Monitoring and Sanctions in a Non-Stationary Structural Job Search Model*

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Abstract

We develop a structural econometric model of job search with monitoring and sanctions. Search environment is nonstationary due to sanction threat and anticipation of benefit reduction. Chances of avoiding the sanction are endogenous and depend on the optimal search behaviour in the period prior to meeting with the monitoring authority. Estimation of the model for the data of a pilot monitoring and sanction programme in Belgium shows weak reemployment effects in the initial phases of the programme and stronger reemployment effects closer to programme termination.

Keywords: Monitoring, sanctions, nonstationary job search, unemployment benefits

JEL Classification: J64, J68, C41.

1 Introduction

In this paper we develop a non-stationary model of job search with monitoring and sanctions. Individual search effort is endogenous and sanctions depend on the amount of search effort exerted by an individual over a prespecified reference period. Under nonstationarity we understand an exogenous change in search environment that may occur as a consequence of getting sanctioned at the end of the reference period. Workers anticipate this change and choose their search intensity accordingly. Once uncertainty about the sanction is revealed, search environment becomes stationary forever.

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Our model can be viewed as an extension of van den Berg (1990) model of nonstationary job search. We extend the paper of van den Berg (1990) along two different lines: a) we endogenize search intensity and describe the evolution of both optimal reservation wage and optimal search effort simultaneously; b) we introduce monitoring and sanctions mechanism that explicitly influences the choice of search effort. In contrast to van den Berg (1990), as well as the major part of search literature, to formulate and solve the model we resort to calculus of variations instead of using dynamic programming. This approach allows preserving tractability of the model once the chance of getting sanctioned is dependent on the search effort exerted in the past.

Section 2 develops the model. Section 3 shows how our model can be applied for evaluation of a monitoring and sanction programme recently proposed by Belgian Federal Ministry of Labour. Section 4 describes the structural econometric model. In Section 5 we discuss the estimation results and assess the incentive effect of the monitoring and sanction programme. Section 6 concludes.

2 Theory

2.1 Search environment

Let time t denote today and time τ denote any other point in future. We concentrate only on two states of the labour market, which are "unemployment" and "employment".

A worker starts as unemployed at time t receiving unemployment benefits b_1. However from the very entry into unemployment the worker is aware that this initial level of benefit payments b_1 may be subject to future change. Namely, at a certain fixed and known to the worker future date T the worker, if still unemployed, will need to attend a meeting with a monitoring authority and provide evidence of search effort undertaken since the start of the unemployment spell. In case the authority decides that the undertaken effort was sufficient the worker is left with b_1 forever. Otherwise, a sanction that reduces benefits from b_1 to b_2 is issued and the worker is left forever with b_2. This mechanism of benefit payments can be summarized as follows

$$b(\tau) = \begin{cases} b_1, & t \leq \tau \leq T \\ \begin{cases} b_1, & \tau > T \text{ and no sanction imposed} \\ b_2, & \tau > T \text{ and sanction imposed} \end{cases} \end{cases} \tag{1}$$

We assume that no worker knows how much effort exactly should one accumulate by the interview date to avoid the sanction. However, the more search effort is exerted, the higher are the chances to escape the sanction. In addition to that, higher search effort implies higher chances of getting a job offer. On the other hand, though, higher search effort brings more disutility. Finally, the stronger is the threat of a sanction, the more willingly will relatively lower offers be accepted. So, utility maximization problem of an unemployed individual is a problem of choosing the optimal path of search intensity and the reservation wage from the moment of entry into unemployment and up to time T, facing the above tradeoffs. After the meeting no changes to benefit payments can happen, and therefore optimal levels of search intensity and reservation wage for $t > T$ will be time-invariant (or, equivalently, search environment becomes stationary). Finally, for simplicity we assume that there is no job loss, and on the job search.

2.2 Optimal behaviour

Let $s(\tau)$ denote search effort, $w_r(\tau)$ denote reservation wage and let $p(s(\tau), w_r(\tau))$ stand for a transition rate from unemployment to employment. Next, let $\alpha[s(\tau)]$ be the arrival rate of job offers, such that $\alpha'[s(\tau)] > 0$, $\alpha''[s(\tau)] \leq 0$, and let $F(w)$ denote the wage offer distribution with $\bar{F}(w) \equiv 1 - F(w)$. Then the transition rate to employment can be written down as

$$p(s(\tau), w_r(\tau)) = \alpha[s(\tau)] \bar{F}(w_r(\tau)) \tag{2}$$

and the probability of staying in unemployment up to τ conditional on being unemployed at t is given by a well-known result

$$P(\tau, t) = \exp\left\{-\int_t^\tau p(s(x), w_r(x))\, dx\right\}. \tag{3}$$

Individuals discount future at rate ρ. We suggest that instantaneous utility $u(y(\tau))$ is a function of net income $y(\tau)$, such that $u'(y(\tau)) > 0$, $u''(y(\tau)) \leq 0$. For an unemployed worker we define net income as $y(\tau) = b(\tau) - c(s(\tau))$, where $c[s(\tau)]$ is a cost of search function, such that $c'[s(\tau)] > 0$, $c''[s(\tau)] \geq 0$. For an employed worker net income $y(\tau)$ is simply the net wage w.

