Unemployed but Optimistic:
Optimal Insurance Design with Biased Beliefs

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Abstract

Biased perceptions of risks change the perceived value of insurance and the perceived returns to avoiding these risks. I show empirically that unemployed workers overestimate how quickly they will find work, but underestimate the return to their search efforts. I analyze the consequences for the optimal design of unemployment insurance, building on the seminal result for unbiased beliefs derived by Baily (1978). With unbiased beliefs, contracts equalizing the marginal smoothing benefit and the moral hazard cost of insurance are optimal. Biased beliefs make such contracts suboptimal and drive a wedge between social and private insurance. A paternalistic social planner corrects the moral hazard cost for the distortion in the insured's effort choice, while private insurers focus on the perceived rather than the true smoothing benefits. When unemployed workers are optimistic, privatizing unemployment insurance may result in inefficiently low or rapidly decreasing unemployment benefits.

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1 Introduction

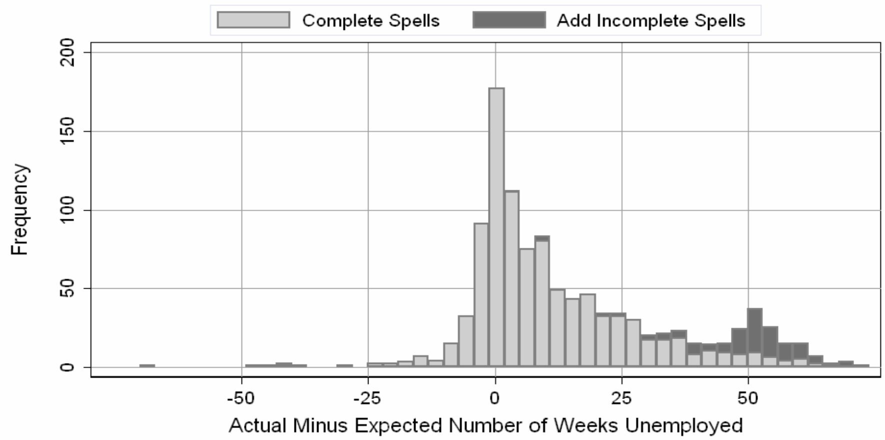
Insurers face the trade-off between providing insurance against risks and incentives to avoid risks. The risk perceptions of the insured are central to this trade-off. The perceived likelihood of risks determines the perceived value of insurance against these risks. The perceived return to precautionary effort determines the effectiveness of incentives to avoid risks. Both types of perceptions are often subject to systematic biases. Psychological research has shown that people often overestimate the probability of positive events and underestimate the probability of negative events (Weinstein 1980, 1982 and 1984, Slovic 2000) and can either be optimistic (Langer 1975) or discouraged about the degree to which they control outcomes (Jahoda 1971). These particular biases complement the heuristics and biases in probabilistic thinking documented by Tversky and Kahneman (1974).

The central contribution of this paper is the theoretical and empirical analysis of unemployment insurance and the biases in beliefs held by the unemployed. On the theoretical side, I analyze how biased beliefs change the optimal design of static and dynamic insurance contracts in the presence of moral hazard. The distinction between the *baseline belief* about the probability of finding work and the *control belief* about the extent to which search efforts increase this probability is shown to be essential. The theoretical results generalize to insurance applications with moral hazard, other than unemployment insurance. On the empirical side, I present new evidence that suggests that job seekers are highly optimistic about the probability of finding a job, but pessimistic about their control.

Using data collected by Price, Vinokur, Howe, and Caplan (1998), I link the expectations of unemployed job seekers with the actual outcome of their job search. The first empirical result is that job seekers largely underestimate the duration of their unemployment spell; on average they expect to remain unemployed for 7 weeks, but actually need 23 weeks to find new employment. Many more job seekers have underestimated rather than overestimated the length of their unemployment spell and the forecast errors are much more pronounced for the optimistic than for the pessimistic job seekers, as presented in Figure 1. The second empirical result is that job seekers who report searching more intensively are less optimistic about the length of their unemployment spell. Controlling for heterogeneity and endogeneity, I provide evidence that job seekers underestimate the returns to their search efforts. Job seekers who search harder expect shorter unemployment spells, but the actual reduction in the unemployment spell is larger than expected. This suggests that job seekers are at the same time baseline-optimistic and control-pessimistic; they overestimate the baseline probability of finding work, but underestimate their control over this probability.

The theoretical analysis builds on a canonical result for social insurance known as the Baily formula. Optimal insurance equalizes the benefit of smoothing consumption

Figure 1: Histogram of Differences between Actual and Expected Unemployment Duration



Source: Unemployed job seekers in Maryland and Detroit between 1996 and 1998 surveyed by Price et al. (1998).

between states and the moral hazard cost at the margin. Baily (1978) formalized this principle for unemployment insurance in a static model with moral hazard. For unemployment insurance to be optimal, the relative difference in marginal utilities of consumption in employment and unemployment has to be equal to the elasticity of the unemployment duration to the unemployment benefit level. I show how this characterization needs to be adjusted when the insured have biased beliefs. I assume that the insurer knows the insured's beliefs and that these beliefs cannot be manipulated by the insurer, nor changed in response to the contract being offered.[1]

I contrast the contracts offered by two extreme types of insurers: a social planner, who is paternalistic and maximizes the insured agent's *true* expected utility, and competing private insurers, who maximize the insured agent's *perceived* expected utility. When beliefs are unbiased, the probability weights in the respective expected utility functions are the same. The social optimum and the competitive equilibrium coincide. Moral hazard, in contrast with adverse selection, is no reason for government intervention as long as beliefs are unbiased. When beliefs are biased, the social optimum and the competitive equilibrium diverge. The implied wedge suggests a previously unexplored welfare cost of privatizing insurance.

In the social optimum the smoothing benefit and the moral hazard cost are still equalized at the margin, but with the moral hazard cost corrected for the *search internality* that arises when the insured agent misperceives the impact of her search on her own true expected utility. An increase in insurance coverage decreases the induced effort level, but when an agent is pessimistic about her control, she already exerts too little effort. Thus with control-pessimistic insurees, the moral hazard cost of insurance needs to be revised upward because of the search internality. The elasticity

[1] These assumptions correspond to a setting with different priors where the insurer and the insured 'agree to disagree'.

of the unemployment duration to unemployment benefits no longer provides sufficient information to implement the optimal insurance contract. A naive policy maker, who ignores the pessimistic control bias and implements the standard Baily formula, sets the unemployment benefit level suboptimally high.

Private insurers do not correct for the search internality and focus on the insured's perceived value of insurance. In the competitive equilibrium, the moral hazard cost of additional insurance is set equal to the *perceived smoothing benefit*. When an agent is optimistic about the baseline probability of finding work, she underestimates the value of unemployment insurance. Private insurers respond to this bias by offering less or even no insurance at all. This may explain the puzzle of why unemployment insurance is almost always publicly provided.[2] Competition disciplines insurers to charge actuarially fair prices, but not to correct people's distorted demand for insurance.

I proceed to consider a dynamic extension of the unemployment model along the lines of Hopenhayn and Nicolini (1997). The conventional wisdom in economic policy debates is that unemployment benefits should be decreasing with the length of the unemployment spell. The threat of falling benefits in the future increases the incentives for unemployed workers to search for work (Shavell and Weiss 1979). First, I show, using Baily-type conditions, that the adjustment of the optimal dynamic characterization for the presence of biases in beliefs is very similar as in the static model; the social planner corrects the moral hazard cost for the search internality, while the private insurers focus on the perceived smoothing benefits. Second, when unemployed agents underestimate the duration of unemployment, the social planner may increase welfare by providing more incentives to the short-term unemployed than to the long-term unemployed. Optimism about the duration of unemployment makes the threat of receiving lower unemployment benefits in the future less effective in inducing search efforts. I show that in contrast with private insurers, the social planner may prefer to make unemployment benefits more rapidly decreasing at the start of the unemployment spell and more slowly later on.

I calibrate the dynamic model in order to numerically analyze the impact of biased beliefs on the optimal design of unemployment insurance. The calibration exercise also shows that the consumption subsidy required to make the agent insured by private insurers as well off as in the social optimum, increases exponentially in the baseline bias. Although the risk of an unemployment spell seems small within a lifetime, privatizing the insurance provision comes at a very high welfare cost if beliefs are strongly biased.

[2] Exceptions are unemployment insurance provided by trade unions or voluntary public unemployment insurance systems in countries like Denmark, Finland and Sweden, grown out of trade union programs (Parsons et al. 2003). The latter are heavily subsidized by the government, as expected with baseline-optimistic insurees. The existence of private information and aggregate risk and the government's advantage in coping with moral hazard have been suggested as explanations for the absence of private unemployment insurance (Chiu and Karni 1998, Barr 2001). Acemoglu and Shimer (2000) conclude: "Why unemployment insurance is almost always publicly provided, in contrast to most other insurance contracts, remains an important, unresolved question."

Related Literature The empirical and experimental evidence on the misperceptions of probabilities has lead to two recent strands of literature. One strand proposes explanations for biases in beliefs and shows how these biases can be sustained in equilibrium. Examples are Bénabou and Tirole (2002 and 2006), Compte and Postlewaite (2004), Glaeser (2004), Van den Steen (2004), Brunnermeier and Parker (2005), Gollier (2005) and Köszegi (2006). These theoretical papers suggest that optimistic beliefs, either about the baseline probability of success or one's control, are more likely to arise and persist than pessimistic beliefs. This corresponds to the empirical evidence that I find for the unemployed's baseline beliefs, but contrasts with the empirical evidence for the unemployed's control beliefs.

The theoretical analysis in this paper is related to the second strand of literature that takes biases in risk perceptions as given and analyzes the consequences for contract design in the presence of moral hazard or adverse selection. De la Rosa (2007) and Santos-Pinto (2008) analyze how incentive contracts proposed by a profit-maximizing principal change in response to particular optimistic biases. The response depends on the extent to which the considered biases make the agent more baseline-optimistic or control-optimistic as defined here. Also, changes in control beliefs change the price of providing incentives relative to insurance. The effect of changing control beliefs on the induced effort level is unambiguous, the effect on the insurance provision is not. The main focus of this paper is on the unambiguous comparison, for a given bias in beliefs, between social and private insurance on the one hand and optimal and naive implementation on the other hand. Jeleva and Villeneuve (2004) and Villeneuve (2005) study the effects of exogenous biased beliefs in models with adverse selection due to heterogeneity in risk. Eliaz and Spiegler (2008), Grubb (2009), Sandroni and Squintani (2007) and Spinnewijn (2009) study adverse selection due to heterogeneity in risk perceptions. Spinnewijn (2009) relaxes the assumption in this model that the agent's prior is known to the principal and analyzes how agents are screened with contracts providing different levels of insurance coverage depending on the difference in baseline and control beliefs.

The comparison between social and private insurance relates to the policy and welfare analysis in the behavioral public economics literature, studying non-standard decision makers.[3] The use of the true probabilities to evaluate welfare is paternalistic, but highlights the contrast with the considerations of profit-maximizing insurers. The comparison also relates to the distinction between a paternalistic and populist government, with the latter catering to its voters' beliefs (Salanié and Treich 2009). The use of the true probabilities also assumes that these are measurable. Bernheim and Rangel (2008) argue that the presence of ancillary conditions, like framing issues, may distort people's choices. To the extent that better informing individuals alleviates ancillary conditions, the perceived probabilities after individuals are informed are more

[3] For reviews, see Kanbur, Pirttila and Tuomala (2004) and Bernheim and Rangel (2007).

appropriate for evaluating their welfare than the perceived probabilities before they are informed. The empirical estimation of the biases in beliefs in this paper can help to identify agents' true preferences from their observed choices, as argued by Köszegi and Rabin (2007 and 2008). Finally, the comparison between the implementation of the standard and adjusted Baily formula adds to the recent literature reviewed by Chetty (2008a) that analyzes conditions under which sufficient statistic formulas for taxation and social insurance apply or need to be adjusted.

The paper is organized as follows. Section 2 introduces a static model of unemployment insurance and defines the baseline bias and control bias in beliefs. Section 3 characterizes the optimal insurance contract given the biases in beliefs, as proposed by the social planner and private insurers. Section 4 extends the analysis to a dynamic framework. Section 5 discusses the data and shows the empirical estimates of the baseline and control bias. Section 6 calibrates the dynamic model given the empirical estimates in order to calculate the optimal contracts and the welfare cost of privatizing insurance numerically. Section 7 concludes. All proofs and tables are presented in the appendix.

2 Static Model

A risk-averse agent, whom I refer to as the *insuree*, is employed with exogenous probability p and unemployed with probability $1-p$.[4] When unemployed, the insuree exerts unobservable search effort at utility cost $e \in E$. She finds work with probability $\pi(e)$ and remains unemployed with probability $1-\pi(e)$. The insuree produces w when employed and 0 when unemployed. A risk-neutral *insurer* offers a contract (b, τ) that provides insurance against the unemployment risk. When the insuree starts the period employed, she consumes her after tax wage $w-\tau$. When the insuree starts the period unemployed, she consumes unemployment benefit b if she does not find work, but wage w if she does find work. This static setup follows Baily (1978) very closely.[5]

Central to this model is the assumption that the insuree may perceive the probability of finding work differently from the true probability. I denote by $\hat{\pi}(e)$ the insuree's belief about the probability of finding work when she exerts effort e. Both the true probability of success $\pi(e)$ and the perceived probability of success $\hat{\pi}(e)$ are increasing and concave in e. I deliberately put no restrictions on how the true and perceived probability are related. The analysis, however, will show that the difference is essential

[4] An insuree is defined in the Oxford English Dictionary as a person whose life or property is insured. I use this term in line with previous literature to clearly contrast the person providing and the person receiving insurance.

[5] I relax Baily's assumption that once unemployed, the agent becomes risk neutral between being unemployed and employed. However, I also assume that the unemployed agent does not pay taxes upon employment. This implies that the optimal search level does not depend on taxes and taxes can be written explicitly as a function of unemployment benefits only. I relax this assumption in the dynamic model.

in two dimensions; the difference in levels $\hat{\pi}(e) - \pi(e)$ and the difference in margins $\hat{\pi}'(e) - \pi'(e)$. The difference in levels, the *baseline bias*, determines the difference between the true and perceived value of insurance. The difference in the margins, the *control bias*, determines the difference between the true and perceived marginal return of search and therefore the distortion in the choice of search effort.

Definition 1 *An insuree is baseline-optimistic (baseline-pessimistic) if* $\hat{\pi}(e) \geq \pi(e)$ *(*$\pi(e) \geq \hat{\pi}(e)$*) for all* $e \in E$.

Definition 2 *An insuree is control-optimistic (control-pessimistic) if* $\hat{\pi}'(e) \geq \pi'(e)$ *(*$\pi'(e) \geq \hat{\pi}'(e)$*) for all* $e \in E$.

For expositional purposes, I consider biases in beliefs that are the same for all effort levels, although only the local biases in beliefs matter for the optimality conditions. Baseline and control beliefs are related, as illustrated in the following two examples.

Example I $\pi(e) = \theta e^{\alpha}$ *and* $\hat{\pi}(e) = \hat{\theta} e^{\alpha}$

In this example the probability of finding work is complementary in the insuree's ability θ and effort e. An insuree who overestimates her ability (i.e. $\hat{\theta} > \theta$) is at the same time baseline-optimistic and control-optimistic.

Example II $1 - \pi(e) = \frac{1 - e^{\alpha}}{\theta}$ *and* $1 - \hat{\pi}(e) = \frac{1 - e^{\alpha}}{\hat{\theta}}$

In this example the insuree's ability θ determines the probability of finding work when no effort is exerted. Ability and effort are now substitutes; effort increases the probability of finding work more if ability is lower. An insuree who overestimates her ability (i.e. $\hat{\theta} > \theta$) is baseline-optimistic, but control-pessimistic.

