Reference-Dependent Job Search: Evidence from Hungary*

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Abstract

We propose a model of job search with reference-dependent preferences, where the reference point is given by recent income. Newly unemployed individuals search hard given that they are at a loss, but over time they get used to lower income, and thus reduce search effort. In anticipation of a benefit cut their search effort rises again, to then decline once they get used to the new 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 unchanged overall generosity. 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 structurally estimate a model with optimal consumption-savings and endogenous search effort, as well as unobserved heterogeneity. The reference-dependent model fits the hazard rates substantially better than the standard model, holding constant the number of parameters. We estimate a significant weight on gain-loss utility and a speed of adjustment of the reference point in the order of six months. The estimates also point to substantial impatience, likely in the form of present-bias. Estimates of a variety of alternative models, including habit formation, do not come close to the fit of the reference-dependent model.

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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. 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, Chetty and Weber 2007a), Slovenia (van Ours and Vodopivec 2008), Germany (Schmieder, Von Wachter and Bender 2012a), or France (Le Barbanchon 2012).

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 empirically for, 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 the reference point. Further, we assume that the 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 the reference point, and so she searches hard at the beginning of 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

the patterns documented above, 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 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 moral hazard.

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 A-1). 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. 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 strikingly 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, 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 structurally estimate a model with optimal search effort, log utility, and unobserved heterogeneity in the search cost.[1] Given that the reference-dependent model has two extra parameters (loss-aversion and updating horizon for the reference point), we allow for one less cost type, two versus three in the standard model, thus equating the number of estimated parameters. We estimate the model with a minimum-distance estimator, matching the empirical hazard rates in the pre- and post-reform to the predictions of the model.

The best estimate for the standard model does a relatively good job of fitting the hazards in the first 200 days. In particular, the presence of heterogeneous types allows it to match qualitatively 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 finding.

The reference-dependent model captures the spike at 90 days and the subsequent decrease, similar to the standard model (and with a closer fit). Importantly, 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 underfits 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.

An important caveat is that these estimates assume hand-to-mouth consumers. And yet, reference-dependent workers should build precautionary savings to smooth the upcoming loss utility due to a benefit decrease, eliminating the elevated hazards at benefit exhaustion. Thus, the good fit of the reference-dependent model may depend crucially on an ad hoc assumption. To address this concern, in our benchmark estimates we incorporate a consumption-savings decision and estimate time preferences in addition to job search parameters.

The results point to an important interaction between reference dependence and impatience. As the intuition above suggested, the reference-dependent model with optimal con-

[1] The model does not allow for a reservation wage choice, a restriction we revisit later.

sumption does not provide a good fit for the data if we impose high degrees of patience. Once we allow for estimated discount rates, however, the reference-dependent model fits the data well, as in the hand-to-mouth estimates. The point estimates indicate a significant weight on gain-loss utility, slow updating of the reference point, and high impatience. The standard model, with similarly high estimated impatience, does no better in fitting the data than in the hand-to-mouth scenario. Thus, the estimates with optimal consumption confirm the results for hand-to-mouth consumers, and additionally point to the role of impatience.

But are these estimates plausible? The estimate for loss aversion is in the range in the literature, but 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 discount factor for the standard model is even smaller) What appears to be extreme impatience may, however, reflect mis-specified time preferences. Building on evidence in a large number of settings, including job search (DellaVigna and Paserman, 2006), we allow 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.

The estimates allowing for present bias do as well (in fact, attain a better fit) as the estimates with exponential discounting, but imply much more reasonable discounting. We estimate a present-bias parameter β=0.59, 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. The standard model also fits somewhat better with present-bias preferences, but still does not match the key features in the data. Thus, the evidence appears to point, not just to reference dependence, but also to impatience and likely present-bias among unemployed workers.

We then unpack further the components of the reference-dependent model. The results do not depend on unobserved heterogeneity: a reference-dependent model with no heterogeneity still provides a significantly better fit than the standard search model with heterogeneity. The results also do not depend on the exact reference-point updating rule, as the fit is at least as good with an alternative AR(1) updating assumption. Further, the fit does not depend on allowing for gain utility (achieved at reemployment). What is critical for the results, as expected, is the loss aversion experienced at income decreases.

How does reference dependence compare to habit formation? Models a la Constantinides (1991) and Campbell and Cochrane (1999), like the reference-dependent model, induce a temporarily higher marginal utility of income following a benefit cut before consumption gets closer to the habit. Thus, they could also plausibly fit the patterns in the data. 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 fits the data less well, since it predicts a large spike at the 90-day (post reform) benefit decrease, and a much smaller spike for later (proportionally smaller) benefit decreases.[2]

Could alternative versions of the standard model fit the data as well as the reference-dependent model? We allow for, among other assumptions, different starting assets, background consumption, and time-varying costs of search. We also estimate the model using different weights, using probability of exit instead of hazard, and excluding the spikes from the moments. None of these changes affect sizeably the fit of the standard model, or of the reference-dependent model. We then examine whether alternative specifications of unobserved heterogeneity make a difference. Allowing for up to six different cost types, for heterogeneity in search elasticity or in reemployment wages does not close the gap with the fit of the reference-dependent model. Finally, adding a reservation wage choice in a simplified version of the model provides qualitatively similar conclusions.

We provide two further pieces of evidence that lend further support to the reference-dependent model. First, we compare the amount of selection implied by the estimated models to the amount of selection on observables in the data. We show that the selection implied by the standard model differs both qualitatively and quantitatively from the estimated selection in the data; instead, the implied selection is closer to the observed selection for the reference-dependent model. Second, we present estimates for alternative samples of unemployed workers in Hungary that faced different unemployment benefit changes, and show that the reference-dependent model again fits the data better.

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 storeable offers (as in Boone and van Ours 2012) could explain the spike in hazard at benefit exhaustion, as unemployed workers may wait for benefit expiration to start a new job. However, this model does not explain why the difference persists for several months. A model of comsumption commitments (as in Chetty, 2003 and Chetty and Szeidl, 2014) can explain some of the spikes if unemployed workers wait to pay a fixed cost needed to reoptimize consumption. Still, given that by day 270 the total benefit payout is the same pre- and post-reform, it is unclear why consumption commitments would predict a difference in the exit rate in the months following benefit exhaustion, as we instead observe in the data.[3]

Thus reference dependence, in combination with impatience, can help explain patterns in job search that are hard to explain with alternative models, even allowing for unobserved het-

[2]In addition, the habit-formation model is also computationally trickier to estimate.

[3]Additionally, the consumption commitment model is significantly harder to estimate than a reference-depedent model since it requires to keep track of a fixed cost decision, while in our model the path of the reference point is exogenous. To address this issue, Chetty (2003) makes the timing of fixed cost payment exogenous. A consumption commitment model with exogenous consumption readjustment, as in Chetty (2003), would not explain our findings.

erogeneity. These results have implications for potential redesigns in unemployment insurance policies, a point to which we return briefly in the conclusions.

The paper relates to the literature on job search and unemployment insurance design. This literature has mainly focused on the impact of the maximum duration and level of benefits, often using the estimated elasticities to gauge the welfare consequences of unemployment insurance (e.g. Chetty 2008, Kroft and Notowidigdo 2010, Schmieder, von Wachter, and Bender 2012). We evaluate a different type of reform: changing the time path of the benefit schedule, keeping the overall payments approximately constant. While the theoretical literature of optimal unemployment insurance (e.g. Hopenhayn and Nicolini 1997, Pavoni 2007) has argued that benefits that gradually decline over the unemployment spell are likely optimal , we are not aware of research that has evaluated reforms that change the time path without also greatly increasing or reducing the generosity of the UI system.

The paper also contributes to a literature on behavioral labor economics, including work on gift exchange between employer and employee (Akerlof, 1982, Fehr, Kirchsteiger, and Riedl, 1993 and Gneezy and List, 2006), horizontal pay equity (Kahneman, Knetsch and Thaler, 1986; Card, Mas, Moretti, and Saez, 2012), and target earnings in labor supply (e.g. Camerer et al., 1997 or Farber, 2015). More relatedly, within job search, DellaVigna and Paserman (2005) consider the impact of present-bias while Spinnewijn (2013) examines the role of overconfidence. We show that a reference-dependent model of job search make unique predictions which are not shared by these other models, and that the data points to a combination of reference dependence and present bias.

The paper also relates to the behavioral literature on reference dependence. Evidence of reference dependence comes from a number of settings including insurance choice (Sydnor 2010, Barseghyan, Molinari, O'Donoghue and Teitelbaum 2013), labor supply (Fehr and Goette 2007), domestic violence (Card and Dahl 2011), goal setting (Allen, Dechow, Pope and Wu n.d.), and tax elusion (Engström, Nordblom, Ohlsson and Persson 2013, Rees-Jones 2013). Across most of these settings, the reference point is the status-quo, or the forward-looking expectation (as in Koszegi and Rabin, 2006). In this paper, we estimate the speed of updating of a backward-looking reference point as in Bowman, Minehart, and Rabin (1999); the only other example we are aware of is (Post, Van den Assem, Baltussen and Thaler 2008). This paper is also part of a growing literature on structural behavioral economics which aims to identify the underlying behavioral parameters (Laibson, Repetto and Tobacman 2007, Conlin, O'Donoghue and Vogelsang 2007, DellaVigna, List and Malmendier 2012).

The papers proceeds as follows. In Section 2, we present a model of job search and reference dependence. In Section 3 we present the institutional details and the data for the Hungary 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, Chetty, and Weber (2007a) and in Lentz and Tranaes (2005) by adding a reference dependent utility function in consumption with a backward looking reference point.

Model Setup. Similarly to Card, Chetty and Weber (2007a) we make two simplifying assumptions. First, jobs last indefinitely once found. Second, wages are exogenously fixed, eliminating reservation-wage choices.[4]

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, $c_t = y_t$.

The direct utility from consumption in period t for an unemployed person is $v(c_t)$, where $v(.)$ is an increasing and concave function. The novel aspect is the fact that the reference-dependent individual has, in addition to consumption utility $v(c_t)$, also gain-loss utility. Following the functional form of Koszegi and Rabin (2006), flow utility in each period is

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

where r_t denotes the reference point for consumption in period t. The utility consists of the consumption utility $v(c_t)$ and in addition of the gain-loss utility $v(c_t) - v(r_t)$. Whenever consumption is on the gain side relative to the reference point ($c_t \geq r_t$), the individual derives gain utility $v(c_t) - v(r_t) > 0$, which receives weight η. Whenever the consumption is on the loss side relative to 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 of consumption is higher on the loss side than on the gain side. This reference-dependent utility function builds on prospect theory (Kahneman and Tversky, 1979) without, for simplicity,

[4] In section 5 we relax this assumption and discuss results where reservation wages are incorporated.

modelling either diminishing sensitivity or probability weighting. The standard model is embedded as a special case for $\eta = 0$.

The second key assumption is the determination of the reference point r_t. Unlike in the literature on forward-looking reference points (Koszegi and Rabin, 2006 and 2007), but in the spirit of the tradition on backward-looking reference points (Bowman, Minehart, and Rabin, 2001), the reference point is the average of income over the N previous periods:[5]

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

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 $y - \Delta y$.[6] In period T, utility changes to $v(y - \Delta y) + \eta\lambda [v(y - \Delta y) - v(y)]$. 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:

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

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: $V_t^U(A_t)$. For the employed, the reference point depends on the current period and on for how long the person has been employed; hence, the value function can be written as $V_{t|j}^E(A_t)$ for an individual who is employed in period t and who found a job in period j. Note also the assumptions on timing: the job-seeker chooses search effort s_t in period t; with probability s_t a job offer materializes, in which case the individual start receiving a wage w starting in period $t + 1$.

[5] 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 embeded. In the estimation below we also consider an alternative AR(1) reference point formation process.

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

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

$$V^E_{t+1|t+1}\left(A_{t+1}\right) = \max_{c_{t+1}>0} u\left(c_{t+1}|r_{t+1}\right) + \delta V^E_{t+2|t+1}\left(A_{t+2}\right). \tag{3}$$

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:

$$c'\left(s_t^*\left(A_{t+1}\right)\right) = \delta\left[V^E_{t+1|t+1}\left(A_{t+1}\right) - V^U_{t+1}\left(A_{t+1}\right)\right]. \tag{4}$$

Thus we can rewrite the unemployed problem as:

$$\begin{aligned} V^U_t\left(A_t\right) &= \max_{A_{t+1}} u\left(A_t + y_t - \frac{A_{t+1}}{1+R}\middle| r_t\right) - c\left(s_t^*\left(A_{t+1}\right)\right) \\ &\quad +\delta\left[s_t^*\left(A_{t+1}\right)V^E_{t+1|t+1}\left(A_{t+1}\right) + \left(1 - s_t^*\left(A_{t+1}\right)\right)V^U_{t+1}\left(A_{t+1}\right)\right] \end{aligned}$$

We solve the model by backwards induction, deriving the optimal consumption in the employed state in steady state. This allows us to solve for the optimal consumption path for each asset level and to obtain the value functions $V^E_{t|t}\left(A_t\right)$ for each t and each asset level A_t. Then we solve the dynamic programming problem for the unemployed, taking as given the value functions for the employed. Starting from the steady state, we move backwards, solving for the optimal consumption path and search effort path for each possible 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 we can solve for s_t^*: $s_t^* = \mathcal{C}\left(\delta\left[V^E_{t+1|t+1} - V^U_{t+1}\right]\right)$,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 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 $\underline{b}$ 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:

$$b_1 T_1 + b_2(T - T_1) = b_{constant} T. \tag{5}$$

Equation (5) implies $\frac{\partial b_2}{\partial b_1} = -\frac{T_1}{T_2 - T_1}$. In Proposition 1 we partially characterize how optimal search effort s_t^* is affected by a marginal increase in b_1 subject to the constraint (5). We express the results in terms of $\frac{ds_t^*}{db_1} = \frac{\partial s_t^*}{\partial b_1} - \frac{T_1}{T_2 - T_1}\frac{\partial s_t^*}{\partial b_2}$, where the total derivative is taking the implied adjustment of b_2 into account[7]

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 $i = 0, 1, ...$

b) In the reference-dependent model ($\eta > 0$ and $\lambda \geq 1$) search effort (weakly) increases temporarily in the first N periods after T, and remains constant in later periods: $\frac{ds_{T+i}^*}{db_1} \leq 0$, for $i = 0, 1, ...N - 1$ and $\frac{ds_{T+i}^*}{db_1} = 0$, for $i = N, N + 1, ...$ 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 $i = 0, 1, ...N - 1$

The first part of this proposition is straightforward. In the standard model, the search decision depends exclusively on future benefits and wages, and the reform leaves unaffected the benefits past period T.

The intuition for part b) of Proposition 1, which we prove in the appendix, is as follows. An increase in b_1 affects search effort in period T through changes in V_T^E and V_T^U. These value functions are affected because frontloading the benefit path (increasing b_1) will reduce the reference point r_T. A lower reference point in turn increases both the value of employment (due to the increase in gain utility) and the value of unemployment (due to a decrease in loss utility). As long as $\lambda \geq 1$ the decrease in loss utility will be larger than the increase in gain utility, leading to a reduction in search effort.

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 benefit in the periods right before period T, given the moral hazard.

In contrast to this, 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 their higher reference point. Second, the difference in hazards persists but shrinks for N periods, at which point the reference point has fully adapted to the lower benefits

[7]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 $t + 1$: $s_t = h_{t+1}$.

under either regime, and thus search effort converges. A third implication (not captured in the Proposition) is that in the last few periods before period T, for sufficiently large loss aversion λ, the hazard is higher under the constant-benefit regime compared to the front-loaded regime. The anticipation of larger future losses under the constant-benefits regime generates this anticipatory effect, counteracting the moral hazard effect of more generous benefits under the constant-benefit regime.

How critical is the hand-to-mouth assumption? 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). Note, however, that the fact that the assumption of constant total benefit payout makes it likely that differences in type composition are likely to be small.

Introducing savings in the model also invalidates Proposition 1 since individuals may arrive at period T with different savings, thus creating differences in hazards, even under the standard model. Once again, however, given that the total benefit payments are constant, such differences in savings are likely to be small. We address both heterogeneity and savings in the estimation section.

Present Bias. We extend the model by allowing 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. The present bias factor β induces time inconsistency and fits behavior in a range of settings (see Frederick, O'Donoghue and Loewenstein (2002) and DellaVigna (2009)). In the context of job search, (DellaVigna and Paserman 2005) solve for a job search model with present-biased preferences. For simplicity, we assume that individuals are naive about their future present-bias and that they (wrongly) assume that in the future they will make decisions based on regular discounting δ.

The naive hyperbolic discounting individual solves the following value functions:

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

and

$$V_{t+1|t+1}^{E,n}\left(A_{t+1}\right) = \max_{c_t > 0} u\left(c_t | r_t\right) + \beta\delta V_{t+2|t+1}^{E}\left(A_{t+1}\right) \quad (7)$$

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. Note that this adds one more step to the solution algorithms, since we first solve for all possible values of V_{t+1}^{U} and $V_{t+1|t+1}^{E,n}$ and then we solve for the optimal

consumption and search path given by $V_{t+1}^{U,n}$ and $V_{t+1|t+1}^{E,n}$.

