(.) > 0$, $f''(.) > 0$, $f(0) = 0$. In order to have an interior solution, the Inada conditions should be satisfied: $f'(0) = 0$ et $f'(1) = +\infty$ (Laffont and Martimort, 2001, chapter 4). In theory, we could assume that for each level of e observed by the principal, there is a different level of sanction. However, for reasons of administrative costs, most control systems simply classify the unemployed workers as shirkers or non-shirkers. This is the assumption we make in our model. The function $h(.)$ is used to detect shirkers, but not the intensity of the fraud.

For simplicity, we present this problem in two steps: first, the UI agency chooses a sequence of reduced unemployment benefits $b_{t,j}^s$ to ensure discounted expected value V^s which gives him the minimum cost $C^s\left[V_{t,j}^s\right]$. Second, given this optimal unemployment contract for the sanctioned unemployed workers, the agency chooses a sequence of unemployment benefits b_t (and a discounted expected value V^u) that minimize the associated cost $C^u\left[V_t^u\right]$. Let us remark that we would obtain the same optimal unemployment contract by resolving this problem in one step.

Then, $C^s\left[V_{t,j}^s\right]$ and $C^u\left[V_t^u\right]$ must satisfy the following Bellman equation:

$$C^s\left[V_{t,j}^s\right] = \min_{b_{t,j}^s, a_{t,j}, V_{t,j+1}^s}\left(b_{t,j}^s + \beta\left[1-\pi(a_{t,j})\right]C^s\left[V_{t,j+1}^s\right]\right) \tag{8}$$

$$\text{subject to} \quad : \quad V_{t,j}^s \leq u(b_{t,j}^s) - a_{t,j} + \beta\Big[\pi(a_{t,j})V_{j+1}^e + \big(1-\pi(a_{t,j})\big)V_{t,j+1}^s\Big] \tag{9}$$

$$\text{and} \quad : \quad 1 \geq \beta\pi'(a_{t,j})\Big[V_{j+1}^e - V_{t,j+1}^s\Big] \tag{10}$$

We denote α the multiplier on the participation constraint (equation (9)) and γ the multiplier on the incentive constraint (equation (10)). The first-order conditions for this principal's problem are:

$$u'(b^s_{t,j}) = 1/\alpha \tag{11}$$

$$C^s\Big[V^s_{t,j+1}\Big] = \alpha\Big[\frac{1}{\beta\pi'(a_{t,j})} - \big(V^e_{j+1} - V^s_{t,j+1}\big)\Big] - \gamma\frac{\pi''(a_{t,j})}{\pi'(a_{t,j})}\big(V^e_{j+1} - V^s_{t,j+1}\big) \tag{12}$$

$$= -\gamma\frac{\pi''(a_{t,j})}{\pi'(a_{t,j})}\big(V^e_{j+1} - V^s_{t,j+1}\big) \tag{13}$$

$$C^{s\prime}\Big[V^s_{t,j+1}\Big] = \alpha - \gamma\frac{\pi'(a_{t,j})}{1-\pi(a_{t,j})} \tag{14}$$

And the envelope condition is:

$$C^{s\prime}\Big[V^s_{t,j}\Big] = \alpha \tag{15}$$

The second equality in equation (13) follows from strict equality of the incentive constraint (10) when $a_{t,j} > 0$. First order condition (13) implies that the multiplier γ is strictly positive. The first order condition (14) and the condition (15) together allow to conclude that $C^{s\prime}\Big[V^s_{t,j+1}\Big] < C^{s\prime}\Big[V^s_{t,j}\Big]$. With the condition (11), it follows that unemployment benefits for sanctioned unemployed workers must decrease over time in order to provide them with the proper incentives. This result is not surprising because once sanctioned, the agent is not monitored anymore by the UI agency.

We analyze now the second step: the UI agency has to choose the optimal unemployment contract proposed to a new unemployed worker (*ie* who is not yet sanctioned). $C^u\left[V^u_t\right]$ must satisfy the following Bellman equation:

$$C^u\left[V^u_t\right] = \min_{b_t, e_t, V^u_{t+1}, V^s_{t+1,1}\mu_t}\Big(b_t + f(\mu_t) + \beta\Big(\mu_t h(e_t)C^s\left[V^s_{t+1,1}\right] + \left[1-\pi(e_t)-\mu_t h(e_t)\right]C^u\left[V^u_{t+1}\right]\Big)\Big) \tag{16}$$

$$\text{subject to} \quad : \quad V^u_t \leq u(b_t) - e_t + \beta\Big[\pi(e_t)V^e_{t+1} + \mu_t h(e_t)V^s_{t+1,1} + \big(1-\mu_t h(e_t) - \pi(e_t)\big)V^u_{t+1}\Big] \tag{17}$$

$$\text{and} \quad : \quad 1 \geq \beta\pi'(e_t)\Big[V^e_{t+1} - V^u_{t+1}\Big] + \beta\mu_t h'(e_t)\Big[V^s_{t+1,j} - V^u_{t+1}\Big] \tag{18}$$