Consider first a worker employed at wage w. In absence of job loss and search on the job, lifetime utility of a worker at the job paying w is simply $u(w)/\rho$.

Consider now an unemployed individual. Let $W(\tau)$ denote the expected lifetime value of an outside option to an unemployed worker, where the expectation is taken with respect to the distribution of wage offers. Then

$$W(\tau) = \int_{w_r(\tau)}^{\infty} \frac{u(w) f(w)}{\rho \bar{F}(w_r(\tau))} dw. \tag{4}$$

With the above definitions it is easy to show (see Appendix A) that the lifetime utility of an unemployed worker who receives benefits according to some general time-dependent scheme $b(\tau)$ is

$$U_t = \int_t^{\infty} [u(b(\tau) - c[s(\tau)]) + p(s(\tau), w_r(\tau)) W(\tau)] P(\tau, t) e^{-\rho(\tau - t)} d\tau, \tag{5}$$

Thus, individual maximizes (5) by choosing optimal paths of search effort $s(\tau)$ and reservation wage $w_r(\tau)$ given $b(\tau)$.

Consider now the shape of $b(\tau)$. As argued in Section 2.1, unemployed worker faces the stepwise benefit scheme (1). The particularity of this scheme is that from T onward benefits are not subject to any change, i.e. search environment becomes stationary, implying time invariant levels of optimal controls. However the initial level of benefits b_1 may be revised at T if monitoring authority deems search effort up to T insufficient. Let $S(\tau, t)$ denote the amount of search intensity accumulated from t to τ. Then, if $S(T, t)$ exceeds some reference value $\bar{S}$ a worker is left with b_1 forever. Otherwise, benefits are reduced to b_2. We assume that worker does not know the reference value $\bar{S}$ exactly. Instead he relies on its subjective probability distribution, so that with probability $\pi_1 = \pi_1\left(\bar{S} \leq S(T, t)\right)$ a worker keeps on receiving b_1 after T and with probability $\pi_2 = 1 - \pi_1\left(\bar{S} \leq S(T, t)\right)$ benefit level goes down to b_2 at the date of the interview. Splitting time horizon in (5) in two intervals, one with $\tau \in [t, T]$, where benefits are equal to b_1 and search environment is nonstationary, and another with $\tau \in (T, +\infty)$, where benefit level is unknown at time t but search environment is stationary, we can rewrite (5) as

$$U_t = \int_t^{T} [u(b_1 - c[s(\tau)]) + p(s(\tau), w_r(\tau)) W(\tau)] P(\tau, t) e^{-\rho(\tau - t)} d\tau + \phi(T, t) \tag{6}$$

where

$$\phi(T, t) \equiv P(T, t) e^{-\rho(T-t)} \sum_{j=1,2} \pi_j \bar{U}(b_j), \tag{7a}$$

$$\bar{U}(b_j) \equiv \frac{u(b_j - c(s_j)) + p(s_j, w_{r,j}) W_j}{\rho + p(s_j, w_{r,j})} \tag{7b}$$

(see Appendix A). The above two expressions have an intuitive interpretation. $\bar{U}(b_j)$ is a lifetime utility of unemployment when b_j is paid forever. $\phi(T, t)$ is the present value of expected lifetime utility in a stationary environment, where expectation is taken over all possible outcomes of benefit levels. Evaluated at the optimal solution of a stationary problem, $\phi(T, t)$ also acts as a salvage value for the nonstationary optimal control problem on $\tau \in [t, T]$.

Consider now state variables $P(\tau, t)$ and $S(\tau, t)$. Differentiating (3) with respect to τ we get the law of motion of the probability of staying unemployed up to time τ

$$\dot{P}(\tau, t) = -p(s(\tau), w_r(\tau)) P(\tau, t). \tag{8}$$

For the stock of accumulated search effort we suggest the following law of motion

$$\dot{S}(\tau, t) = s(\tau), \tag{9}$$

so that the accumulated search intensity $S(\tau, t)$ is just the integral of the effort levels $s(\cdot)$ over the entire (t, τ)-period.

At this end we become able to completely describe the utility maximization problem of an individual. Given the unemployment benefit scheme (1) an individual maximizes his lifetime utility (6) by choosing optimal paths of search effort $s(\tau)$ and reservation wage $w_r(\tau)$ subject to (8) and (9). Present value Hamiltonian for this problem reads

$$\begin{aligned} H(\tau) = {} & [u(b(\tau) - c[s(\tau)]) + p(s(\tau), w_r(\tau)) W(\tau)] P(\tau, t) e^{-\rho(\tau - t)} \\ & - \lambda_P(\tau) p(s(\tau), w_r(\tau)) P(\tau, t) + \lambda_S(\tau) s(\tau) \end{aligned} \tag{10}$$