I focus the analysis on baseline optimism and control pessimism. This corresponds to the second example and is in line with the empirical evidence presented in this paper. The results are opposite for baseline pessimism and control optimism.

2.1 The Insuree's Problem

The insuree's perceived expected utility from the insurance contract (b, τ) and search effort e equals

$$\hat{U}(b, \tau, e) = pu(w - \tau) + (1 - p)\left[\hat{\pi}(e) u(w) + (1 - \hat{\pi}(e)) u(b) - e\right].$$

The Bernouilli-utility u is increasing and concave in consumption. In this static model, the insuree exerts costly search effort when she starts without a job and either finds a job immediately or is unsuccessful and consumes the unemployment benefit b. The insuree weighs the uncertain outcomes of search with the perceived probabilities $\hat{\pi}(e)$ and $1 - \hat{\pi}(e)$. In a dynamic setting, the periodic probability of finding a job is the inverse of the expected duration of unemployment. A baseline-optimistic insuree overestimates

the probability of finding a job or, similarly, underestimates the expected duration of unemployment.

When unemployed, the insuree searches to maximize her perceived expected utility. Her effort choice $\hat{e}(b)$ equalizes the perceived individual benefit and cost of search at the margin,

$$\hat{\pi}'(e)\left[u(w)-u(b)\right]=1. \tag{IC}$$

Higher unemployment benefits reduce the utility gain of finding a job. The induced effort level $\hat{e}(b)$ is thus decreasing in the unemployment benefit b. Moral hazard arises since the insuree does not internalize the impact of her effort on the insurer's budget constraint. The first-best effort level is higher than the effort choice of the insuree and the difference between the two increases with control pessimism. A control-pessimistic insuree exerts less effort than an insuree with unbiased beliefs, since she perceives the marginal return to effort to be lower than the true marginal return, $\hat{\pi}'(e)<\pi'(e)$. Given the concavity of the insuree's problem, the first order condition is sufficient for the unemployment benefit to be incentive compatible with search effort e.[6]

2.2 The Insurer's Problem

The expected profits for the insurer from an insurance contract (b,τ) equal

$$P(b,\tau)\equiv p\tau-(1-p)\left(1-\pi\left(\hat{e}(b)\right)\right)b.$$

The expected expenditures depend on the true probability that the insuree does not find employment $1-\pi(\hat{e}(b))$. Since effort is not contractible, the insurer is constrained by the insuree's effort choice $\hat{e}(b)$. For a given contract, the insurer's profits are higher the more the unemployed insuree searches. I denote by $\hat{\tau}(b)$ the tax required in order to keep the budget balanced,

$$\hat{\tau}(b)\equiv\frac{(1-p)\left(1-\pi\left(\hat{e}(b)\right)\right)}{p}b.$$

I contrast two types of insurers with different objectives; a paternalistic social planner and competing private insurers.

The social planner cares about the insuree's true expected utility and thus weights the uncertain outcomes of the insuree's search effort with the true probabilities $\pi(e)$ and $1-\pi(e)$. Assuming a balanced budget, the (constrained) social optimum solves

$$\begin{aligned}&\max_{b,\tau,e}\ U(b,\tau,e)=pu(w-\tau)+(1-p)\left[\pi(e)\,u(w)+(1-\pi(e))\,u(b)-e\right]\\&\qquad\text{subject to } (IC) \text{ and } P(b,\tau)=0.\end{aligned} \tag{1}$$

[6] I assume that a positive level of effort is exerted in the social optimum or the competitive equilibrium. The condition that $\hat{\pi}'(0)=\infty$ is sufficient for this to hold.

Private insurers maximize their profits and compete to attract insurees. Competition drives profits to zero and insurees choose the contract that maximizes their perceived expected utility. The competitive equilibrium contract solves

$$\max_{b,\tau,e} \hat{U}(b,\tau,e) = pu(w-\tau) + (1-p)\left[\hat{\pi}(e)\,u(w) + (1-\hat{\pi}(e))\,u(b) - e\right] \quad \text{subject to } (IC) \text{ and } P(b,\tau)=0. \tag{2}$$

In contrast with the social planner's objective function in (1), the uncertain outcomes of the insuree's search effort are weighted with the perceived probabilities $\hat{\pi}(e)$ and $1-\hat{\pi}(e)$.[7]

3 Optimal Insurance Contracts

An insurer faces the trade-off between smoothing consumption between employment and unemployment and providing incentives for search. The insuree's perception of the probability to remain unemployed and the returns to her search effort is central to this trade-off.

3.1 Unbiased Beliefs: the Baily Formula

If the beliefs about the returns are unbiased (i.e. $\hat{\pi}(\cdot) = \pi(\cdot)$), the contracts proposed by the social planner and the private insurers in a competitive equilibrium coincide. The optimal contract equalizes the consumption smoothing benefit and the moral hazard cost of insurance at the margin.

Consumption Smoothing Unemployment benefits smooth the risk-averse insuree's consumption when unemployed. The smoothing benefit of further increasing the unemployment benefit b equals the relative difference in marginal utilities of consumption when unemployed and employed,

$$\frac{u'(b) - u'(w-\hat{\tau}(b))}{u'(w-\hat{\tau}(b))}.$$

Everything else equal, the smoothing benefit is decreasing in both the unemployment benefit b and the tax $\hat{\tau}(b)$. Less effort $\hat{e}(b)$ increases the required tax $\hat{\tau}(b)$ and thus decreases the marginal smoothing benefit.

Moral Hazard Higher benefits reduce the incentives for an unemployed insuree to search for work. A tax raise is required to balance the budget in response to an

[7] Chetty and Saez (2008) consider the optimal level of social insurance when private insurance is endogenous. I consider the insurance contract provided by either the social planner without the presence of private insurers or by competing private insurers without the presence of social insurance.

increase in the benefit b. This tax raise is higher the more search decreases. The tax $\hat{\tau}(b)$ is thus increasing in the benefit b, both because of the increased expenditures for an unemployed insuree and the increased probability that an insuree is unemployed,

$$\frac{d\log(\hat{\tau}(b))}{d\log b} = 1 + \varepsilon_{1-\pi(\hat{e}(b)),b}$$

where

$$\varepsilon_{1-\pi(\hat{e}(b)),b} \equiv \frac{d\log(1-\pi(\hat{e}(b)))}{d\log b}.$$

The required tax increase due to moral hazard is completely determined by the elasticity $\varepsilon_{1-\pi(\hat{e}(b)),b}$, which describes the responsiveness of the true probability of unemployment with respect to unemployment benefits. This responsiveness determines the relative price of consumption during unemployment and employment. The lower the responsiveness, the better the rate at which consumption is being transferred from employment to unemployment.

The optimal contract equalizes the relative marginal utility and the relative price of consumption in employment and unemployment.

Proposition 1 *With unbiased beliefs, optimal unemployment insurance is characterized by*

$$\frac{u'(b) - u'(w-\hat{\tau}(b))}{u'(w-\hat{\tau}(b))} = \varepsilon_{1-\pi(\hat{e}(b)),b} \ . \tag{3}$$

The maximization problems in (1) and (2) coincide when beliefs are unbiased. The proposition follows from the first order condition with respect to b,

$$u'(b) - u'(w-\hat{\tau}(b))\left[1+\varepsilon_{1-\pi(\hat{e}(b)),b}\right] = 0.$$

The insurer sets the unemployment benefit such that the utility gain when unemployed from an increase in the benefit b equals the utility loss when employed, coming from the increase in taxes required to satisfy the budget constraint. The increase in the benefit also reduces the exerted effort. However, when insurees have unbiased beliefs, the impact of the reduced effort on the expected utility is of second order by the envelope condition. I assume that the primitives are such that the second order condition holds globally.[8] This requires that $\frac{u'(b)-u'(w-\hat{\tau}(b))}{u'(w-\hat{\tau}(b))}$ decreases more in b than $\varepsilon_{1-\pi(\hat{e}(b)),b}$.

If the insuree is irresponsive to incentives, the moral hazard cost disappears and full insurance is optimal. Everything else equal, a higher elasticity implies a higher moral hazard cost and therefore a lower optimal unemployment benefit. However, if a change in the fundamentals does not only increase the elasticity, but also effort, an increase in both the consumption levels during employment and unemployment becomes feasible. The effect on the optimal unemployment benefit level is ambiguous.

[8] In the appendix, I derive the condition for global concavity of the maximization problem for the generalized model with biased beliefs.

Using a Taylor approximation for the marginal utility in the left hand side of (3) leads to the standard formula derived by Baily (1978),

$$\gamma \frac{\Delta c}{c} \cong \varepsilon_{1-\pi(\hat{e}(b)),b},$$

with γ the relative risk aversion, $\frac{\Delta c}{c}$ the relative change in consumption between employment and unemployment and $\varepsilon_{1-\pi(\hat{e}(b)),b}$ the elasticity of the unemployment duration with respect to benefits. The identification of these three statistics is sufficient to test for the optimality of the current unemployment insurance system (Gruber 1997). For instance, identifying the primitives underlying the moral hazard problem is not necessary if the elasticity $\varepsilon_{1-\pi(\hat{e}(b)),b}$ is known. Chetty (2008a) reviews the recent literature developing "sufficient statistic formulas" for social insurance and optimal taxation. In particular, Chetty (2006) shows how the Baily formula generalizes in a dynamic framework and is robust to the introduction of borrowing constraints, durable goods, search and leisure benefits during unemployment. However, in the presence of biased beliefs, the Baily formula and Chetty's extension prescribe an insurance level that is generally suboptimally high or low. The direction of the bias depends on the nature of the bias in beliefs.

3.2 Biased Beliefs: the Adjusted Baily Formula

If beliefs are biased (i.e. $\hat{\pi}(\cdot) \neq \pi(\cdot)$), the contracts proposed by the social planner and the private insurers in a competitive equilibrium diverge. The social optimum equalizes the true smoothing benefit and the moral hazard cost at the margin, with the moral hazard cost corrected for the search internality(e)-hd cmpbeti(iv)28(e)-316(e)-1(q)1(u)-1(i)1(librium)-317(e

expected utility through the change in effort equals

$$(1-p)\left\{\pi'\left(\hat{e}\left(b\right)\right)\left[u(w)-u(b)\right]-1\right\}\frac{d\hat{e}\left(b\right)}{db}=0.$$

Since the insuree already chooses her effort level to maximize her true expected utility, the effect of a marginal change in effort on her true expected utility is of second order by the envelope condition. However, when the insuree is control-pessimistic, $\pi'(\cdot) > \hat{\pi}'(\cdot)$, she underestimates the marginal return to effort and exerts too little effort. An increase in benefits now causes a first-order decrease in the true expected utility by decreasing the insuree's effort choice. By the IC constraint, this first-order loss equals

$$(1-p)\left\{\pi'\left(\hat{e}\left(b\right)\right)-\hat{\pi}'\left(\hat{e}\left(b\right)\right)\right\}\left[u(w)-u(b)\right]\frac{d\hat{e}\left(b\right)}{db}.$$

This loss is lower the less responsive the effort choice, but higher the more distorted the effort choice. The distortion in the effort choice is increasing in the utility gain from finding a job $u(w)-u(b)$ and the control bias $\left|\hat{\pi}'\left(\hat{e}\left(b\right)\right)-\pi'\left(\hat{e}\left(b\right)\right)\right|$. The loss is therefore non-monotonic in control pessimism, since it decreases the responsiveness, but increases the distortion.

The constrained social optimum still equalizes the relative utility and the relative price of consumption in unemployment and employment, but the relative price is corrected for the search internality. Since control-pessimists exert too little effort, the corrected relative price of unemployment compensation exceeds the uncorrected relative price.

Proposition 2 *The socially optimal unemployment insurance is characterized by*

$$\frac{u'\left(b\right)-u'\left(w-\hat{\tau}\right)}{u'\left(w-\hat{\tau}\right)}=\varepsilon_{1-\pi(\hat{e}),b}\left[1+\frac{\pi'\left(\hat{e}\right)-\hat{\pi}'\left(\hat{e}\right)}{\pi'\left(\hat{e}\right)}I\left(b\right)\right], \tag{4}$$

with $\hat{e}=\hat{e}\left(b\right)$, $\hat{\tau}=\hat{\tau}\left(b\right)$ *and* $I\left(b\right)=\frac{u(w)-u(b)}{bu'(w-\hat{\tau}(b))}>0$.

Biased beliefs change the socially optimal unemployment benefit only if they affect the insuree's behavior. In this static model, the insuree only chooses how much effort to exert and baseline optimism does not change the insuree's choice of effort. Baseline beliefs thus do not change the social optimum.[10] Control pessimism, however, reduces the insuree's effort choice and affects the socially optimal unemployment benefit through three channels. The net effect is ambiguous. The first channel is through the correction for the search internality and decreases the optimal unemployment benefit. The elasticity in (4) is multiplied by a correction greater than 1 for $\hat{\pi}'\left(\hat{e}\right)<\pi'\left(\hat{e}\right)$. The second channel is through the standard smoothing benefit and increases the optimal unemployment benefit. The reduced effort decreases the smoothing benefit through

[10] Notice that this changes if the insuree chooses how much insurance coverage to buy at a given price. A baseline-optimistic insuree buys less insurance coverage than an unbiased insuree does.

an increase in the required tax $\hat{\tau}(b)$. The last channel is through the standard moral hazard cost. Control pessimism may decrease the elasticity $\varepsilon_{1-\pi(\hat{e}(b)),b}$ and therefore decrease the optimal unemployment benefit.[11] The ambiguity of the net effect is not surprising. Control beliefs affect the effort of an insuree for a given level of insurance. As in a standard consumption problem with two goods (effort and insurance), an increase in the price of one good (effort) decreases the consumption of that good. The effect on the other good (insurance) is ambiguous. The increase in the price of inducing effort makes the optimal contract substitute toward providing more insurance, but at the same time, the set of feasible combinations of effort and insurance shifts inward.

Naive Planner Despite the ambiguous response to control beliefs, the difference between the budget balanced insurance schemes solving the standard Baily formula in (3) and the adjusted Baily formula in (4) unambiguously depends on the control bias. This comparison is relevant when a naive planner who is not aware of biases in beliefs implements the standard Baily formula.[12] By implementing such policy, the naive planner ignores the search internality. With control-pessimistic insurees, this implies that the planner underestimates the relative price of unemployment compensation and sets the benefit level suboptimally high.

Corollary 1 *The standard Baily formula overestimates the socially optimal level of unemployment benefits with control-pessimistic job searchers.*

Similarly, for two societies where the consumption smoothing benefits coincide, policy makers implementing the standard Baily formula set the same level of insurance if the observed elasticities are the same. However, if job searchers in the one society are more control-pessimistic, the insurance level in that society should be lower. The corollary emphasizes that formulas based on reduced statistics should be used cautiously when designing insurance contracts.

3.2.2 Private Insurers: Perceived Consumption Smoothing

An insuree who underestimates the duration of unemployment underestimates the value of unemployment insurance. Private insurers respond by providing less insurance. In a competitive equilibrium, private insurers offer unemployment insurance that equalizes the perceived smoothing benefit and the moral hazard cost, not corrected for the search internality.

[11] The elasticity $\varepsilon_{1-\pi(\hat{e}(b)),b}$ equals $-\hat{e}'(b)\frac{\pi'(\hat{e}(b))}{1-\pi(\hat{e}(b))}b \geq 0$. The agent's absolute response $\hat{e}'(b)$ is larger, the higher she perceives the marginal return to her effort. However, the chosen effort level $\hat{e}(b)$ increases with $\hat{\pi}'(\cdot)$ as well. For the elasticity to be higher for control-optimists, it is sufficient that $\frac{d}{de}\left(\frac{\pi'(e)}{1-\pi(e)}\right) > 0$.

[12] This still assumes that the naive planner knows the insuree's utility, the elasticity of unemployment duration, as well as the tax rate $\hat{\tau}(b)$ that keeps the budget balanced as a function of b.

