Reference-Dependent Job Search: Evidence from Hungary*

Stefano DellaVigna§ UC Berkeley, NBER

Attila Lindner‡ University College London, CERS-HAS, IFS and IZA

Balázs Reizer§§ Central European University, CERS-HAS

Johannes F. Schmieder† Boston University, NBER, IZA, and CESIfo

September 2016

Abstract

We propose a model of job search with reference-dependent preferences, with loss aversion relative to recent income (the reference point). Newly unemployed individuals search hard given that they are at a loss, but over time they get used to lower income, and thus reduce their search effort. In anticipation of a benefit cut their search effort rises again, then declines once they get used to the lower benefit level. The model fits the typical pattern of the exit from unemployment, even with no unobserved heterogeneity. The model also makes distinguishing predictions regarding the response to benefit changes, which we evaluate using a unique reform. In 2005, Hungary switched from a single-step UI system to a two-step system, with overall generosity unchanged. The system generated increased hazard rates in anticipation of, and especially following, benefit cuts in ways the standard model has a hard time explaining. We estimate a model with optimal consumption, endogenous search effort, and unobserved heterogeneity. The reference-dependent model fits the hazard rates substantially better than most versions of the standard model. Our estimates indicate a slow-adjusting reference point and substantial impatience, likely reflecting present-bias. Habit formation and a variety of alternative models do not match the fit of the reference-dependent model or are at odds with other evidence.

*We thank Patrick Arni, Saurabh Bhargava, Lajos Bódis, Moshe Buchinsky, David Card, Henry Farber, Sebastian Findeisen, Larry Katz, Gábor Kézdi, Patrick Kline, Matthew Rabin, Hedvig Horváth, Erzo Luttmer, Edward O'Donoghue, Daniele Paserman, Alex Rees-Jones, Emmanuel Saez, Mihály Szoboszlai, Owen Zidar and audiences at Boston University, Columbia, Cornell, Harvard, IZA, Mannheim (Department and ZEW), Tinbergen, UCLA, UCL, University of Regensburg, University of Zurich, the UCSB 2014 Behavioral Conference, the 2014 BEAM conference, the 2014 NBER Labor Studies Summer Institute, the Brookings conference on "Policy lessons from behavioral economics", the 2016 ASSA meetings, and the Hungarian Society of Economists Annual Conference for very helpful comments. We are grateful to János Köllő, Kitti Varadovics, Mónika Bálint, Dániel Biró for giving us access to the administrative data and providing continuous help throughout the project, and to Nagy Csaba and Pelek Zsolt for explaining the practical implementation of the reform. We also thank Tristan Gagnon-Bartsch, Matthew Gudgeon, Avner Shlain, Jessica Shui, Alex Steiny, and Ferenc Szucs for excellent research assistance and Gautam Rao for sharing his code. Financial support from the Center for Equitable Growth at UC Berkeley, from the Alfred P. Sloan Foundation, from the National Science Foundation and from the Firms, Strategy and Performance Lendület Grant of the Hungarian Academy of Sciences is gratefully acknowledged.

§ sdellavi@econ.berkeley.edu, ‡ a.lindner@ucl.ac.uk, §§reizer_balazs@ceu-budapest.edu,† johannes@bu.edu

1 Introduction

Unemployment insurance programs in most Western countries follow a common design. The benefits are set at a constant replacement rate for a fixed period, typically followed by lower benefits under unemployment assistance. In such systems, the hazard rate from unemployment typically declines from an initial peak the longer workers are unemployed, surges at unemployment exhaustion, and declines thereafter.[1]

It is well-known that a basic job search model a la Mortensen (1986) and van den Berg (1990) is unable to match this pattern. This model predicts an increasing exit hazard up until benefit expiration, with a constant exit rate thereafter. To match the time path, job search models add unobserved heterogeneity among workers. More productive workers are more likely to find a job initially, leading to a decrease in the hazard over time as the workers still unemployed are predominantly of the less productive type.

In this paper, we propose, and test, a behavioral model of job search which can account for this time path of unemployment even in the absence of unobserved heterogeneity. Namely, we incorporate one of the best established facts in psychology, that people's perceptions and decisions are influenced by relative comparisons. We assume that workers have reference-dependent preferences over their utility from consumption. As in prospect theory (Kahneman and Tversky, 1979), workers are loss-averse with respect to consumption below a reference point. Further, we assume that this reference point is given by recent earnings.

To fix ideas, consider a reference-dependent worker who was just laid off and assume, for now, hand-to-mouth consumption. At the time of job loss, the reference point of the unemployed is the previous wage, which is significantly higher than the unemployment benefit, the new consumption level. The unemployed, therefore, finds the new state of unemployment particularly painful given the loss relative to the reference point, and so she searches hard at the beginning of a UI spell. Over the weeks of unemployment, however, the reference point shifts as the individual adapts to the lower benefit level, and the loss is thus mitigated. Hence, the worker's search effort decreases. As the end of the UI benefits draws near, the worker, if still unemployed, anticipates the loss in consumption due to the exhaustion of the benefits, and searches harder. This force is at work also in the standard model, but it is heightened by the anticipation of the future loss aversion. If the worker does not find a job by the UI expiration, the worker once again slowly adjusts to the new, lower benefit level.

The hazard from unemployment for this reference-dependent worker decreases from the initial peak, increases at exhaustion, then decreases again. Hence, the predicted hazard matches

[1] This has been shown in a variety of settings, such as in the United States (Katz and Meyer, 1990), Hungary (Micklewright and Nagy, 1999), Austria (Card et al., 2007a), Slovenia (van Ours and Vodopivec, 2008), Germany (Schmieder et al., 2012a), and France (Le Barbanchon, 2012).

the patterns documented in the literature, even in absence of unobserved heterogeneity.

How would one distinguish the standard job search model from a reference-dependent model? Consider two UI systems, the first offering a constant benefit path until period T, with the second offering higher initial benefits up to period $T_1 < T$ but lower benefits between T_1 and T (Figure 1a). The two systems have the same welfare benefit level after period T. The standard model with no heterogeneity predicts that, starting from period T, the hazard rate in the two systems would be the same, as the future payoffs are identical (Figure 1b). Furthermore, the hazard rate in the periods right before period T will be higher in the system with two-step benefits given the lower benefits at that point.

The reference-dependent model makes three different predictions (Figure 1c). First, right after period T the hazard in the one-step system would be higher because of the higher loss in consumption compared to the recent benefits. Second, this difference would attenuate over time and ultimately disappear as the reference point adjusts to the lower benefit level. Third, the hazard rate in the first UI system increases already *in advance of* period T, in anticipation of the future loss aversion. Notice that, while these predictions are developed in the absence of heterogeneity to highlight the intuition, we fully integrate heterogeneity in our estimates.

We evaluate a change in the Hungarian unemployment insurance system which is ideally suited for a test of the above predictions. Before November 2005, the Hungarian system featured a constant replacement rate for 270 days, followed by lower unemployment assistance benefits. After November 2005, the system changed to a two-step unemployment system: benefits are higher in the first 90 days, but lower between days 90 and 270, compared to the pre-period (Figure 2a)). There was no major change in the unemployment assistance system taking place after 270 days. As such, this UI set-up corresponds to the hypothetical case outlined above with period T corresponding to 270 days.

An important feature of the Hungarian reform is that the total benefits paid out until day 270 remain about the same after the reform.[2] Hence, differences in savings and in selection in the pre- and post- period are likely to be small, allowing for a more straightforward comparison.

We evaluate the reform by comparing the hazard rates into employment in the year before and after the reform. The evidence is well in line with the predictions of the reference-dependent model. In the weeks immediately preceding the 270-day exhaustion of benefits, the pre-reform hazard rates rise above the post-reform hazard rates. In the months following the exhaustion, the pre-reform hazard rates remain higher, and they ultimately converge to the post-reform level only after a couple months. The observed pattern around the exhaustion is consistent with the anticipation of, and then the direct effect of the higher loss in consumption for individuals in the pre-reform. The ultimate convergence between the two hazards indicates,

[2] Notice that this does not imply that the reform is revenue neutral, as individuals unemployed for fewer than 270 days receive higher benefits after the reform.

in this interpretation, the timing of the reference point adjustment.

We present several robustness checks. Controlling for a broad set of controls and alternative definitions of our sample barely affects the estimated hazards. Also, an interrupted time series analysis shows that the break in the hazards occurs immediately in the quarter of introduction of the reform, and does not appear to reflect previous trends.

While the evidence is qualitatively consistent with predictions of the reference-dependent model, it is important to compare the quantitative fit of the behavioral model with the fit of the standard model allowing for unobserved heterogeneity. To do so, we estimate a model with both an optimal search effort decision and an optimal consumption-saving decision. The standard model allows for unobserved heterogeneity in the form of three types with different search costs. The reference-dependent model has two extra behavioral parameters (loss-aversion and updating horizon for the reference point) but assumes no unobserved heterogeneity and thus has two fewer parameters overall. We estimate the model with a minimum-distance estimator, with the empirical hazard rates in the pre- and post-reform as moments.

The preferred estimate for the standard model does a relatively good job of fitting the hazards in the first 200 days. More specifically, the presence of heterogeneous types allows the model to qualitatively match the spike in the hazard at 90 days post-reform. The standard model, however, is unable to capture the observed behavior leading up to, and following, the exhaustion of benefits. In particular, the hazard rates from day 270 on in the pre- and post-period are predicted to be almost identical, contrary to the empirical findings.

The reference-dependent model captures the spike at 90 days and the subsequent decrease in the exit hazard, similar to the standard model (and with a closer fit). This behavioral model also captures key features of the data which the standard model does not fit: the increase in hazard in the month prior to the expiration of benefits in the pre-period, the spike at 270 days, the decrease thereafter, and the ultimate convergence of the hazard between the pre- and post-period after a few months. The fit of the model is by no means perfect: the model underpredicts the spike at 270 days and the difference in hazards in the following two months. Still, it captures most of the qualitative features which the standard model does not fit at all. Importantly, it does so without assuming any unobserved heterogeneity.

What parameters characterize the best-fitting reference-dependent model? The estimated loss aversion is in the range of the previous literature and the estimated reference point horizon extends back about six months. A key role is played by the time discounting parameters, which indicate high impatience. The estimated discount factor is arguably implausibly small at 0.9 for a 15-day period, leading to an annual discount factor of 0.08. (The estimated discounting for the standard model is similar). Allowing for present-biased time preferences (Laibson, 1997; O'Donoghue and Rabin, 1999), with an additional discount factor β between the current period and the future, implies much more reasonable discounting. We estimate a present-bias parameter β=0.58, well within the range of estimates in the literature, for an implied annual discount factor of 0.52 for the first year and 0.88 for later years.

Thus, the results point to an important interaction between reference dependence and impatience. The reference-dependent model does not provide a good fit for the data if workers are patient: these workers would build precautionary savings to smooth the upcoming loss utility due to a benefit decrease, eliminating the elevated hazards at benefit exhaustion. If workers are instead impatient, as estimated, consumers essentially go hand-to-mouth, and respond to the loss utility associated with the benefit declines by increasing search effort.

We highlight two key components of the reference-dependent model: loss aversion and a backward-looking, adaptive reference point. We show that estimates with reference points fixed to the pre-unemployment wage, or with forward-looking expectations a la Koszegi-Rabin (2006) do not fit the data. Is our reference-dependence model distinct from habit formation? Models a la Constantinides (1990) and Campbell and Cochrane (1999), like the reference-dependent model, induce a temporarily higher marginal utility of income following a benefit cut as consumption gets closer to the habit. We highlight a key difference. In the reference-dependent model, the impact of the loss on search effort is approximately proportional to the size of the loss. Instead, in the habit-formation model larger decreases in consumption have disproportionate effects. Given this, the habit-formation model underpredicts the spike in hazard at 270 days, since the benefit step-down at 90 days is proportionally larger.

Could alternative versions of the standard model fit the data as well as the reference-dependent model? We allow for, among other assumptions, time-varying search costs and a delay between search effort and the job start. We also estimate the model using probability of exit instead of hazard and excluding the spikes from the moments. None of these changes sizeably affect the fit of the standard model, or of the reference-dependent model.

We then examine alternative forms of unobserved heterogeneity. While so far we assumed heterogeneity in search cost in the spirit of Paserman (2008), we allow for more cost types, for heterogeneity in re-employment wage, or in the search elasticity. The first two forms of heterogeneity do not close the gap with the reference-dependent model, but the model with heterogeneous search elasticity fits better, even outperforming the reference-dependent model. This model explains the spikes by allowing for a type with such high search elasticity (over 50) that she only searches once benefits fall below a threshold. Is this model plausible? This model fits the data well only for very high elasticities, making the unlikely prediction that, if welfare benefits were increased by just 10 percent, individuals on welfare would stop searching.

To provide further evidence on this model with heterogeneous elasticities, as well as on the standard and reference-dependent model, we make two out-of-sample predictions. We consider an earlier UI reform which lengthens the duration of unemployment assistance, and a sample of workers with lower pre-unemployment earnings, and thus a different benefit structure. In both cases, the reference-dependent model provides the best out-of-sample fit, fitting the qualitative patterns well. The standard model with cost heterogeneity does not do as well fit-wise, and the model with heterogeneous elasticity does worst.

As a final piece of evidence, we also compare the dynamic selection implied by the models to the selection on observables in the data. The selection implied by the standard model differs both qualitatively and quantitatively from the observed selection; instead, the implied selection is close to the observed selection for the reference-dependent model.

Finally, we briefly discuss other job search models which we do not estimate but which could potentially explain some of the findings. A model of storable offers (as in Boone and van Ours, 2012) could explain the spike in hazard at benefit exhaustion, but not the pattern of the hazards in the following months. A model of skill depreciation or screening (e.g. Schmieder et al., 2016) can explain decreasing hazards over the spell, but such decreases would plausibly be the same pre- and post-reform. Two relevant models are worker learning and consumption commitments (Chetty, 2003 and Chetty and Szeidl, 2016). A worker may learn over time that finding jobs is harder than expected, and this learning may take place later in the pre-reform period, given the different benefit structure. A worker with committed consumption would increase search effort to avoid paying a fixed cost of adjustment; if despite this, she does not find a job soon enough, she will pay the cost and then decrease search. These dynamics could generate some of the hazard patterns after day 270. While both models have intuitive features, neither is tractable enough to estimate on our sample. For tractability reasons, we also do not estimate models with reservation wage choice and optimal consumption-savings.[3]

To sum up, reference dependence, in combination with impatience, can help explain patterns in job search that are hard to rationalize with most alternative models, even allowing for unobserved heterogeneity. These results have implications for potential redesigns of unemployment insurance policies, a point to which we return briefly in the conclusions.

The paper relates to the literature on unemployment insurance design (e.g. Chetty, 2008; Kroft and Notowidigdo, forthcoming; Schmieder et al., 2012a). Within this literature, we evaluate a unique reform: changing the time path of the benefit schedule, keeping the overall payments approximately constant. The paper is consistent with recent evidence of sharp consumption drops at unemployment entry and UI exhaustion for unemployed workers (Ganong and Noel, 2015; Kolsrud et al., 2015), suggesting approximate hand-to-mouth behavior.

[3]The consumption commitment model requires one to keep track of a fixed cost decision, making the model cumbersome to estimate. To address this issue, Chetty (2003) makes the timing of fixed cost payment exogenous. A consumption commitment model with exogenous consumption readjustment would not explain our findings. We present in the appendix estimates with reservation wage choice for the hand-to-mouth case. The results should be considered only suggestive, as endogenizing consumption is very important.

The paper also contributes to a literature on behavioral job search (DellaVigna and Paserman, 2005 and Spinnewijn, 2013)[4] It also adds to the field evidence on reference dependence. (Sydnor, 2010; Barseghyan et al., 2013; Fehr and Goette, 2007; Farber, 2015; Card and Dahl, 2011; Barberis and Huang, 2001; Allen et al., forthcoming; Simonsohn and Loewenstein, 2006; Engström et al., 2015; Rees-Jones, 2013). We provide evidence on the speed of updating of a backward-looking reference point as in Bowman et al. (1999) and Post et al. (2008). This paper is also part of a literature on structural behavioral economics (Laibson et al., 2007; Conlin et al., 2007; DellaVigna et al., 2012).

The paper proceeds as follows. In Section 2, we present a model of job search with reference dependence. In Section 3 we present the institutional details for the unemployment insurance reform, which we evaluate in Section 4. In Section 5 we present the structural estimates, and we conclude in Section 6.

2 Model

In this section we present a discrete-time model of job search with reference-dependent preferences and present-biased preferences. We build on the job search intensity model presented in Card et al. (2007a) and in Lentz and Tranaes (2005) by adding a reference dependent utility function in consumption with a backward looking reference point.

Model Setup. As in Card et al. (2007a) we make two simplifying assumptions. First, jobs last indefinitely once found. Second, wages are fixed, eliminating reservation-wage choices. In each period, a job seeker decides search effort $s_t \in [0,1]$, representing the probability of receiving a job offer at the end of period t and thus of being employed in period $t+1$. Search costs are given by the function $c(s_t)$, which we assume to be time-separable, twice continuously differentiable, increasing, and convex, with $c(0) = 0$ and $c'(0) = 0$.

In each period individuals receive income y_t, either UI benefits b_t or wage w_t, and consume c_t. Consumers can accumulate (or run down) assets A_t with a borrowing constraint $A_t \geq -L$. Assets earn a return R so that consumers face a budget constraint $\frac{A_{t+1}}{1+R} = A_t + y_t - c_t$. We also consider a simplified model with hand-to-mouth consumption, $c_t = y_t$.

The utility from consumption in period t is $v(c_t)$, where $v(.)$ is an increasing and concave function. Following the functional form of Kőszegi and Rabin (2006), flow utility is

$$u(c_t|r_t) = \begin{matrix} v(c_t) + \eta\left[v(c_t) - v(r_t)\right] & \text{if} & c_t \geq r_t \\ v(c_t) + \eta\lambda\left[v(c_t) - v(r_t)\right] & \text{if} & c_t < r_t \end{matrix} \qquad (1)$$

[4] Koenig et al. (2016) model a reference-dependent reservation wage choice in that the wage offers with some probability equal a previous wage (the reference). Their paper focuses on job matches and reservation wages, as opposed to the dynamics of exit from unemployment.

where r_t denotes the reference point in period t. The utility consists of consumption utility $v(c_t)$ and gain-loss utility $v(c_t) - v(r_t)$. When consumption is above the reference point ($c_t \geq r_t$), the individual derives gain utility $v(c_t) - v(r_t) > 0$, which receives weight η. When consumption is below the reference point ($c_t < r_t$), the individual derives loss utility $v(c_t) - v(r_t) < 0$, with weight $\lambda\eta$. The parameter $\lambda \geq 1$ captures loss aversion: the marginal utility is higher for losses than for gains. This utility function builds on prospect theory of Kahneman and Tversky (1979) without, for simplicity, modeling diminishing sensitivity or probability weighting. The standard model is a special case with $\eta = 0$.

The second key assumption is the determination of the reference point $r_{t.}$ Unlike in the literature on forward-looking reference points (Kőszegi and Rabin, 2006), but in the spirit of the tradition on backward-looking reference points (Bowman et al., 1999), the reference point is the average of income over the N previous periods and including period t:

$$r_t = \frac{1}{N+1} \sum_{k=t-N}^{t} y_k$$

To gain perspective on the impact of reference dependence, consider an individual in steady state with consumption, income, and reference point equal to y. Then in period T, consider a small, permanent decrease in income from y to $y - \Delta y < y$, and an identical decrease in consumption from $c = y$ to $y - \Delta y$.[5] In period T, utility changes to $v(y - \Delta y) + \eta\lambda\left[v(y - \Delta y) - v(y)\right]$. The short-term change in utility equals, up to a linear approximation, $-(1 + \eta\lambda)\Delta y * v'(y)$. Over time, however, the reference point adjusts to $y - \Delta y$ so that the utility after N periods is $v(y - \Delta y)$. Hence, the long-term change in utility equals $-\Delta y v'(y)$. Thus, $\eta\lambda$ captures the weight on additional short-term utility in response to an income loss.

Value Functions. The unemployed choose search effort s_t and consumption c_t in each period and face the following value function, where δ is the discount factor:

$$\begin{aligned} V_t^U(A_t) &= \max_{s_t \in [0,1]; A_{t+1}} u(c_t | r_t) - c(s_t) + \delta\left[s_t V_{t+1|t+1}^E(A_{t+1}) + (1 - s_t) V_{t+1}^U(A_{t+1})\right] \qquad (2) \\ & \quad \text{subject to: } c_t = A_t + y_t - \frac{A_{t+1}}{1+R}. \end{aligned}$$

The assumption that the reference point is function of past income and not of past consumption simplifies the value functions substantially, since the value function of unemployment depends only on assets A_t, while the reference point is fully determined by t and thus is not an explicit state variable: $V_t^U(A_t)$. For the employed, the reference point depends also on how long the person has been employed; hence, the value function can be written as $V_{t|j}^E(A_t)$

[5]A sudden permanent drop in consumption could occur, for example, if the individual were a hand-to-mouth consumer and benefits suddenly dropped.

for an individual who is employed in period t and who found a job in period j, where the combination of t and j are sufficient to determine the reference point..

Once an individual finds a job at time j, the value of employment in period t is given by:

$$V_{t|j}^{E}\left(A_{t}\right)=\max_{c_{t}>0} u\left(c_{t}|r_{t}\right)+\delta V_{t+1|j}^{E}\left(A_{t+1}\right). \tag{3}$$

Given Equation (2) the first order condition for the optimal level of search effort s_t^* in the case of an interior solution can be written as:

$$c'\left(s_{t}^{*}\left(A_{t+1}\right)\right)=\delta\left[V_{t+1|t+1}^{E}\left(A_{t+1}\right)-V_{t+1}^{U}\left(A_{t+1}\right)\right]. \tag{4}$$

Thus we can rewrite the unemployed problem as:

$$\begin{aligned} V_{t}^{U}\left(A_{t}\right) &= \max_{A_{t+1}} u\left(A_{t}+y_{t}-\frac{A_{t+1}}{1+R}\middle| r_{t}\right)-c\left(s_{t}^{*}\left(A_{t+1}\right)\right) \\ &\quad +\delta\left[s_{t}^{*}\left(A_{t+1}\right)V_{t+1|t+1}^{E}\left(A_{t+1}\right)+\left(1-s_{t}^{*}\left(A_{t+1}\right)\right)V_{t+1}^{U}\left(A_{t+1}\right)\right] \end{aligned}$$

We solve the model by backwards induction, deriving first the steady-state consumption in the employed state. This allows us to solve for the consumption path for each asset level and to obtain the value functions $V_{t|t}^{E}\left(A_{t}\right)$ for each t and each asset level A_t. Then we solve the problem for the unemployed, moving backwards from the steady state, solving for the optimal consumption path and search effort path for each starting value of the asset vector.

Front-Loading The Benefit Path. To highlight the implications of reference dependence, we consider a hypothetical unemployment insurance reform that closely corresponds to our empirical setting. To build intuition and for tractability, we consider in detail the case of hand-to-mouth consumers with no heterogeneity and then briefly discuss the extension to the general case. In the case of hand-to-mouth consumers, assets are not a control variable and thus $s_{t}^{*}=\mathcal{C}\left(\delta\left[V_{t+1|t+1}^{E}-V_{t+1}^{U}\right]\right)$,where $\mathcal{C}(.)=c'^{-1}(.)$.

Consider a UI system with benefits b_1 for the first T_1 periods benefits and benefits b_2 from period T_1+1 until T. After period T, there is a lower second tier (such as social assistance) with benefits $\underline{b}$. A single-step UI system, like the one in the US, is captured by $b_1 = b_2 = b_{constant}$ and is illustrated by the blue solid line in Figure 1a).

Consider a reform that front-loads the benefit path by raising benefits b_1 in the first T_1 periods and reducing benefits b_2 in periods T_1 to T, while leaving second-tier benefits $\underline{b}$ unchanged, as illustrated by the red dashed line in Figure 1a). Furthermore, the reform leaves untouched the total amount of benefits paid to an individual unemployed for T periods:

$$b_1T_1 + b_2(T - T_1) = b_{constant}T. \tag{5}$$

Equation (5) implies $\frac{\partial b_2}{\partial b_1} = -\frac{T_1}{T-T_1}$. We now partially characterize how search s_t^* is affected by an increase in b_1 subject to constraint (5). We express the results in terms of $\frac{ds_t^*}{db_1} = \frac{\partial s_t^*}{\partial b_1} - \frac{T_1}{T-T_1}\frac{\partial s_t^*}{\partial b_2}$, where the total derivative takes the implied adjustment of b_2 into account.[6]

Proposition 1. *Assume a hand-to-mouth unemployed job-seeker and consider a shift in the benefit path that front-loads the benefits b_1 keeping the overall benefits paid constant.*

a) In the standard model ($\eta = 0$), the search effort in all periods after benefit expiration at T is unaffected: $\frac{ds_{T+i}^*}{db_1} = 0$, for $i = 0, 1, \ldots$.

b) In the reference-dependent model ($\eta > 0$ and $\lambda \geq 1$) search effort (weakly) decreases in the first N periods after T, and remains constant in later periods: $\frac{ds_{T+i}^*}{db_1} \leq 0$, for $i = 0, 1, \ldots N-1$ and $\frac{ds_{T+i}^*}{db_1} = 0$, for $i = N, N+1, \ldots$ Furthermore, if the adjustment speed N of the reference point is shorter than T, then the inequality is strict: $\frac{ds_{T+i}^*}{db_1} < 0$, for $i = 0, 1, \ldots, N-1$.

These predictions are illustrated in Figures 1b) and c). In the standard model (Figure 1b), optimal search effort increases under both regimes up until period T, and then plateaus after period T at a level that is unaffected by the front-loading of benefits (Proposition 1a). Generally, the hazard rate for the front-loaded regime (the dotted red line) will be higher than the one for constant benefits in the periods right before period T, given the moral hazard.

In contrast, under reference dependence (Figure 1c), search effort in period T is substantially higher under the constant-benefit regime (continuous blue line). Individuals in this regime experience a sharper drop in consumption and thus (for $N < T$) significant loss utility due to the higher reference point (Proposition 1b). The difference in hazards persists but shrinks for N periods, at which point the reference point has fully adapted to the lower benefits under either regime, and thus search effort converges. Another implication (not captured in the Proposition) is that in the last periods before period T, for sufficiently large loss aversion λ, the hazard is higher under the constant-benefit regime: the anticipation of larger future losses counters the moral hazard effect of more generous benefits.

Proposition 1 does not hold with either heterogeneity or optimal consumption. With heterogeneous types, differences in the path of benefits up to period T may lead to a different composition of types surviving at period T, and thus differences in the hazard even in the standard model, violating Proposition 1a). With a savings decision, individuals may have different savings at period T, thus creating differences in hazards. However, given that the total benefit payout is constant, differences in type composition and in savings are likely to be small. We address both heterogeneity and savings in the estimation section.

[6] Note that search effort in period t is not affected by UI benefits in period t, since the individual will only start a job found in period t in period $t+1$. Thus search effort s_t corresponds to the exit hazard from unemployment in period $t+1$: $s_t = h_{t+1}$.

Present Bias. We extend the model to allow for present-bias (Laibson, 1997; O'Donoghue and Rabin, 1999), with an additional discount factor $\beta \leq 1$ between the current period and the future, as in DellaVigna and Paserman (2005). We assume naivete': the workers (wrongly) assume that in the future they will make decisions based on regular discounting δ. We make this assumption mostly for computational reasons, since the naive agent problem can be solved using the value functions of the exponential agent (given that the naive worker believes she will be exponential from next period). In addition, the evidence on present bias is largely consistent with the naivete' assumption (DellaVigna, 2009).

The naive present-biased individual solves the following value functions:

$$\begin{aligned} V_t^{U,n}(A_t) &= \max_{s_t \in [0,1]; A_{t+1}} u\left(c_t | r_t\right) - c\left(s_t\right) + \beta\delta\left[s_t V_{t+1|t+1}^E\left(A_{t+1}\right) + \left(1 - s_t\right) V_{t+1}^U\left(A_{t+1}\right)\right] \quad (6) \\ & \text{subject to: } c_t = A_t + y_t - \frac{A_{t+1}}{1+R}, \end{aligned}$$

where the functions V_{t+1}^U and $V_{t+1|t+1}^E$ are given by equations (2) and (3) above for the exponential discounters. We thus first solve for all possible values of V_{t+1}^U and $V_{t+1|t+1}^E$ and then we solve for the consumption and search paths given $V_{t+1}^{U,n}$.

3 Data and Institutions

3.1 Unemployment Insurance in Hungary

Hungary had a generous two-tier unemployment insurance system up to 2005. In the first tier, potential duration and benefit amount depended on past UI contribution.[7] The maximum potential duration, obtained after around 4 years of contribution, was 270 days,[8] while the benefit level was based on the earnings in the previous year. After the exhaustion of first-tier benefits, unemployment assistance (UA) benefits could be claimed in the second tier. The UA benefit amount was the same for everybody, with the potential duration depending on age.

On May 30th, 2005 the Hungarian government announced a comprehensive reform of the UI system[9], with the goal of speeding up transition from unemployment to employment. The government changed the benefit calculations formula in the first tier, but did not alter the way potential duration and the earnings base were calculated. Before the reform, the benefit in the first tier was constant with a replacement rate of 65% and with minimum and maximum

[7] Every worker in the formal sector must pay a UI contribution. In 2005, employers contributed 3% to the UI fund, while employees 1%. There is no experience rating of UI benefits in Hungary.

[8] More specifically, potential benefit in the first tier was calculated as UI contribution days in the last 4 years divided by 5, but at most 270 days.

[9] The reform was part of a wider government program called "100 steps". Policies related to the labor market and unemployment insurance (such as reemployment bonus and training policies) are discussed later. In addition, VAT and corporate income tax were decreased from January 1st 2006.

benefit caps. The reform introduced a two-step benefit system. For the first step, the length was half of the potential duration in the first tier, and at most 91 days, and the replacement was lowered to 60%, but with increased minimum and maximum benefit caps. In the second tier everybody received the new minimum benefit amount, reducing benefits for most claimants compared to before. The benefit changes are summarized in Web Appendix Figure A-1.

The most prominent change occurred for those with 270 days of eligibility (four years of UI contributions before lay-off) and base year earnings above the new benefit cap (earnings above 114,000 HUF ($570) per month in 2005). As Figure 2a) shows, for this group benefit duration in the first tier remains 270 days, but with higher benefits in the first 90 days, and lower benefits afterwards. Importantly, the increase in weekly benefits in the first 90 days is about twice as large as the decrease in weekly benefits between 90 and 270 days, keeping the total benefit pay-out for individuals unemployed for 270 days the same.

