Web Appendix - Not for Publication

Reference-Dependent Job Search: Evidence from Hungary

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1.1 General Setup

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

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

1.1.1 Consumption Utility

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

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

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

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

1.1.2 Reference Point

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

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

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

1.2 Model under exponential discounting

1.2.1 Value Functions

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

The value of unemployment is given as:

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

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

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

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

1.2.2 Solving the Model

There are 3 steps for solving the model:

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

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

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

1.2.3 Calculating the value of accepting a job in each period

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

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

which immediately implies that:

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

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

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

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

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

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

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

The first order condition for s_t is given as

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

which, given that $c(.)$ is invertible, directly determines the optimal search effort s_t as a function of: $V^E_{t+1|t+1}(A_{t+1})$ and $V^U_{t+1}(A_{t+1})$ and therefore as a function of A_{t+1}. If we write the mapping from future assets to the optimal search effort as $s^*_t(A_{t+1})$, then the value function can be written as:

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

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

This can be solved numerically in a discrete asset space.

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

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

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

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

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

1.3 Model with Present Bias

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

The individual has the following value function in unemployment:

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

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

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

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

1.4 Hand to Mouth Model

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

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

The value functions simplify to:

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

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

The FOC for optimal search effort is given as:

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

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

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

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

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

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

1.4.1 Proof of Proposition 1

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

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

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

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

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

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

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

Notice that for all j we have that:

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

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

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

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

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

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

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

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

Because the UI benefit path is non-increasing, the reference point is also non-increasing over the UI spell. This in turn implies that: $r_{T+i+j}^{T+i} \geq r_{T+i+j}^{T+i+1} \geq r_{T+i+j}^{T+i+2} \geq \ldots$ and therefore, since $v(.)$ is concave, that $v'\left(r_{T+i+j}^{T+i}\right) \leq v'\left(r_{T+i+j}^{T+i+1}\right) \leq \ldots$. Furthermore: $v'(r_{T+i}^{T+i}) = v'(r_{T+i})$, that is in the period right after a person is hired, the reference point is the same as if the person had remained unemployed..

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

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

Therefore if $\lambda > 1$ and $\frac{dr_{T+i+j}}{db_1} \leq 0$ for at least one $j < N$ we have $\frac{d\Delta V_{T+i}}{db_1} \leq 0$ and therefore

$\frac{ds_{T+i}}{db_1} \leq 0$. Therefore frontloading UI benefits by increasing b_1 and reducing b_2, leads to a decrease in search effort in period T, $T+1$, ... $T+N-1$. This is in contrast to the standard model where frontloading benefits will only affect search effort in period $T-1$ and earlier.

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

1.5 Reservation Wage Model

To estimate a model with reservation wages, we assume individuals are receiving job offers from a log-normal wage offer distribution with arrival rate of job offers equal to their choice of search effort. Individuals choose search effort and decide whether or not to accept which means that optimal behavior can be characterized by a reservation wage. For tractability we assume individuals are hand-to-mouth consumers.

For simplicity, we also abstract away from gain (or loss) utility at reemployment. We set the standard deviation of the wage offer distribution at 0.5, close to the standard deviation of the actual reemployment wages, and we estimate the mean of the wage offer distribution. The estimator uses 70 additional moments, the average reemployment wage of individuals exiting unemployment in period t after entering the UI system.[2]

The value of employment in this model is simplified to the assumption of no gain utility

$$V_{t+1}^{E}(w) = \frac{v(w)}{1-\delta}$$

The value of unemployment is:

$$V_t^U = \max_{s_t, \phi_{t+1}} u(b_t | r_t) - c(s_t) + \delta \left(s_t \int_{\phi_{t+1}}^{\infty} V_{t+1}^{E}(w) - V_{t+1}^{U} \, dF(w) + V_{t+1}^{U} \right) \tag{16}$$

where ϕ_{t+1} is the reservation wage with respect to jobs that start in period $t+1$.

Any wage such that $V_{t+1}^{E}(w) \geq V_{t+1}^{U}$ is accepted, therefore the reservation wage ϕ_{t+1} is the lowest such wage and has to satisfy $V_{t+1}^{E}(\phi_{t+1}) = V_{t+1}^{U}$ so using the value function of employment we get:

$$v(\phi_{t+1}) = (1-\delta) V_{t+1}^{U}$$

Given the reservation wage the first order condition determining optimal search effort is:

$$c'(s_t^*) = \delta \left(\int_{\phi_{t+1}}^{\infty} V_{t+1}^{E}(w) - V_{t+1}^{U} \, dF(w) \right)$$

or

$$s_t^* = c'^{-1} \left(\delta \left(\int_{\phi_{t+1}}^{\infty} V_{t+1}^{E}(w) - V_{t+1}^{U} \; dF(w) \right) \right)$$

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

Using the fact that: $v(\phi_t) = (1-\delta)V_t^U$ and $v(\phi_{t+1}) = (1-\delta)V_{t+1}^U$ we can write:

$$s_t^* = c'^{-1}\left(\frac{\delta}{1-\delta}\left(\int_{\phi_{t+1}}^{\infty} v(w) - v(\phi_{t+1})\, dF(w)\right)\right) \tag{17}$$

Given the optimal level of search effort in period t this will pin down the reservation wage in t. Using equation (16) above, we get:

$$\frac{v(\phi_t)}{1-\delta} \quad = \quad u\left(b_t|r_t\right) - c(s_t^*) + \frac{\delta}{1-\delta}\left(s_t \int_{\phi_{t+1}}^{\infty} v(w) - v(\phi_{t+1})\, dF(w) + v(\phi_{t+1})\right)$$

And therefore:

$$v(\phi_t) = (1-\delta)\left(u\left(b_t|r_t\right) - c(s_t^*)\right) + \delta v(\phi_{t+1}) + \delta\left(s_t \int_{\phi_{t+1}}^{\infty} v(w) - v(\phi_{t+1})\ dF(w)\right) \tag{18}$$

As in our baseline model we can solve this using backward induction from the steady state.

The observed moments (that we match to empirical moments) are the hazard rate and the reemployment wage. The hazard rate h_t in period t (that is the number of unemployment spells ending in period t conditional on being unemployed for at least t periods) is given as:

$$h_t = s_t\left(1 - F(\phi_{t+1})\right)$$

The expected log reemployment wage of individuals starting a job in period t is given as:

$$E[\ln w|w \geq \phi_t] = (1 - F(\phi_t)) \int_{\phi_t}^{\infty} \ln w\, d\, F(w)$$

It is computationally useful to note that this integral can be analytically computed:

$$\int_{\phi_t}^{\infty} \ln w\, d\, F(w) = \int_{\ln\ \phi_t}^{\infty} \ln w\, d\, \Phi\left(\frac{\ln w - \mu}{\sigma}\right)$$

Which can be simplified to:

$$\int_{\ln \phi_t}^{\infty} \ln w\, d\, \Phi(\ln w) = \left(1 - \Phi\left(\frac{\ln \phi_t - \mu}{\sigma}\right)\right)\left[\mu + \sigma \frac{f_N\left(\frac{\ln \phi_t - \mu}{\sigma}\right)}{1 - \Phi\left(\frac{\ln \phi_t - \mu}{\sigma}\right)}\right] \tag{19}$$

where $\Phi(.)$ and $f_N(.)$ are the CDF and PDF of the standard normal distribution.

2 Estimation

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

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

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

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

2.2 Optimization Algorithm

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

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

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

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

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

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

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

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

3 Description of the Appendix Tables

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

Table A-2 show the structural estimation results under the assumption that unemployed are hand-to-mouth, and so their consumption equals to their income ($c_t = y_t$). The key parameter estimates are very similar to our benchmark estimates presented in Table I. The estimated loss aversion for the reference-dependence model is 4.84 (vs. 4.54 in the benchmark table) and the speed of adjustment is 189.6 days (versus 167.4 in the benchmark estimates). The goodness-of-fit is slightly worse than in our benchmark case, while the standard model performs slightly better than in the benchmark case but still much worse than the reference dependent model. These results highlight that our main results hold for hand-to-mouth consumers.

In Table A-3 we consider variants of the benchmark reference-dependent model. Column (1) explore the role of gain utility. In our benchmark model, gain utility gets weight η while loss utility gets weight $\eta\lambda$, and for estimation we set $\eta = 1$. In Column (1) we show results when there is no gain utility, but still estimating the loss utility weight. The fit of the model is almost as good as the benchmark reference-dependent one (GOF is 184.2 versus 183.7 in the benchmark), the estimated speed of updating of the reference point is nearly the same, and the estimated loss aversion is slightly smaller to the benchmark specification (GOF is 3.73 versus 4.54 in the benchmark).

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

In Table A-3 Column (3) and Column (4) we explore an alternative reference point formulations. In Column (3) we have the reference point is given by last wage before the start of the unemployment spell. This reference point can be thought as the initial status-quo in our context, and it is still backward-looking, but with no adaptation. This specification does poorly (481.4 vs 183.7 in benchmark), because the adaptation over time is critical to reproduce the initial surge in hazard, the decline, and then increase again at benefit exhaustion. In Column (4) we explore forward looking reference point a' la Koszegi and Rabin (2005). Namely, the reference point in period t is the expected income in period t as in the expectations formed in period t-1. This is because in a personal equilibrium, an agent compares the realization to the expectation formed in the recent past. Notice that, while in Koszegi and Rabin the reference point is stochastic, we follow most of the literature applying the personal equilibrium concept and assume instead that the reference point is deterministic, being the expected income. To compute the expected income at period t, we take the empirical hazards in period t to calculate the expected value of income at period t, as of period t-1 (since in period t-1 the job searcher would have known the search intensity, and thus the probability of getting a job in period t. The forward looking reference point provides a poor fit to the data (475.9 vs 183.7 in benchmark).

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

In Table A-5 and in Table A-6 we present further robustness checks for the standard and reference-dependent model. In Column (1) in Table A-5 we allow for background consumption: workers receive non-market income during unemployment, in addition to the benefits earned, to capture home production. The estimates are very similar to the benchmark ones. In Column (2), while still allowing for background consumption, we make the alternative assumption of a lower welfare payment; thus, benefits fall to 45 after 360 days. This alternative assumption improves somewhat the fit of both the reference-dependent model and the standard model. In Column (3) and (4) we allow for a lower reemployment wage set at two thirds of the average previous wage. The alternative assumption worsens somewhat the fit, especially for the reference-dependent model (where in addition the estimated β is at the lower bound of the parameter space). Still the reference dependent model with 1-type performs better than the standard model (214.5 vs. 236.9), though the parameter estimates on β and loss aversion are unrealistic. In Column (4) we show the results for reference-dependent model with 2-type heterogeneity (Column 4). With the same number of parameters as the standard model, the reference-dependent model achieves a much better than the standard model (190.2 vs. 236.9), while the estimated parameters on the speed of adjustment, loss aversion and the discount factor β are quite similar to our benchmark specification. In Column (5) and (6) we test the importance of the assumption of zero initial assets: endowing workers with \$600 in their last period of employment does not affect much the estimates, though the fit of the reference-dependent model is somewhat worse than under the assumption of zero assets (which itself is most consistent with the estimated high impatience).

