

# An empirically based agent model of labor market transitions

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## Abstract

Previous research highlighted the importance of informal contacts in job search strategies. Real data obtained from the 2011-2013 waves of the Portuguese Labor Force Survey provide the probability distributions of a set of job search strategies and their associated transitions to employment. Together with empirical values of the employment rate observed in the same time period, those probability distributions feed the initial conditions of an agent-based model that simulates individual transitions occurring in the Portuguese labor market during that period. Our conclusion is that the macro conditions are more influential than the job search strategies for the creation of employment.

## 1 Introduction

The impact of job search strategies in the dynamics of the labor market has been a theme in Economics for long. Yet, the procyclical nature of this trend in economic theorizing is confirmed by the recent emergence of new research and attention, given the fact that, several years after the financial crash of 2007-2008, high levels of unemployment and the perspective of a long term slow growth persist. These features highlight how important is it to understand, to compare and to estimate the different job creation alternatives. Furthermore, recent improvements in multidisciplinary methods and, particularly, the availability of prevailing computational tools provide an increasing chance to look into labor markets in its real complex nature.

The implementation of an agent-based approach makes available the representation of global structures from a bottom-up perspective, understood as resulting from the repeated local interaction of economic agents, without disregarding the consequences of the structures (macro) themselves to individual (micro) behavior. Agent-based models (ABM) are at the leading edge of this frontier of economic science.

This paper presents an ABM with the main purpose of evaluating of the joint effect of two different dynamical components, the macro context and the micro seeking strategies. But our approach differs from several other authors, since we do not proceed only to the definition of a simulation to be calibrated accordingly to the requirements of the model. On the contrary, we use real data as a disciplinary constraint, following as closely as possible the empirical distributions and checking for the empirical robustness of our results. For that, the first dynamical component is built on a set of job search strategies of individual agents obtained from real data or randomly generated accordingly to a given probability distribution. The second determinant effect is the dynamics of the employment rate, measured either from real data for 6 semesters (or arbitrarily set, for a convenient computational comparison).

Our paper characterizes the interplay between these two features and their joint contribution to the labor market behavior, their role in the determination of a final rate of employment and their dependence on some initial conditions. Our main research question topic is thus the characterization of the labor market leading feature. Essentially, we are interested to uncover what mainly drives the transitions from unemployment to employment in artificial labor marked: (1) the macro dynamics, measured by rate of employment; or (2) the shape of a the probability distribution of the agent's job search strategies and their (empirically determined) rate of success.

The simulations are grouped into different scenarios, which can be briefly summarized as comprising the following mechanisms: (1) A set of individual (agent) job search strategies and the probability distribution of the agents choices of strategies along the six semesters. This distribution is obtained from the Portuguese Labor Force Survey; (2) The employment rate macro dynamics, defined as the proportion of individuals that have a job in the labor force.

Our simulation results show that in this artificial market the employment rate plays the leading role, implying that the macroeconomic conditions are determinant and that the success of job search strategies is conditional on the dynamics of the economy. Not surprisingly, when both dynamics are simultaneously allowed to take place, labor market behavior, in a society with low employment, seems to be more influenced by the macro dynamics than by individual job seeking strategies. Consequently, our two questions are: Which are the determinants of job intensity? And, do the different job search strategies create relevant patterns of success or failure? Accordingly to the answers, other questions may be the relevance of public and private channels of information for the selection of job search methods and the role of the current institutions in the labor market. We do not address these last questions.

The paper begins with a presentation of the sample used to feed our ABM, being followed by the presentation of the model and the different scenarios to be exploited.

Then, we present and discuss the simulation results. Some final remarks were added, providing an outline of future work.

## 2 Data

The Portuguese Labor Force Survey (LFS) is a CPS-type household survey conducted by the Portuguese statistical agency. The structure of the survey follows the instructions of *Eurostat*, regarding the sampling scheme and labor market state's definitions.

