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Temptation, Self-Control, and the Design of Optimal Unemployment Insurance

Zoe Leiyu Xie
Pei Cheng Yu

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Abstract

This paper studies how the unemployment insurance system should be designed when considering costly self-control. The standard optimal unemployment insurance with dynamic moral hazard features declining benefits over the unemployment spell, without a lower bound on consumption ("immiseration"). As documented in the empirical literature, unemployed workers may be tempted to undervalue the future benefits of job search. The paper models this behavioral bias using costly self-control—a utility cost incurred when a worker's job search choice deviates from the choice that maximizes current period utility and disregards future utility. Compared with the standard setup with moral hazard alone and without behavioral bias, the optimal system features lower benefit levels, a less rapid decline in benefits over the unemployment spell, a lower bound on consumption for the unemployed, and a one-time reward when a worker returns to work. The findings suggest that food assistance benefits and a back-to-work bonus in many U.S. states are broadly in line with such an optimal unemployment system.

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Zoe Leiyu Xie† Pei Cheng Yu‡

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†lxie@worldbank.org, World Bank, United States.
‡pei-cheng.yu@unsw.edu.au, School of Economics, University of New South Wales, Australia

1 Introduction

Involuntary job loss can be financially devastating for individuals, leading to negative effects on their economic well-being. Unemployment insurance (UI) programs provide much-needed financial support, but generous benefits can create a disincentive for job search, ultimately prolonging unemployment. Current debates on welfare programs echo similar concerns. Policymakers have recently proposed cutting support to promote self-sufficiency, targeting not only UI but also long-term programs like the Supplemental Nutrition Assistance Program (SNAP). For instance, the "One Big Beautiful Bill" recently signed into law expands work requirements for SNAP recipients, with proponents arguing that it will reduce dependency and encourage labor force participation. But does decreasing social insurance really encourage job search, or does it risk exacerbating hardship without improving employment outcomes?

The optimal design of UI, as prescribed by traditional dynamic moral hazard settings, involves gradually decreasing benefits over the unemployment spell while keeping the consumption path of the employed undistorted. The optimum aims to provide sufficient insurance to the unemployed while incentivizing continuous job search efforts. In contrast, real-world UI systems often include a constant basic income—such as SNAP—after benefits expire, ensuring a lower bound on consumption for the chronically unemployed, and a one-time back-to-work or reemployment bonus upon securing a job, which incentivizes job search but distorts the consumption path of the employed. Outside of ethical concerns, the basic income and back-to-work bonus do not align with the standard framework's recommendations.

This paper demonstrates how the provision of a basic income and back-to-work bonus can be features of an optimal UI system when considering behavioral factors, specifically temptation and self-control preferences (Gul and Pesendorfer, 2001). Recent literature, both theoretical and empirical, highlights how costly self-control significantly affects effort investment, as individuals can be tempted by short-term benefits and require self-control or commitment to overcome this temptation (Kaur et al., 2010, 2015; Wozny, 2017). In the UI literature, an increasing body of evidence suggests that the unemployed tend to assign less weight to the long-term benefits of employment (DellaVigna and Paserman, 2005; Paserman,

2008; Fluchtmann, 2019; Ganong and Noel, 2019). Specifically, Gerard and Naritomi (2021) demonstrate that this tendency leads the unemployed to search too little. Building on the standard dynamic moral hazard framework, our model accounts for the agent's psychological cost of exercising self-control to search for a job and the tendency to undervalue the future benefits of job search. Therefore, we model self-control cost as proportional to the difference between the flow utility of the most tempting action and that of the chosen action, i.e., temptation is evaluated on present utility and disregards future utility.

We demonstrate how a crucial economic force, unique to temptation and self-control preferences, governs the design of the optimal policy. Specifically, the optimal UI system leverages the temptation of the unemployed by magnifying immediate rewards and punishments. The optimal expected consumption path of the unemployed is relatively more back-loaded compared to the standard setting without temptation and self-control preferences. Specifically, the inverse marginal utility of the unemployed is no longer a martingale, but a submartingale. To understand this, note that in addition to raising incentives for searching, lower benefits help decrease self-control costs when individuals have temptation and self-control preferences.[1] This additional gain from lowering benefits weakens the government's motive to insure against unemployment, and so benefit levels are lower when self-control cost is higher. In other words, the interests of the agent and the government are partially aligned in making job search more appealing. In fact, we show that under certain conditions, the incentive compatibility constraint may not bind. Consequently, the classic immiseration result of dynamic private information models—that the punishment for remaining unemployed becomes arbitrarily high—may not hold. This implies that the optimal UI system may provide a minimal level of benefits (a basic income) to the unemployed, casting doubt on the efficacy of recent cuts to social insurance.

The optimal policy rewards employment by front-loading the consumption path of the

[1] An alternative way of modeling lack of self-control is through present bias. Both approaches result in agents who demand commitment, which helps them stick to their long-term goals. The main difference is that a present-biased agent who can resist temptation does not require commitment, whereas an agent with temptation and self-control preferences still demands commitment even if they resist temptation. This is because an agent with temptation and self-control preferences can reduce the self-control cost by committing, while a present-biased agent does not incur a psychological cost for resisting temptation. In an experiment, Toussaert (2018) used this subtle distinction to show that temptation and self-control preferences are likely to better capture self-control issues than present bias, lending support to our modeling choice.

employed, which can be implemented through a one-time income tax break or a back-to-work bonus. Empirical evidence has shown that back-to-work or reemployment bonuses can shorten unemployment spells (Woodbury and Spiegelman, 1987; Ahn, 2018; Huang and Yang, 2021). Furthermore, recent unemployment policies are in line with this result. In the wake of the COVID-19 pandemic, several US states introduced back-to-work bonuses to provide short-term incentives through a one-time lump-sum payment to those who find and maintain employment.[2] Recently, using the sufficient statistics approach, Komatsu (2025) shows that reemployment bonuses improve welfare and yield sizeable positive welfare impacts. To our knowledge, our paper is the first to offer a theoretical foundation for incorporating back-to-work bonuses into the UI system within a dynamic contracting framework.

Our paper also explores the evolution of the optimal policy over the unemployment spell. When the incentive constraint binds, the income tax for the employed increases and the promised utility to the unemployed decreases as unemployment spell lengthens, in line with standard models. We derive a novel sufficient and necessary condition for benefits to decrease over the unemployment spell when the incentive constraint binds, which holds trivially in the standard model when the cost of self-control is absent. In our quantitative exercise, we show that the optimal benefit decreases over the unemployment spell for our calibrated model, meaning that the condition holds for empirically relevant parameters. Furthermore, we find that the degree of front-loading and back-loading of the consumption paths for the employed and unemployed, respectively, decreases with the unemployment spell when the incentive constraint binds.

We calibrate our model with US data and demonstrate that our unique theoretical results have significant quantitative implications. The optimal unemployment benefit is decreasing but, in contrast to the standard model, it never falls below a replacement ratio of 22%. The optimal back-to-work bonus is 22% of wage income, which is similar to the bonuses introduced by several US states during the pandemic. Therefore, our quantitative analysis lays the groundwork for advocating a basic income and back-to-work bonuses, practices already in place at various levels across the US. Furthermore, compared to the current

[2]The US states that have introduced such bonuses are Arizona, Colorado, Connecticut, Kentucky, Maine, Michigan, Montana, New Hampshire, Oklahoma, and Virginia. It includes a near even mix of Republican and Democratic governors, indicating bipartisan support.

policies in the US, the optimal unemployment benefits are higher and decrease at a slower rate: The existing UI benefits in the US have an average replacement ratio of 45% and run out after 26 weeks, while the optimal benefits have an initial replacement ratio of 58% and remain above 50% for at least the first two years.[3] The average tax rate at the optimum is slightly higher than the prevailing income tax in the US and increases with the length of the unemployment spell. Such a spell-dependent incentive structure allows the optimal policy to achieve the same promised utility at lower costs. We show that the resource cost of our optimal UI system is significantly lower than the current US system. Compared to the current US policy, for each unemployed individual, the optimal policy decreases the resource cost by about one month's average income if the unemployment spell is one month, and up to one year's average income if employment is not secured until the fiftieth month.

When the model is extended to allow for intensive search effort, most of the results stand. Similar to before, the optimal policy with intensive search effort features lower reemployment tax analogous to a back-to-work bonus. In addition, we show that under certain conditions, the incentive constraint may not bind, so the extended model can also support the introduction of basic income in the optimal system.[4] By way of a numerical example, we show that when the incentive constraint binds, the promised utility decreases at a much slower rate compared to standard models without temptation and self-control preferences.

Finally, we examine present bias as an alternative approach to capturing self-control problems. We show that the qualitative properties of the optimal UI system under quasi-hyperbolic discounting—a popular way of modeling present bias—are largely similar to those in the setting with temptation and self-control preferences. However, some policy recommendations differ due to the subtle distinction that a present-biased agent who resists temptation does not suffer a utility loss, while an agent with temptation and self-control preferences incurs a self-control cost even if they avoid temptation. We also extend the present-bias model to consider the case where the agent is not fully aware of the present bias—referred to as non-sophisticated—since it is difficult to incorporate naiveté into temptation and self-control

[3]Many European countries provide UI benefits for up to two years, such as Denmark, France, Italy, the Netherlands, and Spain (https://www.unedic.org/storage/uploads/2023/07/20/Europ-info-2022-EN_uid_64b93e96b505c.pdf).

[4]In a model with search intensity, if the job-finding probability plateaus at a finite effort level, the incentive-compatibility constraint need not bind once the optimal effort reaches that plateau. In the binary-effort baseline, the plateau is built in: once policy induces job search, effort cannot increase further.

preferences. Following Yu (2020, 2021) and Paluszynski and Yu (2023), we show how the government can implement the full information efficient optimum using off-path policies when the agent is non-sophisticated.

1.1 Literature Review

This paper contributes to the literature on the design of UI systems. Since the seminal work of Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997), a large literature on the design of UI in a dynamic moral hazard model has developed. More recently, the literature has examined the optimal design of UI when the government lacks commitment (Golosov and Iovino, 2021; Mitman and Rabinovich, 2021; Pei and Xie, 2021). In contrast, our paper considers the design of the UI system when commitment is costly to the agent. Due to the large and diverse body of literature on UI, rather than attempting to provide an exhaustive review, we will discuss the most relevant studies that are closely related to our research question throughout the paper.

This paper is related to a growing literature in behavioral public finance. In particular, our paper contributes to the literature on the design of paternalistic policies when exercising self-control is costly. Several papers have studied the optimal policy for agents with self-control problems in a complete information environment (Krusell et al., 2010; Pavoni and Yazici, 2017a,b). A large literature studies the optimal trade-off between commitment and flexibility with present-biased agents (Amador et al., 2006; Halac and Yared, 2014; Galperti, 2015; Bond and Sigurdsson, 2018; Beshears et al., 2025). Some recent papers have examined the design of policies for present-biased agents in a Mirrlees environment (Lockwood, 2020; Yu, 2021; Paluszynski and Yu, 2023; Moser and de Souza e Silva, 2025). Cherbonnier (2021) characterizes the optimal dynamic insurance with present-biased agents and private taste shocks, showing that transfers tilt toward those reporting lower immediate consumption to deter over-reporting—a result robust to hidden savings. This literature has primarily focused on hidden types while our paper examines a model with repeated hidden action.

This paper also contributes to the literature on dynamic moral hazard with present-biased agents. By extending the setting of Rogerson (1985), Yilmaz (2013) and Balletta and Immordino (2013) have shown that the inverse marginal utility is not a martingale when the

agent is present biased. Cetemen et al. (2023) examine a dynamic principal-agent setting in continuous time where both the principal and agent can potentially lack commitment. Rivera (2022) also considers a dynamic principal-agent setting in continuous time but with naively present-biased agents. Park (2022) considers the optimal provision of unemployment benefits for naively present-biased agents. In contrast, our paper differs by considering the optimal contract when agents have temptation and self-control preferences.

The paper closest to ours is Wozny (2017), who studies a dynamic moral hazard problem with temptation and self-control preferences. Our paper differs from Wozny (2017) in two important dimensions. First, we consider an infinite horizon model, while Wozny (2017) focuses on a finite period model. Second, our paper focuses on characterizing how the optimal policy changes over time. Wozny (2017) is concerned with the comparative statics of the optimal contract for any given point in time.

The remainder of the paper is organized as follows. Section 2 outlines our model, and Section 3 derives our main theoretical results. Section 4 presents our quantitative analysis. Section 5 analyzes a model with search intensity. Section 6 discusses a model with quasi-hyperbolic discounting, and Section 7 concludes. Proofs for the theoretical results in the paper are in Appendix A.

2 Model

We consider a discrete-time repeated moral hazard problem to study the provision of optimal UI. The agent starts off unemployed. Conditional on being unemployed, in each period, the agent invests effort a in searching for a job. For simplicity, we assume that search effort is binary: search ($a = 1$) or not search ($a = 0$). Section 5 extends the model to a setting with a continuum of search effort. The cost of searching for a job is $h > 0$ and the cost of not searching is normalized to 0. The government does not observe the search effort a. If the unemployed agent searches for a job, the probability of encountering a job offer within the same period is $p \in (0, 1)$; while the probability of finding a job is zero for not searching.[5]

[5]The timing of our model is different from the usual one in the UI literature, which typically assumes that offers are delayed by a period after investment in search effort (Hopenhayn and Nicolini, 1997). Our timing helps generate the front-loaded consumption path for the employed. Under the usual timing assumed

We assume that all job offers pay a wage of w. The agent immediately becomes employed once an offer is given and remains employed forever.[6] To focus on job search incentives, we assume the agent does not save or borrow.[7]

The policy stipulates, for each unemployment date t, the benefit $b_t \geq 0$ that the agent receives and the continuation utilities U_{t+1}^u and U_{t+1}^e for the unemployed and employed, respectively. The government introduces an income tax τ_s^t on all employed agents, where s denotes the employment tenure length and t denotes the date of employment.

In contrast to the literature, we consider an agent with temptation and self-control preferences, à la Gul and Pesendorfer (2001).[8] Due to a lack of commitment to search for a job, the unemployed may be tempted to choose $a = 0$. The unemployed agent must thus exercise self-control to avoid succumbing to temptation. To model this, the Gul-Pesendorfer representation consists of two utility functions: the *commitment utility* and the *temptation utility*. To illustrate, let $v_t(a)$ and $V_{t+1}(a)$ denote the expected flow utility and expected continuation utility after investing search effort $a \in \{0, 1\}$ at t, then the commitment utility is $v_t(a) + \delta V_{t+1}(a)$, where $\delta \in (0, 1)$ denotes the discount factor. We model the temptation as a tendency to disregard future utility, so the temptation utility is $\gamma v_t(a)$, where $\gamma > 0$ represents the strength of the temptation.[9] The agent's decision problem is

$$\max_{a \in \{0,1\}} \left[(1+\gamma) v_t(a) + \delta V_{t+1}(a)\right] - \max_{\hat{a} \in \{0,1\}} \gamma v_t(\hat{a}).$$

The unemployed agent chooses search effort a to maximize the sum of the commitment and

in the literature, the consumption path of the employed is perfectly smoothed. Pei and Xie (2022) also showed that the timing in our environment has the additional benefit of minimizing the government's time inconsistency problem when providing UI.

[6] We do not consider the incentive problems of employed agents. For papers that consider the incentive problems of employed agents, see Zhao (2000) and Wang and Williamson (2002) for on-the-job moral hazard and Hopenhayn and Nicolini (2009) for opportunistic quits.

[7] The assumption of no lending or borrowing is similar to assuming that saving is observable by the government. For analysis on the optimal UI when saving is unobservable, see Werning (2002), Shimer and Werning (2007, 2008), and Mitchell and Zhang (2010).

[8] Recent experimental evidence indicates that preferences for temptation and self-control more consistently explain self-control behavior than do dynamically inconsistent preferences (Toussaert, 2018, 2019). Section 6 explores the implications of adopting the quasi-hyperbolic discounting model.

[9] Our formulation follows from the literature that estimates the strength of temptation γ (Bucciol, 2012; Huang et al., 2015; Kovacs et al., 2021). Krusell et al. (2010) consider a generalized version, where the discounting in the temptation utility is quasi-hyperbolic, i.e., the $\beta - \delta$ model. Our temptation utility is a special case of Krusell et al. (2010) with $\beta = 0$.

temptation utilities. The second maximization problem does not affect the agent's decision. However, it does affect welfare, because it determines the cost of self-control—the willpower needed to choose an effort that is different from the maximally tempting choice, which is the effort choice that maximizes $\gamma v_t(\hat{a})$. Specifically, the cost of self-control is defined as $SC_t = \gamma\left[\max_{\hat{a}\in\{0,1\}} v_t(\hat{a}) - v_t(a)\right]$. Note that the standard model, without temptation and self-control, corresponds to the case when $\gamma = 0$.

We present the rest of the model in recursive terms. Thus, we drop the time subscripts and superscripts. The commitment utility is

$$v(a) + \delta V(a) = \begin{cases} p\left[u(w-\tau_0) + \delta U^e\right] + (1-p)\left[u(b) + \delta U^u\right] - h & \text{if } a = 1 \\ u(b) + \delta U^u & \text{if } a = 0 \end{cases},$$

and the temptation utility is $\gamma v(a)$, where

$$v(a) = \begin{cases} \left[pu(w-\tau_0) + (1-p)u(b) - h\right] & \text{if } a = 1 \\ u(b) & \text{if } a = 0 \end{cases}.$$

The utility u is twice differentiable, strictly increasing, and strictly concave: $u', -u'' > 0$. We also assume that the second-order derivative of u is uniformly bounded.[10] Furthermore, given the income tax policy, the discounted future utility of the employed is $U^e = \sum_{s=1}^{\infty} \delta^{s-1} u(w-\tau_s)$. Finally, we assume that it is always optimal to induce the unemployed agent to search, which holds if w is sufficiently high.[11]

Since search effort is not observable, the UI system must satisfy the incentive compatibility constraint to motivate the unemployed agent to search, i.e., the expected utility from

[10] This assumption, together with the setup of the model, ensures that the unemployment policy instruments are differentiable (Santos, 1991), which we need for the proofs of our theoretical results in Section 3.

[11] We quantitatively verify that it is optimal to induce search effort for our preferred parameterization.

searching ($a = 1$) must be weakly greater than not searching ($a = 0$)[12]:

$$(1+\gamma)\left[u\left(w-\tau_0\right)-u\left(b\right)\right]+\delta\left[\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_s\right)-U^u\right]\geq\frac{(1+\gamma)\,h}{p}. \tag{1}$$

The following lemma shows that, under the optimal incentive compatible policy, the maximally tempting option is for an unemployed agent to not search for a job.

Lemma 1 *The maximally tempting action in an optimal incentive compatible UI system is to not search:* $\max\left\{u\left(b\right),pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}=u\left(b\right).$

With Lemma 1, the cost of self-control is

$$SC\left(b,\tau_0\right)=\gamma\left\{h-p\left[u\left(w-\tau_0\right)-u\left(b\right)\right]\right\}.$$

Therefore, we can rewrite the incentive constraint (1) as

$$p\left\{\left[u\left(w-\tau_0\right)-u\left(b\right)\right]+\delta\left[\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_s\right)-U^u\right]\right\}\geq h+SC\left(b,\tau_0\right). \tag{2}$$

In essence, with temptation and self-control preferences, the incentive compatibility constraints only differ from the ones in standard models by the endogenous self-control cost $SC\left(b,\tau_0\right)$. To incentivize search effort, by (2), the difference between the reward from being employed and the punishment for remaining unemployed has to be larger than the disutility of search effort h and the cost of exerting self-control $SC\left(b,\tau_0\right)$.