Necessary conditions for optimality of the controls are given in Kamien and Schwartz (1991), Ch.7, p.160. First order conditions for state and control variables are standard and transversality conditions are

$$\text{(i):} \quad \lambda_P(T) = \frac{\partial \phi^*(T, t)}{\partial P(T, t)}, \quad \text{and} \quad \text{(ii):} \quad \lambda_S(T) = \frac{\partial \phi^*(T, t)}{\partial S(T, t)},$$

where asterisk in $\phi^*(T, t)$ shows that the salvage value is evaluated at the optimal solution of the stationary problem. To close the specification of the salvage value, we need to describe the stationary model, optimal solution of which is used to compute lifetime utilities from T onward, and so the $\phi(T, t)$. Indeed it is straightforward to show (see Appendix B) that for any b_j, $j = 1, 2$, optimal solution for the stationary problem is described by a pair $\left\{s_j^*, w_{r,j}^*\right\}_{j=1,2}$ which satisfies the system

$$\begin{cases} u'(b_j - c(s_j)) c'(s_j) = \frac{\alpha'(s_j)}{\rho} \int_{w_{r,j}}^{\infty} [u(w) - u(w_{r,j})] dF(w) \\ u(w_{r,j}) = u(b_j - c(s_j)) + \frac{\alpha(s_j)}{\rho} \int_{w_{r,j}}^{\infty} [u(w) - u(w_{r,j})] dF(w) \end{cases} \tag{11}$$

The developments above give us with all information necessary for solving the nonstationary problem. The solution for the nonstationary problem is characterized by the system of two differential equations

$$\begin{aligned} \dot{s}(\tau) \Upsilon(s(\tau), w_r(\tau)) = {} & [\rho + p(s(\tau), w_r(\tau))] u'(y(\tau)) c'[s(\tau)] \\ & - \alpha'[s(\tau)] \left\{[u(w_r(\tau)) - u(b(\tau) - c[s(\tau)])] \bar{F}(w_r(\tau)) + V(w_r(\tau))\right\} \end{aligned} \tag{12a}$$

$$\dot{w}_r(\tau) = \frac{\rho}{u'(w_r(\tau))} \left\{[u(w_r(\tau)) - u(b_1 - c[s(\tau)])] - \frac{\alpha[s(\tau)]}{\rho} V(w_r(\tau))\right\} \tag{12b}$$

for the optimal paths of search effort and reservation wage, where for notational convenience we have defined

$$V\left(w_r(\tau)\right) \equiv \int_{w_r(\tau)}^{\infty} \left[u(w) - u\left(w_r(\tau)\right)\right] dF(w)$$
$$\Upsilon\left(s(\tau), w_r(\tau)\right) \equiv u'\left(y(\tau)\right) c''\left[s(\tau)\right] - u''\left(y(\tau)\right)\left(c'\left[s(\tau)\right]\right)^2 - \frac{\alpha''[s(\tau)]}{\rho} V\left(w_r(\tau)\right)$$

Terminal conditions $\{s(T), w_r(T)\}$ for the optimal paths of control variables in (12a)-(12b) solve the system

$$\begin{cases} u\left(w_r(T)\right)/\rho = \sum_{j=1,2} \pi_j \bar{U}^*\left(b_j\right) \\ u'\left(b(T) - s(T)\right) c'\left[s(T)\right] = \frac{\alpha'[s(T)]}{\rho} V\left(w_r(T)\right) + \frac{\partial \pi_1(S(T,t))}{\partial S(T,t)} \left[\bar{U}^*\left(b_1\right) - \bar{U}^*\left(b_2\right)\right] \end{cases} \tag{13}$$

(see Appendix B). First of all it is very easy to see that once search environment becomes stationary, i.e. $\dot{s}(\tau) = 0$ and $\dot{w}_r(\tau) = 0$, both (12a) and (12b) reduce to the two equations in (11), the latter describing the solution for the stationary model. Furthermore, in the two corner cases with no uncertainty about the sanction ($\pi_1 = 0$ and $\pi_1 = 1$) the system (13) that determines endpoint conditions reduces to the system that describes the stationary problem (for b_2 and b_1 respectively). Finally, if we assume that individuals are risk-neutral and abstract from endogeneity search effort, so that the arrival rate of job offer $\alpha\left[s(\tau)\right]$ is a given constant, the differential equation (12b) that describes the optimal path of the reservation wage reduces to that of van den Berg (1990), Theorem 1.

Optimal solution for $p\left(s(\tau), w_r(\tau)\right)$ provides us with complete description of the distribution of unemployment duration. This opens the way to structural econometric evaluation of any programme that creates incentive effects via a threat of a sanction.

3 Monitoring programme

3.1 Programme setting

We apply the model developed in the previous section to evaluate the incentive effect of the programme recently introduced by Federal Ministry of Labour. From the very beginning we deal only with those individuals who can potentially have flat benefit profile of an unlimited duration (e.g. household heads; see Data Appendix for more information).

