Spatial search strategies of job seekers and the role of unemployment insurance[*]

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December 27, 2014

PRELIMINARY

Abstract

Job search is an activity involving costs and returns. But, because individuals and jobs are scattered across space, it is also a spatially oriented activity. In particular, job acceptance depends on commute distance. Searching within a range of acceptable commute distances is costly: search costs combine effort and money, the latter part depending on the size of the prospection area. Under liquidity constraints of the job seekers, job search efficiency may be itself constrained. We first provide a simple theoretical setup to discuss those questions: job search is represented by draws in a bivariate distribution of wages and commute distances; individuals choose their range of search and the intensity of search within the range.

We then exploit an administrative social security dataset covering all newly unemployed workers in Austria. It contains information on the current residence, the previous workplace and the subsequent workplace for those re-hired. We observe fairly high dispersion in the change of commuting distance and wage and evidence of a reservation frontier. We also see that newly unemployed workers seem to initially target their job search from the same workplace as they used to be employed. As the unemployment spell gets longer, they tend to accept lower wages and progressively enlarge their radius of search, ending up with a job farther away from their previous workplace (but not necessarily farther away from their residence).

We finally extend the model to two types of unemployed workers and to partially directed job search to replicate these facts. We calibrate it and explore the effect of unemployment insurance on job search strategies.

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1 Introduction

Job search is an activity involving costs and returns. Because individuals and jobs are scattered across space, it is also a spatially oriented activity. Individuals may prospect in a local labor market, or conversely in many different remote places. Hence, the acceptance rate of a job, crucial in determining both equilibrium employment and turnover, depends on several spatial dimensions, including commute costs and mobility costs. These dimensions add up to the traditional ones such as wage earnings and its distribution. Hence, a reservation strategy involves both a reservation wage and a reservation commute distance, both being tied to each other. Further, even within acceptable commute distances, searching for jobs remote to one's residence may be expensive. Under liquidity contraints, job search efficiency may be seriously limited. This implies that unemployment insurance plays a role typically overlooked to improve the job search process.

The distance dimension of job search has therefore several policy implications, beyond equilibrium unemployment, on notably on the optimal design of unemployment compensation. Hence, although explicit in many empirical and theoretical works, it is not central in most analyses. As a matter of fact, the commute time dimension is relevant in job acceptance decisions, and its impact is of the order of magnitude of the wage dimension; to illustrate, Table 1 (from Rupert *et al.* (2009)) shows that many job seekers do reject a job offer, not for low wages, but for too high distance. Excluding all reasons but wages and commute distance, the last column shows that 60% of job offers are rejected for too low wages, but 40% are rejected for too high commute distances. The commute distance is therefore a potentially first-order margin in job acceptance decisions.

Several papers have been explicit about commute distance. Crampton (1999) has a discussion of the optimal location of vacancies and their number, illustrated by the classical papers by Seater (1979), Chirinko (1982) and more recently van Ommeren *et al.* (1997). Racial differences have been analysed through the lens of distance and access to jobs in the spatial mismatch literature following Kain (1968): papers include Holzer (1986), Holzer (1987), Holzer (1988), Ihlanfeldt (1997), Zax and Kain (1996), Brueckner and Zenou (2003) and Coulson *et al.* (2001) and are summarized inGobillon *et al.* (2007) and Zenou (2009); see also van Vuuren (imeo) and Nenov (2014); the articulation between commuting decisions and mobility decisions has been studied by Rupert and Wasmer (2012) and applied to ethnic unemployment gaps in Gobillon *et al.* (2014) for commuting vs mobility decisions; more closely related to our work, the role of local labor markets has been investigated in Cheshire (1979), Rogerson (1982), Manning and Petrongolo (2011), Gobillon *et al.* (2011) and Marinescu and Rathelot (imeo). The latter find in particular that job seekers's applications from a particular website, Carreer.Builder decrease by 20% every 5 kilometers of distance between the applicant's address and the vacancy. Manning and Petrongolo (2011) also found a large decay, somewhat higher (approximately 80%), but for a different concept, the concept of job acceptance (and not of simple applications).

In this paper, we will proceed as follows. We first derive a simple theory of job search in space that introduces commute distance and optimal spatial search strategies. This will introduce the key concepts and discipline the empirical analysis in providing simple expression for hazard rates. The three main endogenous variables are: the wage reservation strategy for a given commute distance (or equivalently the optimal reservation distance for a given wage) ; the optimal radius of job search in space ; and within this range, the optimal intensity of search effort. We solve for the optimal acceptance decision where the interplay of accepted wages and accepted commute distance depends on the marginal rate of substitution between the two: individuals can buy short commutes with a lower wage or seek to be compensated with a higher wage for long commutes. This has obvious implications on job search strategies: indeed, once they correctly anticipate their future decision rules, unemployed individuals looking for a job may try to enter

Table 1: Reasons for rejecting offers

	%	% excl. last 3	% excl. last 3 & hrs	% compared to wage rate
1. rate of pay	12.1	21.8	24.7	59.7
2. temporary/insecure job	6.65	12.0	13.6	-
3. type of work	12.9	23.3	26.4	-
4. number of working hours	6.05	11.0	-	-
5. working time (day time, night time, shifts...)	6.42	11.6	12.4	-
6. working conditions / environment	3.06	5.54	6.27	-
7. distance to job / commuting	**8.14**	**14.7**	**16.7**	**40.3**
8. could not start the job at required time	4.82	-	-	-
9. other reasons for not accepting	20.99	-	-	-
10. not yet decided	18.93	-	-	-
Sum	100	100	100	100

Source: Rupert *et al.* (2009).

jobs that pay a higher wage and involve a shorter commute time relative to the previous job. We explore the implications for hazard rates and the role of unemployment insurance under various assumptions on liquidity constraints. As a matter of fact, in several countries, the spatial component of the costs of job search is either partly financed by the employment agencies, or deductible from income taxes.[1]

We then use an exhaustive panel of newly unemployed workers based on an administrative dataset in Austria, covering years 1995 to 2004 and overall more than 100 000 spells of unemployment to establish a few stylized facts related to commute distance and job acceptance decisions. The choice of Austria is motivated by data availability: we know the city of residence and the city of employment and can match these informations with information about transportation time from a private company which provided a matrix of travel time based on the existing network of roads and highways in 2000, approximately in the middle of our sample. The choice of Austria is also relevant because we want to isolate the commute time decision from the residential mobility decision. For unemployed individuals, we calculate that about 6% change their residency over the turn of non-employment. We observe fairly high dispersion in the change of commuting distance and wage.

We explore the dataset through an analysis of a competing risks model and its relative hazard ratios. Newly unemployed workers seem to start the job search from the same workplace as they used to be employed and looking for high wage jobs. As the unemployment spell gets longer, they tend to accept lower wages and progressively enlarge their range of search, ending up with a job farther away from their previous workplace. We offer evidence of a reservation frontier strategy in the wage/distance plane. We then investigate the role of policy and in particular unemployment insurance. We estimate Cox Proportional Hazard models to measure the causal effects of the unemployment insurance replacement rate, the social assistance replacement rate, and benefit duration (proxied by potential benefit duration) and show that their impact varies by destination (distance winners vs. loosers, wage loosers vs. wage winners). This is evidence that policy plays a crucial but complex role on job acceptance decisions and in turn on job search

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[1]Eg. in the US, job search expenses are partly deductible from IRS. "*To qualify for a deduction, your expenses must be spent on a job search in your current occupation. You may not deduct expenses you incur while looking for a job in a new occupation; (...) ; If you travel to look for a new job in your present occupation, you may be able to deduct travel expenses to and from the area to which you travelled. You can only deduct the travel expenses if the trip is primarily to look for a new job ; (...) ; You cannot deduct job search expenses if you are looking for a job for the first time.*" Source ; http://www.irs.gov/uac/Job-Search-Expenses-Can-be-Tax-Deductible. In France, a similar regime of tax deduction applies, complemented with direct subsidies of job search from Pôle Emploi (the employment agency): http://vosdroits.service-public.fr/particuliers/F1640.xhtml ;

processes, and deeply modifies the pattern of search strategies. Ignoring these dimensions leads to potential lack of understanding of the role of welfare policies.

The empirical analysis thus offers guidance in the solution and the calibration of the model. In particular, as discussed above, we exploit the insights on the spatial search starting from the previous workplace to argue what follows. We enrich the model in several dimensions. First, we allow for different unemployment compensation regimes: newly unemployed workers are covered by unemployment insurance, but they can subsequently loose it for a reduced level of benefits, in the unemployment assistance regime. We also introduce some targering of job search activities in space, where workers can divide their effort into job search in the previous workplace and outside the previous workplace. Finally, we also allow for non-separability in consumption and search costs to allow for richer reservation strategies. Once calibrated, the model reproduces the empirical fact that, over time and as unemployment benefits decrease, the unemployed progressively adjust their reservation strategies: their reservation wage goes down and in addition they start prospecting in different areas. The model predicts that individuals remaining unemployed for longer time have a higher probability to enter less paying jobs and/or jobs located farther away, but the relative hazard ratio may increase or decrease with the duration of unemployment spells. The model delivers simple expression for all hazard rates (overall exit to employment, exits towards higher wages than in the previous job, exits towards lower wages, exit towards higher commute distances and towards lower distances) and all relative hazard rates.

The paper is organized as follows. **Section 2** introduces the key concepts behind the spatial analysis of job search. **Section 3** provides various and hopefully exhaustive evidence of the role of space in job search and the spatial dispersion of commute distances, based on our rich data set of unemployment spells in Austria. In **Section 4**, we extend the model in order to provide a realistic calibration. In **Section 5** we draw lessons for policy. **Section** 6 concludes.

2   A simple theory of search in space

The goal of this section is to provide the basic trade-offs of spatial search and draw some implications of the theory. As explained in the introduction, the model derives the reservation strategy, that is the minimum acceptable wage for a given commute distance that implies some costs and effort; or reciprocally, the maximum acceptable commute distance at a given wage ; it derives the range of search, that is the maximum distance within which to prospect; finally, it determines the optimal intensity of search effort, captured by the arrival rate of job offers within the range of search.

2.1   Setup

2.1.1   Notations

Time is continuous. Individuals and firms discount the future at rate r. The level of benefits is b. Searching for a job is more costly in more remote area. Let D be the radius of search, and $2\pi\lambda$ be the rate of arrival of search offers (where 2π is a simple proportionality factor coming from the integration of search around the individuals' location). Job seekers control both the intensity of search effort λ and the range of search at a cost $C(D, \lambda)$. At this stage we do not specify the nature of the search costs but they may be both pecuniary and non-pecuniary. We also assume perfect separability between search costs and consumption ; denote by $U(D, \lambda)$ the value of job search and by $W(w, \rho)$ the value of being employed at a wage w and at a commute distance ρ. The employed workers pay a commute cost $c(\tau\rho)$ which depends on commute time ρ and the cost of transportation τ. We also assume perfect separability in consumption and commute costs.

2.1.2 Unemployment and Employment values

We do not restrict the draws (w, ρ) in the distribution to be independent. With notations $F_\rho(w)$ and $G(\rho)$ for the associated cumulated distributions of each variable separately, we can go one step furher. In this case, the Bellman equations for job search are:

$$rU(D, \lambda) = b - C(D, \lambda) + 2\pi\lambda \int_0^D \left(\int_w Max[W(w, \rho) - U; 0]dF_\rho(w) \right) dG(\rho) \tag{1}$$

The value function for employment is:

$$rW(w, \rho) = w - c(\tau\rho) + s(U - W(w, \rho)) \tag{2}$$

2.2 Interior solutions and strategies

The surplus from employment can easily be calculated, given the linearity in income. Noticing that $\frac{\partial W}{\partial w}(w, \rho) = \frac{1}{r+s}$; and denoting by $R(\rho)$ the reservation wage associated with distance ρ, defined as $W(R(\rho), \rho) = U(D^*, \lambda^*) = U^*$, we can rewrite the value of employment as a linear function of w:

$$W(w, \rho) - U^* = \frac{w - R(\rho)}{r + s} = S(w, \rho) \tag{3}$$

where the notation $S(w, \rho)$ is the surplus value of holding a job paid w at a commute distance ρ.

We can now derive the reservation wage: it turns out to depend on commute costs and on the equity value of being unemployed under the optimal job search strategy. We have:

Lemma 1. *The reservation wage is linearly increasing in commute costs and in the unemployment value:*

$$R(\rho) = c(\tau\rho) + rU^*$$

It is convex or concave in the commute distance, depending on the convexity or concavity of commute costs. Convexity would result from disutility from time spent in commute, while concavity may result from optimization of transportation modes.

The interior optimal search strategies also follow immediately. The first order condition on the radius is as follows. Let $w^{\max}$ be the upper support of the wage distribution. We have

$$rU(D, \lambda) = b - C(D, \lambda) + 2\pi\lambda \int_0^D \int_{R(\rho)}^{w^{\max}} S(w, \rho)dF_\rho(w)dG(\rho) \tag{4}$$

so that $U(D, \lambda)$ is maximised with respect to the search strategy D when the marginal cost of searching at one more unit of distance is equal to the marginal gain. The marginal gain depends on first the direct impact on the flow of offers (first term of the right handside) and second on the change of acceptable offers (second term of the right handside):

$$C'_D(D^*, \lambda^*) = 2\pi\lambda \left(\int_{R(D^*)}^{w^{\max}} S(w, D^*)f_\rho(w)dw \right) g(D^*) \tag{5}$$

$$= 2\pi\lambda g(D^*)\mathbb{E}_w S(w, D^*)$$

The first order condition on optimal search effort affecting the arrival rate of offers λ reads as follows:

$$C'_\lambda(D^*, \lambda^*) = 2\pi \int_0^D \int_{R(\rho)}^{w^{\max}} S(w, \rho) dF_\rho(w) dG(\rho) \qquad (6)$$

$$= 2\pi \mathbb{E}_{w,\rho} S(w, \rho)$$

Both expressions show that the marginal cost has to equal the marginal gain of search, either with respect to extending the range of search by one marginal unit D, or by increasing the intensity of effort within the range. In both expressions, the marginal return on search involves the expected surplus value of holding a job.

Lemma 2. *Under separability of the cost function $C(D, \lambda)$, equation (5) implies that a higher arrival rate of offers λ is associated with a higher return on the range of search D, implying a complementarity of the two dimensions of search.*

Lemma 2 is not general, and under complementarity in the cost function $C(D, \lambda)$, the two search variables may be more substitute to each other: a higher λ raising the marginal cost of raising the range of search may in turn reduce the optimal range D^*. The dominance of each mechanism is an empirical matter and we leave the question unanswered here.

2.3   The effect of distance on wages

The main novelty here is to explicitly account for the role of distance on reservation wage and on expected, accepted wage. The reservation frontier in wage and distance can be represented as in Figure 1, here under the assumption of concave costs of distance $c(\tau\rho)$.

Figure 1: Reservation Frontier and Acceptance-Rejection Areas
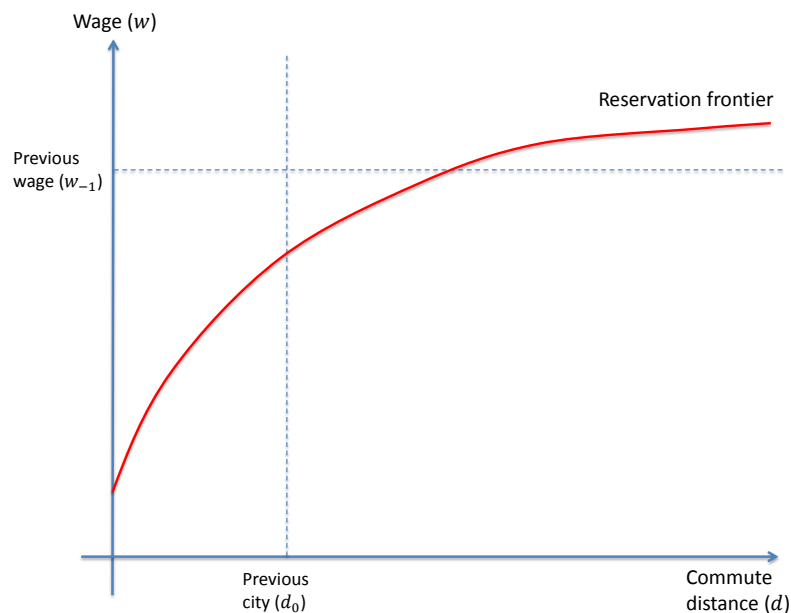
In the data, we will not directly observe the reservation distance but accepted wages. When the two distributions in wages and distances are independent, it is possible to calculate conditional wages and their slope with respect to commute distance with a simpler formula. We have in this specific case:

$$w^e(\rho) = \frac{1}{1 - F(R(\rho))} \int_{R(\rho)}^{w^{\max}} w \, dF(w)$$

and the slope of w^e with respect to ρ is

$$\frac{\partial w^e}{\partial \rho} = \frac{c'(\tau\rho).f(R(\rho))}{[1 - F(R(\rho))]^2} \int_{R(\rho)}^{w^{\max}} w \, dF(w) + \frac{-c'(\tau\rho)R(\rho)f(R(\rho))}{1 - F(R(\rho))}$$

$$= \frac{f(R(\rho))c'(\tau\rho)}{1 - F(R(\rho))} (w^e - R(\rho))$$

The slope is clearly positive, as wages are above reservation distance. It is not linear and might be either convex or concave, depending on the features of the wage distribution $F()$.