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.[8] The maximum potential duration, obtained after around 4 years of contribution, was 270 days,[9] while the benefit 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[10], 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 benefit caps. The reform introduced a two-step benefit system. In 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% with increased minimum and maximum benefit caps. For most UI claimants these changes meant lower benefits than under the old schedule. In the second tier everybody received the new minimum benefit amount, reducing benefits for most UI claimants compared to before. The benefit formula changes are summarized in Figure A-1.

The most prominent change occured for those with 270 days of eligibility (four years of UI contributions before lay-off) and base year earnings above the new benefit cap (that is, they earned more than 114,000HUF ($570) per month in 2005). As Figure 2 shows, for this group the duration of benefits in the first tier remains 270 days. While in the old system the benefits were constant in the first tier, under the new rules benefits increased substantially in the first 90 days, but decreased afterwards. An important feature of the reform for this group is that the weekly benefit increase in the first 90 days about twice as big as the weekly benefit decrease between 90 and 270 days, keeping the total benefit pay-out for individuals unemployed for 270 days the same.

[8] 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.

[9] 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.

[10] 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 polcies) are discussed latter. In addition to that, VAT and corporate income tax were decreased from January 1st 2006.

Even though the main element of the reform was the new benefit formula, there were other changes occurring at the same time. Most notably, a reemployment bonus scheme was introduced with a bonus amount equal to 50% of the remaining total first-tier benefits. However, claiming the bonus was not without costs. If the bonus was claimed, then the entitlement for the unused benefit days was nulled. This could be very costly for risk-averse agents or for those who could only find an insecure job. Also, the bonus could only be claimed after the date of first-tier benefit exhaustion. This meant hussle costs, since 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 of reemployment bonus 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.[11]

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 [12], but somewhat lower, benefit in the second tier.[13] To avoid the potential complication, we only focus on those who claimed their benefits after February 5th, 2005. Second, there were minor changes in financing training programs.[14] Howevever, 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 and were still unemployed could claim means-tested social assistance. The duration of social assistance is indeterminate, 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. [15]

[11]Lindner and Reizer (2014) investigate the reemployment bonus in detail and further show that it does not affect the shape of the hazard function.

[12]Before the reform, the potential duration in the second tier was 270 days above age 45 and 180 days below 45. Those who claimed UI after February 5th, 2005 were eligible for 180 days above age 50 and 90 days below 50 in the second tier.

[13]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 Febraury 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 3.

[14]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).

[15]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.

3.2 Data

We use administrative data[16] 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 all Hungarian citizen who were older than 14 and younger than 75 in 2002.[17] 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 starting and ending date of the UI benefit spells and the earnings base used for benefit calculation.

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 2. 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 precentile earned 100,800 HUF ($504).[18]

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 3 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.

Table 1 shows basic descriptives for the two groups. The basic demographic characteristics, such as age at time of claiming, education and log earnings in the years 2002 - 2004, are very 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.[19] The take-up rates of the reemployment bonus

[16]The dataset is provided by the Institute of Economics - Hungarian Academy of Sciences.

[17]More precisely the sample is composed of everybody born on the 1st of january, 1927, and every second day thereafter (3rd of January, 5th of January etc.)

[18]Our results are robust to alternative earnings thresholds over time. For example, we estimated our main specifications for those whose (real) earnigs base was above 114,000 HUF ($570) and obtained virtually the same results.

[19]Appendix Figure A-1 shows the unemployment rate and GDP growth rate around the two periods in Hungary. The unemployment rate was quite stable at around 7.5 percent during and after the two sample periods. GDP growth was also stable during the sample periods, only slowing down at the beginning of 2007. Below we show extensive robustness checks, showing that our results are not driven by changes in the economic environment that occurred later and that the shape of the hazard rates are in fact very stable over time except

scheme, which was introduced in 2005, are quite low. Below we present robustness checks to address the possibility that this bonus may have affected our results.

4 Reduced Form Results

4.1 Estimating Hazard Plots

In this section, we evaluate the impact of the reform on the exit rates from unemployment. We estimate the hazard rates with a linear probability model separately for each 15-day period[20], indexed by t, after entering unemployment insurance:

$$I(t_i^* = t | t_i^* \geq t) = \beta_{0,t} + \beta_{1,t} POST_i + X_i \gamma + \epsilon_{it}, \tag{8}$$

where i indexes individuals and t_i^* represents the duration of unemployment 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 $t_i^* \geq t$). The estimates for $\beta_{0,t}$ are estimates for the hazard function in the pre-period, while the estimates for $\beta_{1,t}$ represent the shift of the hazard function between the before and after period. In our baseline estimates we do not control for any observables X_i, and show results controlling for X_i as robustness.[21]

4.2 Main Result

Figure 4a) shows the estimates of equation (8) for each t with no controls. The blue line represents the coefficient estimates of $\beta_{0,t}$, the estimated hazard function in the before period, while the red line represents the estimated $\beta_{0,t} + \beta_{1,t}$, the after period hazard. Vertical lines indicate that the difference between the two series is 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,

for the exact point when the UI policy changes.

[20] We choose a 15-day period so as to be able to capture as multiples the benefit shifts after 90 days and 270 days. The results are very similar with hazards computed at 7 days or 30 days.

[21] Note that these hazard functions should not be viewed as consistent estimates at the individual level, but rather as estimates of the average hazard function in the population. While the natural experiment, assuming the CIA holds, identifies the causal effect of the reform on the average population hazard function, the shape of this average hazard function is potentially affected by duration dependence or by changes in selection due to the reform. While we address differential selection in our reduced form results section by comparing the estimated hazards controlling and not controlling for observables, an important aspect of our structural estimation below will be to explicitely model unobserved heterogeneity.

then it 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 introduction of a two-step system. The hazard rate increases at 90 days, at the end of the higher unemployment insurance 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 the 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 the unemployment assistance, the two hazards have once again converge.

The most striking difference occurs around day 270, when in the pre-reform period the exit hazard remains significantly higher after the UI exhaustion point (270 days) relative to the after period. As we discussed above, this difference in hazards is hard to reconcile with the standard model: from day 270 onwards, the benefit levels are identical in the pre- and post-period, and in addition the total amount of benefits received up to day 270 is also almost identical. Hence, as we discussed in Section 2, in the standard model we would expect similar hazards (even with heterogeneity, as we show below). A modified standard model with storable offers could potentially match the spike at 270 days, but it still does not explain the persistent difference in the hazards after the exhaustion of benefits.

The difference in hazards instead 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 with the reference-dependent model.

While we focus mainly on the hazard rate around day 270 because it leads to the most distinct predictions, the observed patterns around day 90 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, the spike itself in this period could also be explained by the standard model with unobserved heterogeneity, as we show below.

Figure 4b) shows the estimated survival function for the two groups. We obtain these estimates using a variant of equation (8), where we estimate the equation again pointwise for all t but including the whole sample and taking $P(t_i^* \geq t)$ as the outcome variable. The

survival functions diverge after 90 days, with lower survival probabilities in the after group than in the before group. This difference persists until around 300 days, after which the two lines converge. Since the expected duration in unemployment is simply the integral over the survival function from 0 onwards, the expected unemployment duration is significantly reduced in the after period. It is striking that even though the reform made the UI system more generous on average (since short term unemployed received more benefits, while the long-term unemployed received about the same), the expected duration decreased.

4.3 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 (Table 1), they could potentially explain differences in the hazard patterns over time if the demographic impacts on the hazard rates are large. Thus, we re-estimate equation (8) controlling for a rich set of observable 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 5a) shows, controlling for observables has virtually no effect on the hazard rates, implying that they cannot explain our findings.[22]

A separate concern regards the introduction of the 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 drop all individuals that received a reemployment bonus and estimate our baseline specification on this restricted sample; the results are virtually unchanged(Figure 5b)).

In order to assure that the differences in the hazard rates are in fact due to the reform in the UI system and not simply the result of some general trend, we exploit the fact that we have additional data from 2004 and after 2006. First we estimate two 'placebo' tests for whether there are differences in the year two years before the reform and the year one year before the reform, using the same estimation strategy as before. We report these results in Appendix Figure A-3a),revealing 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,leading to a slight increase in the hazard at this point in 2005. Similarly Appendix Figure A-3b) 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 exit hazards over

[22] 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).

specific intervals. Figure 6a) shows the evolution over time of the exit hazard between 30 and 90 days (red line) and between 90 and 150 days (black line). Each dot indicates the average hazard for each 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 5. 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 remains largely similar 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 6b) 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 five additional assumptions, some of which we relax later. The first three assumptions concern the utility function. First, we assume that the search cost function has a power form: $c(s) = ks^{1+\gamma}/(1+\gamma)$. This form implies that the parameter γ is the inverse of the elasticity of search effort with respect to the net value of employment.[23]Second, we assume log utility, $v(b) = \ln(b)$. Third, we model heterogeneity as three types of unemployed workers that differ in their cost of search k.

Fourth, 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 2/3 of past wages.[24] Fifth, we assume that individuals start the last period before unemployment 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 that we estimate for the standard model are: (i) the three levels of search cost k_{high}, k_{med}, and k_{low}, with the assumption $k_{high} \geq k_{med} \geq k_{low}$, and the two probability weights p_{low} and p_{med}; (ii) the search cost curvature γ; (iii) the time

[23]To see this, recall that the first-order condition of search effort (equation **??**) is $c'(s^*) = v$, where we denote with v the net value of employment (that is, the right-hand-side of equation **??**). Given the parametric assumption, this yields $s^* = (v/k)^{1/\gamma}$, and the elasticity of s^* with respect to v is $\eta_{s,v} = (ds/dv)\, v/s = 1/\gamma$.

[24]The median ratio of reemployment wages to past wages in the data is 2/3.

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.[25] To keep the number of parameters the same as for the standard model, in the reference-dependent model we assume only two cost types, thus removing parameters k_{med} and p_{med}. Notice that the weight η on gain-loss utility is set to 1 in the benchmark estimates rather than being estimated; thus, the loss-aversion parameter λ can be interpreted also as the overall weight on the losses. The reason for this assumption is that over the course of the unemployment spell the individual is always on the loss side since the benefits are always (weakly) lower than the reference point. Hence, it is difficult to estimate a separate weight on gain utility and loss utility.[26]

Estimation. We use a minimum-distance estimator. 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 minimum-distance estimator chooses the parameters $\hat{\xi}$ that minimize the distance $(m(\xi) - \hat{m})' W (m(\xi) - \hat{m})$, where W is a weighting matrix. As a weighting matrix, we use a diagonal matrix that has as diagonal elements the inverse of the variance of each moment.[27] To calculate the theoretical moments, we use backward induction. First we compute numerically the steady state search and steady state value of being unemployed using a hybrid bisection-quadratic interpolation method, pre-implemented in Matlab as the fzero routine. Then going backward we analytically calculate the searching effort and the value of being unemployed in each period.

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.

Moments. As moments $m(\xi)$ we use 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. We do not use the hazard from the first 15 day period, since it would require modelling search on the job.

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, when benefits remain constant and thus, in absence of heterogeneity, the hazard would be constant in the standard model (but

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

[26] 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 remployment utility does not allow for very precise identification of η.

[27] As robustness check below, we alternatively use the identity matrix as a weighting matrix.

not in the reference-dependent model). 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 very patient, they save in advance of benefit decreases so as to smooth consumption. More 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), the parameter λ denotes the extent of the loss utility. A major component to identification for this parameter is the extent to which the hazard for the pre-group is higher both before and after day 270, in response to a larger loss. Remember that instead the standard model has essentially identical hazards from day 270 onwards. The loss parameter is also identified by the response to other changes in the benefits, 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 fact that the pre- and post-reform hazards converge a few months after day 270. The speed of convergence of the hazard after day 90 also suggests several months of adjustment.

5.2 Hand-to-Mouth Estimates

To build intuition, we first present estimates for the case of hand-to-mouth workers who in each period consume the per-period income, setting the discount factor δ =.995.[28] Figure 8a) 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 8b) displays the fit of the reference-dependent model with two types (and thus the same number of parameters as in the standard model). 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. In particular, the model fits better the surge in the hazard rate in the pre-period in anticipation

[28] In this hand-to-mouth model, unlike in the benchmark specifications with optimal consumption, the time preference parameters are not well identified.

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 most striking aspect of the data which the model does not capture is the very 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 2 we present the parameter estimates. The estimates for the standard model (Column (1)) indicate substantial heterogeneity in cost k and low cost curvature $\hat{\gamma} = .09$. This implies a high elasticity of search effort to incentives, needed to fit the substantial hazard increases in response to benefits changes. The estimates for the reference-dependent model (Column (2)) indicate a substantial weight on loss utility, $\hat{\lambda} = 2.2$ (s.e. 0.2), and slow adjustment of the reference point, $\hat{N} = 225$ (s.e. 27) days. At the bottom of the Table, we report the goodness of fit (GOF) measure $(m(\xi) - \hat{m})' W (m(\xi) - \hat{m})$. The reference-dependent model has a substantially better fit (GOF of 185 versus 244), for equal number of parameters.

5.3 Benchmark Estimates with Consumption-Savings

While the previous estimates indicate that a reference-dependent model can fit the patterns in the data quite well, there is a key concern with the hand-to-mouth estimates. Individuals who anticipate experiencing loss utility from a benefit cut should save in anticipation of the benefit cut, allowing them to smooth consumption around the benefit cut. In turn, this would imply smoother hazards around the benefit cuts than in the data.

To address this concern, we embed a consumption-savings decision, as discussed in the model section. In this benchmark model, we furthermore estimate the discount factor δ, since the rate of time preference plays a crucial role in the consumption-savings choice, in addition to the role in determining search intensity.

Figure 8a) shows the fit for the standard model with three types, compared with the fit in Figure 8b) for a reference-dependent model with two types (with once again the same number of parameters). The qualitative fit is nearly identical to the fit obtained for hand-to-mouth consumers (Figures 7a) and b)): the reference-dependent model better fits the path in the hazard both before benefit expiration and afterwards.

How is that possible in light of the above intuition about counteracting savings? For an answer, we turn to Table 3 which displays the corresponding parameter estimates in Columns (1) and (2). The most striking element is the high estimated degree of impatience: 15-day discount factors of $\delta = 0.90$ for the reference-dependent model and $\delta = 0.88$ for the standard

model. Either estimate implies an annual discount factor of 0.08 or lower. Appendix Figure A-6a) provides further evidence on the identification of the discount factor. Each point in the figure indicates the goodness of fit of the best-fitting estimate for a particular (15-day) discount factor. For patient individuals ($\delta = 0.99$ or higher), the reference-dependent model does poorly. Indeed, 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 $\delta = 0.97$ the reference dependent model has a good fit (and better than the standard model), with the best fit, as we saw in the table, for an even lower discount factor.

The downside of this set of results, thus, is that the model which best accomodates the data – the reference-dependent one – requires a degree of impatience which is hard to reconcile with other estimates in the literature. Yet, this high estimated degree of impatience may be due to a mispecification of the discounting function. A growing body of evidence, summarized among others in Frederick, O'Donoghue and Loewenstein (2002) and DellaVigna (2009), suggests that the beta-delta model of time preferences due to Laibson (1997) and O'Donoghue and Rabin (1999) provides a better fit of observed behavior in a unmber of settings. The beta-delta model includes an additional discount factor β between the present and the next period to capture the present bias, inducing a time inconsistency.

Thus, in a second set of estimates we allow for beta-delta discounting[29] in both the standard model and the reference-dependent model. To keep the number of parameters constant, we set the long-term discount factor δ to .995. The results in Columns (3) and (4) of Table 3 and in Figure 8c) show that the fit is better than in the models with delta discounting (especially for the reference-dependent model)with much more plausible discounting: the estimated present-bias parameter is $\beta = 0.59$, implying a discount factor of 0.52 for the first year and of 0.88 for subsequent years. This indicates a high degree of impatience, in line with estimates in the literature. Paserman (2008), building on the model in DellaVigna and Paserman (2006), estimates a job search model with beta-delta preferences and obtains estimates for beta ranging between 0.40 and 0.89, depending on the sample. Laibson et al. (2005), based on life-cycle consumption choices, estimates a β between 0.51 and 0.82.

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.[30]

How do the two models achieve their fit? In Appendix Figures A-4 and A-5 we report plots

[29] We assume that consumers are naive about the future self-control problem. We take this assumption mostly for computational simplicity, especially given the complexity of estimating the consumption-savings model. In addition, however, the naiveté assumption is arguably also a better fit to several behaviors (DellaVigna 2009).

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

for key model components, focusing on the high-cost type. In the standard model, the flow utility follows the step down in the 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 as expected, while in the reference-dependent model it actually increases over most of the range, reflecting the importance of reference point adaptation. This helps fit the observed decrease in search effort over time, even for a given type. Furthermore, the value of unemployment declines sharply in correpondence to the benefit drop. (This shard drop reflects the estimated impatience). The next panel shows the reference point path, which is decreasing over time. Notice that from around day 250 the reference point is higher in the pre-reform group, which contributes to generate higher loss utility and thus a larger increase in search effort near benefit expiration.