We assume that once entering unemployment an individual receives a constant amount of unemployment benefits forever, unless there is either a prospect of future reduction of benefit payments or the actual reduction of benefit payments, depending on the stage of the monitoring process. Let b_1 be the amount of benefits upon entry into unemployment. We suggest that unemployment starts at $t = 0$.

If duration of unemployment is less then $\bar{t}_0$ no sanction is possible. According to the design of the programme $\bar{t}_0$ is equal to 13 months for all participants. Once unemployment duration reaches $\bar{t}_0$, an individual becomes at risk of receiving a notification letter that requires him to show up for a first meeting with case worker and provide evidence of sufficient search activity. We assume, which is true at least for the first generation of the participants, that neither the individual anticipates the receipt of this letter, nor is he aware of existence of the programme before seeing the notification letter in his mailbox. The data on the issue date of the letter verify that $\bar{t}_0$ is deterministic.

The programme offers three meetings with case worker at most. Upon receipt of the notification an individual is informed that in eight months since now he will be invited to a first meeting where he is to present evidence of sufficient search activity (unless new job is found before that date). In practice, due to processing delays and due to the knowledge that if not showing up immediately the punishment will not be immediately applied, it takes somewhat longer than eight months until the first interview eventually takes place. We define the duration of unemployment until the first interview by $\bar{t}_1$, (so $\bar{t}_1 - \bar{t}_0$ is at least eight months).

If at the first interview an individual provides sufficient evidence of search activity he is left with b_1 forever.[1] Otherwise he is asked to sign an action plan and is invited to attend the second interview, which will take place in four months after the first one. If action plan is signed unemployment benefits are kept at b_1 at least until the second meeting. If, for one or another reason, unemployed worker refuses signing the action plan he faces a temporary reduction of benefits to b_2 until the second meeting. In addition to that, for such individuals the second meeting is going to be the last meeting. Finally, not showing up for the first interview with no justification leads to withdrawal of benefit payments forever. In this case an individual is left with a subsistence minimum b_3, and the programme terminates. Let $\bar{t}_2$ denote duration of unemployment until the second meeting. According to the design of the programme, $\bar{t}_2 - \bar{t}_1$ is at least 4 months.

If at the second interview an individual who has previously signed the action plan provides

[1] This is a simplification. In reality, if within next 16 months the job is not found the interview will take place again. We assume that given at least 21 months of unemployment duration (which is, $\bar{t}_0 + \bar{t}_1$) an individual who has proven that his search is sufficiently active can almost sure find the job within next 16 months. Under this assumption an individual does not expect change in the level of benefit payments until the exit to the job, which is equivalent to b_1 being paid forever. Alternative justification of this simplification is a sufficiently high subjective rate of time preference.

sufficient evidence of search activity he is left with b_1 forever.[2] Otherwise his unemployment benefits are reduced to b_2 until the third meeting. Furthermore, an individual is asked to sign a new action plan and is invited to attend the third interview, which will take place in four months after the second one. Finally, if an individual refuses signing the second action plan or does not show up for the second interview his benefits are withdrawn forever (i.e., subsistence minimum b_3 applies). Let $\bar{t}_3$ denote duration of unemployment until the third meeting. According to our design, $\bar{t}_3 - \bar{t}_2$ is, again, at least 4 months.

If at the third, i.e. the last, interview an individual does provide sufficient evidence of search activity his benefits are set back to b_1 and kept so forever. In all other cases unemployment benefits are set to b_3 and the programme terminates (note that for those who did not sign the first action plan this is the second interview and it takes place at $\bar{t}_2$). Finally, as described in Data Appendix, the sequence $b_3 \leq b_2 < b_1$ may differ across heterogeneous groups of agents. Moreover, in nearly all instances the temporary sanction after the second interview is already a reduction to the subsistence minimum, i.e. $b_2 = b_3$.

3.2 Endpoint conditions

Even though the programme includes multiple interview dates, the theoretical model developed in Section 2 easily encompasses all of them. Since each individual knows the value of benefits at each nod, optimization problem can be solved backwards. From Section 3.1 we see that beyond the third interview search environment becomes stationary. Therefore search strategy on $(\bar{t}_3, \infty)$ interval will be described by (11) given b_1 or b_3 depending on the final decision of the monitoring authority. Once an individual knows the chances of being sanctioned at the third interview, via (13) we immediately obtain the terminal conditions for the nonstationary search problem between the second ($\bar{t}_2$) and the third ($\bar{t}_3$) interviews. Consequently this will allow us to calculate optimal paths of the search effort and reservation wage on the $(\bar{t}_2, \bar{t}_3]$ interval. Knowing these optimal paths we obtain the value of the maximized lifetime utility $U^*_{\bar{t}_2}$ at the second interview. As shown in Appendix B, this value is all we need to know in order to determine the endpoint conditions at the second interview. These conditions will be described by the pair $\{s(\bar{t}_2), w_r(\bar{t}_2)\}$, which solves the system

$$\begin{cases} u\left(w_r\left(\bar{t}_2\right)\right)/\rho = \pi_1 \bar{U}^*\left(b_1\right) + \pi_2 U^*_{\bar{t}_2} \\ u'\left(y\left(\bar{t}_2\right)\right) c'\left[s\left(\bar{t}_2\right)\right] \\ \qquad = \frac{\alpha'[s(\bar{t}_2)]}{\rho} \int_{w_r(\bar{t}_2)}^{\infty} \left[u\left(w\right) - u\left(w_r\left(\bar{t}_2\right)\right)\right] dF\left(w\right) + \frac{\partial \pi_1(S(\bar{t}_2,t))}{\partial S(\bar{t}_2,t)} \left[\bar{U}^*\left(b_1\right) - U^*_{\bar{t}_2}\right] \end{cases} \tag{14}$$

