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Evidence on the relationship between recruiting and the starting wage

R. Jason Faberman[a,1,*], Guido Menzio[b,1]

[a] Federal Reserve Bank of Chicago, United States
[b] University of Pennsylvania and NBER, United States

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ABSTRACT

Using data from the Employment Opportunity Pilot Project, we examine the relationship between the starting wage paid to the worker filling a vacancy, the number of applications attracted by the vacancy, the number of candidates interviewed for the vacancy, and the duration of the vacancy. We find that the wage is positively related to the duration of a vacancy and negatively related to the number of applications and interviews per week. We show that these surprising findings are consistent with a view of the labor market in which firms post wages and workers direct their search based on these wages if workers and jobs are heterogeneous and the interaction between the worker's type and the job's type in production satisfies some rather natural assumptions.

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1. Introduction

Models of directed search have become a very popular tool to study labor markets. The central assumption of directed search models is that firms post wages (or, more generally, employment contracts) and workers direct their search to different firms based on these wages. This assumption implies that firms face a trade-off between paying a lower wage and filling their vacancies faster. If a firm chooses to post a lower wage for its vacancies, it will receive fewer applications and take longer to fill these vacancies. If a firm chooses to post a higher wage, it will receive more applications and take less time to fill its vacancies. Similarly, workers face a trade-off between the wage and the probability of being hired. If a worker chooses to seek jobs with higher wages, he will be competing with more applicants and have a lower probability of being hired. If a worker chooses to seek jobs with lower wages, he will have a higher chance of being hired. Directed search models are appealing because they translate the basic insights of a Walrasian equilibrium to environments with search frictions. Directed search models are also appealing because, unlike random search models, they remain very tractable even in the dynamic versions with heterogeneous agents. For these reasons, the labor economics literature that makes use of directed search models has exploded.[2]

Despite the popularity of directed search models, there is hardly any evidence corroborating its basic implication that firms that choose to post higher wages will attract more applicants and will fill their vacancies faster. Part of the problem is a lack of data that contain information on the number of applications received by different vacancies, the duration of different vacancies, and the wage paid by different vacancies. One exception is the Employment Opportunity Pilot Project (EOPP), a survey conducted in 1980 and 1982 that contains detailed information on the recruiting process for a broad, representative set of vacancies. We use this dataset to estimate the relationship between the starting wage paid to the worker filling a vacancy, the number of applications attracted by the vacancy, the number of candidates interviewed for the vacancy, and the duration of the vacancy.

We find that 20 percent of the hires in our data occur without any recruiting. Among the hires for which recruiting took place, we find that the starting wage paid to the worker filling the vacancy is positively related to the duration of the vacancy, negatively related to the number of applicants to the vacancy, and negatively related to the number of candidates interviewed for the vacancy. These findings are very robust. One can see them directly in the raw data. These findings emerge when we control for the labor market, as defined by time, location, occupation, and industry. They emerge when we additionally control for observable characteristics of the firm and of the job that might affect the non-wage value of the job to the worker. They also emerge when we control for observable characteristics of the hire that might be related with the requirements of the job.

* Corresponding author.
E-mail addresses: jfaberman@frbchi.org (R.J. Faberman), gmenzio@sas.upenn.edu (G. Menzio).

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2 See, for example, Montgomery (1991), Shimer (1996, 2005), Moen (1997), Burdett, Shi, and Wright (2001), Shi (2001), Peters (2012), Menzio and Shi (2010, 2011), Wolthoff (2014), Kaas and Kircher (2015), Menzio, Telyukova, and Visschers (2016), and Schaal (2015), among others.

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We find a great deal of duration dependence in recruitment outcomes. Indeed, we see that vacancies that are filled within 1 week receive a higher number of applications per week than vacancies that are filled in 2 weeks, which, in turn, receive a higher number of applications per week than vacancies that are filled after a month. In light of this observation, we re-estimate the relationship between wages and applications per week under the assumption of true duration dependence (i.e., the assumption that applications per week depend directly on the duration of the vacancy). Under this assumption, we find that the relationship between wages and number of applications per week is weakened, but still negative.

These empirical findings are puzzling from the perspective of a directed search view of the labor market. Why would firms post higher wages if that means attracting fewer applicants and having a lower probability of filling its vacancies? And why would more workers apply to jobs that pay lower wages? We show that, while these empirical findings cannot be rationalized in a simple model of directed search with homogeneous workers, they are perfectly consistent with a model of directed search if workers and jobs are heterogeneous (beyond those basic observable characteristics for which we control in our regressions) and if the interaction between the worker's type and the job's type in the production process satisfies some rather natural conditions.

