Unemployed but Optimistic: Optimal Insurance Design with Biased Beliefs

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December 8, 2009

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 in both a static and dynamic model. Policies that implement the standard reduced-form formula become sub-optimal when beliefs are biased. Biased beliefs also introduce a wedge between social insurance and private insurance. When workers underestimate unemployment durations, privatizing unemployment insurance may result in too low or rapidly decreasing unemployment benefits.

Keywords: Moral Hazard, Biased Beliefs, Unemployment, Optimal Insurance
JEL Classification Numbers: D83, H30, J65

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†I would like to thank Peter Diamond, Jonathan Gruber, Bengt Holmström, and Ivan Werning for valuable discussions and suggestions. I also thank David Autor, Douglas Bernheim, Arthur Campbell, Raj Chetty, Mathias Dewatripont, Geert Dhaene, Florian Ederer, Jesse Edgerton, Laura Feiveson, Tal Gross, Henrik Kleven, Robert Shimer, Frans Spinnewyn, Jean Tirole and seminar participants for helpful comments. All remaining errors are mine.

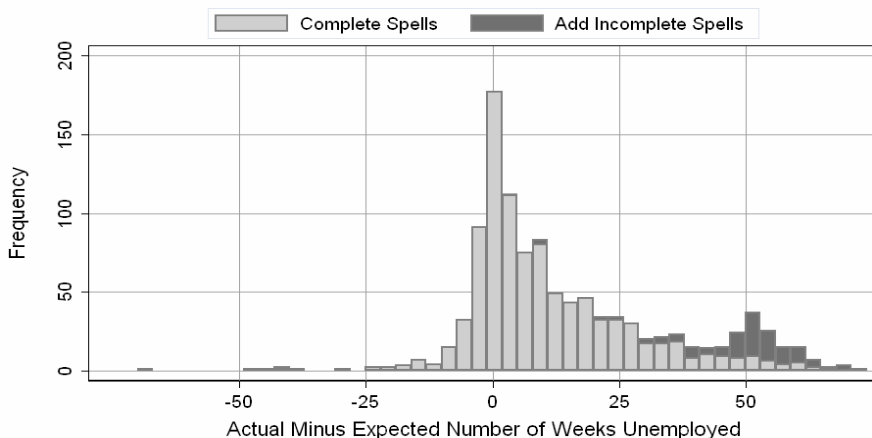
1 Introduction

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 (e.g., Weinstein 1980, 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 contributions of this paper are the theoretical analysis of the role of biased risk perceptions for insurance design and the empirical analysis of the relevant biases in beliefs held by unemployed job seekers. On the theoretical side, I analyze how biased beliefs change the optimal design of static and dynamic unemployment 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 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 the returns to searching more.

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 find 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.

Figure 1: Histogram of differences between actual and expected unemployment duration



The theoretical analysis builds on a canonical result for social insurance known as the Baily formula. An optimal insurance contract equalizes the benefit of smoothing consumption 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. These assumptions correspond to a setting with different priors where the insurer and the insured 'agree to disagree'.

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 the moral hazard cost is 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. The elasticity 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 coverage is set equal to its *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. This may explain the puzzle of why unemployment insurance is almost always publicly provided.[1] Competition disciplines insurers to charge actuarially fair prices, but not to correct people's distorted demand for insurance.

I also analyze the consequences of biased beliefs in 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 similar to the adjustment 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, optimism about the duration of unemployment makes the threat of receiving lower unemployment benefits in the future less effective in inducing search efforts. The loss of unemployment benefits after six months of unemployment, like in the US, does not induce a newly disposed job seeker to search harder when she expects to have left unemployment by then. I show how the social planner, in contrast with private insurers, prefers to shift incentives towards the short term unemployed, by making unemployment benefits more rapidly decreasing at the start of the unemployment spell and more slowly later on.

[1] 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."

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.

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) study the effects of exogenous biased beliefs in models with adverse selection due to heterogeneity in risk. Eliaz and Spiegler (2008), Grubb (2009) and Sandroni and Squintani (2007) study adverse selection due to heterogeneity in risk perceptions.[2]

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

[2] Spinnewijn (2009) analyzes screening contracts with heterogeneity in baseline and control beliefs, building on the model presented here.

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

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 (2009) 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 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 (2009) 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 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 are presented in Appendix A.

2 Static Model

A risk-averse agent, whom I refer to as the *insuree*, is employed with exogenous probability p and unemployed with probability $1-p$. 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 principal, the *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 the 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.[4]

Central to this model is the assumption that the insuree may perceive the probability

[4] 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.