Even though the main element of the reform was the new benefit formula, other changes were introduced, including a reemployment bonus scheme equal to 50% of the remaining total first-tier benefits. However, claiming the bonus was not without costs, as the entitlement for the unused benefit days was nulled. Also, the bonus could only be claimed after the first-tier benefits were exhausted, and UI claimants had to show up and fill out the paper work in the local UI office. Given these costs, it is not surprising that the take-up rate was only 6%, making it unlikely that it had substantial effects. As a robustness check, we show that the results are not sensitive to dropping the reemployment bonus users from the sample.[10]

In addition to the introduction of the reemployment bonus, there were two other minor relevant changes. First, those who claimed UI benefit before February 5th, 2005 faced a longer, but somewhat lower, benefit in the second tier.[11] To avoid this complication, we only focus on those who claimed their benefits after February 5th, 2005. Second, there were minor changes in financing training programs.[12] However, participation in training programs was very low (less than 5%) in our sample and our results are robust to dropping these claimants.

Those who exhausted benefits in both tiers (UI and UA) and were still unemployed could

[10]Lindner and Reizer (2015) further show that the bonus does not affect the unemployment duration.

[11]The change in the duration and benefit level in the second tier was introduced at November 1st, 2005 at the same time as other changes. However, it affected everybody who claimed second tier (UA) benefits after November 1st, 2005. A UI claimant who claimed her benefits after February 5th, 2005 and had 270 days potential eligibility could only claim second tier benefits (UA) after November 1st, 2005. Therefore, claimants between February 5th, 2005 and November 1st, 2005 are under the old benefit system for the first tier, but face the same second tier (UA) insurance scheme, see Figure 2b).

[12]Unemployed participating in training programs received the so-called income substituting benefit. Before November 1st, 2005 this amount was 22,200HUF ($111) or 44,400HUF ($222), depending on household characteristics and type of training. This benefit was payed in excess of the UI. After November 1st, the benefit was 34,200HUF ($171) for everybody, but the UI benefit was suspended during training. Although we only observe training participation after November 1st, 2005, aggregate data show that the probability of participation in training programs remained constant throughout this period Frey (2009).

claim means-tested social assistance. The duration of social assistance is indefinite, while the amount depends on family size, family income, and wealth. In most cases social assistance benefits are lower than the second tier UI benefit level.[13]

3.2 Data

We use administrative data[14] on social security contributions for roughly 4 million individuals between January 2002 and December 2008. The sample consists of a 50% de facto random sample of Hungarian citizens older than 14 and younger than 75 in 2002.[15] The data contains information on UI claims from February 2004 to December 2008 as well as basic information used by the National Employment Service, like the start and end date of the UI benefit spells and the earnings base. This data allows us to calculate non-employment durations, that is the time between claiming UI benefit and the starting date of the next job.

In this paper we only focus on UI claimants who are eligible for the maximum potential duration (270 days) in the first tier. In addition, we restrict our sample to those who are older than 25 years and younger than 49 years, since specific rules apply close to retirement. Moreover, we identify as our main sample UI claimants with high earnings base, since our goal is to explore the variation in Figure 2a). To construct a consistent sample over time, we focus on the unemployed with earnings base above the 70th percentile among the UI claimants in a given year. In 2005, a UI claimant at the 70th percentile earned 100,800 HUF ($504).[16]

To evaluate the reform, we construct two comparison groups of workers who entered UI just before or just after the reform, since the claiming date determined the relevant regime. Due to the change in unemployment assistance in February 2005, we use all UI claimants between February 5th, 2005 and October 15, 2005 (to avoid getting too close to the reform) as our pre-reform group. For the post-reform group, we take UI entrants in the same date range (February 5 to October 15) in 2006 so as to match possible seasonal patterns. Figure 2b) shows the timing of the two comparison groups and the range for which our data is available. For robustness checks, we later show results using data in the earlier and later ranges as well.

The basic demographic characteristics, such as age at time of claiming, education and log earnings in the years 2002 - 2004, are similar before and after the reform.[17] The take-up rates of the reemployment bonus scheme, which was introduced in 2005, are low.

[13]For large families, social assistance can be more generous than UI. However, social assistance cannot be claimed before all other benefits have been exhausted in the UI system.

[14]The data set is provided by the Institute of Economics - Hungarian Academy of Sciences.

[15]The sample is composed of everybody born on the 1st of January, 1927, and every second day thereafter.

[16]Our results are robust to alternative earnings thresholds. For example, we obtain very similar results for individuals with (real) earnings base above 114,000 HUF ($570).

[17]See Web Appendix Table A-1. Furthermore Web Appendix Figure A-3 shows that the unemployment rate was quite stable at around 7 percent, and the GDP growth was also stable during the sample periods, only slowing down at the beginning of 2007.

4 Reduced Form Results

4.1 Estimation of Hazard Into Employment

In this section, we evaluate the impact of the reform on the exit rates from unemployment into employment. We estimate the hazard rates with a linear probability model separately for each 15-day period[18], indexed by t, after entering unemployment insurance:

$$I(t_i^* = t | t_i^* \geq t) = \beta_{0,t} + \beta_{1,t} POST_i + X_i \gamma + \epsilon_{it}, \tag{7}$$

where i indexes individuals and t_i^* represents the duration of non-employment of individual i. The left hand side is an indicator for individual i finding a job in period t, conditional on still being unemployed at the beginning of the period. The variable $POST_i$ is an indicator for individual i claiming benefits in the post-reform period, while X_i is a matrix of control variables. The equation is estimated separately for each period t on the sample of individuals who are still unemployed at time t (that is conditional on $t_i^* \geq t$). In our baseline estimates we do not control for any observables X_i, and show results controlling for X_i as robustness.

Figure 3a) shows the estimates of equation (7) for each t with no controls. The blue line represents the coefficient estimates of $\beta_{0,t}$, the estimated hazard in the before period, while the red line represents the estimated $\beta_{0,t} + \beta_{1,t}$, the after period hazard. Vertical lines between the two series indicate differences that are statistically significant at the 5% level.

The exit rate from unemployment in the pre-reform period shows a familiar pattern for a one-step unemployment system. The exit hazard falls in the first months after entering UI, then increases as it approaches the exhaustion point of UI benefits (at 270 days). After this exhaustion point, it falls and spikes again as people exhaust the second tier benefits, unemployment assistance, at 360 days. The hazard rate then decreases monotonically, as unemployed people are only eligible for welfare programs.

The exit hazard changes substantially after the reform. The hazard rate increases at 90 days, at the end of the higher UI benefit, and remains elevated compared to the pre-reform period for the following 2.5 months. By 180 days, the pre- and post-reform hazards have converged, and both hazards increase at the exhaustion of UI benefits at 270 days. Importantly though, the post-reform hazard increases significantly less, and the pre-reform hazard remains significantly higher for three months following UI exhaustion. Finally, by 360 days, the end of unemployment assistance, the two hazards once again converge.

The most striking difference occurs around day 270, when in the pre-reform period the hazard remains significantly higher after the UI exhaustion point (270 days), relative to the

[18] We choose a 15-day period so that the benefit path steps after 90 days and 270 days occur at integer values of these periods. The results are very similar with hazards computed at 7 days or 30 days.

post-reform period. This difference in hazards fits nicely with the reference-dependent model: the workers in the pre-reform period experience a larger drop-off in benefits around day 270, inducing a spike in loss utility and thus an increase in the value of search. The persistence for three months of the higher hazard indicates slow adjustment of the reference point. Furthermore, the increase in hazard in the pre-period happens already in anticipation of benefit expiration at day 270, consistent again with reference dependence.

While we focus mainly on the hazard rate around day 270 because it leads to the most distinct predictions, other patterns are also consistent with reference dependence. The spike in the hazard at 90 days in the post-period, corresponding to the first step down in benefits, disappears after 3-4 months, consistent once again with loss utility and a slowly-adjusting reference point. However, this spike could also be explained by the standard model with unobserved heterogeneity, as we show below.

Figure 3b) shows the estimated survival function for the two groups. For these estimates we use a variant of equation (7), including the whole sample and taking $I(t_i^* \geq t)$ as the outcome. The survival functions diverge after 90 days, with lower survival in the after group than in the before group. This difference persists until around 300 days, after which the lines converge. Since the expected duration is the integral over the survival function from 0 onward, the expected unemployment duration is significantly reduced in the after period.

4.2 Robustness Checks

The results presented so far do not control for demographic characteristics. Even though the differences in demographics between the pre- and the post-period are quite small (Web Appendix Table A-1), they could potentially explain differences in the hazard patterns if the demographic impacts on the hazard rates are large. Thus, we re-estimate equation (7) controlling for a rich set of characteristics, where we allow these characteristics to have arbitrary effects on the hazard function at each point, the only restriction being that the effect is the same in the before and after period. As Figure 4a) shows, controlling for observables has virtually no effect on the hazard rates, implying that they cannot explain our findings.[19]

A separate concern regards the introduction of a reemployment bonus in November 1st, 2005. While the take-up rate of the bonus was just 6% in our sample, it may still affect the hazard rate in the post-reform period, especially in the first 90 days. As a check, we re-estimate our baseline specification dropping all individuals that received a reemployment bonus; the results are virtually unchanged (Figure 4b)).

Another potential issue is the role of recalls in determining the exit hazards. Web Ap-

[19] Alternatively we also used propensity score reweighting to estimate the hazards in the pre- and post-period, holding the observables constant over time and obtained almost identical results (not shown).

pendix Figure A-5 shows that the share of recalls in our sample is small (around 9 percent). Furthermore, the incidence of recalls does not differ much over the unemployment path, or between the pre- and post-reform periods.

Next, we consider the concern that the differences in the hazard rates may be due to a time trend. We estimate two placebo tests for whether there are differences in the two years before the reform and the one year before the reform. Web Appendix Figure A-7a) shows that the hazard rates are virtually unchanged between 2004 and 2005. There is a small difference right after the 270 line, which is expected due to the reduction in unemployment assistance in February 2005. Similarly Web Appendix Figure A-7b) shows that there are virtually no differences between the hazards 1 and 2 years after the reform, again indicating that the differences between our before- and after-period line up nicely with the reform.

We explore the timing further by plotting time-series graphs of the hazards. Figure 5a) shows the evolution over time of the hazard between 30 and 90 days (red line) and between 90 and 150 days (black line). Each dot indicates the average hazard for a 3-month period between 2004 and 2007, with quarter 1 indicating the first 3-month period after the reform. Prior to the reform, the hazard at 90-150 days is smaller than the hazard at 30-90 days, consistent with the patterns in Figure 3a). Subsequent to the reform introducing a step down of benefits after 90 days, the pattern abruptly changes. Already in the first quarter after the reform, the hazard at 90-150 days increases sizeably, becoming similar to the hazard at 30-90 days, a pattern that persists over the next 6 quarters. The figure provides little evidence of previous trends, suggesting that the changes in hazards are indeed a causal effect of the reform.

Figure 5b) provides parallel evidence for the hazard at 210-270 days versus at 270-330 days. In the quarters pre-reform, the hazard at 270-330 days is significantly higher than the hazard at 210-270 days, a pattern that changes abruptly with the first quarter following the reform. The time-series plots again indicate a change that is coincidental with the reform and not due underlying trends or changes in the macroeconomic environment.

5 Structural Estimation

5.1 Set-up and Estimation

We use the model of Section 2, imposing six additional assumptions, some of which we relax later. The first three assumptions concern the utility function. First, we assume a search cost function of power form as in Paserman (2008) and Chetty (2003): $c(s) = ks^{1+\gamma}/(1+\gamma)$. The parameter γ is the inverse of the elasticity of search effort with respect to the net value of employment.[20] Second, we assume log utility, $v(b) = \ln(b)$. Third, similar to Bloemen (2005), Paserman (2008), Fougere et al. (2009), and van den Berg and van der Klaauw (2015) we model heterogeneity in the cost of search k.

Fourth, to avoid modeling on-the-job search, we start the worker problem in the first period of unemployment, and thus fit the hazard from the second period on.[21] Fifth, we set past wages equal to the median earnings in our sample, which is 135,000 HUF ($675), and assume that reemployment wages are constant over the UI spell and equal to past wages. Sixth, we assume that individuals start with zero assets, that they cannot borrow against their future income, and that they earn no interest on saved assets.

The vector of parameters ξ for the standard model are: (i) the three levels of search cost k_{high}, k_{med}, and k_{low}, with $k_{high} \geq k_{med} \geq k_{low}$, and two probability weights p_{low} and $p_{med;}$ (ii) the search cost curvature γ; (iii) the time preference parameters δ and β. For the reference-dependent model, we estimate in addition: (iv) the loss aversion parameter λ; and (v) the number of (15-day) periods N over which the backward-looking reference point is formed.[22] For the the reference-dependent model we assume no heterogeneity, thus removing parameters k_{high}, k_{med}, p_{low}, and p_{med}. Notice that the weight η on gain-loss utility is set to 1 rather than being estimated; thus, the loss-aversion parameter λ can be interpreted also as the overall weight on the losses. Over the course of the unemployment spell the individual is always on the loss side, hence it is difficult to estimate a separate weight on gain utility and loss utility.[23]

Estimation. Denote by $m(\xi)$ the vector of moments predicted by the theory as a function of the parameters ξ, and by $\hat{m}$ the vector of observed moments. The moments $m(\xi)$ are the 15-day hazard rates from day 15 to day 540 for both the pre-reform and post-reform period, for a total of 35*2=70 moments. The minimum-distance estimator chooses the parameters $\hat{\xi}$ that minimize the distance $(m(\xi) - \hat{m})' W (m(\xi) - \hat{m})$. As weighting matrix W, we use a diagonal matrix that has as diagonal elements the inverse of the variance of each moment. To calculate the theoretical moments, we use backward induction. First we numerically compute the steady-state search and steady-state value of unemployment using a hybrid bisection-quadratic interpolation method, pre-implemented in Matlab as the fzero routine. Then we solve backwards for the optimal search intensity and consumption path in each period as a function of the asset level. Finally, we use the initial asset level as a starting value to determine the actual consumption path and search intensity in each period.

[20] The first-order condition of search effort (equation 4) is $c'(s^*) = v$, where we denote with v the net value of employment. This yields $s^* = (v/k)^{1/\gamma}$, and the elasticity of s^* with respect to v is $\eta_{s,v} = (ds/dv)\, v/s = 1/\gamma$.

[21] Recall that a successful job search in period t yields a job in period $t+1$.

[22] In the estimations tables we report the speed of adjustment in days, which is just N*15.

[23] In principle, the weight on gain utility η can be separately identified as we show in a robustness section, since gain utility affects the utility of reemployment, but the reemployment utility does not allow for very precise identification of η.

Under standard conditions, the minimum-distance estimator using weighting matrix W achieves asymptotic normality, with estimated variance $(\hat{G}'W\hat{G})^{-1}(\hat{G}'W\hat{\Lambda}W\hat{G})(\hat{G}'W\hat{G})^{-1}/N$, where $\hat{G} \equiv N^{-1}\sum_{i=1}^{N}\nabla_{\xi}m_i(\hat{\xi})$ and $\hat{\Lambda} \equiv Var[m(\hat{\xi})]$ (Wooldridge, 2010). We calculate $\nabla_{\xi}m(\hat{\xi})$ numerically in Matlab using an adaptive finite difference algorithm.

Identification. While the parameters are identified jointly, it is possible to address the main sources of identification of individual parameters. The cost of effort parameters k_j are identified from both the level of search intensity and the path of the hazards over time. This is clearest in the standard model, where the heterogeneity in the parameters is needed, for example, to explain the decay in the hazard after day 360. The search cost curvature parameter, γ, is identified by the responsiveness of the hazard rate to changes in benefits since $1/\gamma$ is the elasticity of search effort with respect to the (net) value of finding a job.

The time preference parameters are identified by the presence of spikes around benefit cuts, among other moments. If the unemployed workers are patient, they save in advance of benefit decreases so as to smooth consumption. Impatient workers, instead, save little if at all and thus experience a sharp decrease in consumption around the benefit change. This consumption drop then induces a sharp increase in search effort as the benefits decrease.

Turning to the reference-dependence parameters, for a given value of η (fixed to 1 in the benchmark specification), λ denotes the magnitude of the loss utility. A major component to identification is the extent to which the hazard for the pre-period is higher both before and after day 270, in response to a larger loss. By contrast, the standard model implies essentially identical hazards from day 270 onwards. The loss parameter is also identified by the response to other benefit changes, such as at 90 days in the post-period. The parameter N, which indicates the speed at which the losses are reabsorbed into the reference point, is identified by the speed of convergence of the pre- and post-reform hazards after the benefit decreases.

5.2 Benchmark Estimates

Figure 6a) presents the fit for the standard model with 3-type heterogeneity. The model fits quite well the surge in hazard around day 90 in the post-period, and the decreasing path of the hazard in the first 200 days. The fit is also reasonably good for the period from day 400 on. However, the fit between days 250 and 400 is poor. As discussed above, the standard model predicts that the hazard rates for the pre- and post-period should be almost exactly the same after day 270. As such, the model misses both the sharp difference in hazard between day 260 and day 360, as well as the spikes at both 260 and 360 days.

In comparison, Figure 6b) displays the fit of the reference-dependent model with no heterogeneity (and thus two fewer parameters). The fit in the first 250 days is very good, though it was quite good also for the standard model. But, as anticipated, the model does much better for longer durations, where the standard model fits poorly. The model fits better the surge in the hazard rate in the pre-period in anticipation of the benefit cut after 270 days (which is larger in the pre period than in the post-period), as well as the elevated level for the following three months, compared to the pre-period. Then the model tracks quite well the period following the exhaustion of unemployment assistance (after 360 days).

The fit of the reference-dependent model, while superior to the standard model, is certainly not perfect. The model does not capture the large spike on day 270 for the pre-period; storable offers may play a role in this case. In addition, the reference-dependent model under-fits the difference in hazards between the pre- and post-period after day 270.

In Table 1 we present a formal measure of goodness of fit, as well as the parameter estimates. The goodness of fit (GOF) measure $(m(\xi) - \hat{m})' W (m(\xi) - \hat{m})$ is substantially better for the reference-dependent model, despite having fewer parameters. The estimates for the standard model (Column (1)) indicate substantial heterogeneity in cost k and a relatively high elasticity of search effort to incentives. The estimates for the reference-dependent model (Column (2)) indicate a substantial weight on loss utility, $\hat{\lambda} = 4.9$ (s.e. 0.6), and slow adjustment of the reference point, $\hat{N} = 184$ (s.e. 11) days.

The most striking result, though, is the estimated degree of impatience: 15-day discount factors of $\delta = 0.89$ for the reference-dependent model and $\delta = 0.93$ for the standard model, implying annual discount factors of 0.17 or lower. Web Appendix Figure A-9a) provides evidence on the identification of the discount factor, indicating the goodness of fit of the best-fitting estimate for a particular (15-day) discount factor. For patient individuals ($\delta = 0.995$ or higher), the reference-dependent model does poorly: loss-averse workers with a high degree of patience would build a buffer stock, thus smoothing the loss utility. As individuals become more impatient, already for $\delta = 0.95$ the reference dependent model has a good fit (and better than the standard model), with the best fit for a lower discount factor. The fit of the standard model also improves as the discount factor decreases, though less steeply.

Thus, to fit the data the models require a degree of impatience which is hard to reconcile with other estimates in the literature. Yet, this high degree of impatience may be due to a mis-specification of the discounting function. In Columns (3) and (4) we assume beta-delta preferences (Laibson (1997) and O'Donoghue and Rabin (1999)), allowing for an additional discount factor β between the present and the next period to capture the present bias. To keep the number of parameters constant, we set the long-term discount factor δ to 0.995. The fit is better than in the models with delta discounting for the reference-dependent model with much more plausible discounting: the estimated present-bias parameter is $\beta = 0.58$, implying a discount factor of 0.46 for the first year and of 0.88 for subsequent years. This indicates a substantial degree of impatience, but in line with estimates in the literature.[24]

In light of both the higher plausibility and the better fit, we adopt the reference-dependent model with beta-delta discounting as the benchmark behavioral model in the rest of the paper. For the standard model, especially given the small difference in fit between the two discounting functions, we use the more standard delta discounting.[25]

How do the two models achieve their fit? In Web Appendix Figures A-10 and A-11 we report plots for key model components, focusing on the high-cost type for the standard model. In the standard model, the flow utility follows the step down in benefits, with the size of the later steps accentuated by the curvature of the utility function. In the reference-dependent model, the flow utility captures also the intensity of the loss relative to the reference point. The value of unemployment decreases over time in the standard model, while in the reference-dependent model it actually increases over most of the range, reflecting the importance of reference point adaptation (and fitting the observed decrease in search effort over time). The value of unemployment declines sharply in correspondence to the benefit drop. The reference point is decreasing over time and is higher in the pre-reform group from around day 250, generating higher loss utility and thus a larger increase in search effort near benefit expiration.

The value of employment, which is almost constant in the standard model, increases monotonically over time for the reference-dependent model, as getting a job is associated with a larger gain utility as the reference point declines. This latter force does not account for much of the results, as we illustrate later when we turn off gain utility. Consumption tracks quite closely the per-period earnings, especially in the reference-dependent model, and assets are close to zero over the spell, broadly consistent with Ganong and Noel (e.g. 2015).

5.3 Reference-Dependence Variants and Habit Formation

In Table 2, we consider alternative formulations of reference dependence along two dimensions. First, we keep the same utility function but consider alternative reference points, including status quo and forward-looking expectations. Second, we take as given a backward-looking reference point, but examine alternative utility functions, including habit formation models.

We assumed a backward-looking reference point with a memory of N periods. Does it matter how one models the backward-looking averaging? In Column (2) of Table 2 we assume an updating rule with longer "memory" and smoother adjustment, an AR(1) process: $r_t = \rho r_{t-1} + (1-\rho) y_t = (1-\rho)\sum_{i=1}^{\infty} \rho^i y_{t-i}$. The fit, as Figure 7a shows, is quite similar to our

[24]For example, Paserman (2008), building on DellaVigna and Paserman (2005), using job search data obtains estimates for β ranging between 0.40 and 0.89, depending on the sample. Laibson et al. (2007), based on life-cycle consumption choices, estimates a β between 0.51 and 0.82.

[25]The results for the reference-dependent models with either delta or beta-delta discounting are qualitatively similar in all the subsequent specifications.

standard assumption, indicating that the results are robust to the averaging rule.[26]

While a backward-looking reference point has parallels in the literature (e.g., Simonsohn and Loewenstein 2006), other reference points are also common, such as the status quo. In endowment effect experiments (Kahneman et al. (1991)), this is taken to be the initial allocation, and in asset pricing papers (Barberis and Huang, 2001), it is taken to be the purchase price of the asset. In our context, we thus take the reference point to be the last wage before the start of the unemployment spell. This reference point is still backward-looking, but with no adaptation. This specification does poorly (Web Appendix Table A-3): the adaptation over time is critical to reproducing the initial surge in hazard, the decline, and then second surge at benefit exhaustion.

A second common class are forward-looking reference points a' la Kőszegi and Rabin (2006): individuals use forward-looking rational expectations formed in the recent past as reference points. We thus take as reference point for period t the expected earnings for period t, as expected in period $t-1$.[27] As Web Appendix Table A-3 documents, this reference point also provides a poor fit to the data. Importantly, forward-looking reference points cannot reproduce the large difference in hazards past day 270.

Thus, a backward-looking, adaptive reference point is critical. Does it matter how it is incorporated in the utility function? In our benchmark model, gain utility gets weight η while loss utility gets weight $\eta\lambda$, and for estimation we set $\eta = 1$. To highlight the role of gain and loss utility, we show that assuming no gain utility when workers get a job, but still estimating the loss utility weight $\eta\lambda$, results in a fit similar to the benchmark one (Web Appendix Table A-3); conversely, assuming no loss utility but estimating gain utility with weight η, instead, leads to a worse fit than the standard model, indicating the key role played by loss utility (Column (3) of Table 2). To further focus on loss aversion, we show that assuming no loss aversion ($\lambda = 1$) and estimating η leads to a fit that is not quite as good as that of the benchmark model. When estimating both η and λ, we obtain imprecise estimates for η (1.68, s.e. 3.21). As such, in the rest of the paper we hold η fixed at 1.

More importantly, though, can we distinguish our model from habit formation models, which also share an adaptive reference point component? Models a la Constantinides (1990) and Campbell and Cochrane (1999) assume utility $u(c-zr)$, where r is the habit formed from past consumption and u is a concave function. Habit formation, like reference dependence, induces a temporarily high marginal utility following a benefit cut, as consumption c gets closer to the habit zr. Thus, it could also plausibly fit the patterns in the data.

[26]When we implement this estimate we assume that the memory of the AR(1) update goes back to 1050 days (or 70 15-day periods). We adopt as benchmark the N-period reference point for computational reasons, since the long memory of the AR(1) model makes the estimates more time-consuming.

[27]We provide further details in the Web Appendix.

We estimate a habit formation model replacing the utility function in (1) with $v(c_t, r_t) = \log(c_t - zr_t)$, where z captures the responsiveness to changes in the habit and r_t is calculated as before, but reinterpreted as a measure of habit stock.[28] The estimates, allowing for two unobserved types, are in Columns (6) and (7) (for the habit formed with an AR1 process). The fit is significantly worse than the fit of the reference-dependent model (see also Figures 7c-d).

This may appear surprising given the similar intuition behind the two models. The models however differ in a key aspect. In the reference-dependent model, the impact of the loss, $\lambda(u(c) - u(r))$, on search effort is approximately proportional to the size of the loss. Instead, in the habit-formation model larger decreases in consumption have disproportionate effect, as c gets closer to zr. Given this, the habit-formation model fits the data less well, since it predicts a larger spike at the 90-day (post reform) benefit decrease, and a much smaller spike for the later (proportionally smaller) benefit decreases.[29]

5.4 Robustness and Unobserved Heterogeneity

In Table 3 we consider the robustness of the standard and reference-dependent models to alternative specifications, including alternative assumptions on heterogeneity.

In Column (1) we estimate both time preference parameters, β and δ. While the fit is somewhat better than in the benchmark models, β and δ are quite collinear; thus, in the benchmark specifications we fix one of the two parameters. In Column (2) we allow for a linear time trend in the baseline cost factor allowing for skill depreciation or learning by searching. This additional parameter improves the fit of the reference-dependent model while leaving the fit of the standard model essentially unaffected. In Column (3) we explore the role played by the spikes at days 270 and 360, since one may worry that such spikes play a disproportional role in the identification given the quadratic distance measure. The model estimated dropping these moments from the objective function yields similar patterns.

We also consider the importance of timing in the model. We assume that jobs start one period after the offer is received, but what if the hiring process takes longer? In Column (4) we assume a 2-period (that is, one-month) delay between the job offer and the first wage payment. As Web Appendix Figures A-15a) and b) show, the change in timing does not shift the spike. Rather, job-seekers start their search earlier, taking into account the longer delay.

In Web Appendix Tables A-5 and A-6 we present additional robustness results discussed more in detail in the Web appendix. The results are robust to a series of statistical robustness

[28] Observe that this function is not defined whenever $c_t < zr_t$, complicating the estimation. To avoid this problem, Campbell and Cochrane (1999) made z a non-linear function of $y_t - r_t$. We treat z as a parameter instead and check in the optimum that our utility function is defined for the relevant y_t and r_t.

[29] We provide further detail in Web Appendix Figure A-13. Notice that the habit-formation model is also computationally trickier to estimate, as the estimated habit parameter γ has to always satisfy the condition $c > \gamma r$.

checks, such as using the identity matrix to weight the moments, using the moments estimated after controlling for observables or using the estimated (unconditional) probability of exiting unemployment in each 15-day period as moments. The advantage of the latter procedure is that we can use the full variance-covariance matrix for weights. The estimates are also similar if we use 30-day hazards or 7-day hazards, instead of 15-day hazards.

Turning to modeling assumptions, allowing for background consumption and for alternative assumption on welfare receipt does not significantly affect the results. We also consider alternative assumptions for the reemployment wage and the initial assets. The fit of the models is somewhat worse under the alternative assumptions, but the results are similar qualitatively.

Heterogeneity. So far, we have modeled a single form of heterogeneity, in search costs, and fixed the number of types at 3. We now relax both assumptions.

First, we increase the number of heterogeneous types up to 5 types. Allowing for additional types in the standard model improves the fit all the way to 4 types; estimates with 5 or more types have trouble converging. Even the model with 4 types does significantly worse in terms of fit than the reference-dependent model (Figure 8b). For the reference-dependent model, there is a minor improvement in fit going to 2 types, with no improvement thereafter.

Next, we consider alternative forms of unobserved heterogeneity, such as in the reemployment wage. We take the 10th, 50th, and 90th percentile of the reemployment wage from the data, fix the proportion of each type at 20, 60, and 20 percent respectively, then estimate the three cost parameters k_j. This alternative specification improves somewhat the fit of the standard model, as Web Appendix Table A-7 shows, but the fit of the reference-dependent model is still significantly better.

In Table 3 Column (7) we allow for heterogeneity in the curvature parameter γ, improving dramatically the fit. The estimates fit both the spike at 270 and at 360 days, as well as the difference between the pre- and post-reform period (Figure 8c). Indeed, this is the only specification with a better fit than the reference-dependent model. How does this model attain such good fit? The fit relies on vast heterogeneity in the elasticity of search (which equals $1/\gamma$). Initially, most exits are of the low-elasticity types ($\gamma_{high} = 1.01$), but the spike at day 270 is driven by the medium-elasticity types ($\gamma_{med} = 0.20$), whose search intensity spikes in the presence of lower benefits. The spike at 360 days is due to the high-elasticity types (with elasticities over 50, i.e. $\gamma_{low} = 0.016$), that start searching once benefits hit the welfare level.

The high-elasticity types are critical to the fit, as estimates with elasticity capped at 5 (Column (8) and Figure 8d)) do not match the fit of the reference-dependent model any more. To assess the implications of such elasticities, consider a hypothetical 10 percent increase in the level of welfare benefits paid out after 360 days. In response to such a small benefit change, the search effort of reference-dependent workers would barely change, but in the gamma-heterogeneity model, instead, the hazard rates would plummet (Web Appendix Figure A-18). We find this implied response unrealistic.

5.5 Out-of-Sample Predictions

To further compare the different models, we consider two sets of out-of-sample predictions: a reform of the unemployment assistance system two years prior to our main sample, and the response to our main reform for individuals with a lower earnings basis, who experienced a different change in benefits. We predict the response at the estimated parameters using the reference-dependent model (Column (4) in Table 1), the standard cost-heterogeneity model (Column (1) in Table 1) and the gamma-heterogeneity model (Column (7) in Table 3).