We use the general model of directed search with two-sided heterogeneity of Shimer (2005). We show that if the productivity of some jobs (which we call "sensitive") is more responsive to the quality of the worker manning them than the productivity of some other jobs (which we call "regular"), and the productivity of sensitive jobs when manned by low-quality workers is lower than the productivity of regular jobs, then the equilibrium is such that firms with sensitive jobs pay higher wages, attract fewer applicants and take longer to fill their vacancies. Firms with sensitive jobs pay higher wages not to attract more applicants but to attract a better pool of applicants. In particular, firms with sensitive jobs post higher wages for both high-quality and low-quality workers. In response to this higher wage, high-quality workers apply more frequently to sensitive jobs than to regular jobs. However, low-quality workers do not apply more frequently to sensitive jobs because, even though they would be paid a higher wage, they are very unlikely to be hired as they have to compete with a larger number of more attractive applicants. When low-quality workers are less productive in sensitive jobs than in regular jobs, the total number of applicants attracted by high-wage firms is lower.

The paper's main contribution is to use the EOPP to document the relationship between wages and recruitment outcomes and to make sense of this relationship in the context of the directed search view of the labor market. Our paper complements very nicely recent work by Marinescu and Wolthoff (2015). Marinescu and Wolthoff (2015) use data from CareerBuilder.com for three large metropolitan areas of the U.S. that contain information on the job title, wage, and applications for each vacancy. They find that, controlling for occupation but not for job titles, there is a negative relationship between wages and the number of applications. This finding is consistent with ours, even though our data come from the early 1980s. Our results corroborate their finding by showing that there is also a negative relationship between wages and interviews and a positive relationship between wages and the duration of a vacancy. After also controlling for job titles, however, Marinescu and Wolthoff (2015) find that a higher wage attracts more applications. This finding is perfectly in line with our model. In fact, if, in our model, one could control for different types of jobs by looking at the associated title (i.e., sensitive or regular), one would recover the standard directed-search relationship between wages and the number of applicants. Moreover, our model provides an explanation for why, when one cannot control for the job title, the relationship between wages and applications is negative: it is because high-wage jobs are sensitive jobs where high-quality applicants are especially productive relative to low-quality applicants, and where low-quality applicants have an especially low productivity.

Ketterman, Mueller, and Zweimueller (2016) use matched employer-employee data from Austria, which include information on vacancies. They find that, in the raw data, there is a positive relationship between the wage paid to the worker filling the vacancy and the duration of the vacancy. However, they show that there is a negative relationship between the average wage paid by a firm and its average vacancy duration. These findings are also consistent with our model. Indeed, if we were to add a firm-specific component of productivity to our model, we would find that more productive firms post higher wages for both sensitive and regular jobs and, on average, attract more applicants and fill their vacancies faster. Banfi and Villena-Roldán (2015) use data from the online job search website Trabajando.com to study the relationship between wages and applications in Chile. They find a negative relationship between the average wage of the firm and the average number of applications per month. Again, this finding is consistent with a version of our model where firms differ with respect to their productivity in both sensitive and regular jobs.

Several recent studies are focused, broadly speaking, on the determinants of the job search process. Hall and Kruger (2012) use a survey of workers to see whether they bargained over the wage or faced a take-it-or-leave-it offer. Brenčič (2012) studies the firm's decision of whether to advertise a wage, a wage range, or to not advertise a wage at all in its vacancies using data from Monster.com in the U.S., from local career centers in the U.K., and from a public employment agency in Slovenia. Belot, Kircher, and Muller (2015) run an experiment with job seekers in the U.K. to understand the effect of nudging them to search a broader spectrum of jobs.

2. Data

We use both waves of the Earnings and Opportunities Pilot Project (EOPP) survey, which were conducted in 1980 and 1982. The survey includes a relatively small sample of firms, and is over three decades old, but still provides one of the best sources of detailed information on hiring outcomes at the firm level. It includes information on the initial wage paid and a wide range of information on the hire and related recruiting activity. It has been used numerous times before to examine firm recruiting and hiring behavior.[3] The survey was designed to evaluate several policies targeted towards hiring and training in the early 1980s. As such, it asks employers to report detailed information on their most recent hire. In addition to the wage paid, employers report detailed demographic information, information on the firm's recruiting efforts that led to the hire, the training given after the hire started, and information on the recruiting process (i.e., the duration of the search, the number of applicants, and the number of job interviews).