2.4   Liquidity constraints, unemployment and the role of benefits

The previous results were derived under the assumption that agents face no liquidity constraint. Under the assumption of a search cost taking the form $C(D, \lambda) = M(D) + e(\lambda, D)$, where the first part may be thought as a monetary component and the second part as disutility of effort and distance, this requires that the income from benefits and other assets is larger than the financial cost, or that the unemplyed workers may borrow at the same rate at the employed workers save. Indeed, this assumes that the rate of interest r is the same for borrowers (the unemployed) and savers (some of the employed). Another "almost equivalent" assumption is that the unemployed workers who have just being laid-off and either still have financial assets and full access to financial liquidity. In that case, the situation of the newly unemployed workers is similar to that of the employed workers, which was our working hypothesis so far.

However, one may want to enrich the analysis with regards to the financial situation of the unemployed workers. One option is to model the financial assets and thus introduce a non-stationarity in Bellman equations. The end of next sub-section derives the intuition of this approach. Another track, which is analytically more convenient, is to assume that the newly unemployed workers access to the same rate of interest for a random time, and under some Poisson intensity process, undergo a drop in their financing capacity.

In that case, a *mild liquidity constraint* is that they face a higher interest rate r^+ but may still borrow at this rate and therefore, choose the optimal range of search. Another extreme assumption is that these unemployed workers, after being hit by a financial constraint, cannot even borrow and face a *strict liquidity constraint*, under which their current income must equal their spendings: consumption and monetary search costs. These unemployed workers must now discount the future at their rate of pure time preference, and r^+ must now been interpreted as such a rate, going say from 4% a year to 20% a year. Of course all this has to be anticipated from the start by the newly unemployed, but we are interested here in the unemployed under one of those liquidity constrained regimes.

In other words, the newly unemployed workers are decumulating assets and make optimal search decisions; the post-financial shock unemployed workers have no longer any assets and must either borrow at a higher rate or face cash-constraints and discount the future at their rate of time preferences.Under the last of these alternative assumptions, let us assume that the unemployed have decumulated their assets and face a subsistance level for consumption say $\underline{C}$. It follows that they face a strong cash constraint; the unemployed

now face the following constraint:

$$b \geq \underline{\mathcal{C}} + M(D)$$

Lemma 3 (**strict liquidity constraints**). *In the absence of assets and under separability of the cost function, e.g. $C(D, \lambda) = M(D) + e(\lambda, D)$ where the first part is monetary, the constrained range of search is sub-optimal if*

$$\bar{D}(b) = M^{-1}(b - \underline{\mathcal{C}}) < D^*$$

. The constrained value is increasing in the level of benefits and decreasing in the subsistence level. In turn, the optimal effort λ^* will itself react to the constrained value $\bar{D}(b)$.

This Lemma introduces a new role of unemployment insurance in the presence of imperfect financial markets as studied in Baily (1978), Chetty (2008) or Werning (2002) or Shimer and Werning (2003). It recognizes that search costs are not only time costs or disutility costs, but have a monetary component due to the existence of the spatial dispersion of jobs.

Beyond these results, the analysis can determine the impact of unemployment benefits on the well-being of the unemployed.

Lemma 4 (**unemployment benefits impact**). *i) In the absence of liquidity constraint, an increase in unemployment benefits increases the value of unemployment by a factor $1/r$. ii) Under mild liquidity constraint as in Lemma 5 the impact is $1/r^+$ and thus smaller. iii) Under strict liquidity constraints as in Lemma 3, the impact of benefits on U is larger that the inverse of the rate of discount.*

The proof of the impact of unemployment benefits on the value of unemployment is as follows. Consider the derivatives of

$$rU(D, \lambda) = b - C(D, \lambda) + 2\pi\lambda \int_0^D \int_{R(\rho)}^{w^{\max}} S(w, \rho) dF_\rho(w) dG(\rho)$$

with respect to b for the ongoing rate of interest: we have[2]

$$\begin{aligned}
r\frac{dU}{db} = \ &1 \\
&+ \frac{\partial\lambda^*}{\partial b}\left[-C'_\lambda + 2\pi\mathbb{E}_{w,\rho}S(w,\rho)\right] \\
&+ \frac{\partial\widetilde{D}}{\partial b}\left[-C'_D(\widetilde{D}, \lambda) + 2\pi\lambda\mathbb{E}_w S(w, \widetilde{D})\right] \\
&+ 2\pi\lambda\int_0^D \frac{\partial R(\rho)}{\partial b}\left[-S(R(\rho), \rho)f(\rho)\right] dG(\rho)
\end{aligned}$$

The last line is by definition equal to zero since the surplus is equal to zero at $R(\rho)$. In interior solutions, by the envelope theorem, the second and third lines are equal to zero as well. Hence, the effect of benefits is equivalent to a permanent raise in the income of the unemployed workers, who will enjoy both higher benefits as unemployed and chose higher wages in the future. The situation is different under credit constrained unemployed workers; indeed, if $D = \bar{D}(b) < D^*$ is the constrained level of the range of search, then the envelope condition of the third line does not hold and, given that in that case, $-C'_D + 2\pi\lambda\mathbb{E}_w S(w, D^*) > 0$, then the effect of benefits on the value of unemployment is larger than $1/r$.

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[2] $\widetilde{D}$ is here defined as the minimum between the optimal search radius D^* and the constrained level $\bar{D}(b)$.

This analysis can be extended to accumulated assets. Let $\mathcal{C}_t^* \geq \mathcal{C}$ be the chosen level of consumption and A_0 and A_t be the initial and the current asset after t units of time spent into job search, we have:

$$dA/dt = rA_t + b - \mathcal{C}_t^* - M(D^*)$$

Lemma 5 (**decumulating asset regime**). *i) In a regime of decreasing assests and in the absence of wealth effect, the unemployed choose their optimal range of search D^* independently of their level of asset, as well as their consumption. However, after a finite amount of time, they reach the liquidity constrained stage and then reduce their range to $\bar{D}(b)$. ii) Under wealth effects, one would instead observe a continuous decline in assets A_t, in consumption $\mathcal{C}_t^*$ and in D_t^* until the level of Lemma 3, $\bar{D}(b)$, is reached.*

We also have another interesting implication of our setup with regards to the existence of congestion costs due to simultaneous commute of employed workers. Indeed, large numbers of commuters crowd out both public transportations and roads and highways. Therefore, the social cost of commute may be much larger than the private cost insofar captured by $c(\tau\rho)$. Therefore, even in the absence of liquidity constraints, higher benefits may lead to joint phenomenons: it induces workers to search for higher wages which is generally considered as socially ineffecient as jobs are left unaccepted. But it also induces workers to search for jobs closer to their home, which reduces the congestion externality.

Lemma 6. *In the absence of credit constraints for the unemployed and under social costs of commutes, the social planner wants to give more time to the unemployed to search for job closer to their home, and it can do so in raising the level of benefits.*

2.5   Hazard rates, odds ratios and rejection rate

The hazard rate is:

$$haz = 2\pi\lambda \left[\int_0^D \int_{R(\rho)}^{w^{\max}} dF_\rho(w)dG(\rho) \right]$$

The sub-hazard rates denoted by haz, $haz(w^+, d^+)$, $haz(w^+, d^-)$, $haz(w^-, d^+)$, $haz(w^-, d^-)$ are defined as follows: the first rate is the sum of the next four subhazard rates. The subhazard rates refer to individuals accepting a new job with wage increase ($w > w_{-1}$ where w_{-1} is the previous wage) and with commute distance above the previous commute distance denoted by d_0: d^+means an increase in commute distance relative to the previous job, and d^- means a decrease in commute distance relative to the previous job. The sub-hazard rates write as:

$$hazard(w^+, d^+) = \lambda \int_{d_0}^D \int_{w_{-1}}^{w^{\max}} dF_\rho(w)dG(\rho) = \lambda[1 - F(w_{-1})][G(D) - G(d_0)]$$

$$hazard(w^+, d^-) = \lambda \int_0^{d_0} \int_{w_{-1}}^{w^{\max}} dF_\rho(w)dG(\rho) = \lambda[1 - F(w_{-1})]G(d_0)$$

$$hazard(w^-, d^+) = \lambda \int_{d_0}^D \int_{R(\rho)}^{w_{-1}} dF_\rho(w)dG(\rho) = \lambda \int_{d_0}^D [F_\rho(w_{-1}) - F(R(\rho))]dG(\rho)$$

$$hazard(w^-, d^-) = \lambda \int_0^{d_0} \int_{R(\rho)}^{w_{-1}} dF_\rho(w)dG(\rho) = \lambda \int_0^{d_0} [F_\rho(w_{-1}) - F_\rho(R(\rho))]dG(\rho)$$

One of the hazard rates, namely $hazard(w^+, d^-)$ turns out to only depend on distributions, but not on endogenous variable of the model D and on function R which itself depends on the values of unemployment U. Under the simplifying assumption that F is not indexed by ρ in the expressions above, that is when the two distributions F and G are independent of each other, the odds ratios with respect to $haz(w^+, d^-)$ can therefore be calculated as follows:

$$relhaz = \frac{haz(w^+, d^+)}{haz(w^+, d^-)} = \frac{[G(D) - G(d_0)]}{G(d_0)}$$

$$relhaz^2 = \frac{haz(w^-, d^+)}{haz(w^+, d^-)} = \frac{\int_{d_0}^{D}[F(w_{-1}) - F(R(\rho))]dG(\rho)}{[1 - F(w_{-1})]G(d_0)}$$

$$relhaz^3 = \frac{haz(w^-, d^-)}{haz(w^+, d^-)} = \frac{\int_{0}^{d_0}[F(w_{-1}) - F(R(\rho))]dG(\rho)}{[1 - F(w_{-1})]G(d_0)}$$

Finally, the job rejection rate is, in the general case:

$$reject = \int_{0}^{D} F_\rho(R(\rho))dG(\rho)$$

Under the assumption of independence of the joint distribution of wages and distance, the rejection rate increases in D: at a higher distance, it is more likely that the drawn wage won't compensate for distance.

3   Empirical analysis

3.1   Institutional Background

The unemployment system in Austria, as in many other countries, consists of a first part where eligible individuals receive Unemployment Insurance (UI) benefit. The level of UI benefits are calculated based on previous earnings, the duration of UI benefits are is a function of experience and age. Once unemployment benefits are exhausted, individuals are eligible for means tested Unemployment Assistance (UA; Notstandshilfe) benefits. The means test includes in particular family income.

In the year 2001, 92% of the total workforce commuted and 86% of the total workforce commuted daily. 67% of the daily commuter cover the major commuting distance by car, 20% commute by public transport and 13% either walk or commute by bicycle. 68% of the daily commuting individuals work in a different municipality than they live in. Yet, 80% stay within a political region (there are 99 political regions), hence many stay in the same county. As people do not incur long commutes on average, one concern for our analysis might be that individuals try to avoid commuting by relocating. Although there can be benefits in terms of commuting, there certainly is a cost involved in relocating. Compared to the US, residential mobility in Austria is low. Fischer (2002) provides calculations for the US. We calculate for Austria, that less than 6% (between 10-15% for the US) change the residential municipality and less than 1.6% (above 5% for the US) cross the county border annually.[3]

The geography of Austria adds to make it an interesting country to study commuting. Figure 2 plots Austria and the altitude of each municipality. Austria is a relatively small country yet with potentially large commute distances due to the presence of the Alps in the middle of the country, and the particular longitudinal shape: the maximum distance from west to east is around 700 kilometers. Cutting through München in Germany, the distance between the northwestern city of Bregenz to Wien (Vienna) is 618 kilometers and six hours drive. The distance between the southern city of Klagenfurt to the northern city of Linz

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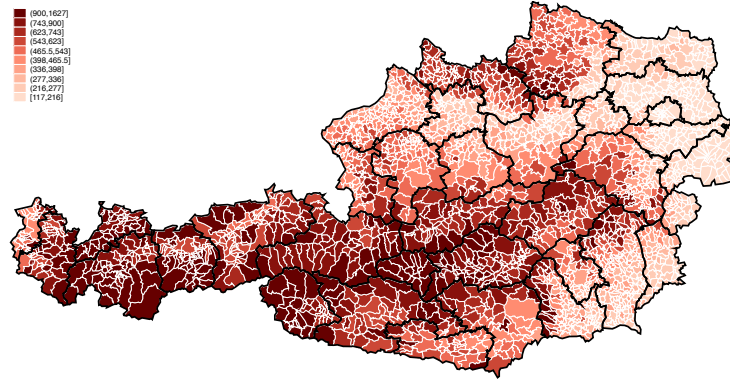[3]Sources: CPS 2001 Statistik Austria, Own calculations from tax records.

Figure 2: Altitude of Municipalities

is only 251km but it takes 3 hours to reach the other city given the mountains. Figure 2 also makes clear that there are many geographic units. The white lines constitute borders of municipalities. We will be able to measure many things on this municipality level. The black lines depict the borders of NUTS3 regions. A dark colour indicates, that the municipality is high above sea level. Altitude ranges from 110 to 1600 meters above sea level. The Alps in the middle of the country are clearly visible as are the flat parts in the east towards Hungary. This variety in the terrain is likely to have an impact on how individuals commute.

3.2 Data and Sample

We combine data from different sources to reach our final data set. First, the Austrian Social Security Database (ASSD)[4] contains detailed information on the work history for all private sector workers from 1972 to present. It contains both, unique plant and person identifier. Second, the unemployment register contains detailed information on both UI and UA benefits for the years 1988 to 2007. Third, we use data from a road trip planning firm to measure travelling time between any two municipalities.

To construct our data set we obtain all unemployment spells from the ASSD that last at least for 7 days. For a given unemployment spell we figure out information about the last and next (if there is one) employment spell. For the relevant employer-employee relation before and after unemployment, we obtain the following variables: exact date of termination and start of the relation, average daily wage (yearly contribution to the social security system divided by the number of working days), geographic location (municipality-level[5]), industry affiliation of the employer. For the individual we know the month of birth and gender and we can calculate tenure on either job, experience, sickness, occupation (blue/white collar). The two variables age and experience allow us to calculate the potential benefit duration for UI benefits. Knowing this duration, we are able to distinguish between time of UI and (potential) UA receipt for each unemployment spell. For each unemployment spell we know the exact duration on days. Futhermore, the data allow us to calculate the non-employment duration. This is the number of days between the succeding and the previous job. The ASSD data allow us to determine the basis on which benefit are calculated which is typically different from the previous wage. We can identify the unemployment spells form the ASSD data in the unemployment register. From the unemployment register, we obtain the municipality of residence, the UI and UA benefit level, education and information on the family situation. The third data set, road

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[4]See Zweimüller *et al.* (2009) for a detailed description of the data set.
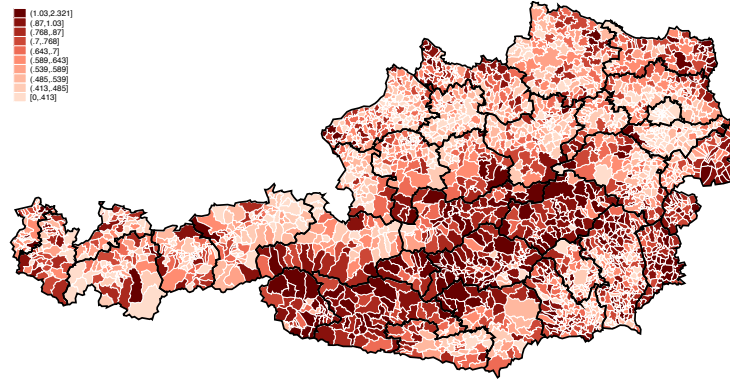[5]There were 2376 municipalities in the year 2014.