Turning to the first case, one year before our 'pre' period (see Figure 2b), the duration of the unemployment assistance was 180 days, compared to 90 days for the individuals in our sample.[30] As Figure 9a) shows, the reference-dependent model fits this earlier period well, with an out-of-sample GOF of 53.9. The gamma heterogeneity model, instead, fits quite poorly the period of the lengthened unemployment assistance (between 300 and 450 days), with an out-of-sample GOF of 110.6. The out-of-sample fit of the standard model with heterogeneity in cost levels is better (GOF of 81.2), but does not reach the reference-dependent model.

Second, we consider individuals in our main sample period, but with lower pre-unemployment income: a low-wage sample and a medium-wage sample (Web Appendix Figure A-1). Both groups experience less generous benefits post reform in the first 90 days, compared to our main sample. Figure 9b) displays the hazards for the low-wage sample in the pre-reform period, and the out-of-sample predictions according to the three models. The reference-dependent model captures quite well the patterns, while the model with heterogeneous elasticity provides the worst fit. Web Appendix Figure A-19 provides similar evidence for this sample in the post-reform period, as well as for the medium-wage sample. The reference-dependent model does consistently better out of sample than the other models.

5.6 Dynamic Selection throughout the UI spell

The standard model captures reasonably well the dynamics in the hazards in the first 270 days as well as some of the trend after that, especially in the gamma-heterogeneity version. To achieve this fit, changes in the unobserved types over time play a key role. How plausible then is the amount of heterogeneity that the standard model requires? While we cannot measure the time-changing unobserved heterogeneity, we propose that a useful metric is the time-

[30] This change applied to individuals aged 45 and lower. Since our sample includes only individuals up to age 50, the reform applies to the large majority of the sample. Excluding the 46-50 year olds barely affects the estimates.

varying selection on observables of the unemployed, under the assumption that unobservable factors that influence job search correlate with these observable characteristics.

To document the dynamic selection along observables, we regress at the individual level the realized unemployment duration (censored at 540 days) on a rich set of observables.[31] As Web Appendix Table A-10 shows, for both individuals in the pre- and post-samples (Columns (1) and (2)), these variables are reliable predictors of non-employment duration, with an R^2 of 0.05-0.06. The predicted duration based on these estimates for the pre-period varies between 230 days (5th percentile) and 370 days (95th percentile), a good amount of variation.

The dotted lines with crosses in Figure 10a)-b) show the predicted duration for individuals who exit unemployment in a given 15-day period. While predicted unemployment increases (unsurprisingly) throughout the spell, the relationship is quite flat: predicted unemployment only increases from 280 days to 295 days after 2 years. Furthermore, the pattern of selection is not much affected by the benefit path, with fairly parallel lines for the pre- and post-reform periods.[32] Selection on observables thus plays only a limited role in the data.

The selection over time in predicted duration has a counterpart in the models. For each type, we compute the expected unemployment duration in the pre-reform period. We then calculate the average expected duration for unemployed individuals who leave in a given period according to the estimated models. The reference-dependent model (solid lines in Figure 10a), which predicts no type shift, is not so dissimilar from what we observe empirically. The standard model with cost heterogeneity (Figure 10a)) instead displays a large amount of dynamic selection, with a large swing until 200 days, with no corresponding evidence in the data. The gamma-heterogeneity model (Figure 10b)) is even more at odds with the data, with an initial swing, and then an abrupt swing between 300 and 360 days, corresponding to the transition from the medium- to the high-elasticity type.

Thus, the patterns of dynamic selection implied by two versions of the standard model appear at odds with the much more muted and monotonic selection in the data. We should be clear that it is not surprising that the selection on observables was more muted than the selection implied by the model, given that we only observe part of the selection. However, the extent of the difference is quite striking, given the rich set of variables used in calculating dynamic selection. Moreover, it is puzzling for the standard model that the observed selection does not display any of the trends in the model predictions, even on a more muted scale.

[31] The controls are education, age groups, gender, waiting period (the number of days between job lost and UI claimed), log past earnings, indicators for county of residence, day of the month UI was claimed, and occupation (1 digit) of the last job.

[32] The fact that dynamic selection seems to be small and not much affected by the UI regime has been shown before, for example Schmieder et al. (2016).

5.7 Reservation Wages

So far the reemployment wage is fixed so the unemployed accept every job offer. While this is consistent with a literature documenting a small role of reservation wages for job search dynamics (e.g. Card et al., 2007a; Krueger and Mueller, 2013; Schmieder et al., 2016), a natural question is whether introducing a reservation wage would change our conclusions. For tractability, we estimate models with choice of search effort and reservation wage, but with hand-to-mouth consumers. These results should be considered only suggestive, as endogenizing consumption is important.

Individuals draw job offers from a (stationary) log-normal wage offer distribution and decide whether or not to accept it. For simplicity, we abstract away from gain (or loss) utility at reemployment. We set the standard deviation of the wage offer distribution at 0.5, close to the standard deviation of the actual reemployment wages, and we estimate the mean of the wage offer distribution. The estimator uses 70 additional moments, the average reemployment wage of individuals exiting unemployment in period t after entering the UI system.[33]

Web Appendix Table A-11 shows that the reference-dependent model has a better fit than the standard model (GOF of 272 versus 308), largely due to the reference-dependent model providing a better fit for the hazard moments (see also Web Appendix Figures A-16). Notice however that the estimates have relatively patient unemployed workers, at odds with the maintained assumption of hand-to-mouth consumption.

6 Discussion and Conclusion

We provided evidence that a model with reference-dependent preferences can explain qualitative features of the hazards which plausible versions of the standard model have a hard time fitting. The model itself builds on one of the most robust behavioral models, reference dependence, and uses a natural candidate for a backward-looking reference point. We also find that job seekers are substantially impatient, likely in the form of present-bias preferences.

This evidence has policy implications. Reference-dependent job-seekers respond strongly in their search effort to front-loaded benefits. Lindner and Reizer (2015) show that the Hungarian UI reform examined here did not just speed up exits to employment, but it was revenue-neutral from the perspective of the government. This evidence suggests that multiple-step unemployment insurance systems could prove advantageous.

[33] The estimates allow for two unobserved types for the reference-dependent model, and three types for the standard model to capture the declining path of the reemployment wage over time. The reemployment wage moments are from Lindner and Reizer (2015), allowing for a linear time trend.

References

Allen, Eric, Patricia Dechow, Devin Pope, and George Wu, "Reference-Dependent Preferences: Evidence from Marathon Runners," *Management Science*, (forthcoming).

Barberis, Nicholas and Ming Huang, "Mental accounting, loss aversion, and individual stock returns," *The Journal of Finance*, *56* (4), (2001), 1247–1292.

Barseghyan, Levon, Francesca Molinari, Ted O'Donoghue, and Joshua C. Teitelbaum, "The Nature of Risk Preferences: Evidence from Insurance Choices," *The American Economic Review*, *103* (2013), 2499-2529.

Bloemen, Hans G, "Job Search, Search Intensity, and Labor Market Transitions an Empirical Analysis," *Journal of Human Resources*, *40* (1), (2005), 232–269.

Boone, Jan and Jan C van Ours, "Why is There a Spike in the Job Finding Rate at Benefit Exhaustion?," *De Economist*, *160* (4), (2012), 413–438.

Bowman, David, Deborah Minehart, and Matthew Rabin, "Loss aversion in a consumption–savings model," *Journal of Economic Behavior & Organization*, *38* (2), (1999), 155–178.

Campbell, John Y and John H Cochrane, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior," *The Journal of Political Economy*, *107* (2), (1999), 205–251.

Card, David and Gordon B. Dahl, "Family Violence and Football: The Effect of Unexpected Emotional Cues on Violent Behavior," *The Quarterly Journal of Economics*, *126* (2011), 103-143.

_ , Raj Chetty, and Andrea Weber, "Cash-On-Hand and Competing Models of Intertemporal Behavior: New Evidence from the Labor Market," *Quarterly Journal of Economics*, *122* (4), (2007a), 1511–1560.

Chetty, Raj, "Consumption commitments, unemployment durations, and local risk aversion," Working Paper 10211, National Bureau of Economic Research (2003).

_ , "Moral hazard versus liquidity and optimal unemployment insurance," *Journal of political Economy*, *116* (2), (2008), 173–234.

_ and Adam Szeidl, "Consumption Commitments and Habit Formation," *Econometrica*, *84* (2), (2016), 855-890.

Conlin, Michael, Ted O'Donoghue, and Timothy J. Vogelsang, "Projection Bias in Catalog Orders," *American Economic Review*, *97* (2007), 1217-1249.

Constantinides, George M., "Habit Formation: A Resolution of the Equity Premium Puzzle," *Journal of Political Economy*, *98* (3), (1990), pp. 519-543.

DellaVigna, Stefano, "Psychology and Economics: Evidence from the Field," *Journal of Economic Literature*, *47* (2), (2009), 315–372.

_ and M. Daniele Paserman, "Job search and impatience," *Journal of Labor Economics*, *23* (3), (2005), 527.

_ , John. A. List, and Ulrike Malmendier, "Testing for Altruism and Social Pressure in Charitable Giving," *Quarterly Journal of Economics*, *127* (2012), 1-56.

Engström, Per, Katarina Nordblom, Henry Ohlsson, and Annika Persson, "Tax Compliance and Loss Aversion," *American Economic Journal: Economic Policy*, *7* (4), November (2015), 132-64.

Farber, Henry S., "Why You Can'T Find a Taxi in the Rain and other Labor Supply Lessons from Cab Drivers*," *The Quarterly Journal of Economics*, (2015).

Fehr, Ernst and Lorenz Goette, "Do Workers Work More if Wages Are High? Evidence from a Randomized Field Experiment," *The American Economic Review*, *97* (2007), 298-317.

Fougere, Denis, Jacqueline Pradel, and Muriel Roger, "Does the public employment service affect search effort and outcomes?," *European Economic Review*, *53* (7), (2009), 846 - 869.

Frey, Maria, "The legal and institutional environment of the labour market," in Fazekas Kroly and KllJnos, eds., *The Hungarian labor market- Review and Analysis*, Institute of Economics IE-HAS, National Employment Service - Hungary, (2009).

Ganong, Peter and Pascal Noel, "How Does Unemployment Affect Consumer Spending?," *mimeo*, (2015).

Kahneman, Daniel and Amos Tversky, "Prospect theory: An analysis of decision under risk," *Econometrica: Journal of the Econometric Society*, (1979), 263–291.

_ , Jack L Knetsch, and Richard H Thaler, "Anomalies: The endowment effect, loss aversion, and status quo bias," *The journal of economic perspectives*, *5* (1), (1991), 193–206.

Katz, Lawrence F and Bruce D Meyer, "Unemployment insurance, recall expectations, and unemployment outcomes," *The Quarterly Journal of Economics*, *105* (4), (1990), 973–1002.

Koenig, Felix, Alan Manning, and Barbara Petrongolo, "Reservation wages and the wage flexibility puzzle," *mimeo*, (2016).

Kolsrud, J., Camille Landais, Peter Nilsson, and Johannes Spinnewijn, "The Optimal Timing of Unemployment Benefits: Theory and Evidence from Sweden," Technical Report (2015).

Kőszegi, Botond and Matthew Rabin, "A model of reference-dependent preferences," *The Quarterly Journal of Economics*, *121* (4), (2006), 1133–1165.

Kroft, Kory and Matthew J. Notowidigdo, "Should Unemployment Insurance Vary with the Unemployment Rate? Theory and Evidence," *Review of Economic Studies*, (forthcoming).

Krueger, Alan B. and Andreas Mueller, "A Contribution to the Empirics of Reservation Wages," *Mimeo*, (2013).

Laibson, David, "Golden eggs and hyperbolic discounting," *The Quarterly Journal of Economics*, (1997), 443–477.

_ , Andrea Repetto, and Jeremy Tobacman, "Estimating Discount Functions with Consumption Choices over the Lifecycle," *Working paper*, (2007).

Le Barbanchon, Thomas, "The Effect of the Potential Duration of Unemployment Benefits on Unemployment Exits to Work and Match Quality in France," *Insee, CREST, Working Paper*, (2012-21), (2012).

Lentz, Rasmus and Torben Tranaes, "Job Search and Savings: Wealth Effects and Duration Dependence," *Journal of Labor Economics*, *23* (July), (2005), 467–489.

Lindner, Attila and Balázs Reizer, "Frontloading the Unemployment Benefits: An Empirical Assessment," *mimeo*, (2015).

Micklewright, John and Gyula Nagy, "Living standards and incentives in transition: the implications of UI exhaustion in Hungary," *Journal of Public Economics*, *73* (1999), 297–319.

Mortensen, Dale T, "Job search and labor market analysis," *Handbook of labor economics*, *2* (1986), 849–919.

O'Donoghue, Ted and Matthew Rabin, "Doing it now or later," *American Economic Review*, (1999), 103–124.

Paserman, M Daniele, "Job search and hyperbolic discounting: Structural estimation and policy evaluation," *The Economic Journal*, *118* (531), (2008), 1418–1452.

Post, Thierry, Martijn J Van den Assem, Guido Baltussen, and Richard H Thaler, "Deal or no deal? Decision making under risk in a large-payoff game show," *The American economic review*, (2008), 38–71.

Rees-Jones, Alex, "Loss Aversion Motivates Tax Sheltering: Evidence from U.S. Tax Returns," *Working paper*, (2013).

Schmieder, Johannes F, Till Von Wachter, and Stefan Bender, "The Effects of Extended Unemployment Insurance over the Business Cycle: Evidence from Regression Discontinuity Estimates over 20 years," *The Quarterly Journal of Economics*, *127* (2), (2012a), 701–752.

_ , Till von Wachter, and Stefan Bender, "The Effect of Unemployment Benefits and Nonemployment Durations on Wages," *The American Economic Review*, (2016).

Simonsohn, Uri and George Loewenstein, "Mistake# 37: The effect of previously encountered prices on current housing demand," *The Economic Journal*, *116* (508), (2006), 175–199.

Spinnewijn, Johannes, "Training and Search during Unemployment," *Journal of Public Economics*, *99* (2013), 49–65.

Sydnor, Justin, "(Over)Insuring Modest Risks," *American Economic Journal: Applied Economics*, *2:4* (2010), 177-199.

van den Berg, Gerard J, "Nonstationarity in job search theory," *The Review of Economic Studies*, *57* (2), (1990), 255–277.

_ and Bas van der Klaauw, "Structural empirical evaluation of job search monitoring," (2015).

van Ours, Jan and Milan Vodopivec, "Does reducing unemployment insurance generosity reduce job match quality?," *Journal of Public Economics*, *92* (3-4), (2008), 684-695.

Wooldridge, Jeffrey M., *Econometric analysis of cross section and panel data*, MIT Press, (2010).

Table 1: Benchmark Estimates of the Standard and Reference-Dependent Model

	δ-discounting		$\beta\delta$-discounting	
	Standard 3 type	Ref. Dep. 1 type	Standard 3 type	Ref. Dep. 1 type
	(1)	(2)	(3)	(4)
Parameters of Utility Function				
Loss aversion λ		4.92 (0.58)		4.69 (0.62)
Adjustment speed of reference point N in days		184.2 (11.0)		167.5 (11.2)
Discount factor (15 days) δ	0.93 (0.01)	0.89 (0.02)	0.995	0.995
Discount factor β	1	1	0.92 (0.01)	0.58 (0.19)
Parameters of Search Cost Function				
Curvature of search cost γ	0.4 (0.046)	0.81 (0.16)	0.07 (0.01)	0.4 (0.2)
Search cost for high cost type k_{high}	168.1 (98.595)	350.6 (150.8)	441.8 (.)	108.5 (18.3)
Search cost for medium cost type k_{med}	49.7 (1.894)		98.0 (9.7)	
Search cost for low cost type k_{low}	12.9 (1.239)		13.3 (1.9)	
Share of high cost UI claimant	0.2 (0.074)		0.2 (0.02)	
Share of medium cost UI claimant	0.6 (0.059)		0.7 (0.01)	
Model Fit				
Number of moments used	70	70	70	70
Number of estimated parameters	7	5	7	5
Goodness of Fit	227.5	194.0	229.0	183.5

Notes:
The table shows parameter estimates for the standard and the reference-dependent search models. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
(.) indicates that the parameter is not well identified, i.e. the Hessian cannot be inverted close to the reported values and therefore we do not provide standard errors. The other standard errors are calculated by inverting the Hessian matrix after dropping the parameter from the matrix.

Table 2: Alternative Specifications for Reference-Dependent Model

	Benchmark RD 1-type	AR(1) Updating	No Loss Utility	Estimate η Fix $\lambda = 1$	Estimate λ and η	Habit Model a la Constantinides (1990) $log(c_t - zr_t)$	
	1-type	1-type	1-type	1-type	1-type	2-type	2-type, AR(1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Parameters of Utility Function							
Loss aversion λ	4.69	9.42	0	1	3.14		
	(0.62)	(2.66)			(4.00)		
Gain utility η	1	1	15.0	40.0	1.68		
			$(.)^{\dagger}$	(22.8)	(3.21)		
Habit formation parameter z						0.45	0.26
						(.)	(.)
Adjustment speed of reference point N in days	167.5		2.1	160.4	168.1	224.1	
	(11.2)		$(.)^{\dagger}$	(20.1)	(12.6)	(14.5)	
AR(1) parameter		0.75					0.87
		(0.11)					(0.07)
Implied half life of AR(1) process		35.6					74.03
		(5.1)					(42.81)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.925	0.903
						(0.002)	(0.007)
Discount factor β	0.58	0.22	0.01	0.04	0.55	1	1
	(0.19)	(0.19)	$(.)^{\dagger}$	(0.05)	(0.35)		
Curvature of search cost γ	0.4	0.80	3.43	1.67	0.40	0.46	0.60
	0.2)	(0.40)	$(.)^{\dagger}$	(0.58)	(0.37)	(0.03)	(0.01)
Model Fit							
Number of moments used	70	70	70	70	70	70	70
Number of estimated parameters	5	5	5	7	6	7	7
Goodness of Fit	183.5	178.4	486.6	196.3	183.5	235.7	251.6

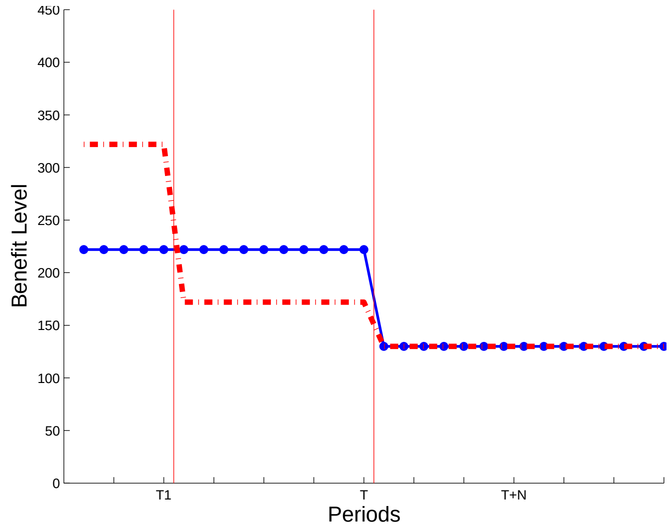
Notes:
The table shows parameter estimates for the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
† The no loss utility does not converge to an interior solution within our parameter space and therefore standard errors are not reported. Column (4) also corresponds to the habit formation model in Abel (1990) with utility function $log(c_t) - \eta log(r_t)$. The gain utility parameter η in this model is close (within 0.01) to the boundary we set for the estimation. In practice, it seems the objective function is almost flat for larger η and the model obtains the same fit but does not generate standard errors if estimated without constraint. In columns (6) and (7), the parameter z is at the upper bound of possible values for z (for higher values the gain loss part would be the log of a negative number) and we therefore do not provide standard errors.

Table 3: Robustness to Alternative Specifications of Utility Function, Estimation Methods and Heterogeneity

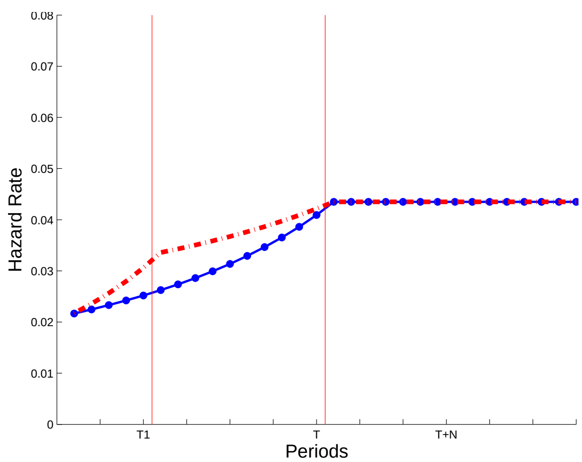
	Estimate β and δ	Time-varying search cost	Estimation without Spikes	Delayed Job Start Date	2 cost types	4 cost types	Heterogeneity search cost curvature γ	Heterogeneity search cost curvature $\gamma \geq 0.2$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standard Model								
Discount factor (15 days) δ	0.937	0.928	0.934	0.927	0.898	0.920	0.889	0.858
	(0.103)	(0.004)	(0.050)	(0.039)	(0.019)	(0.004)	(0.015)	(0.01)
Discount factor β	0.617							
	(0.239)							
Time varying cost		-0.003						
		(0.012)						
Curvature of search cost γ_{high}					0.49	0.32	1.01	1.92
					(0.02)	(0.04)	(0.006)	(0.006)
Curvature of search cost γ_{med}							0.20	0.49
							(0.157)	(0.355)
Curvature of search cost γ_{low}							0.016	0.20
							(0.002)	(0.02)
Number of moments used	70	70	66	68	70	70	70	70
Number of estimated parameters	8	8	7	7	5	9	7	7
Goodness of fit (SSE)	222.0	227.1	152.1*	213.5*	296.8	222.5	154.8	209.6
Reference Dependent Model								
Loss aversion λ	4.61	13.49	5.30	4.08	4.31	4.16	3.89	
	(0.46)	(1.54)	(1.01)	(0.33)	(0.32)	(1.74)	(0.02)	
Adjustment speed of reference point N	169.4	206.3	169.8	185.4	172.8	182.3	186.8	
	(11.5)	(11.7)	(13.4)	(11.8)	(11.6)	(16.8)	(58.4)	
Discount factor (15 days) δ	0.990	0.995	0.995	0.995	0.995	0.995	0.995	
	(0.051)							
Discount factor β	0.58	0.55	0.54	0.704	0.577	0.577	0.576	
	(0.01)	(0.09)	(0.31)	(0.05)	(0.033)	(0.019)	(0.028)	
Time varying cost		-0.020						
		(0.003)						
Curvature of search cost γ_{high}	0.39	0.60	0.54	0.25	0.37	0.37	4.97	
	(0.02)	(0.04)	(0.31)	(0.05)	(0.02)	(0.03)	(0.41)	
Curvature of search cost γ_{low}							0.359	
							(0.858)	
Number of moments used	70	70	66	68	70	70	70	
Number of estimated parameters	6	6	5	5	7	11	7	
Goodness of fit (SSE)	183.5	174.3	132.5*	177.5*	175.9	175.8	175.1	

Notes:
The table shows parameter estimates for the standard and the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
In column (2) we parameterize the search cost function as: $c(s) = k(1 + \xi t)(s^{1+\gamma}/(1 + k))$ and the reported parameter is ξ: the change in the level of search cost per period.
* These are the SSE with the alternative moments and they are not directly comparable to the goodness of fit statistics in the other columns.

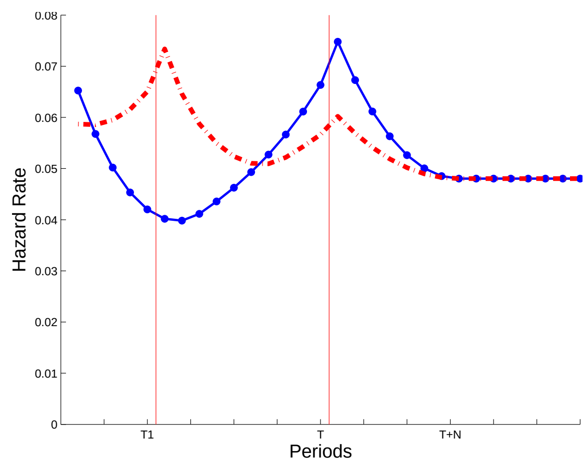
Figure 1: Model Simulations of the Standard and the Reference-Dependent model



(a) Benefits



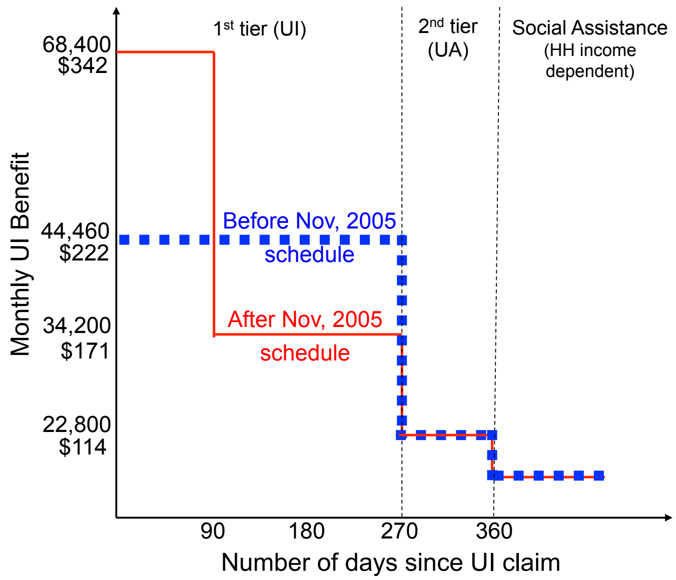
(b) Standard Model



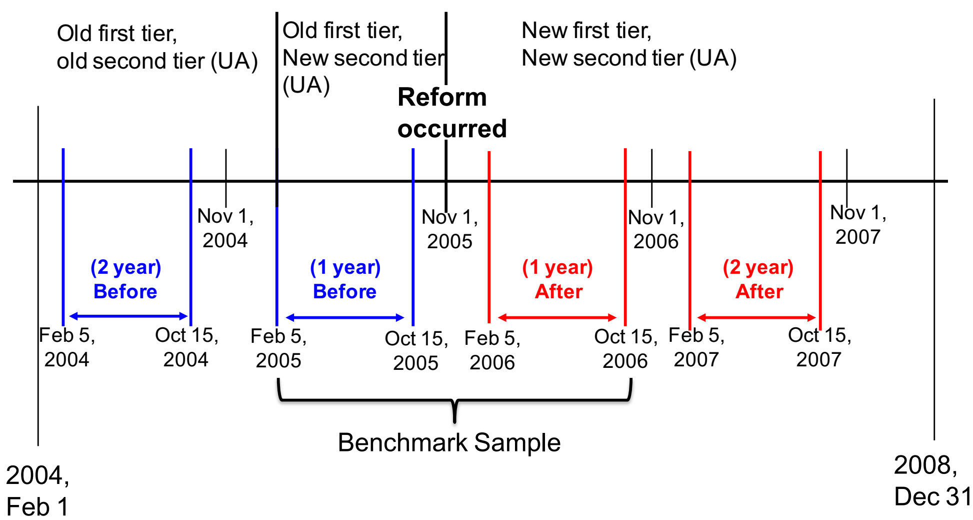
(c) Reference-Dependent Model

Notes: Panel (a) shows two benefit regimes, both of them having a step-down benefit system. After the first step benefits are higher in the regime represented by the circled blue line than in the regime represented by the red dashed line. After the second step benefits drop to the same level. Panel (b) shows the hazard rates predicted by the standard model (with $k = 130$, $\gamma = 0.6$, $w = 555$, $\delta = 0.99$) while Panel (c) the prediction of the reference-dependent model (with $k = 160$, $\gamma = 0.6$, $w = 555$, $\delta = 0.99$, $\lambda = 2$, $N = 10$).

Figure 2: Institutional Setting: Change in Benefit Path and Sample Periods



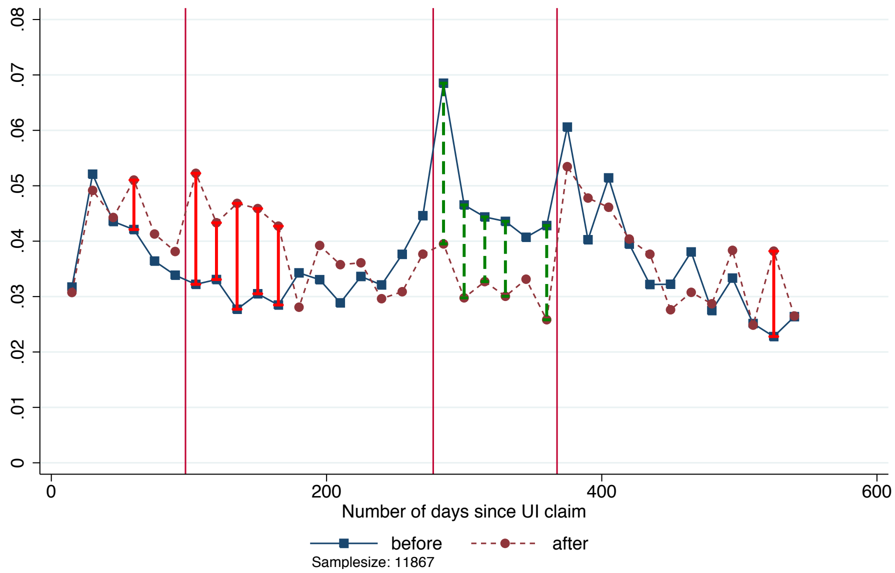
(a) Benefit Path Change, Main Sample



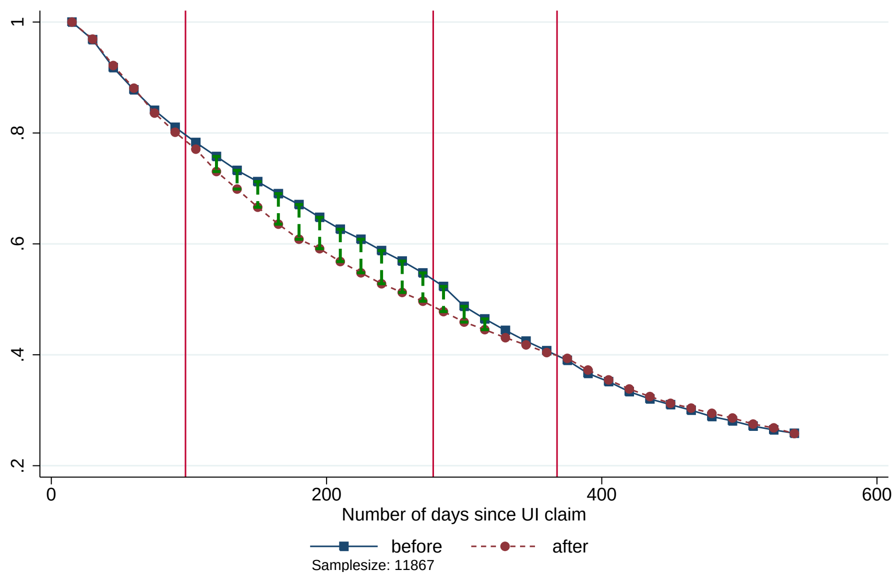
(b) Before-After Comparison Groups

Notes: Panel a) shows the benefit schedule if UI is claimed on October 31, 2005 (old benefit schedule, dashed blue line) and benefit schedule if UI is claimed on November 1st, 2005 (new benefit schedule, solid red line) for individuals who had 270 days potential duration in the first-tier, were less than 50 years old and earned more than 114,000 HUF ($570) prior to entering UI. Benefits levels in social assistance are approximate as they depended on family income, household size and wealth.
Panel b) shows the time frame for which we have access to administrative data on unemployment insurance records, the time of the reform and how we define the before and after periods that we use for our before-after comparison.