The survey initially interviewed 5918 firms in 1980, 3419 of which responded to the 1982 follow-up survey. We focus on firms that report having a hire during the survey's reference period (generally several months prior to the interview). We focus our analysis on the 1982 survey because it has information on the number of applicants to a job opening, which is not present in the 1980 data, and a more relevant definition of the starting wage, but we also appeal to the 1980 data to use the panel dimension of the EOPP for those firms that appear in both surveys.[4] The 1980 survey also asks about the most recent hire separately by whether or not the hire occurred through a federal hiring subsidy program, so firms may have up to three hires reported across the two surveys.

Our main variables of interest are the starting wage paid to the hire, the length of time it took to fill the vacancy (i.e., the vacancy dura-

[3] See, for example, Barron, Bishop, Dunkelberg, (1985), Holzer (1987), Holzer, Katz, Krueger (1991), Sicilian (1995), Barron, Berger, and Black (1997), Burdett and Cunningham (1998), and Wolthoff (2014).

[4] Specifically, the 1982 survey asks employers the starting wage of the most recent hire, while the 1980 survey instead asks what the current starting wage would be for someone in the same position as the most recent hire. We simply note this difference as an important caveat when interpreting our pooled results.

tion), the number of applicants to the vacancy, and the number of interviewed applicants (used as a proxy for applications when comparing across the two surveys). The data also include information on the job (e.g., the occupation, whether the job is a subsidized hire, whether it is a temporary or seasonal job, and the usual hours worked), information on the firm (e.g., location, industry, total employment, employment growth, the percent unionized, and various measures of worker turnover) and basic characteristics of the hire (e.g., age, gender, race, education, veteran status, the amount of experience relevant to the position, and whether the hire had any prior vocational training). The data also include additional information on the hire, the most notable of which are the amount of time employers spent recruiting, the amount of time employers spent training the new hire, whether or not the hire was a referral, and whether the hire is still with the firm. Furthermore, when reporting a vacancy's duration, the surveys in both years allow respondents to explicitly report whether there was "no recruiting" done, implying that the vacancy was filled immediately, or whether they are "always recruiting," allowing us to identify and directly quantify the amount of hiring done without any formal recruiting. In our analysis, we use the real starting wage, deflated by the Consumer Price Index at the time of the reported start date of each hire.[5] We measure the number of applicants, number of job interviews, and the hours employees spent on recruiting on a per-vacancy basis.

Not all firms surveyed had a hire during the survey's reference period, reducing our 1982 sample by 35 percent. Furthermore, a sizable fraction of firms has missing data for one or more key variables in our analysis, reducing the sample by another 37 percent. The remaining 1982 sample contains data on 1512 hires, 1238 of which had a positive, finite vacancy duration (i.e., did not report "no recruiting" or "always recruiting"). Applying similar criteria to our matched 1980-82 panel, we obtain an unbalanced panel of 1922 pooled hires (with a positive, finite vacancy duration) across 1087 firms. In our analysis, our main results come from the samples restricted to hires with a positive, finite vacancy duration, but we also examine the wage and recruiting behavior for the broader sample of hires in the next section. The 1982 sample suffers from attrition, but does not contain updated weights to deal with it. We deal with this by generating non-response adjustment factors based on the survey's sample stratification (the EOPP is stratified by survey wave and metropolitan area) and adjusting the 1980 sample weights accordingly.[6]

3. Summary evidence on starting wages, duration, and recruiting

We begin with basic evidence on the starting wage, vacancy duration, and recruiting behavior by characteristics of the hire and the job. We report sample means for these measures in Table 1. The top row lists the summary statistics for the full sample of 1982 observations. The real starting wage averaged $4.53 and it took about 16 days to fill a vacancy (20 days when excluding vacancies where there was no recruiting done). The average vacancy received 10.4 applications, had 6.2 job interviews conducted for it, and had 8.2 person-hours of recruiting effort exerted for it each week it was open.

The next several rows of Table 1 report these estimates broken out by various demographic characteristics of the hire, restricting the 1982 sample to vacancies with a positive vacancy duration. Jobs that were filled by women tended to pay less, took less time to fill, and had fewer applicants. Starting wages and vacancy durations generally rose with the age of the hire, but there were few differences in other recruiting outcomes by age group. More-educated hires tended to have higher starting wages and positions that took longer to fill, received fewer applications, had fewer interviews, and had less recruiting effort devoted to them per week of the job opening. Hires with more relevant experience exhibited similar patterns, though recruiting effort showed no systematic variation by experience group.