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

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

In Column (3) and Column (4) in Table A-7 we explore heterogeneity in the parameters of the gain-loss utility. Allowing an additional type in the speed of adjustment improves the model fit (168.9 vs. 183.7 in the benchmark). The estimated speed of adjustment is 75 days for the group with quick updating and 225 days for the group with slow adjustment, which suggest that heterogeneity in the speed of adjustment plays some role in the data. In Column (4) we estimate heterogeneity in loss aversion. The model fit is slightly better than in our benchmark specification.

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

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

In the middle and in the bottom panels in Table A-9 we consider the hazard rates for individuals in our main sample period, but with lower pre-unemployment income: a low-wage sample and a medium-wage sample. Both groups experience less generous benefits in the first 90 days post reform, compared to our main sample. We show the out-of-sample predictions keeping all parameter the same as the one estimated on the main sample. The goodness-of-fits are considerably better for the reference-dependence model than for the standard models. Moreover, the standard model with γ heterogeneity, which has the best fit in-sample, has the worst fit out-of sample.

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

Finally, in Table A-11 we show the results related to the reservation wage model. For tractability, we estimate models with choice of search effort and reservation wage, but with hand-to-mouth consumers. Moreover, we also assume no loss/gain utility upon reemployment. In Column (3) and (4) we depict the benchmark model estimates under these new assumptions. The model fits are very similar to our benchmark estimates, which underlines that these assumptions does not alter our main results. In Column (1) and Column (2) we show the main estimates of the reservation wage models. The reference-dependent model has a better fit than the standard model (GOF of 272 versus 300), largely due to the reference-dependent model providing a better fit for the hazard moments (GOF on the hazards is 177.2 versus 196.5).

4 Description of the Appendix Figures

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

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

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

In Figure A-4 and in Figure A-5 we explore the role of recalls by exploiting the CERS-HAS Linked-Employer Employee Database . This database contains information on the employment status of individuals on the 15th day in each month and also the anonimized firm identifiers of the employer. Unemployed is recalled if her last observed employer before the benefit claim and the first observed employer after reemployment belongs to the same firm. The CERS-HAS Linked-Employer Employee Database covers exactly the same population as our main data and follows workers between 2003 and 2011, but it has less information on the unemployed than our main database. As a result we can measure the length of non-employment only at the monthly level and we cannot observe unemployment spells which are shorter than 1 month and do not contain the 15th day of any months. We cannot distinguish severance payments and wages in the CERS-HAS Linked-Employer Employee Database either. As the severance payments do not affect benefit eligibility, the newly obtained data leads to a slightly different sample selection then the benchmark one. In Figure A-4 panel (a) we show that the main results are very similar to this alternative sample. In Figure A-4(b) we show the results in absence of recalls. We define recall as a job finding when the reemployment job is the same as the last job before job loss. Figure A-4(a) and Figure A-4(b) are virtually the same and so dropping recalls does not alter our main results. To further support this latter point in Figure A-5 we show the fraction of recalls among individual who are leaving non-employment in a given month. The graph clearly shows that recall rates are roughly constant over the benefit spell and are not affected by our reform.

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

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

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

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

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

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

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

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

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

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

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

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

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

References

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

Table A-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)		
Number of observations†	6305	5562		

Notes:
Participation in training programs was not recorded prior to 2006.
* Number of days between job loss and UI claim.
† There are some missing values for earnings in 2002-2004 .

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

	Standard 3-type (1)	Ref. Dep. 1-type (2)
Parameters of Utility Function		
Loss aversion λ		4.84
		(0.57)
Adjustment speed of reference point N in days		189.6
		(14.0)
Discount factor (15 days) δ	0.98	0.89
	(0.06)	(0.02)
Parameters of Search Cost Function		
Curvature of search cost γ	0.13	0.79
	(0.26)	(0.17)
Search cost for high cost type k_{high}	127.0	358.3
	(153.3)	(156.9)
Search cost for medium cost type k_{med}	75.9	
	(118.6)	
Search cost for low cost type k_{low}	26.5	
	(45.7)	
Share of high cost UI claimant	0.34	
	(0.17)	
Share of medium cost UI claimant	0.49	
	(0.16)	
Model Fit		
Number of moments used	70	70
Number of estimated parameters	7	5
Goodness of Fit	215.2	185.5

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

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

	No Gain Utility	**Gain-Loss Utility based on Income**	**Reference Point: Pre-Unemp. Wage**	**Reference Point: Forward Looking Koszegi-Rabin**
	(1)	(2)	(3)	(4)
Parameters of Utility Function				
Loss aversion λ	3.73	4.50	0.999	18.5
	(0.69)	(0.56)	(.)	(28.5)
Adjustment speed of reference point N in days	165.0	169.2		
	(12.7)	(13.3)		
Discount factor (15 days) δ	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.57	0.01	1.00
	(0.22)	(0.21)	(.)	(1.22)
Curvature of search cost γ	0.37	0.37	3.23	1.22
	(0.22)	(0.21)	(.)	(1.05)
Model Fit				
Number of moments used	70	70	70	70
Number of estimated parameters	5	5	4	4
Goodness of Fit	184.2	184.1	481.4	475.9

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

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

	δ-discounting				$\beta\delta$-discounting			
	1 type	1 type AR(1)	2 type	2 types AR(1)	1 type	1 type AR(1)	2 type	2 type AR(1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Habit Parameter z	0.328	0.328	0.287	0.264	0.328	0.328	0.328	0.257
Adjustment speed of reference point N in days	414.2		211.1		293.3		202.3	
	(10.4)		(20.7)		(17.5)		(18.4)	
AR(1) parameter		0.93		0.93		0.93		0.956
		(0.01)		(0.01)		(0.01)		(0.001)
Half life of AR(1) process		150.4		150.0		146.0		231.4
Discount factor (15 days) δ	0.996	0.0	0.927	0.926	0.995	0.995	0.995	0.995
	(0.0002)	(.)†	(0.002)	(0.002)				
Discount factor β	1	1	1	1	0.29	0.01	0.77	0.08
					(0.21)	(.)†	(0.17)	(0.12)
Parameters of Search Cost Function								
Curvature of search cost γ	0.11	5.88	0.33	0.52	0.80	2.70	0.20	1.28
	(0.01)	(1.00)	(0.01)	(0.01)	(0.35)	(0.24)	(0.13)	(0.53)
Search cost of high cost type	443.9	658.6	81.3	131.4	97.4	1034.9	6679.6	130.9
	(9.8)	(2182)	(1.5)	(14.1)	(16.5)	(965.2)	(98730745)	(50.7)
Search cost of low cost type			36.1	29.3			70.7	2.0
			(2.6)	(4.1)			(29.5)	(1.7)
Share of high cost UI claimant			0.637	0.776			0.138	0.847
			(0.035)	(0.031)			(0.134)	(0.017)
Model Fit								
Number of moments used	70	70	70	70	70	70	70	70
Number of estimated parameters	5	5	7	7	5	5	7	7
Goodness of fit	362.9	389.9	228.4	247.4	337.9	390.7	235.1	228.8

Notes:
The table shows parameter estimates for the habit-formation model, where the utility function is: $log(c_t - zr_t)$. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses. The parameter estimates for z are not well identified (i.e. the Hessian cannot be inverted for z close to the reported values) and therefore we do not provide standard errors for them. The other standard errors are calculated by inverting the Hessian matrix after dropping z from the matrix.
† In columns (2) and (6), estimates of the discount factors δ and β do not converge to an interior solution within our parameter space and therefore standard errors are not reported.

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

	Background Consumption	Alternative Welfare assumption	Lower Reemployment Wage		Higher Initial Assets	
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Model						
Discount factor (15 days) δ	0.932	0.899	0.916		0.863	
	(0.007)	(0.007)	(0.007)		(0.033)	
Non-market income	12.1	0.45				
	(39.0)	(10.9)				
Number of moments used	70	70	70		70	
Number of estimated param.	8	8	7		7	
Goodness of fit (SSE)	227.5	210.9	236.9		225.1	
Reference Dependent Model						
Number of cost types	1 type	1 type	1 type	2 type	1 type	2 type
Loss aversion λ	4.57	10.26	14.72	4.91	7.67	4.53
	(0.43)	(3.04)	(4.41)	(0.59)	(1.85)	(0.29)
Adjustment speed of reference point N	165.5	165.0	92.5	169.4	120.3	160.0
	(9.7)	(14.1)	(5.8)	(10.8)	(10.1)	(11.1)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.38	$0.01^{\dagger}$	0.45	0.08	0.58
	(0.03)	(0.23)	(0.02)	(0.19)	(0.10)	(0.02)
Non-market income	0.7	117.4				
	(29.4)	(62.7)				
Model Fit						
Number of moments used	70	70	70	70	70	70
Number of estimated param.	6	6	5	7	5	7
Goodness of fit (SSE)	183.8	171.7	214.5	190.2	193.1	177.9

Notes:
The table shows parameter estimates for the standard and the reference-dependent search model. Estimation is based on minimum distance estimation, using the hazard rates in the pre- and post-reform periods as the moments.
Standard errors for estimated parameters in parentheses.
In columns (5) and (6) assets at the start of the UI spell are assumed to be $600.
†Specification has β restricted to be larger than 0.01.

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

	Identity Weighting Matrix	Moments with controls	Probability Moments Full Cov	Probability Moments Not full Cov	7 day time periods	30 day time periods
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Model						
Discount factor (15 days) δ	0.901	0.920	0.932	0.931	0.968	0.989
	(0.006)	(0.044)	(0.007)	(0.006)	(0.002)	(0.0001)
Non-market income						
Number of moments used	70	70	70	70	156	36
Number of estimated param.	7	7	7	7	7	7
Goodness of fit (SSE)	0.0033	187.4	226.2	226.2	414.5	146.3
Reference Dependent Model						
Number of cost types	1 type	1 type	1 type	1 type	1 type	1 type
Loss aversion λ	4.10	5.49	5.66	5.66	4.41	4.53
	(0.39)	(1.03)	(0.39)	(0.41)	(0.46)	(0.29)
Adjustment speed of reference point N	182.3	160.9	170.8	170.8	201.5	156.9
	(11.0)	(17.8)	(9.4)	(9.3)	(15.1)	(8.7)
Discount factor (15 days) δ	0.995	0.995	0.995	0.995	0.995	0.995
Discount factor β	0.58	0.58	0.58	0.58	0.54	0.60
	(0.14)	(0.28)	(0.03)	(0.03)	(0.17)	(0.01)
Model Fit						
Number of moments used	70	70	70	70	154	36
Number of estimated param.	5	5	5	5	5	5
Goodness of fit (SSE)	0.0027	143.3*	184.0*	184.0*	367.6	109.3

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 SSE with the alternative moments are not directly comparable to the goodness of fit statistics in the other columns.