The government's resource cost is the expected discounted value of the net transfers required to deliver a specified utility to the agent. Spear and Srivastava (1987) showed that the discounted promised utility can be used as a state variable for the recursive contracting problem with time-consistent agents. Temptation and self-control preferences are dynamically

[12]The expected discounted utility for an agent who searches at the beginning of each period is

$$p\left[\left(1+\gamma\right)u\left(w-\tau_0\right)+\delta U^e\right]+\left(1-p\right)\left[\left(1+\gamma\right)u\left(b\right)+\delta U^u\right]-\left(1+\gamma\right)h \\ -\gamma\max\left\{u\left(b\right),pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}.$$

The discounted utility is $\left(1+\gamma\right)u\left(b\right)+\delta U^u-\gamma\max\left\{u\left(b\right),pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}$ for an agent who does not search.

consistent, so the standard tools from dynamic programming can be applied.[13]

Let $C(U)$ be the resource cost to providing discounted utility U. By Lemma 1, the promise-keeping constraint is

$$U = p\left[u(w-\tau_0) + \sum_{s=1}^{\infty}\delta^s u(w-\tau_s)\right] + (1-p)\left[u(b) + \delta U^u\right] - h - SC(b,\tau_0),$$

which can be rewritten as

$$U = p\left[(1+\gamma)u(w-\tau_0) + \sum_{s=1}^{\infty}\delta^s u(w-\tau_s)\right] + (1-p)\left[\left(1+\gamma-\frac{\gamma}{1-p}\right)u(b) + \delta U^u\right] - (1+\gamma)h. \quad (3)$$

Then, $C(U)$ satisfies the following Bellman equation:

$$C(U) = \min_{b,U^u,\tau_s}(1-p)\left[b + \delta C(U^u)\right] - p\sum_{s=0}^{\infty}\delta^s\tau_s.$$

subject to the incentive compatibility constraint (1) and the promise-keeping constraint (3). The following lemma shows the properties of the value function C.

Lemma 2 *C is strictly increasing, strictly convex, and twice differentiable. Therefore, the optimal policies (b, U^u, τ_s) are differentiable with respect to U.*

The convexity and monotonicity of C follow from Chapter 4 of Stokey et al. (1989). The result on the differentiability of the policy functions and the twice differentiability of C follows from Santos (1991). It is also important to note that if w is low, then it may be too costly to induce the unemployed agent to search. In that case, the convexity of C is not guaranteed, and the introduction of lotteries may decrease resource costs. Therefore, Lemma 2 results from focusing on a setting where investment in search is welfare improving.

It is crucial to point out how costly self-control changes the economic trade-off between insurance and incentives. Without temptation and self-control ($\gamma = 0$), the government

[13] Section 6.1 considers a quasi-hyperbolic discounting model—alternative method for modeling self-control problems. An agent with quasi-hyperbolic time preference is dynamically inconsistent.

provides as much insurance against unemployment while maintaining enough motivation to invest search effort, so the incentive constraint (1) binds at the optimum. However, in our setting, the cost of self-control rises as insurance improves, which increases the resource cost of delivering a given promised utility—the promise-keeping constraint tightens. Therefore, in contrast to the standard model, the cost of self-control lowers the government's insurance motive. In fact, from (2), we can see that as insurance worsens (the difference between $w-\tau_0$ and b increases), the incentive to search increases and the cost of self-control decreases, relaxing the incentive constraint. In certain cases, the incentive constraint may not bind at the optimum (Wozny, 2015, 2017). In other words, an unemployment policy that incentivizes job search is more aligned with the interests of an agent with costly self-control than in standard models. Kaur et al. (2015) also presented a similar finding in a moral hazard setting with present-biased agents. Furthermore, they found that workers chose strictly dominated contracts that serve to avoid the temptation of slacking off (Kaur et al., 2010, 2015). In fact, from the incentive constraint (1) and promise-keeping constraint (3), if self-control cost is too high, then it is no longer optimal to provide unemployment benefits.

Lemma 3 *If* $\frac{\gamma}{1+\gamma} \geq 1-p$, *then the optimal unemployment benefit is* $b=0$.

Lemma 3 states that when the agent's marginal cost from self-control is greater than the marginal expected benefit of receiving b, then $b=0$ at the optimum. The rest of the analysis will focus on the more policy-relevant and non-trivial case where the self-control cost is sufficiently low. In essence, we will maintain the assumption that $1-p > \frac{\gamma}{1+\gamma}$ for the rest of the paper.

Finally, based on the discussion above, one may wonder whether it could be welfare enhancing to introduce a menu with multiple UI policies. This approach capitalizes on the idea that presenting a variety of choices, some of which are tempting but not ultimately selected, can effectively relax the incentive constraints by exploiting the agent's self-control cost (Esteban and Miyagawa, 2005). In Appendix B, we show that optimally-designed enlarged menus have no effect on the optimal policy in our setting.

2.1 Benchmarks

2.1.1 Full Information

When effort is observable, the government can condition the unemployment benefits on search effort. For instance, it can severely punish an agent if $a = 0$. Thus, the incentive constraint can be ignored. Importantly, this off-path punishment acts as a commitment device for the agent to search, so the cost of self-control becomes zero. Therefore, the agent's utility reduces to the commitment utility. The following proposition characterizes the full information optimum when the agent has temptation and self-control preferences.

Proposition 1 *When search effort a is observable, the full-information efficient optimum is characterized by (i) Consumption smoothing for the unemployed: b and U^u are constant over the unemployment spell, (ii) Consumption smoothing for the employed: $\tau_s = \tau$ for all s, (iii) Full insurance: $w - \tau = b$.*

Proposition 1 is a standard result, so its proof is omitted. In a frictionless environment, consumption paths are independent of unemployment duration or employment tenure. Since consumption plans are the same regardless of employment status, an unemployed agent has no incentive to invest search effort $a = 1$ once effort is not observable. In essence, the full-information efficient effort violates incentive compatibility (1). Another important observation is that, since a commitment device can be provided when effort is observable, the agent's temptation utility does not affect the full information efficient optimum. In other words, the first-best allocations are the same regardless of the agent's temptation γ.

2.1.2 Moral Hazard Without Temptation and Self-Control Preferences

In the standard model with moral hazard, the optimal policy must satisfy the incentive compatibility and promise-keeping constraints, (1) and (3), with $\gamma = 0$. The following proposition characterizes the constrained-efficient optimum when the agent does not have temptation and self-control preferences.

Proposition 2 *If $\gamma = 0$ and search effort a is unobservable, then the constrained-efficient optimum is characterized by (i) Consumption smoothing for the employed: $\tau_s = \tau$ for all s,*

(ii) Rising punishment for the unemployed: b and U^u are strictly decreasing over the unemployment spell and τ is strictly increasing with unemployment spell, (iii) Partial insurance: $w - \tau > b$, and (iv) Immiseration: U converges towards the lowest possible promised utility as unemployment spell goes to infinity.

Proposition 2 is a classic result in the UI literature, so its proof is omitted. First, since there are no informational frictions once the agent is employed and self-control is costless, it is optimal for the government to smooth the consumption of the employed. Second, unemployment benefits must decrease over time to punish the agent for continued unemployment (Shavell and Weiss, 1979; Hopenhayn and Nicolini, 1997). Note that the income tax also rises with the unemployment spell, which also holds in more general settings to insure the agent against consumption differences between employed and unemployed states (Hopenhayn and Nicolini, 1997). Third, due to the moral hazard problem, full insurance is no longer implementable, and consumption in employment must be larger than the unemployment benefit to incentivize search.

Finally, an agent who never finds a job receives the lowest utility possible at the limit. This is the classic immiseration result prevalent in models with dynamic private information (Thomas and Worrall, 1990). This result is due to the fact that the incentive constraint is always binding at the optimum when $\gamma = 0$. Lowering the utility serves to punish an agent who never finds a job, and it also helps decrease the cost of providing job search incentives. Therefore, in the long run, the agent's consumption would converge to zero, regardless of the employment state.

3 Characterizing the Optimum

This section derives some general properties of the optimal UI system. First, we show that, in contrast to the standard setting, the incentive compatibility constraint could be slack. Then, we characterize the optimal distortions to the consumption path for the employed and unemployed. This section ends by showing how the distortions to the consumption paths evolve over time.

3.1 Incentive Compatibility

In contrast to the standard model where $\gamma = 0$, the incentive compatibility constraint may not bind at the optimum. The following lemma shows that the optimal unemployment policy is constant over the unemployment spell when the incentive constraint is non-binding.

Lemma 4 *When the incentive compatibility constraint is non-binding at the optimum, the promised utility is constant over the unemployment spell:* $U^u = U$.

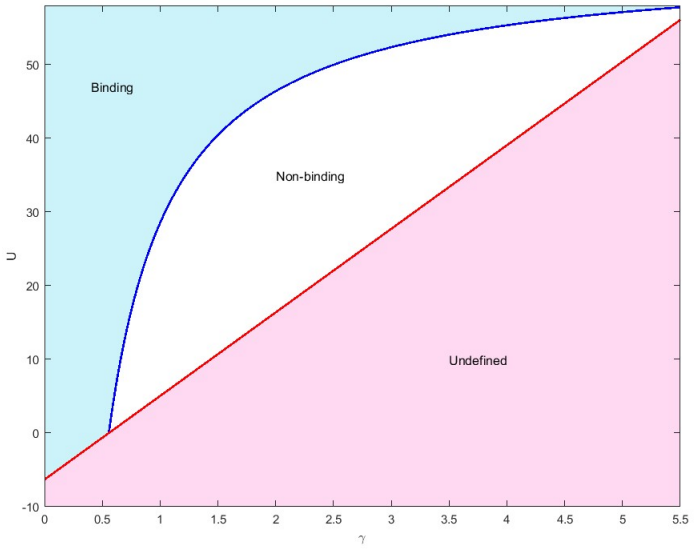
Similar to the full information environment, Lemma 4 implies that the UI system is at a steady state if the incentive constraint is non-binding. However, the optimal policy differs from the full-information case. The reason is that the government cannot offer a commitment device that is dependent on job search effort in the presence of moral hazard, as in Proposition 1. We will later show and explain that full insurance is not possible even when the incentive constraints are non-binding.

Consider an example of non-binding incentive constraints where the flow utility is $u(c) = \frac{1}{\sigma}\left[1 - \exp(-\sigma c)\right]$, with the coefficient of absolute risk aversion $\sigma > 0$. Using the guess and verify method (see Appendix C for details), we can derive the value function and the optimal unemployment policies for when the incentive compatibility constraint (1) is non-binding. By the promise-keeping constraint (3), the incentive compatibility constraint can be rewritten as $U \geq u(b) + \delta U^u$. Therefore, using the optimal benefit b derived in Appendix C and Lemma 4, we find that the incentive compatibility constraint is non-binding if

$$U \leq \frac{1}{\sigma(1-\delta)} - \frac{(1-p)(1+\gamma)h}{p\gamma\left[1-\delta(1-p)\right]}. \tag{4}$$

It is straightforward to verify that (4) does not hold for any promised utility U when $\gamma = 0$, so the incentive constraint is always binding in the standard model without temptation and self-control problems. By (4), as γ increases, the cost of self-control rises and the temptation to remain jobless strengthens. Thus, the agent's demand for insurance decreases to help lower the self-control cost, aligning their incentive with the government's. In essence, (4) shows how costly self-control eases insurance pressure and loosens the incentive constraint, increasing the range of admissible values for U that leave the incentive constraint non-binding.

Figure 1: Regions with binding and non-binding incentive constraints



Note: The preference parameters used to generate the figure are $\sigma = 1$ and $\delta = 0.99$. The probability of finding a job is $p = 0.15$ if the agent invests the search effort cost of $h = 1$. The relevant range of γ is $\left[0, \frac{1-p}{p}\right)$, which in this case is $\left[0, \frac{17}{3}\right)$. These numbers are different from our preferred parameters that are used for the quantitative exercise.

Figure 1 illustrates how it is easier to satisfy the incentive constraint if the temptation strength γ is large. The lowest possible utility for an unemployed agent is $U^L = \frac{p\gamma}{\sigma(1-\delta)(1-p)} - \frac{(1+\gamma)h}{1-\delta(1-p)}$, which is the upward-sloping red line as a function of γ in Figure 1.[14] In essence, the promised utilities in the red-shaded region are not feasible. The upward sloping blue curve in Figure 1 contains the values of promised utility U that satisfies the binding condition of (4) for relevant values of γ (recall that $\frac{\gamma}{1+\gamma} < 1 - p$). If the promised utility is within the unshaded region of Figure 1, then the incentive constraint is non-binding and the UI policy does not change over time. On the other hand, if the promised utility is within the blue-shaded region of Figure 1, then the incentive constraint binds.

As previously discussed, the cost of self-control increases with temptation γ. Consequently, the government reduces unemployment benefits to mitigate the higher self-control costs, thereby improving job-seeking incentives. This dynamic, depicted in Figure 1, illus-

[14] Since $U^u = \frac{1}{\sigma(1-\delta)}\left[1 - \frac{\sigma(1-\delta)(1+\gamma)h}{1-\delta(1-p)} - \left(1 + \gamma - \frac{\gamma}{1-p}\right)\exp\left(-\sigma b\right)\right]$ (Appendix C), $U^u = U^L$ when $b = 0$.

trates how increased temptation reduces the government's motivation to provide extensive insurance, making it less costly to incentivize job search.

Lemma 4 also implies that depending on the initial promised utility U, there are only three qualitatively different ways in which the UI system can evolve. The first possibility occurs when the promised utility starts off at a level where the incentive constraint is non-binding. Then, by Lemma 4, the optimal UI policy remains constant over time. The last two possibilities occur when the promised utility begins at a level where the incentive constraint binds. In this case, the promised utility can evolve over the unemployment spell and either reach the absorbing state where the incentive constraint no longer binds or it may remain binding forever. However, the next theorem shows that one of the two paths is suboptimal.

Theorem 1 *Given any promised utility U, if the incentive compatibility constraint is binding at U, it will continue to bind indefinitely.*

Theorem 1 establishes that if the incentive constraint is binding, transitioning to a non-binding incentive constraint is never optimal. Returning to the example in Figure 1, Theorem 1 implies that the benefits of moving to a non-binding incentive constraint from a promised utility slightly above the threshold (blue curve) are outweighed by the costs incurred from reducing the future promised utility (the continuation utility) to below the threshold. Consequently, only two scenarios are viable: the incentive constraints either remain binding indefinitely or never bind at all.

Even when incentive constraints bind indefinitely, immiseration might be avoided. When we characterize the unemployment benefits in Section 3.3, we will show that promised utility decreases when the incentive constraint binds. However, by Figure 1 and Theorem 1, the promised utility never falls below the threshold indicated by the blue curve for a fixed temptation strength γ that is sufficiently large. For our quantitative analysis in Section 4, we show that for empirically relevant levels of temptation γ, the promised utility is always above a threshold that is strictly above the lowest utility level U^L. As a result, the optimum can be closely approximated by a UI system with a strictly positive basic income.

The literature has found other reasons why immiseration may not be a feature of the optimal UI system, thus justifying the implementation of a basic income. Pavoni (2007)

argued that the government may want to provide a minimal level of expected discounted utility to the unemployed regardless of past history, ensuring that individuals are not left destitute.[15] Pavoni and Violante (2007) and Pavoni (2009) showed that if human capital depreciates while being unemployed, then it may no longer be optimal to incentivize job search once the agent's human capital is sufficiently low. In contrast, our paper demonstrates how, with temptation and self-control preferences, the incentive constraint may not bind, allowing immiseration to be endogenously avoided and leaving room for the introduction of a basic income.

3.2 Income Tax

The following theorem shows that, in contrast to Proposition 2, it is optimal to introduce a tax break to the agent immediately upon employment.

Theorem 2 *The optimal income tax satisfies: (i)* $\tau_0 < \tau_s = \tau$ *for all* $s \geq 1$ *with*

$$u'(w - \tau) = (1 + \gamma)\, u'(w - \tau_0),$$

and (ii) τ_0 *and* τ *are strictly increasing with the unemployment spell if the incentive compatibility constraint binds.*

By Theorem 2, the consumption path of an employed agent is initially front-loaded. The front-loaded consumption path of the employed reduces the unemployed agent's temptation to shirk, which lowers the self-control cost of searching. Therefore, compared to consumption smoothing, it is cheaper to incentivize search effort by lowering the cost of self-control through a promise of immediate tax deduction upon employment. Intuitively, the degree of front loading increases with the strength of the temptation γ. Theorem 2 also shows that the agent's consumption path is smoothed in subsequent periods, because there are no more informational constraints and self-control issues once the agent is employed. As a result, there are no benefits to distorting future consumption, so τ_s is constant for $s \geq 1$.

[15] Alvarez-Parra and Sanchez (2009) consider a setting with an informal labor market sector. In this context, the unemployed can stop searching for a job in the formal sector and work in the informal sector. The wages in the informal sector provide a lower bound on utility, thereby averting immiseration. However, it is not optimal for the government to implement a basic income because the agent can earn income from the informal sector.

Importantly, the intuition for part (i) of Theorem 2 holds regardless of whether the incentive constraint binds or not. In essence, the front-loaded consumption path for the employed decreases the cost of delivering any promised utility independent of the incentive constraints. Finally, similar to Proposition 2, part (ii) of Theorem 2 states that taxes τ_0 and τ are increasing with the unemployment spell if the incentive constraint binds.

The income taxes in Theorem 2 provide a theoretical foundation for back-to-work bonuses, which have become prevalent. Several OECD countries have introduced one-off lump-sum payments called in-work benefits to the unemployed once they find work (OECD, 2005). Recently, a few states in the US, such as Arizona, Michigan and Virginia, have introduced back-to-work bonuses to encourage unemployed workers to reenter the workforce after the COVID-19 pandemic. This is in line with empirical evidence that shows that such bonuses are effective in shortening unemployment duration (Woodbury and Spiegelman, 1987; Ahn, 2018; Huang and Yang, 2021) and raise welfare (Komatsu, 2025).

3.3 Unemployment Benefits

The next theorem demonstrates how, relative to the standard model, the expected consumption path is more back-loaded for an unemployed agent.

Theorem 3 *Let (b', τ_0') denote the policies for next period. The optimal unemployment benefit b and promised utility U^u satisfies: (i) The inverse marginal utility of the unemployed is a submartingale:*

$$\frac{1}{u'(b)} = \frac{1-p}{u'(b')} + \frac{p}{u'(w-\tau_0')} - \left(\frac{\gamma p}{1-p}\right)\frac{1}{u'(w-\tau)},$$

(ii) U^u is strictly decreasing with the unemployment spell if the incentive compatibility constraint binds, and (iii) b is strictly decreasing with the unemployment spell if and only if the incentive compatibility constraint binds and

$$\left(\frac{1-p}{\gamma}\right)\left[\frac{\delta}{C''(U^u)}\right]^{-1} > \frac{p}{\left[u'(w-\tau)\right]^2}\left[-\frac{u'(w-\tau_0)}{u''(w-\tau_0)} - \frac{\delta}{1-\delta}\frac{u'(w-\tau)}{u''(w-\tau)}\right]^{-1}. \tag{5}$$

To understand Theorem 3, note that in the standard model with $\gamma = 0$, the inverse

marginal utility of the unemployed is a martingale (Rogerson, 1985). The martingale property implies that it is optimal to smooth the cost of incentivizing the agent, so rewards and punishments are best delivered in a permanent manner. In contrast, when the unemployed agent suffers from temptation, Theorem 3 shows that expected inverse marginal utility for the next period is strictly greater than the current period's inverse marginal utility.[16] In essence, the inverse marginal utility is a submartingale. This implies that, relative to the case without temptation and self-control, the unemployed's expected consumption path is more back-loaded. This result holds regardless of whether the incentive constraint binds or not. Also, part (ii) of Theorem 3 shows that, similar to Proposition 2, the promised utility U^u is strictly decreasing as unemployment spell increases if the incentive constraint binds.