The last rows of Table 1 report these estimates broken out by the characteristics of the firm and job, again restricting the 1982 sample to vacancies with a positive vacancy duration. Larger firms tended to have higher starting wages and had more effort exerted on recruiting, but otherwise recruiting outcomes were similar across firm size categories. There was substantial variation in recruiting outcomes by both industry and occupation, but no clear pattern emerges when one compares them by their average starting wage. Notably, management positions offer the highest wages and have relatively long vacancy durations and few applications or interviews. Part-time and temporary jobs have relatively lower starting wages, but also more applications and shorter vacancy durations.

Fig. 1 shows the distribution of jobs by their vacancy duration. Surprisingly, employers report that 19.4 percent of all vacancies involved no recruiting at all. That is, they report the vacancy was essentially filled immediately or perhaps had no vacancy associated with it (e.g., an opportunistic hire). This finding is consistent with Davis, Faberman, and Haltiwanger (2013), who find that 42 percent of hires occur at establishments that start a month without a vacancy, of which all but 14 percent can be accounted for by time aggregation and observed heterogeneity. Only 0.4 percent of vacancies were for positions where employers reported that they were always recruiting. About three-quarters of vacancies were filled within their first two weeks, though a nontrivial amount (9.2 percent) took over a month to fill.

Table 2 reports starting wages and recruiting outcomes by vacancy duration. The top panel presents our most basic evidence on the relationship between the starting wage, recruiting outcomes, and vacancy duration. It shows that the starting wage tends to rise with duration, while applications, interviews, and recruiting effort per week all fall with duration—i.e., there is considerable duration dependence in the data. The bottom panel of Table 2 reports the mean estimates of the starting wage and recruiting outcomes after conditioning out observable firm and job characteristics from each measure.[7] Controlling for these characteristics has a notable effect on the amount of wage variation as a function of duration, but does not reduce the degree of duration dependence in the measures of weekly recruiting activity (applications, job interviews, and recruiting).[8] Table 2 also shows that vacancies that were reported as having no recruiting tended to have above-average wages and, as would be expected, minimal applications, interviews, or recruiting effort.

Table 3 explores in detail the relationship between the duration of the vacancy and characteristics of the hiring process (i.e., referral, walk in, etc.), characteristics of the firm and job (i.e., firm size, unionization rate, etc.), and characteristics of the person hired (i.e., gender, age, education, etc.) From this table, the most interesting take-away is the difference between vacancies filled without recruiting activity and other

[5] For the 1980 data, which uses the current starting wage for the position of the most recent hire, we use the date of the survey interview. The timing of the CPI value used is important, given the high rates of inflation during the survey period.

[6] We also experimented with a variety of weighting alternatives, including weighting by total reported hires and total reported vacancies, and examined unweighted results as well. We determined, however, that weighting each vacancy using the sample weights (adjusted for nonresponse) provided the most representative sample when compared to published aggregate statistics by broad industry.

[7] Specifically, we regress each variable in each column of Table 2 on a set of dummies for the starting month of the hire, 2-digit industry, 2-digit occupation, metropolitan area, (log) firm size, the firm's previous 6-month growth rate, the firm's worker turnover rate, the firm's percentage unionized, the job's reported 5-scale index of associated machine costs (a proxy for productivity), and indicators for whether the job was part-time, temporary or seasonal, subsidized, or paid the minimum wage.

[8] We also replicated the exercise adding in controls for the characteristics of the hire (e.g., demographics and relevant experience) and of the match (e.g., job tenure, training), and the results are essentially unchanged from those in the bottom panel of Table 2.

Table 1
Starting Wage and Recruiting Summary Statistics.