It includes around 40000 individuals quarterly, who are interviewed for six consecutive quarters, such that each quarter one-sixth of the sample is rotated out and five-sixths of the sample are retained. This rotational design allows to follow the labor force states' and the traits of the sampled individuals over five consecutive quarters.

In this paper, we used a sample of 25530 individuals from the first LFS wave of 2011. To observe the individual job search strategies and their rate of success in moving to employment, we focused on the job seekers that moved into employment during this period. That left us with a sample of 4255 individuals. As there is a substantial attrition rate, it is difficult to follow the evolution of each individual as far as the success of his strategy is concerned. The survey provides important but limited information.

The LFS asks job seekers which search methods they use, and they can report any of the following categories: (1) contacted public employment office; (2) contacted private employment agency; (3) applied to employers directly; (4) asked family or friends; (5) inserted or answered advertisements newspapers; (6) studied advertisements in newspapers; (7) took a test, interview or examination; (8) looked for land and equipments; (9) looked for financial resources.

## 3 Sample Characteristics

Table 1 reports statistics on main demographic and labor market characteristics. There is a high fraction of respondents with primary education, and it decreases over quarters. This is a predictable result, since panel attrition affects primarily the low educated ones.

The sum of job search methods used by job seekers is an usual measure of their *job search intensity*. As expected, the search intensity is higher among the unemployed. In the first quarter of 2011, the average number of search methods used by the unemployed went up from 3.79 in the first quarter of 2011, to 4.08 in the second of 2012. Additionally, for the previous period (2006-2008) the job search intensity of job seekers was about 2.2 in Portugal ([Bachmann and Baumgarten 2013](#)). By this measure, the search intensity of job seekers seems to be clearly pro-cyclical. Yet, for the recent period, Portugal suffered an unprecedented high level of long term unemployment and this justifies a new attention to the dynamics of the labor market and to the choice of measures and strategies designed to address this crisis.

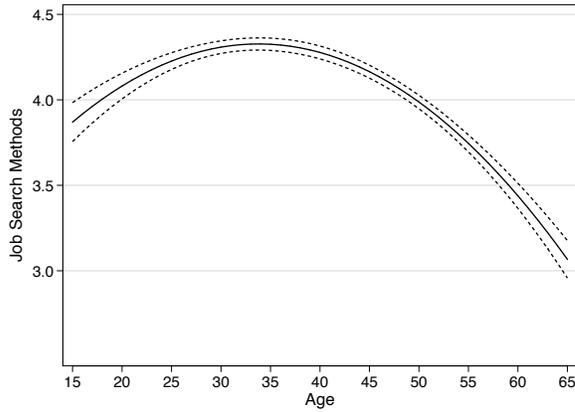
Table 1: Selected characteristics from the first wave of 2011

	2011:1	2011:4	2012:2
Avg. age	41.26	41.88	42.23
% of Males	48.33	47.95	48.34
% Tertiary education	12.88	13.97	13.86
% Secondary education	16.33	17.77	18.41
% Primary education	70.79	68.26	67.73
% Employed	45.62	45.08	45.23
% Unemployed	6.40	6.59	7.34
% Inactive	47.98	48.33	47.42
Avg. Job Search Intensity of the Employed	3.14	3.50	3.45
Avg. Job Search Intensity of the Unemployed	3.79	4.00	4.08
Sample size	7342	6632	6540

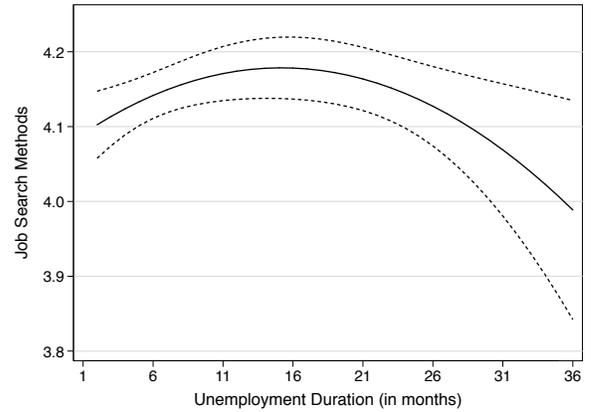
Tertiary education includes levels 5 and 6 of the ISCED classification; Secondary education includes levels 3 and 4; primary education levels 0 to 2. Job search intensity is defined as the average number of total job search methods used by job seekers.