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 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* $e \in E$*.*

Baseline and control beliefs are interdependent. For instance, complementarity between ability and effort implies that an agent who is optimistic about her ability is both baseline- and control-optimistic. I focus the exposition mainly on baseline optimism and control pessimism, in line with the empirical evidence presented in this paper.[5]

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.

[5]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.

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,

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

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

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

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,

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

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 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

$$\max_{b,\tau,e} U(b, \tau, e) = pu(w - \tau) + (1-p)[\pi(e) u(w) + (1 - \pi(e)) u(b) - e] \tag{1}$$

[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.

subject to (IC) and $P(b,\tau)=0$.

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. In contrast with the social planner's objective function (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] The competitive equilibrium contract solves

$$\max_{b,\tau,e} \hat{U}(b,\tau,e) = pu(w-\tau) + (1-p)\left[\hat{\pi}(e)\, u(w) + (1-\hat{\pi}(e))\, u(b) - e\right] \tag{2}$$

subject to (IC) and $P(b,\tau)=0$.

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.

[7] Chetty and Saez (2009) 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.

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 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,

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

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 uniquely 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.

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

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

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

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

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.[8]

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] The second order condition requires that $\frac{u'(b)-u'(w-\hat{\tau}(b))}{u'(w-\hat{\tau}(b))}$ decreases more in b than $\varepsilon_{1-\pi(\hat{e}(b)),b}$. I derive in appendix the condition on the primitives for the second order condition to hold globally.

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 (2009) reviews the recent literature developing "sufficient statistic formulas" for social insurance and optimal taxation. In particular, Chetty (2006) shows how the Baily formula 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 prescribes 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. The competitive equilibrium equalizes the perceived smoothing benefit and the moral hazard cost, without correction for the search internality.

3.2.1 Social Planner: Search Internality

The insuree equalizes the perceived marginal benefit and cost of effort at the margin. If the perceived and true marginal return to search differ, the insuree does not correctly internalize the effect of her search effort on her true expected utility. When determining the optimal unemployment benefit level, the social planner does account for both the externality the insuree imposes on the social planner's budget constraint and the externality she imposes on herself by misperceiving the returns to search. I refer to the latter as the *search internality,* in line with the behavioral public economics literature.

With unbiased beliefs, the effect of increasing unemployment benefits on the true 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, $\pi'\left(\cdot\right)>\hat{\pi}'\left(\cdot\right)$, 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 lower the responsiveness of effort, $\frac{d\hat{e}(b)}{db}$, 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.[9] Control pessimism, however, reduces the insuree's effort choice and affects the socially optimal unemployment benefit through three channels. The net

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

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 $\hat{\pi}'(\hat{e}) < \pi'(\hat{e})$. The second channel is through the standard smoothing benefit and increases the optimal unemployment benefit; the reduced effort decreases the smoothing benefit through an increase in the required tax $\hat{\tau}(b)$. The third and 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.[10]

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. In the one extreme case, in which an insuree becomes more and more pessimistic about her control, the relative price of inducing effort becomes so high that the social planner substitutes away from providing incentives and provides a contract converging to full insurance. In the other extreme case, in which the insuree becomes more and more 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.

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.[11] 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.*

[10] 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 $\frac{d}{de}\left(\frac{\pi'(e)}{1-\pi(e)}\right) > 0$.

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

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 of additional insurance coverage and the associated moral hazard cost, not corrected for the search internality.

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

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

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

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

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

An increase in unemployment benefits is perceived by the insuree to be received with probability $\left(1-p\right)\left(1-\hat{\pi}\left(\hat{e}\right)\right)$, but only paid by the insurer with probability $\left(1-p\right)\left(1-\pi\left(\hat{e}\right)\right)$. 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.

3.3 Comparing Private and Social Insurance

Moral hazard, in contrast with adverse selection, does not raise the need for government intervention by itself; competing private insurers offer the socially optimal insurance contract in equilibrium. However, this is only true 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 (Acemoglu and Shimer 2000); 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 biases in risk perceptions. 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. Moreover, the distorted control beliefs affect the willingness to accept contracts specifying explicit conditions on precautionary efforts to be exerted, which I have not considered in this analysis.

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. The sign of 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*

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

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.

4 Dynamic Model

In this section, I extend the analysis to a dynamic framework with the unemployed continuing to search as long as they have been unsuccessful in finding employment. Static insurance contracts transfer consumption from employment to unemployment. Dynamic insurance contracts can transfer consumption between unemployment spells with different lengths as well, making consumption dependent on the length of the unemployment spell.