Category	N	Starting Wage (1982 $)	Vacancy Duration	Applications per Week	Interviews per Week	Recruiting Effort per Week
Full Sample, 1982	1,512	4.53	16.2	10.4	6.2	8.2
Gender						
Female	599	3.61	18.0	9.8	6.9	9.5
Male	639	5.04	21.7	14.0	7.4	9.2
Age						
Less than 25	636	3.85	17.1	13.3	7.1	9.5
25 to 34	329	5.32	20.4	10.4	5.8	7.6
35 to 44	141	4.64	19.9	9.6	6.6	9.3
> 45	73	4.87	31.1	14.8	9.4	8.6
Education of the Hire						
Less than High School	153	3.58	10.8	18.4	10.2	10.3
High School	719	4.23	19.8	10.9	6.9	9.6
Some College	250	4.52	19.0	15.0	7.6	8.9
College or more	116	6.70	37.5	4.3	3.3	6.8
Relevant Experience						
Zero Years	460	3.55	16.4	15.0	8.1	9.0
1 to 2	452	4.50	21.3	11.5	7.2	10.1
3 to 5	182	4.76	22.3	9.6	5.6	9.9
> 6	144	6.19	24.9	8.5	6.1	8.1
Firm Size						
1–19 Employees	696	4.28	20.9	11.3	6.8	8.4
20–99 Employees	329	4.77	15.5	15.4	9.1	12.7
100–499 Employees	141	5.25	23.6	14.0	5.6	11.3
500+ Employees	73	7.87	25.9	15.4	2.9	16.2
Industry						
Manufacturing	137	4.84	13.7	15.4	5.3	14.3
Professional Services	279	4.33	24.2	8.8	6.4	8.1
Other Services	252	3.88	16.4	16.6	7.3	10.1
Retail	299	3.45	20.6	9.9	6.6	7.5
Occupation						
Management	76	5.84	32.9	4.0	2.7	6.4
Sales	178	5.34	26.6	3.7	3.3	4.9
Production/Maintenance	235	5.06	18.3	8.8	5.7	8.5
Professional/Technical	80	4.29	30.0	16.1	7.3	7.4
Part Time						
Part Time	271	3.21	15.3	14.9	7.9	9.3
Full Time	967	4.80	21.6	11.3	6.9	9.3
Temporary						
Temporary	151	3.84	16.6	14.7	7.1	9.4
Not Temporary	1087	4.52	20.6	11.8	7.2	9.3

Notes: Estimates from authors' calculations using the 1980 and 1982 waves of the EOPP survey. All estimates are sample weighted.

vacancies. Vacancies that had no recruiting were more likely to come from a referral or a "walk-in" (i.e., unsolicited) job applicant.[9] These jobs tended to involve more training, but they also were more likely to have their hire separate by the time of the survey interview. Hires with no recruiting were significantly more likely to occur at smaller firms, but other firm characteristics are generally unrelated to the incidence of no recruiting. Vacancies with no recruiting are more prevalent in retail, in part-time jobs, in temporary or seasonal jobs, and in goods-producing or maintenance jobs. Those hired without any recruiting tended to be older and more educated than most hires, with those with the longest vacancy durations being the exception. The results paint a dichotomous picture of the types of jobs that occur with no recruiting. Many of these jobs appear to be transitory in nature, suggesting that firms may not want to invest too much recruiting effort into a match that may not last too long. Other aspects of these jobs, however, suggest a role for informal networking for specialized or skill-intensive positions, which are traditionally hard-to-fill.

4. Starting wages and recruiting outcomes

We now turn to our main analysis. First, we examine how the starting wage paid to those hired is related to the duration of the vacancy, the number of applications attracted by the vacancy each week, and the number of candidates interviewed each week. We report our findings controlling for the labor market, as defined by time, location, occupation, and industry. We also report our findings for when we introduce additional controls for observable characteristics of the job, the firm and the hire. Second, using the panel structure of the dataset, we control for the unobserved, fixed characteristics of the firm that might affect the non-pecuniary value of the job to a worker. Finally, we re-estimate the relationship between wages and recruitment outcomes under the assumption that applications and interviews per week depend directly on

[9] The importance of hiring through referrals has been documented by Ioannides and Loury (2004) and Topa (2011) and, more recently, by Burks et al. (2015), and Pallais and Sands (2016). Galenianos (2014) develops an interesting model of hiring through referrals, in which jobs may be filled without a formal vacancy.

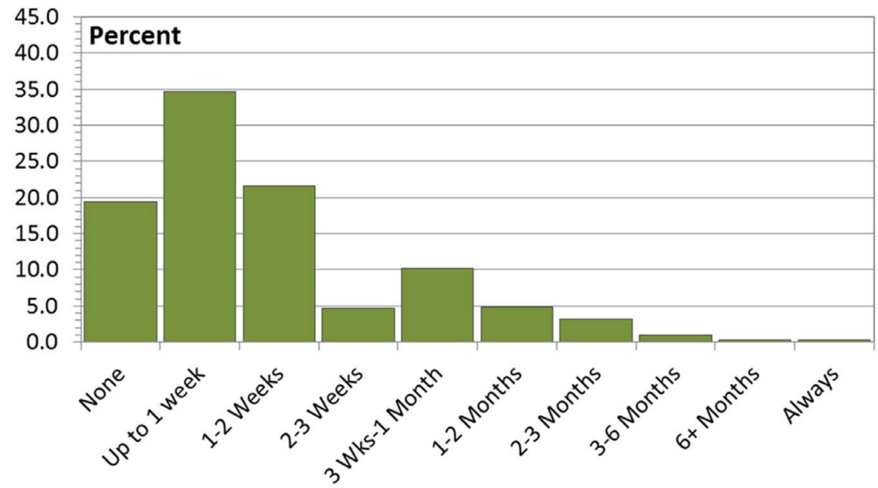

Fig. 1. Cross-Sectional Distribution of Vacancy Durations. Note: Figure reports the sample-weighted distribution of vacancy durations across all hires in the 1982 wave of the EOPP survey. "None" refers to hires were the firm reported "no recruiting" as their vacancy duration (i.e., a zero-duration vacancy). "Always" refers to hires where the firm reported that they are "always recruiting" for the reported position.