Figure 3: Average Commuting Time by Residency

trip planning data from the year 2000, contains for each municipality time and distance in kilometers to each other municipality. This distance is measured between the centroids of the municipalities. Hence, for each unemployed individual we can calculate previous and succeding distance to the workplace.[6] We can obtain additional information from our data sources.

We make several restriction on the overall data set. First, we focus on unemployment spells starting between January 1995 and December 2004. The main reason to start after 1994 is to avoid interactions with a major change in the unemployment system for certain individual that extended the potential benefit duration substantially[7]. Second, we include individuals aged 20 to 54 at the start of unemployment. We do not want to include older individuals to avoid interactions between unemplyoment and early retirement which are strong in Autria as assessed in Inderbitzin *et al.* (2013). Third, we exclude individuals with a commute of more than two hours prior to unemployment. These are most likely weekly commuters and may have a different search patterns relative to daily commuters which are of main interest in our study. Fourth, individuals that quit voluntarily[8] and those who return to the same employer are excluded. The particular data we use need two more restrictions. The average daily wage we are measuring confounds hours and the wage rate. This is a major problem for women but not for men. We focus on men because virtually all men work fulltime. The commuting time we measure is not door to door but municipality to municipality. This is a potential source of measurement error which may be particularly relevant in metropolitan aereas, where the actual commuting time is highly affected by the exact location of residences and workplaces. For this reason, we exclude the largest 6 cities in Austria, including Vienna, Graz, Linz, Salzburg, Innsbruck and Klagenfurt.

A first look at the structure of commuting in Austria is given in Figures 3 and 4. Figure 3 illustrates commuting time by place of residence. It is evident that individuals that live in mountaineous areas commute longer. Those that live in flatter areas (north east) or valleys (west) experience shorter commutes. Hence, workers do trade-off distances with amenities (e.g. living on the countryside). If we draw the same picture not by municipality of residence but municipality of work (Figure 4), we do not see such a clear geographical pattern: for each workplace, there is a more balanced distribution of commute time and we do not find strong evidence of concentration in space of larger commute times by workplace.

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[6]Note that our data contains information on plant location. People who work in headquarters of firms are not in our data as their municipality code is missing.

[7]See Lalive and Zweimueller (2004) for an analysis of this reform.

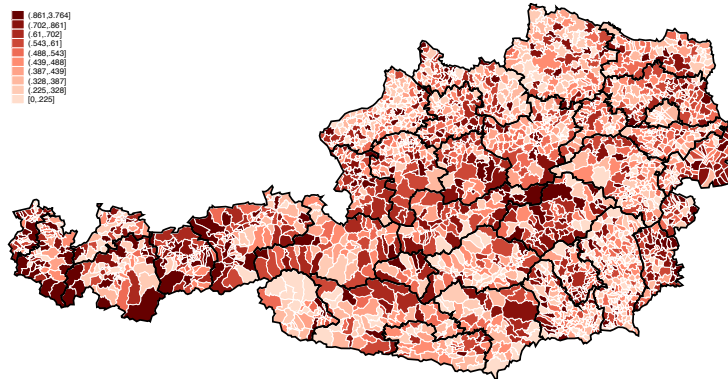[8]Identified through a waiting period of 28 days.

Figure 4: Average Commuting Time by Workplace

Our data set only contains individuals that live and work in Austria. Hence we do miss commuter across national borders. Official statistics suggest that we do not miss out many cases. From the census 2001, there are 3.6 millions individuals listed as employed of which 57,730 (1.59%) said they live in Austria but work abroad, mostly in Germany[9]. Conversely, the tax data authority indicate that of those that have to pay taxes in Austria, 5.8% live abroad and this latter number also includes individuals temporarily living abroad.

3.3   Some stylized facts on wage and commute changes

We report in Table 2 the full summary statistics for the full sample (104,789 spells). We also split these statistics for each of the four possible outcomes (where $w+$, $w-$, $d+$, $d-$ represent respectively workers experiencing a transition from a lower to a higher paid job $(w+)$, workers experiencing a transition from a higher to a lower paid job $(w-)$, workers experiencing a transition from a closer job to a job further away $(d+)$, and finally workers experiencing a transition from a job further away to a closer job $(d-)$, which here, includes also workers who find a job at the same distance denoted hereafter by d_0: conditional on changes, there is a 14% mass of people remaining in the same city before and after a transition through unemployment).

Workers, on average, spend 22 weeks in non-employment, those who find a better wage at a larger commute distance spend 18.88 weeks unemployed (column 2), those even getting closer at a higher wage spend 17.5 weeks unemployed (column 3); instead, those facing wage cut spend 24.7 weeks unemployed if they experience a distance increase (column 4); and 22.67 weeks unemployed if they get closer to their city of residence (column 5). The number of weeks in registered unemployment is smaller (row 2), around 14 to 17 weeks. We also calculate the potential benefit duration, which is around 32 weeks (row 3). The average replacement rate is around 34% for unemployment benefits in the unemployment regime (UI, row 5). A feature of the data is to also provide the amount under an assistance regime (UA), which we will introduce in the next Section to enrich the model). Row 6 gives the mean replacement rate including zeros (that is, for workers eligible to the regular unemployment insurance regime) and row 7 gives the mean replacement rate for workers under the UA regime. The replacement rate of the UA regime is close, and sometimes even larger, than the UI regime, but the population sampled is different - UI is populated by higher wage

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[9]In 2013Q3 there were only 8,119 Austrians who crossed the border at least once a week to work in Switzerland. In 2002Q3 there were 6,985.

workers.

Wage and commute time differences are also quite interesting. Previous daily wage is 59.33 euros (full sample); the next wage is 57.71 after exiting non-employment. For those getting a higher wage, the new wage is 66 or 64 euros (depending on the distance change); for wage losers, instead, the mean wage is around 50 euros. Previous commute time is .46 of an hour (that is 0.46x60=27.6 minutes one way). Commute time after is 0.67 of an hour, that is 40mn. On average those who commute more now commute around an hour; those who commute less commute 0.288 (resp. 0.273) of an hour, that is 17 minutes.

Table 2: Summary Statistics

	Full Sample Mean (Std.Dev.)	w+d+ Mean (Std.Dev.)	w+d- Mean (Std.Dev.)	w-d+ Mean (Std.Dev.)	w-d- Mean (Std.Dev.)
Non-empl [weeks]	22.07 (34.03)	18.88 (28.28)	17.5 (25.24)	24.73 (34.94)	22.67 (31.87)
Unempl [weeks]	15.91 (20.31)	13.96 (17.39)	13.33 (16.44)	17.92 (22.45)	17.08 (21.29)
PBD [weeks]	32.26 (6.1)	31.77 (5.71)	32.07 (6.1)	32.38 (6.06)	32.68 (6.41)
RR UI benefits (B)	0.3439 (0.1621)	0.3803 (0.1752)	0.3768 (0.1796)	0.3115 (0.137)	0.311 (0.1399)
RR UA (overall)	0.015 (0.076)	0.015 (0.079)	0.015 (0.08)	0.014 (0.07)	0.015 (0.072)
RR UA (eligible) (b)	0.346 (0.139)	0.39 (0.151)	0.388 (0.153)	0.311 (0.117)	0.317 (0.12)
Altitude [100m]	4.83 (2.56)	4.94 (2.51)	4.83 (2.66)	4.71 (2.34)	4.74 (2.63)
Time to Next Large City	30.73 (25.75)	33.42 (25.22)	29.38 (26.4)	30.95 (24.4)	28.5 (26.31)
Wage Before ([Euro], w_{-1})	59.33 (20.25)	51.55 (13.76)	51.67 (14.36)	66.54 (23.84)	66.05 (20.54)
Wage After (w^+, w^-)	57.71 (18.16)	66.13 (18.22)	64.82 (17.85)	50.69 (14.71)	50.13 (15.16)
Change Wage	-1.452 (22.435)	14.577 (14.151)	13.148 (13.153)	-15.849 (21.04)	-15.922 (17.486)
Commuting before ([hrs], d^m)	0.46 (0.414)	0.343 (0.35)	0.577 (0.44)	0.34 (0.343)	0.58 (0.441)
Commuting after ([hrs], d^+, d^-)	0.668 (0.828)	1.094 (1.007)	0.288 (0.324)	1.04 (0.964)	0.273 (0.317)
Change Commuting	0.21 (0.86)	0.75 (0.94)	-0.29 (0.34)	0.7 (0.9)	-0.31 (0.36)
Numb. Children	1.097 (0.66)	1.082 (0.632)	1.081 (0.629)	1.103 (0.675)	1.104 (0.689)
Married	0.3934	0.3636	0.3851	0.4034	0.4159
White Collar	0.117 (0.321)	0.106 (0.308)	0.118 (0.323)	0.099 (0.298)	0.119 (0.324)
Exp 0-1.99y [Y]	1.6929 (0.3268)	1.6711 (0.3327)	1.663 (0.3285)	1.7261 (0.3201)	1.7022 (0.3237)
Exp 2-4.99y [Y]	2.497	2.476	2.461	2.525	2.509
Exp 5-9.99y [Y]	3.4433	3.2847	3.3499	3.4804	3.5452
Sector 1	0.033	0.034	0.039	0.025	0.034
Sector 2	0.727	0.727	0.688	0.757	0.732
Count	104789	24538	24031	24775	26777
Years	1995-2004				

Notes: The table reports means and standard deviations in parentheses. The column Full Sample reports individual characteristics of the base sample (5729 spells have no exit in the data). wPlus (wMinus) stands for an increase (decrease) in wages after UI relative to before. dPlus (dMinus) stands for an increase (decrease) in the commuting distance after UI relative to before. No change in wages is attributed to wPlus. No change in commuting distance is attributed to dMinus. The sample consists of men aged 20 to 54 who lost their job outside cities (Vienna, Graz, Linz, Salzburg, Innsbruck, Klagenfurt) in the years 1995 to 2004. Only men who are eligible to unemployment benefits and layoffs (i.e. no voluntary quits) are included. Men with a long commute (i.e. more than 2 hours) prior to unemployment are excluded. Non-employment is measured as time between two jobs over the turn of unemployment. Potential Benefit Duration (PBD) is the time from the loss of the job until the take-up of benefits plus the time the individual is entitled to claim benefits. Replacement Rate UA refers to unemployment assistance and measures how much of previous earnings is granted in this state, given the state is reached. Altitude is measured at the place of residence and refers to the parish hall within a village. Commuting distance is measured as time needed to travel from one geographical midpoint of a village to the respective other one. For the last employer before UI, we determine tenure, wages, occupation, geographical location and industry. Experience is measured net of previous experience. Source: ASSD.

We explore this further in reproducing the distribution of commute changes as the difference in minutes between the commuting time after unemployment minus the commuting time before unemployment. and of changes in the log wage. The dispersion is quite large and in relative terms, given that the mean commute time is about 30 minutes, it turns out that the typical dispersion is higher for commute distances.

We also report in Figure 5 the scatter plot of changes in log wages and commuting distance changes per unemployment status: we distinguish between individuals who find a new job while they are receiving unemployment benefits (black circles) and individuals that find a job only after they have exhausted unemploymet benefits and eventually receive unemployment assistance benefits (crosses). In both cases, the correlation appeares to be positive: higher changes in commute time are associated with larger wage gains while lower commute distances are typically associated with negative wage growth between the previous and the next job. This scatter plot is first evidence that time until a job is found matters: those finding a job under the UA regime face a lower net wage growth conditional on distance change or vice versa.
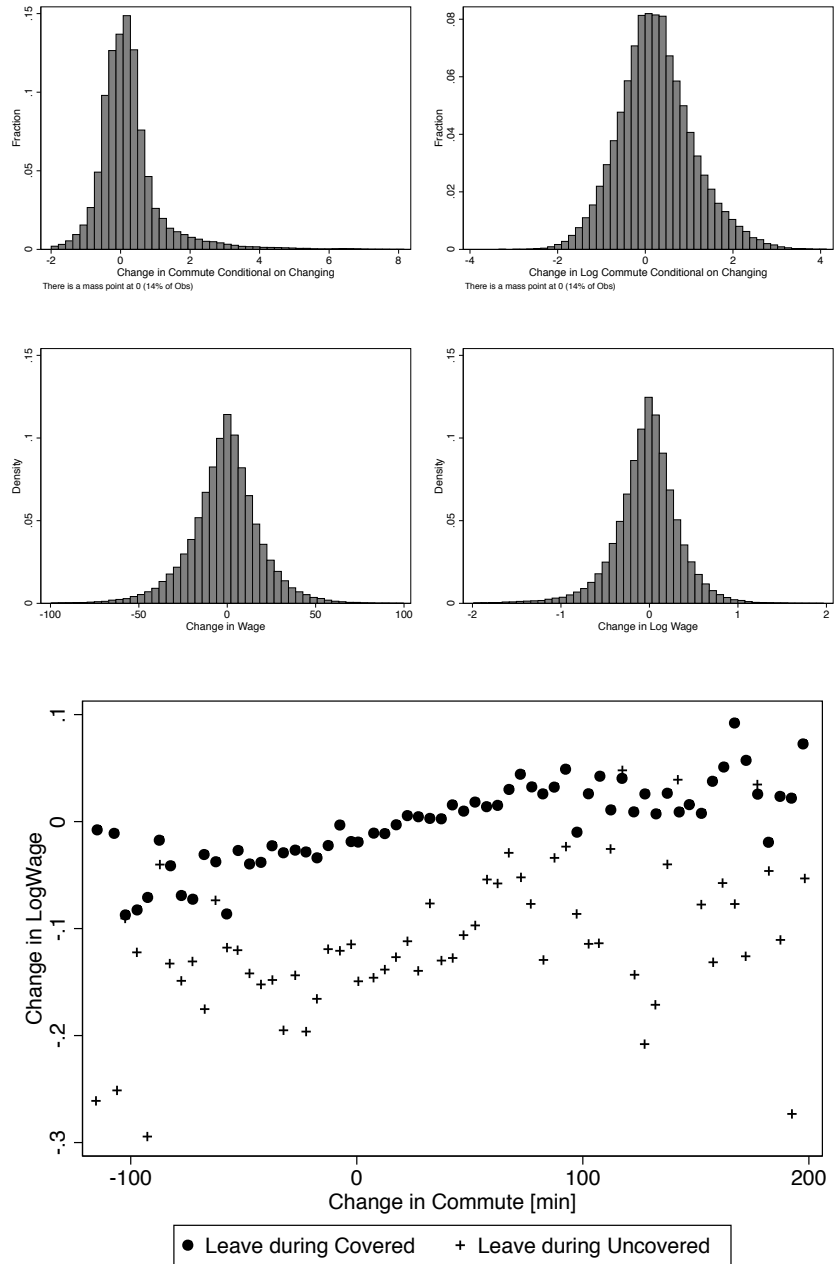
Figure 5: Changes in Commuting Time and Wage. Commute distances are measured in hours. Daily wages are measured in euros.

We finally report the conditional densities of the sample in the cross section of accepted jobs, in Figure 6.
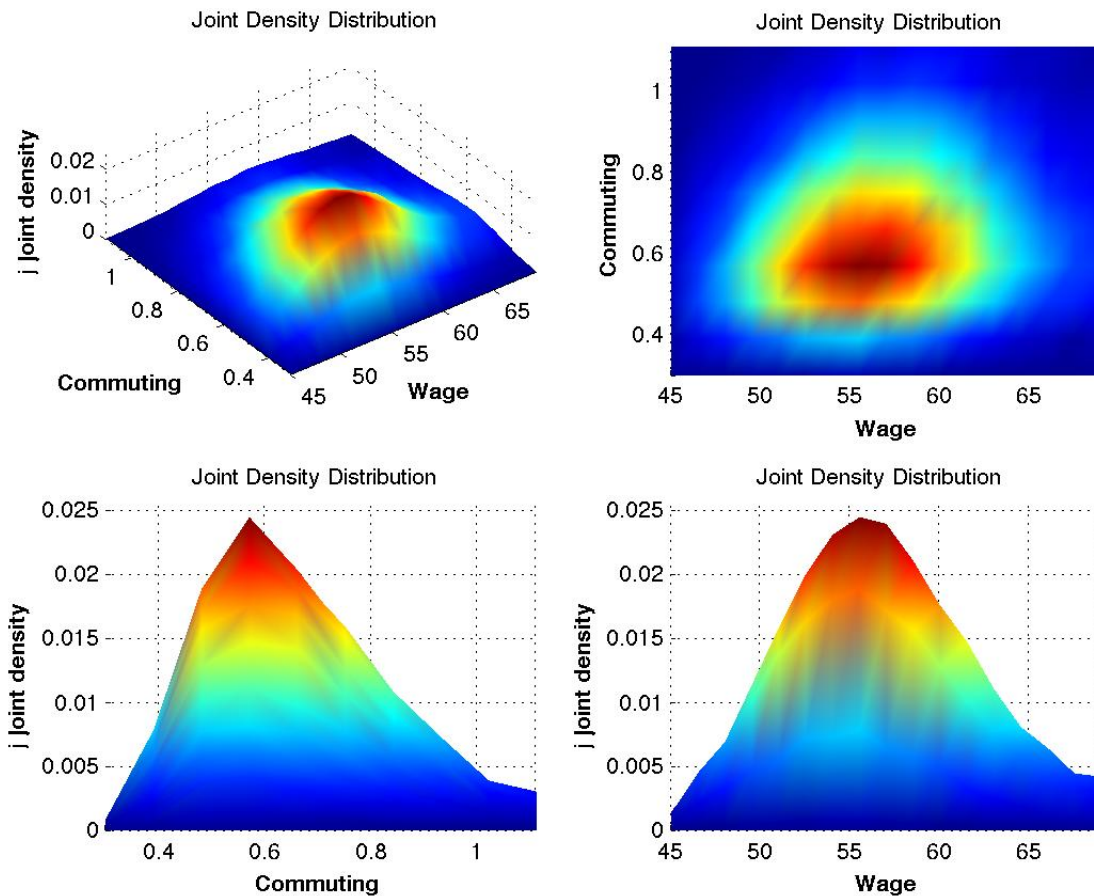
Figure 6: Joint Density Distributions. Commute distances are measured in hours. Weekly wages are measured in euros.