This dynamic extension serves two purposes. First, I derive Baily-type conditions to characterize the dynamic component of the optimal contract and show that the adjustments for biased beliefs are similar to those in the static model. Second, I show how baseline-optimism makes the use of decreasing unemployment benefits less effective in inducing effort. The social planner, in contrast with private insurers, may respond by providing more incentives to the short-term unemployed than to the long-term unemployed.

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.[12] 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

[12]This complements the static analysis of the insurance between insurees who start employed and unemployed in the previous section.

no moral hazard once the insuree is employed, it is optimal to keep consumption constant after employment. The insurer offers a consumption schedule $\{(c_d^u, c_d^e)\}_d$ as a function of the length of the unemployment spell d. The length of the spell is a sufficient statistic for the unemployment history.

I make two simplifying assumptions to focus the analysis. First, I assume that job seekers do not learn about their bias during unemployment; both the true probability function of effort $\pi(e)$ and the perceived probability function of effort $\hat{\pi}(e)$ remain unchanged during unemployment. In Section 5.4 I discuss empirical evidence suggesting that the optimistic baseline bias does not decrease during unemployment. Second, I assume that agents cannot save or borrow. Like the search decision, the savings decision would be distorted when beliefs are biased. Job seekers who underestimate the duration of unemployment consume their savings more rapidly, which affects the insurer's response to biases in beliefs. When savings are not allowed, the optimal consumption allocation can be implemented by a schedule of unemployment benefits and taxes $\{(b_d, \tau_d)\}_d$ such that $b_d = c_d^u$ and $w - \tau_d = c_d^e$. The issue of implementing consumption allocations when savings are unobservable is studied by Werning (2002) and Shimer and Werning (2008).[13] Relaxing both assumptions would further improve the understanding of the role of biases in beliefs for insurance design and is an interesting topic for further research.

4.2 Linear Unemployment Insurance

I consider CARA preferences and restrict the analysis to unemployment schemes for which consumption depends linearly on the unemployment. In the next section, I show that such contracts are optimal for private insurers, regardless of the beliefs of the unemployed, and for the social planner, only when these beliefs are unbiased.

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

A linear contract reduces the insurer's problem to the choice of a vector of three variables $z = (b, w - \tau^u, x)$: 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 2 *The insuree has CARA preferences with monetary costs of effort* e, $u(c-e) = -\exp(-\sigma(c-e))$.

[13] Shimer and Werning (2008) show that with CARA preferences, as considered here, the optimal consumption allocation can still be implemented with unobservable savings.

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

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

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 $c_0 \equiv (b, w-\tau^u)$, 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.[14]

[14]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

I characterize the optimal linear 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 derived from this static change in the dynamic contract and the adjustments for biased beliefs are very similar to the Baily formula and the required adjustments in the static model. 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 4 *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 gain, on the left-hand side of the equation, is again determined by the relative difference in the marginal utility of consumption during unemployment and upon employment. The moral hazard cost, on the right-hand side, 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 increase in the unemployment duration.[15]

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social optimum and the competitive equilibrium respectively.

[15] 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.

When beliefs are unbiased, the corrections in both formulas in the Proposition drop, $I^{\tau}(0,0,z)=0$ and $\frac{\pi(\hat{e}(z))}{\hat{\pi}(\hat{e}(z))}=1$, such that the insurance contracts in the social optimum and the competitive equilibrium coincide. The control beliefs play the same role as in the static model. The baseline beliefs, however, do not only change the perceived value of insurance, to which private insurers respond, but also change the perceived returns to search. Baseline optimism distorts the insuree's effort choice downward 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 $\frac{\hat{\pi}(\hat{e})-\pi(\hat{e})}{\pi(\hat{e})}>0$.[16]

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 5 follows given the functions $J^x(z)\equiv\frac{\beta\pi(\hat{e})[(b+\tau^u)(1-\beta)-x]}{[1-\beta(1-\pi(\hat{e}))]^2x}$ 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 5 *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

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

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

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

[16] 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.

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 from the dynamic change evaluated at the contract (c_0, x) has a simple interpretation as well. This depends on the difference in expected utility gains from an increase in the initial consumption level c_0, denoted by U_{c_0}, starting from a contract $(c_0, 0)$ for which the consumption levels remain fixed at the initial level c_0 and from a contract $(c_0\text{-}x, x)$ for which the initial consumption level is reduced by x. If $x > 0$, the marginal utility of consumption is higher for the second contract, $U_{c_0}(c_0\text{-}x, x, \hat{e}) > U_{c_0}(c_0, 0, \hat{e})$. 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, but an increase in x also increases the induced effort level and thus has a first order impact on the insurer's budget constraint. Hence, 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 unemployment 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 therefore 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 6 *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 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. The considered deviation from the optimal linear contract increases the insuree's welfare if the effect on the search internality is either negative and small or positive.