In Appendix Figure A-5 the value of employment, which is 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. Turning to consumption and assets, consumption tracks quite closely the per-period earnings, especially in the reference-dependent model. As such, assets get depleted quickly and remain at zero or close for the rest of the spell.

In the final set of columns in Table 3 we return to one key motivation of the paper. We argued that the reference-dependent model can, at least in principle, capture the qualitative features of the hazard from unemployment without any heterogeneity. Yet, the estimates of reference-dependent model allow for two heterogeneous types. In Columns (5) and (6), we remove any heterogeneity and estimate the reference-dependent model with only one cost type. This bare-bones model fits the data better than the standard model (goodness of fit of 219 in Column 6 compared to 247), despite having two fewer parameters. As Figure 10d) shows, the qualitative fit is almost as good as in the reference-dependent models with heterogeneity.

5.4 Reference-Dependence Variants

In Table 4 we consider variants of the benchmark reference-dependent model, reproduced in Column (1). First, instead of defining the reference point as the average of income over the N previous periods, we assume an AR(1) process for the reference point:

$$r_t = \rho r_{t-1} + (1-\rho) b_t = (1-\rho) \sum_{i=1}^{\infty} \rho^i b_{t-i}$$

This updating rule has longer "memory" and adjusts more smoothly than the benchmark

reference point, with the speed of adjustment captured by ρ.[31] Column (2) of Table 4 shows the estimated speed of adjustment ρ=0.77, which implies faster adjustment (half-life is 39 days) than in the benchmark case. The estimates for the other parameters are close to the benchmark estimates and the goodness of fit with AR(1) updating (155) is somewhat higher than in the benchmark estimates (167). Figure 10 (d) shows the fit of this AR(1) model.

Next, we disentangle the role played by gain and loss utility in the estimates. So far, we have arbitrarily set the gain utility parameter, η, to 1 and estimated the weight on loss utility, $\eta\lambda$. In Columns (3) and (4) we examine the role of gain and loss utility by including only one at a time in the model. In Column (3) we assume no gain utility when workers get a job, but still estimate the loss utility weight $\eta\lambda$. The fit of the model, visible in Figure 9(b), is almost as good as the standard one, and the estimated speed of updating of the reference point is nearly the same (though not, as expected, the estimated loss aversion). In Column (4), we do the complementary exercise of not allowing for loss utility while unemployed, while modeling gain utility. This model does worse and is unable to reproduce equally well the difference in hazards past 270 days (Figure 9(c)). This indicates the key role played by loss utility.

We present a parallel take on this result in the next three columns. Columns (5) and (6) report the estimates setting, respectively, a value of η of 0.2 and of 5. 10 Interestingly, as the (assumed) weight on gain utilityη increases, the estimated λ decreases, holding the product$\eta\lambda$, which is the weight on loss utility, at comparable (though not constant) levels. The goodness of fit under these alternative assumptions for η is almost the same as in the standard model. In Column (7), we estimate separately η and λ, with the fit shown in Figure 9d). The two parameters are in principle separately identified, but the estimate for η (2.8) is not very precise, and the goodness of fit is again close to the benchmark model. As such, in the rest of the paper we hold η fixed to 1.

5.5 Habit Formation

How does reference dependence compare to habit formation? Models a la Constantinides (1991) 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.

We estimate a version of a habit formation model replacing the reference dependent utility

[31] When we implement this estimate we assume that the memory of the AR(1) update goes back to 1050 days (or 70 15-day period).

function (defined in Equation (1)) with the utility:

$$v(b_t, r_t) = log(c_t - zr_t),$$

where z captures the responsiveness to changes in the habit andr_t is calculated the same way as before, but reinterpreted as a measure of habit stock.[32] The estimates are in Table 5, allowing for both a fixed N for updating of the reference point an an AR(1) process, as well as delta discounting versus beta-delta discounting. In either case, the fit is not close to the fit of the reference-dependent model, and is in fact worse even than the standard model.

We highlight a key difference between the two models. 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 γr. Given this, the habit-formation model fits the data less well, since it predicts a large spike at the 90-day (post reform) benefit decrease, and a much smaller spike for later (proportionally smaller) benefit decreases.[33]

This model, which embeds the standard model for $z = 0$, is similar to the reference-dependent model in that it induces a temporarily high marginal utility of income following a benefit cut. The habit-formation model indeed fits the data better than the standard model (204.6 in the habit model vs 243.1 in the standard model), although its performance lags behind the reference dependence model (172.6), as also Figure 10d) shows.

5.6 Robustness

In Table 6 we consider the robustness of the standard and reference-dependent model, first to alternative specifications of the setting and utility function (Columns (1) to (4)) and then to alternative estimation methods (Columns (5) to (8)).

In Column (1) we change the assumption about the initial assets, endowing workers with \$600 in their last period of employment, as opposed to \$0 in the benchmark model. The estimates are not much affected (see also Appendix Figure A-7a) and b)), though the fit is somewhat worse than under the assumption of zero assets (which itself is most consistent with the estimated high impatience). In Column (2) we allow for background consumption: workers receive non-market income n during unemployment, in addition to the benefits earned, to capture home production. The estimates are very similar to the standard ones. In Column

[32]Observe that for low levels of b_t and high level of z this function is not defined. To avoid this problem(Campbell and Cochrane 1999) made z a non-linear function of $b_t - r_t$. For simplicity we treat z as a parameter instead and we check in the optimum whether our utility function is defined for the relevant b_t and r_t.

[33]In addition, the habit-formation model is also computationally trickier to estimate, as the estimated habit parameter γ has to always satisfy the condition $c > \gamma r$.

(3), 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.[34] The reference-dependent model has a worse fit in this case compared to the benchmark model, but still fits significantly better than the standard model. Finally, in Column (4) we allow for a linear time trend in the baseline cost factor allowing for skill depreciation or conversely learning by searching. This additional parameter leaves the fit of both models essentially unaffected.

In the next specifications we consider variants to the estimation procedure. In Column (5) we use the identity matrix to weight the moments and in Column (6) we use the moments estimated after controlling for observables (shown in Figure 5b)). Though the goodness of fit cannot be compared to the previous estimates, the qualitative conclusions remain the same: the reference-dependent model fits substantially better than the standard model and the behavioral parameters, λ, N, and β are comparable to the benchmark estimates. In Column (7), 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. Once again, while the goodness of fit measures are not comparable to the benchmark models, the pattern of the results is very similar. Finally, in Column (8) we explore the role played by the spikes in periods 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 without such moments (see also Appendix Figure A-7(c) and (d)) yields once again similar patterns indicating that the results are not driven by the spikes.

Unobserved Heterogeneity. So far, we have modeled one form of heterogeneity, in search costs, and allowed for a fixed number of types – three in the standard model and two in the behavioral model. In Table 7, we relax both assumptions. We increase the number of heterogeneous cost types from 2 types (Column (1)) all the way to 6 types (Column (5)). For the reference-dependent model, there is a minor improvement in fit going from 2 to 3 types, with essentially no extra gain from more types. Indeed, estimates of the reference-dependent model with more than 3 types have trouble converging.

Instead, allowing for additional types in the standard model keeps improving the fit, though at a decreasing rate. Increasing the number of types from 2 to 3 lead to a large improvement of fit, and the gain from 4 types is sizable, with a small further gain to adding 5 types. Still, even the model with 5 or 6 types does worse in terms of fit than the reference-dependent model, despite having 11 or 13 parameters, compared to 7. In particular, as Figures 11a) and b) show, the versions of the standard model with many types capture very well the behavior up to day 270, but are still unable to capture the post-day 270 hazards.

[34] While unemployed workers are generally eligible for welfare after benefit exhaustion, the rules are complex and we do not observe a good measure of welfare take up. Thus, we explore this alternative.

Next, we consider alternative forms of unobserved heterogeneity. In Column (6) we allow for heterogeneity 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. The reference-dependent model does about equally well under these specifications, while the standard model does significantly worse, as Figure 11(c) shows. We explore this further in the section on reservation wage choices. Finally, in Column (7) we allow for heterogeneity in the curvature parameter γ instead, with very little impact on the fit of the models, as aslo Figure 11(d) shows.

We conclude that alternative specifications of the heterogeneity do not help by much the fit of the standard model, or even hurt it. The fit of the reference-dependent model is more stable under these alternative assumptions, which should not be surprising given that the behavioral model fits quite well even without any heterogeneity.

5.7 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 (even as it does not capture the hazard changes in response to the reform). To achieve this fit, changes in the unobserved types over time play a key role; without types, the hazards would be monotonically (weakly) increasing over time. How plausible then is the amount of heterogeneity that the standard model requires? And how does it compare to the heterogeneity needed in the reference-dependent model?

While we cannot measure the time-changing unobserved heterogeneity, we propose that a useful metric is the time-varying selection on observables of the unemployed. Assuming that unobservable factors that influence job search correlate with these observable characteristics, these estimates convey useful information, as in Altonji, Elder and Taber (2005).

To document the dynamic selection along observables, we use the pre-reform sample and regress at the individual level the realized unemployment duration (censored at 540 days) on a rich set of observables: sex, age, age square, waiting period (the number of days between job lost and UI claimed), indicators for county of residence, day of the month UI claimed claimed, education, occupation (1 digit) of the last job, and log earnings in 2002 and 2003.[35] We calculate predicted unemployment durations from this regression, including for individuals

[35]The $R^2$of the regression of unemployment duration on these observables is 0.055. Note that while in Altonji et al. (2005), the R^2 of the observables is an important indicator for the power of the test based on observables, this is somewhat different in our context where we are interested in whether selection can explain the pattern of the exit hazard. If individual characteristics are uncorrelated with the exit from UI, then this would imply that the $R^2$of unemployment durations on any characteristics is zero. The fact that it is low is therefore in itself an indicator that there is very limited dynamic selection, despite the fact that we use observables that are generally highly correlated with labor market outcomes.

in the post-reform period (who were not used in the regression).

The lines with round dots in Figure 12 show the predicted unemployment duration averaging across all individuals who are still unemployed in a given month. While predicted unemployment increases (unsurprisingly) throughout the spell, the overall relationship is quite flat: predicted unemployment only increases from 295 days to 310 days after around 2 years. Furthermore, the pattern of dynamic selection is not much affected by the UI benefit path. The lines for the pre- and post-reform period are fairly parallel for most of the spell, except for a gradual change after 270 days, coinciding with the exit spike at 270 days.[36] Selection on observables along the unemployment duration thus plays only a limited role in the data.

The selection over time in predicted unemployment duration has a clear counterpart in the structural models. For each cost type, we compute the expected unemployment duration in the pre-reform period. We then calculate the average expected duration for unemployed individuals who are still unemployed in a given month according to the estimated models. The reference-dependent model (solid lines in Figure 12) predicts that the type composition changes only in the first 90 days and not by much; thus the expected unemployment duration line is quite flat and not so dissimilar from what we observe empirically. The standard model instead displays a large amount of dynamic selection, with an initial swing, and another swing later between 350 and 500 days, for an ultimate increase from 260 expected days to 400 expected days after nearly two years. This pattern of dynamic selection appears at odds with the much more muted and monotonic observed selection in the data.[37]

5.8 Alternative Samples

We have focused so far on individuals with high enough pre-unemployment income that they hit the UI benefit ceiling before and after the reform. We now also examine groups that experienced different rule changes. Figure A-1 highlights two alternative samples: individuals with pre-unemployment income of 75,000 to 85,000 HUF and from 85,000 to 114,000 HUF. While they were not affected by the cap on the first step UI benefits after the reform, they nevertheless experienced the introduction of a two step UI system.

Figure A-7 shows the corresponding actual hazard plots (the moments) and the simulated hazards from the estimated standard model and the reference-dependent models. Since both groups had lower earnings prior to unemployment, their UI benefits in the post-period over the first 90 days are lower than in our main sample, while benefits between 90 and 270 days

[36] The fact that dynamic selection seems to be small and not much affected by the UI regime has been shown before, for example Schmieder, von Wachter and Bender (2013).

[37] Standard models with more types, which attain a better fit, display an even more extreme selection. Conversely, by definition, the one-type reference-dependent model which fit the data quite well displays no selection and is thus closest to the observed selection.

are unaffected. Thus there is a smaller drop-off in benefits after 90 days, which is reflected in the absence of a clear spike in the post-period in Figure A-7a) and c) at 90 days. There is however still a clear difference in the size of the benefit drop at 270 days between the before and after period. As in our benchmark sample, we still see a much larger spike in the hazard rate for the before period at 270 days and then a smaller one at 360 days.

Table 8 Columns (1) and (2), as well as Columns (4) and (5) show the estimates, and Figure A-7 the corresponding figures. For both samples, the standard model again provides a substantially worse fit than the behavioral model (the goodness of fit being 168.0 vs 145.5 for the first sample and 123.7 vs. 91.5 for the second sample). It is also noteworthy that we obtain similar estimates for the behavioral parameters as in the benchmark model. It is reassuring that the estimates are so similar even though they are based on different samples and somewhat different natural experiment.

To do a stricter test of the reference-dependent model on these samples, in Columns (3) and (6) we fix the reference dependence parameters N and λ as well as the present-bias parameter β at the benchmark estimates (i.e. 194, 4.15 and .59). We then estimate models with just four parameters compared to seven for the standard model. For both the medium and low earnings base samples, this restricted estimation of the reference-dependent model yields a significantly better fit than the one obtained with the standard model. We see this as something akin to an out-of-sample validation for the model and parameter estimates.

5.9 Reservation Wages

So far we take the reemployment wage as fixed so that the unemployed accept every job offer.[38] While this is consistent with a growing literature documenting a small role of reservation wages for job search dynamics (e.g. Card, Chetty, and Weber 2007, Schmieder, von Wachter, and Bender 2014, Krueger and Mueller 2013), it is important to know whether introducing a reservation wage would change our conclusions. Thus, we reestimate the model incorporating job acceptance decisions, using additional moments based on reemployment wages and solving by backward induction. In this expanded model, individuals draw job offers from a (stationary) log-normal wage offer distribution and decide whether or not to accept it. For computational reasons, we are unable to solve the full model with optimal consumption; we solve a hand-to-mouth model with, for simplicity, linear utility and no gain utility.

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. As additional moments, we use the average reemployment wage of individuals

[38] In the baseline model there is a single reemployment wage for everyone, while in the models in Table 7, column (6) we allow for 3 different groups of workers, each facing a different fixed reemployment wage.

exiting unemployment in period t after entering the UI system. Since we do this for both the pre- and the post period, this adds 70 additional moments in the minimum distance estimator.

Appendix Figure A-8 shows the empirical moments (hazard rates and reemployment wage path) for both models together with the simulated moments from the model estimates. The reemployment wage moments are quite noisy given the variance in wages, thus most of the identification still comes from the hazard rates. The model fit is similar to the benchmark one: the reference-dependent model fits quite a bit better than the standard model.

Appendix Table **??** shows the results in Columns (1) and (2). The reference-dependent model has a better fit than the standard model (GOF of 381 versus 418). To compare the fit of these models with the ones without reservation wage, one can focus on the fit for the hazard moments, reported at the bottom of the Table. The difference in fit for these moments is not as large as in the benchmark specifications. Yet, the difference is entirely due to the simplifying assumptions of linear utility and no gain utility: the quality of fit and the parameter estimates are very similar in a hand-to-mouth model with no reservation wages, maintaining linear utility and no gain utility. (Columns (3) and (4)). Thus, the reservation wage results are qualitatively similar to the main ones.

6 Discussion and Conclusion

In the previous section, we provided evidence that a model with reference-dependent preferences can explain qualitative features of the hazards which a standard model has a hard time fitting. The model itself builds on one of the most robust behavioral deviations from the standard model, reference dependence, and uses a natural candidate for a backward-looking reference point.

An important implication of the results above is that they open the door to potential redesigns in unemployment insurance policies. Lindner and Reizer (2015) analysis the costs and benefits of Hungarian UI reform examined here. They found that introducing a new step in the UI system did not just speed up exists to employment, but it wasrevenue-neutral from the perspective of the government While presenting a full welfare analysis of such UI plans is beyond the scope of this paper,the evidence presented here suggests that UI systems involving two-steps can be an inexpensive way to alleviate unemployment.

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

	before	after	diff	t-stat
	(1)	(2)	(3)	(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)		
Inconsistent observations	0.024	0.022	0.022	-0.75
	(0.002)	(0.002)		
Number of observations**	6305	5562		

Notes:
Participation in training programs was not recorded prior to 2006.
* number of days between jobb loss and UI claim.
* for log earnings in 2002; 2003; 2004 there are some missing values.

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

	Standard 3-type (1)	RD 2-type (2)
Parameters of Utility Function		
Utility function $v(.)$	log(b)	log(b)
Loss aversion λ		2.23 (0.25)
Gain utility η		1
Adjustment speed of reference point N in days		225 (26.7)
Discount factor (15 days) δ	0.995	0.995
Parameters of Search Cost Function		
Elasticity of search cost γ	0.09 (0.02)	0.06 (0.01)
Search cost for high cost type k_{high}	310.3 (9.35)	310.4 (4.93)
Search cost for medium cost type k_{med}	242.8 (3.45)	–
Search cost for low cost type k_{low}	84.3 (8.40)	107.0 (14.00)
Share of low cost UI claimant	0.42 (0.04)	0.17 (0.04)
Share of medium cost UI claimant	0.58 (0.04)	
Model Fit		
Number of moments used	70	70
Number of estimated parameters	6	6
Goodness of Fit	244.5	185.4

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.