3.4 Empirical hazard rates

From now on, we separate out workers facing transitions at a larger distance $(d+)$, those staying in the same city (d_0) and finally those facing a decline in commute distance $(d-)$.

The results are presented in Figure 7; it displays the profile of the hazard rate for the non-employment duration in the data. People tend to wait a month or two before exiting from unemployment, the hazard rate reaches a maximum between two to six months before it declines continuosuly. Thus is true for overall exits (top chart) and for each of the destinations (middle and lower chart). As time elapses, it turns out that fewer and fewer people exit from unemployment in the two categories $(w+, d_0)$ relative to the other categories $(w-, d+, d-)$.

Figure 7: Empirical Hazard Rates by Exit State
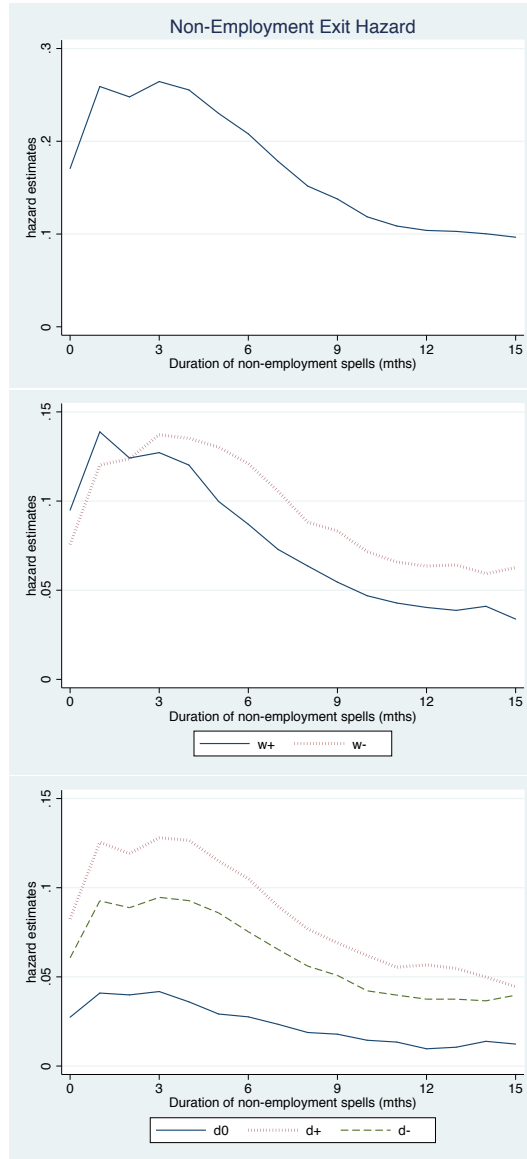
Notes: Figures report Kaplan-Meier estimates for the non-employment exit hazard. w stands for wage, d stands for commuting distance, + stands for increase compared to pre-unemployment, - stands for decrease to pre-unemployment. d_0 indicates there thre is no change in distance. Source: ASSD, own calculations, all cities excluding the six biggest cities

3.5   A competing risks analysis and some intepretations of the data

We can now establish a few stylized facts related to the "competing risks", to assess how the different exits relate to each other over time. For this we build *relative* hazard rates. For instance, we calculate the relative hazard of wages by dividing the hazard estimate for $w-$ by the hazard estimate for $w+$: this tells us, how the relative probability to end up in relatively worse jobs behaves over time. The same can be done with distances. The relative hazards are illustrated in Figure 8. Each plot includes the unconditional relative hazard ratios (black lines in the graphs), as well as the hazard ratio after controlling for a bunch

of observable characteristics (red solid line), that is, a prediction from a Cox-Estimation where we control for a variety of observed characteristics presented in Table 2. The black dashed lines are the corresponding 95% confidence interval.

The upper left figure relates exits in worse paid jobs to exits in better paid jobs. As expected, the relative likelihood that individuals leave into worse paid jobs increases with the duration of non-employment. This is evidence that reservation wages are declining over time, consistent with job search theory when workers loose eligibility.

The remaining three plots deal with changes in the commuting distance. The upper right graph relates exits into jobs farther away to jobs that are closer to home. Both, the unconditional and the conditional relative hazards are almost flat. This implies that the succeding job can be either closer or farther away from home. This ratio is 1.5 and stable over time meaning that there is a larger fraction of distance losers (d+). This may come at as a surprise, since one would have perhaps expected, parallel to the decline in the reservation wage over time, that workers could have faced an increase in their reservation distance. This does not seem to be the case, but for a reason that is not the insentivity of the distance margin, but rather due to an aggregation issue.

Indeed, as the lower part of the figure indicate, dividing the hazard ratios by the hazard ratio of the 14% of the individuals in our sample that do not change the commuting distance and find a job in the old workplace, we obtain instead quite strong trends. The lower left graph relates exits to farther away jobs to exits into jobs at the same distance. Overall, there is a larger portion of unemployed individuals finding a new job farther away than staying in the same city. The proportion of "distance losers" $(d+)$ relative to stayers (d_0) goes *up* over time. It is relatively more likely to find a job in the same place at the beginning of the non-employment duration than towards the end of the non-employment duration. For workers experiencing such a move to a more distant city, this is indeed a change upward of the reservation distance strategy, that may be explained by a decline in the unemployment insurance.

However, we also find a positive trends in time for the "distance winners" $(d-)$ relative to stayers (d_0): it is indeed relatively more likely to find a job in the same place at the beginning of the non-employment duration than to move closer to a job. This suggests that workers tend to search first for jobs closer to their previous workplace. As time goes however, some workers give in and get closer, possibly sacrificing on wages. An interpretation, in line with the discussion on credit contraints, is that as time goes, workers are more and more liquidity constrained and have to reduce the range of search.

Finally, the fact that the old workplace is a relevant margin for job search especially in the beginning of the unemployment spell is not known and can be explained as follows: It is either the case that relevant jobs are concentrated in the place where job seekers used to work (Kline and Moretti, 2014). Another explanation would be that unemployed workers have more information about the old workplace e.g. through informal search channels. Both explanations can be true simultaneously and would produce the same observable consequences. We have explored these explanations by conducting the same analysis for workers who work in gegraphically clustered industries as opposed to workers who work in gegraphically unifromly distributed industries. We obtain similar results for both types of industries suggesting that the information channel is important.

3.6 The impact of unemployment benefits on hazard rates: evidence of moral hazard in aggregate

We now estimate a basic Cox-model of the hazard rates, treating unemployment benefits as exogenous. The level of unemployment benefits is determined by two things. First, previous earnings serve as a base

Figure 8: Relative conditional hazard rates
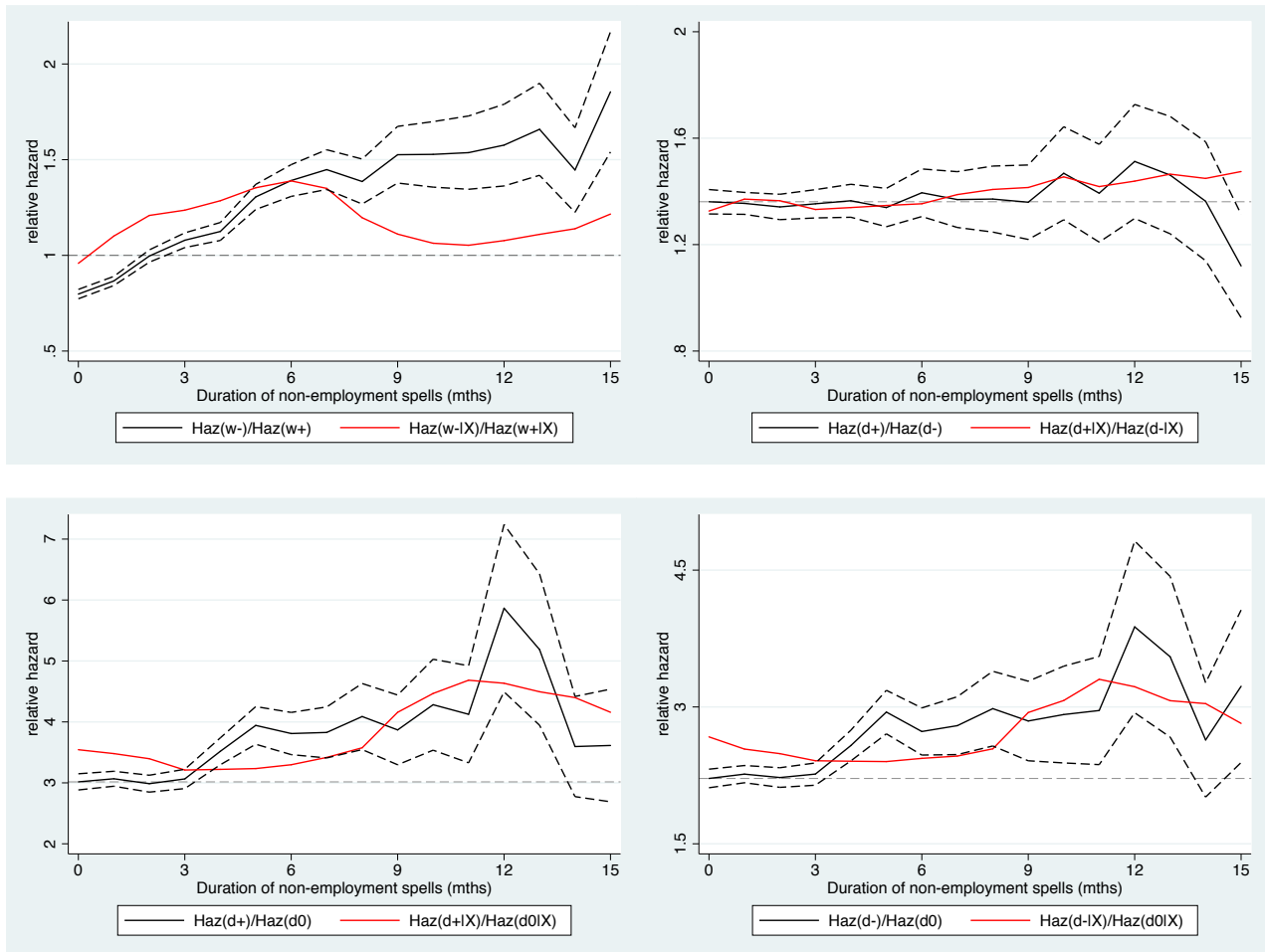
to calculate unemployment benefits. Second, and as is explained in detail in Card *et al.* (2012) the benefit schedule exhibits two kinks, one at the bottom and another at the top. Conditional on previous earnings and other observables, the remaining variation in unemployment benefits mainly stems from the presence of the kinks. If individuals cannot manipulate previous earnings to shift themselves beyond one of the kinks, the variation in unemployment benefits generated by the kink can be assumed to be exogenous. Importantly, the earnings that constitute the benefit base are not necessarily the ones where the job was lost. The relevant earnings to determine unemployment benefits are either from the previous year or the even the year before that depending on when the individual starts claiming unemployment benefits. Hence, it is hardly possible to manipulate the relevant previous earnings that ultimately determine the level of unemployment benefits. Similar reasoning holds for the potential duration of unemployment benefits (PBD). PBD depends on previous work experience and age with discontinuous changes after several work experience thresholds, and two age thresholds (40 years and 50 years). Our strategy to exploit those change is to add flexible functions of previous work experience and age into the Cox-regressions. This ensures that our PBD effects are identified from the age and previous work experience discontinuities in PBD. We are not aware of a quasi-experimental design for unemployment assistance. We use the observed level of unemployment assistance conditioning on some potential determinants of unemployment assistance receipt (marital status, previous wage).

Table 3 displays the effects of the level of benefits from unemployment insurance B and of assistance benefits b on hazard rates. Column 1 displays the results while controling for the effect of benefits under the UI regime (B) and potential benefit duration (PBD). The sign is strongly negative on the hazard rate. The effect of potential benefit duration is also negative and significant. Being close to a large city improves the success of job search. The previous wage has a negative effect, presumably due to higher wage expectations leading to a higher reservation wage. The regressions include a number of other factors, including tenure profiles, marital status and family composition, as well as provincial dummies (NUTS3), industry dummies and year effects.

The second column introduces further the value of unemployment assistance (b) for those having exhausted their UI rights. Hence, each variable B or b is multiplied in the regressions by a dummy indicator for being either in the UI or UA regime. As well as B, the level of b reduces the hazard rate, although by a lower coefficient. The effect of PBD is still negative but less so. Next, for all sub-hazards displayed in columns 3 to 7, the effects of B and b are negative, and larger for hazards rates towards lower wage jobs. The effect of benefits on jobs with a larger distance is actually more negative than for jobs with a smaller distance. The effect of B is largely negative for the hazard rate of city stayers, while the effect of assistance on that hazard rate is not significant.

Separating the hazards into six categories to control for the joint wage/distance change as in Table 4 shows also very strong and negative effects of both B and b. Interestingly, the coefficient of B is more negative for wage losers than for wage gainers; and it is more negative for $(w-, d+)$, those who loose on the two dimensions, wage and distance than for $(w-, d-)$: it is -2.318 in the former against -2.195 in the latter. The coefficient on $(w-, d_0)$ is -2.263, that is in between the two former coefficients. Interestingly, the same is true for the effect of assistance levels b: the coefficient is -0.594 for the $(w-, d+)$ hazard ratios, -0.440 for the $(w-, d-)$ hazard ratios and -0.368 for the $(w-, d_0)$ hazard ratios.

These results are consistent with some liquidity constraints among job seekers in Austria. Indeed, job seekers have a high risk of earning an income that is below the poverty line. Whereas this risk is 14% in the total population, poverty risk is 45% for job seekers who have been unemployed for 5-11 months, and 46% for the long-term unemployed (Statistics Austria, 2013).

Table 3: Cox-model Estimates, hazard rates, all destinations, by wage change and by commute distance change

	(all)	(all)	(w+)	(w-)	(d+)	(d-)	(d0)
B	-0.776***	-0.757***	-0.707***	-2.266***	-0.680***	-0.742***	-1.010***
	(0.038)	(0.032)	(0.043)	(0.055)	(0.046)	(0.050)	(0.075)
b		-0.277***	-0.453***	-0.508***	-0.303***	-0.272***	-0.166
		(0.043)	(0.064)	(0.056)	(0.060)	(0.069)	(0.121)
PBD [weeks]	-0.003***	-0.001*	-0.002	0.002*	-0.004***	-0.001	0.005**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Nuts3 FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spells	104,885	104,885	104,885	104,885	104,885	104,885	104,885
Individuals	81,637	81,637	81,637	81,637	81,637	81,637	81,637
Log L	-1056275	-1056245	-511385	-536979	-518069	-379592	-155120

Notes: Duration variable is nonemployment in months. Estimates refer to coefficients. Control Variables: Potential Benefit Duration, Netwage used for calculation of replacement rate. Experience in the last two, five and ten years (5 is net of 2 and 10 net of 5 years), altitude of the municipality of residence, time to the next large city, age in years, real wage and occupation of the last job before unemployment, marital status and number of children. Voluntary quits and recalls are excluded, only Replacement Rates weakly below 1 and potential benefit durations above 0 are considered. Standard errors are clustered on individual level. Significance is indicated as follows: * (p<0.05), ** (p<0.01), *** (p<0.001)

3.7 Evidence of moral hazard in the top of the wage distribution and of liquidity constraints in the bottom of the wage distribution

Finally, to look for evidence of either moral hazard or liquidity constraints, we split, in Table 5, by previous wage (L meaning below the median wage and H meaning above the median wage). The results provide additional interesting intuitions. For instance, among wage "winners", "distance losers" $(w+, d+)$, unemployment benefits B have a stronger negative impact on the hazard rates for high wage workers than for low wage workers. This is evidence that benefits discourage workers from accepting longer commutes when their initial wage put them away from liquidity constraints. The same is true for wage winners, distance winners $(w+, d-)$: the negative effect of B is larger for the high wage workers. This can be interpreted as evidence of moral hazard in the top of the wage distribution.