Proposition 3 *The equilibrium contract offered by competing private insurers is characterized by*

$$\frac{\frac{1-\hat{\pi}(\hat{e})}{1-\pi(\hat{e})}u'(b)-u'(w-\hat{\tau})}{u'(w-\hat{\tau})}=\varepsilon_{1-\pi(\hat{e}),b}\ , \tag{5}$$

with $\hat{e}=\hat{e}(b)$ *and* $\hat{\tau}=\hat{\tau}(b)$.

The proposition follows from the first order condition of the insurer's profit maximization (2), which simplifies to

$$\frac{1-\hat{\pi}(\hat{e}(b))}{1-\pi(\hat{e}(b))}u'(b)-u'(w-\hat{\tau}(b))\left[1+\varepsilon_{1-\pi(\hat{e}(b)),b}\right]=0.$$

An increase in unemployment benefits is perceived by the insuree to be received with probability $(1-p)(1-\hat{\pi}(\hat{e}))$, but only paid by the insurer with probability $(1-p)(1-\pi(\hat{e}))$. The latter probability determines the tax increase required for the insurer to make zero profits. This explains why the marginal utility when unemployed relative to the marginal utility when employed is weighted by $\frac{1-\hat{\pi}(\hat{e}(b))}{1-\pi(\hat{e}(b))}$. Since the insuree searches to maximize her perceived expected utility, the effect through the change in search efforts is again of second order.

Baseline-optimistic beliefs lower the left-hand side in equation (5). The equilibrium insurance is therefore unambiguously lower when job searchers are baseline-optimistic. If job searchers sufficiently underestimate the unemployment duration, they may receive no unemployment insurance at all in equilibrium.

Naive Insurers The standard Baily formula ignores the difference between the perceived and actual consumption smoothing benefits. This implies the following corollary.

Corollary 2 *The standard Baily formula overestimates the equilibrium level of unemployment insurance with baseline-optimistic job searchers.*

While the difference between the standard and adjusted Baily formula depends on the control bias for the social optimum, it depends on the baseline bias for the competitive equilibrium. A private insurer responds to the control beliefs as well, since these beliefs affect the effort choice $\hat{e}(b)$. This response, however, is the same as the response by an insurer who is unaware of biased beliefs and implements the standard Baily formula.

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itself; competing private insurers offer the socially optimal insurance contract, but only if beliefs are unbiased. The analysis of optimal insurance design with biased beliefs sheds a new light on the topic of privatizing unemployment insurance. First of all, the analysis suggests an alternative explanation for the puzzle of why unemployment insurance is mostly publicly provided; if people are sufficiently optimistic about the risk of unemployment, providing insurance becomes unprofitable for private insurers. Second, the analysis suggests that privatizing unemployment insurance may be undesirable because of the welfare cost due to the biases in beliefs. Competition forces private insurers to charge the actuarially fair price for insurance, but does not force them to sell the socially optimal amount of insurance. A similar caveat holds for the unemployment insurance savings accounts, as proposed by Orszag and Snower (1997) and Altman and Feldstein (2006). In the same way that biased beliefs distort the insuree's willingness to pay for unemployment consumption, they distort the insuree's willingness to save, both before and during unemployment.

Difference in Insurance Coverage The nature of the regulation of private insurance markets depends in the first place on whether the insurance coverage provided in equilibrium is suboptimally high or low. Biases in baseline beliefs and control beliefs drive a wedge between the social optimum and the competitive equilibrium for different reasons. Baseline-optimistic insurees undervalue the consumption smoothing benefit of insurance. The focus of private insurers on the perceived smoothing benefit decreases the unemployment benefit in competitive equilibrium compared to the social optimum. Control-pessimistic insurees exert too little effort. The correction by the social planner for this search internality decreases the unemployment benefit in the social optimum compared to the competitive equilibrium.

If insurees were baseline-optimistic and control-optimistic, the competitive unemployment insurance would be suboptimally low. Baseline optimism and control pessimism, however, change the difference in unemployment benefits in competitive equilibrium and the social optimum in opposite directions. The actual difference depends on which bias dominates, conditional on the term $\frac{\hat{\pi}'(e)}{-\hat{\pi}''(e)}$ which determines the curvature of the perceived probability as a function of effort.

Corollary 3 *The equilibrium insurance provided to baseline-optimistic insurees is suboptimally low, unless the pessimistic control bias is such that*

$$\left\{\pi'(e) - \hat{\pi}'(e)\right\} \frac{\hat{\pi}'(e)}{-\hat{\pi}''(e)} > \hat{\pi}(e) - \pi(e),$$

evaluated at the effort level chosen in the social optimum.

The gain of correcting the control-pessimistic insuree's effort choice is increasing in the control bias $\pi'(e) - \hat{\pi}'(e)$. However, the social planner can only correct for the

insuree's distorted effort choice if the insuree is responsive to incentives. The effort response to a change in benefits $\frac{d\hat{e}(b)}{db}$ is increasing in $\frac{\hat{\pi}'(e)}{-\hat{\pi}''(e)}$. If this response is modest, as for insurees who perceive the marginal return to search to be very low, the social planner's correction is likely to be dominated by the private insurers' focus on the perceived smoothing benefit.

Welfare Comparison for Extreme Control Biases The welfare cost of privatizing insurance due to biases in beliefs depends on the extent to which private insurance diverges from social insurance and the impact of this divergence on the chosen effort levels. This difference becomes very salient for extreme control beliefs.

The moral hazard cost of providing insurance arises from the fact that the insuree does not internalize the positive effect of her search effort on the insurer's profits and therefore chooses an effort level that is lower than the first-best level of effort. Control pessimism increases this wedge with the first best, since a control-pessimistic insuree underestimates even the private benefits of search. If an insuree becomes more and more pessimistic about her control, the relative price of inducing effort in terms of insurance becomes so high that the social planner substitutes away from providing incentives and provides insurance converging to full insurance. Although effort matters, in the limit it is perceived not to matter and the opportunity cost of providing insurance equals zero. Extreme control-pessimistic insurees cannot be induced to do effort, but private insurers nevertheless give less than full insurance in response to the insuree's baseline optimism.[13]

Proposition 4 *When $\hat{\pi}'(e) \to 0$ for all e, the optimal social contract converges to full insurance and the insurance b^p provided in an interior solution to the competitive equilibrium solves*

$$\frac{1-\hat{\pi}(e^p)}{1-\pi(e^p)} = \frac{u'(w-\hat{\tau}(b^p))}{u'(b^p)}.$$

In both cases, the induced effort level converges to zero.

Extreme control optimism also drives the social optimum towards full insurance, but for the opposite reason. The price of inducing effort becomes so low that the social planner prefers to increase insurance as well. If an insuree is very optimistic about her control, a small share of the risk imposed on the insuree suffices to induce the first-best effort level. In the limit, the social contract approximates the first best. The competitive equilibrium diverges now from the social optimum both in terms of the level of insurance provided and the search effort induced. The next proposition considers the case where the perceived probability remains unchanged, but the true returns to effort converge to zero.[14] Effort is perceived to matter, but actually has no true impact in the limit.

[13] If the insuree were baseline-pessimistic, the private insurer would provide more than full insurance.

[14] I do not consider the extreme case with the perceived marginal return $\hat{\pi}'(e)$ increasing without

Proposition 5 *When $\pi'(e) \to 0$ for all e, the interior optimal social contract converges to full insurance and efficiently induces zero effort if the probability to start employed $p \to 1$. The insurance provided in an interior equilibrium solves*

$$\frac{1-\hat{\pi}(e^p)}{1-\pi(e^p)} = \frac{u'(w-\hat{\tau}(b^p))}{u'(b^p)}.$$

The induced effort level $e^p = \hat{e}(b^p)$ is positive and therefore inefficient.

The competitive equilibrium contract imposes too much risk on the baseline-optimistic insurees and induces too much effort if insurees are extremely control-optimistic as well. For baseline-optimistic insurees, the welfare cost of privatizing insurance is higher when they are extremely control-optimistic rather than control-pessimistic.

to shift incentives to the short-term unemployed. Private insurers, however, also take into account that job seekers underestimate the probability that they will experience these lower consumption levels in the future.

4.1 Setup

I follow the optimal contracting approach in Hopenhayn and Nicolini (1997), focusing on the consumption allocation throughout unemployment and upon employment for the insurees who start unemployed. This complements the static analysis of the insurance between insurees who start employed and unemployed in the previous section. The optimal dynamic contract characterized in this section can only be implemented under the assumption that savings are observable (Werning 2002, Shimer and Werning 2008). I also make the simplifying assumption that not only the true probability function of effort, but also the perceived probability function of effort does not change during the unemployment spell. Notice though that I find no empirical evidence suggesting that the optimistic bias becomes smaller during unemployment.

Assumption 1 *Both the true probability* $\pi(e)$ *and perceived probability* $\hat{\pi}(e)$ *remain unchanged during the unemployment spell.*

A risk-averse insuree starts unemployed and exerts effort at cost e to find work. If the insuree does not find work in the current period, she has to search for work again in the next period. Once she finds a job, she remains employed forever. Since there is no moral hazard once the insuree is employed, it is optimal to keep consumption constant after employment. The insurer offers a consumption schedule as a function of the length of the unemployment spell d. The length of the spell is a sufficient statistic for the unemployment history. This contract can be implemented with a schedule of unemployment benefits and taxes $\{(b_d, \tau_d)\}_d$ if no savings are possible.

4.2 Linear Unemployment Insurance

I restrict the analysis to unemployment schemes that are linear in the length of the unemployment spell. In the next section, I show that such contracts are optimal for private insurers when beliefs are unbiased or biased, and for the social planner when beliefs are unbiased.

Assumption 2 *Contracts are linear, i.e.* $b_d = b - xd$ *and* $\tau_d = \tau^u + x(d-1)$ *for* $d \geq 1$.

A linear contract reduces the insurer's problem to the choice of a vector of three variables $z = (b, w\text{-}\tau^u, x)$: the unemployment benefit b at the start of unemployment, the after-tax wage $w - \tau^u$ if the insuree finds work after one period of unemployment and the reduction x in benefit and the after-tax wage for each additional period that the unemployment spell takes.

Assumption 3 *The insuree has CARA preferences with monetary costs of effort e,*

$$u(c-e) = -\exp(-\sigma(c-e)).$$

An insuree with CARA preferences makes her search decision only based on the differences in consumption levels across states. With a linear contract, the only difference between the continuing contracts when short-term unemployed and long-term unemployed is an equal shift in all consumption levels. Hence, the insuree exerts the same search effort throughout the unemployment spell. Using the property for CARA preferences that $u(c-x) = -u(-x)\,u(c)$, it is possible to write the lifetime utility explicitly, rather than rewriting the problem recursively. The true and perceived expected utility of a contract for an insuree who starts unemployed simplify to

$$U(z,e) = \frac{u(b-e) + \beta\pi(e)\frac{u(w-\tau^u)}{1-\beta}}{1-\beta(1-\pi(e))(-u(-x))}$$

and

$$\hat{U}(z,e) = \frac{u(b-e) + \beta\hat{\pi}(e)\frac{u(w-\tau^u)}{1-\beta}}{1-\beta(1-\hat{\pi}(e))(-u(-x))}.$$

The insuree exerts effort e and consumes b during the first period of unemployment and finds employment the next period at the after-tax wage $w-\tau^u$ with probability $\pi(e)$. With probability $1-\pi(e)$, the insuree is still unemployed the next period and faces the exact same prospects as the period before, except that all payments are x lower. As before, the insuree's effort choice $\hat{e}(z)$ maximizes her perceived expected utility $\hat{U}(z,e)$, rather than her true expected utility $U(z,e)$. With $c_0 \equiv (b, w\text{-}\tau^u)$, the initial levels of unemployment benefit and after-tax wage, the effort level $\hat{e}(z)$ solves

$$\beta\hat{\pi}'(\hat{e}(z))\left[\frac{u(w-\tau^u)}{1-\beta} - \hat{U}(c_0\text{-}x, x, \hat{e}(z))\right] = u'(b-\hat{e}(z)).$$

In the dynamic model, both baseline and control beliefs change the insuree's effort choice. If an unemployed insuree is baseline-optimistic, she overestimates the continuation value of remaining unemployed $\hat{U}(c_0\text{-}x, x, \hat{e}) > U(c_0\text{-}x, x, \hat{e})$ and therefore exerts too little effort.

The expected cost for the insurer when facing an insuree who starts unemployed simplifies to

$$C(z,e) = \frac{b-\beta\left\{\pi(e)\frac{\tau^u}{1-\beta} + (1-\pi(e))\frac{x}{1-\beta}\right\}}{1-\beta(1-\pi(e))}.$$

If the insuree finds work, the insurer starts receiving τ^u from the next period on. If the insuree does not find work, the insurer has to pay unemployment benefits again in the next period, but all future consumption levels are reduced by x. For the insurer's budget to be balanced, these expected costs when the insuree starts unemployed need

to be funded with the tax paid when the insuree starts employed, as analyzed in the static model.[15]

I characterize the optimal contract for an insuree who starts unemployed considering two revenue-neutral changes. First, an increase in the unemployment benefit level accompanied with a decrease in the after-tax wage upon employment. Second, an increase in the starting consumption levels accompanied with a faster decrease in the consumption levels throughout unemployment. Again, for the insurance contract to be optimal, the marginal consumption smoothing benefits and the moral hazard cost of such changes have to be equal.

Unemployment vs. Employment I first consider an increase in the unemployment benefit b, accompanied by a decrease in the after-tax wage $w - \tau^u$. Keeping the reduction x constant, this implies an equal increase in all consumption levels during unemployment and an equal decrease in all consumption levels upon employment, regardless of the length of the unemployment spell. The Baily formula and the adjustments for biased beliefs generalize for this change in the dynamic contract. In order to emphasize the similarity with the static contracts, I introduce the functions $J^\tau(z) \equiv \frac{\beta\pi(\hat{e}(z))\left[b+\tau^u-\frac{x}{1-\beta}\right]}{[1-\beta(1-\pi(\hat{e}(z)))]}$ and $I^\tau\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}, \frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}, z\right)$ defined in appendix and discussed below.

Proposition 6 *The unemployment contracts in the social optimum and the competitive equilibrium are characterized by respectively*

$$\frac{u'(b-\hat{e}) - u'(w-\tau^u)}{u'(w-\tau^u)} = \varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)} J^\tau(z)\left[1 + I^\tau\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}, \frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}, z\right)\right]$$

and

$$\frac{\frac{\pi(\hat{e}(z))}{\hat{\pi}(\hat{e}(z))}u'(b-\hat{e}) - u'(w-\tau^u)}{u'(w-\tau^u)} = \varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)} J^\tau(z),$$

with $I_1^\tau > 0, I_2^\tau > 0$ *and* $I^\tau(0,0,z) = 0$.

The consumption smoothing benefit associated with the change is again on the left-hand side of the equation, the moral hazard cost is on the right-hand side. When beliefs are unbiased, $I^\tau(0,0,z) = 0$ and $\frac{\pi(\hat{e}(z))}{\hat{\pi}(\hat{e}(z))} = 1$. The insurance contracts in the social optimum and the competitive equilibrium coincide. The moral hazard cost is determined by the elasticity $\varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)}$, capturing the responsiveness of the expected unemployment duration $\frac{1}{\pi(\hat{e}(z))}$ to the considered change in benefit and tax, and by $J^\tau(z)$, which reflects the increase in expected costs for the insurer $C(z, \hat{e}(z))$ from an

[15] Since the starting consumption level $c_0 = (b, w - \tau^u)$ when unemployed does not change the search effort level with CARA preferences, the characterisation of the consumption allocation between the insurees who start unemployed and who start employed simplifies to $U_{c_0}(z,\hat{e}) = \frac{u'(w-\tau)}{1-\beta}$ and $\hat{U}_{c_0}(z,\hat{e}) = \frac{u'(w-\tau)}{1-\beta}$ in the social optimum and the competitive equilibrium respectively.

increase in the unemployment duration.[16] Longer unemployment spells are more costly if the starting levels of the unemployment benefit b and the wage tax τ^u are higher, but less costly if the consumption levels vanish quickly with the length of the unemployment spell. The consumption smoothing gain is again determined by the relative difference in the marginal utility of consumption during unemployment and upon employment.