Table A-7: Robustness to Alternative Types of Heterogeneity

Models:	5 cost types	Heterogeneity Wages	Heterogeneity in Adjustment Speed N	Heterogeneity in Loss Aversion λ
	(1)	(2)	(3)	(4)
Standard Model				
Discount factor (15 days) δ	0.919	0.937		
	(0.005)	(0.005)		
Curvature of search cost γ	0.31	0.55		
	(0.04)	(0.02)		
Number of moments used	70	70		
Number of estimated parameters	11	5		
Goodness of fit (SSE)	222.6	208.9		
Reference Dependent Model				
Loss aversion λ	*	6.85	7.61	28.8
		(3.79)	(2.00)	(0.11)
Loss aversion λ - Type 2				3.06
				(1.71)
Adjustment speed of reference point N	*	75.0	225.0	205.6
		(7.37)	(35.1)	(10.4)
Adjustment speed N - type 2			75.0	
			(3.24)	
Discount factor (15 days) δ	*	0.995	0.995	0.995
Discount factor beta	*	0.01	0.20	0.89
		(.)†	(0.88)	(.)†
Curvature of search cost γ	*	2.08	0.82	0.10
		(1.06)	(0.48)	(0.08)
Model Fit				
Number of moments used		70	70	70
Number of estimated parameters		7	7	7
Goodness of fit (SSE)		191.2	168.9	180.9

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

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

	Unrestricted γ			Restricted: $\gamma > 0.1$			Restricted: $\gamma > 0.2$		
	2 types	3 types	4 types	2 types	3 types	4 types	2 types	3 types	4 types
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Discount factor (15 days) δ	0.89	0.89	0.90	0.89	0.86	0.86	0.89	0.86	0.86
	(0.03)	(0.01)	(0.01)	(0.04)	(0.39)	(0.38)	(0.02)	(0.34)	(2.22)
Curvature of search cost γ - Type 1	0.57	0.016	0.19	0.57	0.360	1.82	0.200	0.200	0.200
	(0.01)	(0.002)	(0.01)	(0.03)	(0.004)	(0.03)	(0.005)	(0.006)	(0.015)
Curvature of search cost γ - Type 2	0.17	1.02	0.003	0.17	0.10	0.36	0.63	0.49	0.49
	(0.04)	(0.01)	(0.015)	(0.01)	(0.01)	(0.46)	(0.01)	(0.01)	(0.01)
Curvature of search cost γ - Type 3		0.20	1.01		1.85	0.100		1.93	1.92
		(0.16)	(0.16)		(0.40)	(0.01)		(0.06)	(0.01)
Curvature of search cost γ - Type 4			0.01			0.36			1.37
			(0.17)			(0.04)			(2.67)
Level of search cost k	28.8	17.0	19.3	28.5	17.7	17.7	32.1	25.3	25.3
	(1.0)	(0.2)	(2.7)	(1.0)	(0.1)	(2.6)	(1.3)	(0.4)	(0.4)
Share of type 1	0.50	0.37	0.47	0.50	0.52	0.08	0.51	0.41	0.41
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Share of type 2		0.16	0.15		0.41	0.45		0.51	0.51
		(0.02)	(0.12)		(0.01)	(116.87)		(0.02)	(0.04)
Share of type 3			0.16			0.41			0.08
			(0.03)			(0.02)			(0.56)
Model Fit									
Number of moments used	70	70	70	70	70	70	70	70	70
Number of estimated parameters	5	7	9	5	7	9	5	7	9
Goodness of Fit	268.0	155.6	145.5	268.0	192.2	192.1	268.6	209.7	209.7

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

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

	Simulation
2 Year Before Period	
Reference Depenent Model, no heterogeneity	53.9
Standard Model with 3 cost types	81.2
Standard Model with 3 γ-types	110.6
Low Earnings Sample	
Reference Depenent Model, no heterogeneity	155.778
Standard Model with 3 cost types	332.675
Standard Model with 3 γ-types	444.03
Medium Earnings Sample	
Reference Depenent Model, no heterogeneity	214.342
Standard Model with 3 cost types	353.973
Standard Model with 3 γ-types	597.873

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

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

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

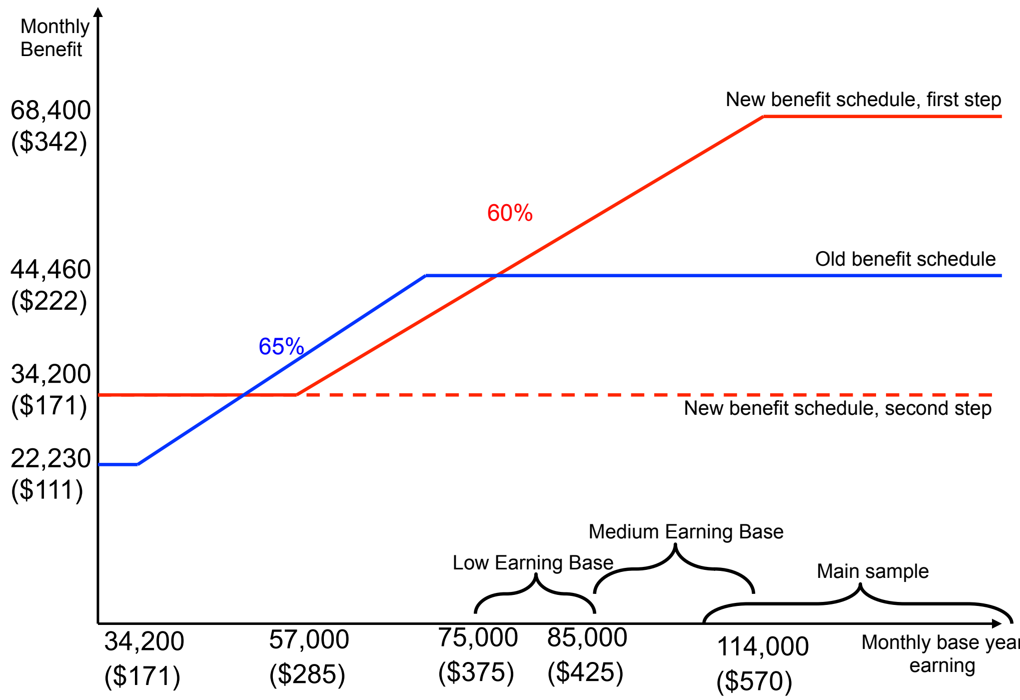
Notes:
Non-employment durations are capped at 540 days.The estimates in columns (1) and (3) are based on the pre-reform period, the estimates in column (2) and (4) on the post reform period. The omitted category is males with finished elementary school, between 25 and 29 years. All columns control for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

Table A-11: Estimates with Reservation Wages

	Reservation Wage Model		HTM Model without Loss / Gain upon reemployment	
	Std Res. Wage	Ref. Dep. Res. Wage	Std HTM	Ref. Dep. HTM
	(1)	(2)	(3)	(4)
Parameters of Utility Function				
Loss aversion λ		1.32		2.06
		(0.12)		(0.38)
Adjustment speed of reference point N		210.0		216.3
		(16.5)		(18.0)
Discount factor (15 days) δ	0.99	0.97	0.98	0.92
	(0.02)	(0.01)	(0.06)	(0.02)
Log reemployment wage	5.99	6.02		
	(0.01)	(0.01)		
Sd of log reemploment wage	0.5	0.5		
Parameters of Cost Function				
Curvature of search cost γ	0.03	0.22	0.13	0.54
	(0.07)	(0.10)	(0.26)	(0.16)
Search cost for high cost type k_{high}	188.3	103.6	127.0	141.1
	(339.0)	(12.6)	(153.0)	(43.4)
Search cost for medium cost type k_{med}	73.8		75.8	
	(139.2)		(118.3)	
Search cost for low cost type k_{low}	15.3	0.0	26.5	12.3
	(31.0)	(1.3)	(45.6)	(5.3)
Share of high cost UI claimant	0.57	0.90	0.34	0.98
	(0.01)	(0.01)	(0.17)	(0.01)
Share of medium cost UI claimant	0.34		0.49	
	(0.01)		(0.16)	
Model Fit				
Number of moments used	140	140	70	70
Number of estimated parameters	8	8	7	7
Goodness of fit (SSE)	300.1	272.6	215.2	170.1
SSE in hazard moments	196.5	177.2		

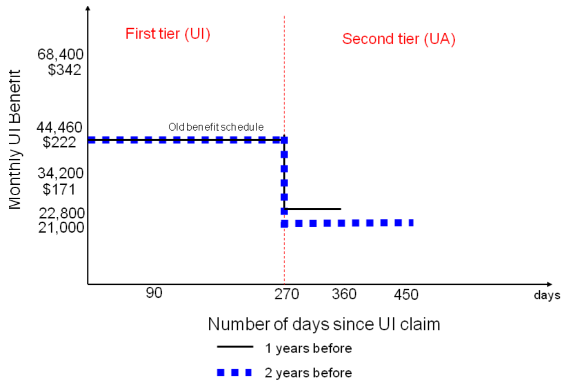
Notes:
The table shows estimates of the standard and reference dependent models with reservation wages and hand-to-mouth consumers in columns (1) and (2), assuming no loss/gain utility upon reemployment. All models assume a log utility function for the flow utility. For comparison, columns (3) and (4)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

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

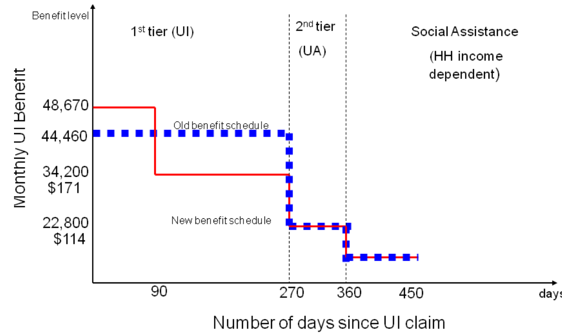


Notes: The figure shows monthly UI benefits in the first tier under the old rule (blue solid line), in the first 90 days under the new rules (red solid line), and between 91-270 days under the new rules (red dashed line) as a function of the monthly base salary. The main sample, defined by being above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