To further examine the search behavior of the unemployed in our sample, we follow the empirical procedures suggested by [Shimer \(2004\)](#). We regress the number of search methods used by the unemployed on a set of demographic controls (sex, marital status, a quadratic in age), on industry and occupation dummies, a quadratic on unemployment duration and on time dummies. As [Table 3](#) shows, women and married people seem to search less intensively, while the search intensity comes higher in the more educated cohorts. Another interesting, although expected, result is the humped-shaped pattern in the response of the search intensity to age and unemployment duration, as displayed in [Figure 1](#). For example, an unemployed who is 34 years old uses about 0.35 more methods than a 50 years old. In the same way, the search intensity seems to peak at the 14 months of unemployment duration, decreasing thereafter.

The *Eurostat* reports data on the proportion of job seekers that adopt each method. However, nothing is known regarding which methods are frequently combined by the unemployed. We define a *job search strategy* as a particular set of job search methods. To compute the all set of possible strategies we specified a bit string that uniquely identifies each strategy. [Figure 2](#) displays the histogram of the job strategies. The most frequent, and also the most successful in moving to employment, seem to be: applied to employers directly and asked friends (96); contacted public employment office, applied to employers directly and asked friends (352); and applied to employers, asked friends and inserted/studied advertisements in newspapers (120).

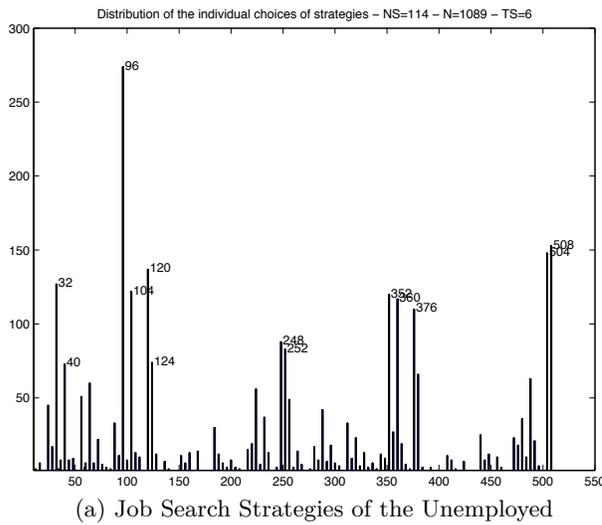


(a) Effect of Age

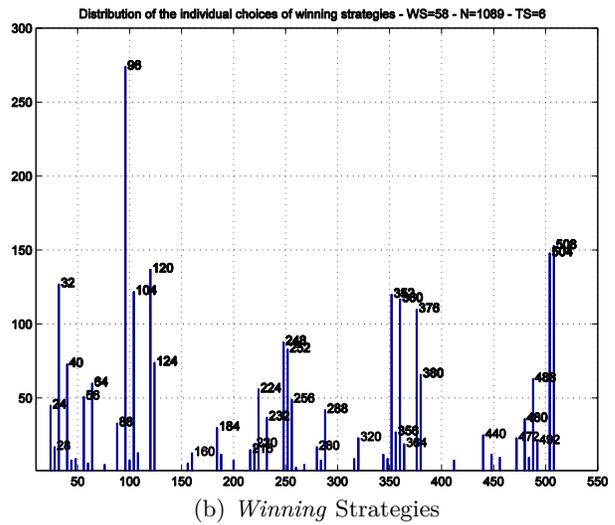


(b) Effect of Unemployment Duration

Figure 1: The effect of age and unemployment duration on the number of search methods used by the unemployed in the regression of Table 3. The dashed lines indicate the 95 percent confidence interval.