[2] This is again a simplification. In reality, if within next 12 months the job is not found the interview will take place again. Our assumptions in this case are similar to those described in Footnote 1.

where $U^*_{\bar{t}_2}$ is the expression in (5) and evaluated at the optimal paths of the control variables from $\bar{t}_2$ onward.

Once the endpoint conditions at $\bar{t}_2$ are known, we can solve for optimal paths of the control variables on the $(\bar{t}_1, \bar{t}_2]$ interval and calculate the maximized lifetime utility $U^*_{\bar{t}_1}$ at the first interview (i.e. at $\bar{t}_1$). Inserting this value into (14) and solving this system at $\bar{t}_1$ will provide us with endpoint conditions at the first interview. Finally, search between the entry into unemployment and the receipt of the letter, i.e. on $(0, \bar{t}_0]$ interval, is stationary, as individuals are unaware of the programme by construction.

One should also notice that all above solutions rely on the knowledge of the probabilities of meeting the effort requirement $\bar{S}$ that allows avoiding sanction at each interview. Estimation of these probabilities is a separate empirical issue addressed in Section 4.2.

4 Econometric model

The model is estimated using both earnings and duration data. Key characteristic of our structural econometric model is that it incorporates all the restrictions that come from the theory. This means that for each and every individual observation we explicitly compute reservation wages and search effort levels using the theoretical results of Sections 2-3.

4.1 Likelihood function

Two points are worth noticing before the likelihood function is written down. First, as is common in the literature (see e.g. Flinn and Heckman 1982; Wolpin, 1987; Christensen and Kiefer, 1994), to avoid maximization under n inequality constraints of the type $w_{r,i}(\tau) \leq w_i$, $i = 1, ..., n$, and to circumvent the nonregularity of the MLE estimator we assume that wages are measured with an error. In particular, we suggest that the wage outcome w^e_i we observe is indeed the true wage w_i multiplied by the error m, the latter being a draw from some unit-mean distribution $H(m)$. At the same time we still explicitly require that for the true wages w_i the restriction $w_{r,i}(\tau) \leq w_i$ holds for any i. Second, our data on unemployment duration are sampled as a stock. Since the probability distribution of the unemployment duration features time-dependent exit rate, to avoid the *ad hoc* assumption about constancy of the entry rate in the past we consider only the distribution of unemployment duration conditional on the elapsed duration. Moreover, our data contain only monthly information, so we appropriately account for grouping.

Let l_e denote the elapsed and l_r denote the residual durations of an unemployment spell. Moreover, let θ be the vector of the parameters of interest. In Appendix C we show in detail that under the above assumptions the individual contribution to the likelihood becomes

$$\ell(\theta) = \left[\exp\left\{-\int_{l_e}^{l_e+l_r} \alpha[s(x)]\bar{F}(w_r(x))\,dx\right\} - d_1 \exp\left\{-\int_{l_e}^{(l_e+l_r)+1} \alpha[s(x)]\bar{F}(w_r(x))\,dx\right\}\right] \times \left[\int_0^{w^e/w_r(\tau)} \frac{f(w^e/m)}{\bar{F}(w_r(\tau))}\frac{1}{m}h(m)\,dm\right]^{d_1 d_2} \quad (15)$$

where d_1 is a dummy variable such that $d_1 = 0$ if exit to job is unobserved and d_2 is a dummy variable such that $d_2 = 0$ if wage is unobserved.

The expression in the first square bracket of (15) describes the contribution of duration data. In absence of censoring this expression appears as a difference between the survivor functions, rather than a single density function evaluated at the observed value of unemployment duration. Thereby we account for grouping induced by the fact that our units of measurement for duration data are months.

The expression in the second square bracket of (15) shows the contribution of the observed wage (in case observed).[3] For certain parametric forms of the offer and error distributions we can also obtain analytical solutions for the contribution of observed wages, which substantially reduces the computation burden. In particular, we assume that offered wages follow the lognormal distribution, $w \sim \mathcal{LN}(w;\mu,\sigma)$, and the distribution of measurement error is a unit-mean lognormal, $m \sim \mathcal{LN}(m;-\omega^2/2,\omega)$.