Table 3: Benchmarks Estimates with Endogeneous Savings

	Standard 3 type delta est	RD 2 type delta est	Standard 3 type beta est	RD 2 type beta est	RD 1 type delta est	RD 1 type beta est
	(1)	(2)	(3)	(4)	(5)	(6)
Parameters of Utility Function						
Utility function $v(.)$	log(b)	log(b)	log(b)	log(b)	log(b)	log(b)
Loss aversion λ		4.45		4.15	8.8	6.25
		(0.69)		(0.4)	(0.62)	(0.91)
Adjustment speed of reference point N in days		204		194	144	141.6
		(16)		(12)	(8.1)	(9.2)
Discount factor (15 days) δ	0.884	0.904	0.995	0.995	0.877	0.995
	(0.011)	(0.022)			(0.013)	
Discount factor β	1	1	0.594	0.59	1	0.5
			(0.335)	(0.1)		(0.200)
Parameters of Search Cost Function						
Elasticity of search cost γ	0.996	0.79	0.45	0.354	1.34	0.558
	(0.039)	(0.183)	(0.343)	(0.107)	(0.024)	(0.249)
Search cost for high cost type k_{high}	461.3	337.4	166	90.9	1783.8	143.1
	(35.9)	(155.8)	(38.4)	(8.7)	(184.5)	(22.6)
Search cost for medium cost type k_{med}	254.8		81.22			
	(13.93)		(28.48)			
Search cost for low cost type k_{low}	58.3	27.8	11.09	2.47		
	(6.45)	(7.95)	(8.51)	(0.76)		
Share of low cost UI claimant	0.400	0.09	0.328	0.112		
	(0.032)	(0.021)	(0.041)	(0.015)		
Share of medium cost UI claimant	0.598		0.669			
	(0.032)		(0.041)			
Model Fit						
Number of moments used	70	70	70	70	70	70
Number of estimated parameters	7	7	7	7	5	5
Goodness of Fit	247.5	183.3	241.1	167.7	228.11	219.07

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.

Table 4: Alternative Specifications for Reference-Dependent Model

Models:	**Benchmark 2-types**	**AR(1) Updating**	**No Gain Utility**	**No Loss Utility**	**Alternative Eta**		**Estimate λ and η**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Parameters of Utility Function							
Utility function $v(.)$	log(b)	log(b)	log(b)	log(b)	log(b)	log(b)	log(b)
Loss aversion λ	4.24	7.04	3.36	0	17.47	1.75	2.13
	(0.43)	(1.03)	(0.40)		(1.94)	(0.12)	(0.80)
Gain utility η	1	1		2.11	0.2	5	2.83
				(0.06)			(2.13)
Adjustment speed of reference point N in days	184.40		178.80	529.83	183.44	176.19	190.88
	(10.27)		(11.82)	(19.43)	(9.42)	(12.73)	(12.13)
AR(1) parameter		0.77					
		(0.01)					
Implied half life of AR(1) process		39.35					
		(3.65)					
Discount factor β	0.59	0.23	0.59	0.41	0.59	0.40	0.54
	(0.11)	(0.10)	(0.10)	(0.11)	(0.09)	(0.14)	(0.17)
Discount factor (15 days) δ	0.995		0.995	0.995	0.995	0.995	0.995
Elasticity of search cost γ	0.36	0.76	0.36	2.41	0.35	0.60	0.42
	(0.11)	(0.19)	(0.10)	(0.04)	(0.10)	(0.18)	(0.19)
Model Fit							
Number of moments used	70	70	70	70	70	70	70
Number of estimated parameters	7	7	7	7	7	7	7
Goodness of Fit	168.09	155.73	171.22	219.94	170.50	167.46	166.10
Heterogeneity in cost	yes	yes	yes	yes	yes	yes	yes

Notes:
The table shows parameter estimates for the reference dependent search model and the habit formation 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.

Table 5: Structural Estimation of the Habit Formation Model

	Habit Formation Delta (1)	Habit Formation + AR(1) Delta (2)	Habit Formation Beta (3)	Habit Formation + AR(1) Beta (4)
Parameters of Utility Function				
Utility function $v(.)$	log(b)	log(b)	log(b)	log(b)
Habit formation parameter z	0.39		0.35	0.31
	(0.02)		(0.02)	(0.01)
Adjustment speed of reference point N in days	311.14		190.07	
	(20.02)		(27.20)	
AR(1) parameter		0.85		0.94
		(0.02)		(0.00)
Implied half life of AR(1) process		63.34		173.12
		(11.66)		(14.00)
Discount factor (15 days) δ	0.89	0.91	0.995	0.995
	(0.01)	(0.01)		
Discount factor β	1	1.00	0.03	0.04
			(0.05)	(0.01)
Parameters of Search Cost Function				
Elasticity of search cost γ	1.11	1.06	1.88	2.08
	(0.11)	(0.18)	(0.68)	(0.28)
Search cost for high cost type k_{high}	606.21	564.41	253.74	700.27
	(218.93)	(343.62)	(184.60)	(499.74)
Search cost for low cost type k_{low}	114.13	174.76	90.16	4.29
	(37.38)	(72.27)	(52.42)	(2.06)
Share of low cost UI claimant	0.18	0.38	0.99	0.19
	(0.10)	(0.06)	(0.009)	(0.022)
Model Fit				
Number of moments used	70	70	70	70
Number of estimated parameters	7	7	7	7
Goodness of Fit	283.68	262.74	287.43	258.25

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.

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

	Robustness on Utility Function				Statistical Robustness			
	Higher initial assets	Background Consumption	Alternative Welfare assumption	Time-varying search cost	Identity Weighting Matrix	Moments with controls	Probability Moments	Estimation without Spikes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Standard Model								
Discount factor (15 days) δ	0.854	0.920	0.00	0.883	0.84	0.88	0.944	0.89
	(0.009)	(0.056)	(0.08)	(0.014)	(0.01)	(0.05)	(0.006)	(0.065)
Elasticity of search cost γ	1.330	1.17	1.00	1.09	1.15	0.97	0.700	1.186
	(0.031)	(0.60)	(1.02)	(0.20)	(0.04)	(0.33)	(0.021)	(0.536)
Time varying search cost				4.1E-07				
				(4.0E-03)				
Non-market Income		167.4	4.24					
		(95.7)	(0.54)					
Number of moments used	70	70	70	70	70	70	70	66
Number of estimated parameters	7	8	8	8	7	7	7	7
Goodness of Fit	249.8	244.7	245.8	246.9	0.0035	226.60	260.82	254.6
Goodness of Fit (excluding spikes)								172.57
Reference Dependent Model								
Loss aversion λ	4.91	4.14	9.55	13.00	3.93	4.30	5.38	4.47
	(0.37)	(0.43)	(6.45)	(2.63)	(0.31)	(0.40)	(0.34)	(0.56)
Adjustment speed of reference	168	193.5	189.9	208.8	193.80	178.75	182.4	194
point N in days	(9)	(12.4)	(39.0)	(10.9)	(11.40)	(11.36)	(6.1)	(14)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.52	1	0.51	0.41	0.59	0.60	0.50	0.51
	(0.04)		(0.56)	(0.13)	(0.08)	(0.09)	(0.04)	(0.18)
Elasticity of search cost γ	0.48	1.09	0.89	0.79	0.31	0.34	0.475	0.474
	(0.05)	(1.22)	(0.90)	(0.19)	(0.08)	(0.09)	(0.035)	(0.201)
Time varying search cost				1.4E-02				
				(4.4E-03)				
Non-market Income		0.355	79.5					
		(0.146)	(19.1)					
Number of moments used	70	70	70	70	70	70	70	66
Number of estimated parameters	7	8	8	8	7	7	7	7
Goodness of Fit	187.2	167.8	205.6	179.7	0.0024	144.66	176.29	174
Goodness of Fit (excluding spikes)								120.947

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.
* These are the SSE with the identity weighting matrix and alternative moments respectively and are not directly comparable to the goodness of fit statistics in the other columns. ** These SSE correspond to the reduced number of moments (that is not including the spikes). The comparable SSE from the standard model (that is also excluding the spike moments) are 176.5 and 122.0 respectively.

Table 7: Robustness to Alternative Types of Heterogeneity

Models:	**2 cost types**	**3 cost types**	**4 cost types**	**5 cost types**	**6 cost types**	**Heterogeneity Wages 90-50-10**	**Heterogeneity seach cost elasticity γ**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Standard Model							
Discount factor (15 days) δ	0.918	0.884	0.870	0.870	0.870	0.930	0.871
	(0.007)	((0.011))	(0.045)	(0.006)	(0.065)	(0.034)	(0.063)
Elasticity of search cost γ	1.50	0.996	0.73	0.72	0.72	1.05	3-types
	(0.32)	(0.039)	(0.24)	(0.02)	(0.29)	(0.19)	
Number of moments used	70	70	70	70	70	70	70
Number of estimated parameters	5	7	9	11	13	5	7
Goodness of Fit	328.8	247.5	220.8	214.7	214.1	292.3	247.2
Reference Dependent Model							
Loss aversion λ	4.15	3.86	3.70	*	*	3.41	3.85
	(0.4)	(0.31)	(0.38)			(0.43)	(0.29)
Adjustment speed of reference point N in days	194	193.8	196.0	*	*	200.0	196.8
	(12)	(11.8)	(10.4)			(16.4)	(11.5)
Discount factor (15 days) δ	0.995	0.995	0.995	*	*	0.995	0.995
Discount factor β	0.59	0.613	0.613	*	*	0.605	0.613
	(0.1)	(0.018)	(0.046)			(0.056)	(0.034)
Elasticity of search cost γ	0.354	0.084	0.33	*	*	0.420	2-types
	(0.107)	(0.024)	(0.05)			(0.073)	
Number of moments used	70	70	70			70	70
Number of estimated parameters	7	9	9			7	7
Goodness of Fit	167.7	161.0	160.5			178.5	171.5

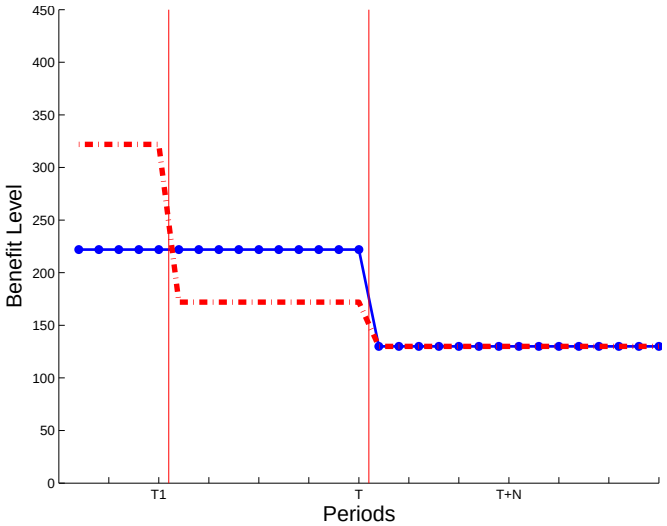
Notes:
The table shows parameter estimates for the standard and the reference dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
* The reference dependent model does not converge with more than 3 types, indicating that additional types are not identified and do not improve the fit.

Table 8: Structural Estimation on Alternative Earnings Samples

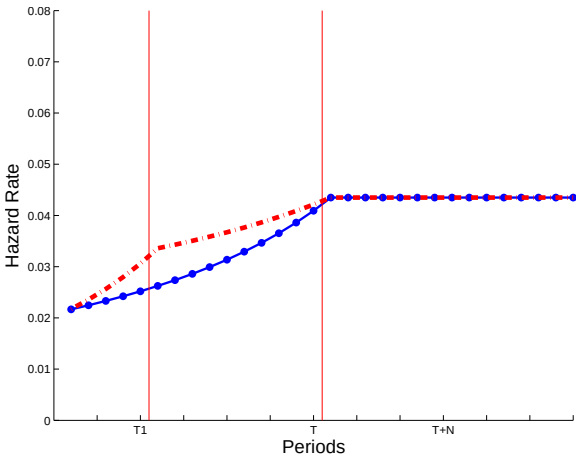
	Pre-UI Income Medium Earnings Base			Pre-UI Income Low Earnings Base		
	Standard Model	Ref. Dep. Model	Ref. Dep. Model restricted	Standard Model	Ref. Dep. Model	Ref. Dep. Model restricted
	(1)	(2)	(3)	(4)	(5)	(6)
Parameters of Utility Function						
Loss aversion λ		3.43	4.15		3.58	4.15
		(0.42)			(0.49)	
Adjustment speed of reference point N in days		165.6	194		157.245	194
		(15)			(15.9)	
Discount factor (15 days) δ	0.918	0.995	0.995	0.915	0.995	0.995
	(0.062)			(0.007)		
Discount factor β	1	0.5	0.59	1	0.6	0.59
		(0.21)			(0.22)	
Elasticity of search cost γ	0.96	0.076	0.07	0.771	0.12	0.121
	(0.54)	(0.022)	(0.02)	(0.184)	(0.03)	(0.022)
Model Fit						
Number of Moments	70	70	70	70	70	70
Number of estimated parameters	7	7	4	7	7	4
Goodness of Fit	168.0	145.5	156.8	123.7	91.5	101.5

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.

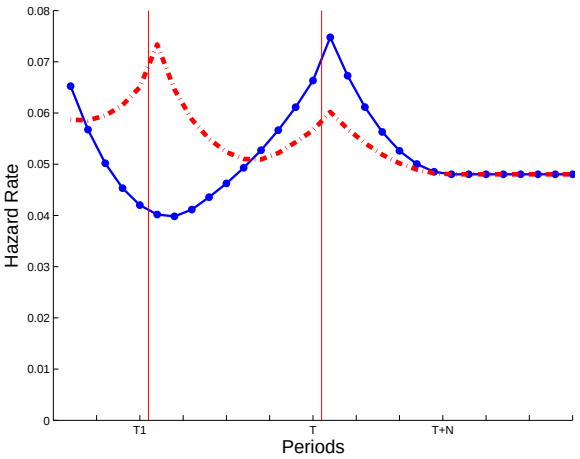
Figure 1: Model Simulations of the Standard and the Reference-Dependent model



(a) Benefits



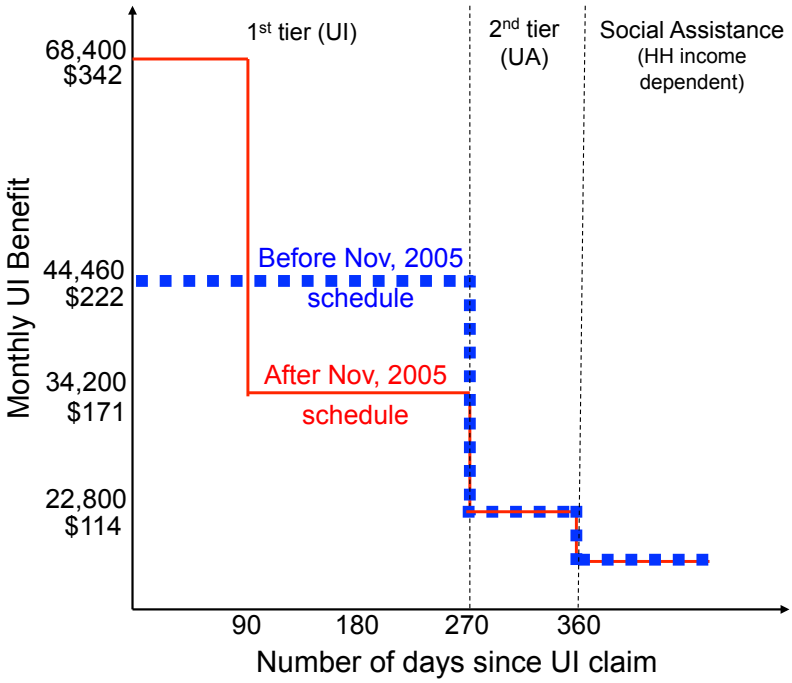
(b) Standard Model



(c) Reference-Dependent Model

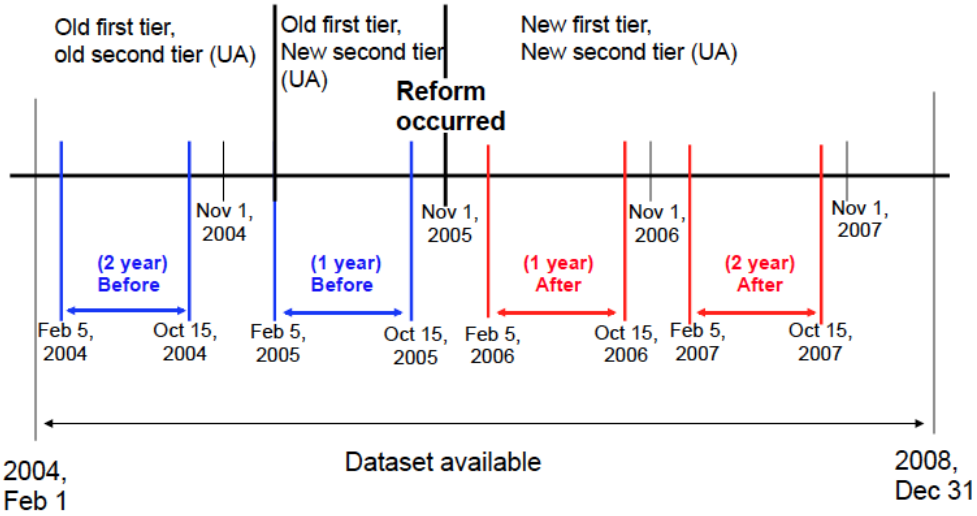
Notes: Panel (a) shows two benefit regimes, both of them having a step-down benefit system. In the first step benefits are higher in the regime represented by squared blue line than in the regime represented by red solid line. In the second step benefits drops to the same level. Panel (b) shows the hazard 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: Benefit Path Change, Main Sample