(a) Job Search Strategies of the Unemployed



(b) Winning Strategies

Figure 2: Plot (a) shows the distribution of the job search strategies of the unemployed. Plot (b) shows the *winning strategies*, ie, the combination of job search methods used by unemployed in the quarter before transitioning to employment.

## 4 Job search strategies in the literature

Job search strategies have been discussed in the literature for long. [Rees \(1966\)](#), [Benhabib and Bull \(1983\)](#), [Morgan and Manning \(1985\)](#), [Blanchard and Diamond \(1990\)](#), [Barron and Mellow \(1979\)](#), and [Meyer \(1988\)](#) are some of the initial contributions to this topic. [Pissarides \(2000\)](#) and [Petrongolo and Pissarides \(2001\)](#) provide detailed accounts of an equilibrium view of the labor market dynamics and the black box of job searches matching the employment demand. More recently, different authors provided empirical analysis or proposed models that may enlighten the conditions of search intensity, the effect of social networks, of public information and levels of education. This is namely the case of [Loury \(2006\)](#), [Riddell and Song \(2011\)](#) and [Cingano and Rosolia \(2012\)](#). In particular, [Weber and Mahringer \(2008\)](#) and [Riddell and Song \(2011\)](#) inquiry into the behavior and actions of the unemployed. [Shimer \(2004\)](#) modeled the job search strategies presuming that: (1) the worker must decide on the *intensity* of his job search. This decision depends on three factors: (i) the marginal increase in the probability of getting a job in response to an increase in search intensity; (ii) the increase in the expected PV of his income in response to obtaining a job; (iii) the marginal cost and search effort; (2) During economic downturn, the marginal product of search intensity will likely fall, due to the fall in the probability of obtaining a job, and the decline in the expected income from work. (3) Assumption that search intensity and the ease of finding a job are complements. (4) However, during booms, a worker knows that a minimal search intensity will suffice in order to get a job, while during recessions it is necessary much harder effort to secure employment. In Shimer's framework, the cyclical effects are discussed. Although this paper does not follow that avenue, since the differences between upswing and downswing are not considered since the only period we study is a recession, the model and method are useful for our research. Finally, different papers investigate the compared evolution across countries, e.g. [Bachmann and Baumgarten \(2013\)](#) provide an extensive identification of the driving factors in the European survey and discuss the importance of individual and households' characteristics for job search strategies. This study of the differences across countries is particularly relevant.

## 5 The Model

The main components of the model are the following. A given state (employed or unemployed) is assigned to a set of  $N$  individuals accordingly to the rate of employment at the beginning of the time period. The labor market itself represented the employment rate values measured along the 6 time steps ( $TS = 6$ ).

At each time step each unemployed individual chooses one strategy in order to find a job; if it happens the agent change his state to Employed. In turn, the probability that an agent find a job is defined: (a) either by the conditional probabilities of the empirical data (Scenarios 1 and 2) which are represented by two probability distributions

Table 2: The characteristics of each scenario and the resulting outputs.

Scenario	Parameters							Outcomes		
	$N$	$TS$	$NST$	$NWS$	$PD$	$PDWS$	$ER$	$E_f$	$U_f$	$H$
1	1089	6	114	58	raw data	raw data	0.56	429	660	0.89
2	1089	6	114	58	raw data	raw data	0.76	663	426	0.99
3	1089	6	114	58	raw data	other	0.56	441	628	0.89

( $PDST$ ): the  $PD$  of a set of existing strategies and the  $PD$  of the subset of strategies that once lead to employment ( $PDWS$  - the  $PD$  of the winning strategies); (b) or by the conditional probabilities obtained from another probability distribution of the winning strategies (Scenario 3). Employed agents may lose their job, changing their states to Unemployed. Losing a job depends exclusively on the employment rate ( $ER$ ) at that time step. Thus, the model has three main parameters:  $PDST$ , the probability distribution of the agent's choices of real world strategies along the six semesters;  $PDWS$ , the probability distribution of the agent's choices of winning strategies obtained from our empirical data set; and  $ER_t$ : the empirically measured employment rate at each semester,  $t = 1, ..6$ .