Figure 3: Empirical Hazard and Survival Rates under the Old and the New Benefit Schedule



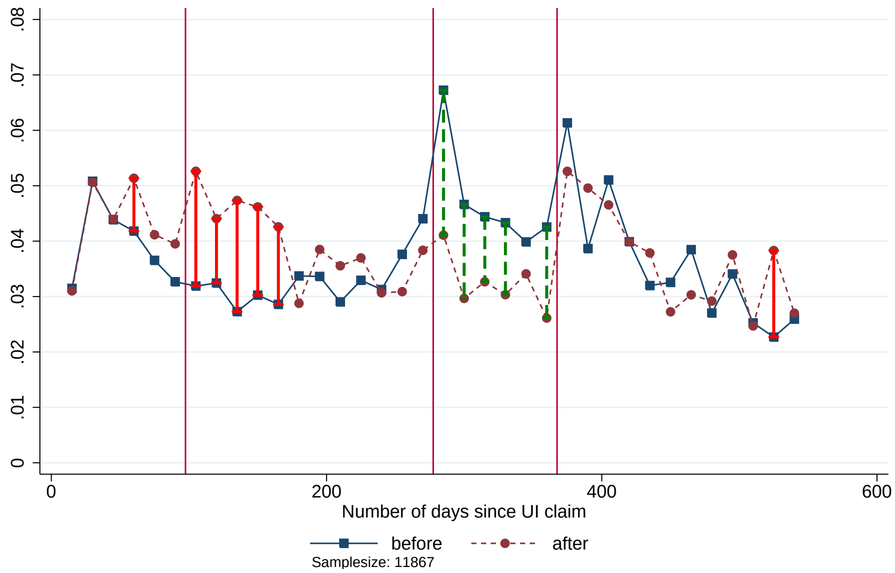
(a) Empirical hazard rates



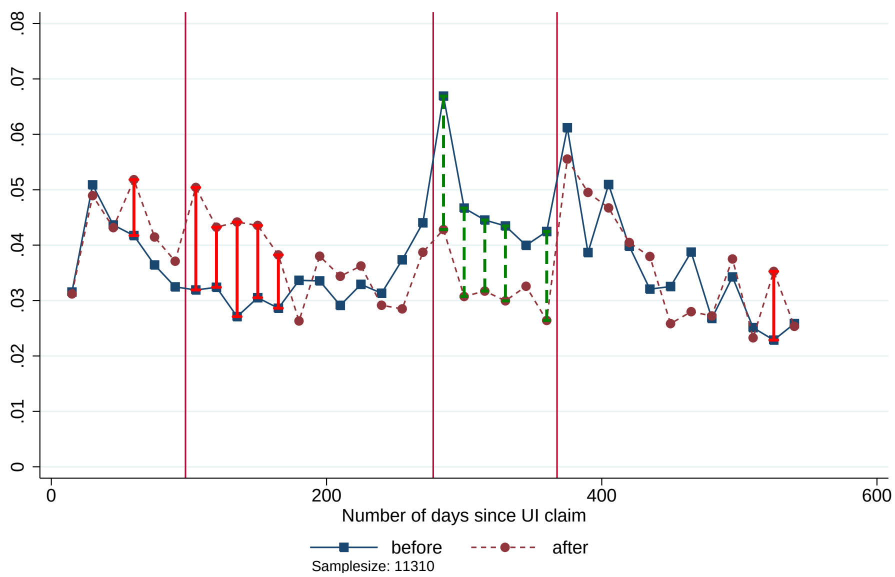
(b) Empirical survival rates

Notes: The figure shows point wise estimates for the empirical hazards, Panel (a), and for the empirical survival rates, Panel (b), before and after the reform. The differences between the two periods are estimated point-wise at each point of support and differences which are statistically significant ($p \leq 0.05$) are indicated with a vertical bar (green dashed if pre-period hazard is above post period hazard, red solid otherwise). The three major (red) vertical lines indicate periods when benefits change in the new system. The sample consists of unemployed workers claiming UI between February 5th, 2005 and October 15th, 2005 (before sample) and February 5th, 2006 and October 15th, 2006 (after sample), who had 270 days of potential duration, were 25-49 years old, and were above the 70th percentile of the earnings base distribution of the UI claimants in the given year.

Figure 4: Robustness Checks for change of Hazard rates before and after the reform



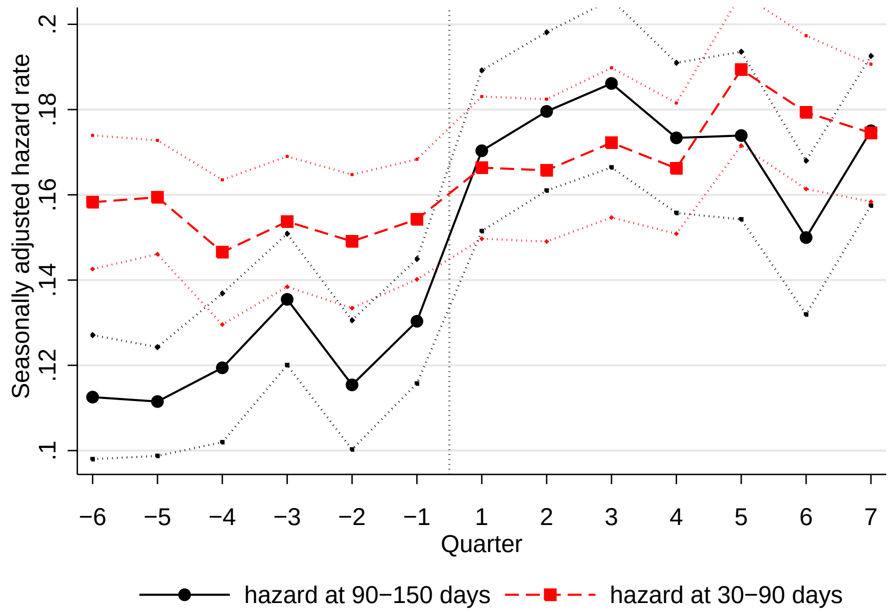
(a) Controlling for observable differences



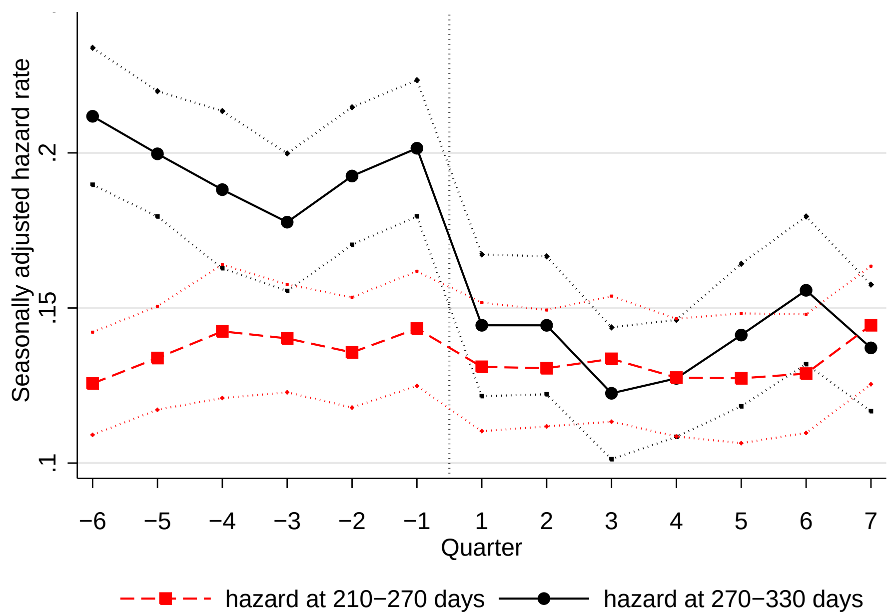
(b) Restricted sample

Notes: The figure shows point wise estimates for the empirical hazards before and after the reform. The differences between the two periods are estimated point-wise at each point of support and differences which are statistically significant are indicated with a vertical bar (green dashed if pre-period hazard is above post period hazard, red solid otherwise). The three major (red) vertical lines indicate periods when benefits change in the new system. In Panel (a) we added demeaned control variables for sex, age, age square, waiting period (the number of days between job lost and UI claimed), the county of residence, day of the month UI claimed, education, occupation (1 digit) of the last job, and log earnings in 2002 and 2003. In Panel (b) in addition to controlling for these control variables we dropped reemployment bonus claimants and those participating in training programs (after the reform), see text for the details. The sample is otherwise the same as in Figure 3.

Figure 5: Interrupted Time Series Analysis of Exit Hazards



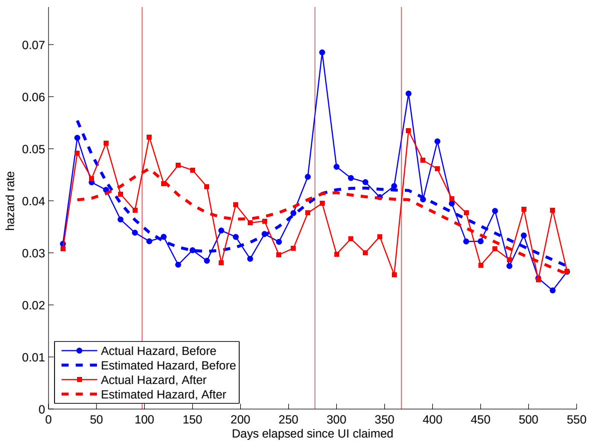
(a) The evolution of the hazard rates between 30 and 150 days



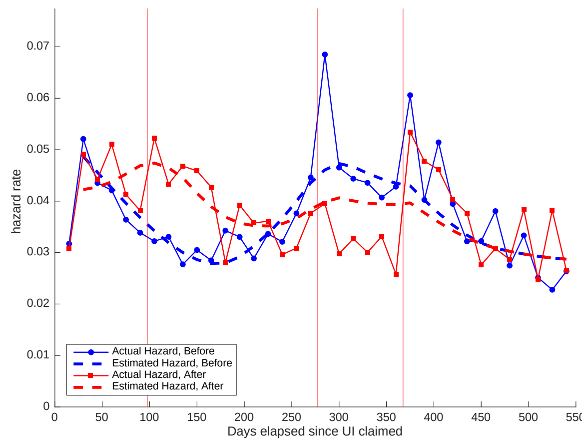
(b) The evolution of the hazard rates between 210 and 330 days

Notes: The figure shows the level of the most important hazard rates 6 quarters before and 7 quarters after the reform. Panel (a) shows the seasonally adjusted hazard rates between 30 and 150 days, while Panel (b) shows the seasonally adjusted hazard rates between 210 and 330 days. The monthly seasonal adjustment of hazard rates takes into consideration the level shift present in the data in November, 2005. The figures highlight that the shift in the hazard plots documented earlier corresponds to the precise timing of the reform. Other sample restrictions are the same as in Figure 3.

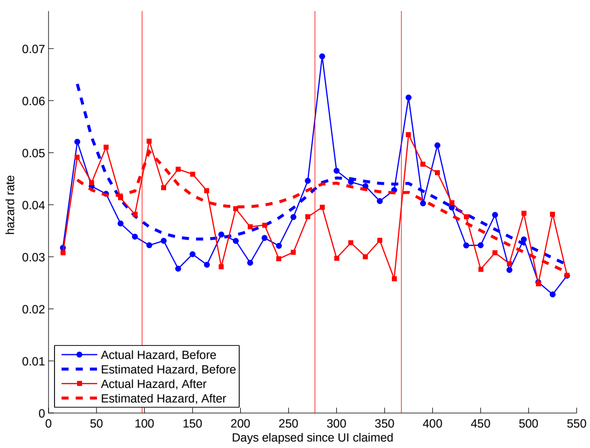
Figure 6: Predicted Hazards of the Benchmark Standard and Reference-Dependent Models



(a) Standard Model, δ-discounting



(b) Ref.-Dep. Model, δ-discounting

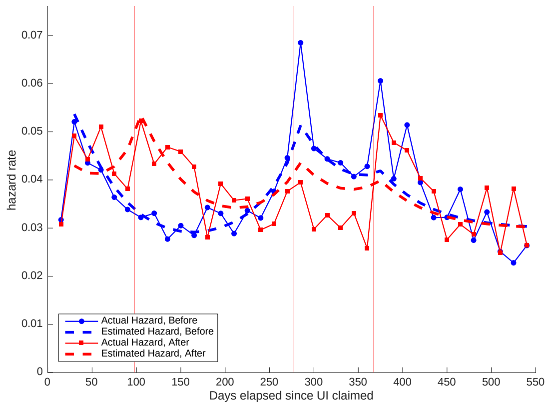


(c) Standard Model, $\beta\delta$-discounting (present bias)

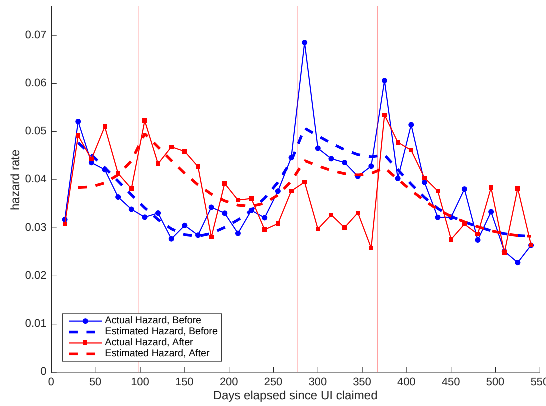
(d) Ref.-Dep. Model, $\beta\delta$-discounting (present bias)

Notes: The figure shows the empirical hazards and the predicted hazards of the standard and the reference-dependent models with endogenous savings shown in Table 1. Panel (a) corresponds to the standard model with 3 cost types and δ-discounting. Panel (b) corresponds to the reference-dependent model with 1 cost type and δ-discounting. Panel (c) shows the standard model (3 cost types) with $\beta\delta$-discounting (present bias) and Panel (d) the corresponding reference-dependent model. The three major (red) vertical lines indicate periods when benefits change in the new system.

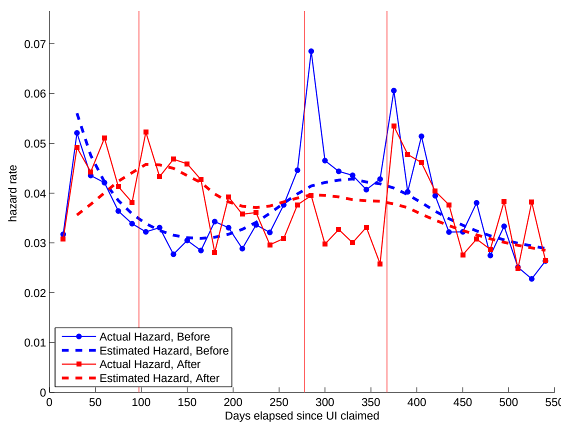
Figure 7: Alternative Models with Reference Dependence and Habit Formation



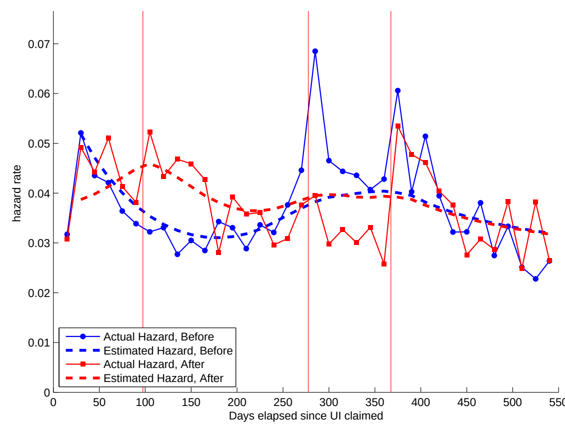
(a) Reference-Dependent Model, AR(1) updating



(b) Reference-Dependent Model, estimate η, fix $\lambda = 1$



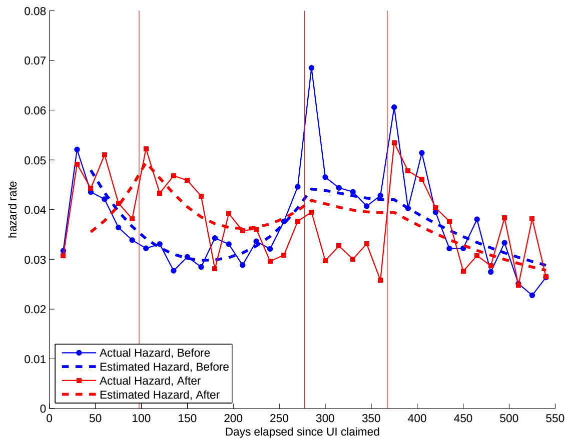
(c) Habit Model with 2 types (Constantinides 1990)



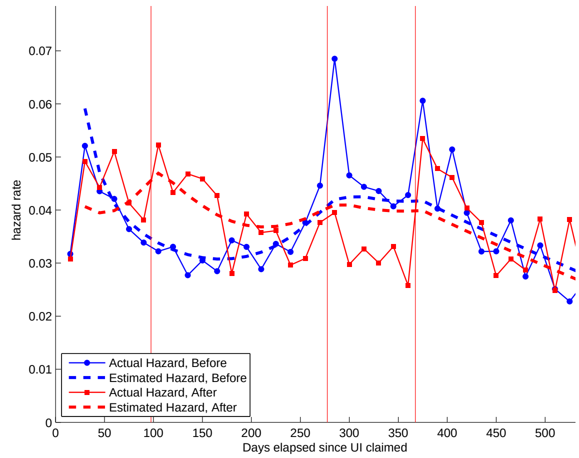
(d) Habit Model with 2 types (Constantinides 1990), AR(1)

Notes: The figure shows the empirical hazards and the predicted hazards of estimates of alternative versions of the reference-dependent model. Panel (a) shows the reference-dependent model where the reference point is updated using a AR(1) process (Table 2 column 2). Panel (b) shows the reference-dependent model with η estimated and λ set to 1 (Table 2 column 4). Panel (c) shows the habit formation model of Constantinides (1990) with 2 types and the same reference point as our baseline model (Table 2 column 6). Panel (d) shows the habit formation model of Constantinides (1990) with 2 types and AR(1) updating of the reference point (Table 2 column 7).

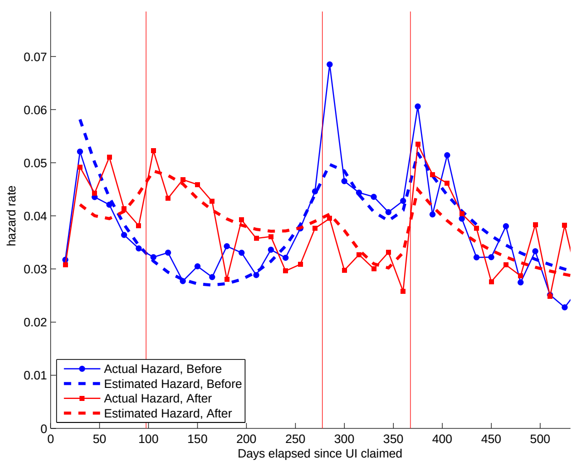
Figure 8: Alternative Estimates of the Standard Model



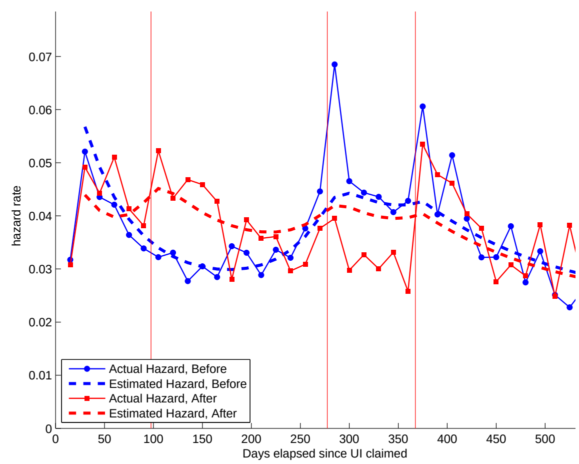
(a) Delayed Job Starting Date



(b) 4 cost types



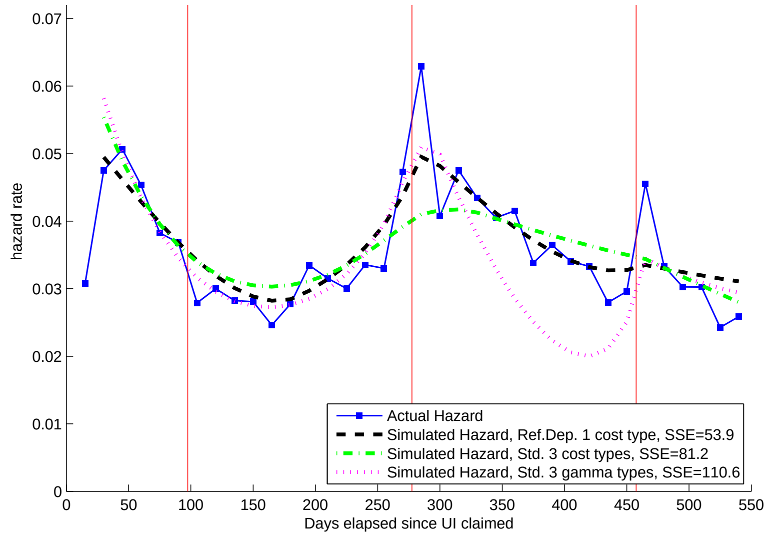
(c) Heterogeneity in Search Cost Curvature



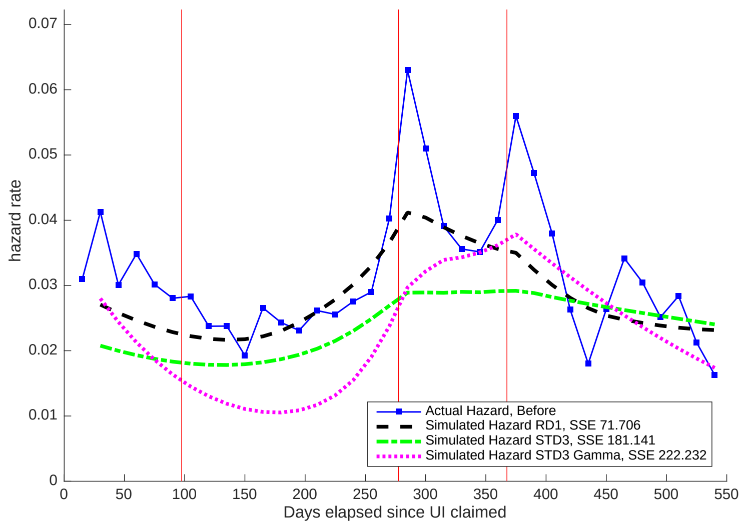
(d) Heterogeneity in Search Cost Curvature (γ restricted to ≥ 0.2)

Notes: The figure shows the empirical hazards and the predicted hazards for estimations of the standard model under different specifications of heterogeneity (See Table 3). Panel (a) allows the job starting date to be delayed by one period. Panel (b) allows for 4 cost types. Panel (c) allows for three different types in the elasticity of the cost of job search γ and Panel (d) is the same as Panel (c) but restricting the γ to be larger or equal than 0.2, which would imply an elasticity of search effort with respect to the returns to job search of less than 5.

Figure 9: Out-of-sample Performance of Models



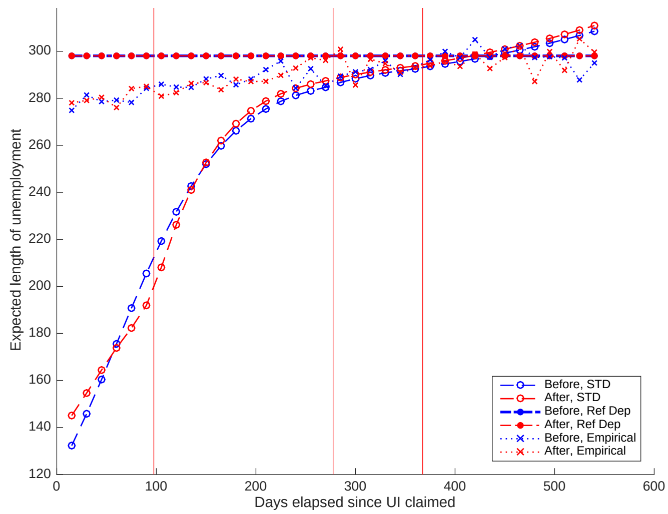
(a) Out-of-sample predictions of models for unemployment system 2 years prior to reform and empirical hazard



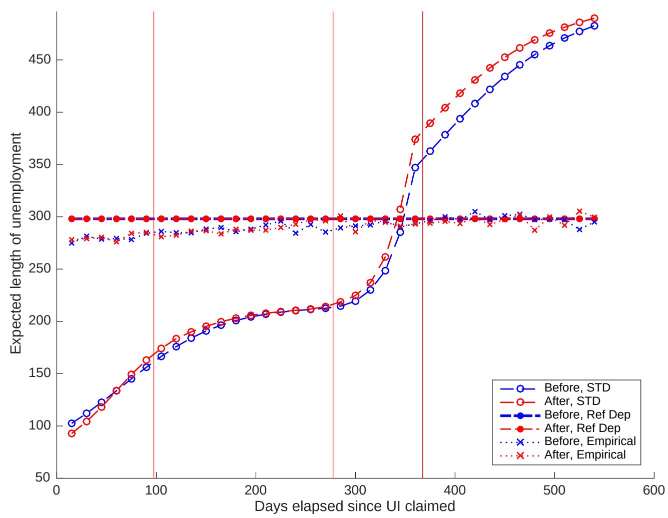
(b) Out-of-sample predictions of models for low earnings sample, pre-reform period

Notes: The figure shows the out of sample fit of the estimated the reference-dependent model with 1 cost type, the standard model with 3 search cost types and the standard model with three γ-types. Panel a) shows the empirical and simulated hazard rates for the period 2 to 1 years before the reform when unemployment assistance could be claimed until 460 days. Panel b) shows the empirical and simulated hazard rates for individuals who had lower pre-unemployment earnings and thus faced a different benefit path (lower benefits during UI), see Web Appendix Figure A-1.

Figure 10: Changes in Heterogeneity throughout the Unemployment Spell: Empirical Heterogeneity vs. Model Predictions



(a) Predicted total unemployment duration of individuals exiting at time t: Heterogeneity in cost levels k



(b) Predicted total unemployment duration of individuals exiting at time t: Heterogeneity in search cost curvature γ

Notes: The figure shows estimates of the expected nonemployment duration of individuals who left unemployment in each time period, contrasting the empirically observed selection with the predicted selection from the estimated standard and reference-dependent models. The empirical expected nonemployment duration (lines with x's) for each individual is calculated as the predicted values from a regression of nonemployment duration on observable characteristics at the time of entering unemployment (see Web Appendix Table A-10). The expected nonemployment durations are calculated for the standard 3 cost type (Table 1, Column 1), the standard 3 gamma type (Table 3 Column 7) and the reference dependent (Table 1, Column 4) model.

Web Appendix - Not for Publication

Reference-Dependent Job Search: Evidence from Hungary

Stefano DellaVigna	Attila Lindner	Balázs Reizer	Johannes F. Schmieder
UC Berkeley, NBER	University College London and IZA	Central European University, CERS-MTA	Boston University, NBER, IZA, and CESIfo

Contents

List of Tables

List of Figures

1 Reference Dependent Model

1.1 General Setup

Each period a job seeker decides search effort $s_t \in [0,1]$, representing the probability of receiving a job offer at the end of period t and thus of being employed in period $t+1$. Search costs are given by the function $c(s_t)$, which we assume to be time-separable, twice continuously differentiable, increasing, and convex, with $c(0) = 0$ and $c'(0) = 0$.

In each period individuals receive income y_t, either UI benefits b_t or wage w_t, and consume c_t. In the general model consumers smooth consumption over time by accumulating (or running down) assets A_t. Assets earn a return R per period so that consumers face a per-period budget constraint $\frac{A_{t+1}}{1+R} = A_t + y_t - c_t$ and a borrowing constraint $A_t \geq -L$. We also consider a simplified model with hand-to-mouth consumption, $c_t = y_t$.

1.1.1 Consumption Utility

Flow utility is a function of current period consumption and the reference point:

$$u(c_t|r_t) = \begin{cases} v(c_t) + \eta\left[v(c_t) - v(r_t)\right] & \text{if} \quad c_t \geq r_t \\ v(c_t) + \eta\lambda\left[v(c_t) - v(r_t)\right] & \text{if} \quad c_t < r_t \end{cases} \tag{1}$$

In the standard model, where $\eta = 0$, this simply collapses to:

$$u(c_t|r_t) = v(c_t)$$

1.1.2 Reference Point

The reference point is the average of income over the N previous periods and the current period:[1]

$$r_t = \frac{1}{N+1}\sum_{k=t-N}^{t} y_k \tag{2}$$

Note that the reference point is only a function of past income and therefore while in unemployment it is fully determined by the current period t. For an employed individual, the reference point will depend on the current period, as well as in which period the person started the post-unemployment job.

[1] This formula implies that if $N = 0$, then $r_t = b_t$. In the hand-to-mouth case, where $c_t = y_t$, the reference-dependent utility then simplifies to the direct-consumption utility, $u(c_t|r_t) = v(c_t)$ and therefore the standard model is embedded. For the model with optimal consumption, even setting $N = 0$ the standard model is not any more embedded. In the estimation below we also consider an alternative AR(1) reference point formation process.

1.2 Model under exponential discounting

1.2.1 Value Functions

The unemployed choose search effort s_t and the asset level for the next period A_{t+1}, which implicitly defines consumption c_t, in each period. The state variables that determine the value of employment and unemployment in period t consist of the asset level A_t at the beginning of the period and the income levels of that individual over the last N periods, including the present: $\{y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-N}\}$ since these past income levels determine the future evolution of the reference point via equation (2). One could thus write the value of unemployment as: $V_t^U(A_t, \{y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-N}\})$. To save notation, we will not make this explicit and instead write $V_t^U(A_t) \equiv V_t^U(A_t, \{y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-N}\})$, which is without loss of generality, since conditional on being unemployed the past income path is deterministically determined by the current period t. For an employed individual the income path over the past N periods depends on the current period t but also on when the individual found a job. We therefore use the notation: $V_{t|j}^E(A_t) \equiv V_t^E(A_t, \{y_t, y_{t-1}, y_{t-2}, \ldots, y_{t-N}\})$ for the value of employment for an individual in period t who started a job in period j. Note that a job that starts in period j is found in the prior period $j-1$.