Theorem 3 follows a similar logic to Theorem 2 for why it is optimal to front-load the consumption of an employed agent. By back-loading, the optimal insurance scheme makes remaining in unemployment less tempting to the agent who overvalues the present. Theorem 2 and Theorem 3 imply that to decrease the cost of self-control and increase the incentives of searching for a job, it is optimal to raise the difference between the expected utilities of being employed and unemployed in the current period relatively more than in future periods.

Theorem 2 and Theorem 3 are in line with other studies that show how altering consumption paths can relax informational constraints in the design of policies for dynamically inconsistent agents within a quasi-hyperbolic discounting framework (Moser and de Souza e Silva, 2025; Yu, 2021; Paluszynski and Yu, 2023). However, the crucial difference here is that with costly self-control, the front- and back-loading of consumption paths also decrease the cost of delivering the promised utility due to lower self-control cost. As a result, in contrast to the setups with quasi-hyperbolic discounting, Theorems 2 and 3 hold even when the incentive compatibility constraint (1) is slack.

Finally, the unemployment benefits may not be decreasing over the unemployment spell, even when the incentive constraints are binding. To understand this result, first recall that in the absence of temptation ($\gamma = 0$), Proposition 2 showed that as the unemployment spell increases, taxes rise while promised utility U^u and benefit b decline. In essence, to

[16] Yilmaz (2013) and Balletta and Immordino (2013) have found results similar to Theorem 3 in a finitely repeated moral hazard setting with a quasi-hyperbolic discounting agent.

smooth costs, it is optimal to decrease the utility across both employed and unemployed states as unemployment spell lengthens. However, with temptation γ, the optimal evolution of unemployment benefits is governed by an additional sufficient condition: inequality (5).

The right-hand side of (5) is the change in the marginal cost of increasing employment utility weighted by the probability of finding a job.[17] In essence, it measures the cost of varying taxes (τ_0, τ) to satisfy the incentive constraint. Similarly, the left-hand side of (5) is the probability-weighted change in the marginal cost of increasing the promised utility δU^u scaled by the inverse of the temptation strength γ. Note that without temptation, when $\gamma = 0$, (5) always holds. However, as γ increases, the relative curvatures of the cost of providing utility in the two employment states become important. In essence, condition (5) compares the cost of varying promised utility versus the cost of changing taxes in an incentive compatible way.

To see why (5) is crucial in determining how benefit b evolves over the unemployment spell, note that for both incentive and promise-keeping constraints to bind as U changes, either the promised utility U^u or benefit b must decrease when taxes, τ_0 and τ, increase (Theorem 2). Theorem 3 has already shown that it is optimal to decrease U^u. However, if the relative convexity of the cost of adjusting U^u is large compared to the cost of changing the taxes, it becomes optimal to also decrease b to smooth costs rather than only lowering U^u. This is not true when (5) is violated.

As a result, with costly self-control, benefits do not necessarily decrease with the unemployment spell. Intuitively, a higher future benefit b' raises the self-control cost the agent expects to pay if still unemployed in the future, which encourages the agent to exert more effort now. Thus, an increasing benefit path may also serve as a deterrent to shirking when self-control costs are high. Despite that, Section 4 shows that the quantitatively relevant case has the unemployment benefit b strictly decreasing with unemployment spell when the incentive constraint binds.

[17] The cost of delivering the continuation utility $U^e = \frac{u(w-\tau)}{1-\delta}$ for the unemployed is $K\left(U^e\right) = \frac{u^{-1}[(1-\delta)U^e]}{1-\delta}$, so $K''(U^e) = -\left(1-\delta\right)\frac{u''(w-\tau)}{[u'(w-\tau)]^3}$.

3.4 Dynamic Change in Intertemporal Distortions

Next, we examine how the intertemporal distortions change as the length of the unemployment spell increases. We define the degree of front-loading in employment consumption as

$$\mathcal{F} = \frac{1}{u'(w-\tau_0)} - \frac{1}{u'(w-\tau)},$$

and the degree of back-loading in the unemployed's expected consumption path is defined as

$$\mathcal{B} = \frac{1-p}{u'(b')} + \frac{p}{u'(w-\tau_0')} - \frac{1}{u'(b)}.$$

Our definitions of front-loading and back-loading are from the government's cost smoothing perspective.[18] This is different from the perspective of the agent, where the degree of loading is encoded in the savings or intertemporal wedges. Immediately, notice that without temptation and self-control, we have: $\mathcal{F} = \mathcal{B} = 0$. By Theorems 2 and 3, under temptation and self-control preferences, $\mathcal{F}$ and $\mathcal{B}$ are strictly positive and are complements:

$$(1-p)\,\mathcal{B} = p\mathcal{F}.$$

Intuitively, this relationship shows that it is cost minimizing to rely on both the front-loading and back-loading of consumption to motivate search. Furthermore, as the probability p of successfully finding a job increases, the degree of back-loading $\mathcal{B}$ increases more than the degree of front-loading $\mathcal{F}$. In essence, it is less costly to distort the expected consumption path of the unemployed when the probability of failing to find a job is low.

Obviously, by Lemma 4, the intertemporal distortions are constant over the unemployment spell if the incentive constraint is non-binding. The next theorem shows that the distortions decrease over the unemployment spell when the incentive constraint binds.

Theorem 4 *$\mathcal{B}$ and $\mathcal{F}$ are strictly decreasing with the unemployment spell if the incentive compatibility constraint binds.*

Since promised utility decreases over the unemployment spell when the incentive constraint binds, the risk-averse agent becomes more responsive to job search incentives as the

[18] The inverse marginal utility is the cost of a marginal increase in utility in consumption terms.

unemployment spell lengthens. Therefore, the optimal UI policy can rely less on the temporal loadings. Recall that temporal loadings are inherently costly because the government would have preferred to smooth the cost of incentives.

4 Quantitative Analysis

This section offers a quantitative analysis of the optimal policy, and an assessment of its impact on welfare. Specifically, we examine the variations in unemployment benefits and income taxes relative to the duration of unemployment spells. This approach enables a comparative analysis of our findings with existing literature.

4.1 Calibration

Table 1 outlines the calibrated parameter values, with the model set to a monthly frequency. We adopt a utility function characterized by constant absolute risk aversion (CARA) for consumption, expressed as $u(c) = \frac{1}{\sigma}\left[1 - \exp\left(-\sigma c\right)\right]$, where the degree of risk aversion σ is set to 1. The discount factor δ is calibrated to target a 4% annual interest rate. The strength of temptation γ is determined based on estimates in the literature. Huang et al. (2015) and Kovacs et al. (2021) provide estimates of $\frac{\gamma}{1+\gamma}$ at 0.19 and 0.22, respectively. We set $\frac{\gamma}{1+\gamma}$ at 0.2, implying $\gamma = 0.25$.

The wage income w, received by employed workers each period, is normalized to 1. The search cost is derived from the average time unemployed US workers spend on job searching, as documented by Krueger and Mueller (2010)—41 minutes daily on weekdays. Given an eight-hour workday and twenty weekdays per month, this search time is translated into a wage equivalent using the normalized wage. The cost is then converted into utility terms. It's important to note that this represents a simplified estimation of search costs, excluding the psychological burdens of job searching, which could elevate the cost. Conversely, considering that unemployed workers typically earn less than their employed counterparts, using the average wage of unemployed workers for this calculation might result in a lower search cost estimate. The likelihood of an unemployed worker securing employment upon searching each period is determined by the US average job finding rate between 2003-07—reflecting a 5%

Table 1: Calibrated parameter values

	Meaning	Parameter value	Target moment
(a) Parameters used in the model			
σ	Risk aversion	1	—
δ	Discount factor	0.9966	4% annual interest rate
γ	Temptation strength	0.25	Implied by avg. estimate in literature
h	Cost of searching	0.0042	Avg. unemployed search time in util terms
w	Wage income	1	Normalization
p	Prob. finding a job if searches	0.38	Avg. US job finding rate 2003-07
(b) Parameters used to calibrate initial promised utility			
$\tau_{0,us}$	Income tax, first period	0.25	US worker avg. tax rate
τ_{us}	Income tax, after first period	0.25	Same as above
b_{us}	UI benefit	0.45	US avg. UI replacement ratio
$\underline{c}_{us}$	Social welfare income	0.036	US SNAP income/earned income ratio

unemployment rate and a 2% monthly job separation rate—yielding a monthly job finding rate of 0.38. Note that, given $p = 0.38$, the strength of temptation γ is sufficiently small to be within the relevant range, i.e., $\frac{\gamma}{1+\gamma} < 1 - p$.

To find the optimal UI policy relevant to the US economy, we calibrate the initial promised utility to reflect US economic conditions. This involves adjusting policy variables to align with those currently observed in the US economy, as detailed in Panel (b) of Table 1. It is crucial to note that these policy variables do not represent the optimal ones but rather approximate the existing US policies. The income tax rates for individuals upon employment and in future periods are fixed at 25% of wage income, mirroring the midpoint between the 2024 average tax rates for single workers (30%) and married workers with two children (20%) in the US.[19] The unemployment benefits are determined based on the US average UI replacement ratio of 45%, with a duration of 26 weeks during non-recessionary periods. Additionally, once unemployment benefits expire, individuals are entitled to a basic income

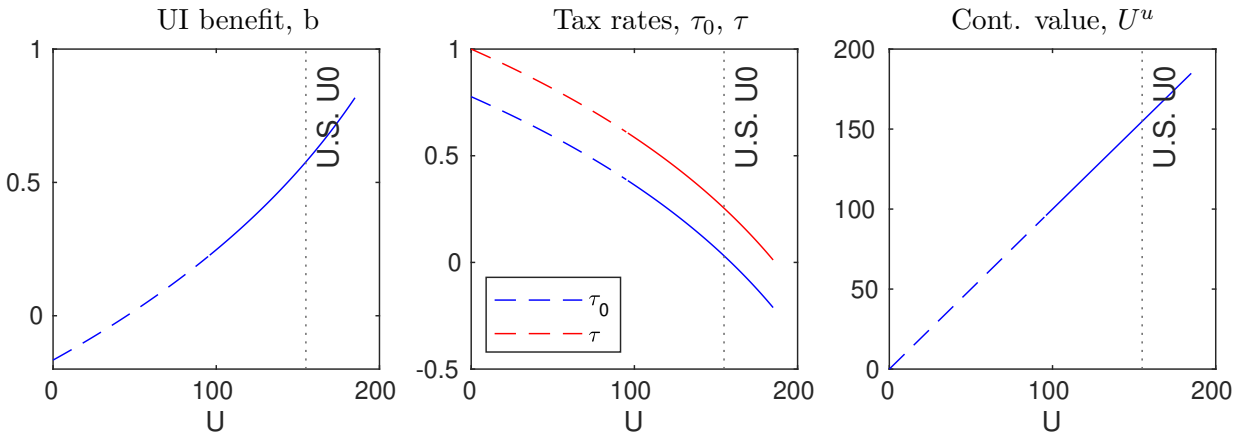
[19] https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/04/taxing-wages-2025-country-notes_16d47563/united-states_e44f6362/4a2a60b9-en.pdf

designed to reflect social welfare income, set in accordance with the SNAP (Supplemental Nutrition Assistance Program) to earned income ratio in the US (Fang et al., 2023). The initial promised utility is then calculated through iterative application of the promise-keeping constraint (3).

4.2 Optimal Policy

This section presents the quantitative properties of the optimal UI system within the calibrated model. Figure 2 illustrates the policy functions corresponding to the optimum, where each policy instrument is a function of the promised utility U.

Figure 2: Optimal policy functions

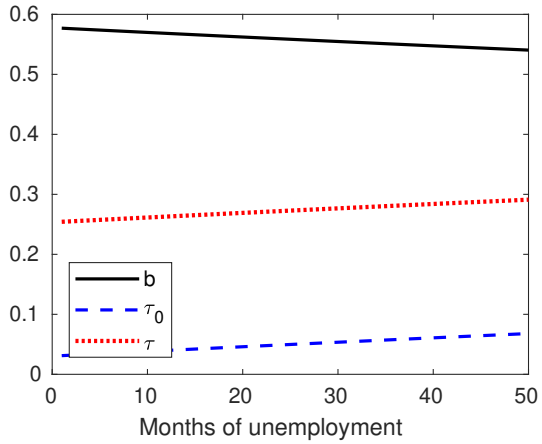


Note: Curves show the optimal policy functions over the initial promised utility. Dashed portions correspond to parts of the policy functions where the incentive compatibility constraint is slack. The vertical dotted line marks the value of US initial promised utility.

Four key properties merit attention. First, for low promised utility values, the incentive compatibility constraint (1) is non-binding, as depicted by the dashed policy function. For this part of the optimal policy, the continuation utility equals the initial promised utility, $U^u = U$ (Lemma 4). Second, for high promised utility values where the incentive compatibility constraint (1) binds, the policy function for U^u is below the 45-degree line so it is increasing in U. This implies that the promised utility falls over the unemployment spell (part (ii) of Theorem 3). Third, unemployment benefit b increases in U, so the optimal benefit falls over the unemployment spell when the incentive constraint binds. This implies that, by part

(iii) of Theorem 3, (5) holds for our quantitative exercise. Fourth, the income taxes τ_0 and τ both decrease in U with $\tau_0 < \tau$ (Theorem 2). In essence, the immediate income tax τ_0 is strictly lower than subsequent income taxes τ, and the longer a worker remains unemployed, the higher the income taxes upon employment when the incentive constraint binds.

Figure 3: Simulated optimal policy for the US



Note: Lines show the values of unemployment benefit b, immediate income tax τ_0, and subsequent income tax τ, depending on the length of the unemployment spell. Initial promised utility is set to the calibrated US value.

To illustrate, Figure 3 simulates the optimal policy starting from the initial promised utility calibrated to the US economy at $t = 0$. Given the calibrated promised utility, the incentive compatibility constraint binds. The unemployment benefit b is strictly decreasing over the unemployment spell. It starts at a value of 0.58 and drops to 0.56 by the twentieth month of the unemployment spell. Consistent with Theorem 4, the speed of decrease becomes smaller over the spell: The period-to-period percentage change falls from 0.14% at the start of unemployment to 0.13% by the twentieth month.

Both the immediate income tax τ_0 and the subsequent income taxes τ progressively increase as the unemployment spell rises. Should a worker secure employment during the initial period of unemployment, the immediate income tax rate τ_0 would be merely 0.03. However, if employment is obtained after twenty months, the immediate income tax rate escalates to 0.046, marking a 50% increase. Similar to unemployment benefits, the speed of change of the immediate income tax rate also falls over the spell, from 2.6% if employ-

ment is obtained in the first month of unemployment to 1.7% if employment is obtained in the twentieth month. For a worker who becomes employed within the first month of unemployment, the subsequent income tax rate τ is set at 0.25, which rises to 0.27 if the worker finds employment after twenty months. The percentage increase of τ drops, from 0.31% for a worker who becomes employed in the first month of unemployment to 0.28% if employment is obtained after twenty months. Furthermore, the subsequent income taxes τ are invariably much higher than the immediate income tax τ_0. The difference between the two stays constant in levels over the unemployment spell, about 22% of wage income.[20]

The optimal policy converges to a lower bound as the unemployment spell increases: The unemployment benefits decline from 58% to 22% of wage income at the limit. The speed of convergence is quite slow: It takes about 2000 months to converge to within 4% of the lower bound. The fact that the lower bound is greater than the lowest possible utility is consistent with the fact that immiseration is averted in our calibrated model.

4.2.1 Comparison with US Policies

The optimal unemployment benefits are more generous than the current average US scheme in both level and schedule. The current US UI policy has an average replacement ratio of 45%, and the policy expires after 26 weeks or about 6 months. The optimal unemployment benefits start at a replacement ratio of 58% and stay above 50% for the first two years. The optimal benefits do not expire but decline gradually to a lower bound of 22% of wage income, much more generous than the SNAP payment that unemployed workers receive after unemployment benefits expire in the US.

The simulated optimal tax policy also differs from the current US framework. The tax rate on earned income in the current US tax system is independent of a worker's previous unemployment history, whereas the optimal tax rate is higher for workers who stay unemployed longer before finding a job. The optimal subsequent tax rates τ range from 0.25 to 0.3 for unemployment spells of up to 50 months, which is similar to the average income tax rate in the US of 25% of wage income.

[20] The difference between τ and τ_0 is constant due to the CARA utility function. To see this, note that by Theorem 2, we have $\tau - \tau_0 = \frac{1}{\sigma}\ln(1+\gamma)$ with CARA utility.

The substantially lower initial tax rate τ_0 upon employment under the optimal policy is analogous to the back-to-work bonus used in the US during the COVID pandemic to incentivize workers to search for jobs. The actual bonus, in the amount of either \$600 (part-time work) or $\$1,200$ (full-time work), is about 20% to 40% of the US monthly average income in 2021, which makes the first-month effective income tax -15% to 5%, compared to the optimal initial tax rate of 3% to 8% for unemployment spells of up to 50 months.

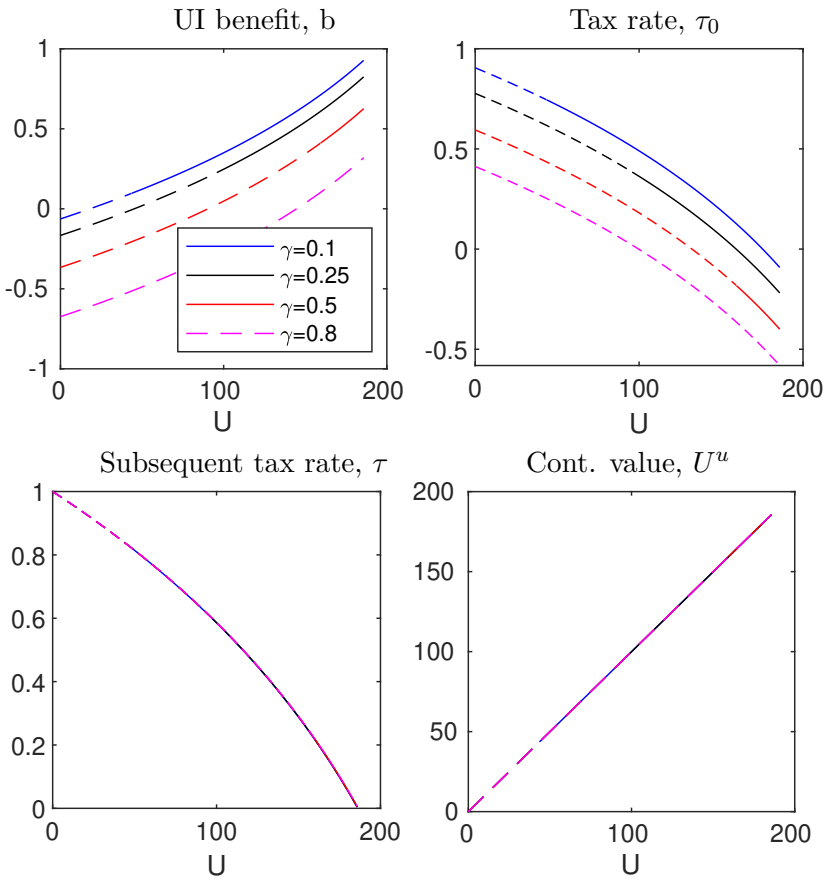
4.3 Effect of Costly Self-Control: Comparative Statics

The main features of our optimal policy are driven by the self-control problem. Figure 4 compares the optimal policy functions across four different values of temptation strength γ : 0.1, 0.25 (calibrated value), 0.5, and 0.8. As we change γ, the general shapes of the optimal policy functions are not affected: Unemployment benefit increases with the promised utility, while tax rates decrease with the promised utility. Consistent with the example in Figure 1, for a larger γ, the incentive constraint is non-binding for a wider range of promised utilities—as indicated by the dashed portions of the optimal policy function curves in Figure 4.