Other parameters are set to the corresponding values obtained from our empirical data set. They are:  $N$ , the number of agents;  $NS$ , the number of job search strategies;  $NWS$ , the number of winning strategies; and  $TS$  the number of time steps.

Simulations are grouped into three different scenarios: (1) In the first scenario, at each period, the probability that an individual find a job is conditioned by the probability distribution of the empirical data and the employment rate are also empirically determined by the value observed at that period; (2) In the second, the probability of finding a job is defined as in Scenario 1 but the employment rate is set to a significantly greater value than the empirical one; (3) Finally, for the third senario the employment rate is set as in Scenario 1 but the process of finding a job conditioned by another the probability distribution.

The model outputs are characterized in terms of: (i)  $H(t)$ , the Shannon entropy of the distribution of the agents choices of winning strategies, obtained from the simulations; (ii) The number of Employed ( $E$ ) and Unemployed ( $U$ ) agents in the beginning and in the end of simulations (at  $t = 0$  and  $t = 6$ , respectively).

## 6 Results and Discussion

Figure 3 shows the results obtained to Scenario 1, where both parameters were set from real empirical data: The average value of  $ER$  along the 6 semesters was set to 0.56 and the frequency of the choices of (job search) strategies by the agents is conditioned by the probability distribution of the same feature measured from our empirical data set. The computation of the Shannon entropy ( $H$ ) helps to characterize the distribution shape. The first plot of Figure 3 shows the distribution of the 114 strategies choice; the second plot shows the same for the set of 58 winning strategies (WS - those that lead to employment). The 3rd and 4th plots show results obtained from the artificial labor market (a typical simulation) dynamics: The  $PD$  of the choice of  $WS$  and the agent's final states,  $t = 6$  (Employed (blue) or Unemployed (pink)) represented on a  $\mathbb{R}^2$  square lattice.

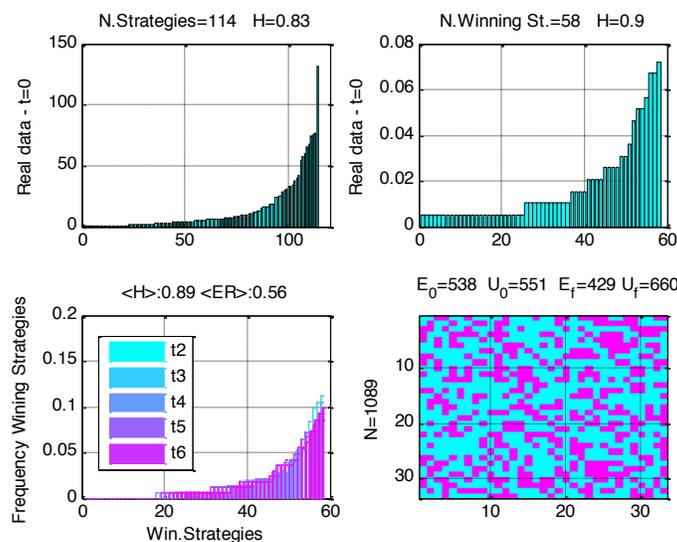


Figure 3: Results for Scenario 1: parameters were set from empirical values

Figure 4 presents the results obtained from Scenario 2, where the initial conditions are those of Scenario 1 except the average value of  $ER_t$  which was set to a higher value of 0.76. In this case we see that the labor market final rate of employment is much higher than in Scenario1, even though the  $PD$  of the agent's choices of strategies remains unchanged. The last plot in Figure 4 shows that, in a typical simulation of the model, the final number of employed agents ( $E_f$ ) increased to 663.