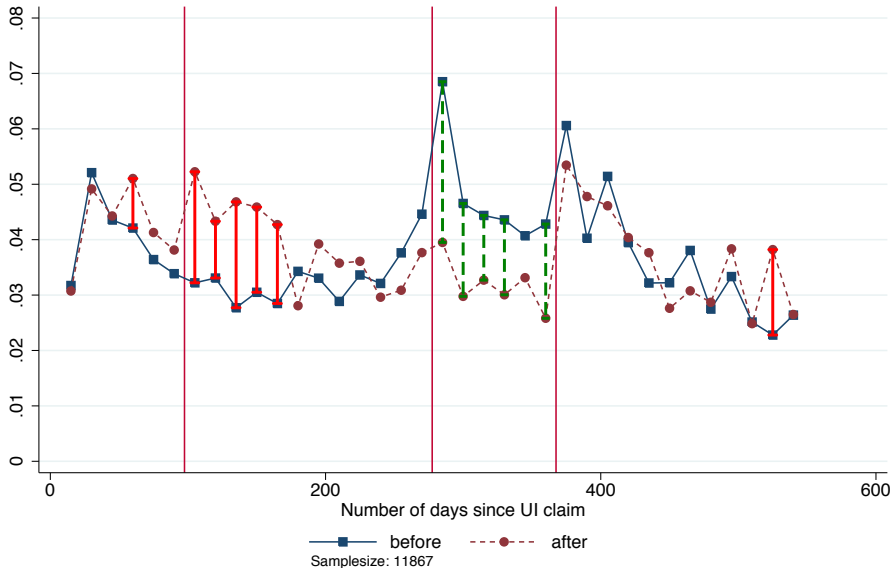
Notes: The figure shows the benefit schedule if UI is claimed on October 31, 2005 (old benefit schedule, dashed blue line) and benefit schedule if UI is claimed on November 1st, 2005 (new benefit schedule, solid red line) for individuals who had 270 potential duration in the first-tier, were less than 50 years old and earned more than 114,000 HUF ($570) prior to entering UI. Hypothetical benefit level is shown under social assistance. Benefits levels in social assistance depended on family income, household size and wealth and we do not observed these variables in our data.

Figure 3: Before-After Comparison Groups for Quasi-experiment

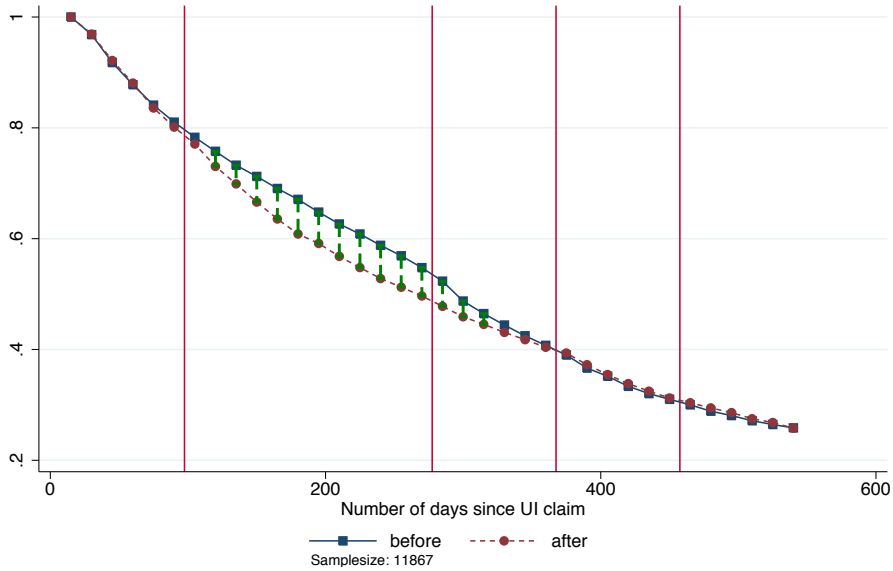


Notes: The figure shows the time frame for which we have access to administrative data on unemployment insurance records, the time of the reform and how we define the before and after periods that we use for our before-after comparison.The timing of the reform was the following: those who claimed UI benefit before February 5th, 2005 faced with the old first tier schedule and old second tier schedule; those who claimed benefit between February 5th, 2005 and October 31th, 2005 faced with the old benefit schedule in the first tier and the new benefit schedule in the second tier; those who claimed benefit after November 1st, 2005 faced with the new benefit schedule in the first tier and the new benefit schedule in the second tier. To avoid complications caused by changes in the second tier, in our main specifications we focus on the (1 year) before sample, claimed UI between February 5th, 2005 and October 15th, 2005, and (1 year) after sample, claimed UI between February 5th, 2006 and October 15th, 2006. We use the (2 year) before sample and the (2 year) after sample to show that the changes in the hazard rates are in line with the timing of the reform. The first tier changes before and after October 31th, 2005 are presented in Figure 2 and Figure 3. The changes in the second tier in February 5th, 2005 were the following: potential duration shortened to 180 days above age 50 and to 90 days below that. Before, it was 270 days above age 45 and 180 days below that. The benefit level was raised slightly from 21,000 HUF ($101) to 22,800 HUF ($114).

Figure 4: Empirical Hazard and Survival Rates under the Old and the New Benefit Schedule



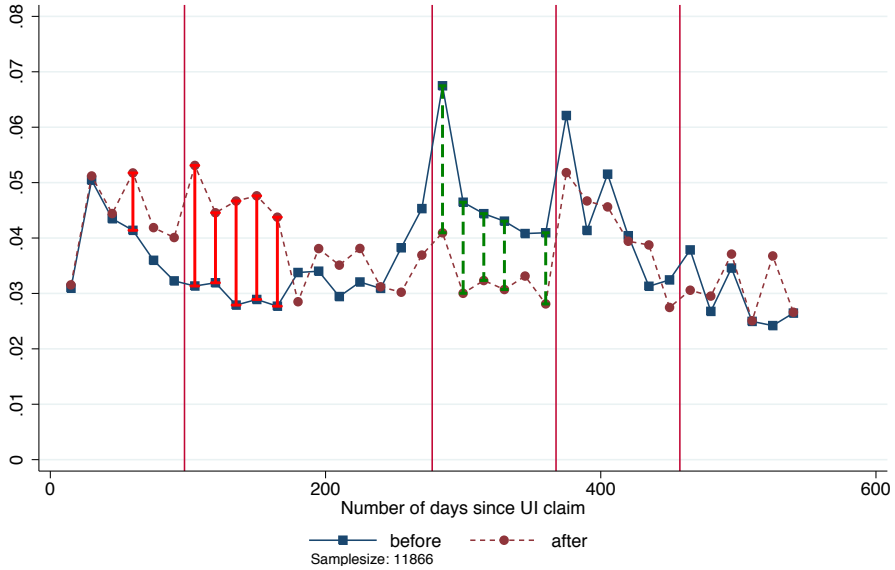
(a) Empirical hazard rates



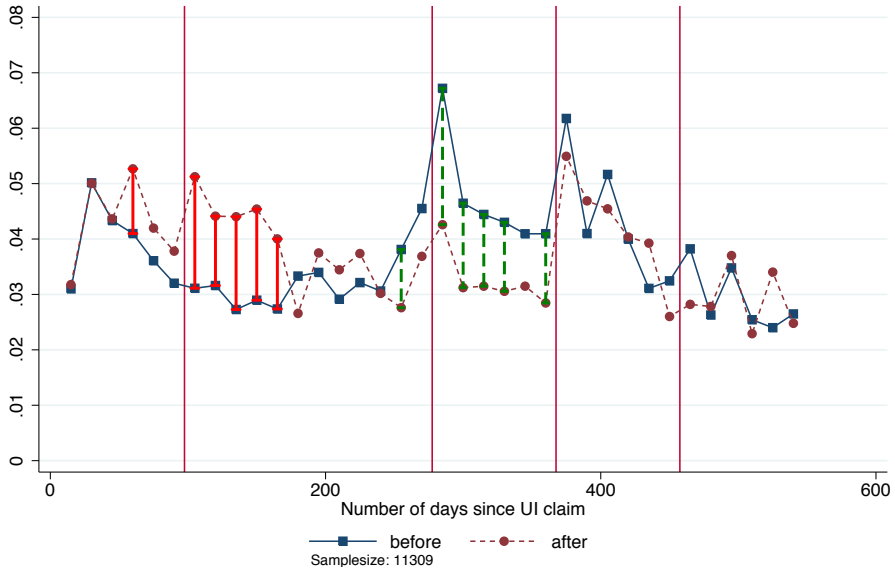
(b) Empirical survival rates

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 are indicated with a vertical bar. 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 (See Figure 4 for details).

Figure 5: Robustness Checks for change of Hazard rates before and after the reform



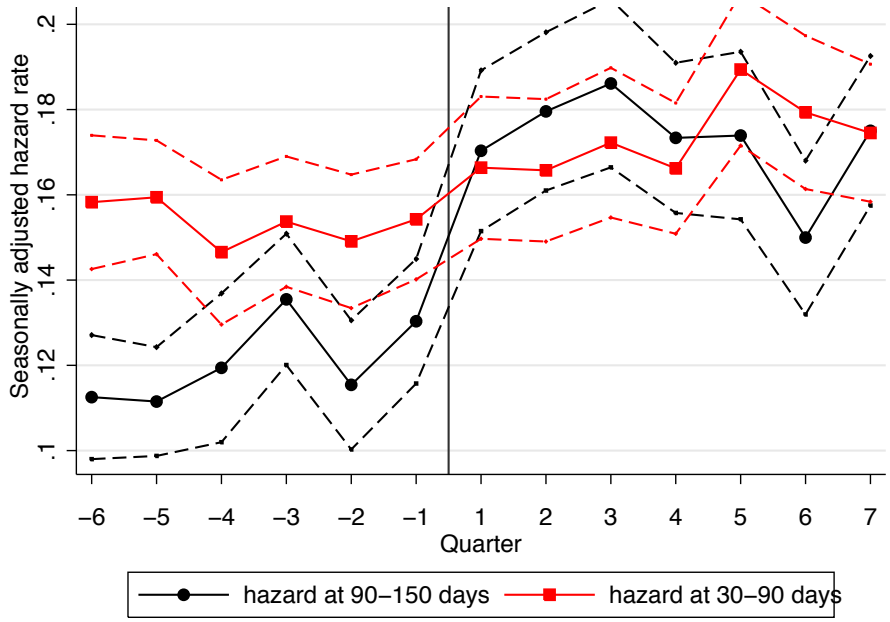
(a) Controlling for observable differences



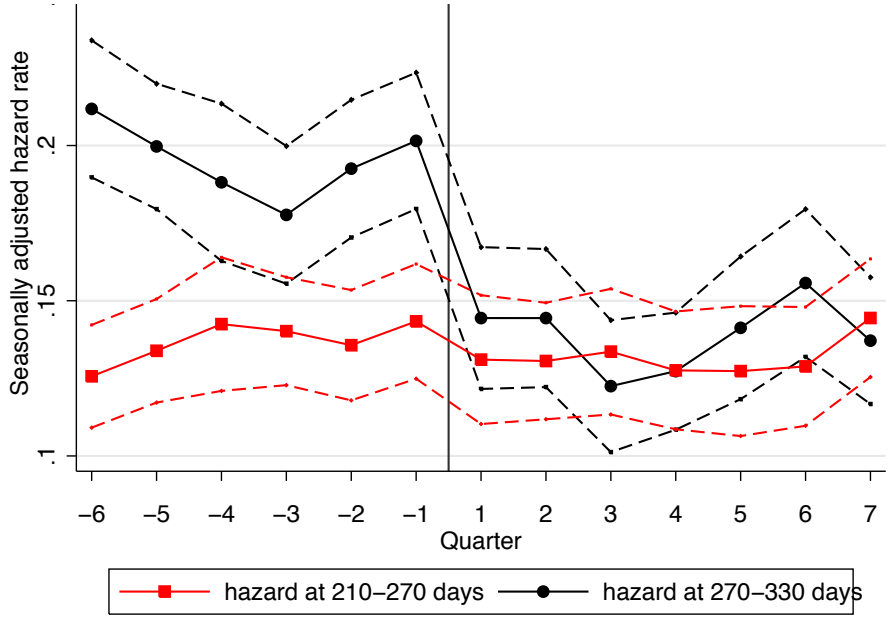
(b) Restricted sample

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. The three major (red) vertical lines indicate periods when benefits change in the new system. In Panel (a) we controlled 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 claimed, education, occupation (1 digit) of the last job, 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 program (after the reform), see text for the details. The sample is otherwise the same as in Figure 5.

Figure 6: Interrupted Time Series Analysis of Exit Hazards



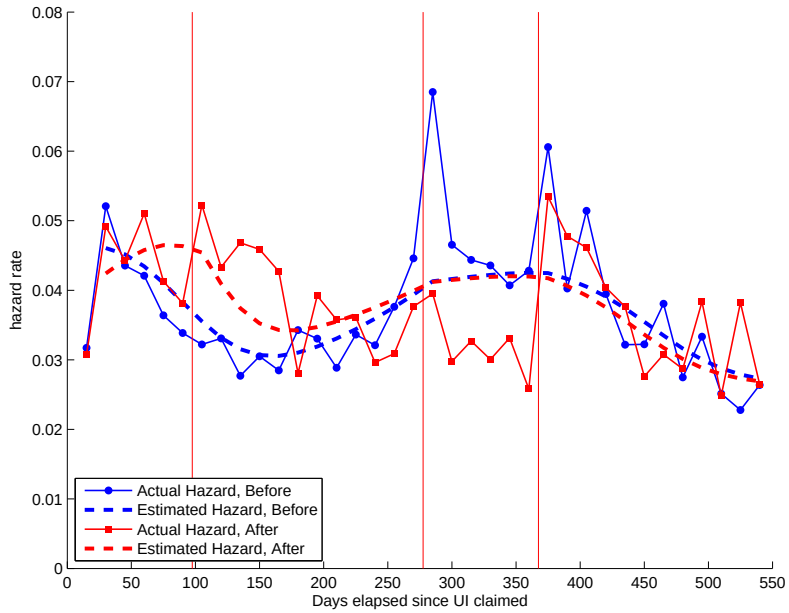
(a) The evolution of the hazard rates between 30 and 150 days



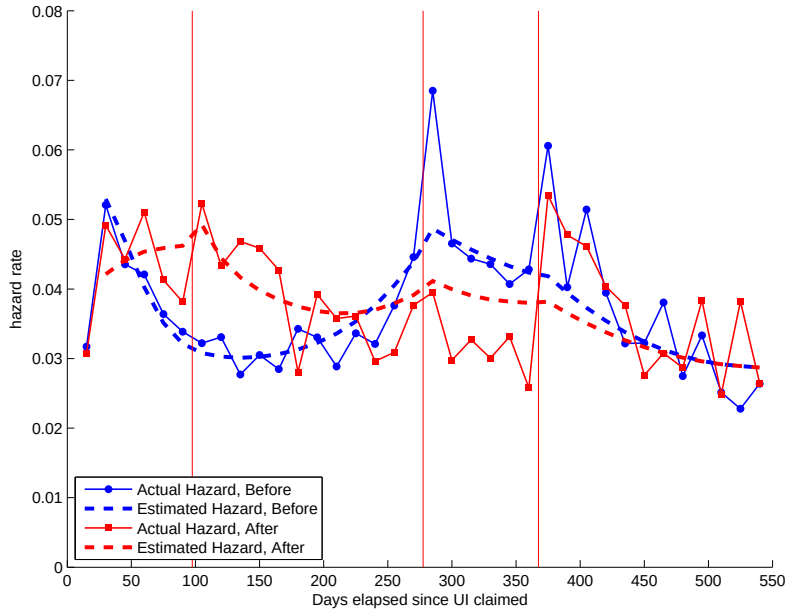
(b) The evolution of the hazard rates between 210 and 330 days

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 5.