Proposition 7 *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 $d > 1$) in a revenue-neutral way 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 that the long-term unemployed should be incentivized less than the short-term unemployed. For private insurers this effect of improved incentives is offset by the fact that insurees need to be compensated less in terms of current consumption for decreases in future consumption the further these decreases are in the future. This shows that the timing of incentives during unemployment is therefore another dimension along which privatizing insurance may decrease welfare in the presence of biased beliefs.

5 Empirical Analysis

In this section, I analyze empirically the baseline and control bias in the beliefs held by unemployed job seekers. Linking the expected duration of unemployment with the actual duration of unemployment, I find strong evidence that job seekers are baseline-optimistic. The identification of the control bias is more difficult. I consider the differential impact of search efforts on the unemployed's expectations and their actual employment outcomes. Controlling for heterogeneity and endogeneity, the estimates suggest that job seekers are control-pessimistic. Finally, I analyze how baseline beliefs change during unemployment and find no evidence that unemployed workers are less biased the longer or the more often they have been unemployed.

5.1 Data

I use data collected by Price et al. (1998) in a study about preventing depression in couples facing job loss. The study was conducted in and around two major urban areas in Michigan and Maryland from 1996 to 1998. All participants were recruited through state unemployment offices. Initial screening retained 1487 job seekers, who were part of a couple. All retained subjects were unemployed for less than 15 weeks and looking for work, but did not expect to be recalled to their former job. About one month after the initial screening, the retained subjects and their partners were interviewed for the first time. Two follow-up interviews were organized about six months and twelve months later. A third follow-up interview was organized one month after the first interview, but only for a subsample of the initial group. In Table 1 in appendix, I show sample averages of the demographics of the retained job seekers. On average, the subjects have been unemployed for 6.9 weeks at the time of the first interview.

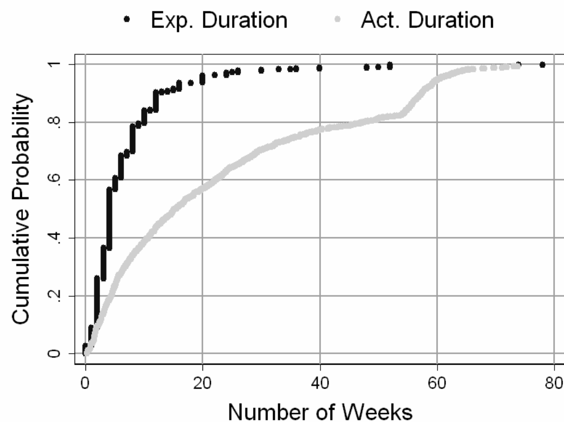

Figure 2: Empirical cumulative distributions: actual duration vs. expected duration of remaining unemployment spell

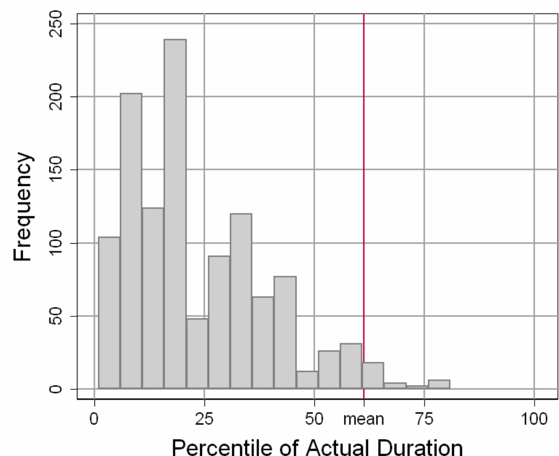

Figure 3: Histogram of the reported expectations with bins labeled by the percentiles of the actual duration

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 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. The cumulative distribution is shown in Figure 2.

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.[17] On average the unemployment spell lasts more than three times as long as expected, suggesting an average baseline bias of more than 200 percent.

[17] In the follow-up interviews, subjects are asked about the start date of their current job only. I exclude 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.

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 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.[18] 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.[19] 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.[20] 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

[18] 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.

[19] 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.

[20] 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.

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 baseline 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 half as much variation in the actual duration of the unemployment spells as all other demographic and employment variables together.[21] 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). 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.[22] 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 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 below the median (and thus below the mean). Finally, an alternative question in the survey asking for a probabilistic forecast suggests similar optimism about the baseline probability of finding work, although it does not allow to quantify the bias, as

[21] The R^2 for regression (1) in Table 2, which regresses the actual duration on all considered covariates, increases from .087 to .128 when including the expected duration as an explanatory variable. The R^2 for regressing the actual duration on only the expected duration equals .052.