Both benefit b and the immediate tax rate τ_0 are lower with a larger γ, and the difference between the immediate and subsequent tax rates is larger, i.e., $\tau - \tau_0$ is bigger. This is because when workers have a larger self-control problem, the government needs to use lower benefits and a larger difference between the immediate and subsequent tax rates to incentivize workers and overcome their temptation. The subsequent tax rate τ and continuation value U^u also change with γ, but the variation is very small—nearly indiscernible in Figure 4. This is because the temptation utility places zero weight on the future, so future policies are far less sensitive to γ.

Finally, we examine the standard setup where there are no self-control problems by solving for the optimal UI system for $\gamma = 0$. The simulated optimal policy for the US is shown in Figure 5. Compared to the optimal policy *with* costly self-control, the setup *without* costly self-control ("standard setup") has more generous unemployment benefit b, and the immediate and subsequent income tax rates are identical: $\tau_0 = \tau$. Consistent with Proposition 2, the benefits decrease with the unemployment spell, while the income taxes are increasing. Quantitatively, compared to the optimal policy in the benchmark *with* costly

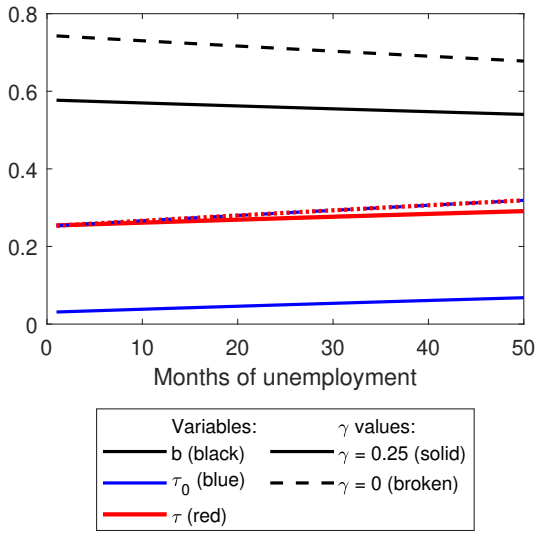
Figure 4: Optimal policy functions for different temptation factors



Note: Curves show the optimal policy functions over the initial promised utility for different values of γ. Dashed portions correspond to part of the policy functions where the incentive constraint is slack.

self-control, the optimal benefit in the standard setup is higher by 29% at the onset and the difference decreases to 25% by the fiftieth month of unemployment. The optimal tax in the standard setup has a steeper schedule: It starts slightly lower than the taxes with costly self-control for workers who are unemployed for more than one month, but increases faster and becomes 9% higher than the taxes in the benchmark. As shown in Theorems 2 and 3, the optimal policy for workers with costly self-control magnifies the immediate benefits of employment and immediate costs of unemployment. However, when workers do not have self-control problems, the optimal policy relies more on future rewards and punishments. The faster decrease of benefits and faster increase of taxes in the standard setup create stronger punishments in the future and hence better incentives to search in the present.

Figure 5: Simulated optimal policy with vs. without costly self-control



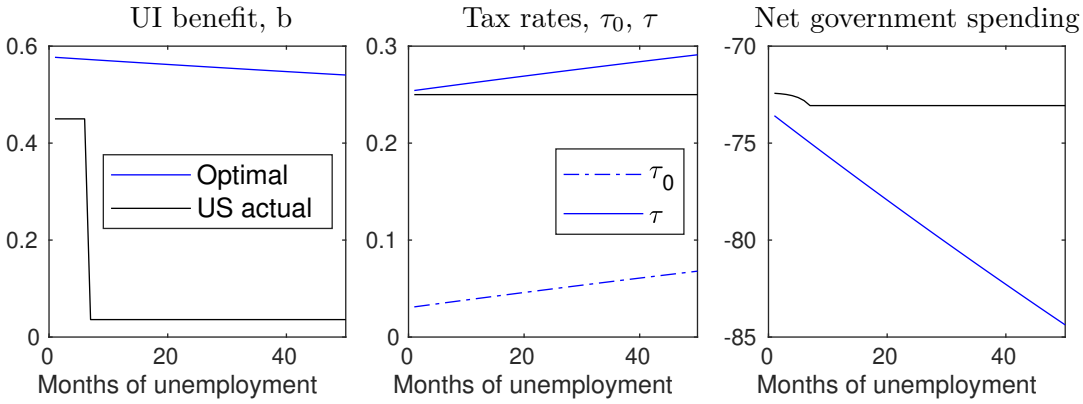
Note: Solid lines show the values of unemployment benefit b, immediate income tax τ_0, and subsequent income tax τ, with costly self-control, same as in Figure 3. Broken lines show the same variables without costly self-control ($\gamma = 0$). Initial promised utility is set to the calibrated US value in both cases.

4.4 Gains from Optimal Policy

To evaluate the welfare gains of the optimal policy from the current US policy, we start from the same initial promised utility and compare the total budget spent by each regime to achieve that promised utility. Appendix D details the method for computing the government's net spending for the optimal policy and the current US policy.

Figure 6 shows the present discounted sum of net government spending to achieve the initial promised utility, under the optimal policy and the actual US policy. The net government spending in the first period and all periods after are higher under the US policy than the optimal policy. Under both the optimal and US policies, the incentive constraint holds, so workers always search, and unemployment spells do not differ between the two policies. Therefore, the difference in resource costs is caused by the differing policy instruments. Specifically, the tax rates under the US policy are too low. Even though the unemployment benefits are more generous under the optimum—both in the first few periods and after the US benefits have expired—subsequent tax rates τ are higher under the optimal policy. Importantly, this difference increases as the optimal tax rates τ_0 and τ rise over the unemployment spell while the US tax rate remains constant.

Figure 6: Policy and net government spending comparison between optimal and US policies



Note: Net government spending shows the sum of benefits to unemployed net of taxes from employed to deliver the initial promised utility. For each period, the value shows the present discounted sum of net government spending from that period onward. Initial promised utility is set to the calibrated US value.

This exercise suggests that the spell-dependent incentive structure allows the optimal policy to achieve the same initial promised utility as the actual US policy, but with lower net government spending. The present discounted net spending under the optimal policy is 1.5% lower than the US policy if a worker finds a job in the first month, and up to 15.5% lower if the job is found in the fiftieth month. This means that for each worker, the optimal policy saves approximately one month's average wage in resource costs if the worker finds a job in the first month and about one year's average wage if employment occurs in the fiftieth month.[21] The optimal policy is also more equitable: With higher and more slowly declining benefits, the difference in utilities between unemployed and employed workers is smaller under the optimum than the actual US policy.

Finally, we also compare the optimal policy with the sub-optimal policy where the government does not correctly account for the strength of temptation. Under this sub-optimal policy, the government mistakenly believes that there is no self-control issue, i.e., $\gamma = 0$, while in fact $\gamma = 0.25$ as calibrated. It turns out that under the *naive* government's policy, the worker's incentive compatibility constraint no longer holds, and so the worker does not

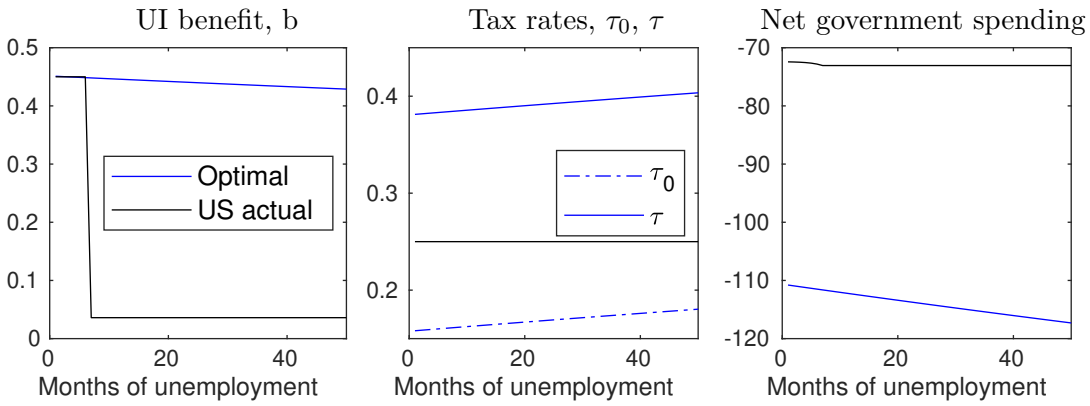
[21]Under the US policy, the total present discounted net spending is approximately -72.4 if employment is secured in the first month, and the optimal policy would save 1.5% of this cost, which is equivalent to one month of normalized wage. If employment is secured in the fiftieth month, the net spending under the US policy is about -73, and the optimal policy would save 15.5% of this cost, which is equivalent to a year of normalized wage.

search. In other words, even a well-designed policy can fail if costly self-control is ignored.

4.5 An Alternative Calibration

An alternative way to find the optimal policy relevant to the US economy is to target the level of the UI replacement ratio—an average of 45% for the first six months. The rationale is that policymakers may not care about the promised utility, but are instead concerned about the benefit replacement ratio. This yields an initial promised utility that is lower than in the benchmark calibration: The initial promised utility would need to be approximately 87.8% of the calibrated promised utility for the benchmark. Figure 7 shows the simulated optimal policy with this alternative calibration. Compared to the optimal policy with the benchmark calibration, this alternative optimal policy retains similar key features: unemployment benefits decline over unemployment spell; taxes increase over unemployment spell; and tax rate in the initial period of employment is lower than subsequent taxes. Due to the lower initial promised utility, the alternative optimal unemployment benefits are lower than in the benchmark calibration, which is by design, while the alternative tax rates are higher than in the benchmark calibration.

Figure 7: Policy and net government spending comparison between optimal and US policies



Note: Net government spending shows the sum of benefits to unemployed net of taxes from employed to deliver the initial promised utility. For each period, the value shows the present discounted sum of net government spending from that period onward. Initial promised utility for the optimal policy is set so that the average UI replacement ratio in the first six months is 45%.

Following a similar process used in the benchmark calibration for assessing the gains from

optimal policy, we compute the government's net spending under the alternative calibration. Figure 7 shows that the optimal policy is again less expensive than the actual US policy, and the cost difference is larger than in the benchmark calibration (in Figure 6), because the alternative calibration requires a lower initial promised utility.

5 Model with Search Intensity

This section examines the optimal UI system with variable search intensity. We extend the model to a continuum of search effort $a \in [0, \overline{a}]$. The probability of finding a job $p(a)$ is a function of search effort, where $p', -p'' > 0$, $p(0) = 0$, with $\lim_{a \to 0} p'(a) = \infty$ and $\lim_{a \to \overline{a}} p'(a) = 0$. The disutility from investing effort a is $h(a)$, where $h' > 0, h'' \geq 0$, and $h(0) = 0$.

The unemployed agent chooses search effort a to maximize the expected discounted utility

$$p(a)\left[(1+\gamma)u(w-\tau_0)+\delta U^e\right]+\left[1-p(a)\right]\left[(1+\gamma)u(b)+\delta U^u\right]-(1+\gamma)h(a)-\gamma v^*(\tau_0,b),$$

where the temptation utility is

$$v^*(\tau_0,b)=p\left(a^T\right)u(w-\tau_0)+\left[1-p\left(a^T\right)\right]u(b)-h\left(a^T\right),$$

and the *temptation effort* a^T satisfies

$$p'\left(a^T\right)\left[u(w-\tau_0)-u(b)\right]=h'\left(a^T\right).$$

Adopting the first-order approach, the incentive compatibility constraint is

$$p'(a)\left\{\left[u(w-\tau_0)-u(b)\right]+\frac{\delta}{1+\gamma}\left[\sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s)-U^u\right]\right\}=h'(a). \tag{6}$$

The promise-keeping constraint is

$$U = p(a)\left[(1+\gamma)\,u(w-\tau_0) + \delta\sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s)\right] + [1-p(a)]\left[(1+\gamma)\,u(b) + \delta U^u\right] - (1+\gamma)\,h(a) - \gamma v^*(\tau_0, b). \quad (7)$$

As a result, we have the following Bellman equation for this environment:

$$C(U) = \min_{a,b,U^u,\tau_s}\left[1-p(a)\right]\left[b+\delta C\left(U^u\right)\right] - p(a)\sum_{s=0}^{\infty}\delta^s\tau_s$$

subject to the incentive constraint (6) and the promise-keeping constraint (7). The cost function $C(U)$ may not be convex and lotteries may be necessary. However, we will proceed by disregarding the possibility of lotteries and verify the convexity of C numerically.

Intuitively, the incentive compatibility constraint binds at the optimum, implying that promised utility decreases as long as the agent remains unemployed. However, with costly self-control, the agent's incentives are more aligned with the government's. Thus, the decline in promised utility would be much slower than in standard models. To see this, the cost of self-control is

$$SC(b, \tau_0, a) = \gamma\left\{\left[h(a) - h\left(a^T\right)\right] - \left[p(a) - p\left(a^T\right)\right]\left[u(w-\tau_0) - u(b)\right]\right\}.$$

The promise-keeping constraint (7) can be rewritten as

$$U = p(a)\left[u(w-\tau_0) + \delta\sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s)\right] + [1-p(a)]\left[u(b) + \delta U^u\right] - h(a) - SC(b, \tau_0, a),$$

and the incentive constraint (6) as

$$p'(a)\left\{\left[u(w-\tau_0) - u(b)\right] + \delta\left[\sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s) - U^u\right]\right\} = h'(a) + \frac{\partial SC(b, \tau_0, a)}{\partial a}.$$

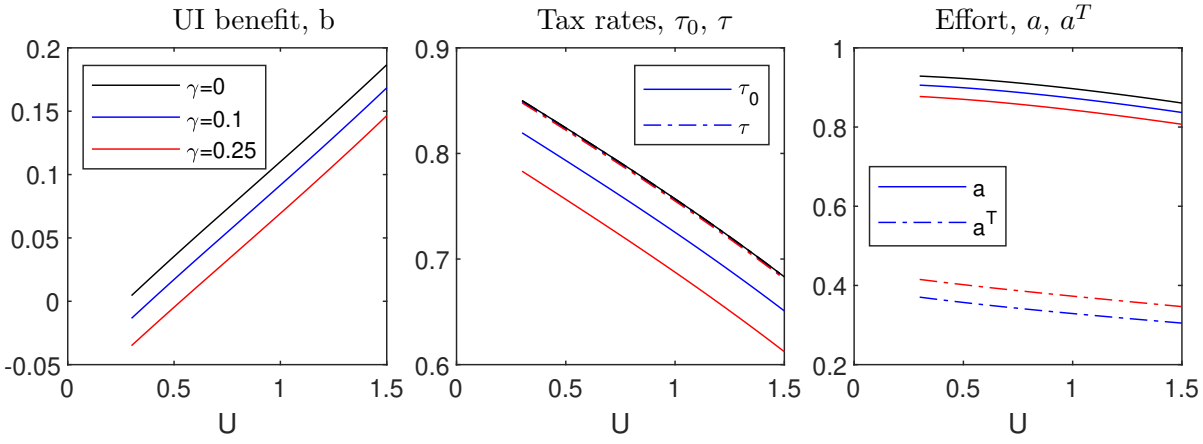
Since $\partial SC(b, \tau_0, a)/\partial a = \gamma\left\{h'(a) - p'(a)\left[u(w-\tau_0) - u(b)\right]\right\}$, the same economic force introduced in the binary search effort model persists in the model with search intensity

if the agent is tempted to search less than the actual invested effort, i.e., $a^T < a$. In other words, as insurance worsens, the incentive to search increases while also relaxing the promise-keeping constraint through a smaller self-control cost, which decreases the cost of delivering promised utility U. Details of the optimality conditions for this model are in Appendix E.

5.1 A Numerical Example

To illustrate the properties of the optimal policy with variable search intensity, we solve the model for some common parameters and compare the policy for different temptation strengths γ in Figure 8.

Figure 8: Optimal policy functions with intensive search for different temptation factors



Note: The lines show the optimal policy functions over the initial promised utility for different values of γ. We consider the following functional forms: $u(c) = (1/\sigma)\,[1 - \exp(-\sigma c)]$, $h(a) = \nu\, a^{1+\psi}/(1+\psi)$, $p(a) = 1 - \exp(-ra)$, with $\delta = 0.9$, $\sigma = 2$, $\psi = 2$, $\nu = 0.5$, $r = 0.5$. $\gamma = 0$ corresponds to the standard case without costly self-control.

Other than the fact that the incentive constraints remain binding, the optimal UI policy for the search-intensity model shares similar properties with the binary-effort model. Just as before, the agent is tempted to search less than the actual invested effort: $a > a^T$. Unemployment benefit b increases in U, so the optimal benefit falls over the unemployment spell. The income taxes τ_0 and τ both decrease in U and $\tau_0 < \tau$ with costly self-control ($\gamma > 0$). Both benefit b and the immediate tax rate τ_0 are lower with a larger γ. The difference between the immediate and subsequent tax rates increases with the temptation strength, i.e., $\tau - \tau_0$ is bigger with a larger γ. The rationale is also the same as before: When

the agent has a more severe self-control problem, the government needs to use lower benefits and a larger difference between the immediate and subsequent tax rates to incentivize search and lower the unemployed's self-control cost.

A few things are new. First, search effort a and temptation effort a^T both rise as promised utility U decreases, i.e., an unemployed worker searches more intensely the longer the unemployment spell. Second, since the difference between $w - \tau_0$ and b increases with γ, reference effort a^T rises with γ. However, since γ increases the marginal cost of self-control, an increase in temptation γ effectively raises the marginal cost of searching, so actual search effort a decreases with γ. As a result, the gap $a - a^T$ shrinks with γ. Third, since search effort varies with γ, subsequent tax rate τ and continuation value U^u are more sensitive to it here than in the binary-effort model (Figure 4).

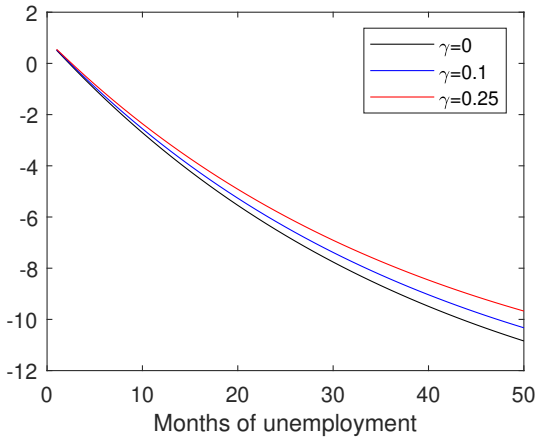
Figure 9 shows that when the strength of the temptation γ is large, promised utility declines more slowly over a worker's unemployment spell. As explained before, as the cost of self-control increases, the agent's incentives become more aligned with the government's. Furthermore, a higher γ makes the unemployed's search incentives relatively more responsive to immediate policy instruments (τ_0 and b) than to future policies (τ and U^u). Thus, the government no longer needs to decrease promised utility as much to incentivize search. This implies that, despite the binding incentive constraint, we approach immiseration much more slowly than the standard models without costly self-control.