Figure 7: Estimates of the Standard and Reference-dependent Model with Hand-to-Mouth Consumers



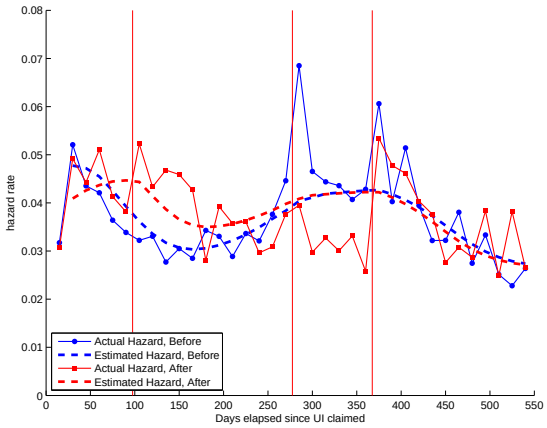
(a) Standard Model



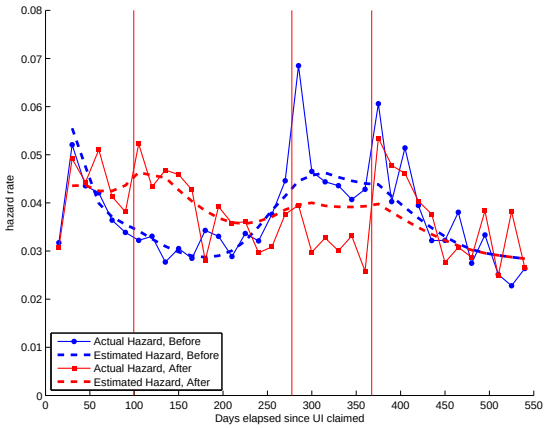
(b) Reference-dependent Model

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, shown in Table 2 column (1), while Panel (b) corresponds to the reference dependent model with 2 cost types shown in Table 2 column (2). The three major (red) vertical lines indicate periods when benefits change in the new system.

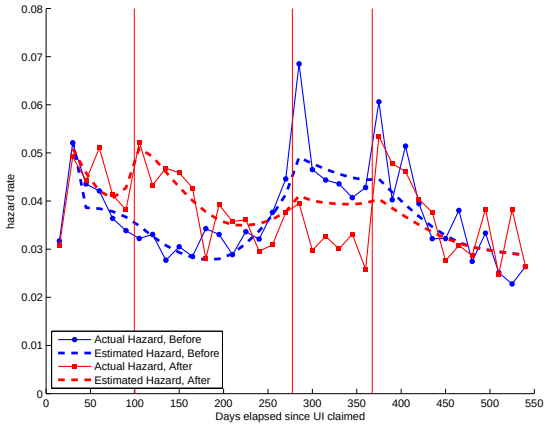
Figure 8: Benchmark Estimates of the Standard and Reference-Dependent Model (with Endogenous Savings)



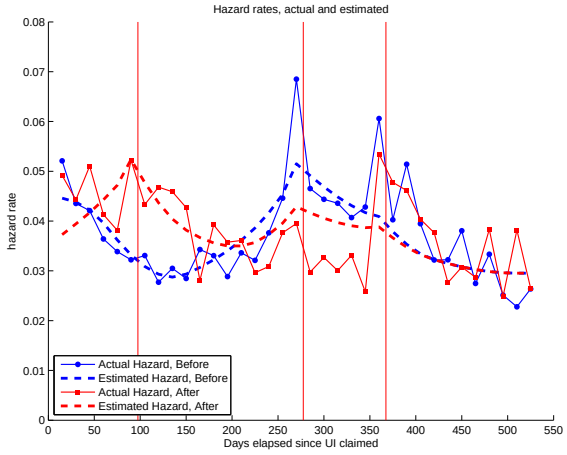
(a) Standard Model with estimated δ



(b) RD Model, 2 cost types, estimated δ



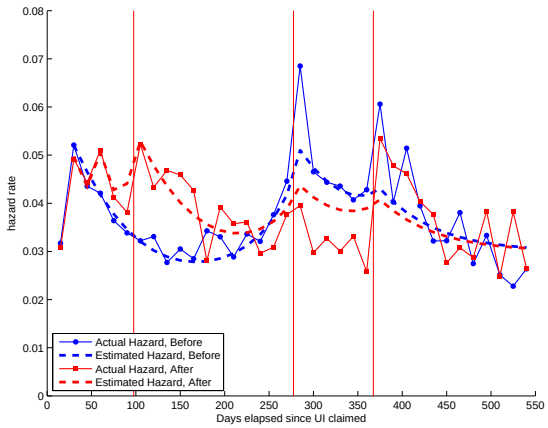
(c) RD Model, 2 cost types, estimated β



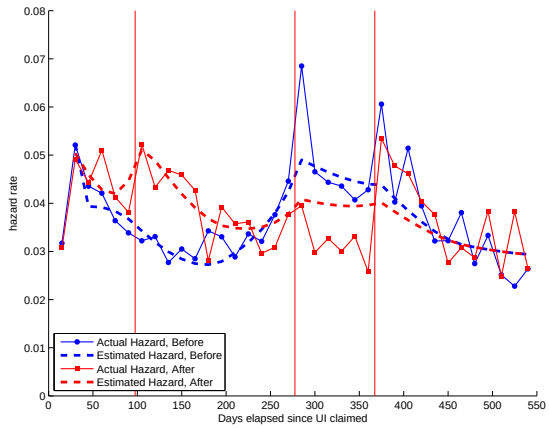
(d) RD Model, no heterogeneity, estimated β

Notes: The figure shows the empirical hazards and the predicted hazards of the standard and the reference-dependent model with endogenous savings. Panel (a) corresponds to the standard model with 3 cost types and estimated δ, shown in Table 3 column (1). Panel (b) corresponds to the reference dependent model with 2 cost types shown in Table 3 column (2). Panel (c) shows the RD model with 2 types but estimated β. Panel (d) shows the RD model with only 1 type and estimated β. The three major (red) vertical lines indicate periods when benefits change in the new system.

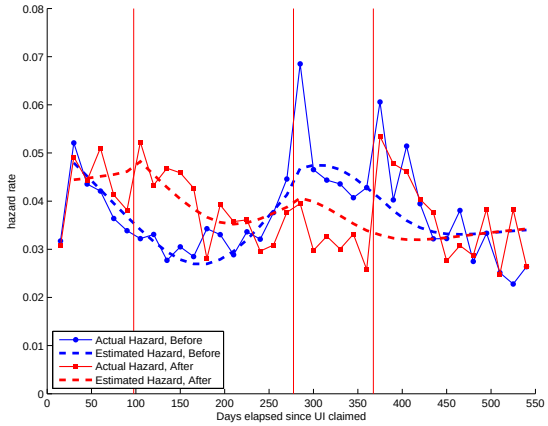
Figure 9: Alternative Estimates of the Reference-dependent Model



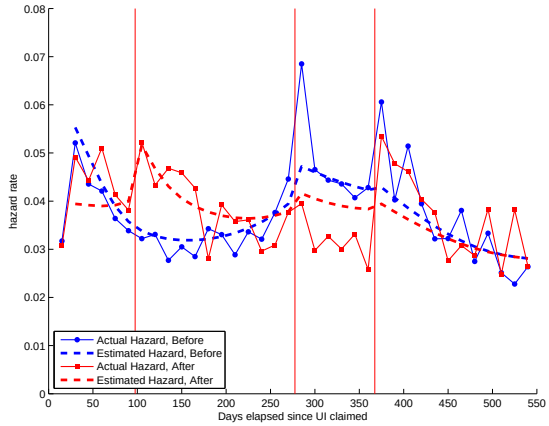
(a) Reference-Dependent Model, AR(1) update



(b) Reference-Dependent Model, no gain



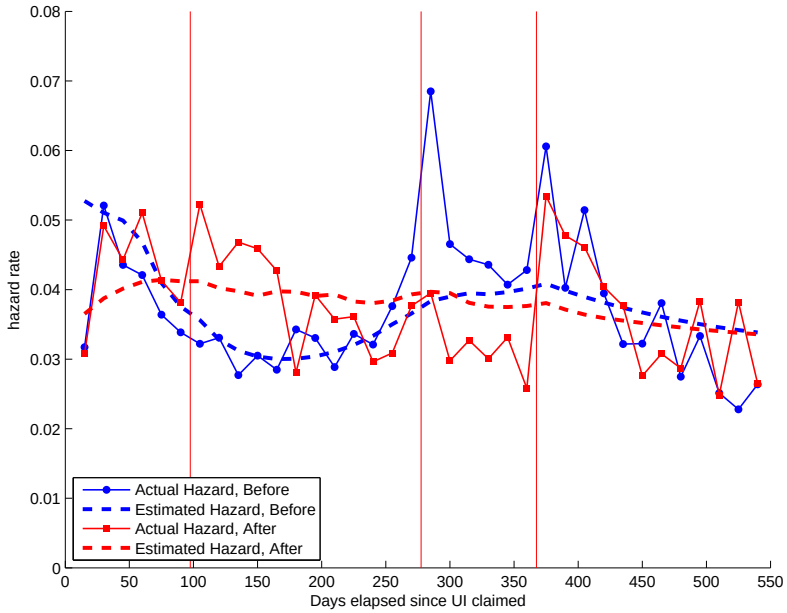
(c) Reference-Dependent Model, no loss utility



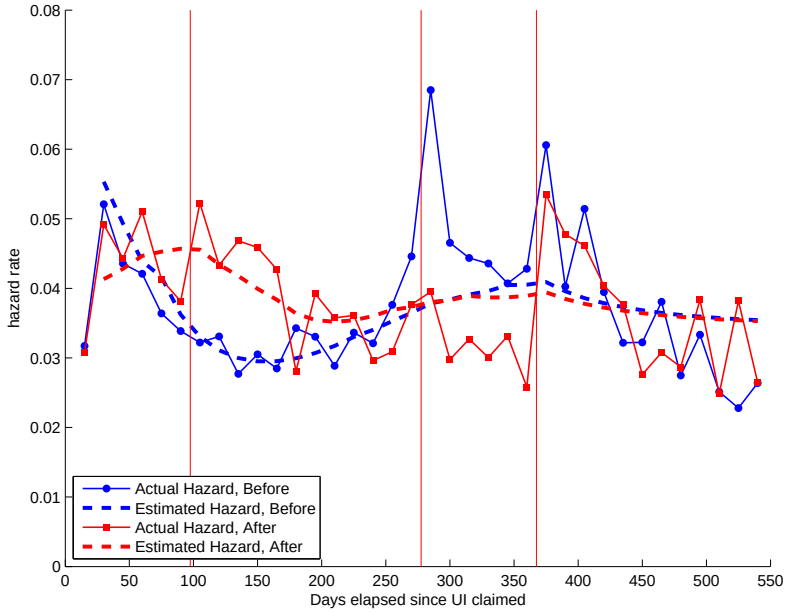
(d) Reference-Dependent Model, estimated η and λ

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. Panel (b) shows the RD model without gain (only loss) utility. Panel (c) without loss (only gain) utility and Panel (d) shows the RD model where both the gain η and the loss part $\lambda\eta$ are estimated .

Figure 10: Habit Formation Model



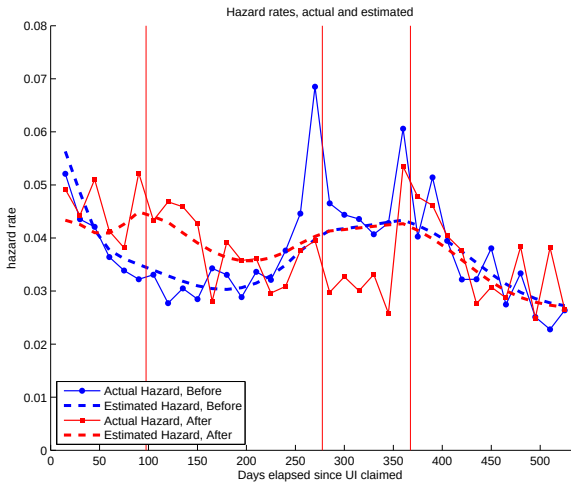
(a) Habit Formation Model



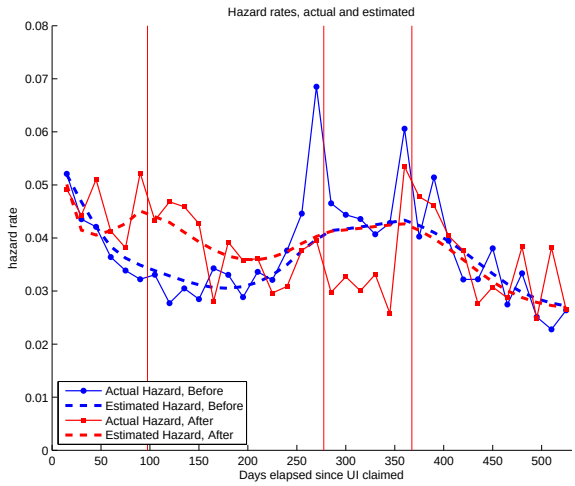
(b) Habit Formation Model - AR(1)

Notes: The figure shows the empirical hazards and the predicted hazards from estimating the habit formation model. The first panel uses the same reference point as our main specifications for the reference dependent model, while the second panel uses a reference point that is updated via an AR(1) process.

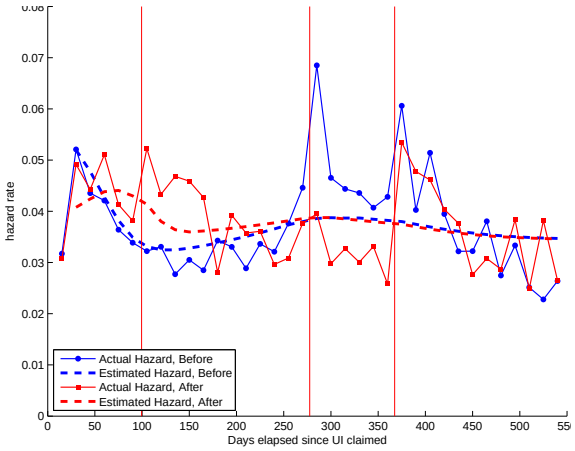
Figure 11: Estimates of the Standard Model under Alternative Heterogeneity



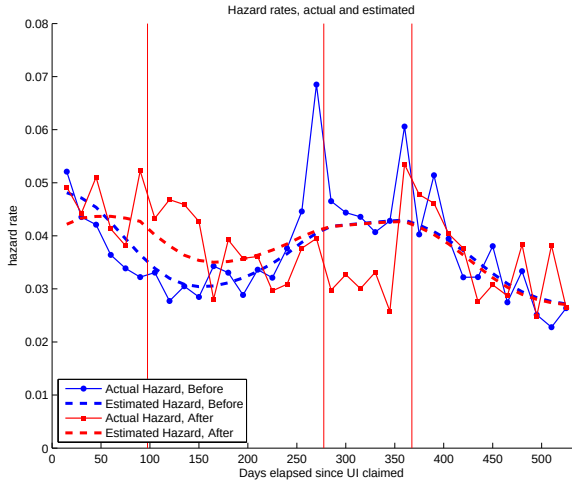
(a) 4 cost types



(b) 5 cost types



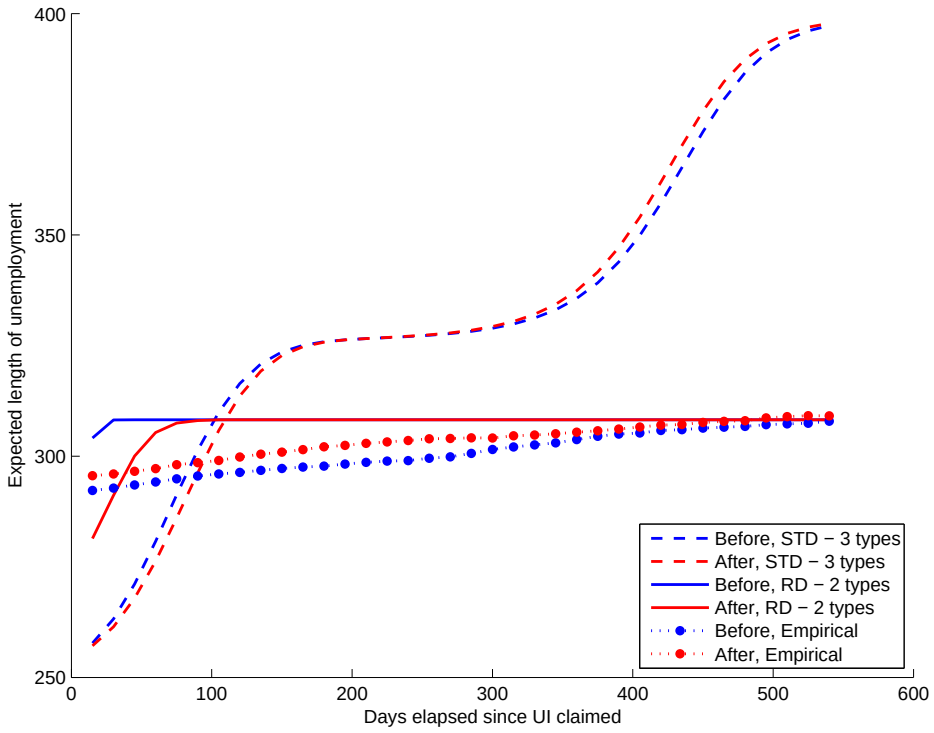
(c) Heterogeneity in Wages



(d) Heterogeneity in Search Cost Elasticity

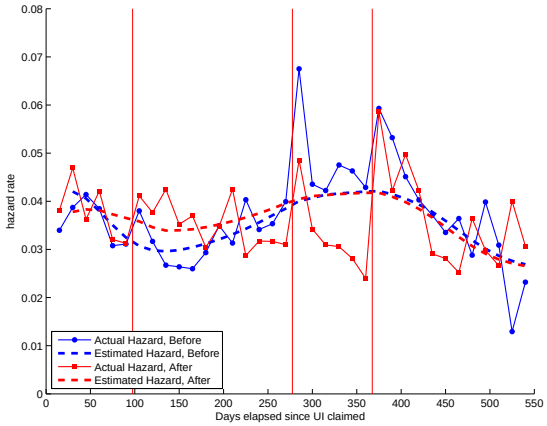
Notes: The figure shows the empirical hazards and the predicted hazards for estimations of the standard model under different specifications of heterogeneity. Panel (a) and (b) allow for 4 and 5 cost types. Panel (c) allows for three different types with different reemployment wages (calibrated to match the empirical distribution of reemployment wages) and Panel (d) allows for three different types in the elasticity of job search γ.