[22] 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.

discussed in Appendix C.

5.3 Control Beliefs: Actual and Perceived Returns to Effort

Subjects are asked how frequently they have searched for work during the month before the interview. The questions ask about reading the newspaper for job opportunities, checking with employment agencies, checking with friends, sending out resumes, etc. I aggregate the answers to these questions, giving each answer the same weight, and I estimate the impact of this search index on the actual and expected duration of unemployment.[23,24] The regressions of interest are

$$\begin{aligned} \textit{actual duration}_i &= \beta_1 \; \textit{search}_i + X_i \gamma_1 + \varepsilon_i, && \text{(6a)} \\ \textit{expected duration}_i &= \beta_2 \; \textit{search}_i + X_i \gamma_2 + \nu_i, && \text{(6b)} \\ \textit{act. duration}_i \text{ - } \textit{exp. duration}_i &= (\beta_1 - \beta_2) \; \textit{search}_i + X_i (\gamma_1 - \gamma_2) + \varepsilon_i - \upsilon_i && \text{(6c)} \end{aligned}$$

with the durations starting from the first interview.

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, which corresponds to doubling the frequency in every search dimension, the actual unemployment spell is 3.4 weeks shorter, but the expected unemployment spell is only 2.0 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 lower optimism about the duration of unemployment (p -value = .08). The average control bias equals -67 percent. This is less pronounced than the baseline bias and also opposite in sign.[25]

The baseline-optimistic bias does not only change with search efforts. I control for many

[23]The correlation between this search index and any of its nine components varies between 0.48 and 0.70. The partner of each subject is asked the 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.

[24]The nine questions are: "During the past month, how often have you; read the newspaper and other publications for job opportunities? checked with employment agencies? talked to friends, family, or other people you know to get information about jobs? used, or sent out a resume? filled out application forms for a job? telephoned, written or visited potential employers? done things to improve the impression you would make in a job interview? contacted a public employment service? went out on information interviews?" The answer options are; 1. Not at all, 2. Once every 3 to 4 weeks, 3. Once every couple of weeks, 4. Every week, 5. Two or three times a week, 6. Every day.

[25]The estimated pessimism about control is robust when including alternative measures of search and controling for the willingness to work, as shown in Appendix C. There I also discuss censoring and truncation issues.

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 (2009).

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 in regression (6a). 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 in regression (6c) is still consistent. This is not sufficient if for instance job seekers differ in their naiveté about their hyperbolic preferences, which affects at the same time the search decision and the optimistic beliefs about the duration of unemployment. 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 in regression (6b). I try to correct for unobserved heterogeneity and 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.[26] 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

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

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 in (6) 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. A job seeker's attachment to work is likely to be correlated with the actual and expected duration of unemployment, in other ways than through search, but may not be correlated with the difference between the two. If job seekers who attach more importance to work are more optimistic about the duration of the unemployment spell, I underestimate how pessimistic they are about their control and vice versa.

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 estimates of the search coefficients increase in absolute value in both regressions compared to the least squares estimates. A job seeker who searches twice as intensively, finds employment 5.7 weeks earlier, but expects the reduction in the unemployment spell to be only 3.3 weeks.[27]

5.4 Change in Beliefs during Unemployment

In the dynamic model, I have made the simplifying assumption that the perceived probability of finding work is not affected by the duration of unemployment. This contradicts learning by unemployed workers. However, the beliefs reported by the job seekers suggest that not much learning is going on.

First, 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 (p -value $= .48$), as shown in Table 2. Second, the number of weeks a job seeker has been unemployed

[27] The job seeker's control pessimism is confirmed when I add alternative instruments that make the first stage stronger, as discussed in appendix C.

in the current spell even tends to increase the optimistic bias (p -value $= .07$). 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. However, sufficient learning 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. 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 for the job seekers who are still unemployed at the time of the last interview, about twelve months after the first interview, the expectations have significantly increased after twelve months. Together these results suggest that if some learning about the bias is going on, it is very modest.[28]

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 -67 percent, which corresponds to the least squares estimates in Table 2, and an optimistic

[28] 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.

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 -67 percent, the unemployment benefit b is significantly lower in the competitive equilibrium than in the social optimum. The respective unemployment benefit levels are .16 and .40. 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 .185 in the competitive equilibrium and .173 in the social optimum.