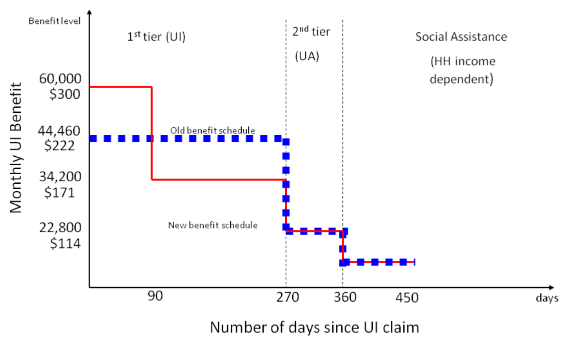
Figure A-2: The Benefit Path 2-years before the reform and for the low / medium earnings samples



(a) 2 years before the reform



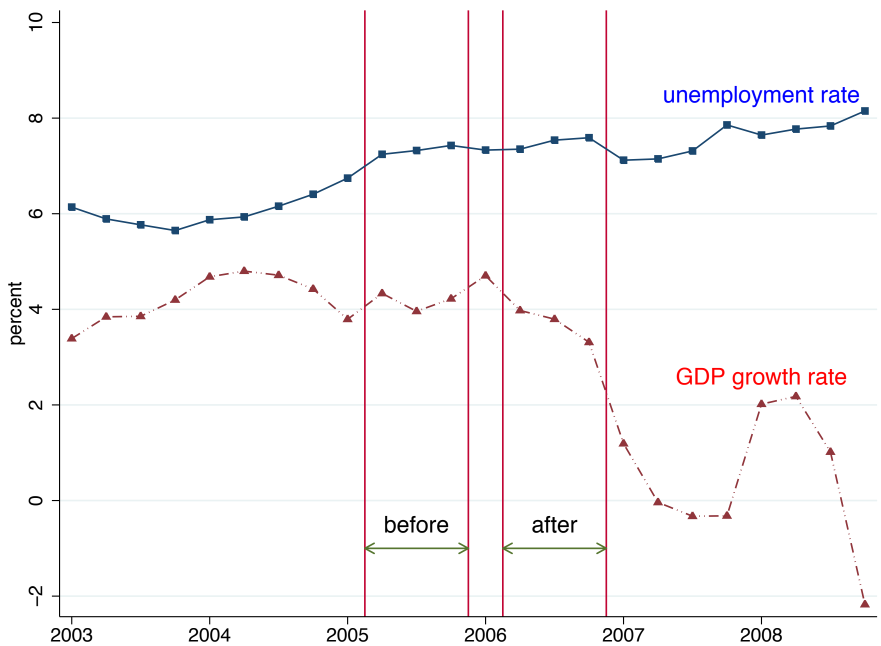
(b) Low earnings sample



(c) Medium earnings sample

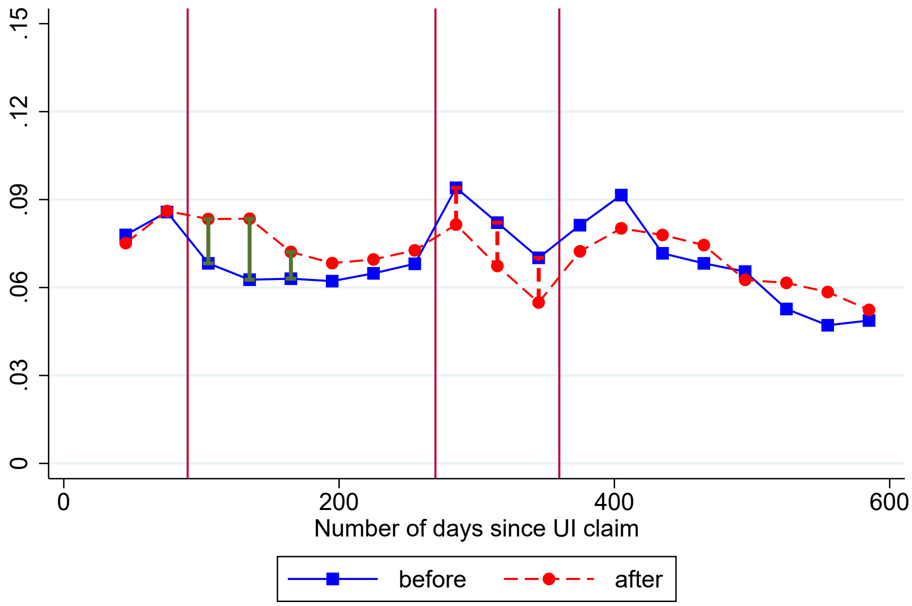
Notes: The figure shows the UI / UA / Welfare benefit paths for the samples used in the out-of-sample predictions. The first panel corresponds to the benefits from 2 years to 1 year prior to the reform, when UA could be claimed for 460 days. The second and third panels correspond to the low and medium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

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

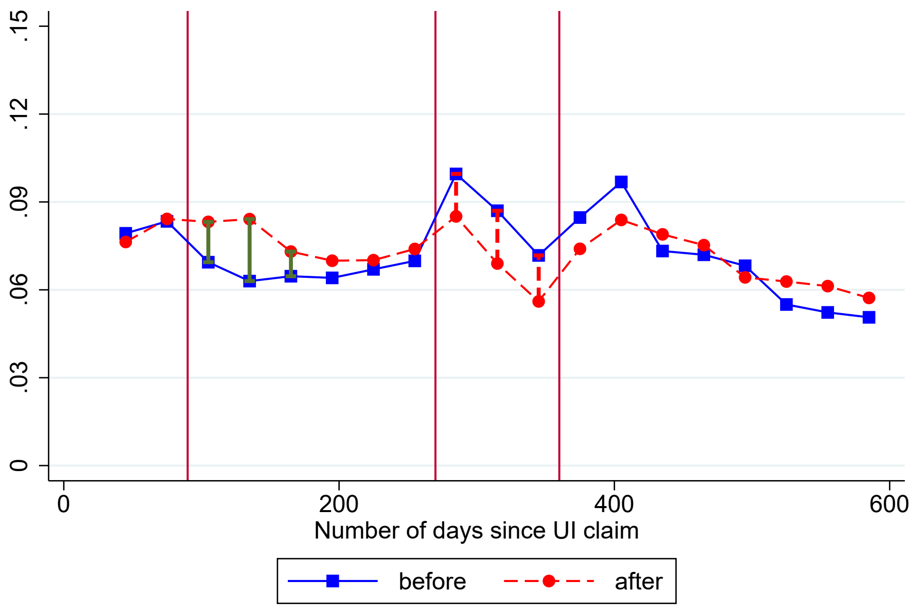


Notes: The figure shows the seasonally adjusted GDP growth rate (dashed red line) and the seasonally adjusted unemployment rate (solid blue) between 2003 and 2008 in Hungary. The major (red) vertical lines indicate the period we use for the before-after comparison. The data was obtained from the Hungarian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

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



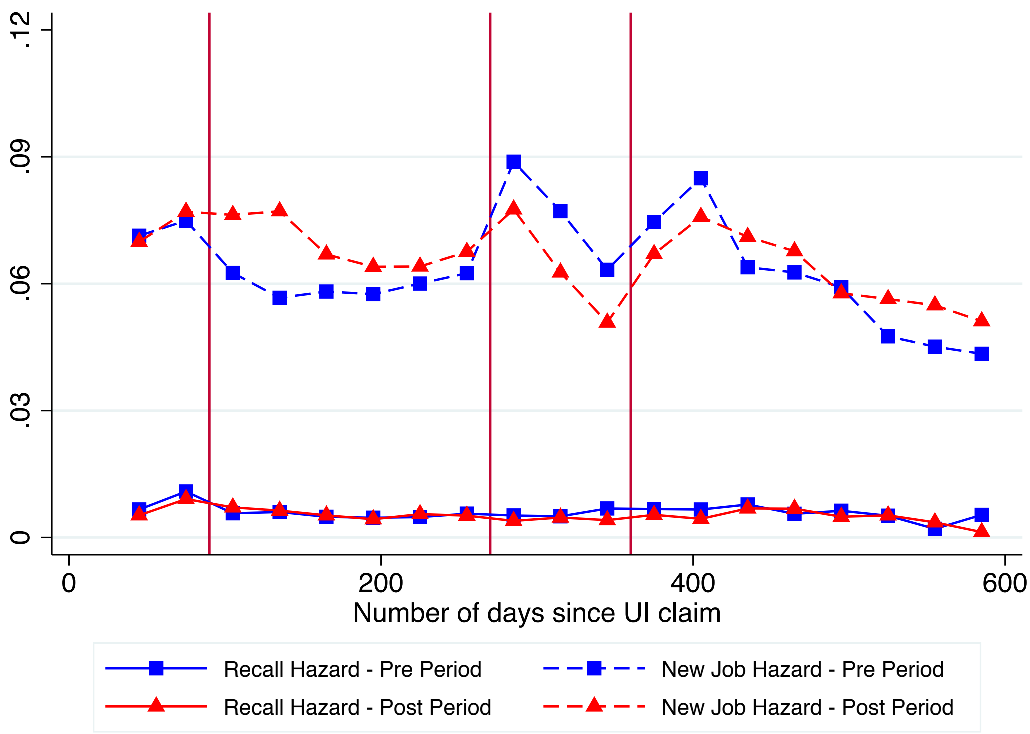
(a) Exit Hazard - All Spells



(b) Exit Hazard - Excluding Recalls

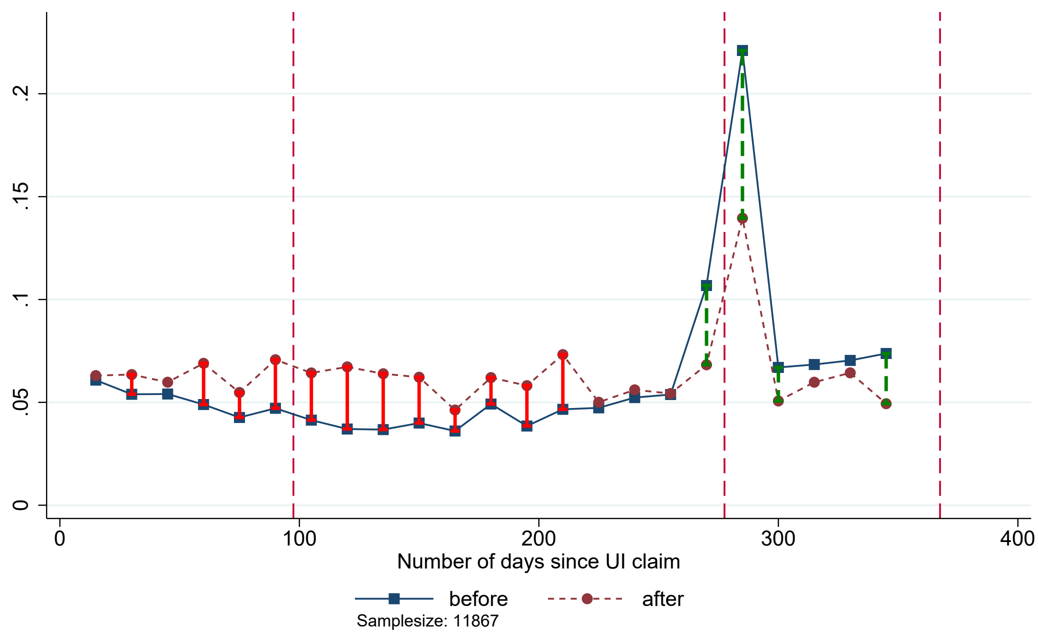
Notes: The figure shows the hazard of leaving non-employment estimated using the CERS-HAS Linked Employer-Employee data, an alternative dataset that measures the length of non-employment only on the monthly level, but allows us to observe recalls to the pre-unemployment employer. We follow the restrictions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

Figure A-5: Recall and New Job Exit Hazards from Non-employment



Notes: Using the same data and sample as for Figure A-4, this figure shows the probability of exiting non-employment conditional on still being non-employed in a given month either to recalls (i.e. the pre-unmployment employer) or to new jobs.