The first-order conditions for the principal's problem are:

$$u'(b_t) = 1/\lambda \tag{19}$$

$$C^u\Big[V^u_{t+1}\Big] = \mu_t\frac{h'(e_t)}{\pi'(e_t)}\Big(C^s\Big[V^s_{t+1,j}\Big] - C^u\Big[V^u_{t+1}\Big]\Big) - \eta\frac{\pi''(e_t)}{\pi'(e_t)}\Big(V^e_{t+1} - V^u_{t+1}\Big) \tag{20}$$

$$C^{u\prime}\Big[V^u_{t+1}\Big] = \lambda - \eta\frac{\pi'(e_t) + \mu_t h'(e_t)}{1-\pi(e_t)-\mu_t h(e_t)} \tag{21}$$

$$C^{u\prime}\Big[V^s_{t+1,1}\Big] = \lambda + \eta\frac{h'(e_t)}{h(e_t)} \tag{22}$$

$$f'(\mu_t) = \beta h(e_t)\Big(C^u\Big[V^u_{t+1}\Big] - C^s\Big[V^s_{t+1,j}\Big]\Big) + \beta\left[\lambda h(e_t) + \eta h'(e_t)\right]\Big[V^s_{t+1,j} - V^u_{t+1}\Big] \tag{23}$$

And the envelope condition is:

$$C^{u\prime}\Big[V^u_t\Big] = \lambda \tag{24}$$

where λ is the multiplier on the participation constraint (equation (17)) and η the multiplier on the incentive constraint (equation (18)). Because of strict equality of the incentive constraint (18) when $e_t > 0$, we obtain the second condition in equation (20). And as long as the insurance scheme is associated with costs $C^u\Big[V^u_{t+1}\Big] > 0$, this first-order condition (20) implies that the multiplier η is striclty positive if $C^s\Big[V^s_{t+1,j}\Big] < C^u\Big[V^u_{t+1}\Big]$. The optimal frequency of monitoring is defined by first-order condition (relation (23)) which represents the equality between the marginal cost and the marginal gain of the monitoring system.

For a better understanding of the qualitive analysis, we assume now that the expected level of utility when sanctioned V^s is constant over time and that b^s is exogenous.[6] It means that the reduced unemployment benefits perceived by the sanctioned unemployed worker is the same during all his remaining duration of unemployment and until he finds a job. In this situation b^s can be understood as an assistance revenue. So this asumption could be understand as if unemployment insurance and unemployment assistance were managed independently. The UI agency takes as given the level of assistance revenue b^s. As a consequence, when shirking is detected, unemployed workers are excluded from the UI system and enter the unemployment assistance system which does not depend on search effort any more.

We analyze the optimal unemployment contract considering different cases.

First, consider the case where there is no control of job search as in Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997). It means that $\mu_t = 0$. The third condition (21) and the envelope condition (24) imply:

$$C^{u\prime}\Big[V^u_{t+1}\Big] = \lambda - \eta\frac{\pi'(e_t)}{1-\pi(e_t)} < C^{u\prime}\Big[V^u_t\Big] \tag{25}$$

The convexity of the cost function[7] of the principal implies that the optimal sequence of unemployment benefits is decreasing with the unemployment spell $V^u_t > V^u_{t+1}$. When there is no control of job search $\mu h(e_t) = 0$, the incentive constraint becomes:

$$\beta\pi'(e_t)\Big[V^e_{t+1} - V^u_{t+1}\Big] = 1$$

The unemployed will realize a level of search effort if his expected utility as an employed worker is greater than his utility as an unemployed. Thus to encourage the unemployed to search for a job, the principal should propose a decreasing level of expected utility V^u and as a result a declining sequence of the unemployment benefits b_t. The explanation is the following. By reducing V^u, the principal increases the net profit to search $V^e_{t+1} - V^u_{t+1}$. The latter contract corresponds to the one considered by Shavell and Weiss (1979). This reasoning remains valid as long as $\pi'(e_t) > -\mu_t h'(e_t)$. It means that an additional search effort increases more the probability of finding a job than the probability of escaping from the

[6] We can assume that the level of b^s_t depends on the date of the sanction. But once sanctioned, the individual gets the same level. We will relax this assumption in the numerical simulations presented in the next section.

[7] Hopenhayn and Nicolini (1997) show that for plausible values of the parameters, the cost function is convex.

sanction. Indeed the probability of being controlled is not sufficiently important to provide the right incentives for the unemployed to search. When the monitoring rate is weak, the unemployed workers know that they have few chances to be excluded from the unemployment insurance. The declining time sequence of unemployment benefits constitutes a complementary incentive to carry out a positive job search effort. Note that as long as $\pi'(e_t) > -\mu_t h'(e_t)$, the sequence of the unemployment benefits will be less declining than in an economy *à la* Shavell and Weiss, because of the existence of a monitoring system which constitutes even though an additional incentive to search. To have a good understanding of this result, recall that there are two components in the incentive constraint: the marginal gain to search for a job and the marginal cost of being sanctioned. Therefore, the decreasing level of expected utility V^u has two effects. First this increases the marginal gain to search for a job $V^e_{t+1} - V^u_{t+1}$. Second, this decreases the marginal cost of shirking $V^u_{t+1} - V^s_{t+1,j}$. Said otherwise, by proposing a decreasing sequence of V^u, the UI agency faces a trade-off between increasing the returns of job search and decreasing the cost of the sanction for the unemployed (the threat of the sanction is weaker). As $\pi'(e_t) > -\mu_t h'(e_t)$, the first effect is greater which implies that a less declining sequence than in Hopenhayn and Nicolini is enough to provide the right incentives.