The full line and dashed line in Figure 4 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 .40 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 .41 for the considered range of

baseline optimistic biases. In the right panel of Figure 4, I present the respective replacement rates for a control bias $\frac{\hat{\pi}'(e)-\pi'(e)}{\pi'(e)}$ ranging from -95 to 95 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. Both the responses by private insurers and the social planner to a change in the control bias are relatively modest. The two panels together show that the wedge between social insurance and private insurance is predominantly driven by the baseline bias rather than by the control bias; only for extreme control-pessimistic beliefs does the wedge between private and social insurance change significantly in response to changes in the control beliefs. This would be different if search effort is modeled along the extensive rather than the intensive margin.

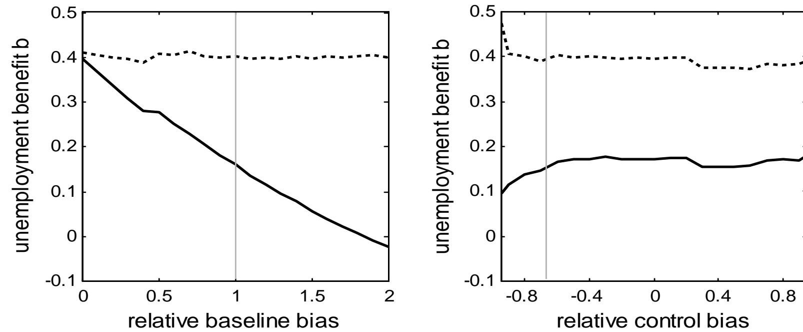

Figure 4: Unemployment benefit in static competitive equilibrium (full) and social optimum (dash) for different baseline and control biases

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 $-.16$ in the competitive equilibrium. The monthly decrease in consumption during unemployment, expressed as a percentage of production, equals only .5 percentage points in the social optimum, but 8 percentage points in the competitive equilibrium. Consumption jumps by .43 upon employment in the social optimum and by 1.40 in the competitive equilibrium. Figure 5 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 by 24 percentage points relative to output for each extra month of unemployment.

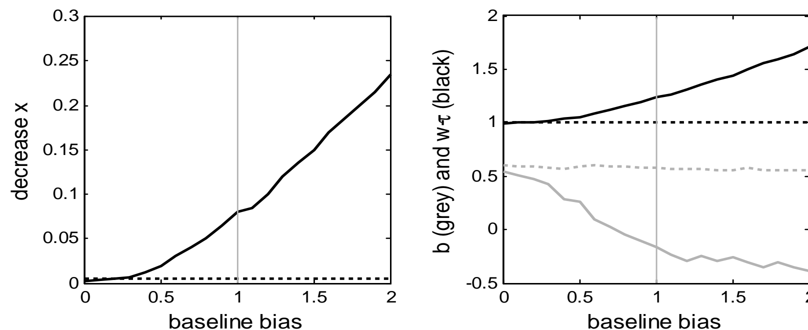

Figure 5: Dynamic contract in competitive equilibrium (full) and social optimum (dash) as a function of the baseline bias

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 .37 and the monthly decrease in consumption x at only .26 percentage points. The socially optimal contract has $w - \tau^u - b = .43$ and $x = .5$, if the baseline bias is 100 percent and the control bias is -67 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 4 and 5 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 67 percent, this consumption subsidy is 9 percent of the output when employed. That means that 9 percent of the economy's production is needed to make people with competitive unemployment insurance as well off as they would be with an insurance system that is optimally designed. More importantly, the numerical simulation suggests that the consumption subsidy increases exponentially in the baseline bias, as shown in Figure 6. When the baseline bias is small, the consumption subsidy is approximately zero and the welfare cost of privatizing insurance is small. However, when the baseline bias is large, the welfare cost of privatizing insurance may be very substantial. 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.

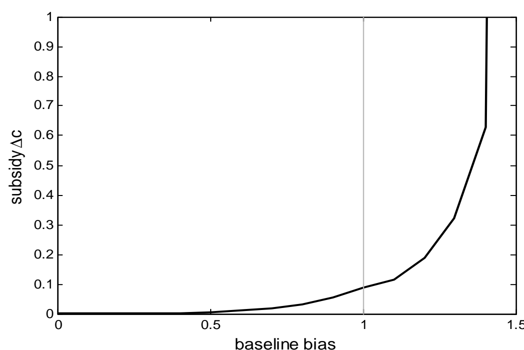

Figure 6: Welfare cost of privatizing insurance
as a function of the baseline bias

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 theoretical analysis also generalizes for other behavioral biases to the extent that these biases distort the decision to exert precautionary efforts or the perceived value of insurance. For example, a job seeker with naive hyperbolic time preferences searches too little (DellaVigna and Paserman 2005), but also overestimates how much he or she will search in the future and thus underestimates the value of unemployment insurance.