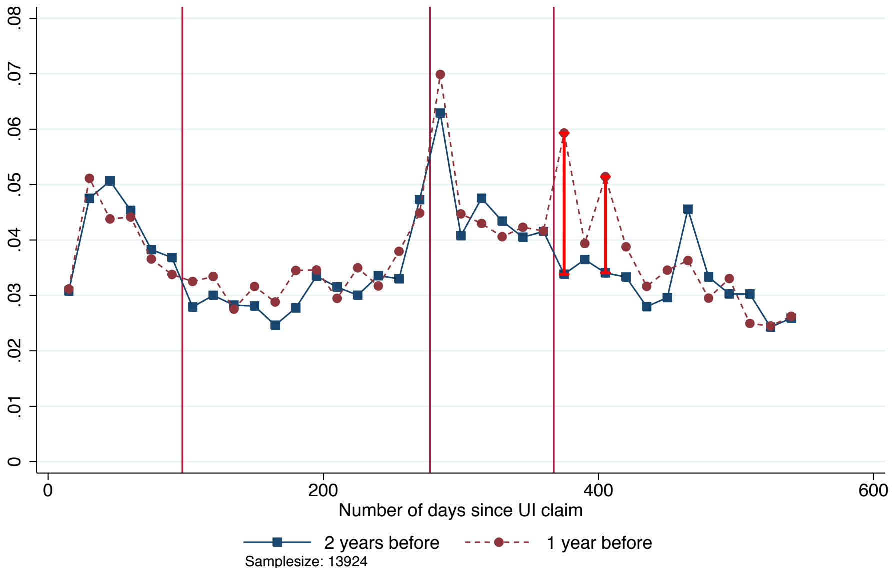
Figure A-6: Exit Hazard from Unemployment Insurance / Unemployment Assistance Benefits



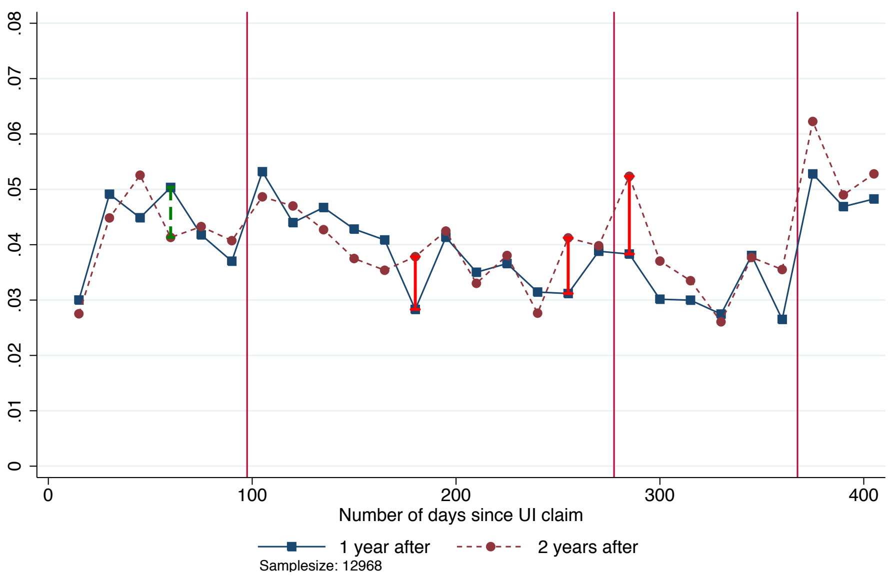
(a) Exit Hazard from UI / UA Benefits

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

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



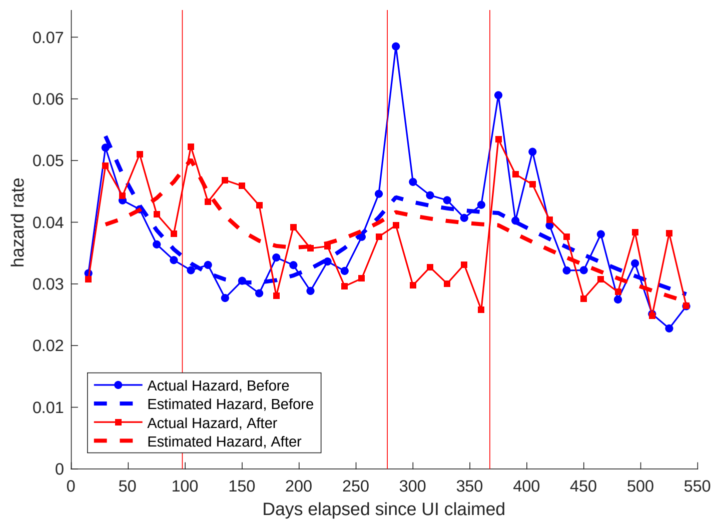
(a) Comparing the hazards 2 year before and 1 year before



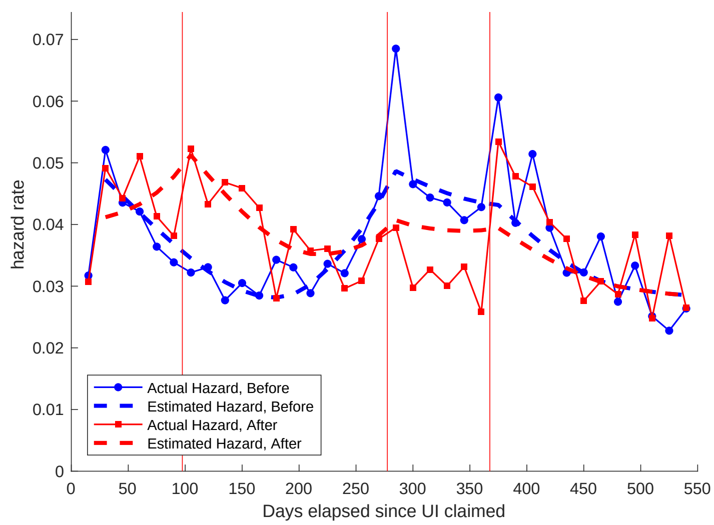
(b) Comparing the hazards 2 year after and 1 year after

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

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



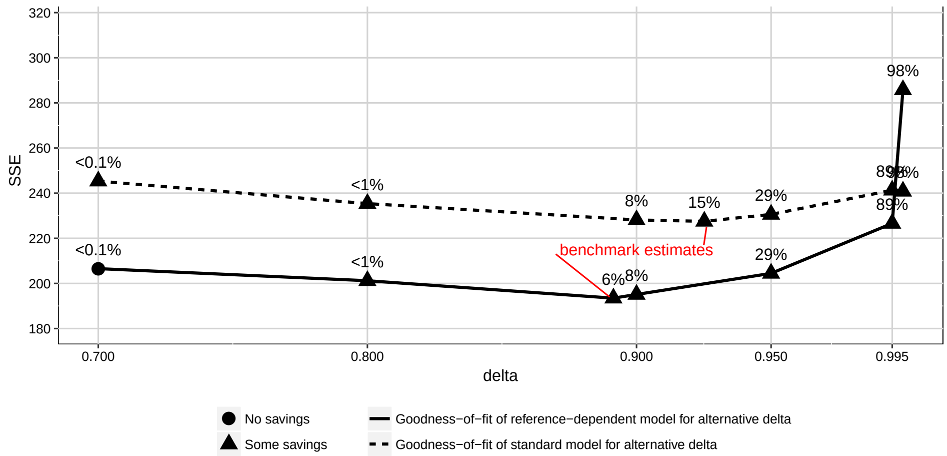
(a) Standard Model



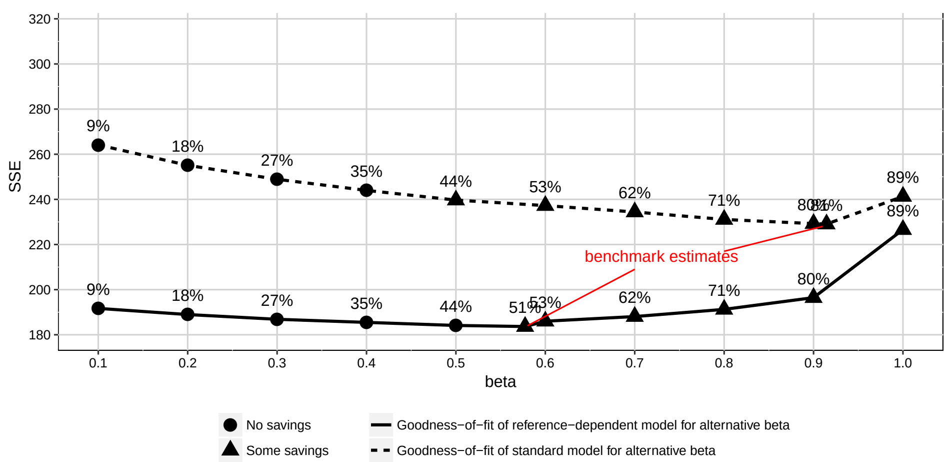
(b) Reference-dependent Model

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

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



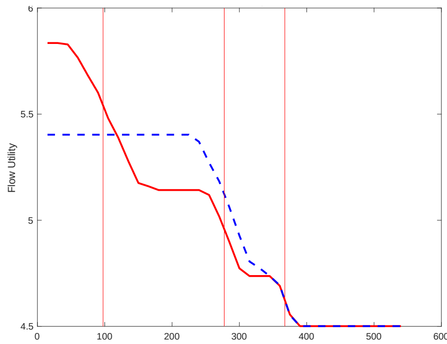
(a) Goodness of Fit of Standard and Reference-Dependent model for different δ