5.2 How to Stop Immiseration: Effort Satiation

Recall that, in the binary-effort model, immiseration can be avoided because the incentive constraint may cease to bind if promised utility U is below a certain threshold. The same logic carries over when search effort is continuous provided the probability p flattens out beyond some finite effort level $\bar{a}$:

$$p(a) = \begin{cases} \tilde{p}(a) & 0 \leq a \leq \bar{a} \\ \bar{p} & a > \bar{a} \end{cases},$$

Figure 9: Simulated promised utility for different temptation levels



Note: The lines show the evolution of the optimal promised utility U^u over the unemployment spell for different values of γ. The functional specifications and the parametric values are the same as the ones used for Figure 8. The initial promised utility U is 0.89.

with $\lim_{a\to\bar{a}^-}\tilde{p}(a)=\bar{p}$ and $\tilde{p}(0)=0$. We denote $\bar{h}=h(\bar{a})$, and the following derivatives: $\bar{p}'=\lim_{a\to\bar{a}^-}\tilde{p}'(a)$ and $\bar{h}'=h'(\bar{a})$.

To see how immiseration can be avoided, note that lowering the promised utility U reduces the provision of insurance, i.e., the gap between unemployed and employed utilities increases. If the probability is still far from the plateau, the agent responds to this gap by raising effort so that the incentive constraint (6) continues to hold. However, once U is dropped far enough that the optimal effort reaches $\bar{a}$, any further reduction in U fails to elicit more effort.

Despite the plateau, with standard preferences ($\gamma=0$), the incentive constraint would still bind: It is optimal to raise insurance until (6) binds to minimize the cost of delivering U. On the other hand, when self-control is costly ($\gamma>0$), increasing insurance can induce the opposite effect. As mentioned before, better insurance may tighten the promise-keeping constraint because it increases the cost of self-control. If temptation γ is sufficiently strong, it may be optimal to leave the incentive constraint slack, which avoids immiseration and ensures a base level of consumption.

Let us return to the example in Section 3.1, where $u(c)=\frac{1}{\sigma}\left[1-\exp\left(-\sigma c\right)\right]$. A non-

binding incentive constraint occurs when effort is at its highest level $\bar{a}$:

$$\bar{p}'\left\{\left[u\left(w-\tau_0\right)-u\left(b\right)\right]+\frac{\delta}{1+\gamma}\left[\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_s\right)-U^u\right]\right\}\geq\bar{h}'$$

Appendix C shows how using the guess and verify method can help us derive the value function and the optimal policies when the incentive constraint is non-binding. Using the optimal policy derived in Appendix C, we have the following upper-bound on promised utility, where the incentive constraint is non-binding below the threshold:

$$U\leq\frac{1}{\sigma\left(1-\delta\right)}-L-\frac{N}{\gamma\left(1-\delta\right)\Delta p}\left(\frac{\bar{h}'}{\bar{p}'}-\frac{\delta}{1+\gamma}L\right),$$

where $\Delta p=\bar{p}-p\left(a^T\right)$,

$$L=\frac{\left(1+\gamma\right)\bar{h}-\gamma h\left(a^T\right)}{1-\delta\left(1-\bar{p}\right)}\text{ and }N=\left[\left(1-\bar{p}\right)-\gamma\Delta p\right]\left[\bar{p}+\gamma\Delta p\right].$$

Notice immediately that no promised utility U satisfies the inequality when $\gamma=0$, i.e., the incentive constraint is always binding in the standard model without self-control issues.[22] However, similar to the binary-effort model, it is possible to find a range of promised utility U such that the incentive constraint is slack for sufficiently high self-control cost.

As a result, costly self-control combined with effort satiation provides a potential mechanism for avoiding immiseration and rationalizes the efficiency of introducing a basic income in a richer model with search intensity. In essence, the model with a plateau form of $p\left(a\right)$ generalizes the binary-effort model. Despite the stylized environment, this satiation is plausible for at least two reasons. First, there is a hard cap on the amount of time the unemployed can

[22] When $\gamma=0$, L and N are strictly positive. Hence, to prove that there is no range of promised utility U such that the incentive constraint is slack, it suffices to show that $\frac{\bar{h}'}{\bar{p}'}>\frac{\delta\bar{h}}{1-\delta(1-\bar{p})}$. First, note that $1-\delta\left(1-\bar{p}\right)>\delta\bar{p}$, so $\frac{\delta\bar{h}}{1-\delta(1-\bar{p})}<\frac{\bar{h}}{\bar{p}}$. Second, let $f\left(a\right)=\frac{h'(a)}{p'(a)}$ on $[0,\bar{a}]$, then

$$\frac{\bar{h}}{\bar{p}}=\frac{\int_0^{\bar{a}}h'\left(t\right)dt}{\int_0^{\bar{a}}p'\left(t\right)dt}=\frac{\int_0^{\bar{a}}f\left(t\right)p'\left(t\right)dt}{\int_0^{\bar{a}}p'\left(t\right)dt}\leq\sup_{t\leq\bar{a}}f\left(t\right),$$

where the inequality comes from the fact that $\int_0^{\bar{a}}f\left(t\right)p'\left(t\right)dt\leq\sup_{t\leq\bar{a}}f\left(t\right)\int_0^{\bar{a}}p'\left(t\right)dt$. Since $h''>0$ and $p''<0$, then f is strictly increasing and $\sup_{t\leq\bar{a}}f\left(t\right)=\frac{\bar{h}'}{\bar{p}'}$. Thus, $\frac{\delta\bar{h}}{1-\delta(1-\bar{p})}<\frac{\bar{h}'}{\bar{p}'}$.

reasonably spend searching. Second, prominent job search websites impose upper bounds on the number of application submissions (e.g., LinkedIn's Easy Apply has a daily limit that resets at the end of the day). A model with effort satiation is a reduced-form way to capture the real-world physical constraints that the unemployed face.

6 Alternative Models

This section discusses a variant of our baseline model. First, we compare our optimal policy in Section 3 with policies for an agent with quasi-hyperbolic time preferences—an alternative way of modeling self-control problems. Then, we extend the quasi-hyperbolic setup to consider a setting with an agent who may not be fully aware of his own bias.

6.1 Present Bias

This section considers a present-biased agent with quasi-hyperbolic time preferences (Strotz, 1955; Phelps and Pollak, 1968; Laibson, 1997). In essence, if v_t denotes the flow utility at t, then the expected present discounted utility of a present-biased agent is $v_t + \beta\delta \mathrm{E}\left[\sum_{s=1}^{\infty} \delta^{s-1} v_{t+s}\right]$, where $\delta \in (0,1)$ denotes the long-run discount factor and β is the short-run discount factor. The agent is time inconsistent when $\beta \neq 1$. We focus on the case with a present-biased agent: $\beta \in (0,1)$. In contrast to an agent with costly self-control, the present-biased agent exhibits preference reversal. Specifically, the discount factor between the current period and the subsequent period is $\beta\delta$, and it is strictly lower than the discount factor δ between any adjacent periods in the future.[23] Furthermore, we consider agents who are fully aware of the magnitude of their bias, i.e., agents are sophisticated. The next subsection considers an extension with a non-sophisticated agent.

[23]Note that present bias is different from impatience. Present bias involves time-inconsistent preferences where individuals disproportionately discount future utility, while impatience is characterized by time-consistency but with a higher discount rate compared to the government or social planner. We consider a model with an impatient unemployed agent in Appendix F. We find that, similar to Farhi and Werning (2007), both the consumption paths for the employed and unemployed are front-loaded. Importantly, they are front-loaded at every single point in time. This is in contrast to our result where the employed agent is only given a tax break in the first period of employment, and the unemployed's inverse marginal utility is a submartingale.

The expected discounted utility for an unemployed agent who searches at the beginning of each period is

$$V^1 = p\left[u\left(w-\tau_0\right)+\beta\delta\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_s\right)\right]+\left(1-p\right)\left[u\left(b\right)+\beta\delta U^u\right]-h.$$

If the unemployed agent does not search, then the expected discounted utility would be

$$V^0 = u\left(b\right)+\beta\delta U^u.$$

Therefore, the incentive compatibility constraint to motivate the unemployed agent to search is $V^1 \geq V^0$, which can be expressed as

$$p\left\{\left[u\left(w-\tau_0\right)-u\left(b\right)\right]+\beta\delta\left[\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_s\right)-U^u\right]\right\}\geq h. \tag{8}$$

In contrast to our main model, a simple argument shows that the incentive compatibility constraint (8) always binds at the optimum.[24]

Conveniently, with a present-biased agent, Cetemen et al. (2023) showed that it is sufficient to consider only the immediate incentives of the agent. This simplification condenses the potentially large set of state variables—containing the promised utility to the agent's future selves—into the promised utility to the agent's current self. As a result, the promised utility to an unemployed present-biased agent is a state variable of the government's dynamic incentive problem:

$$C\left(U\right)=\min_{b,U^u,\tau_s}\left(1-p\right)\left[b+\delta C\left(U^u\right)\right]-p\sum_{s=0}^{\infty}\delta^s\tau_s.$$

subject to the incentive compatibility constraint (8) and the promise-keeping constraint

$$U = p\left[u\left(w-\tau_0\right)+\sum_{s=1}^{\infty}\delta^s u\left(w-\tau_s\right)\right]+\left(1-p\right)\left[u\left(b\right)+\delta U^u\right]-h. \tag{9}$$

[24]Suppose the incentive constraint (8) does not bind at the optimum. Then, the government can implement full insurance (Proposition 1) and the unemployed agent would have no incentives to search.

Importantly, Lemma 2 also holds in this setting. Though the appropriate welfare criterion is ambiguous with a time-inconsistent agent, our setup follows the literature and disregards the short-run preferences.

Our setup does not explicitly take advantage of the intra-personal games a present-biased agent plays with its future selves. The government could potentially introduce a mechanism with off-path threats to relax the incentive constraints.[25] However, it is not possible to screen past effort, so all employed agents must be indifferent between choosing the off-path threat and the on-path option. If not, then all employed agents would choose one over the other, regardless of their history of search effort investments.[26]

Next, we show results that are very similar to Theorems 2 and 3. In essence, the consumption path for the employed is front-loaded, while—compared to the standard setting—the expected consumption path for the unemployed is more back-loaded.

Proposition 3 *Let η denote the multiplier on the incentive constraint (8). The optimal income tax satisfies: $\tau_0 < \tau_s = \tau$ for all $s \geq 1$ with $\frac{1}{u'(w-\tau_0)} = \frac{1}{u'(w-\tau)} + \frac{(1-\beta)\eta}{p}$, and income tax τ increases with the unemployment spell. The inverse marginal utility of the unemployed satisfies $\frac{1}{u'(b)} = \frac{1-p}{u'(b')} + \frac{p}{u'\left(w-\tau_0'\right)} - \frac{(1-\beta)\eta}{1-p}$. Furthermore, promised utility U^u decreases with unemployment spell.*

For a present-biased agent, current incentives are more effective than future incentives in motivating search effort. As a result, to raise search incentives, Proposition 3 shows it is optimal to front-load the reward and punishment by back-loading the unemployed's consumption and front-load the employed's consumption.

Though Proposition 3 is similar to Theorems 2 and 3, the interpretation of Proposition 3 is subtly different from the results in the previous sections. With temptation and self-control

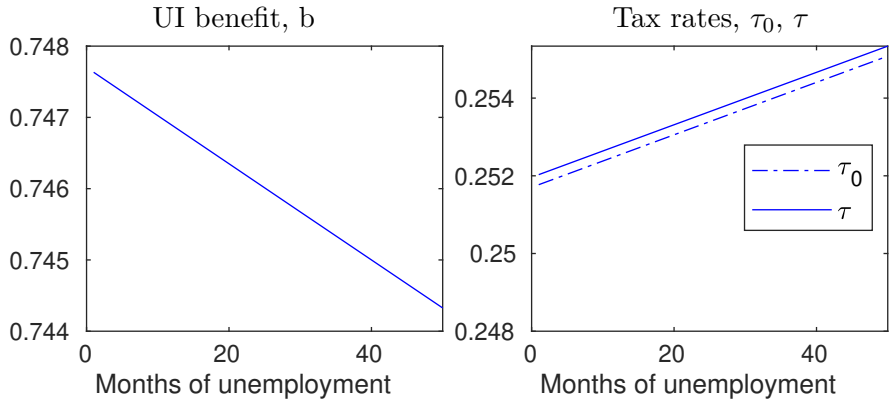
[25] For example, the government can allow agents to report their past search effort and introduce the following off-path threat: Unemployed agents, who find a job but report that they did not invest search effort in at least one of the previous periods, are recommended a large tax break immediately combined with much higher taxes in the future. Meanwhile, agents who find a job and report that they searched in all previous periods are recommended a smoother consumption path. Since the front-loaded off-path threat is appealing to the present-biased agent, but they prefer their future selves to smooth consumption, the off-path threat incentivizes job search.

[26] The proposed off-path threat is closer to the ones discussed in Amador et al. (2003) and Halac and Yared (2014), than in Esteban and Miyagawa (2005) and Yu (2021), where off-path threats can be designed such that dishonest agents strictly prefer them.

preferences, the intertemporal distortions were used to incentivize effort more efficiently by lowering the cost of self-control. However, with present bias, there is no psychological cost of self-control. Instead, the distortions are used to take advantage of the agent's tendency to underweight future benefits.

For a quantitative illustration, we set $\beta = 0.3$, which is in the range of β estimates for low income or unemployed workers summarized by Lockwood (2020). Other parameters remain the same as in Table 1. As shown in Figure 10, similar to the optimal policy with costly self-control, unemployment benefits decline and taxes increase over the unemployment spell, although the changes are much smaller than in the main model. Also similar to the main model, the immediate tax rate τ_0 is lower than the subsequent tax rate τ. However, the implied magnitude of the back-to-work bonus is much less generous than the result in Section 4.

Figure 10: Simulated optimal policy under present-bias



Note: Lines show the optimal policy under present-bias with $\beta = 0.3$ and for different unemployment duration. Initial promised utility is set to the calibrated US value.

6.2 Policies for Non-Sophisticated Agents

With temptation and self-control preferences, the agent is inherently aware of the degree of their temptation and of their self-control cost. However, several studies suggest that individuals may not be fully aware of their own lack of self-control—they are non-sophisticated. There is evidence that job seekers display behaviors that are consistent with them being non-

sophisticated.[27] This section considers the optimal design of unemployment policies with a non-sophisticated agent, where the degree of sophistication is unobserved by the government.

To model non-sophistication, we depart from the temptation and self-control preferences. We follow O'Donoghue and Rabin (2001) and extend the quasi-hyperbolic discounting framework. An agent perceives the future present bias to be $\hat{\beta} \in [\beta, 1]$. If $\hat{\beta} = \beta$, the agent is *sophisticated* and fully aware of the bias. If $\hat{\beta} = 1$, the agent is *fully naïve* and believes the future selves to be time-consistent. A *partially naïve* agent knows about his present-bias, $\hat{\beta} < 1$, but the agent underestimates the severity, $\hat{\beta} > \beta$. For this extension, we assume the agent is non-sophisticated, and the degree of sophistication is drawn from a distribution with support $\left[\underline{\hat{\beta}}, 1\right]$, where $\underline{\hat{\beta}} \in (\beta, 1]$. We assume that the degree of sophistication is unobservable to the government. Furthermore, for simplicity, the agent does not update his beliefs of the bias over time—$\hat{\beta}$ is constant over time.

Yu (2021) showed that it is optimal for the government to take advantage of the misspecified belief of a present-biased agent through the preference arbitrage mechanism (PAM). PAM features off-path allocations used to exploit the incorrect belief, which are referred to as the *imaginary allocations*. The allocations that are implemented on-path are called the *real allocations*. To illustrate how PAM works, assume that u is unbounded below and above ($u(\mathbb{R}_+) = \mathbb{R}$). The next proposition shows how the incentive constraints can be fully relaxed in this setting. In general, PAM weakens the incentive constraints, though perhaps not fully if u is bounded, whenever the agent is non-sophisticated.

Proposition 4 *If search effort is unobservable, the government can implement the full information efficient optimum by using PAM when the present-biased agent is non-sophisticated.*

PAM does not work for a sophisticated present-biased agent, because the agent can accurately predict the future self's behavior. Therefore, a potential problem is if the government does not observe the degree of sophistication, and the present-biased agent is potentially sophisticated. The sophisticated agent can mimic a non-sophisticated agent and enjoy the full-information efficient unemployment benefits while shirking. Therefore, the on-path real

[27] Spinnewijn (2015) argued that unemployed individuals tend to overestimate the probability of finding a job, which can also be rationalized by a model with non-sophisticated job seekers.

allocations necessarily feature distortions characterized in Section 6.1 when there is a possibility that the agent is sophisticated.

7 Conclusion

By taking self-control costs into account in the design of UI systems, this paper lends support to some features in current unemployment policies that would otherwise not be theoretically supported. We showed that when the unemployed agent is tempted by short-run benefits, the income tax features a one-time tax benefit immediately after reemployment, providing theoretical foundation for back-to-work bonuses. Importantly, relative to the standard model, consumption is front-loaded in the first period of employment, while the unemployed face a more back-loaded expected consumption path, which increases incentives to search. When the incentive constraint binds, the optimal unemployment policy evolves over time largely according to the literature, with the distortions in the consumption paths decreasing over the unemployment spell. However, the incentive constraint can be slack when self-control is costly, eliminating immiseration from the optimal policy and reinforcing the rationale for a basic income. The paper's insights provide a new theoretical foundation for strengthening social insurance and cast doubt on the efficacy of recent proposals to cut benefits in the name of self-sufficiency.

One of the critical problems in the UI literature has been the design of unemployment policy when the government cannot fully commit (Pei and Xie, 2021; Mitman and Rabinovich, 2021; Golosov and Iovino, 2021). Future work should consider how the agent's self-control cost interacts with a government that lacks commitment power. Finally, the literature has also identified that reference dependence may also be affecting the behavior of job seekers (DellaVigna et al., 2017). Therefore, it is important to explore how other biases, such as reference dependence, affect the design of UI.

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Temptation, Self-Control, and the Design of Optimal Unemployment Insurance

Zoe Xie and Pei Cheng Yu

APPENDIX FOR ONLINE PUBLICATION ONLY

A Proofs

Proof of Lemma 1: There are two cases to consider: when (1) is binding and when (1) is non-binding.

First, consider the case with a non-binding incentive compatibility constraint (1). Working towards a contradiction, suppose that

$$\max\left\{u\left(b\right), pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}=pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h.$$

This implies that the self-control cost is zero. Therefore, with a non-binding incentive constraint, the full-information optimum of Proposition 1 can be implemented. However, the full information optimum is not incentive compatible, a contradiction. Therefore, it must be the case that,

$$\max\left\{u\left(b\right), pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}=u\left(b\right)$$

when the incentive constraint is non-binding.