The role of control pessimism is the same as in the static model. Baseline optimism distorts the insuree's effort choice downward as well and thus affects the search internality in the same way as control pessimism. Both biases make the social planner revise the moral hazard cost upward and therefore decrease the optimal benefit level, i.e. $I^{\tau} > 0$ if $\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})} > 0$ and $\frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})} > 0$. A naive policy maker who ignores the correction I^{τ} sets the unemployment benefit level too high, like in Corollary 1. The pessimistic control bias and the optimistic baseline bias move this policy error in the same direction.[17] Baseline optimism decreases the perceived consumption smoothing benefits, like in the static model. Private insurers respond to this bias by decreasing the unemployment benefits and increasing the wage tax paid upon employment. This response by the private insurers needs to dominate the social planner's correction for the search internality for equilibrium insurance to be suboptimally low when insurees are baseline-optimistic and control-pessimistic.

Short-term vs. Long-term Unemployed I now consider an equal decrease in the starting level of the unemployment benefit b and the after-tax wage $w - \tau^u$, accompanied with a slower reduction x in consumption during unemployment. The slower reduction smooths the risk-averse insuree's consumption profile, but discourages her from searching for a job. In the optimum, the marginal consumption smoothing gain and moral hazard cost of this change has to be equal. The social planner corrects for the search internality, whereas the private insurers focus on the perceived smoothing cost in the presence of biased beliefs. Proposition 7 follows given the functions $J^x(z) \equiv \frac{\beta\pi(\hat{e})[(b+\tau^u)(1-\beta)-x]}{[1-\beta(1-\pi(\hat{e}))]^2 x}$ and $I^x\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}, \frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}, z\right)$ defined in appendix and discussed below.

Proposition 7 *The unemployment contracts in the social optimum and the competitive equilibrium are characterized by respectively*

$$\frac{U_{c_0}(c_0 - x, x, \hat{e}) - U_{c_0}(c_0, 0, \hat{e})}{U_{c_0}(c_0 - x, x, \hat{e})} = -\varepsilon_{\frac{1}{\pi(\hat{e})},(c_0,x)} J^x(z) \left\{1 + I^x\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}, \frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}, z\right)\right\}$$

and

[16] In the static model, effort did not depend on the change in taxes. Here, the taxes changes the effort level as well. The response in effort captured by the elasticity $\varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)}$ is both to the change in the unemployment benefit and the change in the tax that keeps the revenues constant.

[17] As with control pessimism, the effect of baseline optimism on the optimal wedge between unemployment and employment consumption is ambiguous. Both biases decrease search and increase the required tax change, but may also decrease the responsiveness to insurance coverage. The first effect decreases the smoothing benefit. The second effect decreases the moral hazard cost. The effect on the optimal starting levels b and $w - \tau^u$ is ambiguous.

$$\frac{\hat{U}_{c_0}\left(c_0 - x, x, \hat{e}\right) - \frac{1-\hat{\pi}(\hat{e})}{1-\pi(\hat{e})}\hat{U}_{c_0}\left(c_0, 0, \hat{e}\right)}{\hat{U}_{c_0}\left(c_0 - x, x, \hat{e}\right)} = -\varepsilon_{\frac{1}{\pi(\hat{e})},(c_0,x)} J^x\left(z\right) \ ,$$

with $I_1^x > 0, I_2^x > 0$ *and* $I^x\left(0, 0, z\right) = 0.$

The moral hazard cost is again similar in nature; $J^x(z)$ depends on the increase in the expected costs for the insurer if the unemployment duration increases and the elasticity $\varepsilon_{\frac{1}{\pi(\hat{e})},(c_0,x)}$ depends on the responsiveness of the unemployment duration with respect to the considered change. Given the CARA preferences, the starting level of consumption c_0 has no impact on search, whereas an increase in the reduction x increases search and thus decreases the expected unemployment duration.

The consumption smoothing gain evaluated at the contract (c_0, x) equals the difference in marginal expected utility gains from an increase in c_0, denoted by U_{c_0}, for two unemployment schemes, $(c_0, 0)$ and $(c_0\text{-}x, x)$. The first scheme $(c_0, 0)$ equals the contract (c_0, x) offered to the insuree in the first period of unemployment, but with no decrease in consumption in the next periods of unemployment. The second scheme $(c_0\text{-}x, x)$ equals the contract (c_0, x) offered to the insuree from the second period of unemployment on. That is, the consumption levels start at $c_0 - x$ and decrease with x for every additional period of unemployment. If $x > 0$, the marginal utility of consumption is higher for the second contract, $U_{c_0}\left(c_0 - x, x, \hat{e}\right) > U_{c_0}\left(c_0, 0, \hat{e}\right)$. This consumption smoothing gain is decreasing in x. If $x = 0$, the first and the second scheme coincide. At that point, the consumption smoothing gain of changing x is of second order. Since an increase in x increases the induced effort level and thus has a first order impact on the insurer's budget constraint, x needs to be positive to be optimal. This confirms the well-known result by Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997) that with unbiased beliefs consumption should be decreasing with the length of the unemployment spell.

Biased beliefs change the induced effort level and the responsiveness to x. The impact on the optimal level of x is again ambiguous. However, insurees who overestimate the probability to leave unemployment clearly underestimate the utility cost of a fast decrease in benefits or a fast increase in taxes for longer unemployment spells. This effect on the perceived consumption smoothing tends to increase the equilibrium level of the x. The social planner, however, wants to correct for the search internality. This tends to increase the socially optimal level of x if insurees are more baseline-optimistic or control-pessimistic. If the perceived consumption smoothing effect dominates the search internality effect, equilibrium consumption decreases suboptimally fast during unemployment.

4.3 Optimal Unemployment Insurance

As in the static model, the social optimum and competitive equilibrium coincide for unbiased beliefs. Werning (2002) shows that with CARA preferences the optimal un-

employment schedule is linear of the form $z = (b, w\text{-}\tau^u, x)$ using recursive techniques. The dual problem that minimizes the expected cost of an insurance scheme providing a given level of expected lifetime utility V can be written recursively. The lifetime utilities promised last period to the insuree conditional on unemployment or employment summarizes all relevant aspects of the insuree's unemployment history. The promised utility V is therefore the unique state variable during unemployment. Moreover, starting from an optimal contract which assigns expected utility V, the optimal response to an increase in V is to increase all consumption levels by the same amount today and in the future, while employed and unemployed. The reason is that with CARA preferences search effort only depends on differences in consumption across different states. The provision of search incentives and utility becomes separable. Once the differences in consumption levels are chosen to induce the optimal levels of search effort, the consumption levels can be set to assign the required utility level. Hence, two consecutive periods of unemployment only differ by an equal shift in all expected consumption levels. This implies that the ratio of promised utilities in two consecutive periods of unemployment remains unchanged. The optimal contract is linear with the shift in consumption for an additional period of unemployment being constant throughout the unemployment spell.

It is important that this argument continues to hold for private insurers, but not for the social planner in the presence of biased beliefs. With biased beliefs, the unemployed's search behavior is determined by the perceived expected lifetime utility $\hat{V}$. Since a private insurer does not care about the true expected utility, the recursive problem has still a unique state variable, i.e. the perceived expected lifetime utility $\hat{V}$. The same argument holds as with unbiased beliefs, but now in terms of $\hat{V}$. Linear contracts are still optimal.

Proposition 8 *The profit-maximizing contract offered by competing insurers is linear, whether or not beliefs are biased.*

In contrast to private insurers, the social planner cares about the insuree's true expected utility. However, the perceived expected utility still determines the search behavior. The optimal contract is not linear anymore. If the unemployed worker overestimates the probability of leaving unemployment, decreasing future benefits become an ineffective instrument for inducing effort. Starting from the optimal linear contract, the social planner improves the trade-off between consumption smoothing and inducing effort by making the consumption steeper at the beginning of the unemployment spell and flatter afterwards. Such a variation induces more effort at the start of the unemployment spell, but less effort in any later period. This may increase or decrease the search internality. Hence, the considered deviation from the optimal linear contract increases the insuree's welfare if the effect on the search internality is positive or negative and small.

Proposition 9 *If beliefs are unbiased, the social optimum is a linear contract. With baseline-optimistic beliefs and* $I^x \approx 0$*, making consumption steeper at the start of unemployment (i.e.* $x_1 = x + \varepsilon$*) and flatter afterwards (i.e.* $x_d = x - \delta$ *for all* $d > 1$*) to balance the budget increases welfare for small* $\varepsilon, \delta > 0$*.*

The proposition only shows one local variation that increases welfare. If similar variations for longer unemployment spells lead to the optimal contract, this suggests

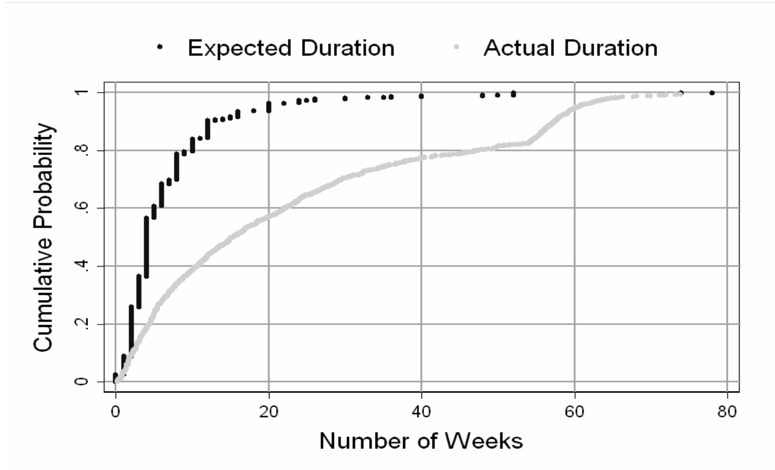

Figure 2: Empirical Cumulative Distributions: Actual Duration vs. Expected Duration

5.2 Baseline Beliefs: Actual and Expected Duration

The subjects are asked about their expectations to find a job. One question asks: "How many weeks do you estimate it will actually be before you will be working more than 20 hours a week?" I interpret the subjects' answers as the number of weeks they expect to remain unemployed. The average expected remaining duration of unemployment at the time of the first interview equals 6.8 weeks. The cumulative distribution is shown in Figure 2. The median expected duration is 4 weeks. More than 90 percent of the subjects expect that they will have found employment within the next 3 months.

In follow-up interviews, subjects are asked when they actually started working. 86 percent of the subjects found work for more than 20 hours a week before the last interview, about one year after the first interview. The average time they needed to find such a job was 17.0 weeks. I compute the minimum duration of an unemployment spell, assuming that the other 14 percent of the subjects found work on the date of the last interview. The average minimum duration for the entire sample equals 23.0 weeks, again starting from the first interview.[18] This suggests that on average the unemployment spell lasts more than three times longer than expected.

Matching the expectations and the actual realizations shows that 80 percent of the job seekers underestimate the duration of their unemployment spell and that the number of weeks by which the durations are underestimated exceed by far the number of weeks by which the durations are overestimated. The distribution of the differences

[18] In the follow-up interviews, subjects are asked about the start date of their current job only. I do not include subjects who report they have found a different job before the one they are currenly working on, but for which no start date is known ($n = 97$). Including these subjects with the date they started their current job when interviewed increases the average optimism with 1.3 weeks. I also do not consider a subject to be reemployed if he or she works less than 20 hours at the start of the new job. This is reported in the data set for 116 subjects. Including these subjects would decrease the average optimism by less than a week.

between the actual and expected number of weeks of unemployment is shown in Figure 1 in the introduction. The difference between the minimum actual duration and the expected duration is shown in dark grey for the job seekers who have not found work before the last interview. The optimistic bias in baseline beliefs also appears clearly in Figure 2, comparing the empirical distributions of the expected and actual unemployment durations. The cumulative distribution of the expected duration stochastically dominates the cumulative distribution of the minimum duration.[19] For any number of weeks, the number of job seekers who expect their unemployment spell will end within that time span exceeds the number of job seekers for whom the unemployment spell actually ends within that time span.

Selection Effects In this sample, job seekers largely underestimate the duration of unemployment. Selection effects seem to play a minor role in explaining this optimistic bias. First, the average unemployment duration decreases in the US between 1996 and 1998, as did the average unemployment rates in four out of the five counties considered in the sample. It seems unlikely that job seekers were surprised by an unexpected deterioration of economic conditions. Second, by screening through state unemployment offices, only job seekers who are filing for unemployment benefits are selected. These job seekers are the most policy relevant group of unemployed workers. Moreover, this selection effect does not necessarily increase the estimate of baseline optimism either. Anderson and Meyer (1997) document that the main reason why displaced workers do not take up unemployment benefits is that they expect that the unemployment spell will be short.[20] Third, the sample characteristics are similar to the characteristics of the unemployed in Maryland and Michigan between 1996 and 1998 in the Current Population Survey.[21] Fourth, the job seekers in this sample have been unemployed for 7 weeks on average at the time of the first interview. This implies that both job seekers with ex post short unemployment spells and baseline-pessimistic job seekers, who search more intensively, are likely to be underrepresented in the sample. However, the average baseline-optimistic bias is hardly smaller for the newly unemployed. For the 249 job seekers who have been unemployed for 3 weeks or less, the average optimistic bias equals 14.5 weeks. The Wilcoxon rank-sum test does not reject that the base-

[19] The kink in the cumulative distribution of the actual duration is due to the fact that I include the minimum duration for the job seekers with incomplete spells. These minimum durations are bunched around 52 weeks, which is the average time between the first and the last interview.

[20] Anderson and Meyer (1997) find that 37 percent of the job losers and leavers eligible for UI give 'Expected to get another job soon/be recalled' as the reason for not applying for UI, whereas no other single reason is given by more than 7 percent of them.

[21] Out of the 425 unemployed in Maryland and Michigan in the March CPS between 1996 and 1998, 54 percent are male and 69 percent are white, compared to 53 percent and 73 percent respectively in the sample considered in this paper. The unemployed in the CPS sample have less education and are younger. This may be explained by the fact that this sample is restricted to couples. Compared with the married unemployed in the CPS, the distributions of education and age are more similar. Notice that baseline optimism is significantly higher for the less educated and not significantly lower for the young job seekers.

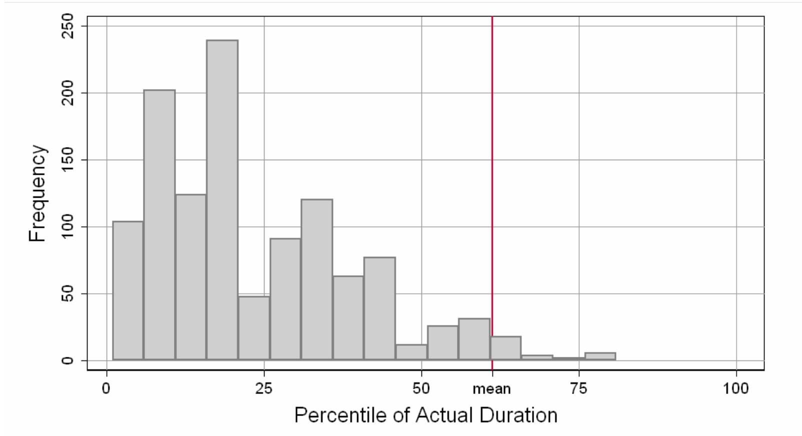

Figure 3: Histogram of the reported expectations with bins labeled by the percentiles of the actual duration

line bias has the same distribution for the recently displaced job seekers and the other job seekers (p-value = .79). Finally, exit rates tend to decrease with the duration of unemployment, which may explain why the average remaining duration in the sample considered here is high. The average duration of unemployment for newly unemployed is about 14 weeks in the US in 1996 (Valletta 1998). This is still twice as long as the average expectation in the sample.