Proposition 1 *Under condition $\pi'(e_t) > -\mu_t h'(e_t)$, the optimal profile of unemployment benefits is decreasing.*

Consider now the interesting case where $\pi'(e_t) < -\mu_t h'(e_t)$. Relations (21) and (24) imply that $C^{u\prime}\left[V^u_{t+1}\right] > C^{u\prime}\left[V^u_t\right]$ and then $V^u_{t+1} > V^u_t$ consequently the optimal sequence of unemployment benefits must increase over time. Here, an additional job search effort increases more the probability of escaping from the sanction than the probability of finding a job. The increasing level of expected utility V^u proposed by the UI agency decreases the marginal gain of job search but increases the marginal cost of shirking. As $\pi'(e_t) < -\mu_t h'(e_t)$, this latter effect is bigger. Then by increasing the expected utility V^u, the UI agency increases the disutility of shirking and thereafter the optimal job search effort. The difference between an insured unemployed worker and a sanctioned unemployed worker has a bigger role in encouraging job search effort. If the agency proposes a decreasing level of utility to the unemployed worker with t, V^u gets closer to V^s then individual has less to lose to be controlled to shirk, which does not encourage him to search for a job. Conversely, by increasing V^u with the duration of unemployment, the agency increases the expected utility of the unemployed who searches for a job. He is encouraged to carry out the search effort since he has more to lose to be controlled "to shirk". By proposing an increasing sequence of unemployment benefits with the unemployment duration, the agency increases the cost for the unemployed to be controlled not to make search effort. This scheme is then an incentive for the unemployed to search for a job.

Therefore, the gap between the benefits from the insurance unemployment benefits (b_t) and the reduced unemployment benefits (b^s) plays a major role. If b_s is very high, unemployed workers may be not encouraged to search for a job because they lose less in case of monitoring. On the contrary, if b^s is low, unemployed workers lose a lot if they do not search, this increases their job search effort. Note that if unemployment benefits and b^s are managed independently, *ie* the first by an insurance regime and the second by an assistance regime, the management of the two schemes is critical. We will discuss this point later.

Proposition 2 *Under condition $\pi'(e_t) < -\mu_t h'(e_t)$, the optimal profile of unemployment benefits is increasing.*

Consider another interesting case where $\pi'(e_t) = -\mu_t h'(e_t)$. This time, an additional search effort increases the probability of finding a job as much as the probability of escaping from the sanction. Relations (21) and (24) imply $C^{u\prime}\Big[V^u_{t+1}\Big] = C^{u\prime}\Big[V^u_t\Big]$ which illustrates a flat profile of the unemployment benefits. The reasoning is the same as previously. The incentive constraint (18) becomes:

$$\beta\pi'(e_t)\Big[V^e_{t+1} - V^s\Big] = 1$$

In this case, the unemployed workers search for a job ($e > 0$) if the expected utility of an employed worker (net of the search cost) is higher than the utility of a punished unemployed worker (V^s). We note that the expected utility of an unemployed does not appear any more in the incentive constraint. Thus in order to provide incentives to search, the principal should propose the same level of utility at each period: $V^u_t = V^u_{t+1}$. It results from this a flat sequence of the unemployment insurance.

Proposition 3 *Under condition $\pi'(e_t) = -\mu_t h'(e_t)$, the optimal profile of unemployment benefits is flat.*

Thus, our results show that the optimal contract depends crucially on the monitoring of job search activity.

5 Quantitative analysis

In this section, we solve numerically a parametrized version of the model.

5.1 Calibration

In order to illustrate numerically the effects of the monitoring and sanctions, we first calibrate the model in order to reproduce the optimal compensation profile of Hopenhayn and Nicolini (HN, thereafter). This calibration strategy allows us to highlight deviations due to monitoring and sanctions in relation to the HN benchmark. Thus parameters and the promise-keeping value are set in order to reproduce the compensation profile obtained by HN for the USA. The model is calibrated on a weekly basis. Table 3 reports the different calibrated values. We assume that the utility function has the form $u(b) = b^{1-\sigma}/(1-\sigma)$