4.2 Subjective escape probabilities

It is reasonable for any unemployed individual to assume that, in general, $\bar{S}$ should differ on the individual basis. Therefore, from the individuals, as well as from the econometricians, point of view the difference $\bar{S}_i - S_i(T,t)$ can be expressed as

$$\bar{S}_i - S_i(T,t) = H(S_i(T,t)) + u_i,$$

where $H(S_i(T,t))$ is some function of the cumulative individual effort and u_i is a random disturbance with zero mean. Assuming that $u_i \sim N(0,\sigma_{u,i})$ it is straightforward to show (see

[3]Clearly, on the intervals $(0,\bar{t}_0]$ and $(\bar{t}_3,\infty)$, where search environment is stationary, the duration part of the individual contribution (15) simplifies to an exponential model, as s and w_r are not yet / no longer time-dependent.

Appendix C) that the probability of escaping the sanction writes

$$\pi_1 \left(u_i \leq -H \left(S_i \left(T, t\right)\right)\right) = \Phi \left(-\frac{1}{\sigma_{u,i}} H \left(S_i \left(T, t\right)\right)\right).$$

While the expression for $-H \left(S_i \left(T, t\right)\right) / \sigma_{u,i}$ can be virtually anything it is reasonable to start with a simple first order approximation, suggesting that $-H \left(S_i \left(T, t\right)\right) / \sigma_{u,i} = \beta_0 + \beta_1 S_i \left(T, t\right)$. This will lead us to

$$\pi_1 \left(u_i \leq -H \left(S_i \left(T, t\right)\right)\right) = \Phi \left(\beta_0 + \beta_1 S_i \left(T, t\right)\right).$$

Since neither β_0, nor β_1, nor $S_i \left(T, t\right)$ are initially known, we consider the following iterative estimation procedure:

Step 1: For a given initial value of β_0 and β_1 compute π_1, estimate the model formulated in (15) and predict $S_i \left(T, t\right)$ [on the very first step set $\beta_1 = 0$].

Step 2: Use the data on the observed outcomes of the interviews to estimate β_0 and β_1 from a probit regression

$$y_i = \beta_0 + \beta_1 S_i \left(T, t\right) + v_i$$

where y_i is a binary variable that takes value 1 if the outcome of the interview with the case worker is positive and an individual is left with b_1 forever.[4] Using the estimated values $\hat{\beta}_0$ and $\hat{\beta}_1$ go to Step 1 and iterate until convergence.

5 Estimation results and discussion

5.1 Estimation results

Here we discuss the estimation results of the benchmark specification of the structural model developed in Sections 2-3. Our data comprises of 1584 observations, 40% of which constitute a group that participates in the programme. For this group the exit rate is a function of optimal paths of the control variables that solve (12a)-(12b) subject to (13) and (14). For the complementary subsample the exit rates are described by the stationary solution (11).

To estimate the model we need further functional form assumptions on the individual preferences on and the way the search costs and the arrival rate of job offers depend on the individual search effort. For our benchmark econometric specification we suggest that individuals are risk

[4]It is also easy to see that, if we represent this regression in terms of the observable (y_i) and latent (y_i^*) variables, the latent variable y_i^* is nothing but $\bar{S}_i - S_i \left(T, t\right)$, which is observable neither for an econometrician nor for the individual

neutral, costs of search are described by a convex power function and arrival rate of job offers is linear in effort, i.e.

$$u\left(y\left(\tau\right)\right)=y\left(\tau\right), \quad c\left[s\left(\tau\right)\right]=\left[s\left(\tau\right)\right]^{1+\varepsilon}, \quad \alpha\left[s\left(\tau\right)\right]=\gamma s\left(\tau\right).$$

For convenience we introduce a parameterization $\gamma=\exp\left\{-\bar{\gamma}\right\}$, which will allow estimating the conditional versions of the structural model later on. Still it is important to notice that even though $\bar{\gamma}$ is not written down as a function of covariates at the moment, the model is not unconditional, because we explicitly use the observed variation in benefit levels to explain the duration/earnings outcomes. In other words, for two individuals with different observed benefit levels the calculated theoretical $\left\{s,w_r\right\}_i$-pairs and $\left\{s\left(\tau\right),w_r\left(\tau\right)\right\}_i$-paths will be different. Furthermore, the magnitude of the benefit payments after the imposition of the sanction also varies over the individual characteristics. Thus, even if any two given individuals have the same initial benefit b_1 but fall into different sanction categories, the optimal paths $\left\{s\left(\tau\right),w_r\left(\tau\right)\right\}_i$ starting from the receipt of the letter, as well as the terminal conditions after the last interview, will still be different.

Finally, to keep the benchmark model as simple as possible we invoke a restriction $\sigma=\omega$ in order to reduce the parameter space. This restriction, however, is not crucial and will be lifted later on.