Reported Expectations One may be concerned about the extent to which the duration predictions capture the job seekers' expectations on which they act. First, the job seekers are not explicitly incentivized to report their expectations truthfully. I do not observe actual behavior either, like their savings for instance, to verify to what extent their behavior is explained by the reported expectations. The expectations do however explain almost as much variation in the actual duration of the unemployment spells as all other demographic and employment variables together.[22] Also, the growing literature on the measurement of expectations confirms the predictive value of surveyed expectations for both actual outcomes and future behavior (Manski 2004, Gan, Gong, Hurd and McFadden 2004). Second, I interpret the job seekers' reported point predictions as their subjective means. However, some job seekers may report different distributional features as their point predictions, like the median or any other percentile.[23] Figure 3 suggests that it is unlikely that these alternative interpretations of the question play an important role in explaining the optimistic bias. The figure shows the distribution of the reported expectations by the percentiles of the actual

[22] The R^2 for regression (1) in Table 2, which regresses actual duration on all considered covariates, increases from .07 to .13 when including the expected duration as an explanatory variable.

[23] Engelberg, Manski and Williams (2009) argue that the elicitation of probabilistic forecasts is therefore more instructive. Notice hovever that the use of these point predictions about the duration of unemployment does avoid bunching issues that arise when eliciting probabilities.

duration distribution. That is, for each job seeker it shows the percentile he or she should have had in mind if his or her reported point prediction were to be accurate ex post. This assumes that the population distribution is the true distribution that all job seekers are facing. The point predictions are centered around the 20th percentile of the actual duration distribution, and more than 90 percent of the predictions are

exact same questions about the subject's efforts. The correlation between the search index as reported by the job seekers and their partners is 0.57.

I estimate the impact of the search index on the actual and expected duration of unemployment. The main regression of interest is

$$y_i = \beta \ search_i + X_i\gamma + \varepsilon_i, \tag{6}$$

with the dependent variable y_i equal to respectively the (minimum) actual duration of unemployment since the first interview, the expected duration of unemployment since the first interview, and the difference between the two. Table 2 reports the ordinary least squares estimates for these three regressions. Unemployment spells are both shorter and expected to be shorter for unemployed workers who report to search more intensively. The first effect is stronger than the second effect. If the search index increases by one unit, the actual unemployment spell is 3.0 weeks shorter, but the expected unemployment spell is only 2.2 weeks shorter. Both effects are significant at the 1 percent level. This suggests that job seekers underestimate the returns to search and thus are control-pessimistic. Higher search levels correspond to significantly lower optimism about the duration of unemployment. The control bias is however less pronounced than the baseline bias.[26]

The baseline-optimistic bias does not only change with search efforts. I control for many covariates, as reported in Table 2. Optimism about the duration is more than 5 weeks lower for white and married job seekers. White job seekers have significantly shorter unemployment spells, but do not have different expectations. The same is true for married job seekers. Unemployed workers who earned more at their last steady job believe their unemployment spell will last longer, but it does not actually last longer, making them significantly less optimistic. Notice that heterogeneity in beliefs is ignored in the theoretical analysis here, but analyzed in Spinnewijn (2008).

Timing of Search The search index measures the search efforts exerted in the month before the first interview. For the actual duration of unemployment starting from the first interview, the search effort actually exerted matters. For the expected duration

[26] When restricting the sample to the completed spells, the relation between search and the actual duration of the unemployment spell weakens and becomes insignificant (Panel C of Table 3). The data set is subject to left-truncation as well. I try to control for this by including in the benchmark regression how many weeks the subject has been unemployed sofar. I also estimate the differential impact of search in a hazard model with Weibull distribution, conditioning on the fact that job seekers have been unemployed for a while and that the duration for the unsuccessful job seekers goes past the last interview date. Here, the actual and expected increase in the hazard rate for job seekers who search more intensively is almost the same (Panel D of Table 3). Finally, all incomplete spells can also be used without censoring when considering the binary outcome whether or not a job seeker expects to find and actually finds work within m months. The estimates in a linear probability model suggest that the actual return to search exceeds the expected return to search for $m \geq 3$, confirming that job seekers are control-pessimistic. However, the results reverse for $m \leq 2$, suggesting that job seekers are control-optimistic in the short run.

of unemployment, the anticipated search effort matters. Unless job seekers perfectly anticipate their efforts, it is not clear whether past effort or actually exerted effort approximate the anticipated effort better. I have an imperfect measure of effort exerted after the first interview. These efforts span the month before the second interview if subjects are still unemployed and the month before they did find work if they are already employed. The measure is only available for a subsample. If the search intensity according to this later measure doubles, actual unemployment spells are on average 4.5 weeks shorter, but only expected to be 1.0 week shorter, as reported in Panel A of Table 3. The estimated effect on the actual duration is larger than for the earlier search variable, but the estimated effect on the expected duration is smaller. The suggested pessimistic bias in control beliefs is larger. Another issue is that low search efforts may be correlated with a lower willingness to work or accept job offers. Job seekers are asked when exactly they would like to start working, if they could choose deterministically. When controlling for this preference, the estimates of the coefficient on search reduce to respectively -2.0 and -1.3 in the actual and expected duration regressions respectively (Panel B of Table 3).

Heterogeneity and Endogeneity The theoretical analysis considers the difference between the actual and perceived impact of search efforts on the duration of unemployment. The causal nature of this relation is essential, but may be inconsistently estimated due to unobserved heterogeneity and endogeneity. Some job seekers may be more employable and have shorter actual unemployment spells, although they search less. This channel suggests that ordinary least squares underestimate the actual returns to search. However, if job seekers accurately perceive the impact of their employable nature on the actual duration of unemployment, the estimate of the effect of search on optimism is still consistent. Another problem is that search efforts depend on the perceived value of remaining unemployed. The theory suggests that someone who believes that it is very likely to leave unemployment in the near future is less inclined to search hard today. This channel suggests that ordinary least squares underestimate the perceived returns to search. This may not be solved by considering the difference between actual and expected duration. I try to correct for endogeneity using instrumental variables.

Both the utility difference between employment and unemployment and the marginal cost of search determine how intensively someone searches for a job. Candidates for instruments are variables that change either the utility differential or the cost of searching, but do not change the difference between the actual and expected duration of unemployment in other ways than through search. I consider two instruments that affect the utility differential: the potential unemployment benefit level and the importance of working to the job seeker. I do not observe the unemployment benefits received, but I calculate what a job seeker would have received if eligible, conditional

on his or her monthly earnings before unemployment.[27] The schedule is approximately linear in earnings up to a maximum amount. The identification of the impact of search comes from the non-linearity in the benefit schedule. The identifying assumption is that by including monthly earnings linearly I control for the underlying relation between earnings and the duration of unemployment, actual or expected. The impact of search is identified only by the difference between the non-linear benefit schedule and the smooth relation between earnings and the duration of unemployment. For the importance of work, I use the job seeker's answer to the question: "How important is work to you as part of your daily life?" The identifying assumption is that the error term for the regression of interest is not correlated with the importance people attach to work. This assumption seems plausible for the job seeker's optimism, the main regression of interest. However, if people who attach more importance to work are more likely to be wishful thinkers and thus more optimistic about the duration of the unemployment spell, the estimate of the pessimistic control bias would be biased downward.

Table 4 reports the two stage least squares estimates and the first stage. The estimated impact of search on the job seeker's optimism increases. The optimistic bias decreases with -2.3 weeks when the job seekers double their search intensity. This confirms the control-pessimistic bias suggested by the least squares estimates. The estimate becomes insignificant though, since the standard error increases even more. The first stage regression shows that the potential unemployment benefit level is a weak instrument. The decrease in search when potential unemployment benefits increase is insignificant. However, job seekers who attach more importance to work search significantly more. Considering the actual and expected duration separately, we see that the estimated impact of search increases in both regressions compared to the least squares estimates. A job seeker who doubles search efforts reduces the unemployment spell by 6.3 weeks, but expects this reduction to be only 4.6 weeks.[28]

5.4 Change in Beliefs during Unemployment

In the dynamic model, I have made the simplifying assumptions that both the true and perceived probability of finding work are not affected by the duration of unemployment. The first assumption contradicts negative dependence of the exit rates on the duration

[27] The replacement rates are different in Maryland and Michigan. I use the UI calculator used in Chetty (2008b) to calculate the replacement rates based on the reported hourly wage before unemployment.

[28] The job seeker's control pessimism is confirmed when I add alternative instruments that make the first stage stronger. A first additional instrument is the job seeker's partner's opinion about how much the job seeker ought to work as an instrument. This instrument changes the cost of searching for the job seeker. The IV estimate of search on optimism is now -7.53, with robust standard error 2.62. A second additional instrument is to use the job seeker's search as reported by the partner. This instrument does solve the endogeneity problem that arises because of measurement error in the search index variable, but does not solve the potential endogeneity problem indicated before. The IV estimate of search on optimism is now -3.73 with robust standard error 1.61. The results are also similar when considering the binary outcome whether or not a job seeker expects to find and actually finds work within m months.

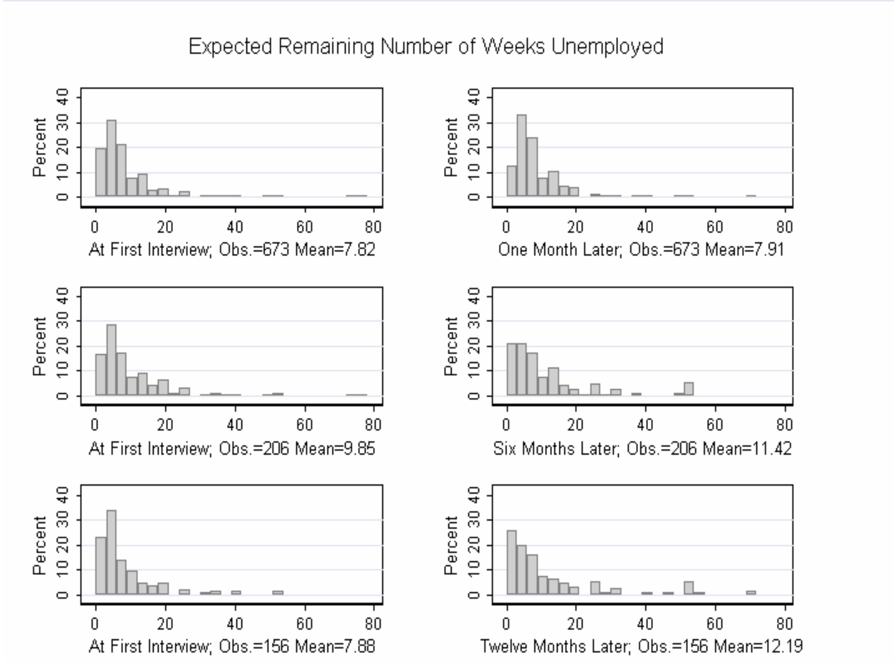

Figure 4: Expectations about Remaining Duration of Unemployment

of the unemployment spell. The second assumption contradicts learning by unemployed workers. However, the beliefs reported by the job seekers suggest that not much learning is going on. The optimistic bias does not disappear with unemployment experience.

First, job seekers who have been unemployed before are not less optimistic about the duration of the current unemployment spell. The number of times a job seeker has been unemployed in the last three years does not significantly lower his or her optimism about the current unemployment spell, as shown in Table 2. Second, job seekers who have been unemployed for longer in the current unemployment spell, are not less optimistic either. One extra week of unemployment before the first interview increases the expected unemployment spell from the first interview on with .17 weeks (p -value = .01) and the actual unemployment spell with .32 weeks (p -value = .04). The long-term unemployed are thus more optimistic about the remaining unemployment spell than the short-term unemployed. Both results are cross-sectional and do not necessarily rule out that the optimistic baseline bias decreases when job seekers become more experienced. Job seekers who are less optimistic about finding a job may search more and leave unemployment earlier. Perfect learning however would overcome this selection effect. A final argument is that unsuccessful job seekers hardly increase their expectations throughout the unemployment spell. I compare the expectations of the same job seekers at different lengths of the unemployment spell in Figure 4. The figure suggest that the distribution of the expected remaining number of weeks of unemployment is very stable throughout the unemployment spell. The average of the

expectations at the first interview is not significantly different from the average of the expectations one month or six months later. Only the expectations twelve months later are significantly higher. Together these results suggest that if some learning about the bias is going on, it is very modest.[29]

6 Numerical Analysis

In this section, I use my empirical estimates to gauge the importance of the biases in beliefs for insurance design. I calibrate the full dynamic model in order to numerically analyze the impact on the social optimum and the competitive equilibrium. I discuss the implied welfare consequences of both the privatization of insurance and the naive implementation ignoring the presence of biases in beliefs.

Calibration The true probability function and perceived probability function in this numerical exercise are of the form

$$\pi(e) = \pi_0 + \pi_1 e^{\rho} \text{ and } \hat{\pi}(e) = \hat{\pi}_0 + \hat{\pi}_1 e^{\rho}.$$

I choose values for the parameters of these functions to match the beliefs and exit rates as a function of effort for the job seekers in the sample considered in the previous section. For the default specification, I consider a pessimistic control bias $\frac{\hat{\pi}'(e)-\pi'(e)}{\pi'(e)} = \frac{\hat{\pi}_1-\pi_1}{\pi_1}$ of -35 percent, which corresponds to the least squares estimates in Table 2, and an optimistic baseline bias $\frac{\hat{\pi}(e)-\pi(e)}{\pi(e)} = \frac{\hat{\pi}_0-\pi_0+(\hat{\pi}_1-\pi_1)e^{\rho}}{\pi_0+\pi_1 e^{\rho}}$ of 100 percent evaluated at the average effort level, which is less extreme than the bias in the sample. For the parameters of the cost of effort function I choose values such that the monthly exit rate in the calibrated model given the current UI system equals 0.188 and the implied elasticity of the unemployment duration to unemployment benefits equals -0.5. These values correspond to respectively the average exit rate in the sample and the empirical estimates of duration elasticities reviewed in Krueger and Meyer (2002). The details of the calibration are presented in Appendix B.

Optimal Static Contracts I first consider contracts (b, τ) transferring consumption from those who start employed to those who start unemployed. This corresponds to the static contracts in Section 3 with $x = 0$ and $\tau^u = 0$. With a baseline bias of 100 percent and a control bias of -35 percent, the unemployment benefit b is significantly lower in the competitive equilibrium than in the social optimum. The respective

[29] Notice that if job seekers are uncertain about their ability to find a job at the start, a longer unemployment spell should make them revise their beliefs about the remaining duration upward. The data suggests that they are revising their beliefs upward, at least after twelve months, however they may not revise sufficiently and become more optimistic compared to an unbiased job seeker who is Bayesian updating, the longer they are unemployed. This is what Falk, Huffman and Sunde (2006) find in a laboratory experiment.

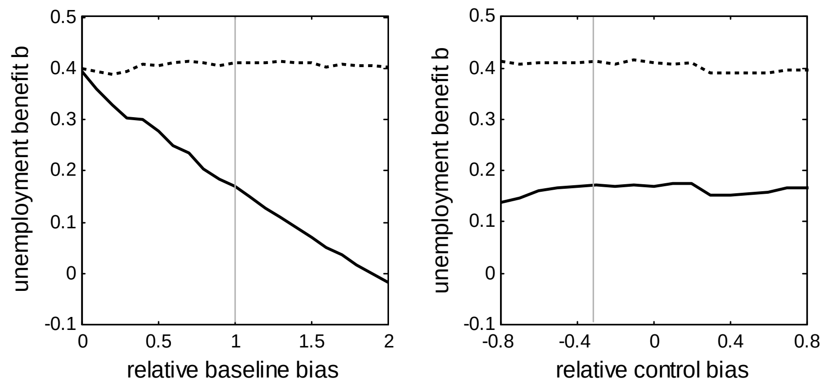

Figure 5: Unemployment Benefit in Static Competitive Equlibrium (full) and Static Social Optimum (dash) for Different Baseline and Control Biases

unemployment benefit levels are .17 and .41. I scaled the individual output level to 1 such that the unemployment benefit level b can be interpreted as a replacement rate. On the one hand, private insurers respond to the perception of the value of insurance held by the baseline-optimistic insurees, which makes them offer lower unemployment benefits than what is socially optimal. On the other hand, private insurers do not correct for the low effort level exerted by the baseline-optimistic and control-pessimistic insurees, which makes them offer higher unemployment benefits than what is socially optimal. The former effect strongly dominates the latter effect for this numerical example. Private insurers hardly offer any insurance against unemployment despite its value. Given the lower replacement rate, the insurees exert more search effort in the competitive equilibrium than in the social optimum. The monthly exit rate is .187 in the competitive equilibrium and .175 in the social optimum.