Table 3: Benchmark computation

Parameters		Values	Targets
Relative risk aversion	σ	0.5	
The required level of search effort	e^*	300	$h(e_t) = \max\left[0, \frac{e^* - e_t}{2u}\right]$
The noise	u	300	
Cost of monitoring	θ	200	$f(\mu_t) = \theta\frac{\mu_t^2}{2}$
Wage	w	100	
Job search technology	r	0.0004	$\pi(e_t) = 1 - exp(-r.e_t)$

where $\sigma > 0$ is the coefficient of relative risk aversion. We set the value of σ to 0.5, giving an intermediate degree of risk aversion as in HN. The discount factor β is set to reproduce a yearly interest rate of 4%. We normalize the wage w to 100. Thus, the unemployment benefit equals the replacement rate. In a first step, we assume a flat replacement ratio equals to 50%. The probability of finding a job depends on search intensity and is given by an exponential distribution, as in HN: $\pi(e_t) = 1 - exp(-re_t)$. Job search technology r is then set to 0.0004 so as to replicate an average unemployment duration of 6 months. With this calibration, we compute the promise value and the average cost for each unemployed worker which is equal to 998.43. This is our benchmark.

We assume that the cost of the monitoring technology is a convex function $f(\mu_t) = \theta\frac{\mu_t^2}{2}$ and we set the parameter θ to 200 so that the monitoring cost represents 1% of the wage for a frequency of job-search monitoring (μ) of every 10 weeks. Setty (2016) reports that there is a wide range of estimates for the cost of monitoring, varying between 4$ and 60$ per worker per month. Boone, Fredriksson, Holmlund, and van Ours (2007) estimate the cost of monitoring at 0.7% of the average wage. Our calibration may overestimate the monitoring cost. In Appendix, we report the results for an increase and a decrease in costs by changing the value of θ. The results are qualitatively the same and quantitatively similar.
Note that the maximization of the principal's program does not make it possible to obtain the optimal level of e. Therefore, we assume that the principal's aim is to replicate the level of effort of an economy where the information would be perfectly observable. Then, the level of search-effort required by the principal e^* corresponds to the search effort required to reproduce the promise keeping value on the assumption that $b = w$. In other words, e^* is the effort that an unemployed worker should do to reproduce the promise keeping value if the effort was perfectly observable.
We consider that the monitoring technology is not perfect. The observed search-effort is given by $\bar{e} = e + \epsilon$ where e is the true search-effort and ϵ mean-zero independently and identically distributed random variable. The role of this "noise" term is to prevent public employment services from perfectly inferring job-search activity. As in Pries (2004) and Pries and Rogerson (2005), we assume that the noisy compo-

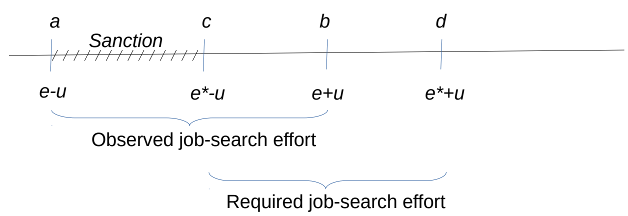

Figure 2: Job-search effort and probability of sanction $h(e)$

nent is uniformly distributed on $[-u, u]$. More precisely, when the unemployed worker provides a level of search effort e, the UI agency observes something which is included in $[e - u, e + u]$ (as shown in figure 2). On average, this means that the principal observes well the job-search intensity. The principal will implement a sanction $h(e)$ only if he is sure that the unemployed workers have not provided the required level of job-search effort $e^* - u$. We want to reduce here Type I errors (where individuals may be falsely sanctioned). Note that the bigger the noise the more the unemployed can hide from the agency. In theory, we could assume that for each level of e observed by the principal, there must be a different level of sanction. However, for reasons of administrative costs, most control systems simply classify the unemployed workers as shirkers or non-shirkers. This is the assumption we made in our model. The function $h(.)$ is used to detect shirkers, but not the intensity of the fraud. Then $h(e)$, the probability that the observed level of search-effort is below the required level e^*, is given by:

$$P(X \leq e^* - u) = \int_a^c f(t)dt = \int_a^c \frac{1}{b-a}dt = \int_{e-u}^{e^*-u} \frac{1}{2u}dt = \frac{e^* - e}{2u} \equiv h(e) \text{ if } e < e^*$$

a, b and c are defined in Figure 2. Note that if $e > e^*$, then $h(e) = 0$.

The sanction rate $\mu h(e)$ reflects both compliance and enforcement efforts. Few data on sanction rates are available and their interpretations may be multiple. Higher sanction rates may be associated with stricter enforcement due to more regular contact with PES. And credible enforcement may achieve compliance and thus result in lower sanction rates. Local offices may also have discretion to cancel sanctions that may not be socially desirable. PES may be willing to apply exemptions and monitoring may be constrained due to higher client to staff ratios and fewer job vacancies. On the ground, sanction rates seem relatively low except in Switzerland and in the United States. Grubb (2001) reports that the sanction rate during the benefit period reached 3.30% in Australia, 2.12% in Denmark, 10.19% in Finland, 1.14% in Germany, 7.32% in Norway, 5.52% in United Kingdom, 38.49% in Switzerland and 35.37% in the United States. More recently, the National Employment Office in Belgium estimates the sanction rate around 3.7% in 2015 (NEO, 2015). In our model, the parameter u is calibrated to obtain an average sanction rate of 3%. Said otherwise, if the agent produces zero effort ($e = 0$) then $h(e) = 0.5$, this implies that he has one chance out of two to be sanctioned if he is controlled. We test the robustness of the value of u in Appendix. Unsurprinsingly, the optimal profile of unemployment benefit is less declining with a more accurate monitoring technology. In particular, in case of control, if the unemployed are sure to be sanctioned if they do not search for a job, then the optimal profile is increasing and the probability of monitoring remains constant (see Table 12 in Appendix).