As regards to wage losers, the opposite is true: for instance, the negative coefficient of B is larger for $(w-, d+)$ for low wage earners than for high wage earners. This is also true for those accepting a wage cut while reducing distance: the coefficient is more negative for low wage earners. This is consistent with the existence of liquidity constraints in the bottom of the wage distribution: benefits B, and also assistance levels b, reduce the likelihood of a reduction of the range of search (lower d) while accepting wage cuts because of a more restricted search area. These findings suggest that the intuition of Lemmas 3 and 5 in the previous Section, the role of liquidity constraints, may be interesting to incorporate in the model.

Table 4: Cox-Model Estimates, sub-hazards

	(w+d+)	(w-d+)	(w+d-)	(w-d-)	(w+d0)	(w-d0)
Benefits	-0.631***	-2.318***	-0.710***	-2.195***	-0.918***	-2.263***
	(0.059)	(0.065)	(0.068)	(0.069)	(0.101)	(0.096)
Assistance	-0.424***	-0.594***	-0.538***	-0.440***	-0.323*	-0.368**
	(0.089)	(0.078)	(0.105)	(0.088)	(0.186)	(0.152)
PBD [weeks]	-0.003*	-0.001	-0.002	0.003	0.003	0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Nuts3 FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Spells	104,885	104,885	104,885	104,885	104,885	104,885
Individuals	81,637	81,637	81,637	81,637	81,637	81,637
Log L	-257208	-256717	-178077	-198600	-74366	-79796

Notes: Duration variable is nonemployment in months. Estimates refer to coefficients. Control Variables: Potential Benefit Duration, Netwage used for calculation of replacement rate. Experience in the last two, five and ten years (5 is net of 2 and 10 net of 5 years), altitude of the municipality of residence, time to the next large city, age in years, real wage and occupation of the last job before unemployment, marital status and number of children. Voluntary quits and recalls are excluded, only Replacement Rates weakly below 1 and potential benefit durations above 0 are considered. Standard errors are clustered on individual level. Significance is indicated as follows: * (p<0.05), ** (p<0.01), *** (p<0.001)

4 Towards a calibrated model of job search in Austria

The model can now be extended to take stock of these finding. It adds several dimensions to the previous analysis in Section 2. In particular, it tries to account:

1. for the particular role of the the local dimension of job search, and the particular role of the previous workplace that seems to be more central in the Austrian case;

2. it also extends the model to the existence of two unemployment compensation profiles, insurance and assistance;

3. it finally introduces liquidity constraints for the unemployed under assistance (as in Lemma 3 in Section 2);

4.1 First extension: introducing two levels of unemployment compensation

We assume that there are now two levels of benefits: B (insurance) and b (assistance). Workers switch randomly from B to b with Poisson rate α. The value of unemployment depends on the eligibility status; let U_c and U be these values and ρ the commute distance. Let λ and λ_c be the arrival rates of job offers per unit of superficy, and first simplify the exposition in treating λ and λ_c as simple parameters: this will be a problem here given that the optimal values of λ being easily calculated since the decision in λ is easily derived once D has been chosen as already shown in Section 2.

We also assume that the financial constraint of the unemployed gets more severe as time goes. However, instead of assuming that agents can accumulate and decumulate wealth, we make the simplifying assumption,

Table 5: Cox-Model Estimates, sub-hazards by previous wage (L: below median; H: above median)

Table 6: Cox-Model

	(w+d+ | L)	(w+d+ | H)	(w-d+ | L)	(w-d+ | H)	(w+d- | L)	(w+d- | H)	(w-d- | L)	(w-d- | H)	(w+d0 | L)	(w+d0 | H)	(w-d0 | L)	(w-d0 | H)
Benefits	-0.588***	-1.029***	-2.454***	-1.678***	-0.696***	-1.091***	-2.292***	-1.598***	-0.828***	-1.356***	-2.153***	-1.890***
	(0.069)	(0.114)	(0.077)	(0.101)	(0.077)	(0.141)	(0.082)	(0.118)	(0.127)	(0.179)	(0.126)	(0.156)
Assistance	-0.314***	-0.561***	-0.689***	-0.272**	-0.487***	-0.686***	-0.556***	-0.097	-0.115	-1.049***	-0.441**	-0.006
	(0.112)	(0.150)	(0.112)	(0.113)	(0.127)	(0.190)	(0.125)	(0.130)	(0.213)	(0.363)	(0.218)	(0.222)
PBD [weeks]	-0.001	-0.005*	-0.001	-0.001	-0.006**	0.005	-0.001	0.006**	0.005	0.002	0.005	0.012***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Nuts3 FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	60,301	61,924	60,301	61,924	60,301	61,924	60,301	61,924	60,301	61,924	60,301	61,924
Spells	104,885	104,885	104,885	104,885	104,885	104,885	104,885	104,885	104,885	104,885	104,885	104,885
Individuals	81637	81637	81637	81637	81637	81637	81637	81637	81637	81637	81637	81637
Log L	-137376	-102967	-102478	-137121	-100943	-65576	-83905	-101328	-35592	-33702	-30004	-44426

Notes: Duration variable is nonemployment in months. Estimates refer to coefficients. Control Variables: Potential Benefit Duration, Netwage used for calculation of replacement rate. Experience in the last two, five and ten years (5 is net of 2 and 10 net of 5 years), altitude of the municipality of residence, time to the next large city, age in years, real wage and occupation of the last job before unemployment, marital status and number of children. Voluntary quits and recalls are excluded, only Replacement Rates weakly below 1 and potential benefit durations above 0 are considered. Standard errors are clustered on individual level. Significance is indicated as follows: * (p<0.05), ** (p<0.01), *** (p<0.001)

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already discussed in Section 2.4, that individuals face a higher rate of discount after a Poisson shock; although in principle the loss of eligibility to unemployment insurance and the more difficult access to liquidity are distinct stochastic processes, we assume that they occur simultaneously, which simplifies the derivation of the model: it simply consist on specifying that the rate of access to credit of the covered unemployed workers r_c is lower than that of the uncovered workers denoted by r.

We do not restrict the draws (w, ρ) in the distribution to be independent. With notations $F_\rho(w)$ and $G(\rho)$ for the associated cumulated distributions of each variable separately, we can go one step furher. We also assume that search efforts dimensions (here D only) and consumption to be non-separable, with an interaction term proportional to parameters δ and δ_c which capture the non separability; δ (δ_c) positive (negative) means that the disutility of distance is lower (higher) for higher income recipients.

In this case, the Bellman equations can be rewritten as:

$$r_c U_c(D) = B - c(D) + \delta_c D_c B + 2\pi\lambda_c \int_0^D \left(\int_w Max[W(w,\rho) - U_c; 0] dF_\rho(w) \right) dG(\rho) + \alpha(U - U_c) \quad (7)$$

$$rU(D) = b - c(D) + \delta Db + 2\pi\lambda \int_0^D \left(\int_w Max[W(w,\rho) - U; 0] dF_\rho(w) \right) dG(\rho) \quad (8)$$

The value functions for employment are, under the assumption that the employed workers have the same easy access to credit and saving plans than the covered unemployed:

$$r_c W(w, \rho) = w - c(\tau\rho) + \delta(\tau\rho)w + s(U_c - W(w,\rho)) \quad (9)$$

where $c(\tau\rho)$ is the commute cost for employees. The presence of τ captures the possibility that search and commuting distance may affect disutility differently. Equation 9 similarly applies to covered workers.

The solutions proceed from the previous analysis, except that $\frac{\partial W}{\partial w}(w, \rho) = \frac{1}{r_c+s}(1 + \delta\tau\rho)$; $\frac{\partial W}{\partial \rho}(w, \rho) = \frac{1}{r_c+s}(-c'(\tau\rho)\tau + \delta\tau w)$ so that, denoting by $R_c(\rho)$ the reservation wage of an eligible worker associated with distance ρ, defined as $W(R_c(\rho), \rho) = U_c(D_c^*) = U_c$ (for simplicity we drop the optimal strategy D_c^*) and by $R(\rho)$ the reservation wage of an uneligible worker associated with distance ρ, defined as $W(R(\rho), \rho) = U(D^*) = U$, we can rewrite the value of employment as a linear function of w:

$$W(w, \rho) - U_c = \frac{1 + \delta_c\tau\rho}{r_c + s}(w - R_c(\rho)) = S_c(w, \rho) \quad (10)$$

Similar steps lead to

$$W(w, \rho) - U = \frac{1 + \delta\tau\rho}{r_c + s}(w - R(\rho)) = S(w, \rho)$$

We can now derive the reservation wages:

$$R(\rho) = \frac{1}{1 + \delta\tau\rho}[c(\tau\rho) + r_c U + s(U - U_c)] \quad (11)$$

$$R_c(\rho) = \frac{1}{1 + \delta_c\tau\rho}[c(\tau\rho) + r_c U_c] \quad (12)$$

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From 11 and 12 we can compute the derivative of the reservation wage with respect to distance:

$$\frac{\partial R}{\partial \rho} = \frac{c'(\tau\rho)}{1+\delta\tau\rho} - \frac{\delta\tau}{(1+\delta\tau\rho)^2}\left[c(\tau\rho) + r_c U + s(U - U_c)\right] \tag{13}$$

Equation 13 shows that the reservation wage is a non linear function of commute distance. This slope should be compared to the slope of the empirical relationship displayed in the last panel of Figure 5. Our calibration ensures the positivity of the relationship.

Lemma 7. *Assuming $\delta = \delta_c$ and $r = r_c$, the reservation wage for a given distance is higher for eligible unemployed workers than for uneligible workers. The difference is in(de)creasing in commute distance if $\delta < (>)0$.*

$$R_c(\rho) - R(\rho) = \frac{r_c + s}{1+\delta\tau\rho}(U_c - U) > 0. \tag{14}$$

4.1.1 Optimal search strategies

The first order condition on the radius can now been derived. Let $w^{\max}$ be the upper support of the wage distribution. We have

$$rU(D) = b - C(D) + \delta Db + 2\pi\lambda\mathbb{E}_{w,\rho}S(w,\rho) \tag{15}$$

so that $U(D)$ is maximised with respect to the search strategy D when the marginal cost of searching at one more unit of distance is equal to the marginal gain, which depends on first the direct impact on the flow of offers (first term of the right handside) and second on the change of acceptable offers (second term of the right handside):

$$C'_D(D^*) - \delta b = 2\pi\lambda\mathbb{E}_w S(w, D^*)g(D^*) \tag{16}$$

where the second step is obtained from the value of employment in equation 9. Similarly, $U_c(D_c, \lambda_c)$ is maximised when:

$$C'_D(D_c^*) - \delta_c B = 2\pi\lambda_c\mathbb{E}_w S(w, D_c^*)g(D_c^*)g(D_c^*) \tag{17}$$

Similar expression as in Section 2 hold for the optimal search intensity λ and λ_c of covered unemployed workers

4.1.2 Reservation wage profiles under two unemployment regimes

We can grasp the main intuition by focusing on the simple case with separability between monetary income and distance and linear commute distance cost function. In this case, we already proved that reservation wages are linear in the commute distance and the marginal rate of substitution is constant, denoted by τ. In this case, the linearity comes from the fact that wages enter linearly in the utility function and that commute costs are linear in distance. It follows that the reservation frontier in wage and distance is linear, and can be represented as in Figure 9.

Figure 9: Reservation Frontier and Acceptance-Rejection Areas
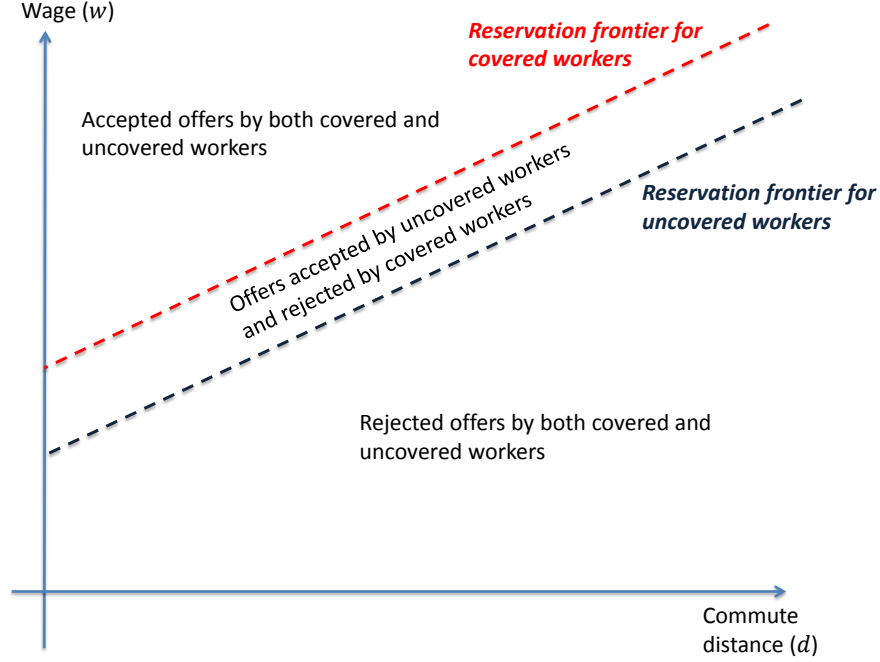
4.2 Directing search towards the previous city

The main insight of the previous empirical part is that workers seem to search first in the previous city more in the early times after job separation, and then extend their range of search. We want to give a theoretical counterpart to this complex job strategy. Assume now that workers can target explicitly, not only the range of search D but also the effort strategy λ differentially in space, contrary to what was assumed before. To keep things relatively simple, we assume that workers can distribute their search effort either in the previous city (with intensity of arrival of offers λ^0) or in any city within the range D (with intensity of arrival of offers λ) except the previous workplace. Because time is continuous in our setting, we define the previous workplace as a range of values centered on the mean of the distance distribution (d_0): the lower and the upper bounds of the range are denoted as d_{0-} and d_{0+}, respectively.

The optimal search strategy is therefore six-uple (D, D_c, λ^0, λ_c^0, λ, λ_c). The first order conditions for the optimal search radius stay as in the benchmark model (see eq. 16 and 17). The new first order conditions on optimal search intensity now read as follows:

$$C'_\lambda(D, \lambda, \lambda^0) = 2\pi \left[\int_0^{d_{0-}} \int_{R(\rho)}^{w^{\max}} \left[\frac{1 + \delta\tau\rho}{r + s} (w - R(\rho)) \right] dF_\rho(w) dG(\rho) \right.$$
$$\left. + \int_{d_{0-}}^{D} \int_{R(\rho)}^{w^{\max}} \left[\frac{1 + \delta\tau\rho}{r + s} (w - R(\rho)) \right] dF_\rho(w) dG(\rho) \right] \tag{18}$$

$$C'_{\lambda^0}(D, \lambda, \lambda^0) = 2\pi \int_{d_{0-}}^{d_{0+}} \int_{R(\rho)}^{w^{\max}} \left[\frac{1 + \delta\tau\rho}{r + s} (w - R(\rho)) \right] dF_\rho(w) dG(\rho) \tag{19}$$

The specification we will adopt for the cost functions is the following:

$$C(D, \lambda, \lambda^0) = \tau D + c^0 D^{\eta_c} + c^\lambda \left[\gamma^{\lambda^0} (\lambda^0)^{\eta_\lambda} + (\lambda)^{\eta_\lambda} \right]$$

$$C'_\lambda(D, \lambda, \lambda^0) = c^\lambda \eta_\lambda (\lambda)^{\eta_\lambda - 1}; \quad C'_{\lambda^0}(D, \lambda, \lambda^0) = c^\lambda \gamma^{\lambda^0} \eta_\lambda (\lambda^0)^{\eta_\lambda - 1};$$

As regards the part of the search cost which depends on distance (D), we assume that it is made by two components: the first one is a monetary component, and the second one is a convex function which represents agent's disutility from searching farther away from his residence. As discussed in Section 2.4, the monetary component of the search cost enters the agent's budget constraint. In this way we can study the case of binding liquidity constraints, which leads to sub-optimal choices of the radius of search. We assume $\gamma^{\lambda^0} < 1$ to indicate that the search efficiency is likely to be larger in the previous workplace, either for industry concentration or for existing social networks.