Finally, consider the case when (1) is binding. We have

$$u\left(b\right)-\left[pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right]=h-p\left[u\left(w-\tau_0\right)-u\left(b\right)\right]=\frac{p\delta}{1+\gamma}\left(U^e-U^u\right). \quad (10)$$

The third equality comes from the fact that (1) is binding. Thus, suppose that the most tempting action is to search,

$$\max\left\{u\left(b\right), pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h\right\}=pu\left(w-\tau_0\right)+\left(1-p\right)u\left(b\right)-h,$$

then it must be that $U^u \geq U^e$. Next, under the assumption that the most tempting action

is to search, the planner's problem is

$$C(U) = \min_{b,U^u,\tau_s} (1-p)\left[b + \delta C\left(U^u\right)\right] - p\sum_{s=0}^{\infty}\delta^s\tau_s$$

subject to the incentive constraint (1) and promise-keeping constraint

$$U = p\left[u(w-\tau_0) + \sum_{s=1}^{\infty}\delta^s u(w-\tau_s)\right] + (1-p)\left[u(b) + \delta U^u\right] - h. \tag{11}$$

Let (η, λ) be the multipliers on (1) and (11), respectively. The first-order conditions on $\left[b, (\tau_s)_{s\geq 1}, U^u\right]$ are

$$\frac{1}{u'(b)} = \lambda - \eta\frac{1+\gamma}{1-p}, \text{ and } \frac{1}{u'(w-\tau_s)} = \lambda + \frac{\eta}{p} \text{ for all } s \geq 1, \text{ and } C'\left(U^u\right) = \lambda - \frac{\eta}{1-p},$$

with the envelope condition $C'(U) = \lambda$. Let $\tau = \tau_s$ for all $s \geq 1$. Since (1) binds, we have $\eta > 0$, so the conditions above imply that $u(w-\tau) > u(b)$ and $U > U^u$ when C is strictly convex (Lemma 2). Given the definition of U^e, (11) can be rewritten as

$$\begin{aligned} U &= p\delta\left(U^e - U^u\right) - \left\{h - p\left[u(w-\tau_0) - u(b)\right]\right\} + u(b) + \delta U^u \\ &= \frac{p\delta\gamma}{1+\gamma}\left(U^e - U^u\right) + u(b) + \delta U^u, \end{aligned}$$

where the second equality comes from (10). Therefore, we have

$$\frac{p\delta\gamma}{1+\gamma}\left(U^e - U^u\right) = U - u(b) - \delta U^u > (1-\delta)\left[U^u - \frac{u(b)}{1-\delta}\right],$$

where the inequality comes from the fact that $U > U^u$. Recall that $U^u \geq U^e$ when (1) binds and the most tempting option is to search. Since $U^e = \frac{u(w-\tau)}{1-\delta} > \frac{u(b)}{1-\delta}$, the right-hand side of the inequality is strictly positive. However, the left hand side is weakly negative, which is a contradiction. ■

Proof of Lemma 2: Define $z^b \equiv u(b)$, $z_0^\tau = u(w-\tau_0)$, and $z^\tau = u(w-\tau)$, where $\tau_s = \tau$. (We conjecture that $\tau_s = \tau$ for all $s \geq 1$, which we verify in Theorem 2.) We can rewrite the

Bellman equation as

$$V(U) = \max_{z^b, U^u, z_0^\tau, z^\tau} r\left(z^b, z_0^\tau, z^\tau\right) + (1-p)\,\delta V\left(U^u\right) + \frac{pw}{1-\delta}$$

subject to

$$U \leq p\left[(1+\gamma)\, z_0^\tau + \frac{\delta z^\tau}{1-\delta}\right] + (1-p)\left[\left(1+\gamma-\frac{\gamma}{1-p}\right) z^b + \delta U^u\right] - (1+\gamma)\, h,$$

$$z_0^\tau - z^b + \frac{\delta}{1+\gamma}\left(\frac{\delta z^\tau}{1-\delta} - U^u\right) \geq \frac{h}{p},$$

where $r\left(z^b, z_0^\tau, z^\tau\right) = -pu^{-1}\left(z_0^\tau\right) - (1-p)\, u^{-1}\left(z^b\right) - p\frac{\delta}{1-\delta} u^{-1}\left(z^\tau\right)$. The rewritten problem is equivalent to the cost minimization problem. Furthermore, the promise-keeping constraint can be written as an inequality without loss, since it binds at the optimum. The rest of the proof shows that V is strictly decreasing, strictly concave, and twice differentiable, which would imply the result.

First, we show that the value function V is bounded. Immediately, the non-negativity of consumption implies V is bounded above by $\frac{w}{1-\delta}$. To show that V is bounded below, it suffices to show that there exists an upper bound on promised utility $\bar{U} < \infty$ with

$$\bar{U} = p\left[(1+\gamma)\, u\left(w - \bar{\tau}_0\right) + \sum_{s=1}^{\infty} \delta^s u\left(w - \bar{\tau}_s\right)\right] + (1-p)\left[\left(1+\gamma-\frac{\gamma}{1-p}\right) u\left(\bar{b}\right) + \delta\bar{U}\right] - (1+\gamma)\, h.$$

Clearly, $V \geq -\max\left\{\frac{\bar{b}}{1-\delta}, \frac{w-\bar{\tau}_0}{1-\delta}, \frac{w-\bar{\tau}}{1-\delta}\right\}$. By Lemma 4 and Theorem 3, we verify that the promised utility is weakly decreasing. Therefore, we can set $\bar{U} = U + M$, where U is the initial promised utility and $0 < M < \infty$ is a large number chosen such that the promised utility is never above $\bar{U}$.

Next, we show that the function r is defined on a compact domain, and its Hessian is a negative definite diagonal matrix with bounded norm, i.e., Assumption B.1 of Santos (1991) is satisfied. By the strict concavity of u, it is straightforward to see that the Hessian matrix of r is negative definite and diagonal. Also, following a similar argument to the boundedness

of V, we can show that r is defined on a compact domain. Therefore, r is strongly concave. By the assumption that u'' is uniformly bounded, the eigenvalues for the Hessian matrix of r are bounded. Since the norm of a diagonal matrix is equal to its largest eigenvalue, the norm of the Hessian of r is bounded.

Finally, it is easy to check that the rewritten problem satisfies the conditions for Theorem 4.6 to Theorem 4.8 in Stokey et al. (1989) to hold, so V is strictly decreasing and strictly concave. Also, the problem satisfies Assumptions A to C in Santos (1991), so V is twice differentiable and the policy functions are differentiable with respect to promised utility U. ■

Proof of Lemma 3: First, notice that the incentive compatibility constraint (1) is relaxed when b is lowered. Next, when $1-p \leq \frac{\gamma}{1+\gamma}$, then the promise-keeping constraint is also relaxed or stays the same when b is lowered. Therefore, it is optimal to choose $b=0$ when $1-p \leq \frac{\gamma}{1+\gamma}$. ■

Before proving the other theoretical results, we first derive the necessary optimality conditions. Let (λ, η) denote the multipliers on the promise-keeping constraint (3) and incentive constraint (1), respectively. The first-order conditions for the government's cost minimization problem are

$$\frac{1}{u'(b)} = \lambda\left(1+\gamma-\frac{\gamma}{1-p}\right) - \eta\frac{1+\gamma}{1-p}, \tag{12}$$

$$\frac{1}{u'(w-\tau_0)} = (1+\gamma)\left(\lambda+\frac{\eta}{p}\right), \tag{13}$$

$$\frac{1}{u'(w-\tau_s)} = \lambda+\frac{\eta}{p}, \text{ for all } s \geq 1, \tag{14}$$

$$C'(U^u) = \lambda - \frac{\eta}{1-p}, \tag{15}$$

The envelope condition is

$$C'(U) = \lambda. \tag{16}$$

Notice the assumption that the strength of the temptation is small, $1-p > \frac{\gamma}{1+\gamma}$, ensures an interior solution. Also, from the optimality conditions above, we immediately have $\lambda > 0$.

Proof of Lemma 4: When $\eta = 0$, from (15) and (16), we have $U^u = U$. Therefore, if the incentive constraint is non-binding at the optimum, the promised utility remains constant over time. ■

Proof of Theorem 1: Let $\tilde{C}$ denote the value function when the incentive constraint is slack, and $\hat{C}$ be the value function when the incentive constraint is binding. Suppose for the given initial value U, the incentive compatibility constraint is binding but becomes slack in the subsequent period. Then, the policy solves the following Bellman equation:

$$\hat{C}(U) = \min_{b,\tau_0,\tau,U^u} (1-p)\left[b + \delta \tilde{C}(U^u)\right] - p\left(\tau_0 + \sum_{s=1}^{\infty} \delta^s \tau_s\right)$$

subject to the binding incentive constraint (1) and the promise keeping constraint (3). By Lemma 4, $\tilde{C}(U^u)$ is formally defined as

$$\tilde{C}(U^u) = \min_{\tilde{b},\tilde{\tau}_0,\tilde{\tau}} (1-p)\left[\tilde{b} + \delta \tilde{C}(U^u)\right] - p\left(\tilde{\tau}_0 + \sum_{s=1}^{\infty} \delta^s \tilde{\tau}_s\right)$$

subject to the promise-keeping constraint

$$U^u = p\left[(1+\gamma)\, u(w - \tilde{\tau}_0) + \frac{\delta u(w-\tilde{\tau})}{1-\delta}\right] + (1-p)\left[\left(1+\gamma - \frac{\gamma}{1-p}\right) u\left(\tilde{b}\right) + \delta U^u\right] - (1+\gamma)\, h. \quad (17)$$

Let $\tilde{\lambda}$ denote the multiplier on (17). Therefore, from the envelope condition and first-order condition on $\tilde{b}$, we have $\tilde{C}'(U^u) = \tilde{\lambda}$ and

$$\frac{1}{u'\left(\tilde{b}\right)} = \tilde{\lambda}\left(1+\gamma - \frac{\gamma}{1-p}\right).$$

Note that (15) is rewritten as

$$\tilde{C}'(U^u) = \lambda - \frac{\eta}{1-p}.$$

This implies that $\tilde{\lambda} = \lambda - \frac{\eta}{1-p}$. Comparing the first-order condition on $\tilde{b}$ and (12), we have $\tilde{b} > b$. Therefore, if the incentive constraint transitions from binding to non-binding, unemployment benefit is strictly increasing.

Next, we show that $U^u < U$. Note that the first-order conditions on τ_0 and τ_s are

$$\frac{1}{u'(w - \tilde{\tau}_0)} = (1+\gamma)\tilde{\lambda} \text{ and } \frac{1}{u'(w - \tilde{\tau}_s)} = \tilde{\lambda}, \text{ for all } s \geq 1.$$

Since $\tilde{\lambda} = \lambda - \frac{\eta}{1-p}$ and by (13) and (14), we have $\tau_s < \tilde{\tau}_s$ for all $s \geq 0$. Therefore, for subsequent policies $\left(\tilde{b}, \tilde{\tau}_0, \tilde{\tau}, U^u\right)$ to satisfy the incentive constraint, $U^u < U$.

Finally, note that the promise-keeping constraints imply that the incentive constraints from the two periods can be rewritten as

$$U = u(b) + \delta U^u \text{ and } U^u \geq u\left(\tilde{b}\right) + \delta U^u.$$

As a result, we have

$$\frac{u(b)}{1-\delta} > U \geq u(b) + \frac{\delta u\left(\tilde{b}\right)}{1-\delta},$$

where the first inequality comes from the fact that $U^u < U$. This is a contradiction because $\tilde{b} > b$ when the incentive constraint transitions from binding to slack. Hence, if the incentive compatibility constraint is binding, it stays binding indefinitely. ■

Proof of Theorem 2: First, from (14), $\tau_s = \tau$ for all $s \geq 1$. Then, (14) and (13) yields

$$\frac{1}{u'(w - \tau_0)} = \frac{1+\gamma}{u'(w - \tau)}.$$

The result that $\tau_0 < \tau$ immediately follows.

Finally, to show that the taxes increase over the unemployment spell when (1) binds,

differentiate the promise-keeping and incentive constraints by state variable U :

$$-p\left[(1+\gamma)u'(w-\tau_0)\frac{\partial\tau_0}{\partial U}+\frac{\delta}{1-\delta}u'(w-\tau)\frac{\partial\tau}{\partial U}\right] + \left[(1-p)(1+\gamma)-\gamma\right]u'(b)\frac{\partial b}{\partial U}+\delta(1-p)\frac{\partial U^u}{\partial U}=1, \quad (18)$$

$$(1+\gamma)\left[u'(w-\tau_0)\frac{\partial\tau_0}{\partial U}+u'(b)\frac{\partial b}{\partial U}\right]+\left[\frac{\delta}{1-\delta}u'(w-\tau)\frac{\partial\tau}{\partial U}+\delta\frac{\partial U^u}{\partial U}\right]=0. \quad (19)$$

By Lemma 2, the unemployment policies are differentiable and C is twice differentiable. Differentiating the first-order conditions by U gives us

$$\frac{\partial b}{\partial U}=-\frac{\left[u'(b)\right]^2}{u''(b)}\left[\left(1+\gamma-\frac{\gamma}{1-p}\right)\frac{\partial\lambda}{\partial U}-\frac{1+\gamma}{1-p}\frac{\partial\eta}{\partial U}\right], \quad (20)$$

$$\frac{\partial U^u}{\partial U}=\frac{1}{C''(U^u)}\left(\frac{\partial\lambda}{\partial U}-\frac{1}{1-p}\frac{\partial\eta}{\partial U}\right),$$

$$\frac{\partial\tau}{\partial U}=\frac{\left[u'(w-\tau)\right]^2}{u''(w-\tau)}\left(\frac{\partial\lambda}{\partial U}+\frac{1}{p}\frac{\partial\eta}{\partial U}\right), \quad (21)$$

$$\frac{\partial\tau_0}{\partial U}=\frac{\left[u'(w-\tau_0)\right]^2}{u''(w-\tau_0)}(1+\gamma)\left(\frac{\partial\lambda}{\partial U}+\frac{1}{p}\frac{\partial\eta}{\partial U}\right), \quad (22)$$

which we substitute into (18) and (19) to yield

$$\left[G+H-(1+\gamma)\left(1+\gamma-\frac{\gamma}{1-p}\right)I-J\right]x+\left[\frac{G}{p}+\frac{H}{p}+\frac{(1+\gamma)^2}{1-p}I+\frac{1}{1-p}J\right]y=0,$$

$$\left[p(G+H)+\left[(1-p)(1+\gamma)-\gamma\right]\left(1+\gamma-\frac{\gamma}{1-p}\right)I+(1-p)J\right]x + \left[G+H-\left[(1-p)(1+\gamma)-\gamma\right]\frac{1+\gamma}{1-p}I-J\right]y=1,$$

where $x=\frac{\partial\lambda}{\partial U}$ and $y=\frac{\partial\eta}{\partial U}$ and

$$G=-(1+\gamma)^2\frac{\left[u'(w-\tau_0)\right]^3}{u''(w-\tau_0)}, H=-\frac{\delta}{1-\delta}\frac{\left[u'(w-\tau)\right]^3}{u''(w-\tau)}, I=-\frac{\left[u'(b)\right]^3}{u''(b)}, J=\frac{\delta}{C''(U^u)}.$$

Notice immediately that $G, H, I, J > 0$. By Cramer's rule, we have

$$x = \frac{R}{D} \text{ and } y = \frac{-Q}{D},$$

where $D = SR - Q^2$, and

$$Q = G + H - (1+\gamma)\left(1 + \gamma - \frac{\gamma}{1-p}\right) I - J,$$

$$R = \frac{G}{p} + \frac{H}{p} + \frac{(1+\gamma)^2}{1-p} I + \frac{1}{1-p} J,$$

$$S = p(G+H) + [(1-p)(1+\gamma) - \gamma]\left(1 + \gamma - \frac{\gamma}{1-p}\right) I + (1-p) J,$$

Next, note that (15) and (16) and the convexity of C imply the promised utility and λ decrease over the unemployment spell, so $x > 0$. This implies that $D > 0$ since $R > 0$. Next, note that

$$x + \frac{y}{p} = \frac{1}{pD}(pR - Q) > 0,$$

so $-\frac{\partial \tau}{\partial U}, -\frac{\partial \tau_0}{\partial U} > 0$ by (21) and (22). Thus, by Lemma 4, taxes (τ_0, τ) increase as promised utility decreases over the unemployment spell, and it is strictly increasing if (1) binds. ■

Proof of Theorem 3: Let (λ', η') denote the multipliers on next period's constraints. In particular, $C'(U^u) = \lambda' = \lambda - \frac{\eta}{1-p}$ by (15) and (16). Then, by iterating (12) and (13), we have $\frac{1}{u'(b')} = \lambda'\left(1 + \gamma - \frac{\gamma}{1-p}\right) - \eta' \frac{1+\gamma}{1-p}$ and $\frac{1}{u'\left(w-\tau_0'\right)} = (1+\gamma)\left(\lambda' + \frac{\eta'}{p}\right)$. Therefore,

$$C'(U^u) = \frac{1-p}{u'(b')} + \frac{p}{u'(w - \tau_0')}.$$

Thus, by (15) and (12), we have

$$\frac{1}{u'(b)} = \frac{1-p}{u'(b')} + \frac{p}{u'(w-\tau_0')} - \frac{\gamma p}{1-p}\left(\lambda + \frac{\eta}{p}\right),$$

and the result follows immediately from (14).

Next, by Lemma 4, (15) and (16) imply that U^u is strictly decreasing over the unem-

ployment spell as (1) binds since $1-p>\frac{\gamma}{1+\gamma}$.

Finally, to derive the condition that guarantees a decreasing b when (1) binds, note that with the expressions derived for $\frac{\partial\lambda}{\partial U}$ and $\frac{\partial\eta}{\partial U}$ derived in the proof of Theorem 2, (20) can be rewritten as

$$\frac{\partial b}{\partial U}=-\frac{1}{(1-p)\,D}\frac{\left[u'\left(b\right)\right]^{2}}{u''\left(b\right)}\left(\frac{G+H}{p}-\frac{\gamma J}{1-p}\right).$$

Given the definition of G, H, and J and by the fact that $D>0$ (shown in the proof of Theorem 2), $\frac{\partial b}{\partial U}$ is strictly positive if and only if

$$\frac{(1-p)\,C''\left(U^{u}\right)}{\gamma\delta}>\frac{p}{-\left(1+\gamma\right)^{2}\frac{\left[u'(w-\tau_{0})\right]^{3}}{u''(w-\tau_{0})}-\frac{\delta}{1-\delta}\frac{\left[u'(w-\tau)\right]^{3}}{u''(w-\tau)}}.$$

Since from (13) and (14), we have $u'\left(w-\tau\right)=\left(1+\gamma\right)u'\left(w-\tau_{0}\right)$, inequality (5) follows. ■

Proof of Theorem 4: First, we show that the temporal loadings are monotonically decreasing with unemployment spell. From Theorem 2 and Theorem 3,

$$\mathcal{F}=\gamma\left(\lambda+\frac{\eta}{p}\right)\text{ and }\mathcal{B}=\frac{\gamma p}{1-p}\left(\lambda+\frac{\eta}{p}\right).$$

By (13), $\lambda+\frac{\eta}{p}=\frac{1}{(1+\gamma)u'(w-\tau_{0})}$. By Theorem 2, τ_0 is strictly increasing over the unemployment spell when (1) binds. Therefore, by the strict concavity of u, $\mathcal{F}$ and $\mathcal{B}$ is strictly decreasing over the unemployment spell if (1) binds. ■

Proof of Proposition 3: First, we derive the necessary optimality conditions. Let (λ,η) denote the multipliers on the promise-keeping constraint (9) and incentive constraint (8), respectively. The first-order conditions for the government's cost minimization problem are

$$\frac{1}{u'\left(b\right)}=\lambda-\frac{\eta}{1-p},\tag{23}$$

$$\frac{1}{u'\left(w-\tau_{0}\right)}=\lambda+\frac{\eta}{p},\tag{24}$$

$$\frac{1}{u'\left(w-\tau_{s}\right)}=\lambda+\frac{\beta\eta}{p},\text{ for all }s\geq1,\tag{25}$$

$$C'\left(U^u\right) = \lambda - \frac{\beta\eta}{1-p}, \tag{26}$$

The envelope condition is

$$C'\left(U\right) = \lambda. \tag{27}$$

Next, from (25), $\tau_s = \tau$ for all $s \geq 1$. Then, subtracting (25) from (24) yields

$$\frac{1}{u'\left(w-\tau_0\right)} = \frac{1}{u'\left(w-\tau\right)} + \frac{\left(1-\beta\right)\eta}{p}.$$

Since $\eta > 0$, the result that $\tau_0 < \tau$ immediately follows from comparing (24) and (25).