The value of unemployment is given as:

$$V_t^U(A_t) \quad = \max_{s_t \in [0,1]; A_{t+1}} u(c_t|r_t) - c(s_t) + \delta \left[s_t V_{t+1|t+1}^E(A_{t+1}) + (1 - s_t) V_{t+1}^U(A_{t+1}) \right] \tag{3}$$

The value of employment in period t for an individual who starts a job in period j is given by:

$$V_{t|j}^E(A_t) = \max_{A_{t+1} > 0} u(c_t|r_t) + \delta V_{t+1|j}^E(A_{t+1}). \tag{4}$$

In both cases maximization is subject to the budget constraint: $c_t = A_t + y_t - \frac{A_{t+1}}{1+R}$ and the liquidity constraint: $A_t \geq -L$ for all t.

1.2.2 Solving the Model

There are 3 steps for solving the model:

1. For each period $j = 1, 2, \ldots$ find the value of employment $V_{j|j}^E(A_j)$ for an individual who starts a job in period j. This value will be a function of the asset level in period j: A_j. To do so, we first solve for the steady state value of employment which occurs when the environment becomes stationary at some point $j + M$ after taking on a job. From this steady state function we can solve the optimal consumption path between j and $j + M$ and infer from that the value of employment when accepting a job $V_{j|j}^E(A_j)$ for each asset level.

2. Once the value function of accepting a job at a given asset level is known, we can solve for the steady state value of unemployment at some point in the future S when the environment is stationary and then solve backwards for the optimal search intensity and consumption path in each period as a function of the asset level.

3. Finally, once we know the value of unemployment as a function of the asset level in each period, we use the initial asset level as a starting value to determine the actual consumption path and actual search intensity in each period.

1.2.3 Calculating the value of accepting a job in each period

Stationary environment in employment: We assume that M periods after an individual takes on a job the environment for an employed individual becomes stationary. We require that an individual pays back his/her assets at this point so that we have that $r_t = c_t = w$ and $A_t = A_{t+1} = 0$.[2] Note that the value of employment in this stationary environment is given as:

$$V^E_{j+M|j}(0) = v(w) + \delta V^E_{j+M|j}(0).$$

which immediately implies that:

$$V^E_{j+M|j}(0) = \frac{1}{1-\delta} v(w) \tag{5}$$

Backwards induction to solve for optimal consumption path during employment One can use equation (4) together with equation (5) to solve for the value of accepting a job in period j, via backwards induction. Plugging the budget constraint into equation (4)

$$V^E_{t|j}(A_t) = \max_{A_{t+1}} u\left(A_t + y_t - \frac{A_{t+1}}{1+R} \middle| r_t\right) + \delta V^E_{t+1|j}(A_{t+1}). \tag{6}$$

Note that the utility function has a kink at the reference point, so that one has to be careful using the first order conditions. Specifically, an Euler equation will determine the consumption path at employment on either side of the reference point but will break once there is a crossing of consumption and reference point. In practice we solve this problem numerically whenever there is potential for crossing, such that we find the optimal value of A_{t+1} for each possible value of A_t and then calculate the value of employment in period t using equation (6).

1.2.4 Solving for the optimal search effort and consumption path during unemployment

General first order conditions Substituting the budget constraint into equation (3):

$$V^U_t(A_t) = \max_{s_t \in [0,1]; A_{t+1}} u\left(A_t + y_t - \frac{A_{t+1}}{1+R_t} |r_t\right) - c(s_t) + \delta\left[s_t V^E_{t+1|t+1}(A_{t+1}) + (1-s_t) V^U_{t+1}(A_{t+1})\right]$$

The first order condition for s_t is given as

$$c'(s_t) = \delta\left[V^E_{t+1|t+1}(A_{t+1}) - V^U_{t+1}(A_{t+1})\right] \tag{7}$$

which, given that $c(.)$ is invertible, directly determines the optimal search effort s_t as a function of: $V^E_{t+1|t+1}(A_{t+1})$ and $V^U_{t+1}(A_{t+1})$ and therefore as a function of A_{t+1}. If we write the mapping from

[2] This will hold if $\delta \leq \frac{1}{1+R}$, which is the case in all of our estimations.

future assets to the optimal search effort as $s_t^*(A_{t+1})$, then the value function can be written as:

$$V_t^U(A_t) = \max_{A_{t+1}} u\left(A_t + y_t - \frac{A_{t+1}}{1+R_t}|r_t\right) - c\left(s_t^*(A_{t+1})\right) + \delta\left[s_t^*(A_{t+1})V_{t+1|t+1}^E\left(A_{t+1}\right) + \left(1 - s_t^*(A_{t+1})\right)V_{t+1}^U\left(A_{t+1}\right)\right] \tag{8}$$

This can be solved numerically in a discrete asset space.

Stationary environment in unemployment: Once an individual is unemployed and a stationary environment $t \geq S$ is reached, we have that: $r_S = c_S = y_S$ and $A_S = A_t = A_{t+1} = -L$, where $-L$ is the lower bound of the asset space if an individual is impatient enough (or the interest rate low enough) such that $\delta < \frac{1}{1+R}$. This implies that the value function of unemployment simplifies to:

$$V_S^U(0) = \max_{s_S \in [0,1]; A_S} v\left(b_S\right) - c\left(s_S\right) + \delta\left[s_S V_{S|S}^E\left(L\right) + \left(1 - s_S\right)V_S^U\left(L\right)\right] \tag{9}$$

In this case the first order condition for search intensity simplifies to:

$$c'(s_S) = \delta\left[V_{S|S}^E\left(0\right) - V_S^U\left(0\right)\right] \tag{10}$$

Backwards induction Going backwards from the steady state we can solve for the optimal consumption path and search effort during unemployment using equations (7) and (8).

1.3 Model with Present Bias

The naive present biased individual is present biased when it comes to the trade-off between current period search effort and consumption and the future return to search. The individual is naive in the sense that she assumes that in the future she will not be present biased and choose a consumption and search effort path as if she were a standard exponential discounter.

The individual has the following value function in unemployment:

$$V_t^{U,n}(A_t) = \max_{s_t \in [0,1]; A_{t+1}} u\left(c_t|r_t\right) - c\left(s_t\right) + \beta\delta\left[s_t V_{t+1|t+1}^E\left(A_{t+1}\right) + \left(1 - s_t\right)V_{t+1}^U\left(A_{t+1}\right)\right] \tag{11}$$

where the functions V_{t+1}^U and $V_{t+1|t+1}^E$ are given by equations (3) and (4) above for the exponential discounters and the budget constraint is the same.

This adds one more step to the solution algorithm, since we first solve for all possible values of V_{t+1}^U and $V_{t+1|t+1}^E$ before solving for the optimal consumption and search path given by $V_{t+1}^{U,n}$ and $V_{t+1|t+1}^{E,n}$. Note that in practice we never have to solve for the optimal consumption path of the present biased individual, since only her (naively) predicted exponential consumption path enters the decision making process during unemployment. For completeness sake, the value function during employment for the naive present biased individual is provided here and could be used to solve for the consumption path in employment:

$$V_{t+1|t+1}^{E,n}\left(A_{t+1}\right)=\max_{A_{t+1}>0} u\left(c_t|r_t\right)+\beta\delta V_{t+2|t+1}^{E}\left(A_{t+1}\right) \tag{12}$$

1.4 Hand to Mouth Model

In the hand to mouth model we have that $c_t = b_t$ when unemployed and $c_t = w$ when employed.

Note that the reference point at time t depends only on whether a worker is unemployed or, if employed, when a worker found a job. To make this distinction explicit, let's denote r_t the reference point in period t if the individual was unemployed until period $t-1$ (i.e. the individual started a job in period t), and let's denote r_t^j the reference point of an individual in period t who started a job in period j.

The value functions simplify to:

$$V_t^U=\max_{s_t\in[0,1]} u\left(b_t|r_t\right)-c\left(s_t\right)+\delta\left[s_t V_{t+1}^E+\left(1-s_t\right)V_{t+1}^U\right] \tag{13}$$

$$V_{t+1}^E=\frac{v\left(w\right)}{1-\delta}+\eta\sum_{i=1}^{N}\delta^i\left[v\left(w\right)-v\left(r_{t+i}^{t+1}\right)\right].$$

The FOC for optimal search effort is given as:

$$c'\left(s_t^*\right)=\delta\left[V_{t+1}^E-V_{t+1}^U\right]. \tag{14}$$

The assumptions on c(.) imply that $c'(.)$ is invertible and the inverse is differentiable, such that we can define $\mathcal{C}(.)\equiv c'^{-1}(.)$ and thus have that the optimal search effort is given as:

$$s_t^*=\mathcal{C}\left(\delta\left[V_{t+1}^E-V_{t+1}^U\right]\right)$$

Furthermore let $\Delta V_{t+1}\equiv V_{t+1}^E-V_{t+1}^U$. Taking derivatives of the FOC we get:

$$\frac{ds_t^*}{db_j}=\frac{d\Delta V_{t+1}}{db_j}\delta\mathcal{C}'\left(\Delta V_{t+1}\right)$$

Note that as long as the reemployment wage is always above the level of UI benefits ΔV_{t+1} is always strictly greater than zero. Furthermore, given that the cost function $c(.)$ is strictly increasing, the inverse has to be increasing and therefore $\mathcal{C}'\left(\Delta V_{t+1}\right)>0$.

1.4.1 Proof of Proposition 1

We want to prove that in the reference-dependent model $\frac{ds_{T+i}^*}{db_1}\leq 0$, for $i=0,1,...,N-1$. Since $\mathcal{C}'\left(\Delta V_{t+1}\right)>0$, this is the case as long as $\frac{d\Delta V_{T+i}}{db_1}\leq 0$. Note that $\frac{dr_{T+i}}{db_1}\leq 0$ and $\frac{dr_{T+i+j|T+i}}{db_1}\leq 0$, for all $j > 0$. We will show that $\frac{d\Delta V_{T+i}}{db_1} \leq 0$ by rewriting the terms $\frac{dV^E_{T+i}}{db_1}$ and $\frac{dV^U_{T+i}}{db_1}$ and showing that the sum is weakly smaller than 0.

Let us define the probability that an individual who is unemployed in period t is still unemployed j periods later: $\beta_{t,j} \equiv \Pi_{k=1}^{j}(1 - s_{t+k-1})$, and $\beta_{t,0} \equiv 1$.

Consider the effect of an increase in b_1 on the value of employment in period $T + i$:

$$\begin{aligned}
\frac{dV^E_{T+i}}{db_1} &= \sum_{j=0}^{N-1} \delta^j \frac{du\left(w|r^{T+i}_{T+i+j}\right)}{db_1} \\
&= \frac{du\left(w|r^{T+i}_{T+i}\right)}{db_1} + \sum_{j=1}^{N-1} \delta^j \frac{du\left(w|r^{T+i}_{T+i+j}\right)}{db_1}
\end{aligned}$$

The utility function is not differentiable at $r_t = b_t$ due to the kink. This is a minor technical issue and the following derivation holds if a) we assume the unemployed are always at a loss and the employed at a gain or b) if all derivatives are interpreted as right derivatives.

Similarly, it is helpful to write out $\frac{dV^U_{T+i}}{db_1}$ as the summation of all the possible nodes that can be reached in the probability tree and then sum them up. Using the envelope theorem, the effect of b_1 on s_t does not have a first order effect on the value of unemployment and we can write:

$$\begin{aligned}
\frac{dV^U_{T+i}}{db_1} &= \frac{du(b_{T+i}|r_{T+i})}{db_1} + \dots \\
&\quad \delta\beta_{T+i,1}\frac{du(b_{T+i+1}|r_{T+i+1})}{db_1} + \delta\beta_{T+i,0}s_{T+i}\frac{du(w|r^{T+i+1}_{T+i+1})}{db_1} + \dots \\
&\quad \delta^2\beta_{T+i,2}\frac{du(b_{t+3}|r_{T+i+2})}{db_1} + \delta^2\beta_{T+i,0}s_{T+i}\frac{du(w|r^{T+i+1}_{T+i+2})}{db_1} + \delta^2\beta_{T+i,1}s_{T+i+1}\frac{du(w|r^{T+i+2}_{T+i+2})}{db_1} + \dots \\
&\quad \delta^3\beta_{T+i,3}\frac{du(b_{t+4}|r_{T+i+3})}{db_1} + \delta^3\beta_{T+i,0}s_{T+i}\delta\frac{du(w|r^{T+i+1}_{T+i+3})}{db_1} + \delta^3\beta_{T+i,1}s_{T+i+1}\frac{du(w|r^{T+i+2}_{T+i+3})}{db_1} + \delta^3\beta_{T+i,2}s_{T+i+1}\frac{du(w|r^{T+i+3}_{T+i+3})}{db_1} + \dots \\
&= \frac{du(b_{T+i}|r_{T+i})}{db_1} + \sum_{j=1}^{N-1}\delta^j\left[\beta_{T+i,j}\frac{du(b_{T+i+j}|r_{T+i+j})}{db_1} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}\frac{du(w|r^{T+i+k}_{T+i+j})}{db_1}\right]
\end{aligned}$$

Notice that for all j we have that:

$$\beta_{T+i,j} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k} = 1,$$

since this is simply the sum of all probabilities of where an individual is in the possible employment-unemployment path tree in period j conditional on being unemployed at the beginning of t.

Now we can combine the two terms to get $\frac{d\Delta V_{T+i}}{db_1}$:

$$\frac{d\Delta V_{T+i}}{db_1} = \frac{dV^E_{T+i}}{db_1} - \frac{dV^U_{T+i}}{db_1}$$

$$
\begin{aligned}
&= \frac{du\left(w|r_{T+i}^{T+i}\right)}{db_1} + \sum_{j=1}^{N-1}\delta^j \frac{du\left(w|r_{T+i+j}^{T+i}\right)}{db_1} \\
&\quad - \frac{du(b_{T+i}|r_{T+i})}{db_1} - \sum_{j=1}^{N-1}\delta^j\left[\beta_{T+i,j}\frac{du(b_{T+i+j}|r_{T+i+j})}{db_1} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}\frac{du(w|r_{T+i+j}^{T+i+k})}{db_1}\right]
\end{aligned}
$$

Note that: $\frac{du\left(w|r_t^j\right)}{db_1} = -\eta\frac{dv\left(r_t^j\right)}{db_1} = -\eta v'\left(r_t^j\right)\frac{dr_t^j}{db_1}$ and $\frac{du(b_t|r_t)}{db_1} = -\lambda\eta\frac{dv(r_t)}{db_1} = -\lambda\eta v'(r_t)\frac{dr_t}{db_1}$. Therefore:

$$
\begin{aligned}
\frac{d\Delta V_{T+i}}{db_1} &= -\eta v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}^{T+i}}{db_1} - \eta\sum_{j=1}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}^{T+i}}{db_1} \\
&\quad + \eta\lambda v'\left(r_{T+i}\right)\frac{dr_{T+i}}{db_1} + \eta\lambda\sum_{j=1}^{N-1}\delta^j\left[\beta_{T+i,j}v'\left(r_{T+i+j}\right)\frac{dr_{T+i+j}}{db_1} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}v'\left(r_{T+i+j}^{T+i+k}\right)\frac{dr_{T+i+j}^{T+i+k}}{db_1}\right]
\end{aligned}
$$

Finally, if the benefit change b_1 affects only the benefit path prior to period $T+i$, as we presume in Proposition 1, then $\frac{dr_{T+i+j}^{T+i+i}}{db_1} = \frac{dr_{T+i+j}}{db_1} \leq 0$. We can therefore rewrite this as:

$$
\begin{aligned}
\frac{d\Delta V_{T+i}}{db_1} &= -\eta v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} - \eta\sum_{j=1}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1} \\
&\quad + \eta\lambda v'\left(r_{T+i}\right)\frac{dr_{T+i}}{db_1} + \eta\lambda\sum_{j=1}^{N-1}\delta^j\left[\beta_{T+i,j}v'\left(r_{T+i+j}\right)\frac{dr_{T+i+j}}{db_1} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}v'\left(r_{T+i+j}^{T+i+k}\right)\frac{dr_{T+i+j}}{db_1}\right] \quad (15)
\end{aligned}
$$

Because the UI benefit path is non-increasing, the reference point is also non-increasing over the UI spell. This in turn implies that: $r_{T+i+j}^{T+i} \geq r_{T+i+j}^{T+i+1} \geq r_{T+i+j}^{T+i+2} \geq \ldots$ and therefore, since $v(.)$ is concave, that $v'\left(r_{T+i+j}^{T+i}\right) \leq v'\left(r_{T+i+j}^{T+i+1}\right) \leq \ldots$. Furthermore: $v'(r_{T+i}^{T+i}) < v'(r_{T+i})$.

We can substitute these terms in the second line of equation (15) to get the following inequality:

$$
\begin{aligned}
\frac{d\Delta V_{T+i}}{db_1} &< -\eta v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} - \eta\sum_{j=1}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1} \\
&\quad + \eta\lambda v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} + \eta\lambda\sum_{j=1}^{N-1}\delta^j\left[\beta_{T+1,j}v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1}\right] \\
&= -\eta v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} - \eta\sum_{j=1}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1} \\
&\quad + \eta\lambda v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} + \eta\lambda\sum_{j=1}^{N-1}\delta^j\left[v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1}\left(\beta_{T+i,j} + \sum_{k=1}^{j}\beta_{T+i,k-1}s_{T+i+k}\right)\right] \\
&= -\eta\sum_{j=0}^{N-1}\delta^j v'\left(r_{T+i}^{T+i}\right)\frac{dr_{T+i}}{db_1} \\
&\quad + \eta\lambda\sum_{j=0}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1} \\
&= \eta\left((\lambda-1)\sum_{j=0}^{N-1}\delta^j v'\left(r_{T+i+j}^{T+i}\right)\frac{dr_{T+i+j}}{db_1}\right)
\end{aligned}
$$

Therefore if $\lambda > 1$ and $\frac{dr_{T+i+j}}{db_1} \leq 0$ for at least one $j < N$ we have $\frac{d\Delta V_{T+i}}{db_1} \leq 0$ and therefore $\frac{ds_{T+i}}{db_1} \leq 0$. Therefore frontloading UI benefits by increasing b_1 and reducing b_2, leads to a decrease in search effort in period T, $T+1$, ... $T+N-1$. This is in contrast to the standard model where frontloading benefits will only affect search effort in period $T-1$ and earlier.

Since $\frac{dr_{T+i}}{db_1} < 0$ for $i = 0, 1, ...N-1$, this proves Proposition 1.

2 Estimation

2.1 Reducing the Dimensionality of the Endogenous Savings Model from $|A|^2$ to $|A|$

In order to find the optimal consumption and search effort path we need to find the value functions (either at employment or unemployment) for every t for each pair of (A_t, A_{t+1}) and then find the optimal $A^*_{t+1}(A_t)$ that maximizes the value. In practice, we discretize the asset space to be of size $|A| = L$, so $A_t \in \{A^1, A^2, ..., A^L\}$.

It is then clear that the problem becomes of complexity of L^2 for every period t, which is highly demanding. But, we can reduce the complexity to be linear in L. Imagine you solved for the state variable A^l_t, obtaining the optimal $A^*_{t+1}(A^l_t)$. When considering the adjacent state variable, A^{l+1}_t, the optimal $A^*_{t+1}(A^{l+1}_t)$ will likely be in the neighborhood of $A^*_{t+1}(A^l_t)$. In practice, we find the global maximum for $A^*_{t+1}(A^l_t)$;[3] then, for $A^*_{t+1}(A^{l+1}_t)$ we search for the numerical maximum only for A_{t+1}'s in a fixed size bandwidth around $A^*_{t+1}(A^l_t)$; if the maximum lies on the boundary of the bandwidth, we search again for the global maximum. This method is applied for both the value of employment and of unemployment.

We use a state space with increments of 10 and allow for 50 possible values in the baseline models (i.e. asset values of 0, 10, 20, ... 490). We carefully check whether we get close to the upper bound of the state space in each estimation run and if so increase the state space.

2.2 Optimization Algorithm

We estimate the model in Matlab and use the Matlab optimizer fmincon to find the vector of parameters that minimizes the objective function. We set the following optimization options:

- Maximum function evaluations: 3000
- Maximum iterations: 3000
- Function tolerance: 10^{-12}
- X tolerance: 10^{-9}
- Algorithm: interior-point
- Large scale: off

[3] We also find the global maximum for $l = 1$ and for some additional intermediates $1 < l < L$ to verify we are not erring.

When estimating the model we draw starting values for each parameter from uniform distributions with upper and lower bounds that are wide but roughly economically reasonable, for example a γ between 0.1 and 1.3. We restrict the values of some parameters within an economically plausible range, for example $N < 800$ (days), $0 < \gamma \leq 50$, $\lambda < 30$, and $\beta \geqslant 0.01$.[4] We estimate each model using at least 200 random draws of starting values and carefully check convergence. In most cases the best 10 to 20 runs all converge to the same or virtually the same solutions. For some models convergence is less reliable and we increase the number of initial starting values.

Running time for a single specification on a server using 12 cores is usually in the the range of 8-16 hours. It depends on the number of types, and of course the number of parameters. Without the dimensionality reduction procedure described above, each run would have taken weeks to converge.

Another method we used to improve convergence was to do a two stage estimation. First, we draw a large number (e.g. 200) of initial values from a uniform distribution with a large yet reasonable support of parameter values. Second, we draw a lower number (e.g. 20 or 50) of initial values from a tighter support around the first stage best estimates (e.g. $\pm 20\%$ of first-stage best estimates). This method improves the fit considerably in a few cases, but mostly has very minor effects.

Standard errors are computed by inverting the numerically calculated Hessian matrix at the optimal solution.

[4] In the reference dependent model with heterogeneity in reemployment wages (Table 7, Column 5), we used the restriction $\beta \geq 0.1$, since otherwise we still ended up with an implausibly low estimate for β, though qualitatively the results were similar.

3 Description of the Appendix Tables

Table A-1 shows the demographic and other observable characteristics for the UI claimants in our benchmark sample. The basic demographic characteristics, such as age at time of claiming, education and log earnings in the years 2002 - 2004, are similar before and after the reform. The waiting period (the number of days between job loss and the time of claiming UI benefits) is almost identical across the two groups, indicating that people towards the end of our before sample were not trying to delay UI claiming dates in order to become eligible to the new regime. The take-up rates of the reemployment bonus scheme, which was introduced in 2005, are quite low.

Table A-2 show the structural estimation results under the assumption that unemployed are hand-to-mouth, and so their consumption equals to their income ($c_t = y_t$). The key parameter estimates are very similar to our benchmark estimates presented in Table 1. The estimated loss aversion for the reference-dependence model is 4.92 (vs. 4.92 in the benchmark table) and the speed of adjustment is 184.2 days (versus 184.6 in the benchmark estimates). The goodness-of-fit is slightly better than in our benchmark case, but the difference between the standard and reference-dependence model remains the same. These results highlight that our main results hold for hand-to-mouth consumers.

In Table A-3 we consider variants of the benchmark reference-dependent model. Column (1) explore the role of gain utility. In our benchmark model, gain utility gets weight η while loss utility gets weight $\eta\lambda$, and for estimation we set $\eta = 1$. In Column (1) we show results when there is no gain utility, but still estimating the loss utility weight. The fit of the model is almost as good as the benchmark reference-dependent one (GOF is 184.1 versus 183.5 in the benchmark), the estimated speed of updating of the reference point is nearly the same, and the estimated loss aversion is also very similar to the benchmark specification (GOF is 4.02 versus 4.69 in the benchmark).

In Table A-3 Column (2) we explore an alternative gain-loss utility formulation. In the benchmark specification the reference point depends on average past income, while the unemployed compares their current *consumption* to this reference point. Here we estimate the model with gain/loss utility formulated comparing current *income* to the reference point. The fit of this specification and the estimated parameters are very similar to the benchmark specifications, which is not surprising given that in our benchmark specification unemployed are so impatient that they essentially go hand-to-mouth, and so their consumption and income nearly coincide.

In Table A-3 Column (3) and Column (4) we explore an alternative reference point formulations. In Column (3) we have the reference point is given by last wage before the start of the unemployment spell. This reference point can be thought as the initial status-quo in our context, and it is still backward-looking, but with no adaptation. This specification does poorly (481.8 vs 183.5 in benchmark), because the adaptation over time is critical to reproduce the initial surge in hazard, the decline, and then increase again at benefit exhaustion. In Column (4) we explore forward looking reference point a' la Koszegi and Rabin (2005). Namely, the reference point in period t is the expected income in period t as in the expectations formed in period t-1. This is because in a personal equilibrium, an agent compares the realization to the expectation formed in the recent past. Notice that, while in Koszegi and Rabin the reference point is stochastic, we follow most of the literature applying the personal equilibrium concept and assume instead that the reference point is deterministic, being the expected income. To compute the expected income at period t, we take the empirical hazards in period t to calculate the expected value of income at period t, as of period t-1 (since in period t-1 the job searcher would have known the search intensity, and thus the probability of getting a job in period t. The forward looking reference point provides a poor fit to the data (478.2 vs 183.5 in benchmark).

In Table A-4 we show alternative versions of the habit formation model presented in Column (6) and (7) in Table 2. We show that habit the results with 1-type (Column (1) and Column (2)) and with 2-type heterogeneity in cost level (Column (2) and Column (4)) with AR(1) updating the reference point. In Column (6) and (7) we also explore the habit formation model with $\beta\delta$ discounting. In all specifications, the fit is significantly worse than our benchmark reference dependence suggesting that the reference-dependent model presented here has distinct predictions from habit formation models.

In Table A-5 and in Table A-6 we present further robustness checks for the standard and reference-dependent model. In Column (1) in Table A-5 we allow for background consumption: workers receive non-market income during unemployment, in addition to the benefits earned, to capture home production. The estimates are very similar to the benchmark ones. In Column (2), while still allowing for background consumption, we make the alternative assumption that workers are not eligible for welfare; thus, benefits fall to 0 after 360 days. This alternative assumption improves somewhat the fit of both the reference-dependent model and the standard model. In Column (3) and (4) we allow for a lower reemployment wage set at two thirds of the average previous wage. The alternative assumption worsens somewhat the fit, especially for the reference-dependent model. Still the reference dependent model with 1-type performs better than the standard model (216.8 vs. 236.9), though the parameter estimates on β and loss aversion are unrealistic. In Column (4) we show the results for reference-dependent model with 2-type heterogeneity (Column 4). With the same number of parameters as the standard model, the reference-dependent model achieves a much better than the standard model (189.5 vs. 236.9), while the estimated parameters on the speed of adjustment, loss aversion and the discount factor β are quite similar to our benchmark specification. In Column (5) and (6) we test the importance of the assumption of zero initial assets: endowing workers with $600 in their last period of employment does not affect much the estimates, though the fit of the reference-dependent model is somewhat worse than under the assumption of zero assets (which itself is most consistent with the estimated high impatience).

In Table A-6 Column (1) we use the identity matrix to weight the moments and in Column (2) we use the moments estimated after controlling for observables. Though the goodness of fit cannot be compared to the previous estimates, the qualitative conclusions remain the same. In Columns (3) and (4), instead of using the hazard rates as moments, we use the estimated (unconditional) probability of exiting unemployment in each 15-day period. The advantage of this alternative procedure is that we can use the full variance-covariance matrix for weights, which we do in Column (3). Once again, while the goodness of fit measures are not comparable to the benchmark models, the pattern of the results is very similar. Finally, the estimates are similar if we use the 30-day hazards or 7-day hazards, instead of 15-day hazards (Column (5) and Column (6)).

In Table A-7 we explore robustness to alternative types of heterogeneity. First, we increase the number of heterogeneous types to 5. Allowing for additional types in the standard model improves the fit all the way to 5 types; estimates with 6 or more types have trouble converging. Still, even the standard model with 5-types does significantly worse in terms of fit than the reference-dependent model with 1-type. For the reference-dependent model, there is essentially no improvement in fit going from 2 types to more types. Indeed, estimates of the reference-dependent model with more than 3 types have trouble converging. Next, we consider alternative forms of unobserved heterogeneity, such as in the reemployment wage. We take the 10th, 50th, and 90th percentile of the reemployment wage, as well as the fractions of each type (taken to be 20 percent, 60 percent, and 20 percent respectively) from the data. We then estimate three cost parameters k_j , one for each type. This alternative specification (Column (2)) improves somewhat the fit of the standard model, but the fit of the reference-dependent model is still significantly better.

In Column (3) and Column (4) in Table A-7 we explore heterogeneity in the parameters of the gain-loss utility. Allowing an additional type in the speed of adjustment improves the model fit (170 vs. 183.5 in the benchmark). The estimated speed of adjustment is 90 days for the group with quick updating and 236 days for the group with slow adjustment, which suggest that heterogeneity in the speed of adjustment plays some role in the data. In Column (5) we estimate heterogeneity in loss aversion. The model fit is almost the same as in our benchmark specification, so we found no indication for the presence of that type of heterogeneity.

In Table A-8 we show further results for the standard model with heterogeneity in the curvature of the search cost, γ. In Column (1) to (3) we increase the number of types from 2 to 4 and allow γ to take any values. The results highlight that the γ heterogeneity model needs at least 3 types to perform well. In Column (4) to (9) we restrict the gamma to rule out extremely high elasticity of search. Again, the fit of these models improve considerably from moving from 2-type to 3-type, but there is no additional improvement from adding more types. The results also highlight that once we rule-out extremely high elasticities of search, the model-fit of the standard model does not get reach the fit of the reference-dependent model.

In Table A-9 we evaluate the out-of-sample performance of three models: standard model with 3-type in cost levels, the reference-dependent model with 1-type, and the standard model with 3-type in search cost curvature. In the upper panel we show the goodness-of-fit on the unemployed claimed benefit two years before the reform. These unemployed faced with very similar benefit schedule as the one who claimed benefit 1 year before the benefit reform except the duration of the unemployment assistance was 180 days, compared to 90 days. The reference-dependent model fits the pre-period well, with an out-of-sample GOF of 53.9. The gamma heterogeneity model, instead, fits quite poorly the period of the lengthened unemployment assistance (between 300 and 450 days), with an out-of-sample SSE of 110.6. The out-of-sample fit of the standard model with heterogeneity in cost levels is better (GOF of 81.2), but does not reach the reference-dependent model.