Figure 12: Changes in Heterogeneity throughout the Unemployment Spell: Empirical Heterogeneity vs. Model Predictions

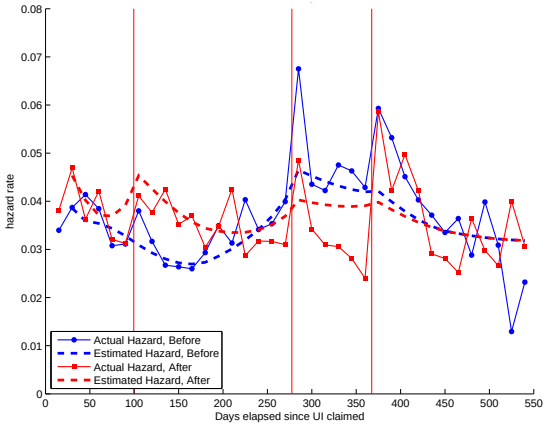


Notes: The figure shows estimates of the expected nonemployment duration of individuals who are remaining in unemployment in each time period, contrasting the empirically observed selection with the predicted selection from the estimated standard and RD models. The empirical expected nonemployment duration (lines with circles) for each individual is calculated as the predicted values from a regression of nonemployment duration on observable characteristics at the time of entering unemployment. These observable characteristics are the following: 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 claimed, education, occupation (1 digit) of the last job, log earnings in 2002 and 2003. The regression is run on the pre-reform sample only and the same coefficients are used to predict unemployment durations pre- and post 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. The three major (red) vertical lines indicate periods when benefits change in the new system. The expected nonemployment durations predicted by the estimated standard (3 type) and reference dependent (2 type) model are displayed as the solid and dashed lines. For each cost type, we calculate the expected nonemployment duration in the pre-period. Then we plot the average of the expected nonemployment durations for each person still in unemployment at time t based on the type composition at time t pre and post reform.

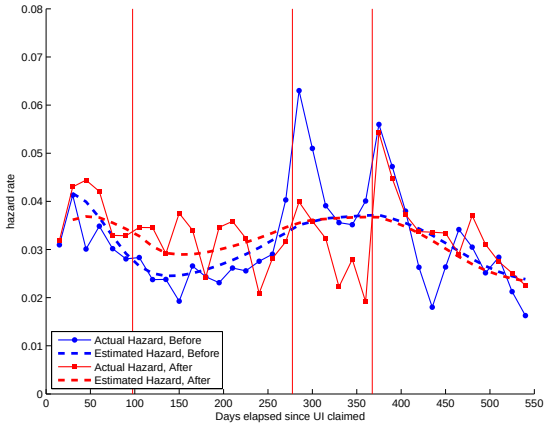
Figure 13: Estimates for Samples with Alternative Earnings Base



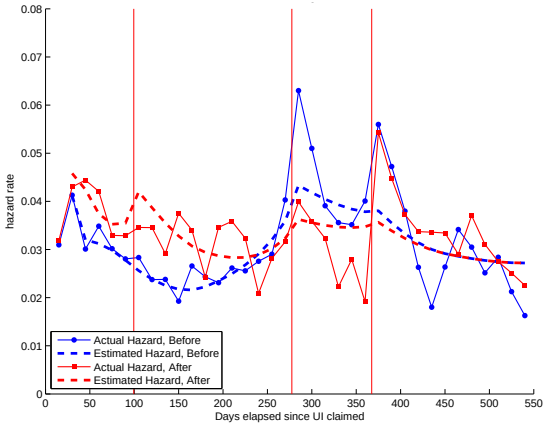
(a) Standard model, Medium Earnings Base



(b) Reference-Dependent Model, Medium Earnings Base



(c) Standard Model, Low Earnings Base



(d) Reference-Dependent Mode, Low Earnings Base

Notes: The figure shows the empirical hazards and the predicted hazards of the UI claimant with alternative earnings base. Panel (a) and Panel (b) present estimates for those whose earnings base were between the 60th and the 78th percentile of the earnings base distribution of the UI claimants in the given year. Panel (a) shows the fit of the standard model (column (3), Table 7) and Panel (b) for the reference-dependent model (column (5), Table 7). Panel (c) and Panel (d) present the results for those whose earnings base were between the 49th and the 60th percentile of the earnings base distribution of the UI claimants in the given year. Panel (a) shows estimates for the standard model (column (5), Table 7) and Panel (b) illustrates the estimates for the reference-dependent model (column (6), Table). All panels present estimations with three cost types. The three major (red) vertical lines indicate periods when benefits change in the new system.

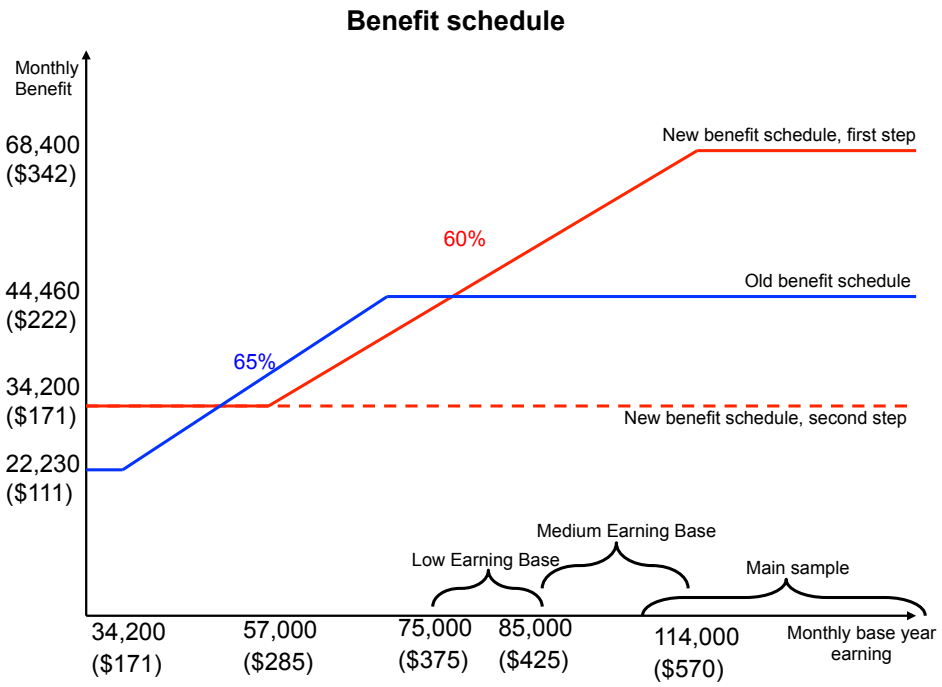
Appendix

Table A-1: Estimates with Reservation Wages

	Std Res. Wage est. δ	RD Res. Wage est. δ	Std No Res. Wage	RD No Res. Wage
	(1)	(2)	(3)	(4)
Parameters of Utility Function				
Utility function	linear	linear	linear	linear
Loss aversion λ		0.93		1.09
		(0.09)		(0.11)
Adjustment speed of reference point N		192.4		194.9
		(14.8)		(13.6)
Discount factor (15 days) δ	0.929	0.984	0.995	0.995
	(0.027)	(0.002)		
Mean of log reemployment wage	6.01	5.99		
	(0.01)	(0.01)		
Sd of log reemploment wage	0.5	0.5		
Parameters of Search Cost Function				
Elasticity of search cost γ	0.68	0.10	0.05	0.04
		(0.00)	(0.01)	(0.00)
Search cost for high cost type k_{high}	50576.1	26036	69113.8	65868.7
	(37383.2)	(2676)	(1204.9)	(604.0)
Search cost for medium cost type k_{med}	32373.1		58912.2	
	(19129.6)		(877.8)	
Search cost for low cost type k_{low}	7335.4	0.01	28177.5	14478.3
	(1679.3)	(127)	(2267.6)	(2789.9)
Share of low cost UI claimant	0.37	0.19	0.38	0.08
	(0.04)	(0.01)	(0.03)	(0.01)
Share of medium cost UI claimant	0.62		0.61	
	(0.04)		(0.03)	
Model Fit				
Number of moments used	140	140	70	70
Number of estimated parameters	8	8	6	6
Goodness of fit (GOF)	418.3	381.4	241.2	209.3
GOF in hazard moments	241.6	212.8		

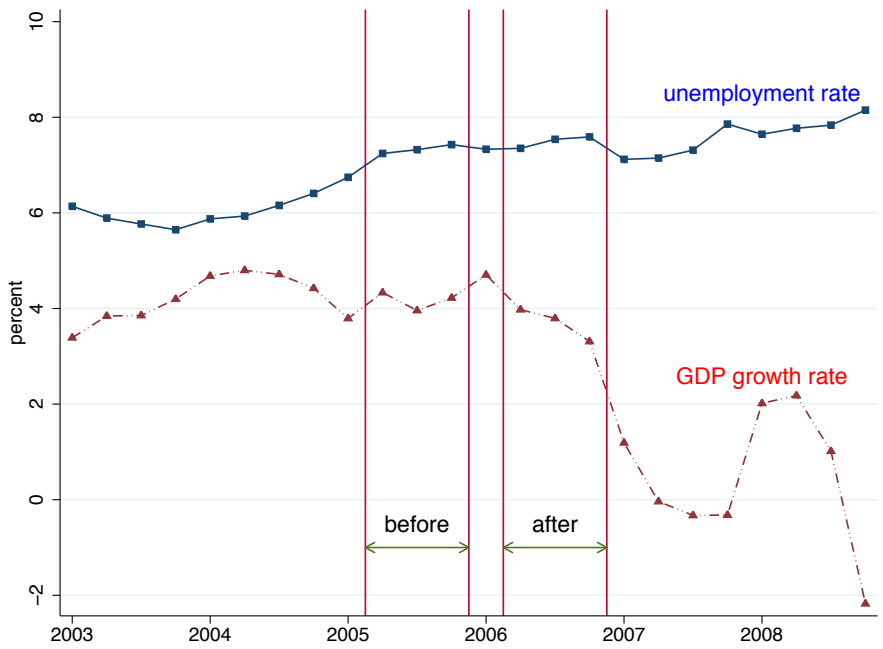
Notes:
The table shows estimates of the standard and RD model with reservation wages and hand-to-mouth consumers in columns (3) to (6). All models assume a linear utility function for the flow utility. For comparison the first two columns (1) and (2) show the hand-to-mouth standard and reference-dependent model with linear utility functions. 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-reseravation wage model.

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



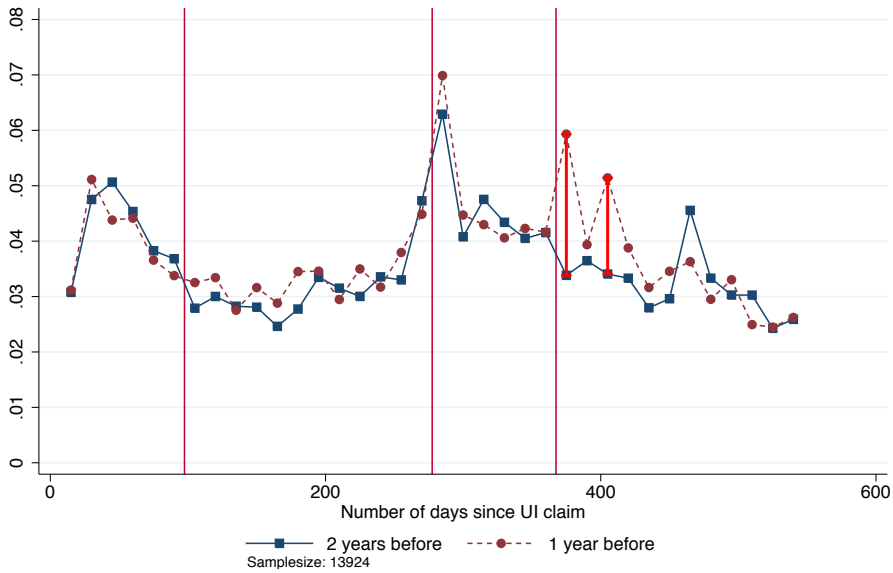
Notes: The figure shows monthly UI benefits in the first tier under the old rule (blue solid line) in the first 90 days under the new rules (red solid line) and between 91-270 days under the new rules (red dashed line) as a function of the monthly base salary. The main sample, defined by being above the 70th percentile of the earnings base distribution of the UI claimants in the given year, denoted by the curly brackets. We also show the sample definitions used for our out of sample analysis (results presented in Table 5): medium earnings base sample is defined by being between the 60th and 78th percentile of the earnings base distribution of the UI claimants in the given year, low earnings base sample is defined by being between the 60th and 78th percentile of the earnings base distribution of the UI claimants in the given year.

Figure A-2: GDP growth and unemployment rate in Hungary

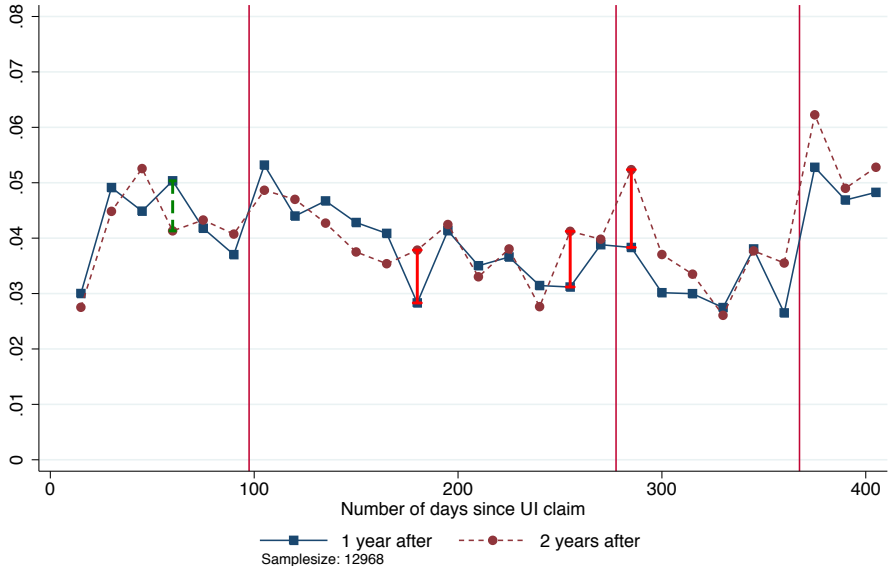


Notes: The figure shows the seasonally adjusted GDP growth rate (dashed red line) and the seasonally adjusted unemployment rate (solid blue) between 2003 and 2008 in Hungary. The major (red) vertical lines indicate the period we use for the before-after comparison. The data was obtained from the Hungarian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

Figure A-3: Comparison of Hazards over Longer Time Frame



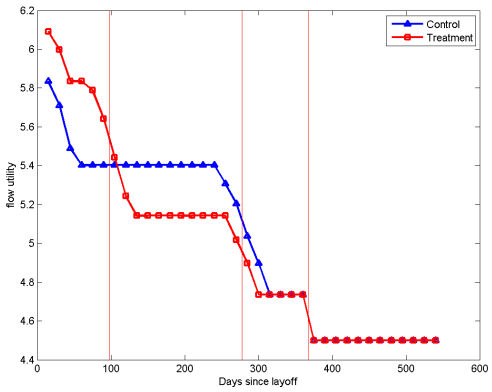
(a) Comparing the hazards 2 year before and 1 year before



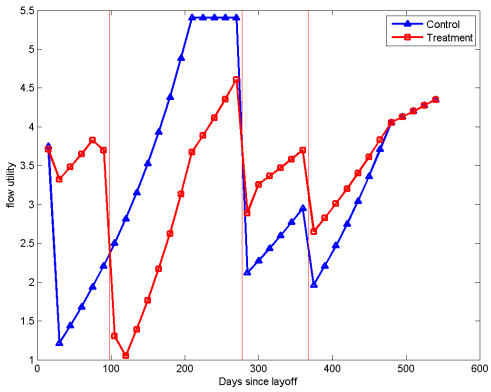
(b) Comparing the hazards 2 year after and 1 year after

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 year 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 (red) vertical lines indicate periods when benefits change in the new system. Other sample restrictions are the same as in Figure 5.