The full line and dashed line in Figure 5 shows the optimal static contract in respectively the competitive equilibrium and the social optimum for different biases in beliefs underlying the data. For every alternative beliefs specification, I recalibrate the cost function to match the exit rate and duration elasticity. In the left panel, I present the respective replacement rates for a baseline bias $\frac{\hat{\pi}(e)-\pi(e)}{\pi(e)}$ ranging from 0 to 200 percent, evaluated at the average effort level. I change the baseline bias by changing $\hat{\pi}_0$, which leaves the control bias unaffected. Private insurance is much more responsive to changes in the baseline beliefs than social insurance, accommodating the baseline optimists' changing perception of the value of insurance. The private insurers decrease the rate from .39 to even negative values for sufficiently high baseline optimism. The social planner only responds to the changed price of inducing effort and corrects for the search internality due to the baseline-optimistic beliefs. The socially optimal replacement rate varies between .39 and .42 for the considered range of baseline

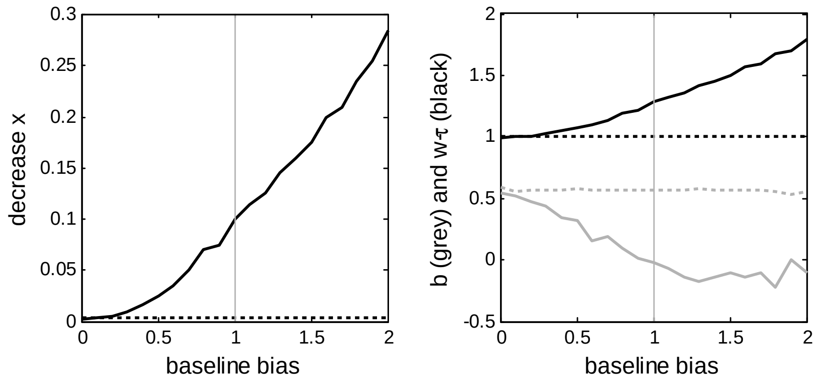

Figure 6: Dynamic Contract in Competitive Equlibrium (full) and Social Optimum (dash) as a Function of the Baseline Bias

optimistic biases. In the right panel of Figure 5, I present the respective replacement rates for a control bias $\frac{\hat{\pi}'(e)-\pi'(e)}{\pi'(e)}$ ranging from -80 to 80 percent. I change the control bias by changing $\hat{\pi}_1$. I also change $\hat{\pi}_0$ such that the baseline bias, evaluated at the average effort level, remains at 100 percent. The two panels together clearly show that the wedge between social insurance and private insurance is predominantly driven by the baseline bias rather than by the control bias. Both the responses by private insurers and the social planner to a change in the control bias are relatively modest. This would be different if effort is modeled along the extensive rather than the intensive margin.

Optimal Dynamic Contracts I now allow the insurers to impose a wage tax τ^u on the unemployed from the moment they find employment and to decrease the unemployment benefit b and the after-tax wage $w-\tau^u$ by x for any additional month of unemployment. This corresponds to the linear contracts considered in Section 4. For the benchmark specification, search effort is induced both by rewarding a successful job seeker with a net wage $w-\tau^u$ that exceeds the unemployment benefit b and by punishing an unsuccessful job seeker by decreasing all future consumption levels by x. Both the reward $w-\tau^u-b$ and the punishment x are much larger in the competitive equilibrium. The unemployment benefit level starts at .58 in the social optimum and at $-.02$ in the competitive equilibrium. The monthly decrease in consumption during unemployment, expressed as a percentage of production, equals only .4 percentage points in the social optimum, but 10 percentage points in the competitive equilibrium. Consumption jumps by .42 upon employment in the social optimum and by 1.30 in the competitive equilibrium. Figure 6 shows the dynamic contracts in the social optimum and the competitive equilibrium for different baseline biases underlying the data (with the cost function recalibrated). In the social optimum, x is slightly higher when insurees

are baseline-optimistic. Still the change is very small compared to the exponential increase in x in the competitive equilibrium. For an optimistic baseline bias of 200 percent, consumption falls at a rate of 0.28 for each extra month of unemployment. Also the reward upon employment $w - \tau^u - b$ increases much more with baseline optimism in the competitive equilibrium than in the social optimum.

Naive Policies A policy maker uses data to test for the optimality of current policies and to implement new policies. When unaware of biases in beliefs, the policy maker would miscalibrate his model by matching the empirical moments under the assumption that the job seekers' beliefs are unbiased. In the spirit of this calibration exercise, the policy maker who naively assumes that job seekers have correct beliefs, would use the cost function that matches the exit rate and unemployment duration elasticity if beliefs were to be unbiased. This miscalibrated cost function leads the policy maker to reward and punish the job seekers too little. He sets the reward for finding employment $w - \tau^u - b$ at .39 and the monthly decrease in consumption x at only .25 percentage points. The socially optimal contract has $w - \tau^u - b = .42$ and $x = .4$, if the baseline bias is 100 percent and the control bias is -35 percent. This is in line with Corollary 1. The naive policy maker ignores that the additional incentives increase welfare by correcting the lowered incentives due to the bias in beliefs. Figure 5 and 6 show how the changes in the social optimum when assuming different biases in beliefs underlying the data are small relative to the difference between the social optimum and the competitive equilibrium. This suggests that the impact of miscalibration is small relative to the impact of privatizing insurance.

Welfare Effects An insuree does not internalize the impact of her effort on the insurer's budget constraint. This moral hazard problem lowers the insuree's welfare in the social optimum below the first best. Baseline optimism and control pessimism decrease the effort choice further and aggravate the moral hazard problem. The true expected utility in the social optimum is therefore decreasing in both biases. If in contrast insurees are sufficiently baseline-pessimistic or control-optimistic, the social planner could approximate the first best.

In the competitive equilibrium, the true expected utility is not only lower than in the social optimum when agents have biased beliefs, but also tends to decrease more than in the social optimum when insurees become more baseline-optimistic or control-pessimistic. I calculate the consumption subsidy Δc required in every period of the insuree's life such that she achieves the same true expected utility in the competitive equilibrium as in the social optimum. For an optimistic baseline bias of 100 percent and a pessimistic control bias of 35 percent, this consumption subsidy is 14 percent of the output when employed. That means that 14 percent of the economy's production is needed to make people with competitive unemployment insurance as well off as

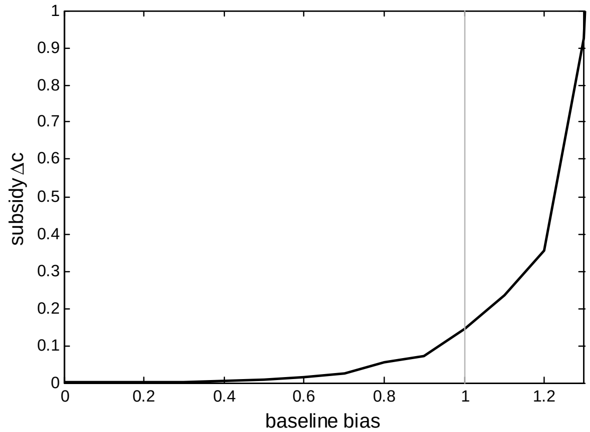

Figure 7: Welfare Cost of Privatizing Insurance as a Function of the Baseline Bias

they would be with an insurance system that is optimally designed. The consumption subsidy increases exponentially in the baseline bias, as shown in Figure 7. When the baseline bias is small, the consumption subsidy is approximately zero. However, the subsidy exceeds 100 percent of output when the optimistic baseline bias is large. The exponential increase in welfare cost reflects the exponential increase in the monthly consumption reduction x and the wedge $w - \tau^u - b$ in the competitive equilibrium.

The welfare cost is mostly driven by the dynamic component of the contract. When the insurers are restricted to static contracts, the required consumption subsidy never exceeds 1 percent of output for the beliefs considered. In contrast with the static contracts, the dynamic contracts allow the private insurer to exploit both the fact that the insuree overestimates the probability of finding work, by giving higher consumption levels upon employment, and the fact that the insuree underestimates the probability of being unemployed for a long term, by offering steeper consumption profiles. The equilibrium contract implies a strong disparity in lifetime utility between the long-term unemployed on the one hand and the employed and the short-term unemployed on the other hand. People accept this disparity, but only because they underestimate the probability of being among the long-term unemployed.

7 Conclusion

The perception of risk is at the heart of optimal insurance design. This paper focuses on the optimal design of unemployment insurance, presenting new evidence that suggests that job seekers are optimistic about the probability of finding a job, but pessimistic about the returns to their search effort. The theoretical analysis applies to insurance and incentive contracts in other contexts in which biases in beliefs may be important, like for instance car insurance, health insurance and labor contracts. Young drivers

may overestimate the probability of avoiding car accidents, but underestimate the returns to driving safely. Women may overestimate the probability of being spared from breast cancer, but underestimate the returns to preventive care. Employees may overestimate the probability of good outcomes and at the same time their control over this probability.

The analysis assumes that the bias in beliefs is representative and stable. The assumption that the bias is representative is restrictive if insurers can offer a menu of contracts. People have heterogeneous perceptions of risks (Slovic 2000) and this heterogeneity is typically not observable to insurers. In concurrent research, I explore how insurers screen insurees with different private perceptions (Spinnewijn 2009). The assumption that the bias in beliefs is stable excludes a natural way to correct for behavioral distortions due to biased beliefs, that is by informing the insuree about her biased perception. Changing biased perceptions seems important, but has proven to be difficult though. Moreover, insurers may prefer not to inform insurees or even mislead them such that the information provided by insurers loses credibility. A paternalistic government always prefers an insuree to be more control-optimistic, because control optimism mitigates the moral hazard problem. A profit-maximizing insurer always prefers an insuree to be more baseline-pessimistic, because baseline pessimism increases the willingness to pay for insurance.

The biases in baseline and control beliefs result in an unambiguous difference between optimal and naive insurance design, on the one hand, and social and private insurance, on the other hand. First, policy makers should be aware of people's perceptions when evaluating or implementing policies. Given the lack of information, the design of policies is often based on the responsiveness of observable outcomes, like the response in employment to unemployment benefits, in health outcomes to the copay and deductible, in production to taxes or in retirement decisions to pension benefits. These statistics play a different role when people's perceptions are biased. Second, policy makers have a reason to intervene when insurance is provided to insurees with biased beliefs by private insurers. Although competition disciplines private insurers to charge actuarially fair prices, it does not induce them to correct the insurees' distorted choices. The welfare gains from intervening are exponentially increasing in the biases in beliefs.

The analysis is restricted to the design of the monetary structure of unemployment insurance. The perceptions of the unemployed are central to the evaluation of other unemployment policies as well. The empirical analysis suggests that job seekers search too little, since they underestimate the returns to search and overestimate the probability of leaving unemployment. This sheds a new light on the role of active labor market policies. The biased perceptions unambiguously increase the value of policies that monitor job search efforts or induce the unemployed to search harder. An alternative policy that reduces moral hazard is the replacement of unemployment insurance by individual

unemployment savings accounts, as proposed by Altman and Feldstein (2006). If the choice to save is given to individuals, similar issues arise as with the privatization of insurance. Workers who are optimistic about the probability of finding work would choose to save too little in employment and dissave too fast in unemployment. Saving mandates are therefore an indispensable part of such a policy.

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Appendix A: Proofs

Proof of Proposition 1

With unbiased beliefs, the two maximization problems (1) and (2) coincide. The first order condition of this problem equals

$$\begin{aligned} &(1-p)\left(1-\pi\left(\hat{e}\left(b\right)\right)\right)u'(b)-pu'\left(w-\hat{\tau}\left(b\right)\right)\tfrac{d\hat{\tau}(b)}{db}+ \\ &\qquad (1-p)\left[\pi'\left(\hat{e}\left(b\right)\right)\left[u(w)-u(b)\right]-1\right]\tfrac{d\hat{e}(b)}{db}=0. \end{aligned} \tag{7}$$

The last term equals zero by (IC). Under the assumption that $\pi\left(\hat{e}\right)<1$, dividing by $(1-p)\left(1-\pi\left(\hat{e}\right)\right)$ gives

$$u'(b)-u'\left(w-\hat{\tau}\left(b\right)\right)\frac{b}{\hat{\tau}\left(b\right)}\frac{d\hat{\tau}\left(b\right)}{db}=0.$$

Using $\frac{d\hat{\tau}(b)}{db}\frac{b}{\hat{\tau}(b)}=1+\varepsilon_{1-\pi(\hat{e}(b)),b}$, the Baily formula (3) follows by dividing both terms by $u'\left(w-\hat{\tau}\left(b\right)\right)$.□

Proof of Proposition 2

The first order condition of the social planner's problem (1) equals

$$\begin{aligned} &(1-p)\left(1-\pi\left(\hat{e}\left(b\right)\right)\right)u'(b)-pu'\left(w-\hat{\tau}\left(b\right)\right)\tfrac{d\hat{\tau}(b)}{db}+ \\ &\qquad (1-p)\left\{\pi'\left(\hat{e}\left(b\right)\right)\left[u(w)-u(b)\right]-1\right\}\tfrac{d\hat{e}(b)}{db}=0. \end{aligned}$$

Using the incentive compatibility constraint to substitute for the marginal cost of search 1 by the perceived and dividing by $(1-p)\left(1-\pi\left(\hat{e}\left(b\right)\right)\right)$, this simplifies to

$$\begin{aligned} &u'(b)-u'\left(w-\hat{\tau}\left(b\right)\right)\left(1+\varepsilon_{1-\pi(\hat{e}(b)),b}\right)+ \\ &\qquad \left\{\pi'\left(\hat{e}\left(b\right)\right)-\hat{\pi}'\left(\hat{e}\left(b\right)\right)\right\}\left[u(w)-u(b)\right]\frac{\pi'\left(\hat{e}\left(b\right)\right)b}{\pi'\left(\hat{e}\left(b\right)\right)b}\frac{1}{\left(1-\pi\left(\hat{e}\left(b\right)\right)\right)}\frac{d\hat{e}\left(b\right)}{db}=0. \end{aligned}$$

Rewritten in elasticities, this becomes

$$u'(b)-u'\left(w-\hat{\tau}\left(b\right)\right)=u'\left(w-\hat{\tau}\left(b\right)\right)\varepsilon_{1-\pi(\hat{e}(b)),b}+\frac{\hat{\pi}'\left(\hat{e}\left(b\right)\right)-\pi'\left(\hat{e}\left(b\right)\right)}{\pi'\left(\hat{e}\left(b\right)\right)}\frac{u(w)-u(b)}{b}\varepsilon_{1-\pi(\hat{e}(b)),b}.$$

The adjusted Baily formula (4) for the social optimum follows by dividing both sides by $u'\left(w-\hat{\tau}\left(b\right)\right)$.□