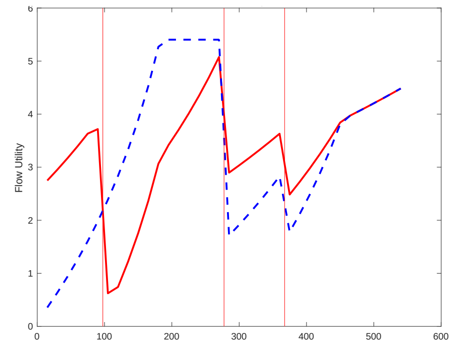
(b) Goodness of Fit of Standard and Reference-Dependent model for different β

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

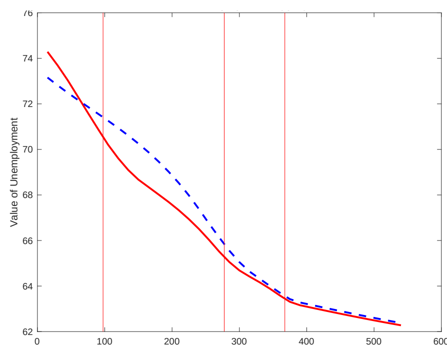
Figure A-10: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part I



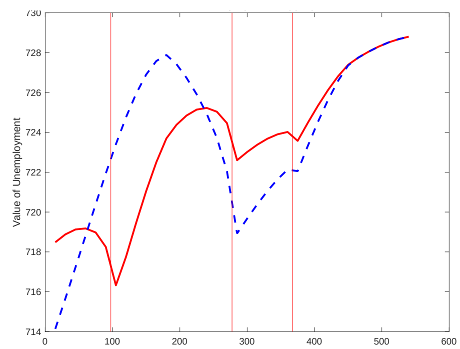
(a) Flow Utility, Standard Model



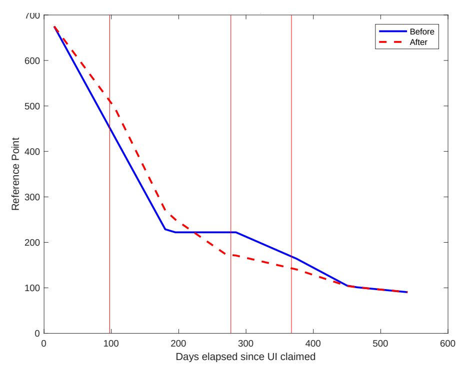
(b) Flow Utility, Reference-Dependent model



(c) Value of Unemployment, Standard Model



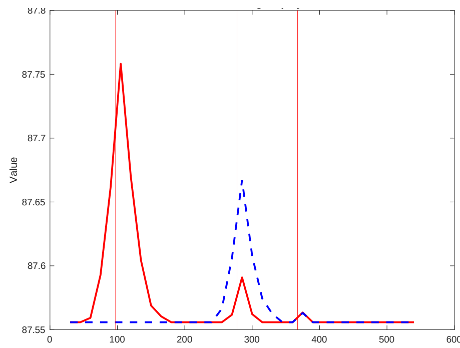
(d) Value of Unemployment, Reference-Dependent model



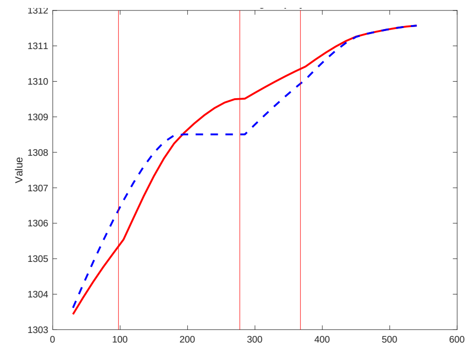
(e) Reference Point, Reference-Dependent Model

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

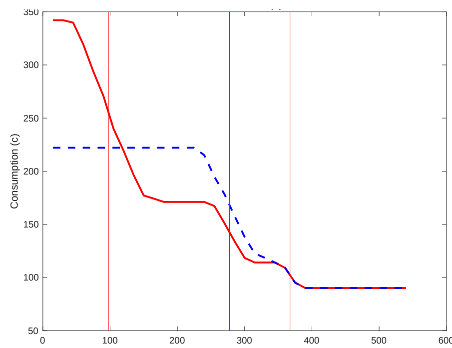
Figure A-11: Model Components for Benchmark Estimates of Standard and Reference-Dependent Model, Part II



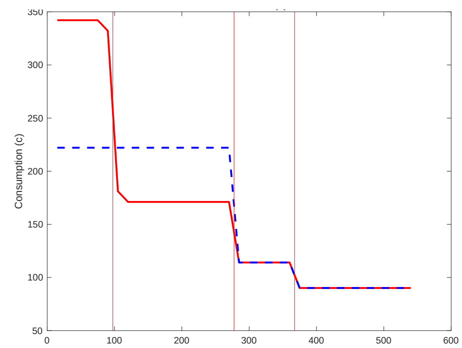
(a) Value of Employment, Standard Model



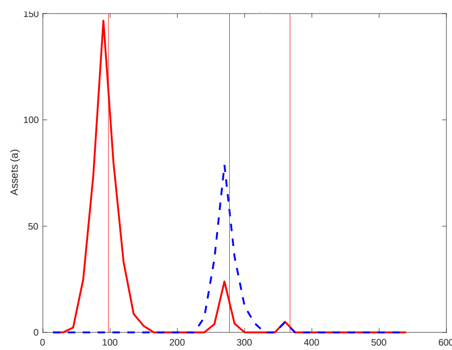
(b) Value of Employment, Reference-Dependent model



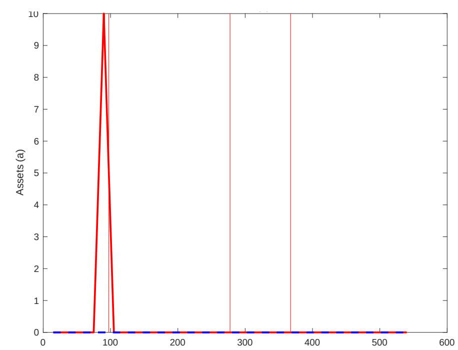
(c) Consumption, Standard Model



(d) Consumption, Reference-Dependent model



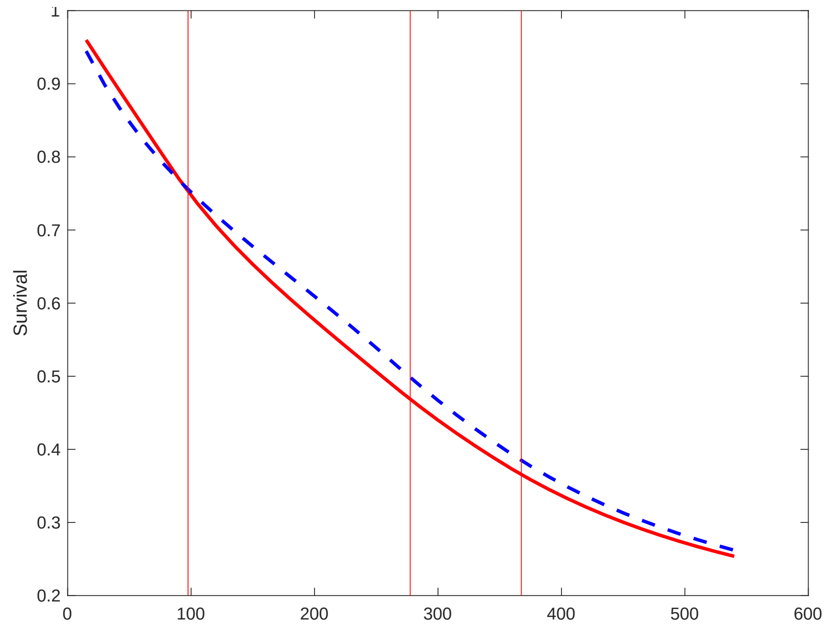
(e) Assets, Standard Model



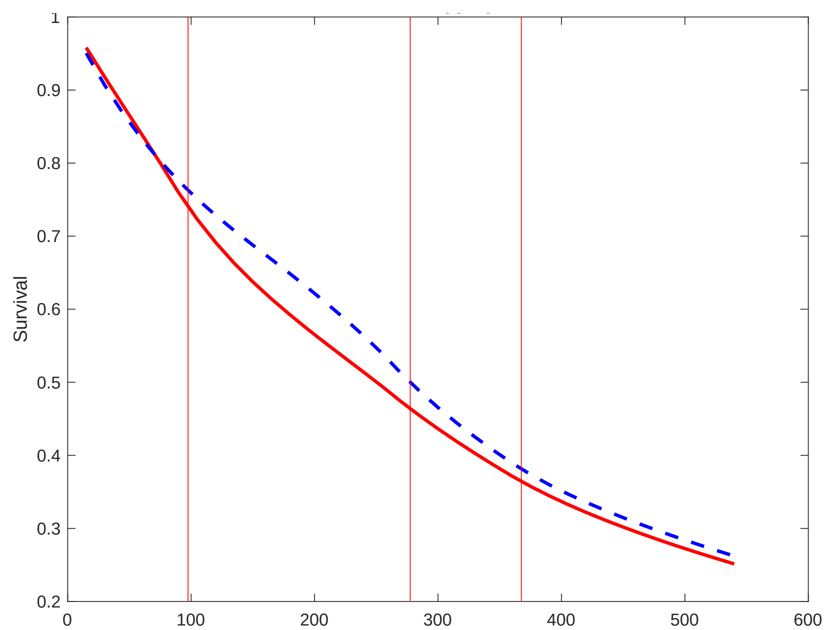
(f) Assets, Reference-Dependent model

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

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



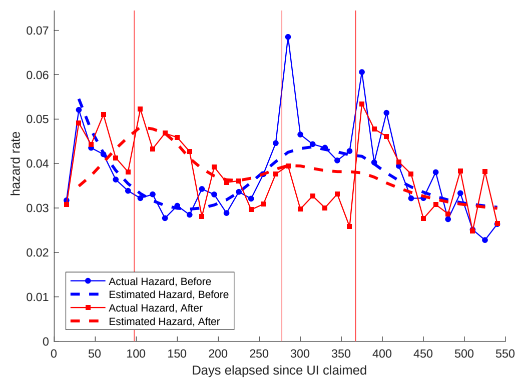
(a) Survival Function, Standard Model, δ-discounting