5.2 Numerical results

5.2.1 Optimal UI with an exogenous monitoring rate

In this section, we analyze how job-search monitoring modifies the profile of unemployment benefits. In Table 4, we consider that the monitoring rate μ is exogenous. The insurer minimizes its costs for a given monotoring rate, a given amount of unemployment assistance (b^s) and a given promised level of future expected discounted utility V_1^u. We assume that b^s is exogeneous and equals to 0.1. As we will see in our simulations, this unemployment assistance level corresponds to the optimal amount of unemployment insurance after a duration of unemployment of 1 year when there is no control.

Let us recall that the unemployed worker is sanctioned and is no more eligible at unemployment insurance if the search effort observed by the UI agency is below the required level of search e^*. After the sanction is imposed, unemployed worker perceives an assistance revenue which is runned by an unemployment assistance program. Table 4 presents the optimal replacement ratio according to different values of the monitoring rate μ. The first column reports the case where there is no control of job search activity as in the model of HN without taxes. In one year, the replacement ratio decreases from 0.87 to 0.13. This system is the least expensive because it offers good protection against loss of income at the beginning of the unemployment period while limiting the risk of moral hazard by promising a reduction of benefits in long-term. The average cost $C(V_1^u)$ by unemployed worker is equal to 807.7, i.e 8.07 months of wage.

Columns 2, 3, 4 and 5 give the optimal design for different values of monitoring rate. For $\mu = 0.1$, the unemployed worker is monitored every 10 weeks[8], the UI agency should propose a less declining profile to ensure the promised value. The replacement ratio deacreases from 0.82 to 0.3. This decreasing sequence

[8]The risk of control follows a Poisson process. Thus, the average duration between two controls is equal to the inverse of the probabilities.

at a fairly slow rate is the optimal contract because *(i)* risk-averse unemployed workers want to smooth their revenue and *(ii)* monitoring is a way to counter disincentive effects of unemployment insurance. Indeed, since agents are risk-averse, the loss of unemployment benefits implies a sharp reduction in utility. Therefore, the control implies a cost of being sanctioned for unemployed workers, this increases the level of job-search effort. To guarantee the promised value to the unemployed worker, the principal offsets the loss of utility due to the increase in search effort by a less decreasing profile. Although the compensation profile is more generous, the cost of the principal does not increase as a result of a faster return to work. Thus, note that the cost is reduced to 729.9 which represents a decrease of 1.8% compared to the benchmark case.

Note also that an increase of the frequency of monitoring tends toward a smoothing of the replacement ratio over time (from 0.77 to 0.64) and that for a frequency greater than 30% (a control every 3 weeks) the replacement ratio increases over time (from 0.75 to 1.06). The higher the control rate, the lower the utility of the unemployed. As a result, the insurer have to compensate for these losses by increasing the level of benefits. Thus, for a high level of control, the optimal ratio profile becomes increasing. An increase in unemployment benefits with the duration of unemployment decreases the gain to search for a job (the difference $(V^e - V^u)$ decreases) but increases the cost of shirking (the difference $(V^u - V^s)$ increases). Therefore as predicted by our theoretical result when monitoring is almost perfect or very frequent, the cost of shirking dominates the gain to search for a job. Then, to encourage the unemployed workers to search for a job, the UI agency has to increase the replacement ratio with the duration of unemployment because being sanctioned will induce a higher loss of revenue for them.

Increasing the unemployment benefits can also be interpreted as a bonus: in a system without monitoring, staying unemployed is automatically sanctioned by a reduction in the unemployed benefits. Whereas in a monitoring system, proving a job-search activity during each control is rewarded by higher unemployment benefits. This is a clearly positive view of the monitoring of unemployed workers job-search. If there is a monitoring of job-search activity, only those who do not search for job will be sanctioned. The others will be rewarded by higher benefits. Without monitoring of job-search activity, every unemployed worker will suffer from the reduction in unemployment benefits over time.

However, for values of μ greater than 0.2, the monitoring increases the average cost of an unemployed worker for the principal for two main reasons. First, higher frequencies of monitoring imply higher management costs for the UI agency and these higher costs are not offset by lower unemployment spells. Second, as we consider a given expected value of unemployment (promised value), a more frequent control has to be offset by less declining unemployment benefits over time which implies an increase in spending. Therefore, our numerical results suggest that the potential gains of the monitoring are around 1.8% for a relatively low frequency of control (every 10 weeks) and around 0.6% for a control every 5 weeks.