Furthermore, covered workers are assumed to be relatively more efficient in searching in the previous workplace ($\gamma_c^{\lambda^0} < \gamma^{\lambda^0}$): in absence of other dimensions of heterogeneity, the asymmetry in the search cost is needed to rationalize the empirical observations that covered workers exit unemployment more quickly and they are relatively more "city stayers". Moreover, there are several empirical reasons that may justify this choice: shorter non-employment spells are often associated with a richer human and social capital and are considered as a positive signal by potential employers.

4.3 Calibration parameters and summary of the main variables

As Figure 7 showed, the hazard rates decrease over time. This is something that the calibrated version of the model needs to capture. This may be due to several factors, some being in the model, some not being in the current version of the model. Let us list them all and then we will explain which one we did select.

The reasons are as follows: i) discouragement from job seekers as time goes - e.g time varying search costs; ii) lower quality of job offers due to the exhaustion of offers in the initial pool of search (e.g. the same city); iii) a stigma effect from being long-term unemployed and thus less efficient search as time goes; iv) more impatient workers over time, hence reducing their search effort; v) illiquid workers who cannot afford paying for the optimal search effort and who restrict their range of search; vi) finally, heterogeneity of workers and a composition effect in the pool, those less efficient dominate over time.

What we will assume here is consistent with all these explanations, to some degree. We will make use of the existence of two types of unemployed workers: the covered, and the uncovered workers. The covered workers face a relative higher efficiency of search in the same city, and the uncovered workers face instead a less efficient search effort; the covered unemployed face a lower rate of interest and are thus more patient and search ceteris paribus more; the uncovered, under assistance, face a higher rate of interest and search less. Hence, as time goes, we observe both a decline in the absolute hazard rate and, under adequate choice of the relative efficiency of search in the same city, a decrease over time of the hazard rate in the same city relative to the hazard rate outside the city. Let us denote by $N_c(t)$ and $N_{nc}(t)$ the number of covered and uncovered unemployed workers at time t for a given cohort entering unemployment at time $t = 0$. We have, for all $t > 0$:

$$dN_c/dt = -(haz_c + \alpha)N_c$$
$$dN_{nc}/dt = -haz N_{nc} + \alpha N_c$$

These first order partial differential equations are easy to solve. In particular, we have that:

$$N_c(t) = N_c(0)e^{-(haz_c+\alpha)t} \tag{20}$$

$$N_{nc}(t) = N_{nc}(0)e^{-haz.t} + \frac{\alpha e^{-haz.t}}{haz_c + \alpha - haz}N_c(0)\left(1 - e^{-(haz_c+\alpha-haz)t}\right) \tag{21}$$

where the both lines are obtained in fixing the integration constant to get the initial value at time $t = 0$ (entrance into the unemployment spell). Further, if all new entrants are covered, we have that $N_{nc}(0) = 0$. The two equations (20) and (21) determine the fractions of each of the four groups, that is, the covered and uncovered job seekers in the population of applicants.

We then choose the various parameters so as to replicate the qualitative results on hazards, relative hazards and sub-hazards as in Section 2. The full calibration is reported in Table 7. The rate of interest is set to 4% annually for the employed workers and for the covered unemployed workers (under UI), and at 12% for the uncovered workers (under UA). The discount in the search cost of prospecting in the same city is $\gamma_c^{\lambda^0}$=0.07 for covered workers, but that comparative advantage of the previous city decreases for the uncovered workers and that discount parameter goes to γ^{λ^0}=0.14 instead. Further details on the calibration strategy are relegated to the Appendix.

Table 8 reports the main equilibrium variables of the model. Table 9 reports the induced hazard rates, the odds ratios and the rejection rates, both for covered and uncovered workers. These numbers are sightly too small compared to the data but of the same order of magnitude. The simulated reservation frontier, the counterpart of the theoretical Figure 9, is instead represented in Figure 10: since we assume a negative $\delta = \delta_c$ and a linear cost function, the reservation frontier turns out to be convex . The blue and the red vertical lines represent the radius of search for uncovered and covered workers, respectively.

An outcome of the model is that covered workers ask for higher wages $(R_c > R)$[10], search closer $(D_c < D)$ and search more intensely $(\lambda_c > \lambda; \lambda_c^0 > \lambda^0)$. The higher search intensity of covered workers is due to their comparatevely higher efficiency, as stressed in the previous section. This allows them to exit unemployment more quickly $(haz_c > haz)$.

4.4 Search strategies, hazard and relative hazards as a function of non-employment spells

Figures 11 and 12 plot the results of the simulations. The model performs relatively well under different dimensions. First, we are able to replicate the decrease in the absolute hazard and in the sub-hazard rates (cfr. Figure 11). Second, we match the empirical result that share of workers exiting unemployment as wage loosers is increasing over time (cfr. the top left figure in the second part of Figure 11). Third, the model can account for the fact that agents are more likely to expand the radius of search the more time they spend into unemployment (second part of Figure 11, second panel). Fourth, agents exaust job offers inside the previous workplace as time goes.

All the mechanics of the model can be represented in Figure 12: as time goes, the reservation wage R goes down, the search radius D increases. This happens because covered workers search closer and are more picky regarding the wage. The right panel of Figure 12 however shows a new finding: a large part of the action here also comes from the changes over time of the hazard rate for the category of "city stayers" d_0,

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[10]More exactly, covered workers have a higher reservation frontier: their reservation wage is higher for any given commute distance. The figures reported in Table 8 are the reservation wages calculated at D.

Table 7: Calibration parameters, with mild liquidity constraints $(r > r_c)$

Parameter	Interpretation	Value	Notes
r	discount rate, uncovered	0.12	Annual
r_c	discount rate, covered	0.04	Annual
s	separation rate	0.004	Monthly
c^0	cost of search (distance)	5.00	
$c^\lambda = c_c^\lambda$	cost of search effort	80000.00	
η_c, η_λ	elasticity of the search effort cost	1.50	
γ^{λ^0}	cost of search in the same city, unc.	0.14	
$\gamma_c^{\lambda^0}$	cost of search in the same city, cov.	0.07	
$\delta = \delta_c$	complementarity between income and distance	-0.20	
Policy parameters			
B	unemployment insurance (covered)	20.59	35 % average w
b	unemployment benefit (uncovered)	1.76	3 % of average w
α	rate of switching from uneligibility to eligibility	0.20	1/PBD
τ	unit commuting cost	1.00	
Wage distribution $(F(w))$			
μ^F	mean wage uncovered workers	58.84	
σ^F	sd wage uncovered workers	18.90	
μ_c^F	mean wage covered workers	58.84	
σ_c^F	sd wage uncovered workers	18.90	
Distance distribution $(G(\rho))$			
Log-normal			
μ^G	mean distance uncovered workers	0.47	
σ^G	sd distance uncovered workers	0.47	
μ_c^G	mean distance covered workers	0.47	
σ_c^G	sd distance uncovered workers	0.47	

Figure 10: Simulated reservation frontiers.
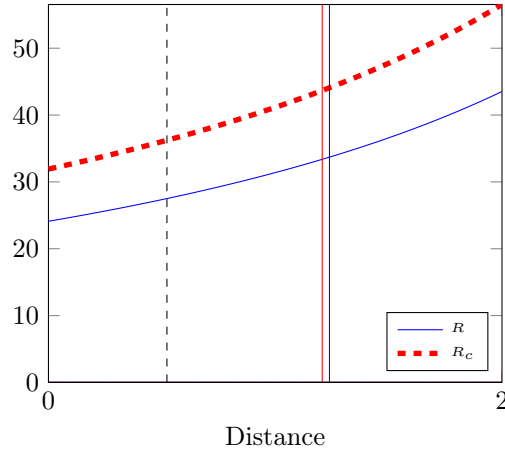
Notes: The vertical dashed line is the previous city (d^0); the vertical red (resp. blue) solid line is the optimal range of search of covered unemployed workers D_c^* (resp. of uncovered workers D^*)

Table 8: Main endogenous variables of the calibrated model with mild liquidity constraints ($r > r_c$)

Variable	Interpretation	Result
R	reservation wage uncovered workers	31.58
R_c	reservation wage covered workers	41.77
D	reservation distance uncovered workers	1.04
D_c	reservation distance covered workers	1.21
U	unemployment value uncovered workers	2619.39
U_c	unemployment value covered workers	3183.70
λ	search effort outside same city, uncovered workers	0.0081
λ_c	search effort outside same city, covered workers	0.0171
λ^0	search effort in the same city, uncovered workers	0.0052
λ_c^0	search effort in the same city, covered workers	0.0462
u_c	unemployment covered workers	0.012
u_{nc}	unemployment uncovered workers	0.056
u	total unemployment	0.068
Relative gaps (uncovered-covered)		
$\%\Delta R$	rel. gap reservation wage	-24.3992
$\%\Delta D$	rel. gap distance	-13.4311
$\%\Delta U$	rel. gap unemp. value	-17.7250

Table 9: Hazard rates and relative hazard rates, calibrated model with mild liquidity constraints ($r > r_c$)

Hazard rates		Covered	Uncovered
haz	total hazard	0.1085	0.0435
$haz(w+, d+)$	hazard(w+,d+)	0.0111	0.0046
$haz(w+, d-)$	hazard(w+,d-)	0.0280	0.0133
$haz(w+, d_0)$	hazard(w+,d_0)	0.0123	0.0014
$haz(w-, d+)$	hazard(w-,d+)	0.0123	0.0057
$haz(w-, d-)$	hazard(w-,d-)	0.0325	0.0169
$haz(w-, d_0)$	hazard(w-,d_0)	0.0136	0.0017
$haz_{decay} = 0.4$			
Relative hazard rates (4 exits)			
$relhazard^1$	haz(w+,d+)/haz(w+,d-)	0.41	0.58
$relhazard^2$	haz(w-,d+)/haz(w+,d-)	0.51	0.61
$relhazard^3$	haz(w-,d-)/haz(w+,d-)	1.27	1.14
Relative hazard rates (2 exits)			
$relhazard^1$	haz(w-)/haz(w+)	1.2623	1.1095
$relhazard^2$	haz(d+)/haz(d-)	0.3097	0.2558
Rejection rates			
rej	rejection rate (%)	0.27	1.14

that is people getting job offers in the same city where they used to work. This is an interesting finding, because it suggests that two spatial margins matter: a) the commute distance, based on search strategy D centered around the city of residence; b) the targeted search strategy λ but especially λ_0, that may temporarily be centered around the city of work.

5   Policy implications

The next stage is to describe the comparative statics of unemployment insurance for non liquidity-constrained agents; then we add liquidity constrained agents and we observe the difference in their search behaviour.

5.1   Comparative statics on B, b and α

5.1.1   Policy effects for non liquidity-constrained agents

The model is simulated for different values of the policy parameters. Let us focus on the solid lines in Figures 13 and 14, which refer to the benchmark simulation with mild liquidity constraints ($r > r_c$). They show the response of the main results of the model to a variation of the policy parameters, namely the unemployment insurance enjoyed by covered workers (B), the unemployment benefit enjoyed by workers who lost the insurance (b) and the switching rate α. The latter needs to be interpreted as the inverse of the potential benefit duration in the data.

Variation of B often have opposite effects on covered (on UI) and uncovered (on UA) workers. Increases in B make the covered workers choosier: they decrease their radius of search and their reservation wage increases. Furthermore, they reduce the search intensity both inside and outside the previous workplace. The joint effect is a reduction in the hazard rate for covered workers. On the contrary, we can observe a mild entitlement effect on uncovered workers, whereby we mean that future benefits B raise the value of re-employment and therefore the effort made by uncovered worke to find a job without the disincentive effect of B since they actually do not get them. The result of a larger B on uncovered workers is therefore that D increases as long as the search effort, while R decreases. As a result, uncovered workers are more likely to exit unemployment. Changes in b makes both types of workers choosier, leading to a reduction of the hazard rate for both types of searchers. Similar considerations applies to the effect of α: as the benefit duration is extended (lower α), covered workers becomes pickier. Conversely, the entitlement effect pushes uncovered workers to accept lower wages and to commute more.

Finally, Table 10 summarizes the elasticities of the main variables w.r.t. different parameters of the model.

5.1.2   Policy effects for liquidity-constrained agents

Dotted lines in Figures 13 and 14 represent policy simulations under a calibration that implies strict liquidity constraints for uncovered workers ($D = \bar{D}(b)$) . Covered workers turn out not to be constrained because the unemployment insurance they are entitled to is substantially higher than assistance. The results are especially interesting for policy changes affecting unemployment assistance (b). For low values of b, uncovered agents are liquidity constrained: this implies a sub-optimally low search radius and hazard rate. Notice that the presence of liquidity constraints affect search strategies also at early stages of the unemployment spell, since agents take into account the possibility of switching to the uncovered state.

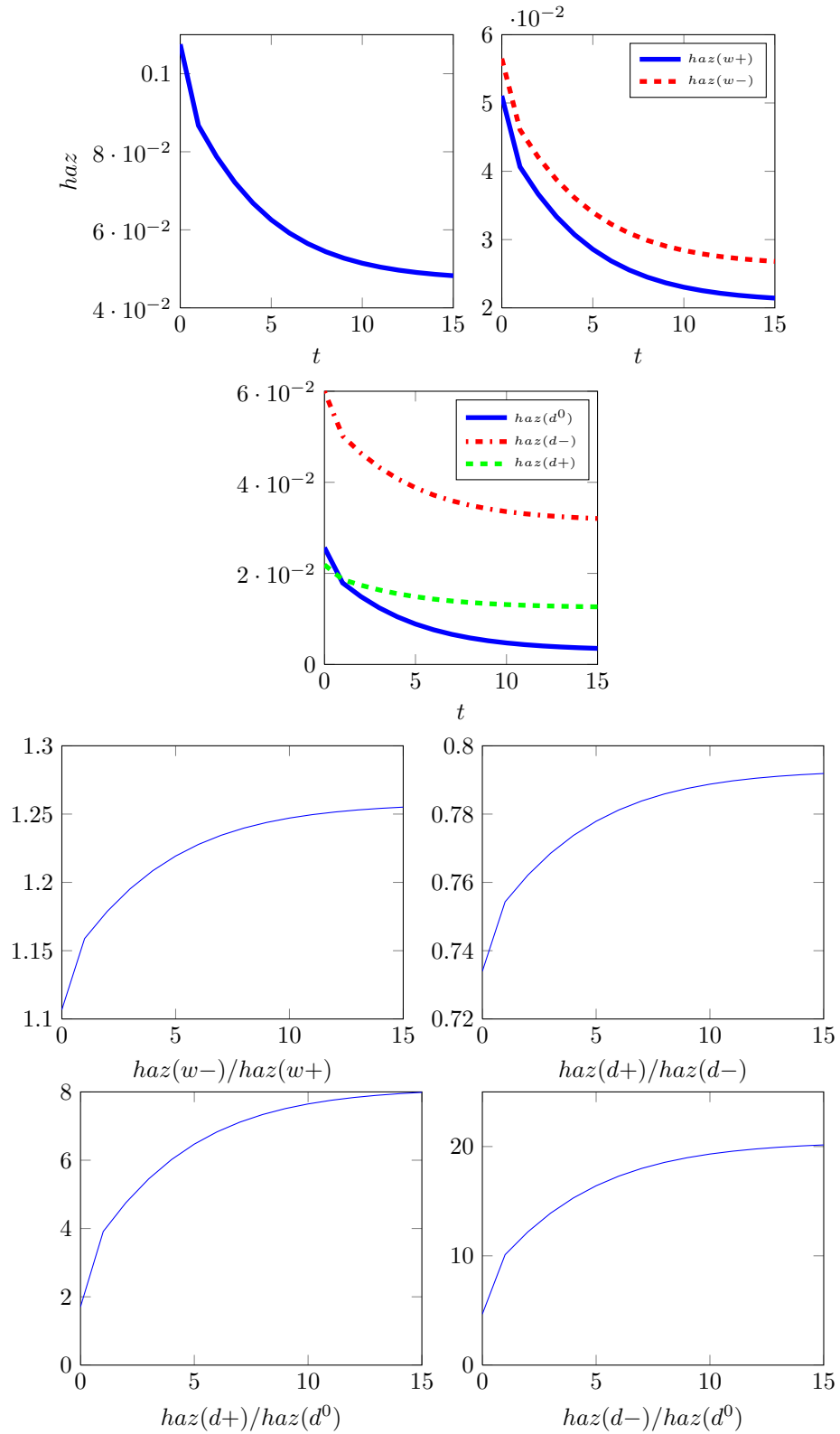Figure 11: Simulated hazard rates, with mild liquidity constraints $(r > r_c)$