In the middle and in the bottom panels in Table A-9 we consider the hazard rates for individuals in our main sample period, but with lower pre-unemployment income: a low-wage sample and a medium-wage sample. Both groups experience less generous benefits in the first 90 days post reform, compared to our main sample. Column (1) shows the out-of-sample predictions keeping all parameter the same as the one estimated on the main sample. Column (2) estimates a new cost-level, k, for each model, to capture the idea that workers with different wages might have different search costs.[5] Both Column (1) and Column (2) show that goodness-of-fits are considerably better for the reference-dependence model than for the standard models. Moreover, the standard model with γ heterogeneity, which has the best fit in-sample, has the worst fit out-of sample.

In Table A-10 we show individual-level regression estimates of the realized unemployment duration (censored at 540 days) on a rich set of observables (in Column (1) for the pre- and in Column (2) for the post-sample). These variables are reliable predictors of non-employment duration, with an R^2 of 0.05-0.06. In Panel B we also show the predicted duration based on these estimates. For the pre-period it varies between 230 days (5th percentile) and 370 days (95th percentile), a good amount of variation. In Column (3) and (4) we show the regression estimates for the log reemployment wage. The R^2 squares are between 0.16 and 0.18, which underlines the predicted power of these variables.

Finally, in Table A-11 we show the results related to the reservation wage model. For tractability, we estimate models with choice of search effort and reservation wage, but with hand-to-mouth consumers. Moreover, we also assume no loss/gain utility upon reemployment. In Column (3) and (4) we depict the benchmark model estimates under these new assumptions. The model fits are very similar to our benchmark estimates, which underlines that these assumptions does not alter our main results. In Column (1) and Column (2) we show the main estimates of the reservation wage models. The reference-dependent model has a better fit than the standard model (GOF of 272 versus 308), largely due to the reference-dependent model providing a better fit for the hazard moments (GOF on the hazards is 177.2 versus 218.2).

[5] In the upper panel, we calculate the goodness-of-fit for workers who happened to claim benefit 2 year before the reform but have the same wage as the one in the benchmark sample. Therefore, we should not expect that their search cost differs from the estimated one and so we do not need to reestimate them. Therefore, we only report simulation for that panel (Column 1).

4 Description of the Appendix Figures

In Figure A-1 we highlight the UI benefit schedule in the first-tier as a function of UI benefit base before and after the 2005 Reform in Hungary. The UI benefit base is calculated based on the UI contributions preceding the job loss. The figure shows that the new benefit schedule has higher-level for most earnings base in the first 90 days and then it drops to a lower level. We also highlighted the benchmark, the medium, and the low wage samples.

In Figure A-2 we present the benefit structure for the alternative samples that we consider in the out-of-sample validation: the 2-year-before sample, the low-wage sample, and the medium-wage sample.

In Figure A-3 we show the evolution of the unemployment rate and GDP growth around the reform. The unemployment rate was quite stable at around 7 percent, and the GDP growth was also stable during the sample periods, only slowing down at the beginning of 2007.

In Figure A-4 and in Figure A-5 we explore the role of recalls by exploiting a new matched employer-employee data from Hungary. In the employer-employee data we measure the length of unemployment on the monthly precision and we can identify unemployment spells that are longer than 1 month and then connect them to the UI records. This newly obtained data leads to a slightly different sample selection then the benchmark one. In Figure A-4 panel (a) we show that the main results are very similar to this alternative sample. In Figure A-4(b) we show the results in absence of recalls. We define recall as a job finding when the reemployment job is the same as the last job before job loss. Figure A-4(a) and Figure A-4(b) are virtually the same and so dropping recalls does not alter our main results. To further support this latter point in Figure A-5 we show the fraction of recalls among individual who are leaving non-employment in a given month. The graph clearly shows that recall rates are roughly constant over the benefit spell and are not affected by our reform.

Throughout the paper we calculated the hazard rates to employment. In Figure A-6 we plot the exit rate from the unemployment insurance system instead. The hazard rates from unemployment follows closely the hazard rates to employment, though the spikes at benefit exhaustion are more prominent as we expect. Moreover, the hazard rates from unemployment cannot be estimated after 300 days, since by that time nobody left in the unemployment insurance system.

In Figure A-7 we show the empirical hazard rates over longer time frame. In Panel (a) we compare the hazard rates 1 year and 2 year prior to the reform (see the sample definitions in Figure 2(b)). The strong overlap in the hazard rates suggests that our results are not driven by trend shifts in the hazard rate. In Panel (b) we compare the hazard rates 1-year after and 2-year after. Again, the hazards overlap, which proves that the documented changes in the hazards are in line with the timing of the reform.

In Figure A-8 we show graphically the fit of the hand-to-mouth model (estimated parameters in Table A-2). The pattern of the hazards and the difference between the standard 3-type and the RD 1-type model is very similar to our benchmark estimates with consumption (see Figure 6 for those results).

In Figure A-9 we present the model fit as a function of the discount factor. More precisely, we run estimations where we fix the discount factor at a particular level, and in the plot we display the goodness of fit. In Figure A-9(a) we assume no present bias and we vary delta. In Figure A-9(b) we vary instead the present-bias beta, holding delta at 0.995.

In Figures A-10 and A-11 we display the key components for the fit of the benchmark standard model (Column (1) of Table 1) and the benchmark reference-dependent model (Column (4) of Table 2): the flow utility, the value of unemployment, the reference point (for the reference-dependent model), the value of employment, the consumption, and the accumulated assets.

In Figure A-12 we plot the simulated survival function for the benchmark estimates of the standard model and of the reference-dependent model.

In Figure A-13 we display key components of the best-fitting habit formation model (with 2 types, as the 1-type model does not fit the data at all, unlike the reference-dependent model). Figure A-13(b) shows that the difference with the reference-dependent model in fit is not due to the estimated path of the reference point, as that is very similar to the reference point path for the reference-point model (appendix figure A-10). The key difference is in the flow utility (Appendix Figure A-13(c)), for a given reference point. Given the different functional form of the habit model, what matters the most is how close the reference point is to consumption at different points in the unemployment spell, as the marginal utility gets extremely high for $c$close to zr. The flow utility plot shows that this occurs first and foremost at the beginning of the unemployment spell for the pre-reform period. This makes sense, as there is a major drop from salary on the job to unemployment benefits. The next largest decline in flow utility occurs in the post-reform period around 90 days, when benefits decline from the first step to the second step. This drop is smoothed by the decumulation of assets (documented in panel (d)). Compared to these shifts, there is almost no impact of the decline in benefits at period 270, when individuals enter unemployment assistance (that is because, given the habituation in the reference point, comparatively speaking this is not a big benefit drop). Because of this, the habit formation model is unable to fit any of the patterns after day 270, in contrast to the loss-aversion model.

This is a case in which functional form differences really play an important role. The differences – $u(c) - u(r)$ versus $u(c - zr)$ -- are not a detail but rather are at the core of the differences between the two models. In our setting, the loss aversion model does much better, as it is less sensitive to small differences in which income drop is the largest.

In Figures A-14 and A-15 we present the fit of the model for some of the robustness checks presented in the Appendix Tables.

In Figure A-16 we present the fit of the reservation wage model estimated in Appendix Table A-11.

In Figure A-17 we present the fit of the hazard corresponding to some of the gamma-heterogeneity models estimated in Appendix Table A-8.

In Figure A-18 we show simulations of the hazards for the case in which the level of the welfare benefits received after 360 days were to be increased by 10 percent, or decreased by 10 percent. Notice that we do not observe one such reform in our time period, but the figure shows how the gamma-heterogeneity model would display an extreme response to a reform of this type.

Finally, in Figure A-19 we present the out-of-sample predictions, holding the estimated models at the benchmark estimates, for the medium-wage sample and the low-wage sample discussed in Appendix Figure A-2.

Table A-1: Descriptive Statistics: Comparing Means of Main Variables Pre- and Post UI Reform

	before (1)	after (2)	diff (3)	t-stat (4)
Percent Women	41%	46%	5.2%	5.75
	(0.006)	(0.006)		
Age in Years	36.8	36.9	0.06	0.47
	(0.1)	(0.1)		
Imputed Education (years)	12.83	13.00	0.17	4.20
based on occupation	(0.028)	(0.031)		
Log Earnings in 2002	11.55	11.52	-0.03	-3.56
	(0.006)	(0.006)		
Log Earnings in 2003	11.70	11.68	-0.03	-2.72
	(0.005)	(0.007)		
Log Earnings in 2004	11.79	11.78	-0.01	-1.37
	(0.007)	(0.007)		
Waiting period*	31.1	32.0	0.84	1.18
	(0.47)	(0.51)		
Reemployment bonus claimed	0.000	0.059	0.059	19.81
	(0)	(0.003)		
Participate in training	N.A.	0.042		
		(0.003)		
Number of observations†	6305	5562		

Notes:

Participation in training programs was not recorded prior to 2006.

* Number of days between job loss and UI claim.

† There are some missing values for earnings in 2002-2004 .

Table A-2: Structural Estimation of Standard and Reference Dependent Model with Hand-to-Mouth Consumers

	Standard 3-type	Ref. Dep. 1-type
	(1)	(2)
Parameters of Utility Function		
Loss aversion λ		4.92
		(0.76)
Adjustment speed of reference point N in days		184.6
		(9.0)
Discount factor (15 days) δ	0.98	0.89
	(0.06)	(0.02)
Parameters of Search Cost Function		
Curvature of search cost γ	0.13	0.84
	(0.26)	(0.17)
Search cost for high cost type k_{high}	126.59	381.4
	(151.97)	(169.1)
Search cost for medium cost type k_{med}	75.65	
	(117.65)	
Search cost for low cost type k_{low}	26.38	
	(45.36)	
Share of high cost UI claimant	0.34	
	(0.17)	
Share of medium cost UI claimant	0.49	
	(0.16)	
Model Fit		
Number of moments used	70	70
Number of estimated parameters	7	5
Goodness of Fit	215.2	186.0

Notes:
The table shows parameter estimates for the standard and the reference dependent search model with hand-to-mouth consumption $y_t = c_t$. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.

Table A-3: Alternative Specifications for Reference-Dependent Model

	No Gain Utility	**Gain-Loss Utility based on Income**	**Reference Point: Pre-Unemp. Wage**	**Reference Point: Forward Looking Koszegi-Rabin**	**Reference Point does not include current period**
	(1)	(2)	(3)	(4)	(5)
Parameters of Utility Function					
Loss aversion λ	4.02	4.70	0.997	8.56	4.54
	(0.31)	(0.63)	(.)	(16.9)	(0.56)
Adjustment speed of reference point N in days	161.1	165.8			152.3
	(10.5)	(10.7)			(12.7)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.57	0.01	0.10	0.58
	(0.03)	(0.19)	(.)	(0.06)	(0.21)
Curvature of search cost γ	0.37	0.37	3.23	3.27	0.37
	(0.02)	0.19)	(.)	(2.26)	(0.21)
Model Fit					
Number of moments used	70	70	70	70	70
Number of estimated parameters	5	5	4	4	5
Goodness of Fit	184.1	184.1	481.8	478.2	183.7

Notes:
The table shows parameter estimates for the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments. Standard errors for estimated parameters in parentheses. Column (3) is at the boundary of the parameter space ($\beta \geq 0.01$) and we therefore do not compute standard errors.

Table A-4: Estimation of the Habit Formation Model - a la Constantinides (1990)

	δ-discounting				βδ-discounting			
	1 type	1 type AR(1)	2 type	2 types AR(1)	1 type	1 type AR(1)	2 type	2 type AR(1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Parameters of Utility Function								
Habit Parameter z	0.336	0.238	0.342	0.238	0.339	0.239	0.344	0.238
Adjustment speed of reference point N in days	402.640		223.5		303.490		205.3	
AR(1) Parameter		0.90		0.93		0.95 (0.03)		0.97
Half life of AR(1) process		99.7		141.2		198.6		341.3
Discount factor (15 days) δ	0.998		0.926	0.923	0.995	0.995	0.995	0.995
Discount factor β	1	1	1	1	0.252	0.51	0.78	0.094
Parameters of Search Cost Function								
Curvature of search cost γ	0.047	10.19	0.48	0.853	1.78	1.76	0.19	1.26
Search Cost for high cost type	658.7	9876.7	150.5	87.3	97.7	9360.3	6679.2	207.8
Search Cost for medium cost type			67.4	26.4			72.7	5.3
Share of high cost UI claimant			0.51	0.74			0.14	0.77
Model Fit								
Number of moments used	70	70	70	70	70	70	70	70
Number of estimated parameters	5	5	7	7	5	5	7	7
Goodness of Fit	360.4	434.9	235.9	247.6	337.6	438.7	235.1	232.4

Notes:
The table shows parameter estimates for the habit-formation model, where the utility function is: $log(c_t - zr_t)$. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses. The parameter estimates for z in columns (1) and (2) are not well identified (i.e. the Hessian cannot be inverted for z close to the reported values) and therefore we do not provide standard errors for them. The other standard errors are calculated by inverting the Hessian matrix after dropping z from the matrix.

Table A-5: Robustness to Alternative Specifications for Utility Function and Estimation Methods

	Background Consumption	Alternative Welfare assumption	Lower Reemployment Wage		Higher Initial Assets	
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Model						
Discount factor (15 days) δ	0.932	0.901	0.916		0.884	
	(0.009)	(0.007)	(0.008)		(0.005)	
Non-market income	14					
	(21.7)					
Number of moments used	70	70	70		70	
Number of estimated param.	8	8	7		7	
Goodness of fit (SSE)	227.6	211.1	236.9		225.9	
Reference Dependent Model						
Number of cost types	1 type	1 type	1 type	2 type	1 type	2 type
Loss aversion λ	4.72	10.33	11.85	4.97	8.73	5.13
	(0.87)	(3.14)	(3.52)	(0.66)	(0.91)	(1.04)
Adjustment speed of reference point N	166.3	156.2	97.4	171.7	126.1	170.3
	(10.3)	(16.4)	(8.3)	(11.2)	(9.3)	(15.3)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.23	$0.05^{\dagger}$	0.46	0.07	0.31
	(.)	(0.22)	(.)	(0.18)	(0.05)	(0.21)
Non-market income	0.99	130				
	(.)	(.)				
Model Fit						
Number of moments used	70	70	70	70	70	70
Number of estimated param.	6	6	5	7	5	7
Goodness of fit (SSE)	183.7	173.5	216.8	189.5	192.5	181.4

Notes:
The table shows parameter estimates for the standard and the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
In columns (5) and (6) assets at the start of the UI spell are assumed to be $600.
†Specification has β restricted to be larger than 0.05. Without the restriction, β hits the constraint at 0.01 with a similar SSE.

Table A-6: Robustness to Alternative Specifications for Utility Function and Estimation Methods

	Identity Weighting Matrix	Moments with controls	Probability Moments Full Cov	Probability Moments Not full Cov	7 day time periods	30 day time periods
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Model						
Discount factor (15 days) δ	0.872	0.918	0.928	0.928	0.968	0.876
	(0.008)	(0.044)	(0.011)	(0.011)	(0.001)	(0.018)
Non-market income						
Number of moments used	70	70	70	70	156	36
Number of estimated param.	7	7	7	7	7	7
Goodness of fit (SSE)	0.0033	187.5	226.1	226.1	414.6	148.19
Reference Dependent Model						
Number of cost types	1 type	1 type	1 type	1 type	1 type	1 type
Loss aversion λ	4.33	5.69	5.78	5.78	4.46	4.69
	(0.48)	(1.17)	(1.13)	(1.13)	(0.46)	(0.66)
Adjustment speed of reference point N	174.6	157.5	171.4	171.4	200.2	163.8
	(13.0)	(14.0)	(12.1)	(12.1)	(12.6)	(12.4)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.55	0.58	0.58	0.54	0.60
	(0.17)	(0.25)	(0.22)	(0.22)	(0.15)	(0.20)
Model Fit						
Number of moments used	70	70	70	70	154	36
Number of estimated param.	5	5	5	5	5	5
Goodness of fit (SSE)	0.0027	143.6*	183.7*	183.7*	367.5	107.1

Notes:
The table shows parameter estimates for the standard and the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
In column (8) assets at the start of the UI spell are assumed to be $600.
* The SSE with the alternative moments are not directly comparable to the goodness of fit statistics in the other columns. †Specification has β restricted to be larger than 0.05. Without the restriction, β hits the constraint at 0.01 with a similar SSE.

Table A-7: Robustness to Alternative Types of Heterogeneity

Models:	5 cost types	Heterogeneity Wages	Heterogeneity in Adjustment Speed N	Heterogeneity in Loss Aversion λ
	(1)	(2)	(3)	(4)
Standard Model				
Discount factor (15 days) δ	0.920	0.934		
	(0.004)	(0.005)		
Curvature of search cost γ	0.32	0.58		
	(0.04)	(0.03)		
Number of moments used	70	70		
Number of estimated parameters	10	5		
Goodness of fit (SSE)	222.5	209.1		
Reference Dependent Model				
Loss aversion λ	*	2.68	7.98	29.89
		(1.04)	(2.56)	(1.25)
Loss aversion λ - Type 2				3.88
				(0.35)
Adjustment speed of reference point N	*	164.71	236.89	170.7
		(33.16)	(31.83)	(844.3)
Adjustment speed N - type 2			90.24	
			(3.345)	
Discount factor (15 days) δ	*	0.995	0.995	0.995
Discount factor beta	*	0.57	0.23	0.65
		(0.38)	(0.66)	(1.58)
Curvature of search cost γ	*	0.41	0.76	0.30
		(0.34)	(0.44)	(0.31)
Model Fit				
Number of moments used		70	70	70
Number of estimated parameters		7	7	7
Goodness of fit (SSE)		193.4	170.0	183.09

Notes:
The table shows parameter estimates for the standard and the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
Column (2) allows for 3 different types with different reemployment wages (calibrated to match the empirical distribution of reemployment wages). * The reference dependent model does not converge with more than 4 types, indicating that additional types are not identified and do not improve the fit.

Table A-8: Standard Model with Heterogeneity in Curvature of Search Cost γ - Alternative Specifications

	Unrestricted γ			Restricted: $\gamma > 0.1$			Restricted: $\gamma > 0.2$		
	2 types	3 types	4 types	2 types	3 types	4 types	2 types	3 types	4 types
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Discount factor (15 days) δ	0.89	0.89	0.90	0.89	0.86	0.86	0.89	0.86	0.86
	(0.04)	(0.01)	(0.01)	(0.04)	(0.01)	(1.66)	(0.01)	(0.01)	(2.22)
Curvature of search cost γ - Type 1	0.17	0.2	1.02	0.17	1.84	0.36	0.63	0.49	0.20
	(0.01)	(0.0)	(0.00)	(0.010)	(0.01)	(0.00)	(0.05)	(0.01)	(0.01)
Curvature of search cost γ - Type 2	0.57	1.00	0.004	0.57	0.10	0.10	0.20	1.92	0.49
	0.03	(0.02)	(0.164)	(0.03)	(0.39)	(0.03)	(0.02)	(0.02)	(0.01)
Curvature of search cost γ - Type 3		0.02	0.01		0.36	1.83		0.20	4.14
		(0.16)	(0.03)		(0.01)	(0.01)		(0.34)	(0.02)
Curvature of search cost γ - Type 4			0.19			0.44			1.89
			(0.00)			(0.63)			(349.26)
Level of search cost k	28.9	17.1	19.3	28.8	17.7	17.7	32.13	25.26	25.26
	(1.0)	(0.2)	(0.1)	(1.0)	(0.1)	(0.14)	(1.34)	(0.36)	(0.36)
Share of type 1	0.49	0.47	0.16	0.50	0.08	0.50	0.49	0.51	0.41
		(0.02)	(0.03)	(0.01)	(0.02)	(0.38)	(0.01)	(0.02)	(0.02)
Share of type 2		0.16	0.15		0.41	0.41		0.08	0.51
		(0.03)	(0.12)		(0.01)	(0.10)		(0.02)	(0.02)
Share of type 3			0.22			0.08			0.001
			(0.12)			(0.04)			(0.213)
Model Fit									
Number of moments used	70	70	70	70	70	70	70	70	70
Number of estimated parameters	5	7	9	5	7	9	5	7	9
Goodness of Fit	267.8	154.8	145.7	267.8	192.0	192.1	268.4	209.6	209.6

Notes:
The table shows estimates of the standard model with heterogeneity in the curvature of the search cost function γ. The first three columns allow for 2, 3 and 4 types of heterogeneity without restricting γ. Columns (4) to (6) restrict $\gamma > 0.1$ and columns (7) to (9) restrict $\gamma > 0.2$.

Table A-9: Out-of-Sample Performance of Models for low and medium pre-unemployment earnings samples

	Simulation	Estimation with 1 cost shifter
2 Year Before Period		
Reference Depenent Model, no heterogeneity	53.9	
Standard Model with 3 cost types	81.2	
Standard Model with 3 γ-types	110.6	
Low Earnings Sample		
Reference Depenent Model, no heterogeneity	157.531	117.236
Standard Model with 3 cost types	331.796	142.496
Standard Model with 3 γ-types	440.053	181.798
Medium Earnings Sample		
Reference Depenent Model, no heterogeneity	215.303	156.147
Standard Model with 3 cost types	353.611	172.337
Standard Model with 3 γ-types	594.36	187.133

Notes:
The table shows the goodness of fit statistics (SSE) for the out-of-sample fit of the estimated the reference-dependent model with 1 cost type, the standard model with 3 search cost types and the standard model with three γ-types. The first panel shows the out-of-sample fit for the period 2 years before the reform. The second panel for the low pre-unemployment earnings sample and the bottom panel for the medium pre-unemployment earnings sample. See Figure A-1 and A-2 for the samples and respective benefit paths.

Table A-10: Predicting non-employment durations and reemploment wages for test of dynamic selection

	Non-employment duration		**Log Reemployment Wages**	
	Pre-reform	Post-reform	Pre-reform	Post-reform
	(1)	(2)	(3)	(4)
Completed vocational school	-39.98***	-31.49***	0.037	0.091***
	(8.25)	(8.95)	(0.03)	(0.029)
Completed secondary school	-30.02***	-15.26	0.11***	0.150***
	(8.86)	(9.64)	(0.03)	(0.03)
Completed tertiary education	-49.10***	-40.79***	0.42***	0.44***
	(11.64)	(11.77)	(0.04)	(0.038)
Age between 30-34	7.12	22.48***	-0.002	-0.003
	(7.40)	(8.13)	(0.02)	(0.025)
Age between 35-39	10.85	31.44***	-0.013	-0.004
	(7.57)	(8.31)	(0.02)	(0.03)
Age between 40-44	19.76**	29.53***	-0.014	-0.014
	(7.95)	(8.84)	(0.02)	(0.028)
Age between 45-49	30.24***	51.25***	-0.007	-0.022
	(7.82)	(8.64)	(0.02)	(0.027)
Female	6.55	12.48**	-0.068***	-0.094***
	(5.79)	(6.22)	(0.02)	(0.020)
Waiting period	0.44***	0.49***	0.000	-0.0005**
	(0.07)	(0.07)	(0.0002)	(0.0002)
Log-earnings in 2002	6.66	17.43	0.039	0.04
	(11.31)	(11.88)	(0.04)	(0.04)
Log-earnings in 2003	-33.14***	-52.86***	0.19***	0.20***
	(10.43)	(10.76)	(0.03)	(0.03)
Observations	6,305	5,562	5,460	4,678
R-squared	0.048	0.059	0.155	0.177
Panel B predicted percentiles				
5th percentile	228	206	11.05	11.17
25th percentile	264	247	11.19	11.27
median	291	280	11.3	11.39
75th percentile	320	313	11.48	11.59
95th percentile	366	362	11.83	11.93

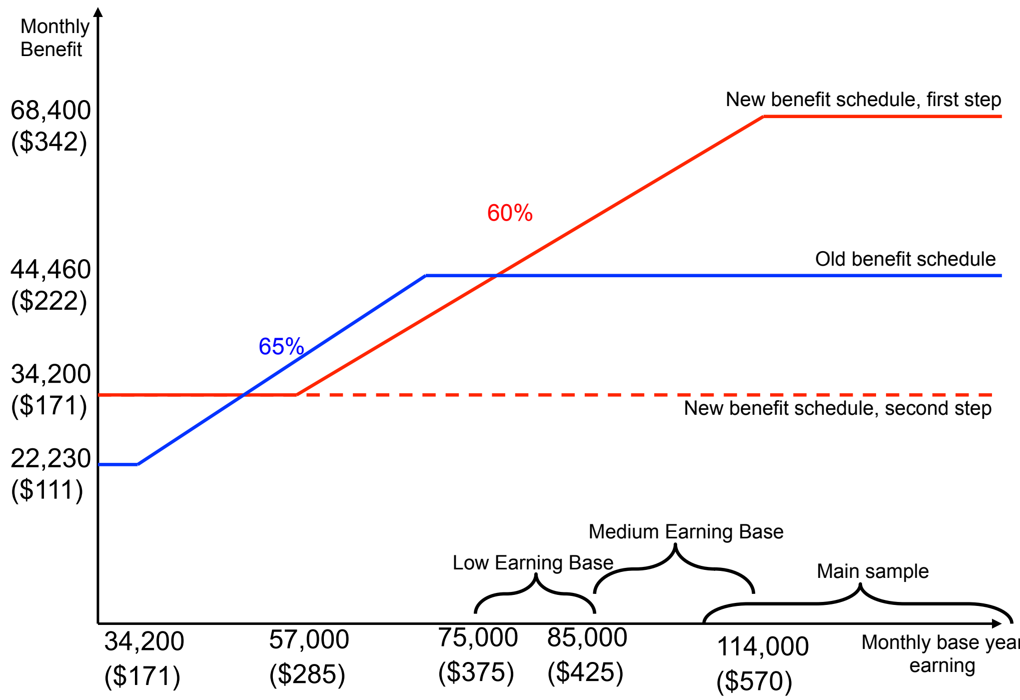
Notes:
Non-employment durations are capped at 540 days.The estimates in columns (1) and (3) are based on the pre-reform period, the estimates in column (2) and (4) on the post reform period. The omitted category is males with finished elementary school, between 25 and 29 years. All columns control for the county of residence, day and the month when UI claimed and occupation before job loss (1 digit) Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A-11: Estimates with Reservation Wages

	Reservation Wage Model		HTM Model without Loss / Gain upon reemployment	
	Std Res. Wage	Ref. Dep. Res. Wage	Std HTM	Ref. Dep. HTM
	(1)	(2)	(3)	(4)
Parameters of Utility Function				
Loss aversion λ		1.38		2.16
		(0.19)		(0.40)
Adjustment speed of reference point N		210.0		216.2
		(16.4)		(17.9)
Discount factor (15 days) δ	0.98	0.97	0.97	0.92
	(0.02)	(0.01)	(0.06)	(0.02)
Log reemployment wage	6.00	6.02		
	(0.01)	(0.01)		
Sd of log reemploment wage	0.5	0.5		
Parameters of Cost Function				
Curvature of search cost γ	0.15	0.22	0.13	0.54
	(0.14)	(0.10)	(0.26)	(0.16)
Search cost for high cost type k_{high}	668583.9	103.7	127.0	141.2
	(.)	(12.7)	(153.3)	(43.0)
Search cost for medium cost type k_{med}	76.2		75.9	
	(39.5)		(118.6)	
Search cost for low cost type k_{low}	14.5	0.0	26.5	12.2
	(10.6)	(1.3)	(45.7)	(5.3)
Share of low cost UI claimant	0.22	0.10	0.17	0.02
	(0.02)	(0.09)	(0.04)	(0.01)
Share of medium cost UI claimant	0.61		0.49	
	(0.03)		(0.16)	
Model Fit				
Number of moments used	140	140	70	70
Number of estimated parameters	8	8	7	7
Goodness of fit (SSE)	308.1	272.3	215.2	170.1
SSE in hazard moments	218.2	177.2		

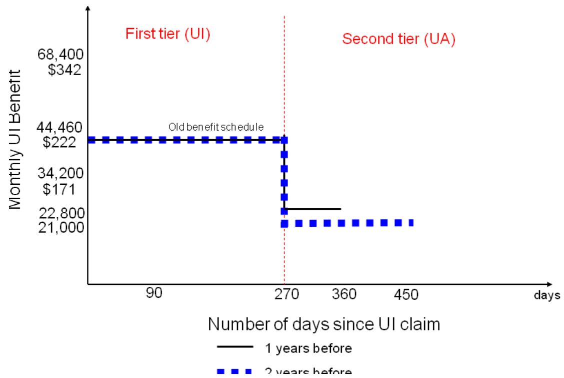
Notes:
The table shows estimates of the standard and reference dependent models with reservation wages and hand-to-mouth consumers in columns (1) and (2), assuming no loss/gain utility upon reemployment. All models assume a log utility function for the flow utility. For comparison, columns (3) and (4) show the hand-to-mouth standard and reference-dependent models with loss/gain utility shut down. Furthermore we show the goodness of fit statistic for all moments (hazard and reemployment wage moments), as well as for only the hazard moments to make it easier to compare with the non-reservation wage model.

Figure A-1: The UI Benefit Schedule Before and After the 2005 Reform in Hungary

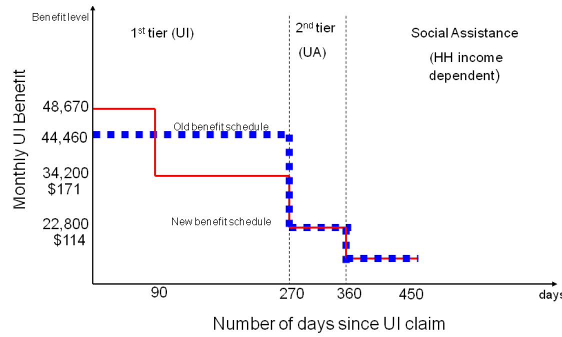


Notes: The figure shows monthly UI benefits in the first tier under the old rule (blue solid line), in the first 90 days under the new rules (red solid line), and between 91-270 days under the new rules (red dashed line) as a function of the monthly base salary. The main sample, defined by being above the 70th percentile of the earnings base distribution of the UI claimants in the given year, is indicated by the curly brackets.