Table 4: Optimal unemployment insurance and monitoring

Weeks of unemployment	Frequency of job-search monitoring $\mu = 0$	$\mu = 0.1$	$\mu = 0.2$	$\mu = 0.3$	$\mu = 0.4$
1	0.87	0.82	0.77	0.75	0.77
2	0.83	0.79	0.76	0.76	0.77
3	0.78	0.77	0.76	0.77	0.78
4	0.73	0.76	0.76	0.77	0.79
5	0.69	0.74	0.76	0.78	0.79
6	0.67	0.72	0.76	0.78	0.80
7	0.63	0.69	0.75	0.79	0.81
8	0.61	0.68	0.75	0.79	0.82
12	0.48	0.63	0.74	0.83	0.84
16	0.41	0.57	0.73	0.86	0.87
20	0.35	0.53	0.72	0.88	0.89
24	0.30	0.48	0.71	0.90	0.92
28	0.26	0.45	0.70	0.92	0.94
32	0.22	0.42	0.69	0.94	0.98
36	0.20	0.38	0.68	0.96	1.00
40	0.17	0.36	0.67	0.98	1.02
44	0.16	0.34	0.66	1.01	1.03
48	0.14	0.32	0.65	1.04	1.05
52	0.13	0.30	0.64	1.06	1.07
Cost	807.7	792.9	802.6	833.2	875.6

5.2.2 Optimal UI with an endogenous monitoring rate

In this section, we consider that the principal has two other tools to define the optimal contract: the optimal frequency of control (μ is now endogenous) and the sequence of replacement ratio for sanctioned workers. Thus, the UI agency chooses the optimal sequence of unemployment benefits over time, the optimal frequency of control and non-degressive replacement ratio for sanctioned workers. In other words, the principal chooses the replacement ratio for sanctioned workers according to the date of sanction, but this replacement ratio remains flat during the rest of the unemployment duration.

Table 5 reports the optimal unemployment contract under these conditions. Column 1 gives the sequence of unemployment benefits over time for insured unemployed workers. The replacement ratio decreases from 0.80 to 0.23. It is a less decreasing profile than the one without control, but more decreasing than the one with an exogenous control rate. Column 2 reports the optimal probability of monitoring. μ decreases with the duration of unemployment (from 0.12 to 0.02, one control every 8 weeks at the beginning of the unemployment speel to one control per year). In other words, unemployed workers are actively controlled during the first weeks of their unemployment spell, then if they search for a job actively (*ie* if their level of job-search is higher than the required level of job-search), the frequency of control decreases. So, a sufficiently high job-search effort is rewarded by a drop in the probability of monitoring over the remaining duration of unemployment. This is clearly in contrast with what is practiced in France: monitoring is weak during the first weeks of the unemployment duration but is more intense for long-term unemployed.

Finally, column 3 gives the optimal flat ratio for sanctioned unemployed. This ratio is very low and decreases with the date of the sanction. For instance, an unemployed who is sanctioned at his 4th week of unemployment, perceives a replacement ratio of 19%. This ratio falls to 6% if he is sanctioned after a year of unemployment. This very low ratio for sanctioned unemployed is explained by the flat profile of the replacement ratio during the remaining duration of unemployment. So, to provide the right incentives to search, the principal has to propose a less generous replacement ratio.

In the presence of these 3 tools, the average cost of an unemployed person for the principal is 654.2, which is 17.5% less than in the case with exogenous control. The main strategy for the principal is to reward over time the unemployed providing the requested effort. Thus, the decline in the replacement ratio is lower and the control rate decreases with time. The disappearance of control is a way of rewarding the unemployed who have made an effort at the beginning of the period of unemployment. This strategy is not costly insofar as it is sufficiently incentive for few unemployed workers to be present after one year. Moreover, since agents are risk-averse, the small amount of ratio for sanctioned agents is a strong incentive to produce the required effort. The decrease in reduced unemployment benefits with the date of the sanction b^s allows to reduce the control rate. However, we made the assumption that, once sanctioned, the benefits of the agents were stable over time. Theoretically, nothing prevents the principal from also

Table 5: Optimal unemployment insurance and flat sanction

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring	Optimal flat ratio for sanctioned workers
1	0.80	0.12	0.19
2	0.78	0.12	0.19
3	0.76	0.12	0.19
4	0.75	0.12	0.19
5	0.74	0.11	0.18
6	0.73	0.11	0.18
7	0.72	0.11	0.17
8	0.71	0.11	0.17
12	0.64	0.10	0.16
16	0.59	0.09	0.15
20	0.54	0.08	0.14
24	0.49	0.07	0.13
28	0.44	0.06	0.12
32	0.39	0.05	0.11
36	0.35	0.04	0.10
40	0.32	0.03	0.09
44	0.29	0.03	0.08
48	0.26	0.02	0.07
52	0.23	0.02	0.06
Cost	654.20		

modulating these benefits to give good incentives to the sanctioned unemployed workers. This is what we will see in the next section.