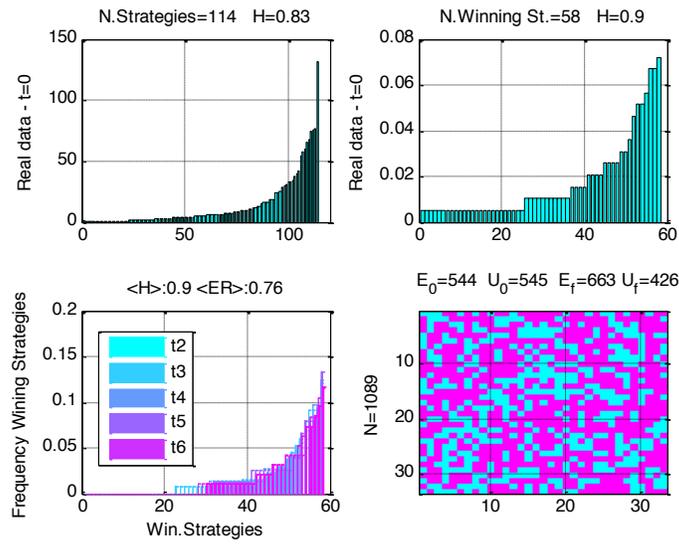


Figure 4: Results for Scenario 2: PD and PDWS parameters were set from empirical values but the employment rate is increased to 0.76.

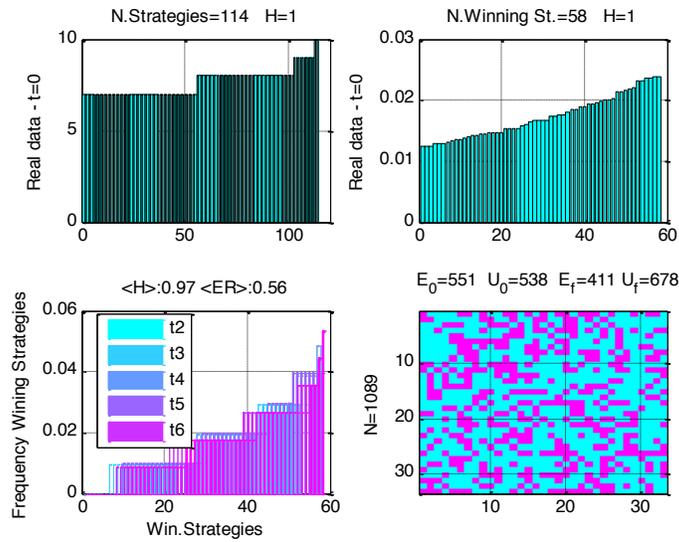


Figure 5: results for Scenario 3: The Employment rate is the same as in Scenario 1, but PD and PDWS have an almost uniform shape.

Figure 5 shows the results obtained from Scenario 3, where the average value of  $ER_t$  was set to 0.56 as in Scenario 1 but the parameters  $PD$  and  $PDWS$  have an almost uniform shape. In this case we see that the labor market final rate of employment is close to the one obtained in Scenario 1, even though the  $PDs$  of the agent's choices of strategies have a entirely different shape, as the first 3 plots of Figure 5 show. The last plot in Figure 5 shows that, in a typical simulation of the model, the final number of employed agents ( $E_f$ ) is similar to the one of Scenario 1 meaning that, regardless the job search strategies individually chosen, low employment rates have a determinant role in the labor market final state.