Table 1 reports the estimation results.[5] As for the direct interpretation of the estimated parameters, we can see that the estimate of ε is significant at 5% level, which provides evidence of sufficient convexity of the cost of search function. While the rest of the parameters are also significant at 5% level, implying a significant exit risk and showing a sufficient degree of variation in the offer distribution, it is more convenient to discuss the meaning of these parameters in terms of the arrival and acceptance rates. For the stationary environment that precedes the notification, these statistics are reported in Table 2. Once the environment becomes nonstationary, the arrival and acceptance rates become time-dependent, so their optimal paths are drawn in Figures 1-2. When plotting the predictions for the nonstationary model it is implicitly assumed that after the last interview an individual does not escape the sanction, so from that point onward the stationary solution is shown conditional on the lower benefit level. Otherwise, the solution will be identical to the one that precedes the notification. The results in Table 2 and Figures 1-2 are currently reported for the household heads, who constitute the largest part of the sample. All predictions in Table 2 are calculated using the average observed initial benefit level b_1.

[5] Due to very high CPU time demand for the calculation of the optimal paths of the control variables initially we experiment with the random subsample which is three times smaller than the entire sample.

Table 1: Estimation results

	Coeff.	S.E.	z-Stat.	p-Value
$\varepsilon^{\S}$	0.3604	0.2161	1.6675	0.0477
$\bar{\gamma}$	8.4520	1.8626	4.5376	0.0000
μ	7.4946	0.0863	86.8266	0.0000
$\sigma^{\S}$	0.1480	0.0132	11.1926	0.0000
$\ln \mathcal{L}$	-2201.97		Obs. treated:	213
			Obs. control:	315

§ p-Values for ε and σ are from the one-sided test with $H_0 : \varepsilon > 0$ and $H_0 : \sigma > 0$ respectively

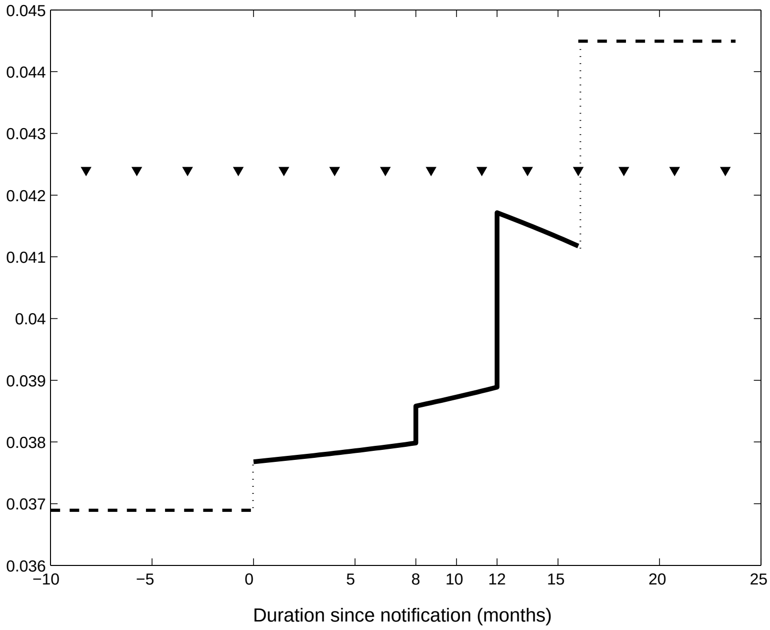
From Table 2 we see that optimal search effort chosen at the level of 294.22 ⟨effort units⟩ implies that a job offer will arrive at a rate of 0.0628, i.e. about every 16 months. Optimal reservation wage set at €1740.42 tells us that 58.74 percent of the incoming offers, i.e., about three out of five incoming offers, will be accepted. This leads to an endogenous distribution of unemployment duration with mean equal to 27 months. In the stationary environment this

Table 2: Model predictions: Stationary environment

Reservation wage [w_r]	€1740.42	Job arrival rate [$\alpha(s)$]	0.0628
Search effort [s]	294.22	Acceptance rate [$\bar{F}(w_r)$]	0.5874
		Exit rate [$p(s, w_r)$]	0.0369

Sequence of escape probabilities	1st meeting	2nd meeting	3rd meeting
	0.7635	0.5988	0.4495