5.2.3 Optimal UI with endogenous monitoring rate and optimal decreasing sanction

In this section, we assume that the principal can design an unemployment insurance contract where each tool is endogenous: the sequence of unemployment benefits for insured and sanctioned unemployed (b_t, $b^s_{t,j}$) and the probability of monitoring μ. The results are reported in table 6. This optimal contract is characterized by a decreasing profile of unemployment benefits (from 0.80 to 0.24), a lowering probability of monitoring over time and reduced unemployment benefits b^s that decrease with the date of the sanction T and that decrease also over time j as sanctioned unemployed.

Note that this reduced unemployment benefits is higher than when the replacement ratio is flat during the remaining spell of unemployment (see Table 5). In fact, the replacement ratio when agents are monitored in $T = 1$ is 29%. Without a declining sequence of this replacement ratio, the principal should propose a less generous replacement ratio of 19%. As b^s decreases with j, job search effort is

Table 6: Optimal unemployment insurance and decreasing sanction

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring	Optimal decreasing ratio for sanctioned workers				
			$T = 1$	$T = 4$	$T = 8$	$T = 16$	$T = 32$
1	0.80	0.13	0.29				
2	0.79	0.12	0.28				
3	0.77	0.12	0.27				
4	0.76	0.12	0.26	0.26			
5	0.74	0.12	0.26	0.26			
6	0.73	0.11	0.25	0.25			
7	0.71	0.11	0.25	0.25			
8	0.70	0.11	0.24	0.24	0.24		
12	0.64	0.10	0.20	0.20	0.20		
16	0.59	0.09	0.17	0.17	0.17	0.17	
20	0.54	0.08	0.15	0.15	0.15	0.15	
24	0.49	0.07	0.13	0.13	0.13	0.13	
28	0.44	0.07	0.12	0.12	0.12	0.12	
32	0.40	0.06	0.11	0.11	0.11	0.11	0.11
36	0.36	0.05	0.11	0.11	0.11	0.11	0.11
40	0.33	0.04	0.10	0.10	0.10	0.10	0.10
44	0.29	0.04	0.10	0.10	0.10	0.10	0.10
48	0.26	0.03	0.09	0.09	0.09	0.09	0.09
52	0.24	0.03	0.09	0.09	0.09	0.09	0.09
Cost	651.20						

more stimulated than with a flat profile. In fact, the replacement ratio and the control rate of non-sanctioned agents are not significantly changed by the introduction of this new hypothesis. This means that the principal offers the same utility to the sanctioned unemployed that in the case studied in Table 5. However, this utility is given in a different way: The replacement ratio is higher when applying the penalty, but decreasing with time. In the long run, it tends to zero. Unlike the flat penalty profile, this mechanism gives new incentives to the unemployed who are sanctioned while improving their income at the beginning of the penalty period. As a result, the cost of the optimal contract is 651.2 being a saving of 19.37% with respect to the system of HN and a saving of 34.8% with respect to a system where unemployment benefits are not decreasing and where there is no control.

6 Conclusion

This paper reconsiders the traditional thoughts on optimal unemployment insurance. In a more general framework than Hopenhayn and Nicolini (1997) and Shavell and Weiss (1979), we show that job-search monitoring and sanctions can modify the optimal sequence of unemployment benefits with the unemployment duration.

We show that when unemployment insurance (UI) and unemployment assistance (UA) are managed independently, a growing profile increases the cost to be controlled to shirk but decreases the profit to carry out a search effort and to become an employed worker. While a decreasing profile reduces the cost with being controlled to shirk and increases the profit to search for a job. Therefore if the probability of finding a job is stronger (and the probability of monitoring is weak), the effect on the profit to carry out the search effort dominates. To encourage the unemployed ones to search, the agency must then propose decreasing allowances with the unemployment duration in order to increase the profit to find a job. Conversely with a strong probability of monitoring job-search activity, the effect on the cost of shirking dominates. Under these conditions, the agency should propose an increasing profile of the unemployment benefits in order to make costly the absence of search effort.

On the other hand, when UI and UA are managed jointly, we show that the optimal contract is characterized by a decreasing profile of unemployment benefits and sanctioned benefits and a lowering probability of monitoring over time. It is noteworthy that, in each cases, this optimal sequence of unemployment benefits is smoother than in the Hopenhayn and Nicolini's system without tax and this optimal contract is associated with a sharp saving cost.

Appendix

Clearly, the previous results may be strongly dependent on two of the values adopted in our calibration: the cost of monitoring θ and the noise u. The following tables present the results with the benchmark calibration (Table 7) and sensitivity tests on these two parameters. In all cases, the simulations are realized for the case where the principal can use all the economic policy tools: the sequence of the unemployment benefits for non-sanctioned unemployed workers, the monitoring rate and the penalty level (unemployment benefits for sanctioned unemployed).