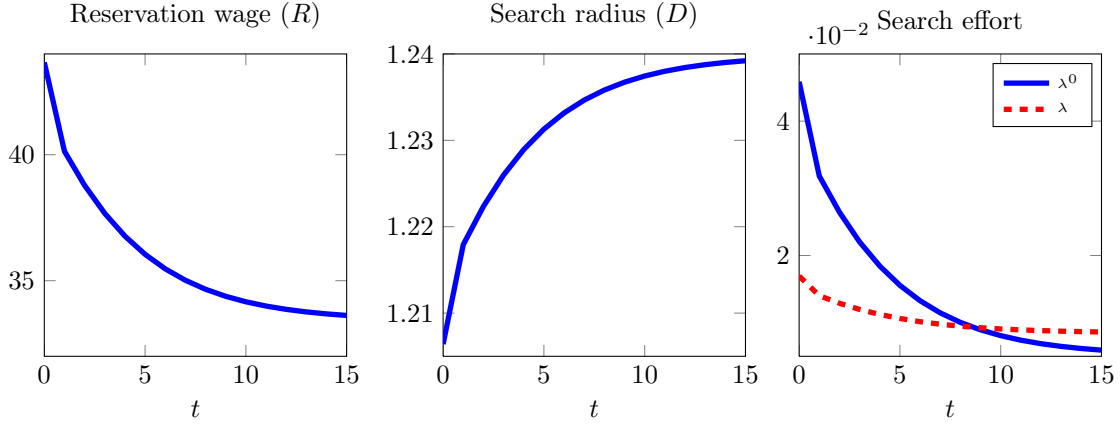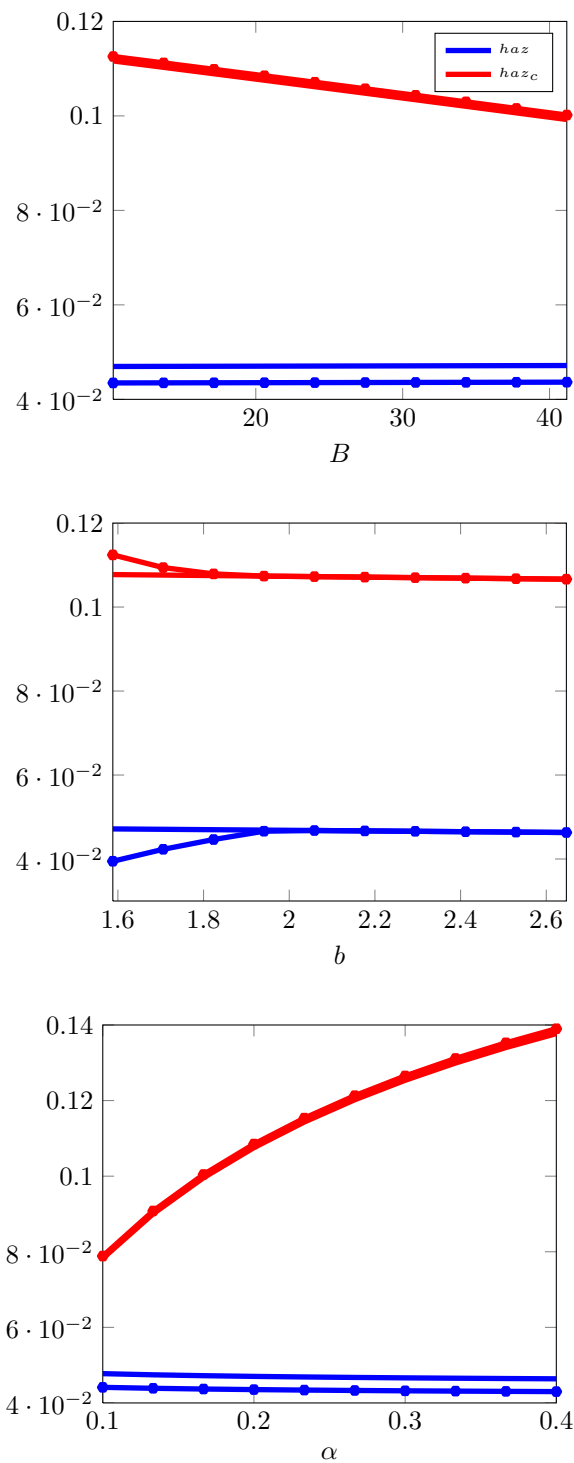Figure 12: Search strategies with mild liquidity constraints $(r > r_c)$

Table 10: Elasticities comparing the model in the absence and with liquidity constraints (for the workers under the UA regime)
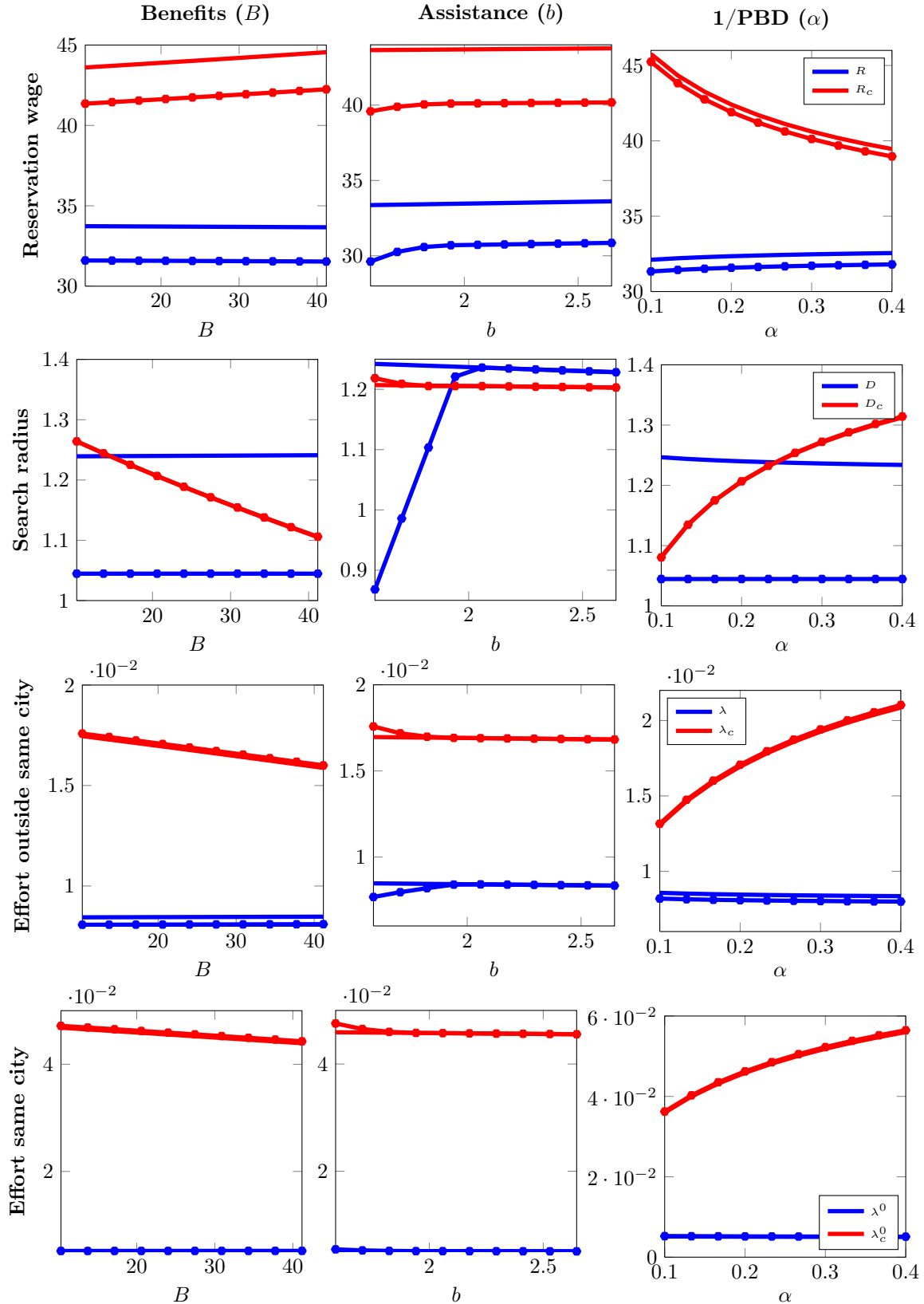
	Unconstrained			Liquidity constrained		
	B	b	α	B	b	α
D	0.00148	-0.01668	-0.01021	0.00000	0.62236	0.00000
D_c	-0.12562	-0.00501	0.21355	-0.12506	-0.01899	0.21631
R	-0.00197	0.01128	0.01377	-0.00211	0.06273	0.01496
R_c	0.02171	0.00413	-0.13784	0.02158	0.02236	-0.13877
λ	0.00375	-0.02344	-0.02564	0.00350	0.12871	-0.02426
λ_c	-0.09060	-0.01271	0.59611	-0.08988	-0.06462	0.59869
λ^0	0.00352	-0.01999	-0.02408	0.00370	-0.10314	-0.02561
λ_c^0	-0.06171	-0.01215	0.55674	-0.06106	-0.06352	0.55827
$hazard$	0.00419	-0.02726	-0.02860	0.00369	0.26019	-0.02556
$hazard_c$	-0.11099	-0.01532	0.76018	-0.11006	-0.07721	0.76264
rej	-0.01147	0.06222	0.08335	-0.01358	0.96889	0.10095
rej_c	0.03184	0.01313	-0.37227	0.03197	0.07609	-0.37652

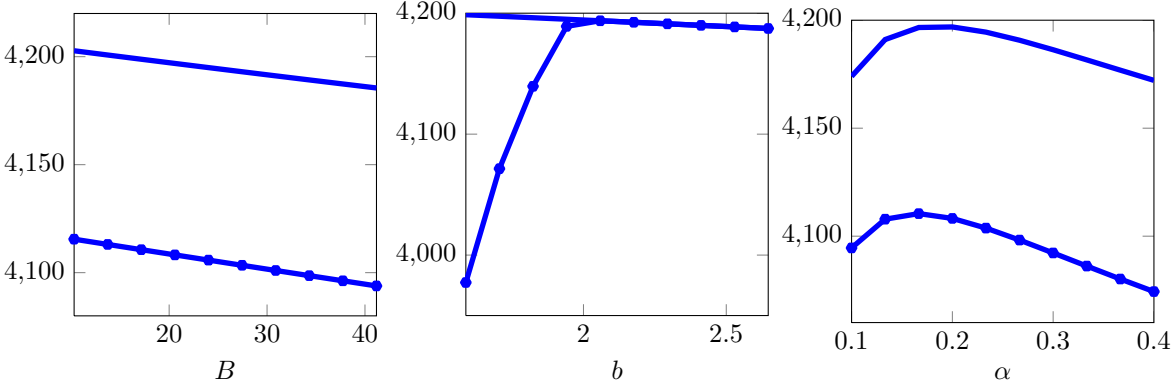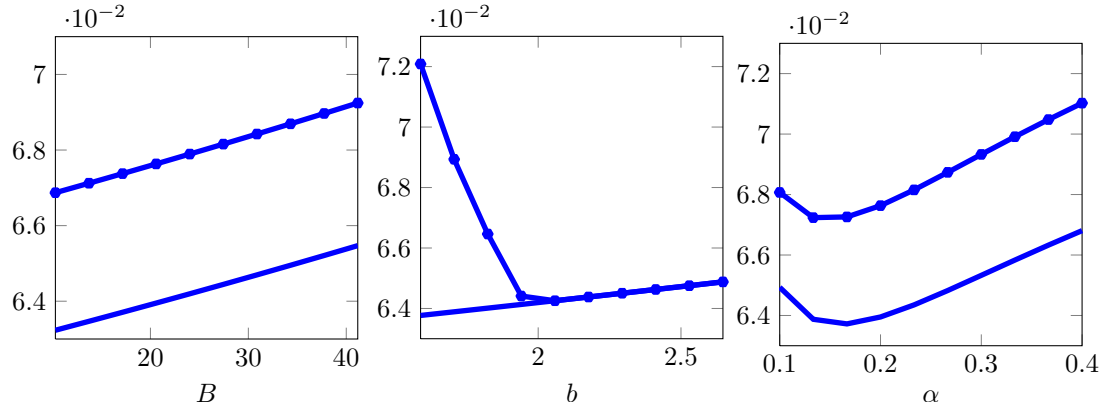Figure 13: Policy effects on hazard rates

Notes: solid lines refer to the regime with mild liquidity constraints ($r > r_c$); dotted lines show results when unemployed agents under UA are subject to strict liquidity constraints.

Figure 14: Policy effects on search strategies

Figure 15: Policy effects on social welfare: liquidity-constrained agents (the unemployed under the UA regime)

Notes: solid lines refer to the regime with mild liquidity constraints $(r > r_c)$; dotted lines show results when unemployed agents under UA are subject to strict liquidity constraints.

Figure 16: Policy effects on the unemployment rate: liquidity-constrained agents (the unemployed under the UA regime)

Notes: solid lines refer to the regime with mild liquidity constraints $(r > r_c)$; dotted lines show results when unemployed agents under UA are subject to strict liquidity constraints.

5.2 Maximizing the social welfare function with benefits

The social welfare function is the sum of the value of unemployment and the social value of employment, possibly incorporating the social costs of commutes, to which unemployment insurance and assistance must be deducted. Some intermediate results will be useful. Denote by u_c and u_{nc} the number of unemployed workers who are covererd and non covered respectively, we have the differente rates of unemployment by equality of inflows and outflows:

$$s(1 - u_c - u_{nc}) = u_c.(hazard_c + \alpha)$$

$$u_c \alpha = u_{nc}.hazard_{nc}$$

$$u_c = \frac{s}{\alpha + s + hazard_c + \alpha s / hazard_{nc}};$$

$$u_{nc} = \frac{s}{\alpha + s + hazard_c + \alpha s / hazard_{nc}} \frac{\alpha}{hazard_{nc}}$$

$$u = u_c + u_{nc}$$

There are two special cases: when $\alpha = 0$ we obtain $u = s/(s + hazard_c)$; and when $hazard_c = hazard_{nc}$, we also have $u = s/(s + hazard_c)$.

Introducing the notations:

$$r\tilde{U}(D, \lambda) = 0 \times b - C(D, \lambda) + 2\pi\lambda \int_0^D \int_{R(\rho)}^{w^{\max}} \tilde{S}(w, \rho) dF_\rho(w) dG(\rho)$$

$$r_c \tilde{U}_c(D_c, \lambda_c) = 0 \times B - C(D_c, \lambda_c) + 2\pi\lambda \int_0^D \int_{R(\rho)}^{w^{\max}} \tilde{S}(w, \rho) dF_\rho(w) dG(\rho) + \alpha(\tilde{U} - \tilde{U}_c)$$

the social welfare function is therefore

$$\Omega = u_{nc}\tilde{U}(D, \lambda) + u_c\tilde{U}(D_c, \lambda_c) + (1 - u_c - u_{nc})\mathbb{E}_{w,\rho}\left[W(w, \rho) - SC(\rho)\right].$$

We vary B and b under two polar cases: one where agents under unemployment assistance (b) are only mildly constrained; one where agents under unemployment insurance B are not liquidity constrained but agents under unemployment assistance b cannot afford to pay for long search distances. The effects of policy changes on social welfare are plotted in Figure 15, where the solid line represents the behavior of the social welfare function under the absence of financial constraints and the starred line refers to the case where the uncovered workers are liquidity constrained for low values of assistance. It can be seen that the socially optimal level of unemployment insurance is zero, since welfare declines monotonically with B. Instead, if under the absence of strict liquidity constraint, the same is true from b (unemployment assistance), in the more realistic case of liquidity contraints for households in the assistance regime, there is an optimal level of unemployment assistance and social welfare first first goes up as the range of search can be extended as the constraints is being reduced. Once the cash constraint is suppressed however, higher levels of assistance reduce search intensity and welfare goes down again.