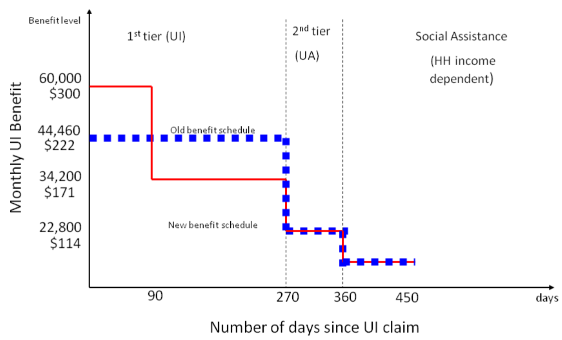
Figure A-2: The Benefit Path 2-years before the reform and for the low / medium earnings samples



(a) 2 years before the reform



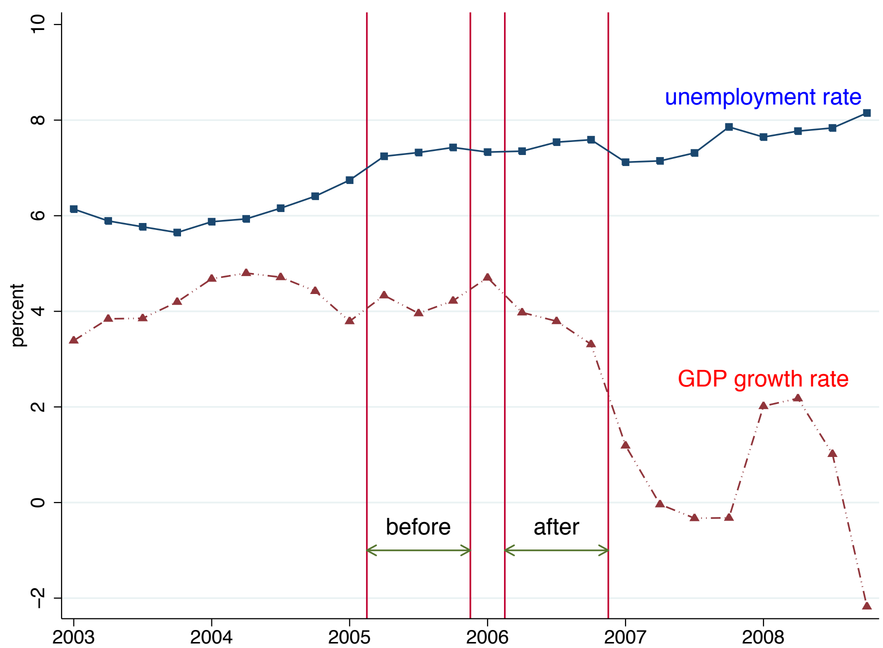
(b) Low earnings sample



(c) Medium earnings sample

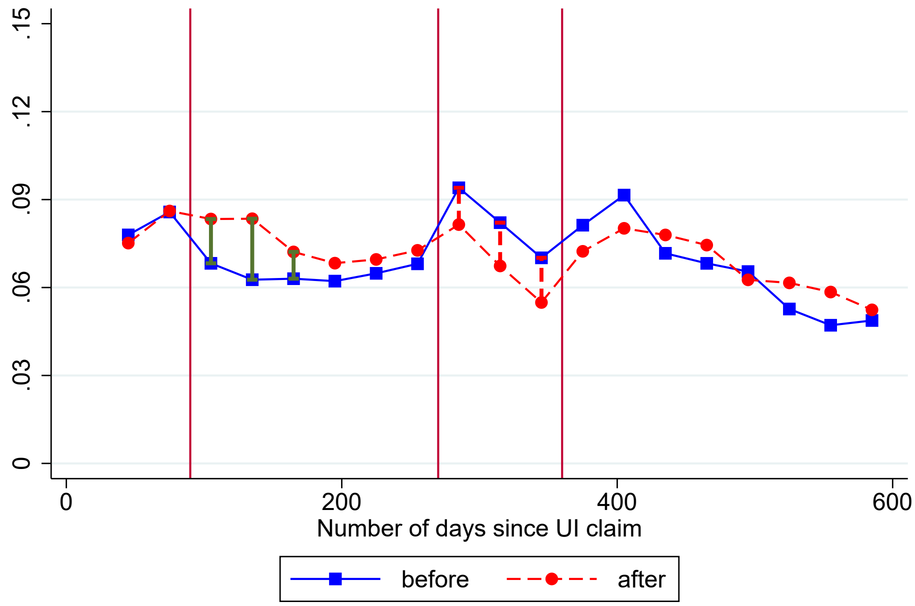
Notes: The figure shows the UI / UA / Welfare benefit paths for the samples used in the out-of-sample predictions. The first panel corresponds to the benefits from 2 years to 1 year prior to the reform, when UA could be claimed for 460 days. The second and third panels correspond to the low and medium earnings samples (see Figure A-1).

Figure A-3: GDP growth and unemployment rate in Hungary

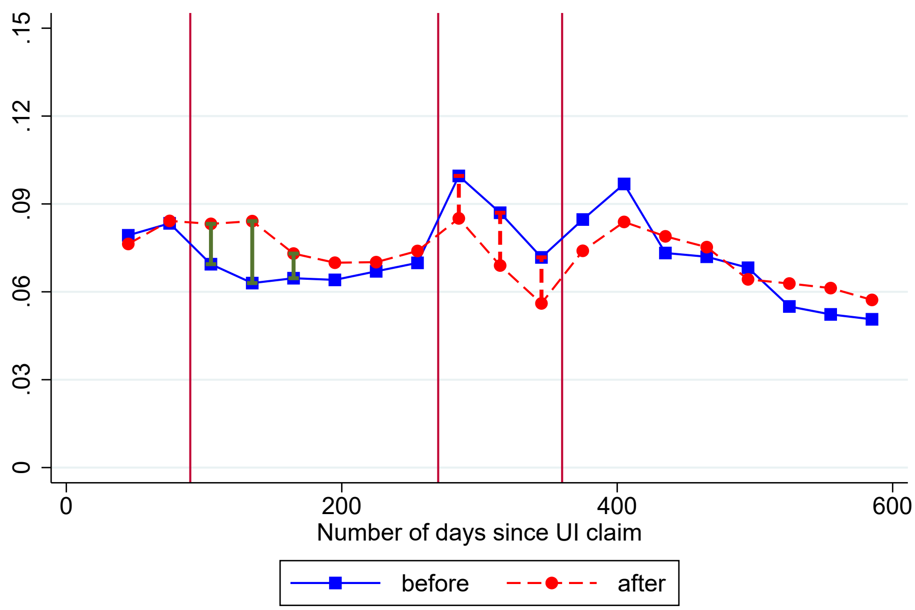


Notes: The figure shows the seasonally adjusted GDP growth rate (dashed red line) and the seasonally adjusted unemployment rate (solid blue) between 2003 and 2008 in Hungary. The major (red) vertical lines indicate the period we use for the before-after comparison. The data was obtained from the Hungarian Central Statistical Office.

Figure A-4: Exit Hazard in alternative Linked Employer-Employee Data, with and without Recalls



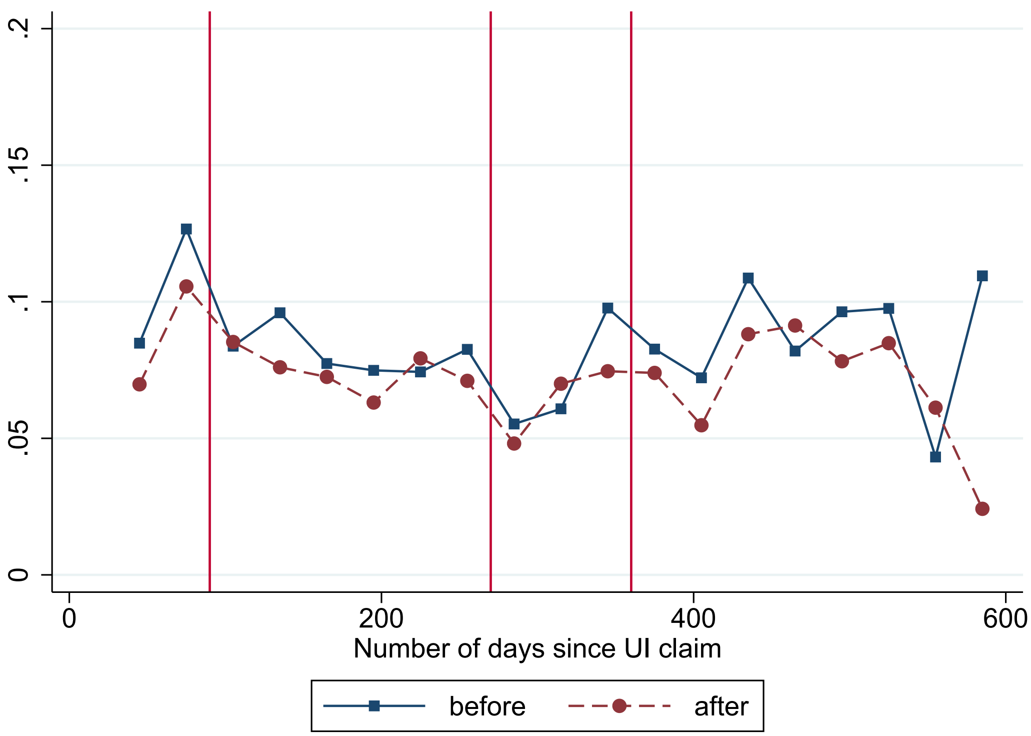
(a) Exit Hazard - All Spells



(b) Exit Hazard - Excluding Recalls

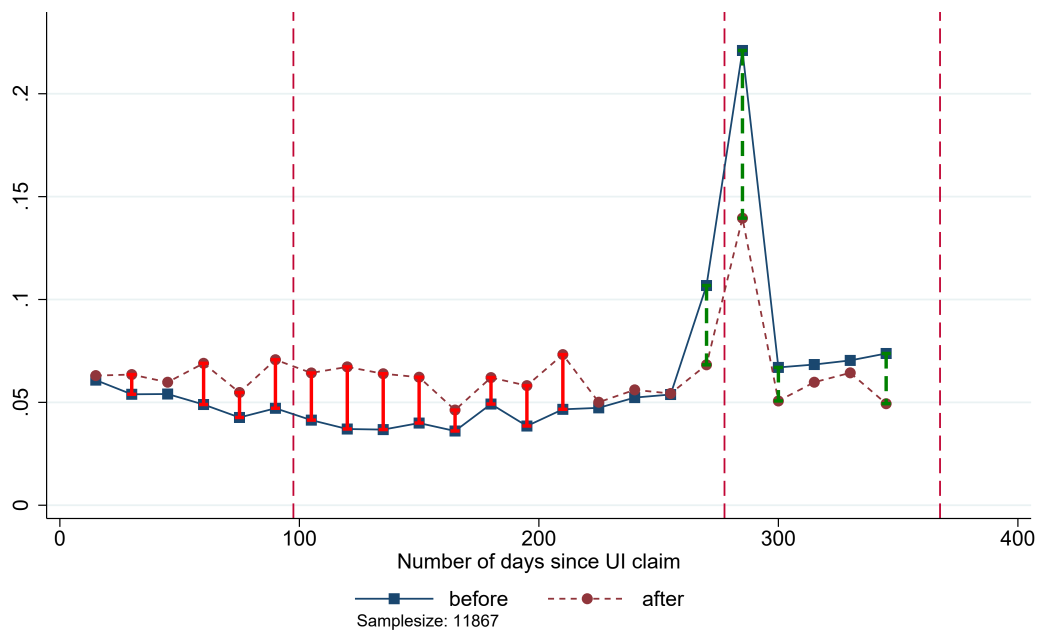
Notes: The figure shows the hazard of leaving non-employment estimated using the Hungarian Linked Employer-Employee data, an alternative dataset that measures the length of non-employment only on the monthly level, but allows us to observe recalls to the pre-unemployment employer. We follow the restrictions from our main sample as far as possible and identify non-employment spells lasting at least one month. Due to the frequency of the data we show the hazards on the monthly level. The top figure shows the hazard for the full sample while the bottom figure drops recalls, that is individuals who return to their pre-unemployment employer.

Figure A-5: Fraction of Recalls by Non-employment Duration in Alternative Linked Employer-Employee Data



Notes: Using the same data and sample structure as for Figure A-5, this figure shows the fraction of recalls among individuals who are leaving non-employment in a given month.

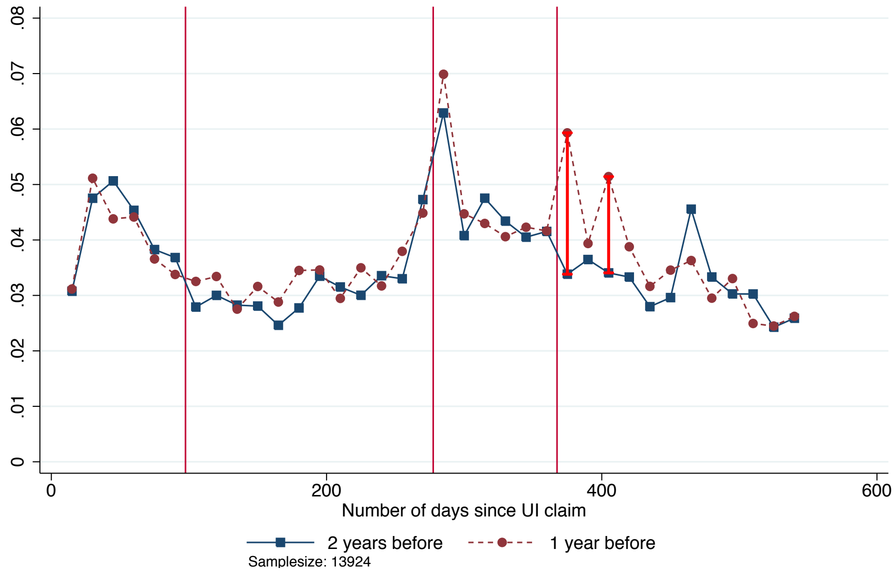
Figure A-6: Exit Hazard from Unemployment Insurance / Unemployment Assistance Benefits



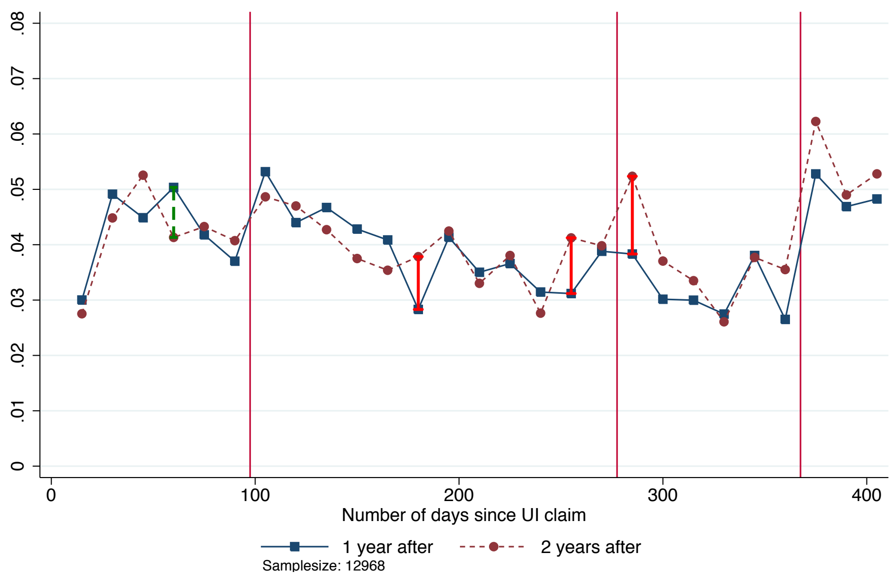
(a) Exit Hazard from UI / UA Benefits

Notes: The figure shows the hazard of leaving the UI / UA system, irrespective of whether an individual leaves non-employment. The spike at 300 days is due to individuals not taking up UA benefits. We omit the spike at 360, where UA benefits expire and the hazard rate is mechanically equal to 1.

Figure A-7: Comparison of Hazards over Longer Time Frame



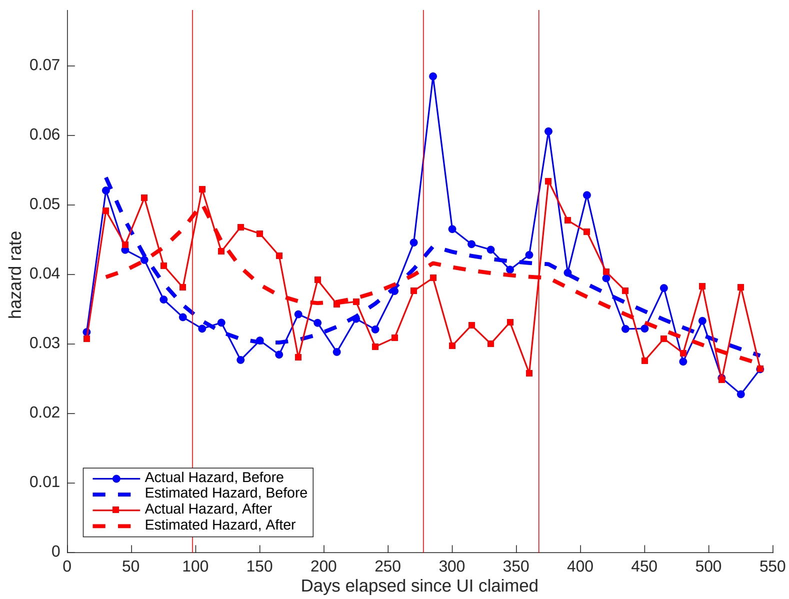
(a) Comparing the hazards 2 year before and 1 year before



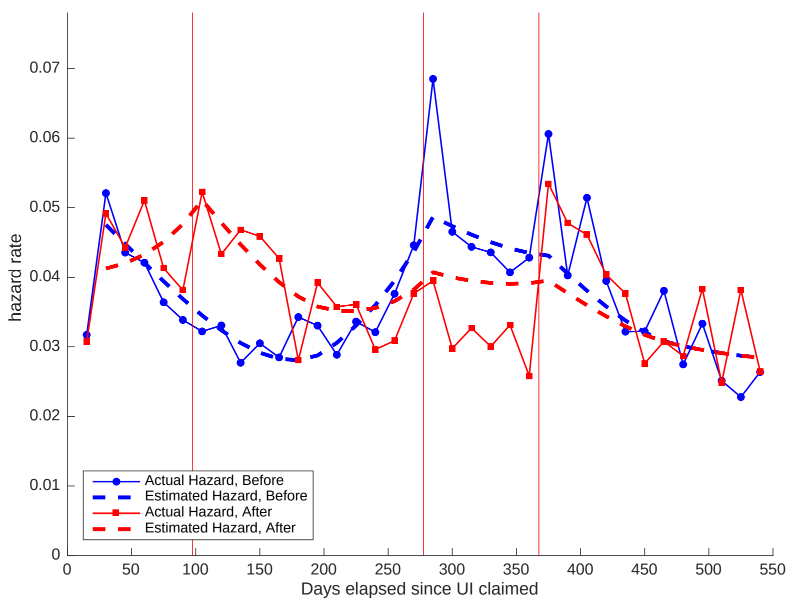
(b) Comparing the hazards 2 year after and 1 year after

Notes: Panel (a) shows point wise estimates for the empirical hazards for two year before (claimed benefit between February 5st, 2004 and October 15th, 2004) and one year before (claimed benefit between February 5th, 2005 and October 15th, 2005) the actual reform. Panel (b) shows point wise estimates for the empirical hazards for one year after (claimed benefit between February 5th, 2006 and October 15th, 2006) and two years after (claimed benefit between February 5th, 2007 and October 15th, 2007) the actual reform. This graph is censored at 400 days because of data limitations. The differences between the two periods are estimated point wise at each point of support and differences which are statistically significant are indicated with a vertical bar. The three major vertical lines indicate periods when benefits change in the new system. Other sample restrictions are the same as in Figure 3 in the main text.

Figure A-8: Estimates of the Standard and Reference-dependent Model with Hand-to-Mouth Consumers



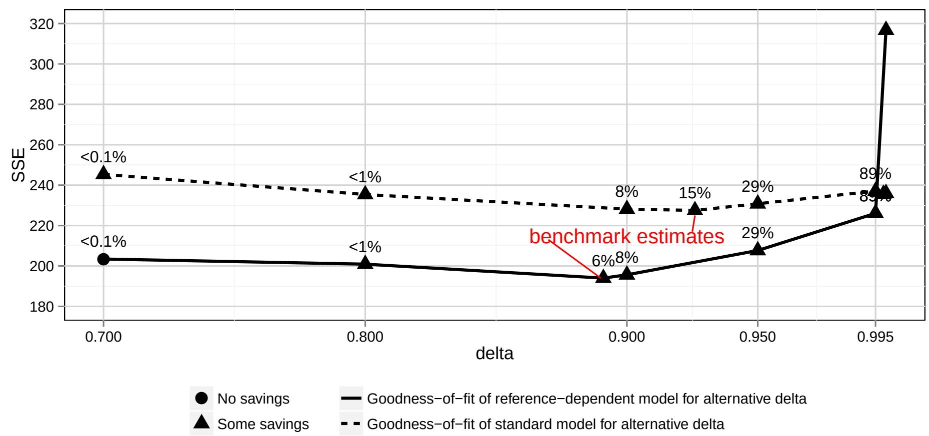
(a) Standard Model



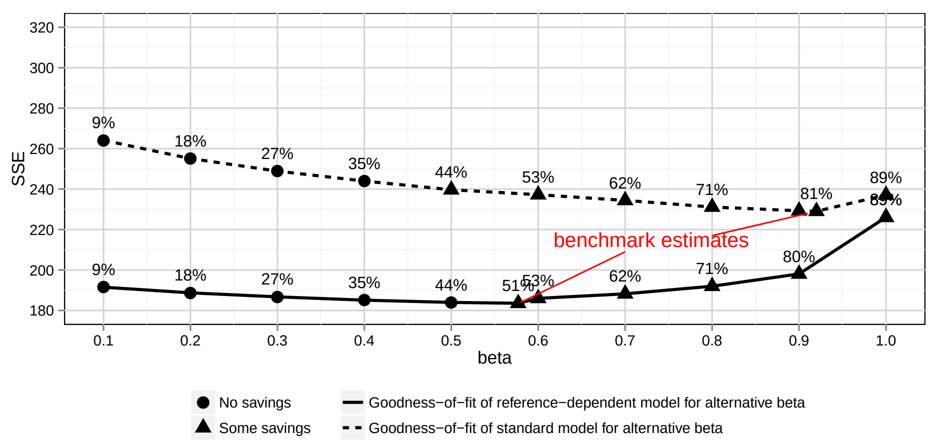
(b) Reference-dependent Model

Notes: The figure shows the empirical hazards and the predicted hazards of the standard and the reference-dependent model with hand-to-mouth consumers. Panel (a) corresponds to the standard model with 3 cost types, while Panel (b) corresponds to the reference-dependent model with 1 cost type. The three major (red) vertical lines indicate periods when benefits change in the new system.

Figure A-9: Model Fit as Function of Different Discount Rates



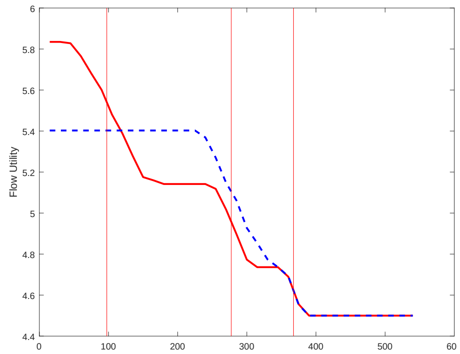
(a) Goodness of Fit of Standard and Reference-Dependent model for different δ



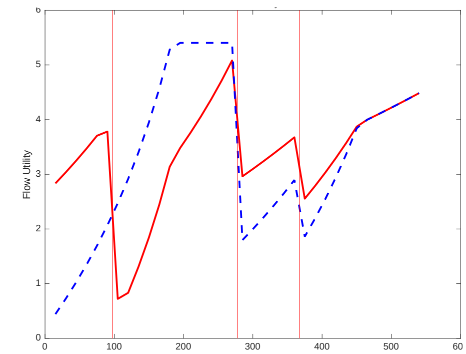
(b) Goodness of Fit of Standard and Reference-Dependent model for different β

Notes: The figures show the goodness of fit statistics for the standard and reference-dependent model for different parameter values for δ (Panel a) and β (Panel b). The standard model is estimated with 3 types of heterogeneity (in search costs) and the reference dependent model without heterogeneity. Each symbol represents one estimation run. For each set of estimates we also indicate whether the estimated model features any savings on the side of individuals. The numbers next to the markers indicate the implied annual discount factor.

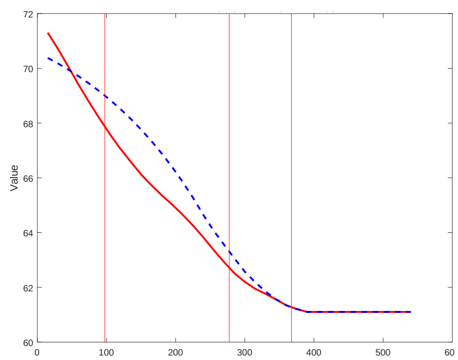
Figure A-10: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part I



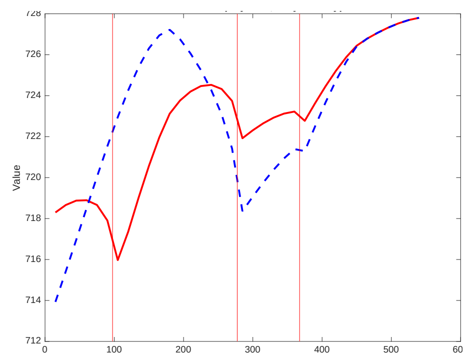
(a) Flow Utility, Standard Model



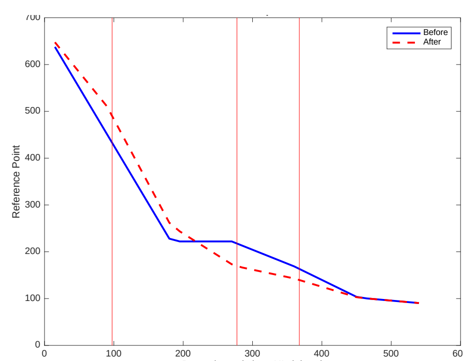
(b) Flow Utility, Reference-Dependent model



(c) Value of Unemployment, Standard Model



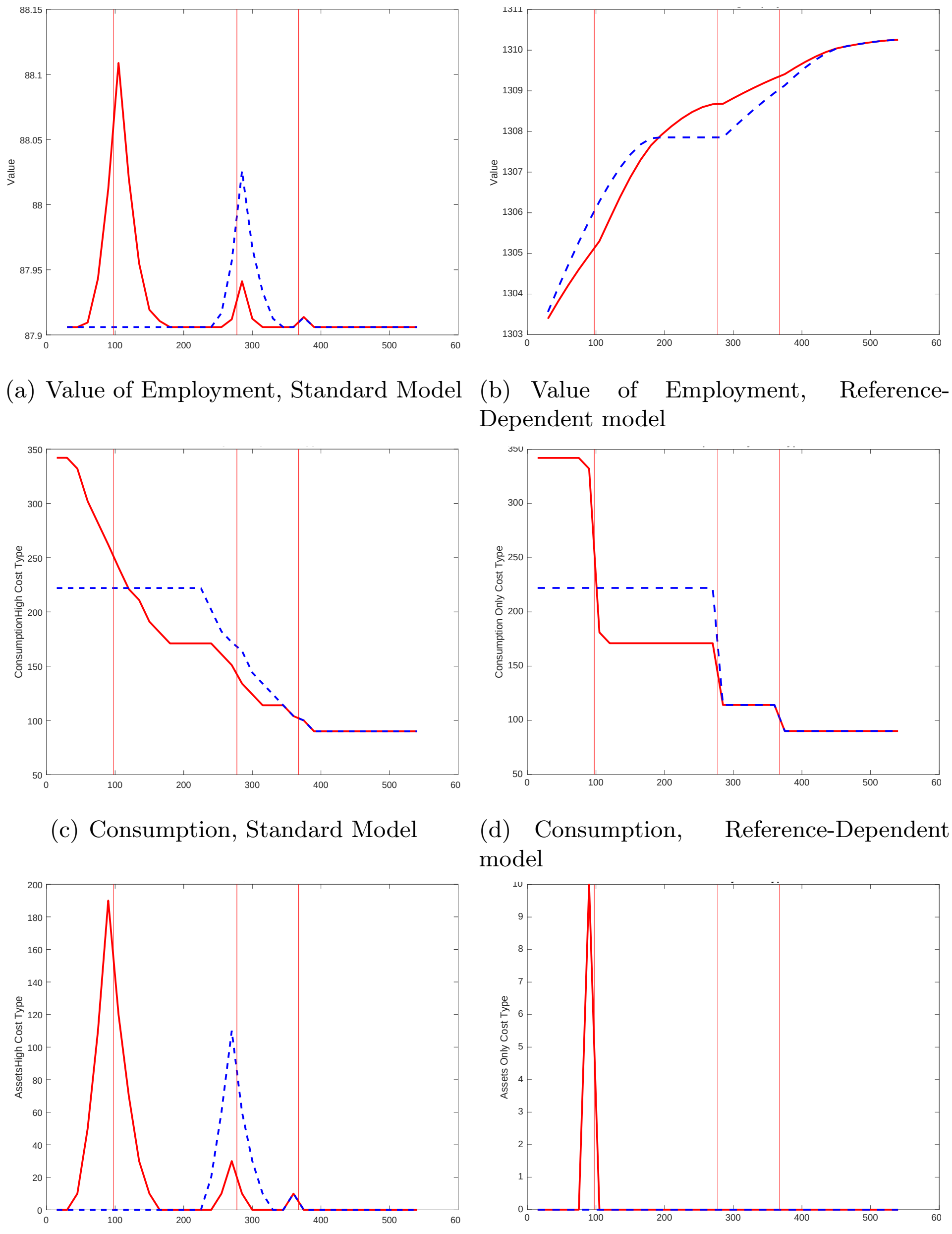
(d) Value of Unemployment, Reference-Dependent model



(e) Reference Point, Reference-Dependent Model

Notes: The figure shows the model components for the standard model (estimates shown in column (1) in Table 1) and for the reference-dependent model (estimates shown in column (4) in Table 1). For the standard model the high cost type is shown. Panel (a) and Panel (b) show the flow utility for the standard model and for the reference-dependent model, respectively. Panel (c) and Panel (d) shows the value of unemployment for the high cost type for the standard model and for the reference-dependent model, respectively. Panel (e) shows the evolution of the reference point in the reference dependent model. The three major (red) vertical lines indicate periods when benefits changed in the new system.