Table 2
Starting Wage and recruiting summary statistics by vacancy duration.

(a) Unconditional Estimates					
Vacancy Duration	***N***	**Starting Wage (1982 $)**	**Applications per Week**	**Interviews per Week**	**Recruiting Effort per Week**
No recruiting reported	266	4.95	2.3	1.8	3.4
1 week or less	560	4.02	22.3	12.3	14.2
1–2 weeks	331	3.87	6.9	4.9	7.5
2 weeks-1 month	215	5.16	3.0	2.1	5.0
1 month or more	132	6.12	1.5	1.2	2.1
(b) Conditional on Observable Firm and Job Characteristics					
Vacancy Duration	***N***	**Starting Wage (1982 $)**	**Applications per Week**	**Interviews per Week**	**Recruiting Effort per Week**
No recruiting reported	266	4.94	6.3	3.5	5.4
1 week or less	560	4.38	17.3	10.2	12.1
1–2 weeks	331	4.09	7.7	5.1	7.8
2 weeks-1 month	215	4.64	6.2	3.4	5.3
1 month or more	132	4.97	5.7	3.8	4.6

Notes: Estimates from authors' calculations using the 1982 wave of the EOPP survey. All estimates are sample weighted.

the duration of the vacancy. Our main finding is very robust: vacancies that pay higher wages tend to attract fewer applicants per week, fewer interviewees per week and take more time to fill.

4.1. Vacancy duration, applications, interviews, and the starting wage

We begin by estimating the relationship between the starting wage and recruiting outcomes conditional on our definition of a labor market and on firm, job, worker, and recruitment characteristics. Our baseline specification is

$$\ln Y_{ijk} = \alpha_m + \beta \ln w_{ijk} + J_j \gamma + Z_k \delta + \varepsilon_{ijk}, \tag{1a}$$

where Y_{ijk} represents one of our three recruiting outcome variables (vacancy duration, applications received per week of vacancy duration, or job interviews given per week of vacancy duration) for hire i to job j at firm k. The starting month and year of the hire are controlled for with a vector of dummy variables, α_m. Our main variable of interest is the (log) real starting wage, $\ln w_{ijk}$. The vector of observed job characteristics, J_j, includes a set of dummy variables for two-digit occupation code, and separate indicators for whether the job was temporary or seasonal, involved a subsidized hire, was a minimum-wage job, or was a part-time position. The vector of firm characteristics, Z_k, includes a set of dummy variables for metropolitan area and a set of dummy variables for two-digit industry code. We consider this specification as our "baseline" since it includes the controls that seem most likely to define a particular labor market (e.g., a full-time accountant within the finance industry in New York).

Our extended specification is

$$\ln Y_{ijk} = \alpha_m + \beta \ln w_{ijk} + \eta \ln e_{ijk} + \tilde{J}_j \gamma + \tilde{Z}_k \delta + X_i \theta + \varepsilon_{ijk}, \tag{1b}$$

where $\ln e_{ijk}$. is recruiting effort measured as the (log) number of employee hours per week dedicated to recruiting, $\tilde{J}_j$ includes additional characteristics of the job, $\tilde{Z}_k$ includes additional characteristics of the firm, and X_i is a set of characteristics of the worker hired. In this specification, the additional job and firm controls include firm size (the log of employment), the percent of the workforce unionized, the firm's employment growth rate over the previous six months, and a measure of worker turnover (total quits and fires in the preceding quarter, as a percent of employment). The worker controls, included in the vector X_i, include sex, age, age squared, education categories, (log) relevant work experience, veteran status, and an indicator for any vocational training. We include recruitment effort because we are curious about the relationship between effort and recruitment outcomes (although we understand

Table 3
Summary statistics by incidence of recruiting.