Proof of Proposition 3

The first order condition of the social planner's problem (2) equals

$$\begin{aligned} &(1-p)\left(1-\hat{\pi}\left(\hat{e}\left(b\right)\right)\right)u'(b)-pu'\left(w-\hat{\tau}\left(b\right)\right)\tfrac{d\hat{\tau}(b)}{db}+ \\ &\qquad (1-p)\left\{\hat{\pi}'\left(\hat{e}\left(b\right)\right)\left[u(w)-u(b)\right]-1\right\}\tfrac{d\hat{e}(b)}{db}=0. \end{aligned}$$

The last term equals zero by the incentive compatibility constraint. Dividing by

$(1-p)(1-\pi(\hat{e}(b)))$ gives

$$\frac{1-\hat{\pi}(\hat{e}(b))}{1-\pi(\hat{e}(b))}u'(b)-u'(w-\hat{\tau}(b))\frac{b}{\hat{\tau}(b)}\frac{d\hat{\tau}(b)}{db}=0.$$

Using $\frac{d\hat{\tau}(b)}{db}\frac{b}{\hat{\tau}(b)}=1+\varepsilon_{1-\pi(\hat{e}(b)),b}$, the adjusted Baily formula (5) for the competitive equilibrium follows by dividing both sides by $u'(w-\hat{\tau}(b))$.□

Proof of Proposition 4

The interior social optimum (b^s,e^s) satisfies

$$\begin{aligned}&[(1-\pi(e^s))u'(b^s)-(1-\pi(e^s))u'(w-\hat{\tau}(b^s))]+\\&\qquad\{\pi'(e^s)[u(w)-u(b^s)]-1+\pi'(e^s)u'(w-\hat{\tau}(b^s))b^s\}\frac{d\hat{e}(b^s)}{db}=0\end{aligned}\tag{8}$$

, whereas an interior competitive equilibrium (b^p,e^p) satisfies

$$\begin{aligned}&(1-\hat{\pi}(e^p))u'(b^p)-(1-\pi(e^p))u'(w-\hat{\tau}(b^p))+\\&\qquad\left\{\hat{\pi}'(e^p)[u(w)-u(b^p)]-1+\pi'(e^p)u'(w-\hat{\tau}(b^p))b^p\right\}\frac{d\hat{e}(b^p)}{db}=0.\end{aligned}\tag{9}$$

Since $\hat{e}(b)$ solves $\hat{\pi}'(e)[u(w)-u(b)]=1$, both $\frac{d\hat{e}(\cdot)}{db}$ and the induced effort level $\hat{e}(\cdot)$ converge to 0 when $\hat{\pi}'(e)\to 0$. The conditions (8) and (9) converge to respectively

$$\begin{aligned}(1-\pi(e^s))\left[u'(b^s)-u'(w-\hat{\tau}(b^p))\right]&\to 0 \text{ and}\\\left[(1-\hat{\pi}(e^p))u'(b^p)-(1-\pi(e^p))u'(w-\hat{\tau}(b^p))\right]&\to 0.\end{aligned}$$

The proposition immediately follows.□

Proof of Proposition 5

With $\pi'(e)\to 0$, the optimality condition (8) for an interior solution (b^s,e^s) converges to

$$(1-\pi(e^s))\left[u'(b^s)-u'(w-\tau(e^s,b^s))\right]-\frac{d\hat{e}(b^s)}{db}\to 0.$$

For any benefit level $b\leq w-\hat{\tau}(b)$, the left hand side is strictly positive. This cannot be socially optimal in the limit, except for an upper bound on b. If insurers are restricted not to overinsure, full insurance maximizes the true expected utility in the limit. Evaluated at $b^s=w-\tau(e^s,b^s)$, the utility gain of a further increase in b^s is indeed $-\frac{d\hat{e}(b^s)}{db}>0$. Moreover, if $p\to 1$, $b^s\to w$. Hence, the induced effort level converges to 0, which is efficient for $\pi'(e)\to 0$.

Using the IC constraint, the optimality condition (9) for an interior solution (b^p,e^p) converges to

$$(1-\hat{\pi}(e^p))u'(b^p)-(1-\pi(e^p))u'(w-\tau(e^p,b^p))\to 0.$$

With $\hat{\pi}(e^p)>\pi(e^p)$, $b^p\in(0,w-\tau(e^p,b^p))$ and the induced effort level is positive if

$\hat{\pi}'(0)[u(w) - u(b^p)] > 0.\Box$

Proof of Proposition 6

I consider an increase in b together with an increase in τ^u such that the budget constraint, accounting for the changes in $\hat{e}(z)$, is still satisfied. That is,

$$\frac{-db + \beta\pi(\hat{e}(z))\frac{d\tau^u}{1-\beta}}{1-\beta(1-\pi(e))} - C_e(z,e)\left\{\frac{\partial\hat{e}(z)}{\partial b}db + \frac{\partial\hat{e}(z)}{\partial\tau^u}d\tau^u\right\} = 0,$$

with

$$C_e(z,e) = -\frac{\beta\pi'(e)}{[1-\beta(1-\pi(e))]^2}\left\{b + \tau - \frac{x}{1-\beta}\right\},$$

the decrease in the expected cost of the contract for the insurer when e increases. Notice $C_e(z,e) < 0$ if $b+\tau > \frac{x}{1-\beta}$. This always holds in the numerical simulations considered. Denote the elasticity of unemployment duration $\frac{1}{\pi(\hat{e})}$ with respect to an increase in b, balanced by an increase in τ^u, by

$$\varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)} = -\frac{\pi'(\hat{e}(z))}{\pi(\hat{e}(z))}\left\{\frac{\partial\hat{e}(z)}{\partial b} + \frac{\partial\hat{e}(z)}{\partial\tau^u}\frac{d\tau^u}{db}\right\}b > 0,$$

then the revenue-neutral change implies

$$\frac{d\tau^u}{db} = \frac{1-\beta}{\beta\pi(\hat{e}(z))}\left\{1 + \frac{\beta\pi(\hat{e}(z))}{1-\beta(1-\pi(\hat{e}(z)))}\frac{b+\tau^u-\frac{x}{1-\beta}}{b}\varepsilon_{\frac{1}{\pi(\hat{e})},(b,\tau^u)}\right\}.$$

The gain in true expected utility from an increase in b, balanced by an increase in τ^u equals zero if

$$\frac{\partial U(z,\hat{e}(z))}{\partial b} + \frac{\partial U(z,\hat{e}(z))}{\partial\tau^u}\frac{d\tau^u}{db} + \frac{\partial U(z,\hat{e}(z))}{\partial e}\left\{\frac{\partial\hat{e}(z)}{\partial b}db + \frac{\partial\hat{e}(z)}{\partial\tau^u}d\tau^u\right\} = 0,$$

with

$$\begin{aligned}
\frac{\partial U(z,\hat{e})}{\partial b} &= \frac{u'(b-\hat{e})}{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)}\\
\frac{\partial U(z,\hat{e})}{\partial\tau^u} &= \frac{-\beta\pi(\hat{e})\frac{u'(w-\tau^u)}{1-\beta}}{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)}\\
\frac{\partial U(z,\hat{e})}{\partial e} &= \left\langle[\hat{\pi}(\hat{e}) - \pi(\hat{e})] + [\pi'(\hat{e}) - \hat{\pi}'(\hat{e})]/\sigma\left\{1 - \frac{1-\beta\exp(\sigma x)}{(1-\beta)\exp(\sigma x)}\frac{u(w-\tau^u)}{u(b-\hat{e})}\right\}\right\rangle\\
&\quad\times\frac{u'(b-\hat{e})[\beta\exp(\sigma x)]}{\{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)\}^2}.
\end{aligned}$$

For the expression for $\frac{\partial U(z,\hat{e})}{\partial e}$, I make use of the fact that $\hat{e}(z)$ maximizes $\hat{U}(z,e)$. Notice that $\frac{\partial U(z,\hat{e})}{\partial e}$ is increasing in $\hat{\pi}(\hat{e}) - \pi(\hat{e})$ and in $\pi'(\hat{e}) - \hat{\pi}'(\hat{e})$, since both $\frac{1-\beta\exp(\sigma x)}{(1-\beta)\exp(\sigma x)}$ and $\frac{u(w-\tau^u)}{u(b-\hat{e})}$ are smaller than 1. Using the same algebraic manipulations as in the proof of Proposition 2, I find the first result in the proposition with the correction for the

search internality

$$I^{\tau}\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}, \frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}, z\right) \equiv \frac{\frac{\partial U(z,\hat{e})}{\partial e}}{-\frac{(1-\beta)(b+\tau^u)-x}{1-\beta(1-\pi(\hat{e}))}\frac{\partial U(z,\hat{e})}{\partial \tau^u}}.$$

The function depends on the baseline bias and control bias through $\frac{\partial U(z,\hat{e})}{\partial e}$. We find $I^{\tau}(0,0,z) = 0$ and $I_1^{\tau} > 0$ and $I_2^{\tau} > 0$ if $C_e(z,\hat{e}) < 0$.

The gain in perceived expected utility from an increase in b, balanced by an increase in τ^u equals zero if

$$\frac{\partial \hat{U}(z,\hat{e}(z))}{\partial b} + \frac{\partial \hat{U}(z,\hat{e}(z))}{\partial \tau^u}\frac{d\tau^u}{db} = 0,$$

with

$$\frac{\partial \hat{U}(z,\hat{e})}{\partial b} = \frac{u'(b-\hat{e})}{1-\beta(1-\hat{\pi}(\hat{e}))\exp(\sigma x)} \text{ and } \frac{\partial \hat{U}(z,\hat{e})}{\partial \tau^u} = \frac{-\beta\hat{\pi}(\hat{e})\frac{u'(w-\tau^u)}{1-\beta}}{1-\beta(1-\hat{\pi}(\hat{e}))\exp(\sigma x)}.$$

The effect through effort on the perceived utility is of second order by the envelope condition. Using the same algebraic manipulations as in the proof of Proposition 3, I find the second result in the Proposition.□

Proof of Proposition 7

I consider an increase in x together with an increase in c_0 (i.e. both b and $w-\tau^u$) such that the budget constraint, accounting for the changes in $\hat{e}(z)$, is still satisfied. That is,

$$-dc_0 + \frac{\beta(1-\pi(\hat{e}(z)))}{1-\beta(1-\pi(\hat{e}(z)))}dx - C_e(z,\hat{e}(z))(1-\beta)\frac{\partial \hat{e}(z)}{\partial x}dx = 0.$$

Only the change in x affects the effort choice, since the insuree has CARA preferences. Denote the elasticity of unemployment duration $\frac{1}{\pi(\hat{e})}$ with respect to an increase in c_0 together with an increase in x by $\varepsilon_{\frac{1}{\pi(\hat{e})},(c_0,x)} \equiv -\frac{\pi'(\hat{e}(z))}{\pi(\hat{e}(z))}\frac{\partial \hat{e}(z)}{\partial x}\frac{dx}{dc_0}x > 0$, then revenue-neutrality implies

$$\frac{dx}{dc_0} = \frac{1-\beta(1-\pi(\hat{e}(z)))}{\beta(1-\pi(\hat{e}(z)))}\left\{1 + \frac{\beta\pi(\hat{e}(z))}{[1-\beta(1-\pi(\hat{e}(z)))]^2}\frac{(b+\tau)(1-\beta)-x}{x}\varepsilon_{\frac{1}{\pi(\hat{e}(z))},(c_0,x)}\right\}.$$

The gain in true expected utility from an increase in c_0, balanced by an increase in x equals zero if

$$\frac{\partial U(z,\hat{e}(z))}{\partial c_0} + \frac{\partial U(z,\hat{e}(z))}{\partial x}\frac{dx}{dc_0} + \frac{\partial U(z,\hat{e}(z))}{\partial e}\frac{\partial \hat{e}(z)}{\partial x}\frac{dx}{dc_0} = 0$$

with $\frac{\partial U(z,\hat{e})}{\partial c_0} = -\sigma U(z,\hat{e}(z))$ and $\frac{\partial U(z,\hat{e})}{\partial x} = \sigma U(z,\hat{e}(z))\frac{\beta(1-\pi(\hat{e}))\exp(\sigma x)}{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)} < 0.$

Using similar algebraic manipulations as in the proof of Proposition 6, I find

$$\frac{\frac{u'(b-\hat{e})+\beta\pi(\hat{e})\frac{u'(w-\tau^u)}{1-\beta}}{1-\beta(1-\pi(\hat{e}))}-\frac{u'(b-\hat{e})+\beta\pi(\hat{e})\frac{u'(w-\tau^u)}{1-\beta}}{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)}\exp(\sigma x)}{\frac{u'(b-\hat{e})+\beta\pi(\hat{e})\frac{u'(w-\tau^u)}{1-\beta}}{1-\beta(1-\pi(\hat{e}))\exp(\sigma x)}\exp(\sigma x)} = J^x(z)\,\varepsilon_{\frac{1}{\pi(\hat{e}(z))},(c_0,x)}\left\{1+I^x\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})},\frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi'(\hat{e})},z\right)\right\}$$

with

$$\begin{aligned} J^x(z) &= \frac{\beta\pi(e)}{[1-\beta(1-\pi(e))]^2}\frac{(b+\tau^u)(1-\beta)-x}{x} \\ I^x\left(\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})},\frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})},z\right) &= \frac{1}{\frac{(b+\tau^u)(1-\beta)-x}{[1-\beta(1-\pi(e))]}\frac{\pi'(e)}{(1-\pi(\hat{e}))}}\frac{\frac{\partial U(z,\hat{e}(z))}{\partial e}}{-\frac{\partial U(z,\hat{e}(z))}{\partial x}}. \end{aligned}$$

The first result in Proposition 7 immediately follows. $I^x(0,0,z)=0$, $I_1^x>0$, $I_2^x>0$ again follows from the derivative from $\frac{\partial U(z,\hat{e}(z))}{\partial e}$ with respect to the biases in beliefs, as in Proposition 6.

The gain in perceived expected utility from an increase in c_0, balanced by an increase in x equals zero if

$$\frac{\partial\hat{U}(z,\hat{e}(z))}{\partial c_0}+\frac{\partial\hat{U}(z,\hat{e}(z))}{\partial x}\frac{dx}{dc_0}=0,$$

with

$$\frac{\partial\hat{U}(z,\hat{e})}{\partial c_0}=-\sigma\hat{U}(z,\hat{e}(z)) \text{ and } \frac{\partial\hat{U}(z,\hat{e})}{\partial x}=\sigma\hat{U}(z,\hat{e}(z))\frac{\beta(1-\hat{\pi}(\hat{e}))\exp(\sigma x)}{1-\beta(1-\hat{\pi}(\hat{e}))\exp(\sigma x)}<0.$$

Using the same manipulations again, the second result immediately follows as well.□

Proof of Proposition 8

Private insurers only care about the perceived expected utility of the contract they offer. The equilibrium contact solves

$$C(\hat{V})=\min_{c^u,V',V^e,e} c^u+\beta\left[\pi(e)C^e(V^e)+(1-\pi(e))C(\hat{V}^u)\right]$$

such that

$$\begin{aligned} u(c^u-e)+\beta[\hat{\pi}(e)V^e+(1-\hat{\pi}(e))\hat{V}^u] &= \hat{V} \\ e\in\arg\max u(c^u-e)+\beta\left[\hat{\pi}(e)V^e+(1-\hat{\pi}(e))\hat{V}^u\right], \end{aligned}$$

and $C\left(\hat{V}\right)=0$. The true expected utility of the contract plays no role. Starting from an optimal contract assigning expected utility $\hat{V}$, the optimal response to an increase in $\hat{V}$ is to increase all consumption levels, today and in the future, while employed and unemployed, by the same amount. This leaves the margins for search effort unchanged.