A Robustness test on cost of monitoring θ

Tables 8 and 9 respectively represent the case of a decrease and a rise of 10% in the cost of control. It appears that the higher the cost of the control, the higher the profile of unemployment benefits is decreasing. To encourage return back to work, the principal has two solutions: *(i)* increase the decreasing of benefits or *(ii)* increase the level of control. Therefore, all other things being equal, the principal reduces the level of control and instead uses the declining benefits when the cost of monitoring increases.

Table 7: Benchmark calibration

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.80	0.13
2	0.79	0.12
3	0.77	0.12
4	0.76	0.12
5	0.74	0.12
6	0.73	0.11
7	0.71	0.11
8	0.70	0.11
12	0.64	0.10
16	0.59	0.09
20	0.54	0.08
24	0.49	0.07
28	0.44	0.07
32	0.40	0.06
36	0.36	0.05
40	0.33	0.04
44	0.29	0.04
48	0.26	0.03
52	0.24	0.03

However, this effect remains relatively small since that the expenses associated with the monitoring are insignificant compared to the compensation expenses.

B Robustness test on the noise u

In order to analyze the effects of the precision of the monitoring technology, we propose a noise sensitivity test. The tables 10 and 11 show the results for values of the noise u of 200 and 400. Table 11 shows that the higher the noise, the more the profile is decreasing. This result can be explained simply: when the noise is high, the monitoring technology is less accurate for an identical monitoring cost. Therefore, the principal prefers to use declining benefits with the unemployment duration to encourage the return to work. For a noise level that tends towards infinity, the probability of detection $h(.)$ tends to 0. Then, this situation is identical to the one where there is no control and the model converges to the case HN. Conversely, if the noise is low, the principal observes the effort more precisely. Then this tool can be

Table 8: Calibration $\theta = 180$

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.78	0.14
2	0.77	0.14
3	0.76	0.13
4	0.75	0.13
5	0.74	0.13
6	0.72	0.13
7	0.71	0.13
8	0.70	0.12
12	0.66	0.12
16	0.62	0.11
20	0.56	0.10
24	0.52	0.09
28	0.49	0.08
32	0.44	0.07
36	0.40	0.06
40	0.36	0.05
44	0.33	0.05
48	0.29	0.04
52	0.27	0.04

Table 9: Calibration $\theta = 220$

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.81	0.12
2	0.78	0.12
3	0.77	0.12
4	0.75	0.12
5	0.73	0.11
6	0.72	0.11
7	0.71	0.11
8	0.70	0.11
12	0.64	0.10
16	0.58	0.08
20	0.53	0.08
24	0.48	0.07
28	0.42	0.06
32	0.38	0.05
36	0.35	0.04
40	0.32	0.03
44	0.29	0.03
48	0.25	0.02
52	0.22	0.01

Table 10: Calibration $u = 200$

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.76	0.13
2	0.76	0.13
3	0.75	0.13
4	0.75	0.13
5	0.75	0.13
6	0.75	0.13
7	0.74	0.13
8	0.74	0.13
12	0.71	0.12
16	0.69	0.12
20	0.67	0.12
24	0.66	0.12
28	0.64	0.11
32	0.61	0.11
36	0.60	0.11
40	0.58	0.11
44	0.57	0.10
48	0.53	0.10
52	0.52	0.10

used instead of degressivity to encourage a return to work. Since agents are risk-averse, the principal can increase the level of monitoring and in return proposes a less declining profile that limits income fluctuations, as shown on Table 10.

In Table 12, we increase the accuracy of the monitoring technology. For an unemployed worker who does not search for a job, the probability to enter the sanction regime is equal to 1 ($h(e) = 1$ for $e = 0$). Said otherwise, if he is controlled, he is sure to be sanctioned. In this case, the optimal profile of unemployment benefits is increasing ranging from 0.76 to 0.88. And the probability of monitoring is flat (one control every 8 weeks). As the monitoring is almost perfect, monitoring is more efficient and the principal can propose increasing unemployment benefits with the unemployment spell.

Table 11: Calibration $u = 400$

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.82	0.12
2	0.80	0.11
3	0.78	0.11
4	0.75	0.10
5	0.74	0.10
6	0.70	0.10
7	0.69	0.10
8	0.66	0.09
12	0.60	0.08
16	0.52	0.07
20	0.46	0.05
24	0.40	0.05
28	0.36	0.04
32	0.31	0.03
36	0.28	0.03
40	0.24	0.02
44	0.22	0.02
48	0.20	0.01
52	0.17	0.01

Table 12: Calibration u=150

Weeks of unemployment	Unemployment benefits	Probability μ of monitoring
1	0.73	0.12
2	0.73	0.12
3	0.73	0.12
4	0.74	0.12
5	0.74	0.12
6	0.74	0.12
7	0.75	0.12
8	0.75	0.12
12	0.76	0.12
16	0.78	0.13
20	0.77	0.13
24	0.79	0.13
28	0.80	0.13
32	0.82	0.13
36	0.83	0.13
40	0.84	0.13
44	0.86	0.13
48	0.87	0.13
52	0.88	0.13

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