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, as analyzed in 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. 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 use their savings too rapidly in unemployment. Saving mandates are therefore an indispensable part of such a policy.

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Table 1: Summary Statistics

	Obs.	Mean	StDev		Obs.	Mean	StDev
Male	1339	.55	.50	Partner's education	1137	13.50	2.20
Age	1339	38.48	9.96	Monthly wage[2]	1320	2.60	1.72
White	1339	.67	.47	Times unemployed	1339	.34	.47
Married	1339	.81	.39	Weeks displaced[3]	1339	6.91	4.16
Children	1339	1.30	1.25	Search (at 1st int.)	1249	3.34	.87
Education[1]	1334	13.63	2.14	Search (at 3rd int.)	1249	3.35	.95
Maryland	1339	.45	.50	Actual duration[4]	1223	23.04	21.03
Partner empl.	1139	.79	.41	Expected duration	1182	6.83	8.60

[1] Expressed in number of years. [2] Earned on the last job before unemployment, expressed in 1000 USD. [3] Since the start of the current unemployment spell. [4] Includes censored spells with the duration between the first and last interview.

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	Expected duration	Optimism
	(1)	(2)	(3)
Search	-3.30 [757]**	-2.03 [.369]**	-1.36 [.780]
Male	-3.45 [1.34]*	-1.88 [.457]**	-1.58 [1.39]
Age	.201 [.073]**	.048 [.021]*	.153 [.072]*
White	-5.82 [1.50]**	-.544 [.596]	-5.28 [1.54]**
Married	-5.07 [1.89]**	.306 [.576]	-5.37 [1.89]**
Children	.783 [.528]	.410 [.274]	.373 [.544]
Education	-.343 [.368]	.317 [.126]*	-.659 [.362]
Maryland	-2.97 [1.35]*	.124 [.493]	-3.09 [1.34]*
Partner employed	-2.78 [1.62]	.242 [.501]	-3.02 [1.64]
Partner education	.014 [.337]	.205 [.115]	-.192 [.333]
Monthly wage before unemp.	-.732 [.392]	.490 [.194]*	-1.21 [.369]**
Times unemployed	-1.22 [1.35]	-.294 [.453]	-.925 [1.32]
Weeks since displacement	.428 [.165]**	.134 [.064]*	.294 [.163]
Obs.	1007	1007	1007
R^2	.087	.115	.078

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

Table 3: 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	Expected duration	Optimism	First Stage
	(1)	(2)	(3)	(4)
Search	-5.66 [3.20]	-3.32 [1.18]**	-2.34 [3.04]	
Potential Benefit				-.0004 [.0006]
Job Importance				.270 [.032]**
Observations	1004	1004	1004	1004
R^2	.08	.099	.077	.182
Overidentification	.011	.150	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.

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

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

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

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

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

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

Rewriting this in terms of elasticities, I find

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

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

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

The last term equals zero by (IC). Dividing by $(1-p)\left(1-\pi\left(\hat{e}\left(b\right)\right)\right)$ gives

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

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

Proof of Proposition 4

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

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

with

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

the decrease in the expected cost of the contract for the insurer when e increases. 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

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

then the revenue-neutral change implies

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

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

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

with

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

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

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

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 $I_2^\tau > 0$.

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 5

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

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

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

Using similar algebraic manipulations as in the proof of Proposition 4, 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 5 immediately follows. $I^x(0,0,z)$ equals 0. $I_1^x > 0$ and $I_2^x > 0$ again follow from the derivative from $\frac{\partial U(z,\hat{e}(z))}{\partial e}$ with respect to the biases in beliefs, as in Proposition 4.

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.$\square$

Proof of Proposition 6

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

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

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 7

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

$$\frac{\partial U}{\partial x_0}dx_0 - \frac{\partial U}{\partial x_+}dx_+ + \lambda\left[\frac{\partial \Pi}{\partial e_0}\left(\frac{\partial \hat{e}_0}{\partial x_0}dx_0 - \frac{\partial \hat{e}_0}{\partial x_+}dx_+\right) + \frac{d\Pi}{de_+}\left(\frac{\partial \hat{e}_+}{\partial x_0}dx_0 - \frac{\partial \hat{e}_+}{\partial x_+}dx_+\right)\right] > 0, \quad (8)$$

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 we introduce the variation starting from the optimal linear contract, 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 (8) 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 $\hat{\pi}\left(\hat{e}\right)>\pi\left(\hat{e}\right)$.$\square$