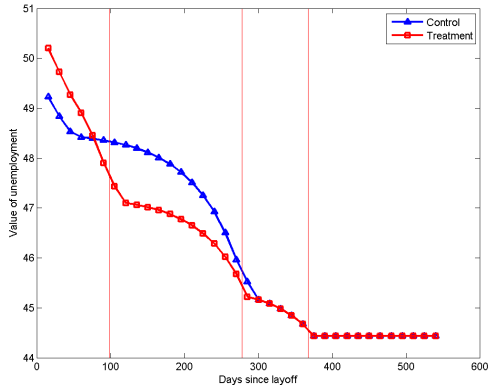
Figure A-4: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part I



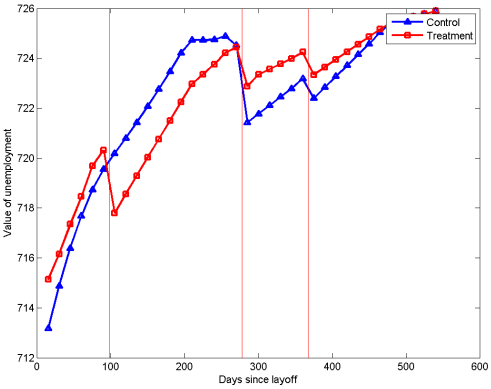
(a) Flow Utility, Standard Model



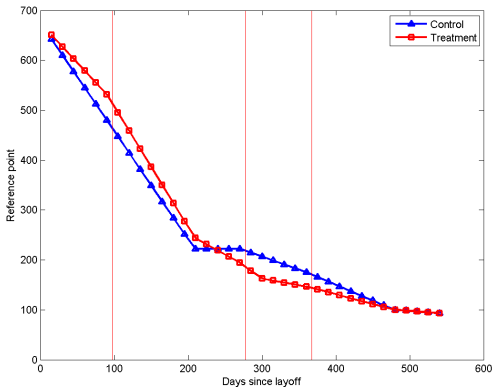
(b) Flow Utility, Reference-Dependent model



(c) Value of Unemployment for the Low Cost Type, Standard Model



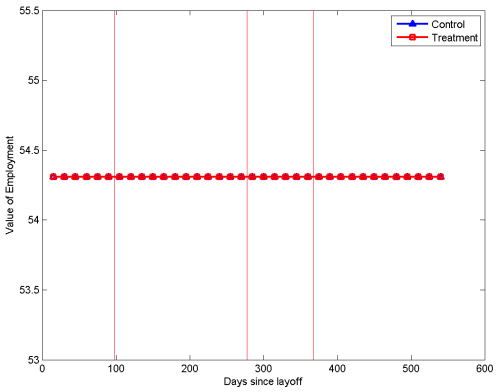
(d) Value of Unemployment for the Low Cost Type, Reference-Dependent model



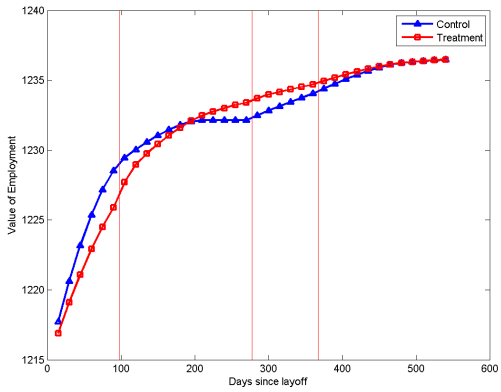
(e) Reference Point, RD Model

Notes: The figure shows the model components for the standard model (estimates showed in column (2) in Table 2) and for the reference-dependent model (estimates showed in column (5) in Table 2). Panel (a) and Panel (b) shows 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 low cost type for the standard model and for the reference-dependent model, respectively. The three major (red) vertical lines indicate periods when benefits change in the new system.

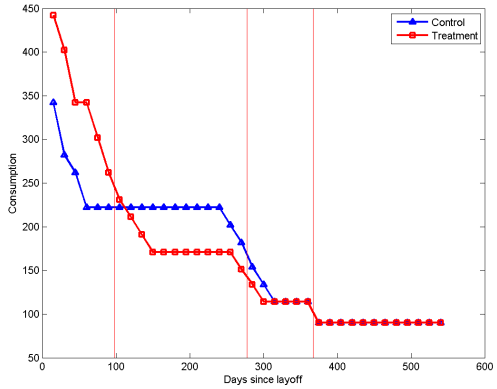
Figure A-5: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part II



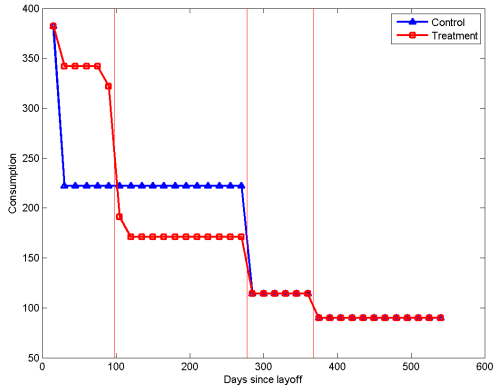
(a) Value of Employment, Standard Model



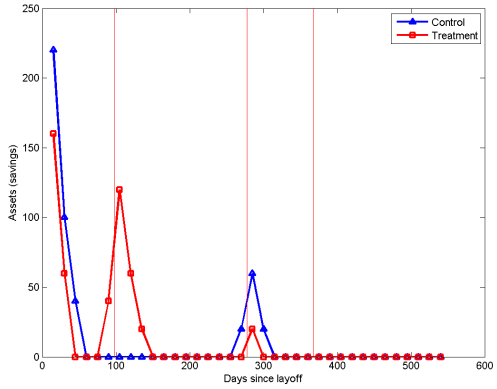
(b) Value of Employment, Reference-Dependent model



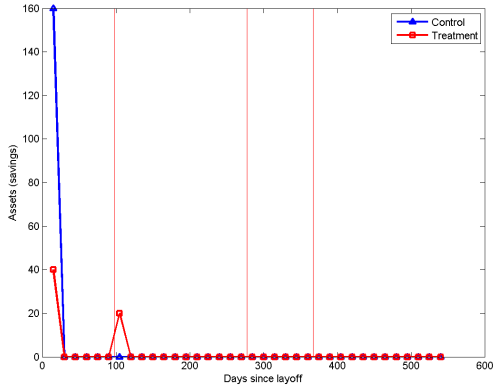
(c) Consumption, high cost type, Standard Model



(d) Consumption, high cost type, Reference-Dependent model



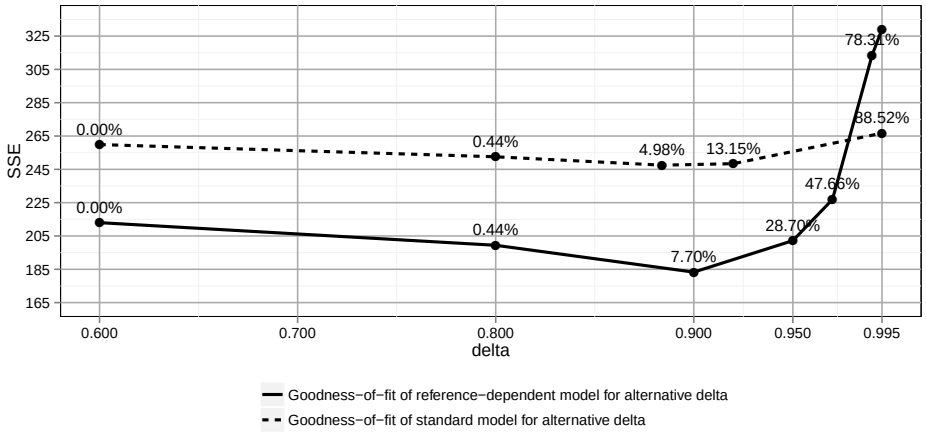
(e) Assets, high cost type, Standard Model



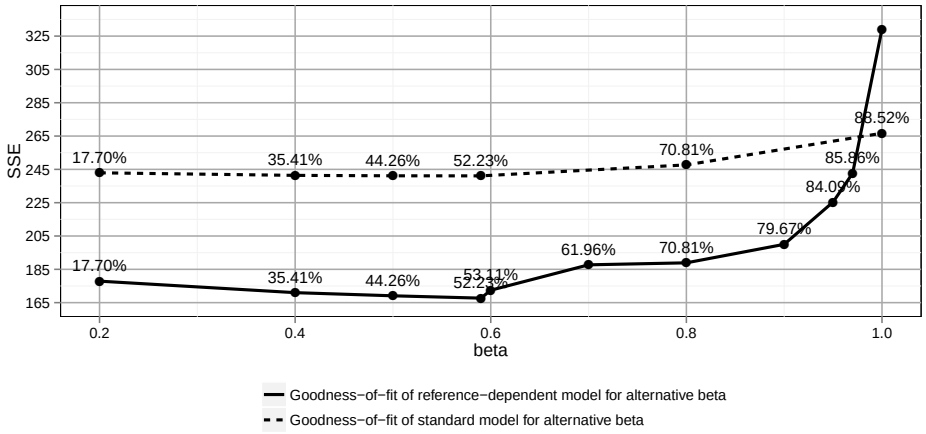
(f) Assets, high cost type, Reference-Dependent model

Notes: The figure shows the model components for the standard model (estimates showed in column (2) in Table 2) and for the reference-dependent model (estimates showed in column (5) in Table 2). Panel (a) and Panel (b) shows the value of employment for the standard model and for the reference-dependent model, respectively. Panel (c) shows the the evolution of the reference point in the reference-dependent model. The three major (red) vertical lines indicate periods when benefits change in the new system.

Figure A-6: Model Fit as Function of Different Discount Rates



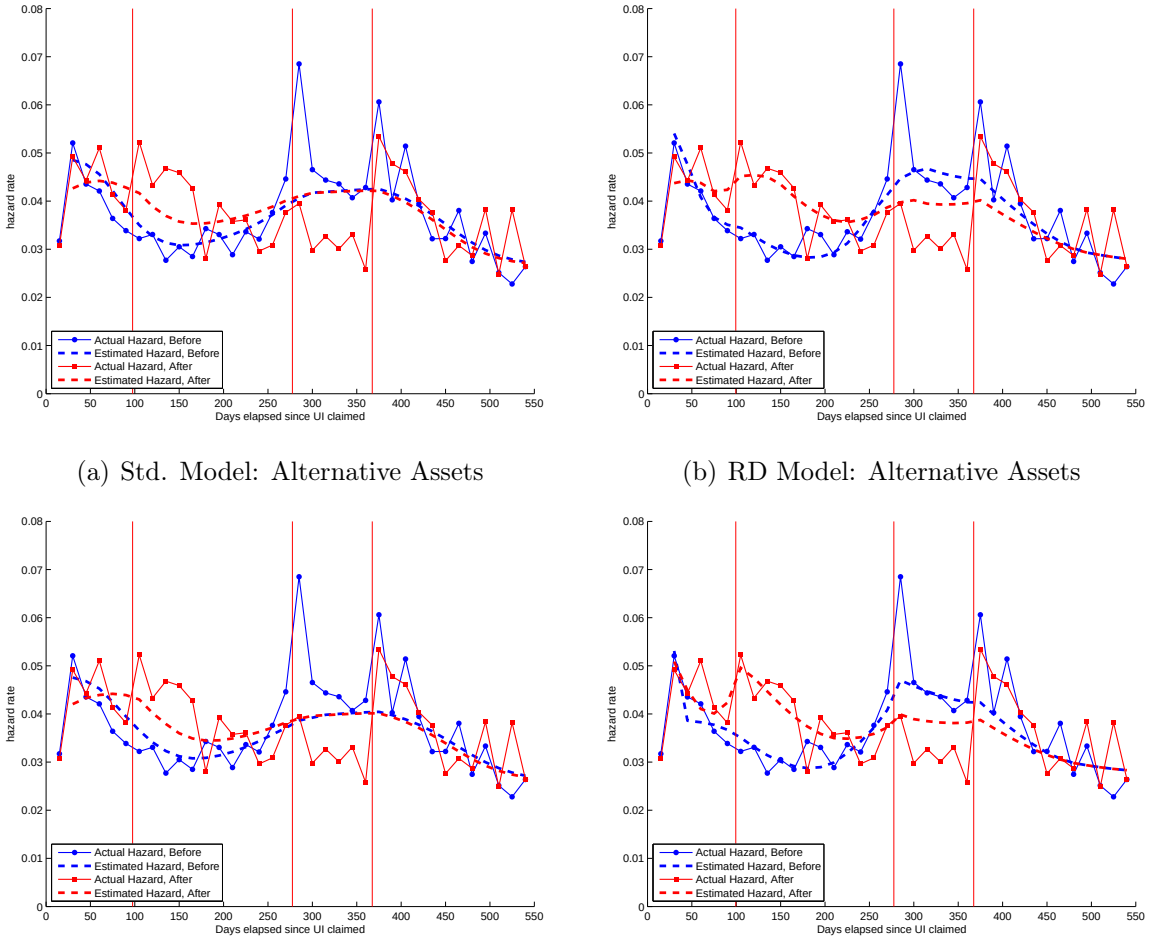
(a) Goodness of Fit of Standard and Reference-Dependent model for different δ



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

Notes: The figures shows 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 and the reference dependent model with 2 types of heterogeneity.

Figure A-7: Robustness Checks - Alternative Assets and Estimation without Spikes



(a) Std. Model: Alternative Assets

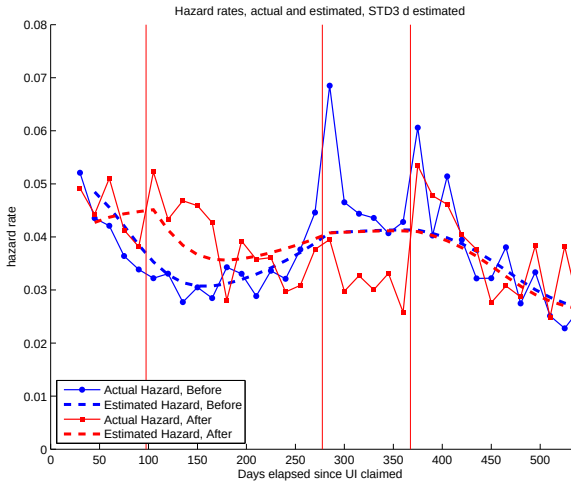
(b) RD Model: Alternative Assets

(c) Std. Model: Estimation without Spikes

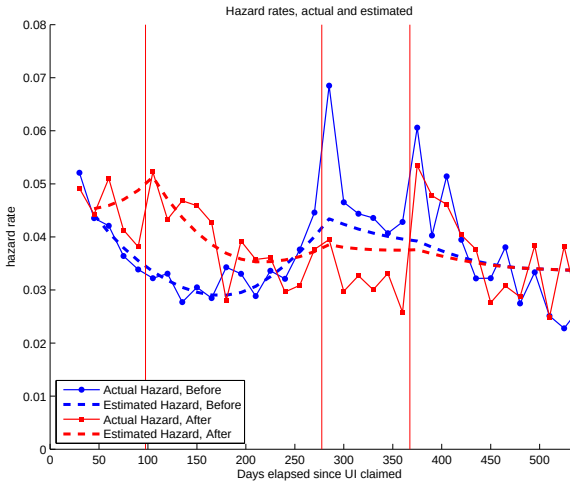
(d) RD Model: Estimation without Spikes

Notes: The figures shows estimates of the standard and RD model when we assume starting assets of 600 (Panel a and b) or when we estimate the model not using the sharp spikes in the exit hazard as moments (Panel c and d).

Figure A-8: Structural Estimation Incorporating Reservation Wages

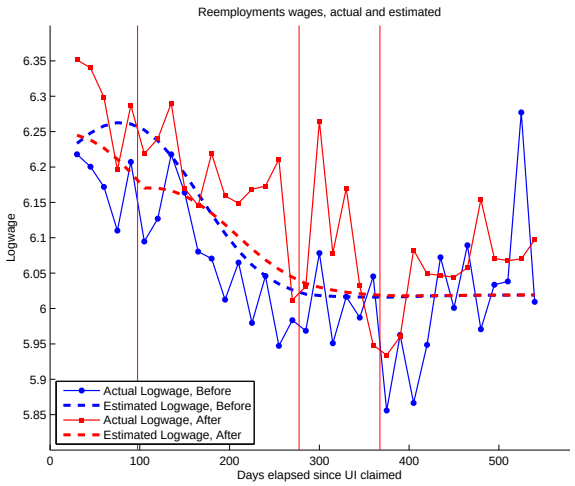


(a) Hazard rate in Standard Model



(b) Hazard rate in RD Model

(c) Reemployment Wage in Standard Model



(d) Reemployment Wage in RD 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 6.