Since an increase in $\hat{V}$ is accommodated by an equal increase in all consumption levels and $\hat{V}$ is the only state variable in the recursive problem, the optimal policy functions satisfy

$$\frac{\hat{V}}{\hat{V}^u\left(\hat{V}\right)} = \frac{\hat{V}}{V^e\left(\hat{V}\right)} = \frac{\hat{V}^u\left(\hat{V}\right)}{V^e\left(\hat{V}^u\left(\hat{V}\right)\right)} \text{ for any } \hat{V}.$$

This implies that the optimal contract is linear.□

Proof of Proposition 9

I consider an increase in x for the first period of unemployment dx_0 and a decrease in x for all later periods dx_+, such that the budget constraint is still satisfied,

$$\frac{dx_0}{dx_+} = -\frac{\beta\left(1-\pi\left(\hat{e}\right)\right)}{1-\beta\left(1-\pi\left(\hat{e}\right)\right)}.$$

With the effect on the search internality small, this increases welfare if and only if

$$\frac{\partial U}{\partial x_0}dx_0 - \frac{\partial U}{\partial x_+}dx_+ + \lambda\left[\frac{\partial \Pi}{\partial e_0}\left(\frac{\partial \hat{e}_0}{\partial x_0}dx_0 - \frac{\partial \hat{e}_0}{\partial x_+}dx_+\right) + \frac{d\Pi}{de_+}\left(\frac{\partial \hat{e}_+}{\partial x_0}dx_0 - \frac{\partial \hat{e}_+}{\partial x_+}dx_+\right)\right] > 0, \tag{10}$$

with $\hat{e}_0$ the effort exerted in the first period and $\hat{e}_+$ the effort exerted in all later periods. Using the fact that the linear contract is optimal, i.e.

$$\begin{aligned} \frac{\partial U}{\partial x} + \lambda\left[\frac{\beta\left(1-\pi\left(\hat{e}\right)\right)}{\left(1-\beta\right)\left[1-\beta\left(1-\pi\left(\hat{e}\right)\right)\right]} + \frac{d\Pi}{de}\frac{d\hat{e}}{dx}\right] &= 0 \\ \frac{\partial U}{\partial c_0} &= \frac{\lambda}{1-\beta}, \end{aligned}$$

condition (10) simplifies to

$$\left(\hat{\pi}\left(\hat{e}\right)-\pi\left(\hat{e}\right)\right)\left(-\sigma U\right)\beta\exp\left(\sigma x\right)\left[\frac{\beta\left(1-\pi\left(\hat{e}\right)\right)\left[\exp\left(\sigma x\right)-1\right]}{\left(1-\beta\left(1-\pi\left(\hat{e}\right)\right)\right)\left(1-\beta\left(1-\pi\left(\hat{e}\right)\right)\exp\left(\sigma x\right)\right)}\right] > 0,$$

which holds if and only if $\hat{\pi}\left(\hat{e}\right) > \pi\left(\hat{e}\right)$.□

Proof of Corollary 1

When $\hat{\pi}'\left(\hat{e}\right) \leq \pi'\left(\hat{e}\right)$, $1 + \frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})} I\left(b\right) \geq 1$. By assumption, $\frac{[u'(b)-u'(w-\hat{\tau})]/u'(w-\hat{\tau})}{\varepsilon_{1-\pi(\hat{e}),b}}$ is decreasing in b. In the standard Baily formula (3) this term needs to be equal to 1. In the adjusted Baily formula (4) this term needs to be greater than 1. Hence, the benefit implemented by the standard Baily formula exceeds the benefit implemented by the adjusted Baily formula.□

Proof of Corollary 2

When $\hat{\pi}\left(\hat{e}\right) \geq \pi\left(e\right)$, $\frac{u'(b)-u'(w-\hat{\tau})}{u'(w-\hat{\tau})} \geq \frac{\frac{1-\hat{\pi}(\hat{e})}{1-\pi(\hat{e})}u'(b)-u'(w-\hat{\tau})}{u'(w-\hat{\tau})}$. In the standard Baily formula (3) and the adjusted Baily formula for the competitive equilibrium (5), respectively the

left hand side and the right hand side need to be equal to 1. Since $\frac{[u'(b)-u'(w-\hat{\tau})]/u'(w-\hat{\tau})}{\varepsilon_{1-\pi(\hat{e}),b}}$ is decreasing in b, the benefit implemented by the standard Baily formula exceeds the benefit implemented by the adjusted Baily formula.□

Proof of Corollary 3

I consider the marginal rate of transformation (MRT) and the marginal rate of substitution (MRS) between e and b, with τ being determined by the budget constraint. The MRT is the same for social planner and private insurer, determined by the IC constraint. The MRS is different.

The interior social optimum (b^s, e^s) with $e^s = \hat{e}(b^s)$ satisfies

$$[(1-\pi(e^s))\,u'(b^s) - (1-\pi(e^s))\,u'(w-\hat{\tau}(b^s))] + \\ \{\pi'(e^s)[u(w)-u(b^s)] - 1 + \pi'(e^s)\,u'(w-\hat{\tau}(b^s))b^s\}\,\tfrac{d\hat{e}(b^s)}{db} = 0$$

Given global concavity, a private insurer in the competitive equilibrium offers more insurance if and only if an increase in insurance, evaluated at the social optimum, increases the perceived expected utility. That is, if and only if

$$\left[(1-\hat{\pi}(e^s))\,u'(b^s) - (1-\pi(e^s))\,u'(w-\hat{\tau}(b^s))\right] + \\ \left\{\hat{\pi}'(e^s)[u(w)-u(b^s)] - 1 + \pi'(e^s)\,u'(w-\tau(e^s,b^s))b^s\right\}\frac{d\hat{e}(b^s)}{db} > 0.$$

Using the condition for the social optimum, this inequality simplifies to

$$\{\pi(e^s) - \hat{\pi}(e^s)\}\,u'(b^s) + \left\{\hat{\pi}'(e^s) - \pi'(e^s)\right\}[u(w)-u(b^s)]\,\frac{d\hat{e}(b^s)}{db} > 0.$$

With $\frac{d\hat{e}(b^s)}{db} = \frac{\hat{\pi}'(e^s)}{\hat{\pi}''(e^s)}\frac{u'(b^s)}{u(w)-u(b^s)}$, the result immediately follows.□

Condition for Concavity of the Maximization Problem

The program is strictly concave for the social planner if

$$\eta + \pi''(e)[u(w)-u(b)] + \pi'(e)\left(2\frac{u'(w-\tau)}{u'(b)} - 1\right)\xi + \\ (1-\pi(e))\left(1-\frac{u'(w-\tau)}{u'(b)}\right)\left(\zeta + 2\xi\frac{\hat{\pi}''(e)}{\hat{\pi}'(e)}\right) < 0,$$

and for the private insurer if

$$\eta + \pi'(e)\left[2\frac{u'(w-\tau)}{u'(b)} - \frac{\hat{\pi}'(e)}{\pi'(e)}\right]\xi + \\ (1-\hat{\pi}(e))\left[1-\frac{1-\pi(e)}{1-\hat{\pi}(e)}\frac{u'(w-\tau)}{u'(b)}\right]\left(\zeta + 2\xi\frac{\hat{\pi}''(e)}{\hat{\pi}'(e)}\right) < 0,$$

for all (e, b, τ) satisfying IC and BC/ZPC with

$$\begin{aligned}
\eta &= \frac{(1-p)}{p} u''(w-\tau) \left\langle \pi'(e)\, b - \frac{1-\pi(e)}{u'(b)} \xi \right\rangle^2 \\
&\qquad + \pi''(e)\, u'(w-\tau) b + (1-\pi(e)) \frac{u'(w-\tau)}{u'(b)} \frac{u''(b)}{u'(b)^2} \xi^2 \\
\xi &= \frac{\hat{\pi}''(e)}{\hat{\pi}'(e)^2} \\
\zeta &= \frac{\hat{\pi}'''(e)}{\hat{\pi}'(e)^2}.
\end{aligned}$$

Notice that every single term in η is negative as is ξ. The last term in the conditions may be positive, but is small if $\frac{u'(w-\tau)}{u'(b)}$ is close to 1. One can find $\bar{p} < 1$ such that for all $p > \bar{p}$ the optimization problem is globally concave.□

Appendix B: Calibration of the Dynamic Model

The unit of time is one month. The monthly discount factor equals $\beta = 0.9956$, which corresponds to a yearly discount factor equal to 0.95. I assume that the monthly output equals 1 when employed and 0 when unemployed. I consider the probability of starting employed $p = 1/2$.[30] The agents have CARA preferences with monetary costs of efforts and absolute risk aversion $\sigma = 2$. Both the true and perceived monthly probability of finding work are assumed not to change throughout the unemployment spell, other than through changes in effort.

True Probability of Finding Work I assume that effort e is linear in the number of times a job seeker reports to have engaged in any of the search activities discussed in section 5.3. I rescale this effort variable such that $e = 0$ corresponds to not having searched in any dimension during the entire month and $e = 1$ corresponds to having searched every day in every dimension, averaged over the entire month. In this interpretation, $e = 0.15$ corresponds to the sample average of search effort (i.e. search in all dimensions between 'once every couple of weeks' and 'every week'). For these three values of search effort, the probability function

$$\pi(e) = \pi_0 + \pi_1 \times e^{0.62} \text{ with } \pi_0 = 0.1448 \text{ and } \pi_1 = 0.1417$$

approximates the average duration of unemployment, estimated using ordinary least squares (Table 2).

Perceived Probability of Finding Work The empirical section suggests strong baseline optimism and some control pessimism. I assume that the true monthly probability of finding work as a function of effort equals

$$\hat{\pi}(e) = \hat{\pi}_0 + \hat{\pi}_1 \times e^{0.62} \text{ with } \hat{\pi}_0 = 0.3488 \text{ and } \hat{\pi}_1 = 0.0921.$$

This implies an optimistic relative baseline bias $\frac{\hat{\pi}(e)-\pi(e)}{\pi(e)}$ equal to 100 percent (at the average effort level $e = 0.15$) and a pessimistic relative control bias $\frac{\hat{\pi}'(e)-\pi'(e)}{\pi'(e)}$ equal to -35 percent. Notice that the baseline bias is more modest than the average baseline bias in the sample of about 200 percent. The control bias corresponds to the relative ratio of the least squares estimates of the actual and perceived impact of search (Table 2).

[30] The simplication that employment is an absorbent state and the horizon is infinite makes a calibrated choice of p difficult. The NLSY 1979 shows that only 10.1 percent of the individuals does not experience any unemployment spell between age 18 and 40. However, many of the individuals who are unemployed at some point, are unemployed when they are young. Between age 36 and 40, 74.7 percent of the individuals do not experience any unemployment spell.

Monetary Cost of Effort I finally calibrate the monetary cost of search function

$$\psi(e) = \psi_0 e^{\psi_1},$$

in order to match the empirical exit rate and unemployment duration elasticity. I assume that the monetary cost of effort when employed equals the monetary cost of searching daily in every dimension $\psi(1) = \psi_0$. For the standard specification of beliefs, I find $\psi_0 = 0.475$ and $\psi_1 = 2.34$. I recalibrate these parameters for the alternative beliefs specifications such that the implied exit rate and unemployment duration elasticity given the current UI system remain constant. If beliefs were to be unbiased, the calibrated parameter values are $\psi_0 = .477$ and $\psi_1 = 1.16$.

Implied Exit Rate and Search Elasticity In the US, unemployed workers are eligible for unemployment benefits for six months. The mean and median replacement rate for which the unemployed workers are eligible equal respectively 0.43 and 0.48. When implementing a contract that pays $b = 0.45$ in the first six months and $b = 0$ afterwards, the standard specification predicts an average monthly probability of finding work equal to 0.19. This equals the average monthly exit rate in the sample. Moreover, the implied elasticity of unemployment duration with respect to a constant benefit level $b = 0.45$ equals $-.5$. This corresponds to the empirical estimates reviewed in Krueger and Meyer (2002).

Appendix C: Tables

Table 1: Summary Statistics

	Obs.	**Mean**	**Std. Dev.**
Demographics			
Male	1339	.55	.50
Age	1339	38.48	9.96
White	1339	.67	.47
Married	1339	.81	.39
Children	1339	1.30	1.25
Education	1334	13.63	2.14
Maryland	1339	.45	.50
Partner			
Employed	1139	.79	.41
Education	1137	13.50	2.20
Employment			
Monthly wage before unemp.	1320	2595	1720
Times unemployed	1339	.34	.47
Weeks since displacement	1339	6.91	4.16
Search (at First Interview)	1249	3.34	.87
Search (at Third Interview)	1249	3.35	.95

Table 2: OLS Estimates of the Effect of Search and Covariates on the Actual Duration of Unemployment (1), the Expected Duration of Unemployment (2) and the Difference Between the Actual and the Expected Duration of Unemployment (3)

	Actual duration (1)	Expected duration (2)	Optimism (3)
Search	-2.961**	-2.193**	-1.359
	(.747)	(.371)	(.780)
Demographics			
Male	-4.045**	-1.816**	-1.579
	(1.351)	(.446)	(1.389)
Age	.197**	.049*	.153*
	(.071)	(.020)	(.072)
White	-5.122**	-.856	-5.278**
	(1.412)	(.620)	(1.544)
Married	-3.946*	.397	-5.373**
	(1.806)	(.528)	(1.888)
Children	.809	.409	.373
	(.513)	(.257)	(.544)
Education	-.457	.275*	-.659
	(.357)	(.127)	(.362)
Maryland	-2.456	-.185	-3.091*
	(1.297)	(.478)	(1.343)
Partner			
Employed	-2.098	.464	-3.022
	(1.565)	(.477)	(1.641)
Education	-.059	.240*	-.192
	(.319)	(.119)	(.333)
Employment			
Monthly wage before unemp.	-.0006	.0006**	-.001**
	(.0004)	(.0002)	(.0004)
Times unemployed	-.723	-.558	-.925
	(1.307)	(.435)	(1.317)
Weeks since displacement	.319*	.170**	.294
	(.157)	(.065)	(.163)
Obs.	1120	1095	1007
R^2	.073	.125	.078

Robust standard errors are in parentheses. * denotes statistical significance at the 5 percent level, ** at the 1 percent level.

Table 3: OLS Estimates of the Effect of Search for Alternative Specifications. Dependent Variables: the Actual Duration of Unemployment (1), the Expected Duration of Unemployment (2) and the Difference Between the Actual and the Expected Duration of Unemployment (3)

	Actual Duration	Expected Duration	Optimism
	(1)	(2)	(3)
Panel A: Using Later Measure of Search			
Search	-4.535**	-.956**	-3.587**
	(.716)	(.308)	(.747)
Obs.	942	868	852
Panel B: Include Ideal Duration under Certainty			
Search	-1.990**	-1.281**	-.991
	(.764)	(.363)	(.817)
Ideal duration	.328**	.376**	.094
	(.118)	(.109)	(.118)
Obs.	1098	1081	994
Panel C: Complete Spells Only			
Search	-1.096	-1.436**	-.103
	(.613)	(.301)	(.684)
Obs.	976	886	886
Panel D: Hazard Model with Weibull Distribution			
Search	1.19**	1.32**	
	(.046)	(.049)	
Obs.	1120	1068	

Robust standard errors are in parentheses. * denotes statistical significance at the 5 percent level, ** at the 1 percent level. Other covariates are as in Table 2.

Table 4: 2SLS Estimates of the Effect of Search. Dependent Variables: Actual Duration of Unemployment (1), Expected Duration of Unemployment (2) Difference Between the Actual and the Expected Duration of Unemployment (3), and the First Stage Regression (4)

	Actual Duration (1)	Expected duration (2)	Optimism (3)	First Stage (4)
Search	-6.315*	-4.634**	-2.339	
	(3.159)	(1.442)	(3.021)	
Potential Benefit				-.0004
				(.0006)
Job Importance				.270**
				(.032)
Covariates	✓	✓	✓	✓
Observations	1116	1092	1004	1004
R^2	.059	.069	.077	.167
Overidentification	.015	.097	0.149	

Robust standard errors are in parentheses. * denotes statistical significance at the 5 percent level, ** at the 1 percent level. Other covariates are as in Table 2. Overidentification reports the p-value for the overidentification test using Hansen J statistic.