Next, to show that τ decreases over the unemployment spell, Lemma 2 allows us to differentiate the promise-keeping and incentive constraints by state variable U :

$$-p\left[u'\left(w-\tau_0\right)\frac{\partial\tau_0}{\partial U} + \sum_{s=1}^{\infty}\delta^s u'\left(w-\tau_s\right)\frac{\partial\tau}{\partial U}\right] + \left(1-p\right)\left[u'\left(b\right)\frac{\partial b}{\partial U} + \delta\frac{\partial U^u}{\partial U}\right] = 1, \tag{28}$$

$$\left[u'\left(w-\tau_0\right)\frac{\partial\tau_0}{\partial U} + u'\left(b\right)\frac{\partial b}{\partial U}\right] + \beta\left[\sum_{s=1}^{\infty}\delta^s u'\left(w-\tau_s\right)\frac{\partial\tau}{\partial U} + \delta\frac{\partial U^u}{\partial U}\right] = 0. \tag{29}$$

Differentiating the first-order conditions by U gives us

$$\begin{aligned}
\frac{\partial b}{\partial U} &= -\frac{\left[u'\left(b\right)\right]^2}{u''\left(b\right)}\left(\frac{\partial\lambda}{\partial U} - \frac{1}{1-p}\frac{\partial\eta}{\partial U}\right), \\
\frac{\partial U^u}{\partial U} &= \frac{1}{C''\left(U^u\right)}\left(\frac{\partial\lambda}{\partial U} - \frac{\beta}{1-p}\frac{\partial\eta}{\partial U}\right), \\
\frac{\partial\tau}{\partial U} &= \frac{\left[u'\left(w-\tau\right)\right]^2}{u''\left(w-\tau\right)}\left(\frac{\partial\lambda}{\partial U} + \frac{\beta}{p}\frac{\partial\eta}{\partial U}\right), \\
\frac{\partial\tau_0}{\partial U} &= \frac{\left[u'\left(w-\tau_0\right)\right]^2}{u''\left(w-\tau_0\right)}\left(\frac{\partial\lambda}{\partial U} + \frac{1}{p}\frac{\partial\eta}{\partial U}\right),
\end{aligned} \tag{30}$$

which we substitute into (28) and (29) to yield

$$\left[p\left(G+I\right) + \left(1-p\right)\left(H+J\right)\right]x + \left(G+\beta I - H - \beta J\right)y = 1,$$

$$\left(G+\beta I - H - \beta J\right)x + \left(\frac{G+\beta^2 I}{p} + \frac{H+\beta^2 J}{1-p}\right)y = 0,$$

where $x = \frac{\partial \lambda}{\partial U}$ and $y = \frac{\partial \eta}{\partial U}$ and

$$G = -\frac{\left[u'\left(w-\tau_0\right)\right]^3}{u''\left(w-\tau_0\right)},\ H = -\frac{\left[u'\left(b\right)\right]^3}{u''\left(b\right)},\ I = -\frac{\delta}{1-\delta}\frac{\left[u'\left(w-\tau\right)\right]^3}{u''\left(w-\tau\right)},\ \text{and}\ J = \frac{\delta}{C''\left(U^u\right)}.$$

Notice that $G, H, I, J > 0$. By Cramer's rule, we have $x = \frac{N_x}{D}$ and $y = \frac{N_y}{D}$, where

$$D = \begin{vmatrix} p\left(G+I\right)+\left(1-p\right)\left(H+J\right) & G+\beta I-H-\beta J \\ G+\beta I-H-\beta J & \frac{G+\beta^2 I}{p}+\frac{H+\beta^2 J}{1-p} \end{vmatrix},$$

$$N_x = \begin{vmatrix} 1 & G+\beta I-H-\beta J \\ 0 & \frac{G+\beta^2 I}{p}+\frac{H+\beta^2 J}{1-p} \end{vmatrix},\ \text{and}\ N_y = \begin{vmatrix} p\left(G+I\right)+\left(1-p\right)\left(H+J\right) & 1 \\ G+\beta I-H-\beta J & 0 \end{vmatrix}.$$

Next, note that (26) and (27) and the convexity of C imply the promised utility and λ decrease over the unemployment spell, so $x > 0$. This implies that $D > 0$ since $N_x > 0$. As a result, by (30), we have

$$\frac{\partial \tau}{\partial U} = \frac{\left[u'\left(w-\tau\right)\right]^2}{u''\left(w-\tau\right)}\frac{\left[\left(1-\beta\right)\frac{G}{p}+\left(\frac{1}{1-p}+\frac{\beta}{p}\right)H+\beta^2\left(\frac{1}{1-p}+\frac{1}{p}\right)J\right]}{D},$$

which is strictly negative. Thus, τ increases as promised utility decreases over the unemployment spell.

Finally, let (λ', η') denote the multipliers on next period's constraints. In particular, $C'\left(U^u\right) = \lambda' = \lambda - \frac{\beta\eta}{1-p}$ by (26) and (27). Then, by iterating (23) and (24), we have $\frac{1}{u'(b')} = \lambda' - \frac{\eta'}{1-p}$ and $\frac{1}{u'\left(w-\tau_0'\right)} = \lambda' + \frac{\eta'}{p}$. Therefore,

$$C'\left(U^u\right) = \frac{1-p}{u'\left(b'\right)} + \frac{p}{u'\left(w-\tau_0'\right)}.$$

Thus, subtracting (26) from (23) yields

$$\frac{1}{u'\left(b\right)} = \frac{1-p}{u'\left(b'\right)} + \frac{p}{u'\left(w-\tau_0'\right)} - \frac{\left(1-\beta\right)\eta}{1-p}.$$

Also, (26) and (27) imply that U^u decreases over the unemployment spell. ■

Proof of Proposition 4: Let (b^*, U^*, τ^*) denote the full information efficient optimum. (Recall from Proposition 1 that the full-information efficient allocations are constant over time.) Also, let W^I denote the imaginary promised utility to an employed agent. Here, the imaginary promised utility is used to relax the incentive constraint, which can be rewritten as

$$h \leq p\left\{\left[u\left(w-\tau^*\right)+\beta\delta W^I\right]-\left[u\left(b^*\right)+\beta\delta U^*\right]\right\}. \tag{31}$$

The incentive constraint (31) replaces the promised utility in (1), $\frac{u(w-\tau^*)}{1-\delta}$, with the imaginary promised utility, W^I. The imaginary promised utility is defined by imaginary allocations, which we denote with the superscript I. Specifically, let the imaginary promised utility W^I be defined as

$$W^I = n + \delta N,$$

where

$$n = u\left(w-\tau_1^I\right) \text{ and } N = \sum_{s=2}^{\infty}\delta^{s-2}u\left(w-\tau_s^I\right).$$

In constructing PAM, the values of the imaginary allocations do not matter. We will focus on finding the imaginary utilities (n, N).

The fooling constraint ensures that a non-sophisticated agent with belief $\hat{\beta}$ evaluates future utility using the imaginary promised utilities

$$n + \hat{\beta}\delta N \geq u\left(w-\tau^*\right)+\frac{\hat{\beta}\delta u\left(w-\tau^*\right)}{1-\delta}. \tag{32}$$

Meanwhile, the executability constraint ensures that, instead of the imaginary allocations, the full information efficient optimal allocations are implemented on the equilibrium path:

$$u\left(w-\tau^*\right)+\frac{\beta\delta u\left(w-\tau^*\right)}{1-\delta} \geq n + \beta\delta N. \tag{33}$$

The fooling and executability constraints imply that $\frac{u(w-\tau^*)}{1-\delta} \geq N$. Therefore, if the fooling constraint holds for the least naïve agent with belief $\underline{\hat{\beta}}$, then the fooling constraint holds for all agents with $\hat{\beta} > \underline{\hat{\beta}}$. Thus, we focus on non-sophisticated agents with belief $\underline{\hat{\beta}}$.

We choose (n, N) such that (33) binds. Following the same argument as above, we can

set

$$n = W^I - \delta N \text{ and } N = \frac{W^I - u\left(w - \tau^*\right) - \frac{\beta\delta u(w-\tau^*)}{1-\delta}}{(1-\beta)\,\delta}.$$

Then, the fooling constraint (32) can be written as

$$\left(\frac{\hat{\underline{\beta}} - \beta}{1-\beta}\right)\left[W^I - \frac{u\left(w-\tau^*\right)}{1-\delta}\right] \geq 0.$$

Therefore, for (31) and (32) to hold, we can set

$$W^I = \max\left\{\frac{u\left(w-\tau^*\right)}{1-\delta}, \frac{\frac{h}{p} + u\left(b^*\right) + \beta\delta U^* - u\left(w-\tau^*\right)}{\beta\delta}\right\}.$$

The construction above guarantees that the full information efficient optimum is implemented. ■

B Enlarged Menus

In Section 6.2, we demonstrated how enlarged menus with extraneous options can relax incentive compatibility constraints when the agent is non-sophisticated and present biased. However, in this section, we show that enlarged menus are ineffective for agents with costly self-control.

First, it is important to notice that expanding the policy menu for an employed agent does not enhance welfare. The rationale behind this is rooted in the necessity for extraneous options to be tempting to the agent for them to have any impact. Yet, the inclusion of such tempting choices in the policy menu for an employed agent would impose additional self-control costs. Thus, any additional choices for an employed agent undermines the incentives for an unemployed agent to search for jobs.

Next, we focus on introducing tempting extraneous options in the policy menu for an unemployed agent. Suppose an agent fails to find a job and is being presented with the following menu:

$$\left\{\left(b, U^u\right), \left(b^T, U^T\right)\right\}.$$

In our setup, $\left(b^T, U^T\right)$ is the most tempting option for the agent, but it is meant to be an off-path option. Using the language of Yu (2021), the unemployment policies satisfy the *executability constraint*

$$u\left(b^T\right) + \delta U^T \leq u\left(b\right) + \delta U^u, \tag{34}$$

and the *threat constraint*

$$u\left(b^T\right) \geq u\left(b\right). \tag{35}$$

The tempting option $\left(b^T, U^T\right)$ is used to punish the unemployed agent by raising the cost of self-control. Therefore, the unemployed agent's utility is

$$\left(1+\gamma\right) u\left(b\right) + \delta U^u - \gamma u\left(b^T\right),$$

which is decreased by the additional self-control cost caused by the extraneous option.

Under this mechanism, the expected discounted utility for an unemployed agent is

$$\begin{aligned} & p\left[\left(1+\gamma\right) u\left(w-\tau_0\right) + \delta \sum_{s=1}^{\infty} \delta^{s-1} u\left(w-\tau_s\right)\right] \\ & \qquad + \left(1-p\right)\left\{\left(1+\gamma\right)\left[\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right)\right] + \delta U^u\right\} - \left(1+\gamma\right) h \\ & - \gamma \max\left\{\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right), pu\left(w-\tau_0\right) + \left(1-p\right)\left[\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right)\right] - h\right\}. \end{aligned}$$

If the unemployed agent does not search, then the expected discounted utility is

$$\begin{aligned} & \left(1+\gamma\right)\left[\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right)\right] + \delta U^u \\ & - \gamma \max\left\{\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right), pu\left(w-\tau_0\right) + \left(1-p\right)\left[\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right)\right] - h\right\}. \end{aligned}$$

As a result, the incentive compatibility constraint is

$$\begin{aligned} & \left(1+\gamma\right)\left\{u\left(w-\tau_0\right) - \left[\left(1+\gamma\right) u\left(b\right) - \gamma u\left(b^T\right)\right]\right\} \\ & \qquad + \delta\left[\sum_{s=1}^{\infty} \delta^{s-1} u\left(w-\tau_s\right) - U^u\right] \geq \frac{\left(1+\gamma\right) h}{p}. \end{aligned} \tag{36}$$

The following lemma is similar to Lemma 1, and it shows that, even with the enlarged menu, the maximally tempting option is for an unemployed agent to not search.

Lemma 5 *The maximally tempting action in an optimal incentive compatible unemployment insurance system is to not search:*

$$\max\left\{(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right),pu(w-\tau_0)+(1-p)\left[(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right)\right]-h\right\}$$
$$=(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right).$$

Proof Suppose that

$$\max\left\{(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right),pu(w-\tau_0)+(1-p)\left[(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right)\right]-h\right\}$$
$$=pu(w-\tau_0)+(1-p)\left[(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right)\right]-h.$$

Then, the planner's problem is

$$C(U)=\min_{b,U^u,\tau_s,b^T,U^u}(1-p)\left[b+\delta C\left(U^u\right)\right]-p\sum_{s=0}^{\infty}\delta^s\tau_s$$

subject to the executability (34), threat (35), incentive compatibility (36), and promise-keeping constraint

$$U=p\left[u(w-\tau_0)+\sum_{s=1}^{\infty}\delta^s u(w-\tau_s)\right]+(1-p)\left\{\left[(1+\gamma)\,u(b)-\gamma u\left(b^{T}\right)\right]+\delta U^u\right\}-h.$$

Let (χ,ξ,η,λ) be the multipliers on (34), (35), (36), and promise-keeping constraint, respectively. The first-order conditions are

$$\frac{1}{u'(b)}=(1+\gamma)\left(\lambda-\eta\frac{1+\gamma}{1-p}\right)+\chi-\xi,$$

$$\frac{1}{u'(w-\tau_0)}=\lambda+(1+\gamma)\frac{\eta}{p}$$

$$\frac{1}{u'(w-\tau_s)}=\lambda+\frac{\eta}{p}\text{ for all }s\geq 1,$$

$$C'\left(U^u\right) = \lambda - \frac{\eta + \chi}{1-p},$$

$$\chi = 0 \text{ and } \xi = \gamma\left(\lambda - \eta\frac{1+\gamma}{1-p}\right).$$

The envelope condition is $C'(U) = \lambda$. Let $\tau = \tau_s$ for all $s \geq 1$. Consider two cases: if (36) is binding and if (36) is non-binding.

First, consider the case with a non-binding incentive constraint (36). Then, when $\eta = 0$ in the first-order conditions, the full-information optimum of Proposition 1 can be implemented. However, the full information optimum is not incentive compatible, a contradiction. Therefore, it must be the case that

$$\max\left\{(1+\gamma)\,u(b) - \gamma u\left(b^T\right), pu(w-\tau_0) + (1-p)\left[(1+\gamma)\,u(b) - \gamma u\left(b^T\right)\right] - h\right\}$$
$$= (1+\gamma)\,u(b) - \gamma u\left(b^T\right).$$

when the incentive constraint is non-binding.

Finally, consider the case when (36) is binding. We have

$$\begin{aligned}\left[(1+\gamma)\,u(b) - \gamma u\left(b^T\right)\right] - \left\{pu(w-\tau_0) + (1-p)\left[(1+\gamma)\,u(b) - \gamma u\left(b^T\right)\right] - h\right\} \\ = h - p\left\{u(w-\tau_0) - \left[(1+\gamma)\,u(b) - \gamma u\left(b^T\right)\right]\right\} \\ = \frac{p\delta}{1+\gamma}\left[\sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s) - U^u\right].\end{aligned} \tag{37}$$

The third equality comes from the fact that (36) is binding. Under the assumption that the most tempting action is to search, then (37) implies $U^u \geq \sum_{s=1}^{\infty}\delta^{s-1}u(w-\tau_s)$. Since (36) binds, we have $\eta > 0$, so the first-order conditions above imply that $u(w-\tau) > u(b)$ and $U > U^u$. Furthermore, it must be the case that $\xi > 0$, so $b^T = b$. As a result, the promise-keeping constraint can be rewritten as

$$U = \frac{p\delta\gamma}{1+\gamma}\left[\frac{u(w-\tau)}{1-\delta} - U^u\right] + u(b) + \delta U^u.$$

Therefore, we have

$$\frac{p\delta\gamma}{1+\gamma}\left[\frac{u\left(w-\tau\right)}{1-\delta}-U^{u}\right]=U-u\left(b\right)-\delta U^{u}>\left(1-\delta\right)\left\{U^{u}-\frac{u\left(b\right)}{1-\delta}\right\},$$

where the inequality comes from the fact that $U>U^{u}$. Recall that $U^{u}\geq\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_{s}\right)=\frac{u(w-\tau)}{1-\delta}$ when (36) binds and the most tempting option is to search. Since $u\left(w-\tau\right)>u\left(b\right)$, the right-hand side of the inequality is strictly positive. However, the left hand side is weakly negative, which is a contradiction. ■

Given Lemma 5, we have the following Bellman equation:

$$C\left(U\right)=\min_{b,U^{u},\tau_{s},b^{T},U^{T}}\left(1-p\right)\left[b+\delta C\left(U^{u}\right)\right]-p\sum_{s=0}^{\infty}\delta^{s}\tau_{s}.$$

subject to the executability (34), threat (35), incentive compatibility constraints (36), and the promise-keeping constraint:

$$\begin{aligned}p\left[\left(1+\gamma\right)u\left(w-\tau_{0}\right)+\delta\sum_{s=1}^{\infty}\delta^{s-1}u\left(w-\tau_{s}\right)\right]\\+\left(1-p\right)\left\{\left(1+\gamma-\frac{\gamma}{1-p}\right)\left[\left(1+\gamma\right)u\left(b\right)-\gamma u\left(b^{T}\right)\right]+\delta U^{u}\right\}-\left(1+\gamma\right)h.\end{aligned}$$

Notice that since $\left(b^{T},U^{T}\right)$ is never chosen, the government does not incur the cost of adding off-path options in the unemployed agent's menu.

Proposition 5 *The optimal off-path options are* $b^{T}=b$ *and* $U^{T}\leq U$.

Proof By Lemma 5, the planner's problem is

$$C\left(U\right)=\min_{b,U^{u},\tau_{s},b^{T},U^{u}}\left(1-p\right)\left[b+\delta C\left(U^{u}\right)\right]-p\sum_{s=0}^{\infty}\delta^{s}\tau_{s}$$

subject to the executability (34), threat (35), incentive compatibility (36), and promise-

keeping constraint

$$U = p\left[(1+\gamma)\,u\,(w-\tau_0) + \sum_{s=1}^{\infty}\delta^s u\,(w-\tau_s)\right] + (1-p)\left\{\left(1+\gamma-\frac{\gamma}{1-p}\right)\left[(1+\gamma)\,u\,(b) - \gamma u\left(b^T\right)\right] + \delta U^u\right\} - (1+\gamma)\,h.$$

Let $(\chi, \xi, \eta, \lambda)$ be the multipliers on (34), (35), (36), and promise-keeping constraint, respectively. From the first-order conditions, we have

$$\frac{1}{u'\,(b)} = (1+\gamma)\left[\lambda\left(1+\gamma-\frac{\gamma}{1-p}\right) - \eta\frac{1+\gamma}{1-p}\right] + \chi - \xi,$$

$$\chi = 0 \text{ and } \xi = \gamma\left[\lambda\left(1+\gamma-\frac{\gamma}{1-p}\right) - \eta\frac{1+\gamma}{1-p}\right].$$

Therefore, it must be that $\xi > 0$. By complementary slackness, we have $b^T = b$ and $U^T \leq U$. ■

Proposition 5 shows that it is not optimal for the government to add a tempting option that increases the unemployed agent's self-control cost, suggesting that enlarged menus do not enhance welfare. Although introducing an extraneous option relaxes the incentive compatibility constraint (36) by raising the unemployed's self-control cost, it concurrently increases the cost of delivering the promised utility. At the optimum, the welfare cost imposed by the promise-keeping constraint outweighs any benefits from the relaxed incentive constraint, due to a higher shadow price. Consequently, the additional cost of fulfilling the promised utility with enlarged menus surpasses any advantages from a relaxed incentive constraint.