Proof of Corollary 1

When $\hat{\pi}'\left(\hat{e}\right)\leq\pi'\left(\hat{e}\right)$, $1+\frac{\pi'(\hat{e})-\hat{\pi}'(\hat{e})}{\pi'(\hat{e})}I\left(b\right)\geq1$. By the second order condition, $\frac{\left[u'(b)-u'(w-\hat{\tau})\right]/u'(w-\hat{\tau})}{\varepsilon_{1-\pi(\hat{e}),b}}$ 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.$\square$

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 $\frac{\left[u'(b)-u'(w-\hat{\tau})\right]/u'(w-\hat{\tau})}{\varepsilon_{1-\pi(\hat{e}),b}}$ is decreasing in b, the benefit implemented by the standard Baily formula exceeds the benefit implemented by the adjusted Baily formula.$\square$

Proof of Corollary 3

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

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

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

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

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

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

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

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

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

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

Notice that every single term in η is negative as is ξ. Also $\pi''(e)$ and ξ are negative. The last term in the conditions may be positive, but is small if $\frac{u'(w-\tau)}{u'(b)}$ is close to 1. The term before is positive only if $\frac{u'(w-\tau)}{u'(b)}<\frac{1}{2}$ and $\frac{u'(w-\tau)}{u'(b)}<\frac{1}{2}\frac{\hat{\pi}'(e)}{\pi'(e)}$ respectively.□

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 $p = 1/2$.[29] 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

$$\pi(e) = \pi_0 + \pi_1 \times e^{0.662} \text{ with } \pi_0 = 0.140 \text{ and } \pi_1 = 0.170$$

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

Perceived Probability of Finding Work The empirical section suggests baseline optimism, but control pessimism. I assume that the perceived monthly probability of finding work as a function of effort equals

$$\hat{\pi}(e) = \hat{\pi}_0 + \hat{\pi}_1 \times e^{0.662} \text{ with } \hat{\pi}_0 = 0.361 \text{ and } \hat{\pi}_1 = 0.056.$$

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 -67 percent. Notice that the baseline bias is more modest than the average baseline bias in the sample

[29] 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.

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).

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 $\psi_0 = 0.483$ and $\psi_1 = 2.65$. 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 $\psi_0 = .489$ and $\psi_1 = 1.19$.

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: Robustness Checks

Baseline Beliefs: Probability of Finding Work The subjects are asked a second question about their expectations: "How likely is it that you will be employed more than 20 hours a week in the next two months?" The subjects have the choice among five options; 'very unlikely', 'unlikely', 'neither likely, nor unlikely', 'likely', 'very likely'. I interpret the first two and last two options as the beliefs that the probability to be employed is smaller than a half ($\hat{\pi} < 1/2$) and greater than a half ($\hat{\pi} > 1/2$) respectively. I find the following distribution of subjects who do and don't find employment within two months;

	$\hat{\pi} < 1/2$	$\hat{\pi} > 1/2$
not-employed	0.14	0.47
employed	0.05	0.34

Although the answers do not allow to quantify the bias, they suggest similar optimism about the baseline probability of finding work. Among those who believe that the probability of becoming employed within two months is strictly greater than one half, less than half actually do. Moreover, while 47 percent believe that the probability is greater than a half and do not find work, only 5 percent believe that the probability is smaller than a half, but do find work.

Control Beliefs: Search, Censoring and Instruments 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 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 0.9 weeks shorter, as reported in Panel A of Table 4. 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 -2.1 and -1.2 in the actual and expected duration regressions respectively (Panel B of Table 4).

When restricting the sample to the completed spells, the relation between search and the actual duration of the unemployment spell weakens. The impact of search on the baseline bias becomes insignificant (Panel C of Table 4). 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 exponential 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 expected increase in the hazard rate for job seekers who search more intensively is slightly higher than the actual increase (Panel D of Table 4). 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.

Finally, 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.

Table 4: 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	-4.47 [.762]**	-.878 [.309]**	-3.59 [.747]**
Obs.	852	852	852
Panel B: Include Ideal Duration under Certainty			
Search	-2.15 [.769]**	-1.16 [.353]**	-.991 [.817]
Ideal duration	.462 [.097]**	.369 [.112]**	.094 [.118]
Obs.	993	993	993
Panel C: Complete Spells Only			
Search	-1.54 [.643]*	-1.44 [.301]**	-.103 [.684]
Obs.	886	886	886
Panel D: Hazard Model with Exponential Distribution			
Search	.213 [.042]**	.258 [.038]**	
Obs.	1007	983	

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.