Figure A-11: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part II



(a) Value of Employment, Standard Model

(b) Value of Employment, Reference-Dependent model

(c) Consumption, Standard Model

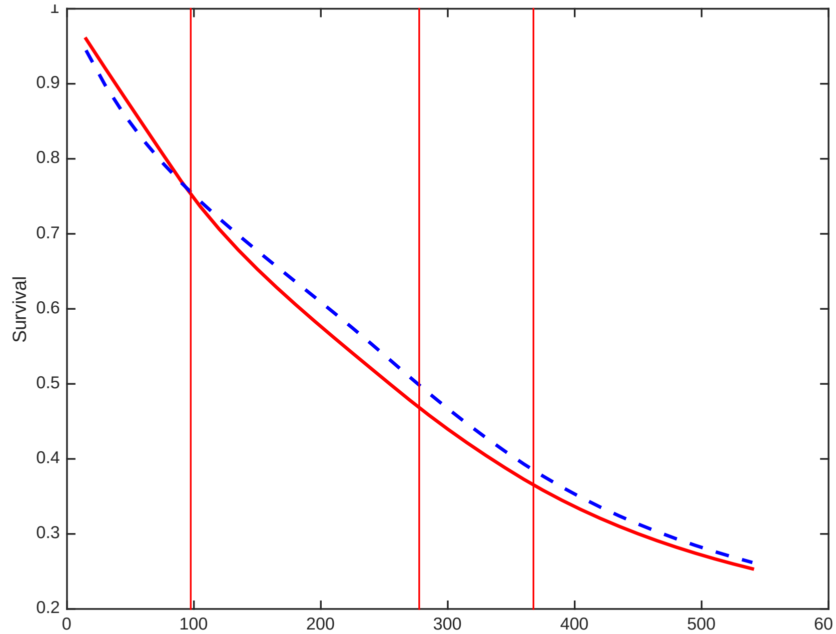
(d) Consumption, Reference-Dependent model

(e) Assets, Standard Model

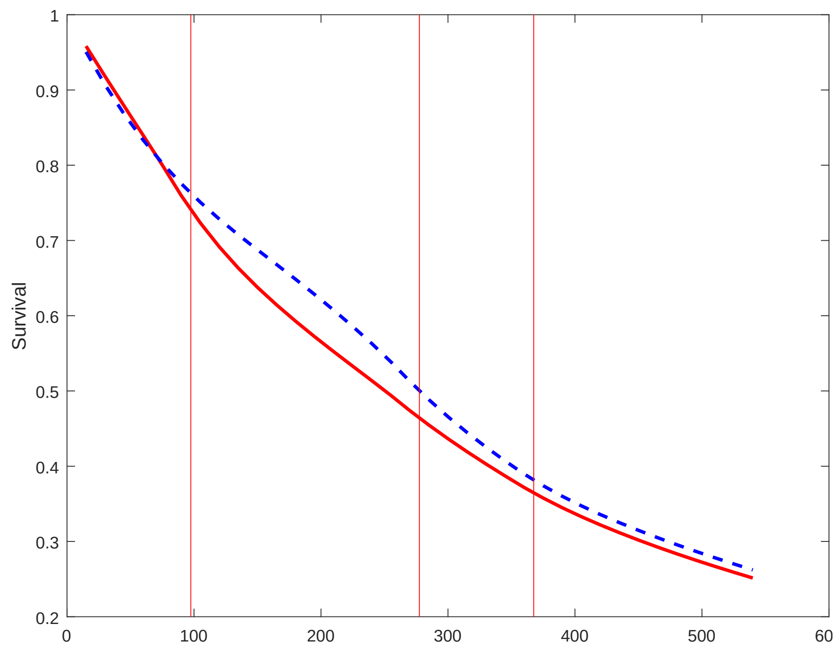
(f) Assets, Reference-Dependent model

Notes: The figure shows the model components for the standard model (estimates shown in column (1) in Table 1) and for the reference-dependent model (estimates shown in column (4) in Table 1). For the standard model the high cost type is shown. Panel (a) and Panel (b) shows the value of employment for the standard model and for the reference-dependent model, respectively. Panel (c) to (f) show consumption and asset path for the two models. The three major (red) vertical lines indicate periods when benefits changed in the new system.

Figure A-12: Simulated Survival Function of Benchmark Standard and Reference-Dependent Model



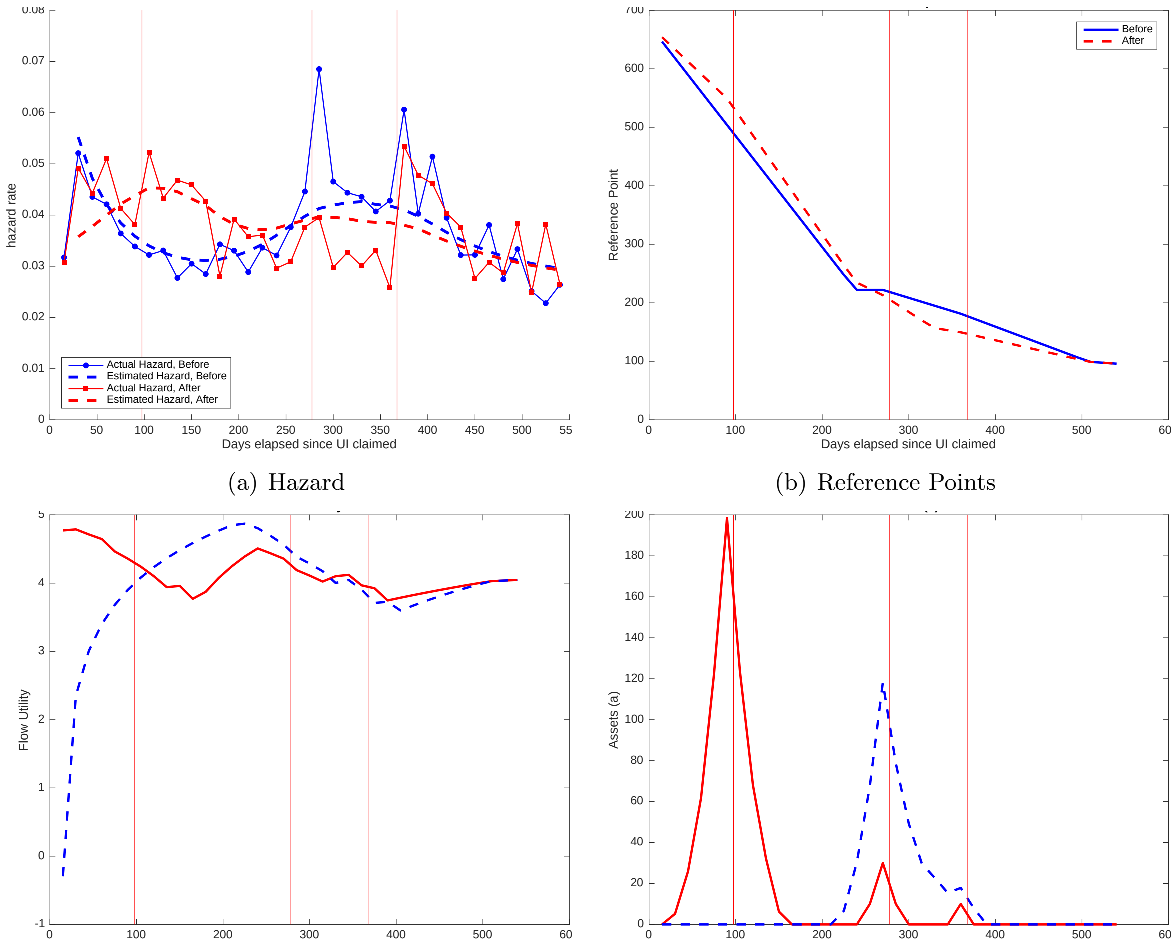
(a) Survival Function, Standard Model, δ-discounting



(b) Survival Function, Reference-Dependent model, $\beta\delta$-discounting

Notes: The figure shows the simulated survival function for the standard model (estimates shown in column (1) in Table 1) and for the reference-dependent model (estimates shown in column (4) in Table 1).

Figure A-13: Investigation of Constantinides Habit Formation Model, 2 types, delta

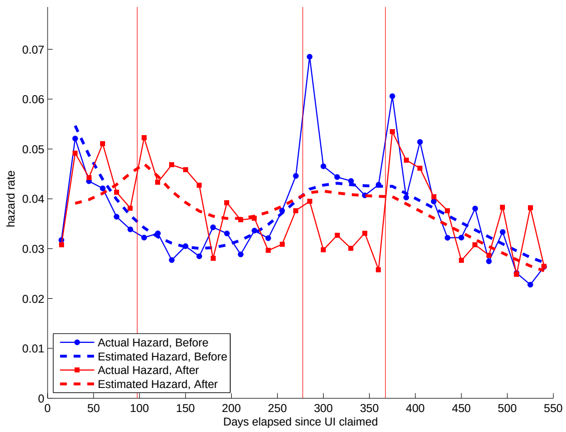


(a) Hazard (b) Reference Points

(c) Flow Utility (d) Assets

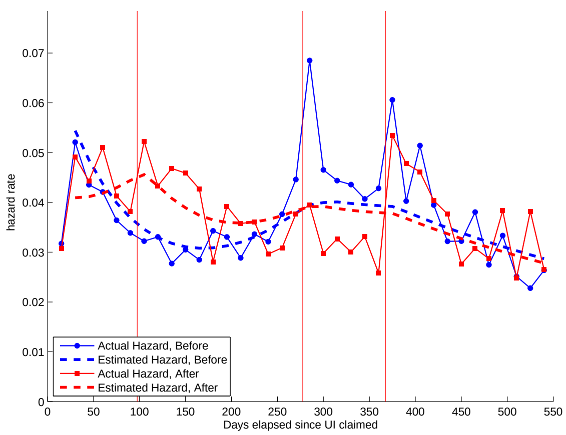
Notes: The figure shows key components for the benchmark estimate of the Constantinides habit formation model with 2 types. Panel (b) displays the path of the reference point, Panel (c) displays the flow utility and Panel (d) displays the assets.

Figure A-14: Robustness Checks I

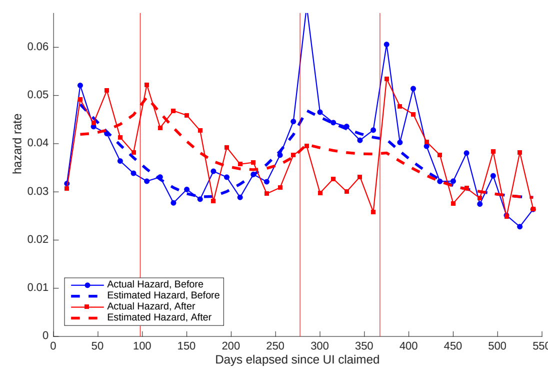


(a) Std. Model: Time-varying Search Cost

(b) Ref. Dep. Model: Time-varying Search Cost



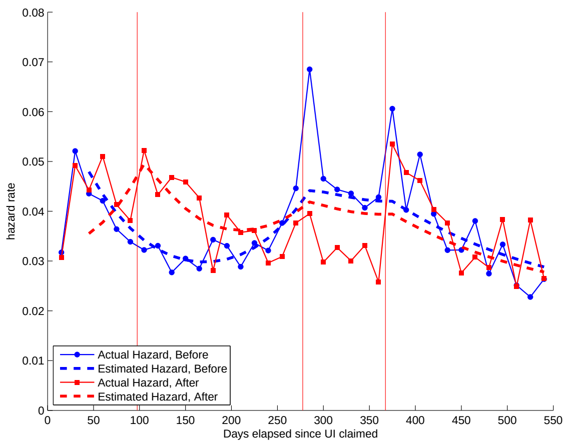
(c) Std. Model: Estimation without Spikes



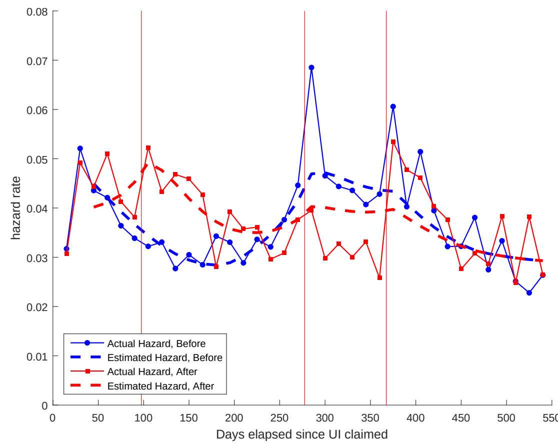
(d) Ref. Dep. Model: Estimation without Spikes

Notes: The figures show estimates of the standard and reference-dependent model with search costs being a linear function of time (Panels a and b) or when we estimate the model not using the sharp spikes in the exit hazard as moments (Panels c and d). See Table 3 for estimates.

Figure A-15: Robustness Checks II

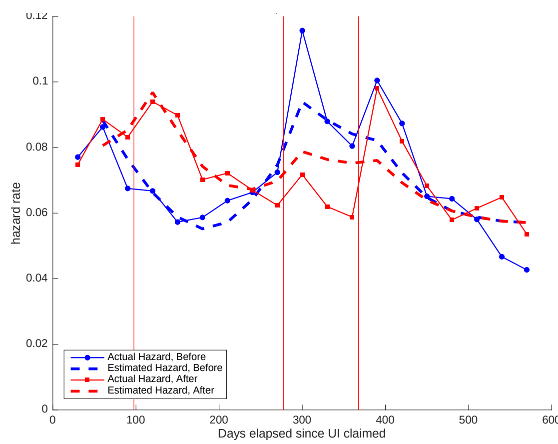


(a) Std. Model: Delayed Job Starting Date



(b) Ref. Dep. Model: Delayed Job Starting Date

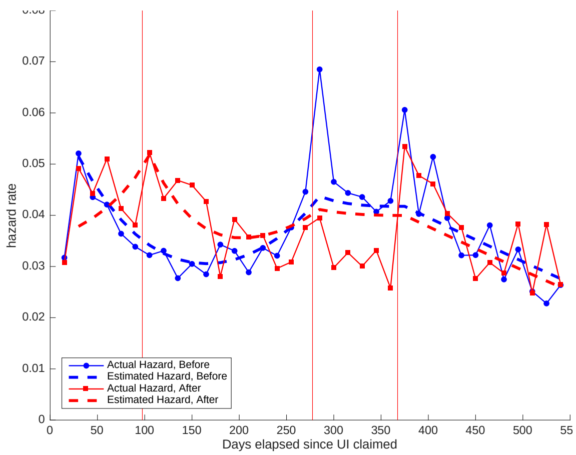
(c) Std. Model: 30-Day Hazards



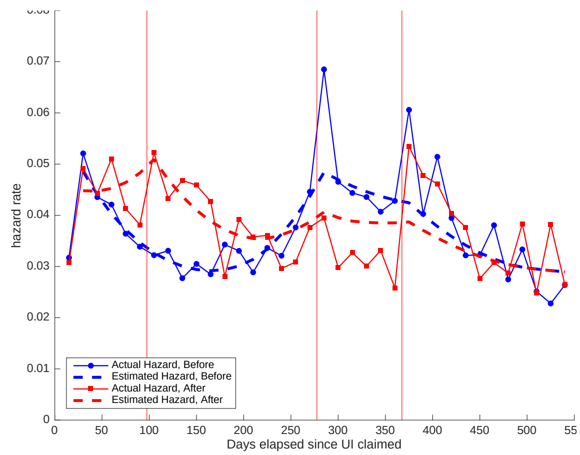
(d) Ref. Dep. Model: 30-Day Hazards

Notes: The figures show estimates of the standard and reference-dependent model when we assume that jobs start with a 2 week delay (Panels a and b), see Table 2, or when we estimate the model using 30-day time periods (Panels c and d), see Appendix Table A-6.

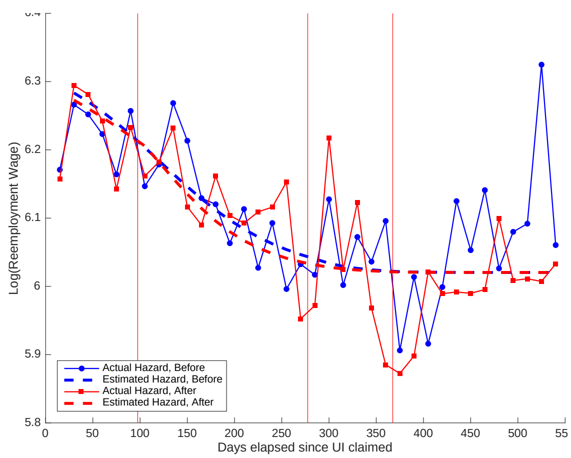
Figure A-16: Structural Estimation Incorporating Reservation Wages



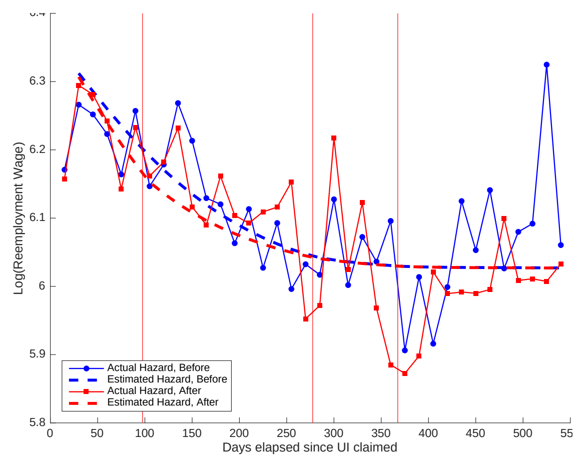
(a) Hazard rate in Standard Model



(b) Hazard rate in Ref. Dep. Model



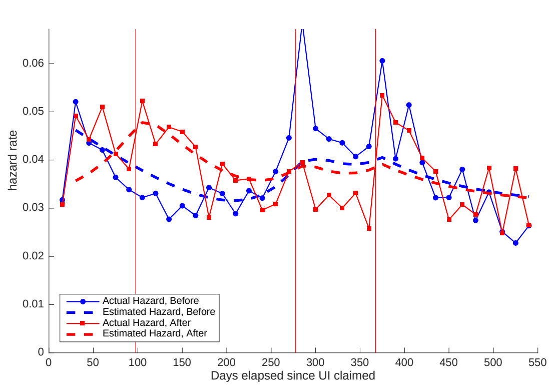
(c) Reemployment Wage in Standard Model



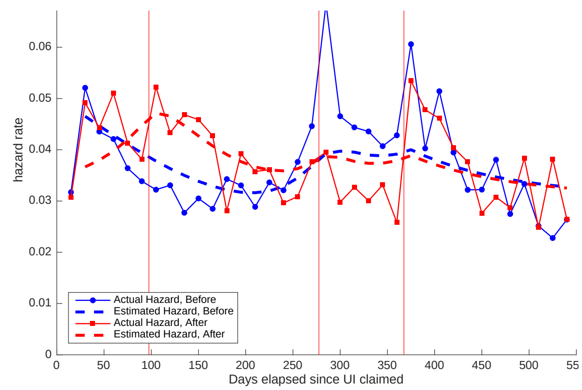
(d) Reemployment Wage in Ref. Dep. Model

Notes: The figure shows the empirical hazards and the predicted hazards for estimations of the standard model and reference dependent model incorporating reservation wages and using reemployment wages by unemployment duration as additional moments. The figure corresponds to the columns (1) and (2) in Table A-11.

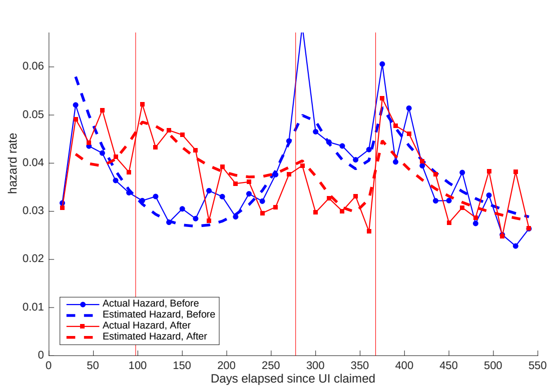
Figure A-17: Standard Model with Heterogeneity in Curvature of Search Cost - Alternative Specifications



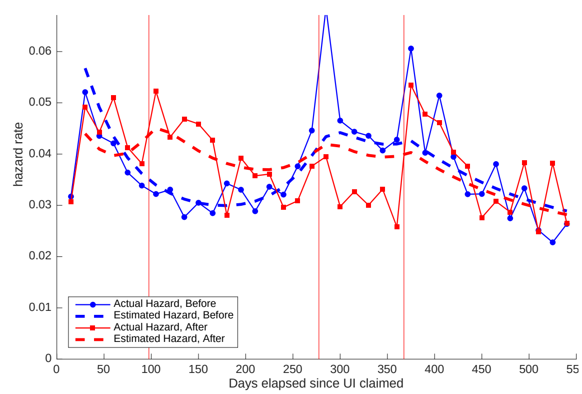
(a) Std. Model, 2 γ-types



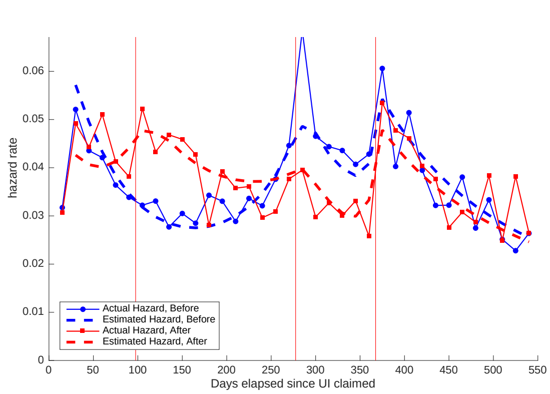
(b) Std. Model, 2 γ-types (γ restricted to ≥ 0.2)



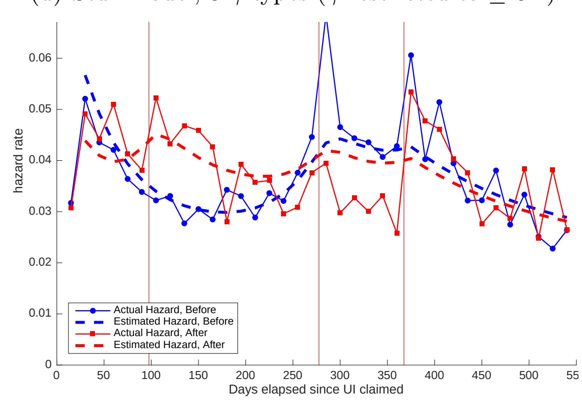
(c) Std. Model, 3 γ-types



(d) Std. Model, 3 γ-types (γ restricted to ≥ 0.2)



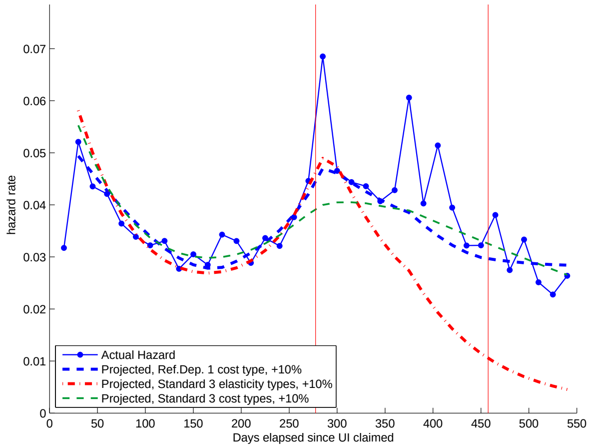
(e) Std. Model, 4 γ-types



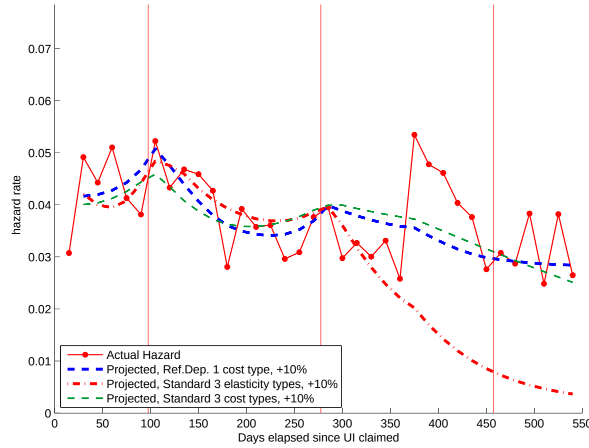
(f) Std. Model, 4 γ-types (γ restricted to ≥ 0.2)

Notes: The figure shows the empirical and predicted hazards for the standard model with heterogeneity in γ from Table A-8, with different numbers of γ-types (2, 3 and 4) and with and without restricting $\lambda > 0.2$.

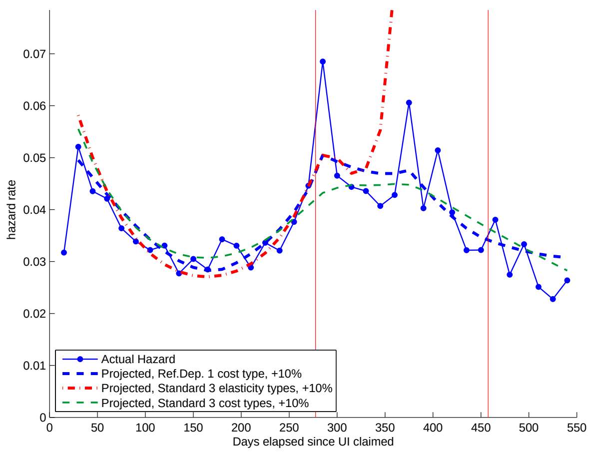
Figure A-18: Sensitivity to small changes in benefit path



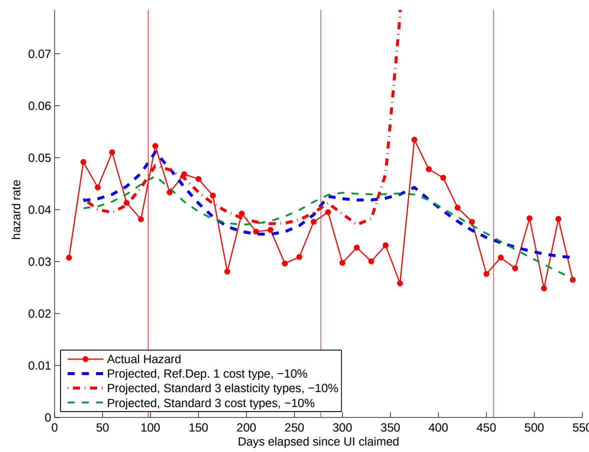
(a) Simulated hazard path for increasing welfare level to 110% in before period



(b) Simulated hazard path for increasing welfare level to 110% in after period



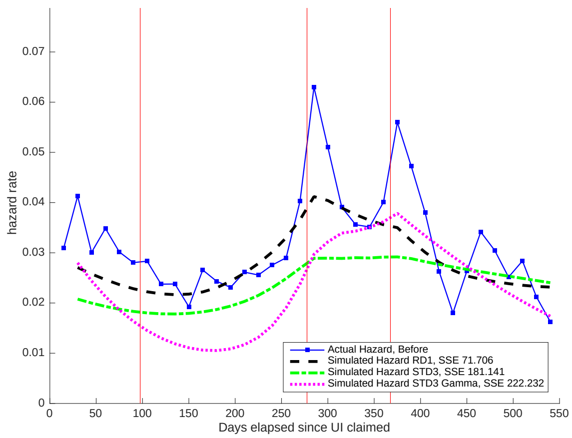
(c) Simulated hazard path for decreasing welfare level to 90% in before period



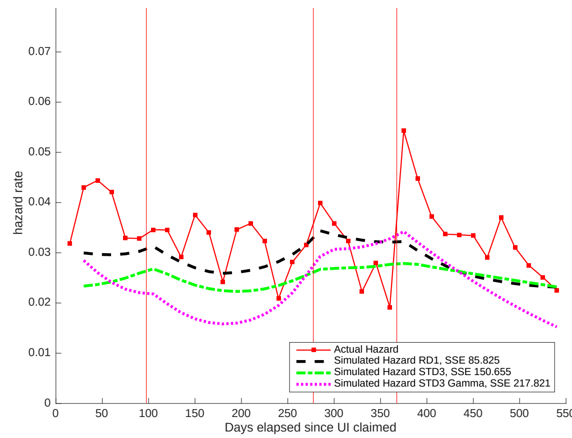
(d) Simulated hazard path for decreasing welfare level to 90% in after period

Notes: The figures show the sensitivity of the estimated standard model with 3 search elasticity types (Table 3, column 7, top panel) and the reference-dependent model (Table 1 column 4) to changes in the benefit path. Panel a) shows the estimated hazard rates in the pre-reform periods. In addition it shows the simulated hazard rates from the two models if the level of welfare benefits (which start after 360 days) is increased to 110 percent of the actual level. Panel b) shows the same but for the post-reform period. Panels (c) and (d) respectively show the simulation for a reduction in welfare benefits to 90 percent of the actual level.

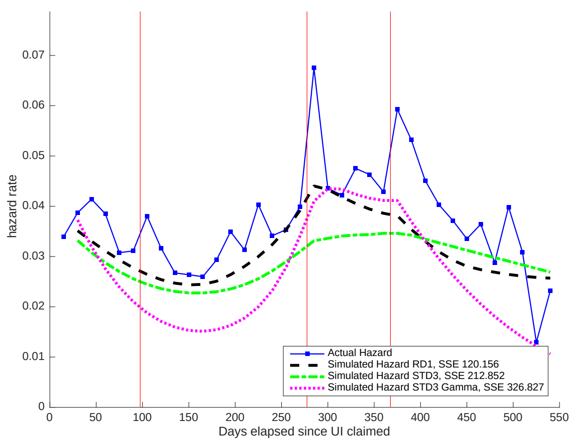
Figure A-19: Out-of-sample Performance of Models - Low and Medium Earnings Sample



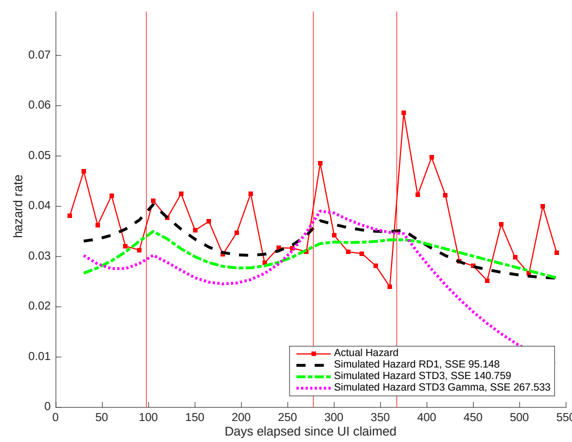
(a) Out-of-sample predictions of models for low earnings sample, pre-reform period



(b) Out-of-sample predictions of models for low earnings sample, post-reform period



(c) Out-of-sample predictions of models for medium earnings sample, pre-reform period



(d) Out-of-sample predictions of models for medium earnings sample, post-reform period

Notes: The figure shows the out of sample fit of the estimated the reference-dependent model with 1 cost type, the standard model with 3 search cost types and the standard model with three γ types. Panel a) replicates Figure 9a) from the paper for comparison, which shows the empirical and simulated hazard rates for individuals who had lower pre-unemployment earnings and thus faced a different benefit path (lower benefits during UI). Panel b) shows the same but for the post-reform period. Panels c) and d) show the same but for the medium earnings sample.