Existing research has generally found that in settings with hidden types and agents with self-control issues, whether it be present bias or costly self-control, enlarged menus featuring extraneous options are typically Pareto improving (Esteban and Miyagawa, 2005; Galperti, 2015; Yu, 2021). In such environments, these extraneous options are strategically included in the menus of certain types to prevent others from imitating them. Importantly, the standard single-crossing condition ensures that these extraneous options can be structured in a way that agents who report truthfully will never select them, rendering them costless to

introduce. In contrast, our model focuses on a moral hazard setting. Although the tempting option $\left(b^T, U^T\right)$ motivates job search, there remains a possibility that the unemployed agent, despite the effort, may not secure employment and will have to exert more costly self-control.

An immediate policy implication is that the unemployment insurance system should never provide individuals with options. For example, it is not optimal to give the unemployed a choice between receiving a lump-sum benefit payment or regularly timed payments.

C Guess and Verify for CARA Utility

C.1 Model with Binary Effort

Using the guess and verify approach, first guess that when (1) is non-binding, $C(U)$ takes the form

$$C(U) = -\frac{\ln\left[-\sigma(1-\delta)U + A\right]}{\sigma(1-\delta)} + B,$$

where A and B are constants.

Next, substitute the guess into the constrained optimization problem:

$$C(U) = \min_{b,U^u,\tau_s} (1-p)\left\{b + \frac{\delta}{1-\delta}\left[-\frac{1}{\sigma}\ln\left(A - \sigma(1-\delta)U^u\right) + (1-\delta)B\right]\right\} - p\sum_{s=0}^{\infty}\delta^s\tau_s.$$

subject to the promise-keeping constraint

$$U = p\left\{(1+\gamma)\left[\frac{1-\exp\left(-\sigma\left(w-\tau_0\right)\right)}{\sigma}\right] + \sum_{s=1}^{\infty}\delta^s\left[\frac{1-\exp\left(-\sigma\left(w-\tau_s\right)\right)}{\sigma}\right]\right\}$$
$$+ (1-p)\left\{\left(1+\gamma-\frac{\gamma}{1-p}\right)\left[\frac{1-\exp\left(-\sigma b\right)}{\sigma}\right] + \delta U^u\right\} - (1+\gamma)h.$$

Let λ denote the multiplier on the promise-keeping constraint. The first-order conditions are

$$1-p = \lambda\left[(1-p)(1+\gamma) - \gamma\right]\exp\left(-\sigma b\right),$$

$$\frac{1}{A - \sigma(1-\delta)U^u} = \lambda,$$

$$\lambda(1+\gamma)\exp\left(-\sigma\left(w-\tau_0\right)\right) = 1,$$

$$\lambda \exp\left(-\sigma\left(w-\tau_s\right)\right)=1, \text{ for all } s \geq 1.$$

Denote τ_s as τ for all $s \geq 1$. From the first-order conditions, we have

$$U^u=\frac{1}{\sigma(1-\delta)}\left[A-\left(1+\gamma-\frac{\gamma}{1-p}\right)\exp\left(-\sigma b\right)\right],$$

$$\tau_0=w-b-\frac{1}{\sigma}\ln\left[\frac{(1-p)(1+\gamma)}{(1-p)(1+\gamma)-\gamma}\right], \text{ and } \tau=w-b-\frac{1}{\sigma}\ln\left[\frac{1-p}{(1-p)(1+\gamma)-\gamma}\right].$$

Use the expressions above to eliminate the promised utility U^u and taxes τ_s from the promise-keeping constraint yields the following expression for benefit b :

$$b=-\frac{1}{\sigma}\ln\left[-\sigma U+1-\sigma(1+\gamma)h+\frac{\delta}{1-\delta}\left[p+(1-p)A\right]\right]+\frac{1}{\sigma}\ln\left[\frac{(1-p)(1+\gamma)-\gamma}{(1-p)(1-\delta)}\right].$$

Finally, substituting the expression for b back into the objective function verifies the functional form assumption for $C(U)$ and implies

$$A=1-\frac{\sigma(1-\delta)(1+\gamma)h}{1-\delta(1-p)},$$

$$B=\frac{1}{1-\delta(1-p)}\left\{\frac{1}{\sigma}\ln\left(1+\gamma-\frac{\gamma}{1-p}\right)+\frac{p}{\sigma}\ln\left[\frac{(1-p)(1+\gamma)}{(1-p)(1+\gamma)-\gamma}\right]-\frac{pw}{1-\delta}\right\}.$$

Then, substituting A and B into the expressions for U^u, b, and τ_s yields the optimal unemployment insurance policy.

C.2 Model with Search Intensity and Effort Satiation

We now repeat the same guess and verify procedure for the model with search intensity and keep the same guess:

$$C(U)=-\frac{\ln\left[-\sigma(1-\delta)U+A\right]}{\sigma(1-\delta)}+B.$$

Crucially, we assume that the incentive constraint is non-binding with the optimal effort level at $\bar{a}$. The Bellman equation remains the same, but the promise-keeping constraint becomes

$$U = \bar{p}\left\{(1+\gamma)\left[\frac{1-\exp\left(-\sigma\left(w-\tau_0\right)\right)}{\sigma}\right] + \sum_{s=1}^{\infty}\delta^s\left[\frac{1-\exp\left(-\sigma\left(w-\tau_s\right)\right)}{\sigma}\right]\right\}$$
$$+ \left(1-\bar{p}\right)\left\{(1+\gamma)\left[\frac{1-\exp\left(-\sigma b\right)}{\sigma}\right] + \delta U^u\right\} - (1+\gamma)\,\bar{h} - \gamma v^*\left(\tau_0, b\right).$$

With λ denoting the multiplier on the promise-keeping constraint, the first-order conditions are

$$\lambda\left[(1+\gamma) - \frac{\gamma\left(1-\tilde{p}\left(a^T\right)\right)}{1-\bar{p}}\right]\exp\left(-\sigma b\right) = 1,$$

$$\frac{1}{A - \sigma\left(1-\delta\right)U^u} = \lambda,$$

$$\lambda\left[(1+\gamma) - \frac{\gamma\tilde{p}\left(a^T\right)}{\bar{p}}\right]\exp\left(-\sigma\left(w-\tau_0\right)\right) = 1,$$

$$\lambda\exp\left(-\sigma\left(w-\tau_s\right)\right) = 1, \text{ for all } s \geq 1.$$

Again, denoting $\tau = \tau_s$ for all $s \geq 1$, the first-order conditions yield

$$U^u = \frac{1}{\sigma\left(1-\delta\right)}\left\{A - \left[1+\gamma - \frac{\gamma\left(1-\tilde{p}\left(a^T\right)\right)}{1-\bar{p}}\right]\exp\left(-\sigma b\right)\right\},$$

$$\tau_0 = w - b - \frac{1}{\sigma}\ln\left[\frac{(1+\gamma) - \frac{\gamma\tilde{p}\left(a^T\right)}{\bar{p}}}{(1+\gamma) - \frac{\gamma\left(1-\tilde{p}\left(a^T\right)\right)}{1-\bar{p}}}\right],$$

$$\tau = w - b - \frac{1}{\sigma}\ln\left[\frac{1-\bar{p}}{\left(1-\bar{p}\right)(1+\gamma) - \gamma\left(1-\tilde{p}\left(a^T\right)\right)}\right].$$

Note that the expressions above coincide with the binary-effort model if $a^T = 0$. From the promise-keeping constraint, we have

$$b = -\frac{1}{\sigma}\ln\left[-\sigma U + 1 - \sigma\left(1+\gamma\right)\bar{h} + \sigma\gamma h\left(a^T\right) + \frac{\delta}{1-\delta}\left[\bar{p} + \left(1-\bar{p}\right)A\right]\right]$$
$$+ \frac{1}{\sigma}\ln\left[\frac{\left(1-\bar{p}\right)(1+\gamma) - \gamma\left(1-\tilde{p}\left(a^T\right)\right)}{\left(1-\bar{p}\right)\left(1-\delta\right)}\right].$$

Finally, substituting the expression for b into the objective function verifies the guess with

$$A = 1 - \frac{\sigma(1-\delta)\left[(1+\gamma)\bar{h} - \gamma h\left(a^T\right)\right]}{1-\delta(1-\bar{p})},$$

$$B = \frac{\left\{\frac{(1-\bar{p})}{\sigma}\ln\left(1+\gamma-\frac{\gamma\left(1-\tilde{p}\left(a^T\right)\right)}{1-\bar{p}}\right) + \frac{\bar{p}}{\sigma}\ln\left[1+\gamma-\frac{\gamma\tilde{p}\left(a^T\right)}{\bar{p}}\right] - \frac{\bar{p}w}{1-\delta}\right\}}{1-\delta(1-\bar{p})}.$$

Notice that when $\tilde{p}\left(a^T\right) = h\left(a^T\right) = 0$, these expressions collapse to the baseline case with binary effort.

D Computing Net Government Spending

To compute the present-discounted government spending under the optimal policy needed to support the initial promised utility, first recursively define C_t^{opt} as the period-t discounted sum of government spending starting from period t of unemployment spell:

$$C_t^{opt} = (1-p)\left(b_t + \delta C_{t+1}^{opt}\right) - p\left(\tau_0^t + \frac{\delta}{1-\delta}\tau^t\right)$$

where τ_0^t and τ^t are the initial and subsequent taxes for a worker who becomes employed in period t of unemployment. The spending is given by the sum of period-t benefits paid to the worker, discounted future spending if the worker does not become employed in period t, less revenue from taxes if the worker becomes employed in period t. The probability of employment is always p because under the optimal policy, the incentive constraint always binds for the calibrated model. For some T large, optimal policies approximately converge to some "steady-state" level, and the government spending starting from this period T can be approximated by:

$$C_T^{opt} = \left(\frac{1}{1-(1-p)\delta}\right)\left[(1-p)b_T - p\tau_0^T - \frac{p\delta\tau^T}{1-\delta}\right]$$

Thus, we have a way to iterate backwards to obtain the spending from the first period of unemployment spell.

To compute the government spending under the current US policy, first check if the

incentive compatibility constraint holds in each period: If it holds, then worker searches; otherwise, worker does not search in the period. Start from some period T large, the actual government net spending in this period is given by:

$$C_T^{us} = \left(\frac{1}{1-\left[IC_T\left(1-p\right)+\left(1-IC_T\right)\right]\delta}\right)\left(\left[IC_T\left(1-p\right)+\left(1-IC_T\right)\right]b_T^{us} - IC_T\frac{p\tau_T^{us}}{1-\delta}\right)$$

where $IC_T = 1$ if the incentive constraint holds and worker searches in period T; $IC_T = 0$ if the incentive constraint does not hold and worker does not search in period T. The benefit is consistent with the actual policy in the US: a 26-week (6-month) unemployment insurance duration, so $b_t^{us} = b_{us}$ if $t \leq 6$ and $b_t^{us} = \underline{c}_{us}$ if $t > 6$. Similarly, to be consistent with the flat income tax profile in the US, we have $\tau_t^{us} = \tau_{us}$. Given the net spending in period T, iterate backwards:

$$C_t^{us} = \left[IC_t\left(1-p\right)+\left(1-IC_t\right)\right]\left(b_t^{us}+\delta C_{t+1}^{us}\right) - pIC_t\frac{\tau_t^{us}}{1-\delta}$$

For the purpose of this exercise, we choose $T = 5000$ which is sufficiently large such that C_T^{opt} and C_T^{us} both converge to within 0.0001%.

E Details on Model with Search Intensity

Let $a^T = \arg\max_{\hat{a}} p\left(\hat{a}\right)u\left(w-\tau_0\right) + \left[1-p\left(\hat{a}\right)\right]u\left(b\right) - h(\hat{a})$, and let (η, λ) denote the Lagrange multipliers on (6) and (7), respectively. The first-order conditions are

$$\frac{1}{u'\left(b\right)} = \lambda\left[\left(1+\gamma\right) - \gamma\left(\frac{1-p\left(a^T\right)}{1-p\left(a\right)}\right)\right] - \frac{\eta p'\left(a\right)}{1-p\left(a\right)},$$

$$\frac{1}{u'\left(w-\tau_0\right)} = \lambda\left[\left(1+\gamma\right) - \frac{\gamma p\left(a^T\right)}{p\left(a\right)}\right] + \frac{\eta p'\left(a\right)}{p\left(a\right)},$$

$$\frac{1}{u'\left(w-\tau\right)} = \lambda + \frac{\eta p'\left(a\right)}{\left(1+\gamma\right)p\left(a\right)}, \text{ where for all } s \geq 1, \tau_s = \tau,$$

$$C'\left(U^u\right) = \lambda - \frac{\eta p'\left(a\right)}{\left(1+\gamma\right)\left[1-p\left(a\right)\right]},$$

$$b + \tau_0 + \delta\left[C\left(U^u\right) + \frac{\tau}{1-\delta}\right] = -\eta\left(\frac{p''\left(a\right)}{\left[p'\left(a\right)\right]^2}h'(a) - \frac{h''(a)}{p'(a)}\right),$$

Combining the last condition and the Bellman equation yields

$$C(U) = -\eta\left(\frac{p''(a)}{[p'(a)]^2}h'(a) - \frac{h''(a)}{p'(a)}\right)[1-p(a)] - \left(\tau_0 + \delta\frac{\tau}{1-\delta}\right).$$

Then, carrying forward one period to $C(U^u)$ and combining with the first-order condition for a gives

$$b + \tau_0 + \delta\left[-\eta'\left(\frac{p''(a')}{[p'(a')]^2}h'(a') - \frac{h''(a')}{p'(a')}\right)[1-p(a')] - \left(\tau_0' + \delta\frac{\tau'}{1-\delta}\right) + \frac{\tau}{1-\delta}\right]$$
$$= -\eta\left(\frac{p''(a)}{[p'(a)]^2}h'(a) - \frac{h''(a)}{p'(a)}\right),$$

where a', τ_0', τ', and η' are from the next period. The envelope condition is

$$C'(U) = \lambda = \frac{p(a)}{u'(w-\tau_0)} + \frac{1-p(a)}{u'(b)} = \frac{p(a)}{u'(w-\tau)} + [1-p(a)]\,C'(U^u).$$

The conditions above, along with (6) and (7), characterize the optimum and were used for the numerical simulation in Section 5.1.

F Impatience

In this section, we compare our results with a setting where the agent is time consistent but less patient than the government. Henceforth, we refer to a time-consistent agent who discounts more than the government as *impatient*. From the government's perspective, an impatient agent also invests too little search effort. However, in contrast to models of self-control, the impatient agent has no demand for a commitment device. This section's environment is similar to Farhi and Werning (2007), which studies a dynamic contracting problem between a time-consistent principal and an impatient agent.

Let α and δ denote the discount factor of the agent and government, respectively, and assume that $\delta > \alpha$. The government's objective function remains the same, but the constraints

are slightly different. The promise-keeping constraint is

$$U = p\sum_{s=0}^{\infty}\alpha^s u\left(w-\tau_s\right)+\left(1-p\right)\left[u\left(b\right)+\alpha U^u\right]-h,$$

and the incentive compatibility constraint is

$$p\left\{\sum_{s=0}^{\infty}\alpha^s u\left(w-\tau_s\right)-\left[u\left(b\right)+\alpha U^u\right]\right\}\geq h.$$

The following proposition characterizes the optimum when the agent is time consistent but less patient than the government.

Proposition 6 *When the agent is time consistent but more impatient than the government, the constrained-efficient optimum is characterized by (i) Unemployment benefits b and continuation utility U^u are decreasing over time, (ii) Front-loaded consumption for employed: τ_s increases with s, and (iii) Front-loaded incentives for unemployed: $\frac{\alpha}{\delta u'(b)}=\frac{1-p}{u'(b')}+\frac{p}{u'\left(w-\tau_0'\right)}$.*

Proof Let (λ,η) denote the multipliers on the promise-keeping constraint and incentive constraint, respectively. The first-order conditions for the government's cost minimization problem are

$$\frac{1}{u'\left(b\right)}=\lambda-\frac{\eta}{1-p}, \tag{38}$$

$$\frac{1}{u'\left(w-\tau_s\right)}=\left(\frac{\alpha}{\delta}\right)^s\left(\lambda+\frac{\eta}{p}\right)\text{ for all }s, \tag{39}$$

$$C'\left(U^u\right)=\frac{\alpha}{\delta}\left(\lambda-\frac{\eta}{1-p}\right), \tag{40}$$

The envelope condition is

$$C'\left(U\right)=\lambda. \tag{41}$$

Since $\alpha<\delta$, from (38), (40), and (41), we have $C'\left(U\right)>\frac{1}{u'(b)}>C'\left(U^u\right)$, which implies that b and U^u must decrease over time if C is strictly convex. Next, with $\alpha<\delta$, (39) implies that as s goes up, τ_s must increase with employment tenure s. Finally, from (38) and (40), we have $\frac{\alpha}{\delta u'(b)}=C'\left(U^u\right)$. Note that (38), (39), and (41) imply $C'\left(U\right)=\frac{1-p}{u'(b)}+\frac{p}{u'(w-\tau_0)}$. Iterating this expression forward yields $\frac{\alpha}{\delta u'(b)}=\frac{1-p}{u'(b')}+\frac{p}{u'\left(w-\tau_0'\right)}$. ■

Proposition 6 shows that the income taxes for an impatient agent are also front-loaded. However, the key difference here is that the income taxes continuously increase over time for an impatient agent, while an agent with temptation and self-control preferences or a present-biased agent only experiences a one-time increase after one period of employment. To understand this difference, recall that for an agent with temptation and self-control preferences, the temptation from unemployment benefits disappears once they become employed. Meanwhile, the present-biased agent's time preference for the future is aligned with the government's, i.e., the present-biased agent wants to consume more in the present but wishes that the future-selves are time-consistent. However, the impatient agent never agrees with the government. Therefore, it decreases the resource cost when the impatient agent's consumption is front-loaded at every single point in time, simply because the agent prefers to have consumption shifted forward.[28]

For the same reason, the unemployment benefits for an impatient agent are also different. In contrast to the relatively more back-loaded consumption path for an unemployed agent with temptation and self-control preferences or present bias, Proposition 6 shows that the incentives for an unemployed impatient agent is front-loaded. This implies that the incentives for employment and remaining unemployed are both front-loaded for the impatient agent. Furthermore, the unemployment benefits for an impatient agent are unambiguously decreasing over time.

[28]This is similar to a sequential general equilibrium model where a patient agent trades with an impatient agent. The patient agent's consumption is back-loaded, while the impatient agent's consumption is front-loaded.