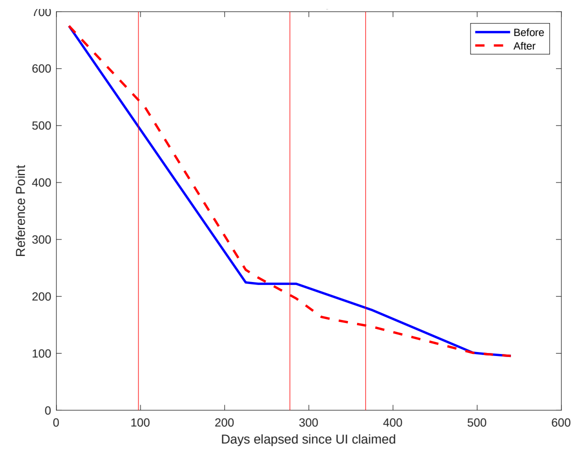
(b) Survival Function, Reference-Dependent model, $\beta\delta$-discounting

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

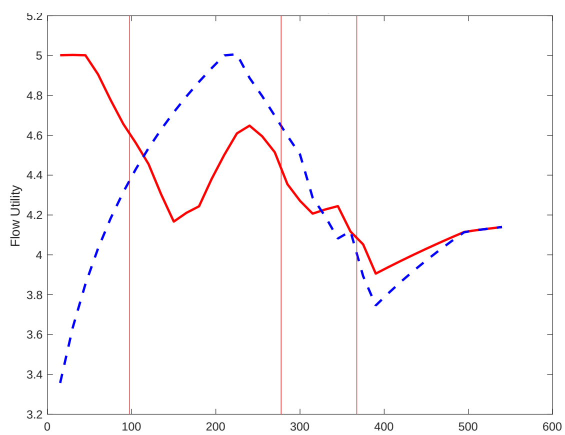
Figure A-13: Investigation of Constantinides Habit Formation Model, 2 types, delta



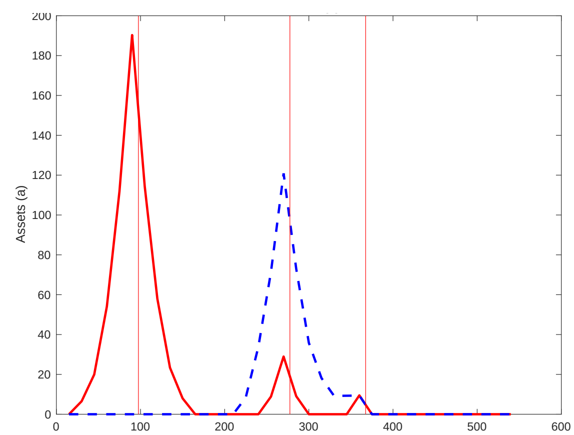
(a) Hazard



(b) Reference Points



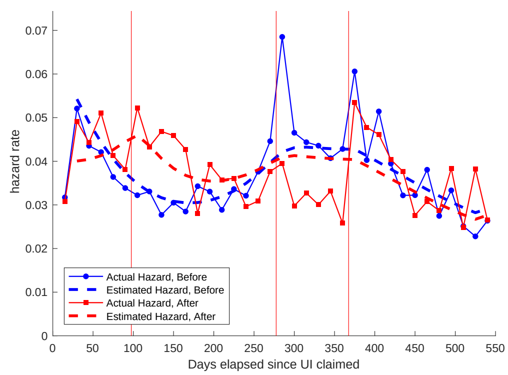
(c) Flow Utility



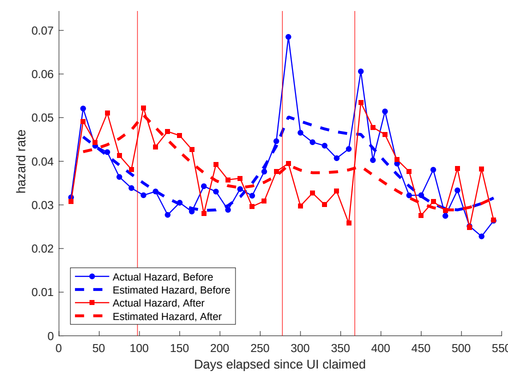
(d) Assets

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

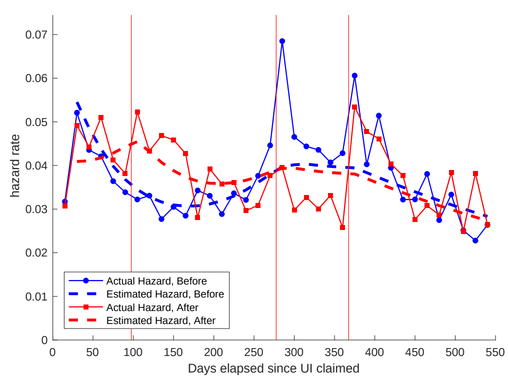
Figure A-14: Robustness Checks I



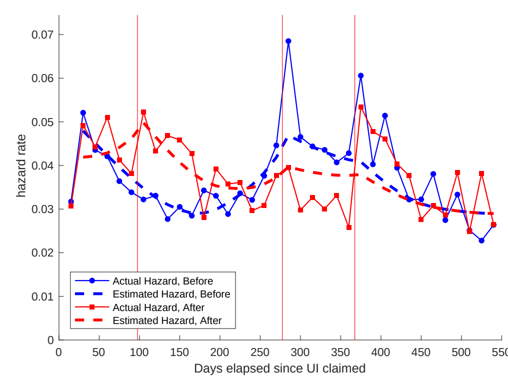
(a) Std. Model: Time-varying Search Cost



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



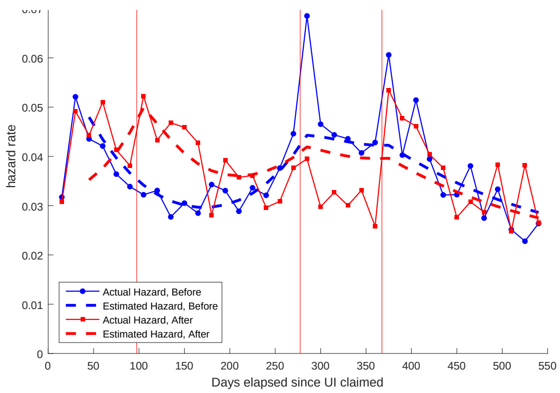
(c) Std. Model: Estimation without Spikes



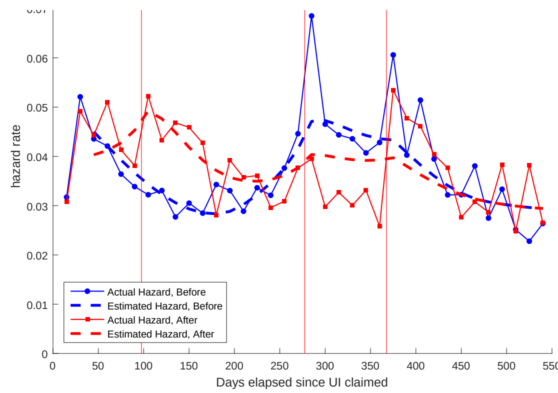
(d) Ref. Dep. Model: Estimation without Spikes

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

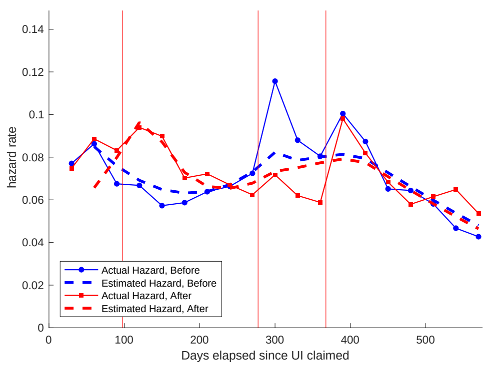
Figure A-15: Robustness Checks II



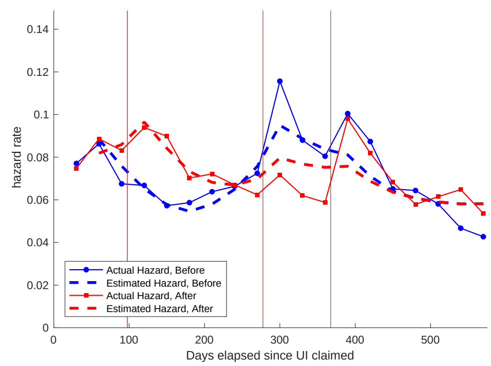
(a) Std. Model: Delayed Job Starting Date



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



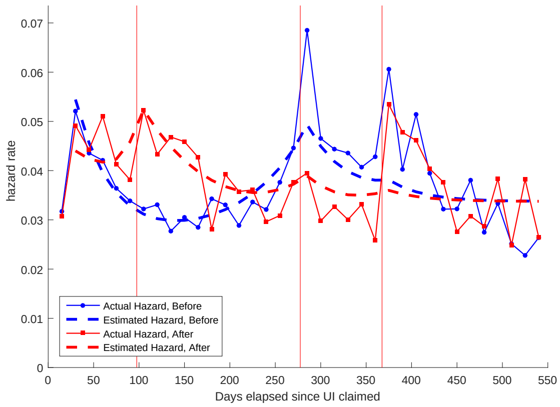
(c) Std. Model: 30-Day Hazards



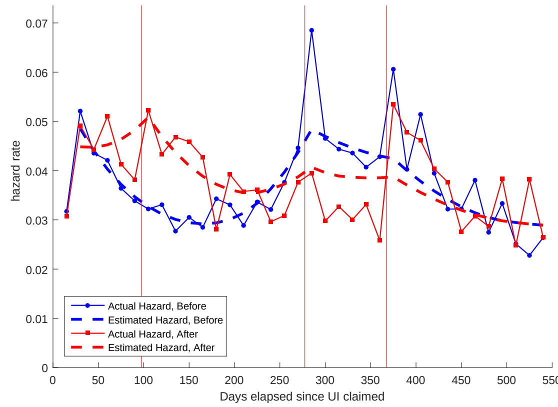
(d) Ref. Dep. Model: 30-Day Hazards

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

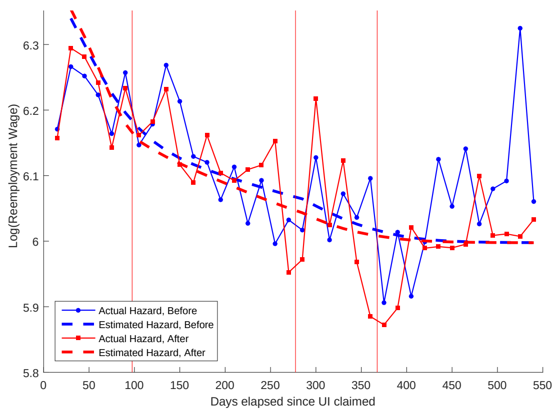
Figure A-16: Structural Estimation Incorporating Reservation Wages