Category	Vacancy Duration			
	No Recruiting	Up to 1 Week	1 Week - 1 Month	> 1 Month
Observations	266	560	546	140
Fraction from a Referral	0.804	0.629	0.659	0.730
Fraction from a "Walk-In" Applicant	0.194	0.180	0.145	0.138
Mean Hours Spent Training Hire	115.7	59.5	78.7	119.7
Fraction Still with Firm	0.649	0.725	0.721	0.709
Firm and Job Characteristics				
Firm Size (employees)	9.6	22.4	28.4	22.9
Firm Growth (Jul-Dec 1981, percent)	–3.7	3.7	–2.3	2.6
Firm Turnover (1981, percent of employment)	31.9	53.3	31.7	26.5
Fraction of Workforce Unionized	0.052	0.061	0.045	0.050
Fraction Manufacturing	0.108	0.100	0.058	0.046
Fraction Professional Services	0.240	0.195	0.286	0.248
Fraction Other Services	0.172	0.206	0.179	0.141
Fraction Retail Trade	0.263	0.174	0.212	0.205
Fraction Part-Time	0.273	0.318	0.197	0.096
Fraction Temporary/Seasonal Work	0.234	0.182	0.109	0.099
Fraction Subsidized Hire	0.026	0.025	0.044	0.030
Mean Productivity Index (Highest = 5)	2.02	2.19	2.04	2.20
Fraction Management	0.103	0.025	0.086	0.130
Fraction Professional/Technical Job	0.080	0.065	0.098	0.104
Fraction Goods-Producing or Maintenance	0.282	0.207	0.203	0.247
Fraction Sales Job	0.175	0.122	0.136	0.344
Characteristics of the Hire				
Fraction Female	0.442	0.387	0.514	0.264
Mean Age	29.1	25.7	27.4	29.6
Yrs. Education	12.90	12.21	12.65	13.30
Yrs. Relevant Experience	3.07	2.07	3.79	3.51

Notes: Estimates from authors' calculations using the 1982 wave of the EOPP survey. All estimates are sample weighted.

that we need to be cautious in interpreting the coefficient η because of potential endogeneity). We include additional job and firm characteristics to try and capture aspects of the value of the job to a worker that are not captured by the wage (e.g., expected duration of the job, union protection, etc.) or aspects of the firm that affect its prominence in the market and hence its ability to attract applicants (e.g., firm size, firm growth). We include controls for worker's characteristics as an attempt to capture additional requirements of the job that might affect the size of the pool of applicants that are qualified for the job (e.g., experience, education, etc.), or that might be reflected into the wage after the applicant has been selected (e.g., age, gender, etc.)

The main coefficient of interest is β , which is the "elasticity" of the recruiting outcome with respect to the starting wage.[10] The regressions are run on the sample of 1982 observations with a positive, finite vacancy duration and regression estimates are sample-weighted. Table 4 presents the regression results for the regressions of the (log) vacancy duration, (log) applications per week, and (log) interviews per week in three panels, respectively. We first show results for specifications that only control for the month of the hire (column 1). We then show results for the "baseline" regression model (column 2), for the regression model with additional controls for job and firm characteristics (column 3), for worker characteristics (column 4), and for recruitment effort (column 5). Finally, we show results for the full regression model (column 6).

In the regression model with only time controls, the estimated elasticity with respect to the wage of vacancy duration is large and positive, while the elasticities with respect to the wage of applications and interviews per week is large and negative. In the baseline regression model, which controls for the labor market characteristics (time, location, industry and occupation), the estimated elasticities of recruitment outcomes with respect to the wage are smaller in magnitude but maintain the same sign. In particular, the elasticity of vacancy duration with respect to the wage is 0.39, the elasticity of the number of applications per week with respect to the wage is -0.40, and the elasticity of the number of interviews per week with respect to the wage is -0.39. All of these elasticities are statistically significant. We do not interpret these findings in a casual sense—i.e., if a firm were to increase its wage, it would attract fewer applicants. Rather, we interpret them as simply saying that the firms in our dataset that do pay higher wages attract fewer applicants per week, interview fewer candidates per week, and take longer to fill their vacancies.

In the regression models with additional controls, the elasticities of recruitment outcomes with respect to the wage have different point estimates. However, in all specifications, the elasticities maintain the same sign, are similar in magnitude, and maintain statistical significance.[11]

We also find that the amount of recruiting effort per week is also strongly and significantly related to the three recruiting outcomes. It is strongly negatively related to vacancy duration and strongly positively related to applications and interviews per week.In other words, higher recruiting effort is correlated with more applicants and interviews and leads to shorter vacancy durations (i.e., higher job-filling rates). The fact

[10] Even though we are going to use the word elasticity, we do not mean to imply any direct causal relationship between the wage and recruitment outcomes. We simply use the word elasticity to refer to the empirical relationship between the log of the wage and the log of one of our recruitment outcomes.