## 7 Conclusion

Summarizing, there are two fundamental parameters in our ABM: the rate of employment along six semesters and the probability distribution of the choices of a set of winning strategies. Both parameters can be either set from our empirical data set or arbitrarily specified. Taking this possibility, we built 3 different scenarios, the first two scenarios differing in the value of  $ER$  and coinciding in the probability distribution of the winning strategies. Likewise, scenarios 1 and 3 coincide in the value of  $ER$  and differ in the probability distribution of the winning strategies ( $PDWS$ ). In so doing we are able to evaluate the role of each of these independent contributions to the final number of individuals that were able to find a job. The simulation results show that as the final number of employed agents obtained in scenario1 is very close to the same indicator obtained in scenario 3, regardless the job search strategies individually chosen (set by the parameter  $PDWS$ ). The fact that the low employment rate is low in these two scenarios (1 and 3) and unemployment is high determines the labor market final state. On the contrary, when the employment rate is artificially increased in the simulations (scenario 2) and unemployment substantially decreases, this macro indicator changes the dynamics of the labor market. Even if we artificially set the individual choices of the job search strategies to an uniform distribution (scenario 3), admitting that all strategies are equally chosen by individuals when they look for a job, even in this unlikely situation their success is strongly constrained by the values of the employment rate. Consequently, we conclude from this model, its empirical foundation and simulation that the management or macroeconomic conditions is the most promising avenue for addressing unemployment and that changes in job search strategies or institutions and attitudes are scarcely influential in the immediate dynamics or the the state of the labor market.

## References

- Bachmann, R. & Baumgarten, D. (2013), 'How do the unemployed search for a job?—evidence from the eu labour force survey', *IZA Journal of European Labor Studies* **2**(1), 1–25.
- Barron, J. M. & Mellow, W. (1979), 'Search effort in the labor market', *Journal of Human Resources* pp. 389–404.
- Benhabib, J. & Bull, C. (1983), 'Job search: The choice of intensity', *The Journal of Political Economy* pp. 747–764.
- Blanchard, O. J. & Diamond, P. (1990), 'The cyclical behaviour of the gross flows of u.s. workers', *Brookings Papers on Economic Activity* **21**(2), 1–30.
- Cingano, F. & Rosolia, A. (2012), 'People i know: job search and social networks', *Journal of Labor Economics* **30**(2), 291–332.
- Loury, L. D. (2006), 'Some contacts are more equal than others: Informal networks, job tenure, and wages', *Journal of Labor Economics* **24**(2), 299–318.
- Meyer, B. D. (1988), Unemployment insurance and unemployment spells, Technical report, National Bureau of Economic Research.
- Morgan, P. & Manning, R. (1985), 'Optimal search', *Econometrica: Journal of the Econometric Society* pp. 923–944.
- Petrongolo, B. & Pissarides, C. A. (2001), 'Looking into the black box: A survey of the matching function', *Journal of Economic literature* pp. 390–431.
- Pissarides, C. A. (2000), *Equilibrium unemployment theory*, MIT Press.
- Rees, A. (1966), 'Information networks in labor markets', *American Economic Review* **56**, 559–566.
- Riddell, W. C. & Song, X. (2011), 'Education, job search and re-employment outcomes among the unemployed'.
- Shimer, R. (2004), Search intensity, Technical report, mimeo, University of Chicago.
- Weber, A. & Mahringer, H. (2008), 'Choice and success of job search methods', *Empirical Economics* **35**(1), 153–178.

## Appendix

Variable	Coefficient (Std. Err.)
Married	-0.048 (0.032)
Male	0.217 (0.031)
Age	0.087 (0.008)
Age <sup>2</sup>	-0.001 (0.000)
Primary or less	omitted
Less than Secondary	0.281 (0.037)
Secondary	0.540 (0.042)
College or more	0.598 (0.061)
Unemployment duration	quadratic
Industry controls	yes
Occupation controls	yes
Region dummies	yes
Time dummies	yes
N	21061
R <sup>2</sup>	0.094
F <sub>(33,21027)</sub>	60.229

Table 3: Linear regression coefficients. The dependent variable is equal to the number of search methods used by the unemployed. The independent variables with coefficient estimates and standard-errors shown are dummy variables equal to one if the condition holds and zero otherwise.