The gap between the dotted line and the solid line in Figure 16 represents the percentage points of unemployment that can be attributed to the existence of strict liquidity constraints, the fact that the unemployed cannot search over the optimal range. This gap is 0.3 percentage points in the left panel, but the gap depends very much on the value of b which determines the value of D in the case of strict liquidity constraints; in the middle panel, the difference is as high as 0.072-0.064 that is 0.8 percentage points of unemployment.

6 Summary and conclusion

Our paper has taken the wage-commute distance arbitrage seriously. It has developed a simple search theory where the unemployed choose a range over which to search, an intensity of search in that area and then accept or reject offers according to a reservation strategy, which is a frontier in the space (wage, commute distance). This model allows us to define the main concepts and discipline the empirical analysis; in particular it defines new efficiency role for unemployment insurance, namely alleviate the liquidity constraints of the unemployed, the search of whom may be costly, away from their city of residence.

The data analysis uncovers many regularities. Based on an administrative social security dataset covering all newly unemployed workers in Austria, which contains information on the current residence, the previous workplace and the subsequent workplace for those re-hired, we established a set of facts. We find that:

1. **Commute time is dispersed and leads to a wage-distance trade-off**:

   (a) in a sample of employed workers having entered the unemployment spells, 57.2% of them had more than 20 minutes of one way commute distance, while 23.7% had nore than 40 mn of the workplace; 22.6% of them used to work in the same city as where they live;

   (b) there is a positive correlation in the data between finding a job with a higher wage and finding a job with a higher distance;

   (c) almost as many people face a wage increase as a wage decrease after finding a new job;

   (d) almost as many workers face a commute distance increase as people facing a commute distance decrease;

2. **Reservation wage strategies vary over time**:

   (a) the hazard rate of getting a lower paid job decreases relative to the hazard rate of getting a better paid jobs, both for individuals facing an increase in the commute distance and for individuals facing a decline in the commute distance;

   (b) an interpretation is that the reservation wages, a function of the commute distance of a job offer, decreases over time for all distances.

3. **Spatial search strategies vary over time too:**

   (a) over time, after the initial peak, people are much less likely to find a job in the same city than to face an increase in the commute distance;

   (b) an interpretation is that job seekers initially search more intensely in the same city and then prospect relatively more outside the city; those propspecting at a shorter distance may be those liquidity contrained unemployed, who will accept a lower wage but cannot afford expensive job search;

   (c) over time, the likelihood to commute longer distances increases relative to other hazard rates (no distance change or lower distance); an interpretation is that, for a given wage offer, the reservation distance increases over time for those not liquidity constrained;

4. **Liquidity constrained unemployed workers may reduce their range of search:**

   (a) Job search costs have a monetary component which may be may be unaffordable;

(b) For this reason, the optimal level of unemployment assistance is strictly positive even with risk-neutral agents;

(c) Quantitatively, our calibrated model implies that it may account between 0.3 to 0.8 percentage points of unemployment out of an average rate of 6.4 percent, that is almost up to 12.5%=0.8/6.4 of the total number of unemployed workers and an even more sizeable fraction of those long-term unemployed (15%).

Future work should extend the model and its two spatial dimensions to account for endogenous labor demand. If anything, the introduction of endogeneous demand will amplify the effects of liquidity constraints and thus of a potential positive role of unemployent assistance. Once done, we can deliver a new measure of geographical mismatch where the optimal unemployment rate corresponds to the case where the costs of commute and the spatial terms in search costs are driven down to zero.

Theory Appendix

Proof of Lemma 7, applied to Lemma 1 and 2

Proof. The proof is easy. The reservation wage $R(\rho)$ is defined by

$$r_c W(R(\rho), \rho) = R(\rho) - c(\tau\rho) + s(U_c - W(R(\rho), \rho))$$
$$= R(\rho) - c(\tau\rho) + s(U_c - U) = r_c U$$

so that

$$R(\rho) = \tau\rho + r_c U + s(U - U_c) \tag{22}$$

and similarly,

$$r_c W(R_c(\rho), \rho) = R_c(\rho) - c(\tau\rho) + s(U_c - W(R_c(\rho), \rho))$$
$$= R_c(\rho) - c(\tau\rho) = r_c U_c$$

so that

$$R_c(\rho) = c(\tau\rho) + r_c U_c \tag{23}$$

Hence Lemma 7. One gets back to Lemmas 1 and 2 with $\alpha = 0$, and $r_c = r$.

Hazard rates with UI and UA

There are now six sub-hazard rates $haz(w^+, d^+)$, $haz(w^+, d^-)$, $haz(w^-, d^+)$, $haz(w^-, d^-)$, $haz(w^+, d_0)$, $haz(w^-, d_0)$, where the sum of these six subhazard rates is the total hazard rate haz. Taking advantage of the empirical evidence, we assign a peculiar role to the previous workplace, here proxied by the median distance. To discretize space, we define the area around the previous workplace as a small circle centered in d_0. Let ε be the radius of this small circle, it is useful to define $d_0^- = d_0 - \varepsilon$ and $d_0^+ = d_0 + \varepsilon$. We calibrate ε to be 10% of d_0.

Moreover, we allow for the possibility that individuals exert effort in the previous workplace at a different (possibly higher) rate, denoted by λ^0 and λ_c^0 for uncovered and covered workers, respectively. Notice that, under this assumption, the value of unemployment should be rewritten:

$$rU(D) = b - c(D) + \delta Db + 2\pi\lambda^0 \mathbb{E}_\rho\big|_{\rho \in [d_0^-, d_0^+]} S(w, \rho) + 2\pi\lambda \mathbb{E}_\rho\big|_{\rho \in [0, d_0^-) \cup (d_0^+, D]} S(w, \rho)$$

The optimality conditions coversely do not change, provided that we always ensure $D > d_0^+$ and $D_c > d_{0,c}^+$.

We thus define he total hazard rate **of covered and uncovered workers** are:

$$haz = 2\pi\lambda\left[\int_0^{d_0^-}\int_{R(\rho)}^{w^{\max}}dF_\rho(w)dG(\rho) + \int_{d_0^+}^{D}\int_{R(\rho)}^{w^{\max}}dF_\rho(w)dG(\rho)\right] + 2\pi\lambda^0\left[\int_{d_0^-}^{d_0^+}\int_{R(\rho)}^{w^{\max}}dF_\rho(w)dG(\rho)\right]$$

$$=2\pi\lambda\left[\int_0^{d_0^-}[1 - F_\rho(R(\rho))]dG(\rho) + \int_{d_0^+}^{D}[1 - F_\rho(R(\rho))]dG(\rho)\right] + 2\pi\lambda^0\left[\int_{d_0^-}^{d_0^+}[1 - F_\rho(R(\rho))]dG(\rho)\right]$$

$$haz_c = 2\pi\lambda_c\left[\int_0^{d_{0,c}^-}\int_{R_c(\rho)}^{w^{\max}}dF_{c,\rho}(w)dG_c(\rho) + \int_{d_{0,c}^+}^{D_c}\int_{R_c(\rho)}^{w^{\max}}dF_{c,\rho}(w)dG_c(\rho)\right] + 2\pi\lambda_c^0\left[\int_{d_{0,c}^-}^{d_{0,c}^+}\int_{R_c(\rho)}^{w^{\max}}dF_{c,\rho}(w)dG_c(\rho)\right]$$

$$= 2\pi\lambda_c\left[\int_0^{d_{0,c}^-}[1 - F_{c,\rho}(R_c(\rho))]dG_c(\rho) + \int_{d_{0,c}^+}^{D_c}[1 - F_{c,\rho}(R_c(\rho))]dG_c(\rho)\right] + 2\pi\lambda_c^0\left[\int_{d_{0,c}^-}^{d_{0,c}^+}[1 - F_{c,\rho}(R_c(\rho))]dG_c(\rho)\right]$$

Extension of Lemma 4 to two types of unemployed workers.

We now have:

$$rU(D,\lambda) = b - C(D,\lambda) + 2\pi\lambda\int_0^{D}\int_{R(\rho)}^{w^{\max}}S(w,\rho)dF_\rho(w)dG(\rho)$$

$$r_cU_c(D_c,\lambda_c) = B - C(D_c,\lambda_c) + 2\pi\lambda\int_0^{D}\int_{R(\rho)}^{w^{\max}}S(w,\rho)dF_\rho(w)dG(\rho) + \alpha(U - U_c)$$

The first value equation, through the envelope condition, leads as before to: $r\frac{dU}{db} = 1$; the second value equation leads to

$$(r_c + \alpha)\frac{dU_c}{dB} = 1 + \alpha\frac{dU}{dB}$$

Calibration Appendix

Calibration

The calibration strategy is as follows. First, we fix the parameters for which we have some information. For instance, we set B (the unemployment insurance) and b (unemployment benefits) to be 35 % and 3% of the average wage, respectively. Our benchmark calibration assumes an annual interest rate of 4 % for workers covered by unemployment insurance (B), while long-term unemployed face a higher borrowing rate ($r_c = 12\%$ annually). We assume wages and distances are distributed log-normally and we set the mean and the standard deviation to their empirical counterparts. We can allow for arbitrary values of correlation, but in the baseline calibration strategy we start with independent distributions. We set the separation rate so as to match an average unemployment rate around 6 %. For the desutility component of the search cost function we assume separability between distance and search intensity and convexity in each argument ($\eta_c = \eta_\lambda = 1.5$). Importantly, we assume that agents (both covered and uncovered) weight less the effort provided to search in the previous workplace rather than outside ($\gamma^{\lambda^0}, \gamma_c^{\lambda^0} < 1$). Moreover, covered workers suffer less from the intensity of search in the previous workplace than uncovered agents ($\gamma_c^{\lambda^0} < \gamma^{\lambda^0}$). This is an important assumption: because at this stage we do not introduce other dimensions of heterogeneity, the asymmetry in the search cost is needed to rationalize the empirical observations that covered workers exit unemployment more quickly and they are relatively more "city stayers". The weight on the cost of search intensity has an alternative interpretation as the efficiency of the search process. It is rational to make the

assumption that covered workers are relatively more efficient in searching jobs for several not self-excluding reasons, as discussed in Section 4.3.

We set $\delta = \delta_c = -0.2$; this calibration implies that, for any given income (consumption) level, agents are better off when they search/commute less.

Given that our dataset do not provide any specific information about the private cost of commuting and the transport infrastructures, we choose a linear commuting cost function with coefficient (τ) equal to 1. This monetary component also enters the search cost function with the same coefficient.

For a given set of parameters, the dynamic of the hazard rate, the subhazards and their ratios is driven by the relative share of workers belonging to the covered or uncovered state, respectively. More precisely, in each period the hazard rate is a weighted average of the hazard rate of covered and uncovered workers, where the weights are represented by the share of workers in these two states, respectively. As time goes, the share of uncovered workers increases, thus triggering the dynamic of the hazard rates. Hence, in the model, the dynamic is entirely due to the different search strategies chosen by covered and uncovered workers.

Appendix: additional results for liquidity constrained agents

Figures 17 and 18 compare the dynamics of the simulated hazard rates and of the search strategies with and without liquidity constraints.

Figure 17: Simulated hazard rates over the unemployment spell: liquidity-constrained agents
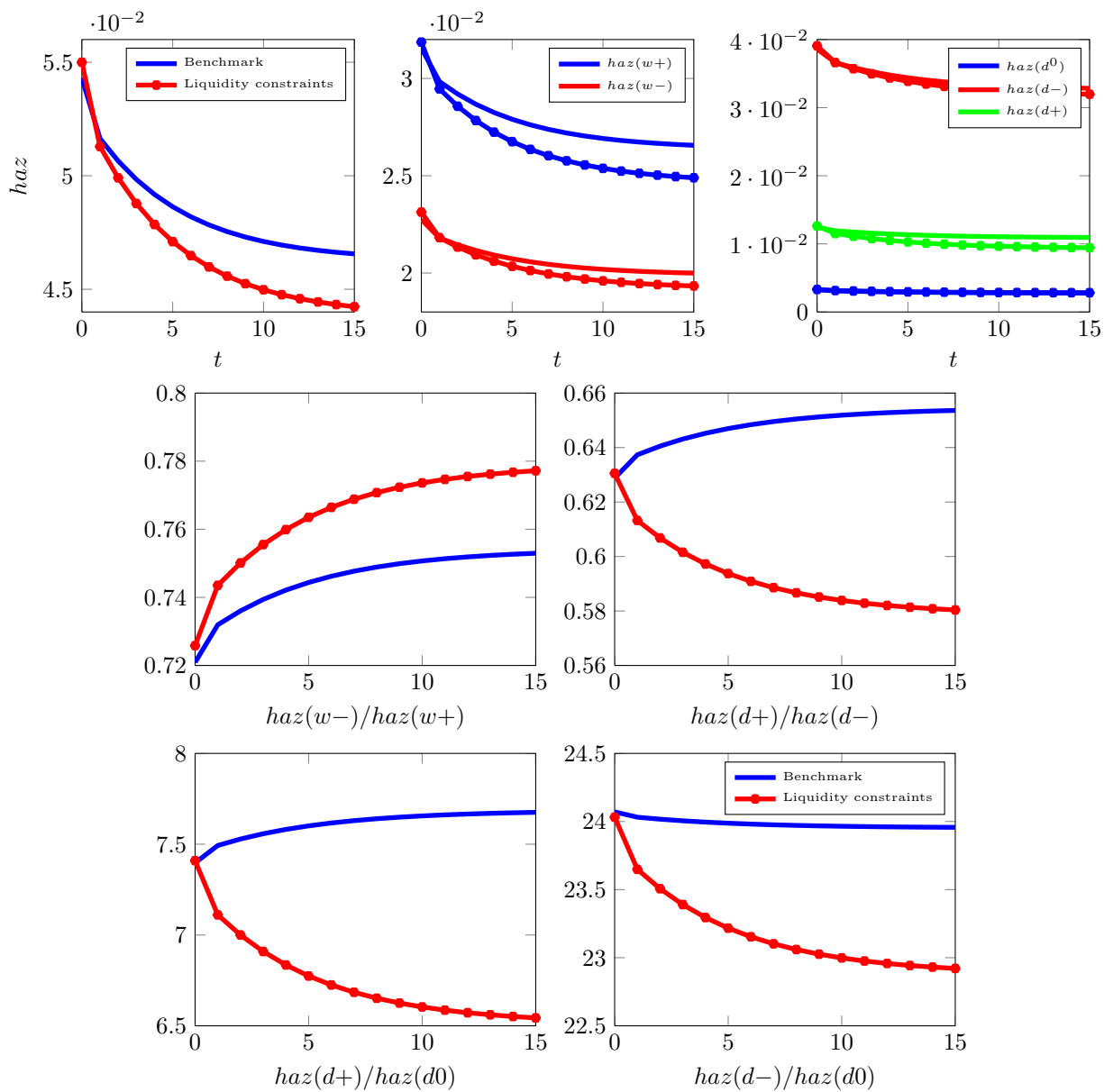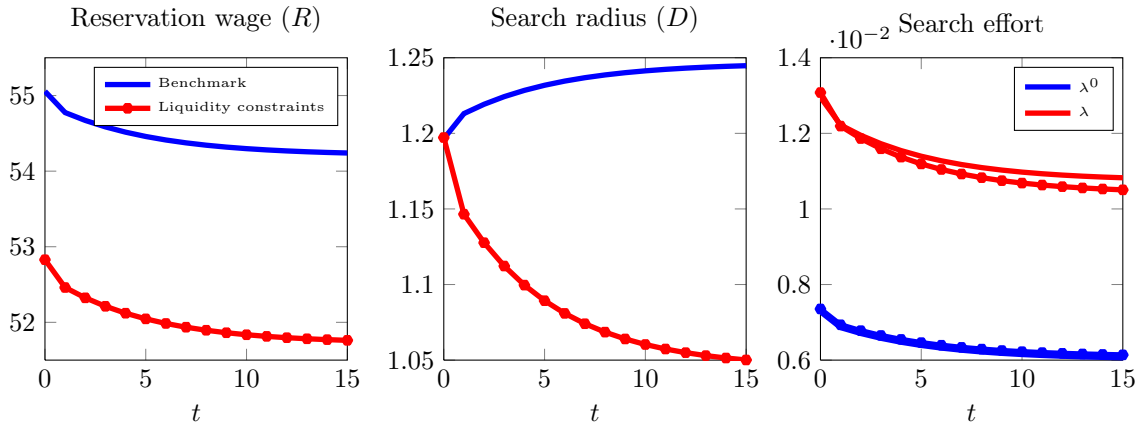
Figure 18: Search strategies over the unemployment spell: liquidity-constrained agents

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