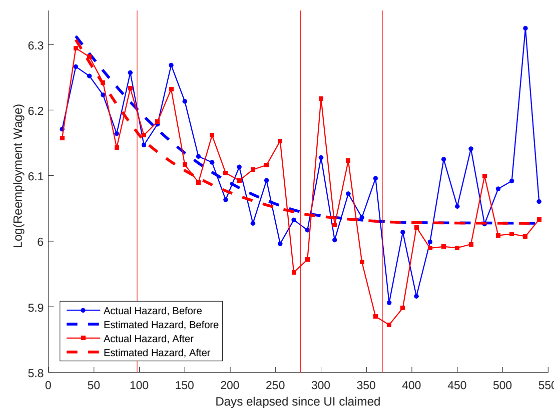
(a) Hazard rate in Standard Model



(b) Hazard rate in Ref. Dep. Model



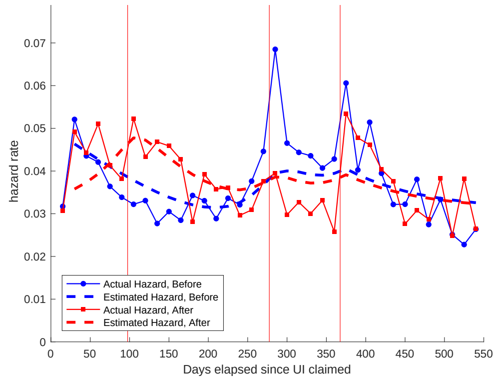
(c) Reemployment Wage in Standard Model



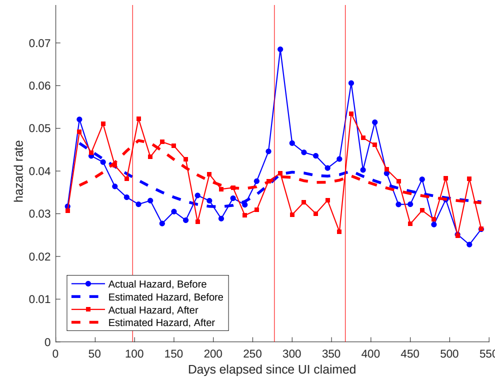
(d) Reemployment Wage in Ref. Dep. Model

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

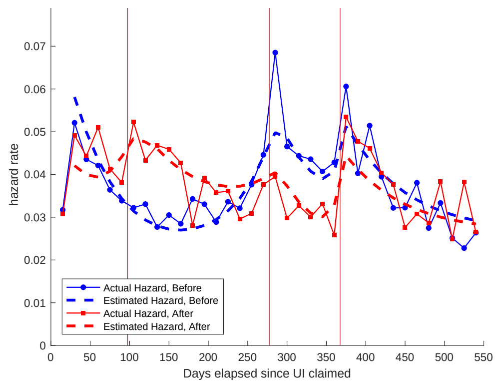
Figure A-17: Standard Model with Heterogeneity in Curvature of Search Cost - Alternative Specifications



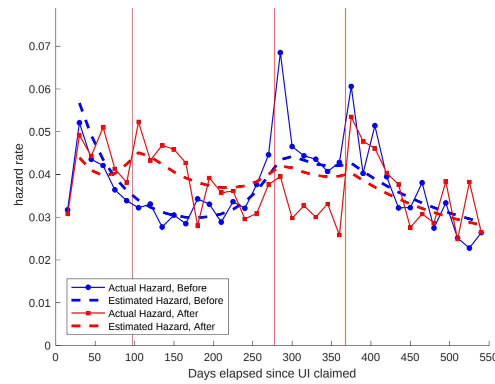
(a) Std. Model, 2 γ-types



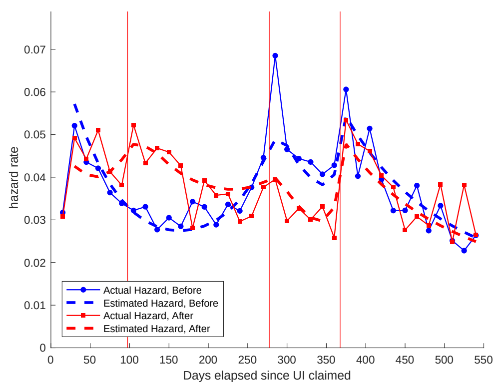
(b) Std. Model, 2 γ-types (γ restricted to ≥ 0.2)



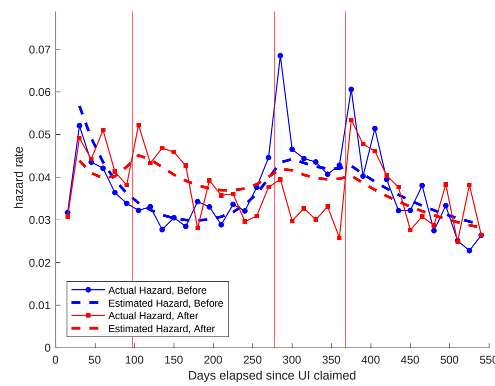
(c) Std. Model, 3 γ-types



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



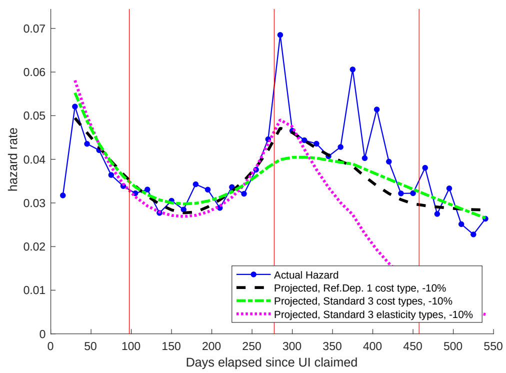
(e) Std. Model, 4 γ-types



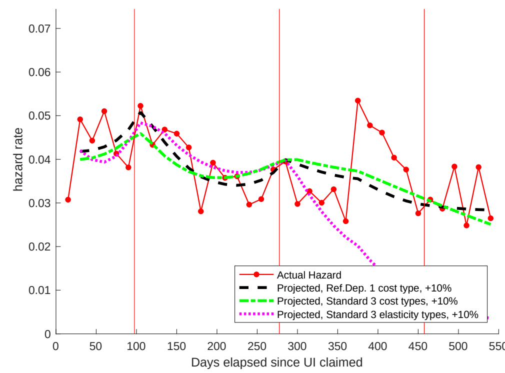
(f) Std. Model, 4 γ-types (γ restricted to ≥ 0.2)

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

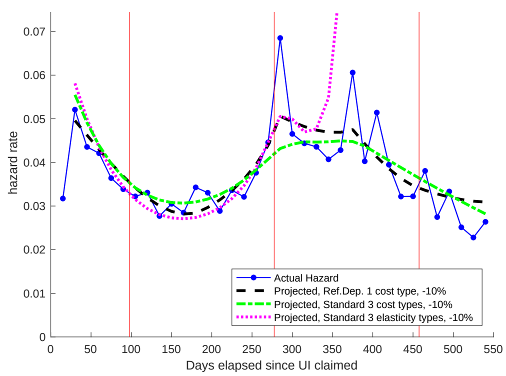
Figure A-18: Sensitivity to small changes in benefit path



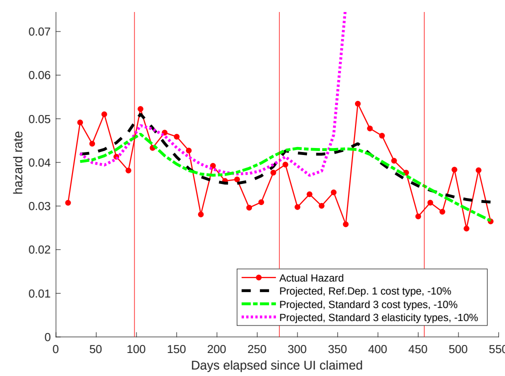
(a) Simulated hazard path for increasing welfare level to 110% in before period



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



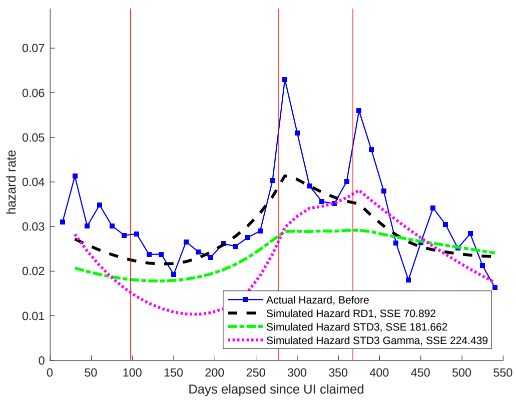
(c) Simulated hazard path for decreasing welfare level to 90% in before period



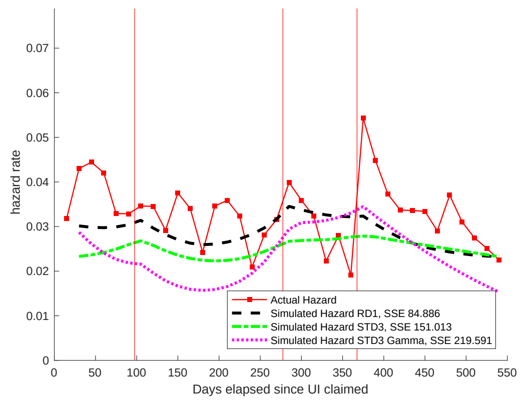
(d) Simulated hazard path for decreasing welfare level to 90% in after period

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

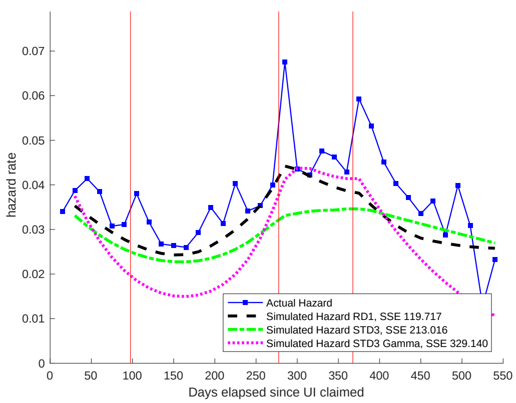
Figure A-19: Out-of-sample Performance of Models - Low and Medium Earnings Sample



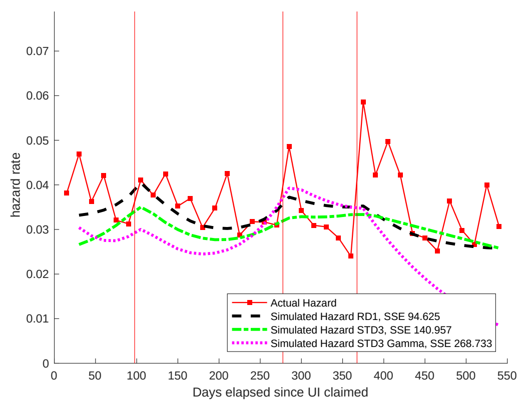
(a) Out-of-sample predictions of models for low earnings sample, pre-reform period



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



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



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

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