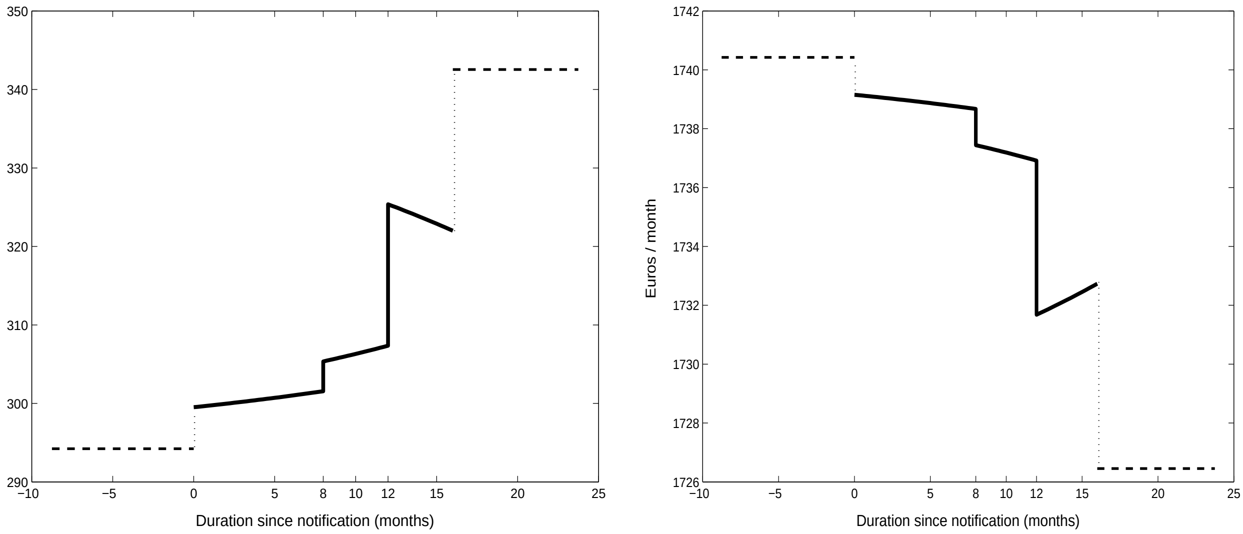
Figure 1: Transition rate to employment



mean is just the reciprocal exit rate (the latter being equal to 0.0369). Finally the chances of escaping the sanction steadily fall from interview to interview. All these results are consistent with the broad search literature and with the nature of the process under consideration.

Consider now Figures 1-2 that plot the evolution of the optimal paths once the environment becomes nonstationary. From Figure 1 we see that at the moment of the receipt of the notification letter the exit rate discontinuously jumps upwards and steadily increases due to anticipation of a potential future loss in case the sanction is imposed. Yet, no withdrawal of benefits at the first interview is possible, which makes the first discontinuous jump not too big and the increase of the exit risk before the first interview not too steep. Once the first interview is attended and the necessary requirements for search effort sufficiency are not met, an individual signs the first action plan (8th month since notification). At this stage the threat becomes more strong, because noncompliance with sufficiency requirements will lead to a temporary withdrawal of benefits at the next interview. That's why immediately after the first interview we observe another discontinuous jump upwards and a faster increase in the exit risk than before. If at the second interview (12th month since notification) the sufficiency requirements are still not met, a temporary sanction is imposed, i.e. the benefit level is reduced from the group average of €918 down to €715 until the next interview. This leads to another discontinuous jump of the exit rate upwards. For the group of household heads, the reduction to €715 is already the reduction to a subsistence minimum. That's why on the last interview

Figure 2: Search effort (left) and reservation wage (right)



a person can either expect the benefit to be restored at the original level, if complying, or kept at the current reduced level forever, if not complying. So the last phase of the programme will represent a pure disincentive effect, as the individual expects a future utility gain instead of future utility loss. As a result the optimal exit rate between the second and the third interview reduces and not increases. Finally, at the third interview the permanent decision about the benefit level is made and the environment becomes stationary.

Interpretation of the graphs for the search effort (Figures 2, left panel) and the reservation wage (Figures 2, right panel) at each nod of the programme is identical. With respect to the reservation wage, remarkable result is that its' entire nonstationary dynamics is locked within the $[0.590, 0.605]$interval. This implies that incentive effect induced by the programme translates into the changes of the exit rate mostly via the adjustment of search effort.

5.2 Incentive effect of the programme

As we have seen above, Figures 1-2 describe all aspects of the optimal behaviour of an individual exposed to the programme. The programme implies an overall increase in the exit risk and a particular optimal path of the exit risk between the notification (beginning of the programme) and the last interview (termination of the programme). The key question we want to ask is whether the programme design can induce a significant increase of the exit rate, leading to a significant decrease in the expected unemployment duration of long-term unemployed workers.

One way to answer this question is to construct a confidence interval for the optimal exit risk of the individuals which are not subject to the programme and reconsider the transition rate of the participants on the plot of this interval. If the programme is successful the nonstationary path of the participants has to jump out of the confidence interval for those who are not influenced by the programme.

Continuing our example with household heads, the relevant 95% confidence interval for the stationary exit rate can be readily obtained using delta method. The upper bound of this confidence interval is equal to 0.0424. This upper bound is illustrated in Figure 1 by the horizontal line of downward looking triangles. We can see that the entire time path of the nonstationary transition rate of an individual who participates in the programme lies below this bound, i.e. lies within the confidence interval for the stationary transition rate. The maximal value of the exit rate, which obtains immediately after the third interview and approaches the bound most closely, is equal to only 0.0417. This implies that the programme is not sufficiently strong to reduce the expected unemployment duration. Thus, at least for household heads, our benchmark model predicts no significant effect of the suggested incentive design.

6 Preliminary conclusion

While it is still too early to conclude, at this stage we can already be quite sure that even if the programme will have a significant effect on the exit behaviour after we further refine the data and the model, this effect will hardly manifest itself at the first phase of the programme, i.e. between the receipt of the notification letter and signing of the first action plan.

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7 Data Appendix

Data Appendix coming soon ..

Appendices A-C

Appendices A-C are available upon request.