[11] We also estimated specifications that regress log applications and log interviews on the right-hand side of (1a) and (1b), including log vacancy duration on the right-hand side. To deal with potential division bias, we also included (log) recruiting effort, in levels, in the specifications that include effort. All specifications produce estimates that are somewhat smaller in magnitude but otherwise qualitatively similar to those in Table 4.

Table 4
Elasticity of recruiting outcomes with respect to the starting wage, 1982 EOPP survey.

(a) Dependent Variable: ln (Vacancy Duration)

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Real Starting Wage)	0.763**	0.385**	0354**	0293**	0.466**	0.273**
	(0.082)	(0.104)	(0.109)	(0.120)	(0.078)	(0.089)
ln(Recruiting Effort per Week)					−0.577**	−0.598**
					(0.021)	(0.021)
Baseline Controls Included?		Yes	Yes	Yes	Yes	Yes
Additional Firm and Job Controls?			Yes			Yes
Additional Worker Controls?				Yes		Yes
R-squared	0.216	0.539	0.542	0.549	0.740	0.754

(b) Dependent Variable: ln (Applications per Week)

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Real Starting Wage)	−0.839**	−0.395**	−0.431**	−0.519**	−0.515**	−0.491**
	(0.104)	(0.134)	(0.140)	(0.140)	(0.086)	(0.098)
ln(Recruiting Effort per Week)					0.860**	0.874**
					(0.023)	(0.023)
Baseline Controls Included?		Yes	Yes	Yes	Yes	Yes
Additional Firm and Job Controls?			Yes			Yes
Additional Worker Controls?				Yes		Yes
R-squared	0.241	0.533	0.539	0.548	0.806	0.811

(c) Dependent Variable: ln (Interviews per Week)

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Real Starting Wage)	−0.794**	−0.392**	−0.420**	−0.466**	−0.502**	−0.441**
	(0.092)	(0.118)	(0.124)	(0.137)	(0.072)	(0.082)
ln(Recruiting Effort per Week)					0.789**	0.808**
					(0.019)	(0.019)
Baseline Controls Included?		Yes	Yes	Yes	Yes	Yes
Additional Firm and Job Controls?			Yes			Yes
Additional Worker Controls?				Yes		Yes
R-squared	0.247	0.538	0.541	0.549	0.829	0.838

Notes: Estimates from authors' calculations using the 1982 wave of the EOPP survey. All regressions are sample-weighted weighted and include dummy variables for the starting month of the hire. See text for variables included in the baseline controls, firm and job controls, and worker controls. $N = 1{,}238$. Standard errors are in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.

that recruiting effort would significantly affect recruiting outcomes is not surprising. Most, however, would expect recruiting effort to have the largest impact on the screening and selection process (see, e.g., Wolthoff, 2014). In contrast, we find that higher recruiting effort is related to a vacancy having more applicants, which in turn is related to a higher job-filling rate. One interpretation of these findings is that recruiting effort may not only aid in improving match quality but may also improve the probability of a hire as well. Another interpretation is that recruiting effort increases mechanically with applications because, for every application received, some effort has to be devoted to vet it.

4.2. Panel data estimates, accounting for firm heterogeneity

Next, we attempt to control for the role of fixed, unobserved firm heterogeneity using an unbalanced panel of firms from the 1980 and 1982 surveys. This is an important robustness check as one might worry that the relationship between wages and recruiting outcomes is spuriously driven by heterogeneity in unobserved features of the firm that affect the worker's valuation of the job or by heterogeneity in unobserved features of the firm that affect its visibility in the labor market. For example, one might worry about the possibility that firms with a pleasant work environment can attract more applicants even though they offer lower wages. Similarly, one might worry about the possibility that some firms are better known than others and, hence, can attract more applicants even though they offer lower wages.

As we noted in Section 2, firms originally surveyed in 1980 are re-interviewed in 1982. The 1980 survey also asked firms about their most recent subsidized and non-subsidized hire, implying that a firm can have up to three hires reported in the pooled sample. Note that while the panel data approach allows us to control for any fixed unobservable characteristics of the firm, it does not allow us to control for any fixed unobservable characteristics of the job or the hire. It also has the additional drawback that we are limited to the variables that are available in the 1980 survey. Therefore, we only report results using (log) vacancy duration and (log) job interviews per week as dependent variables. We focus on firms that report a hire in both 1980 and 1982. The panel remains unbalanced because, in addition to the potential for two hiring observations in 1980, some of these hires were done without recruiting, and are therefore excluded from the sample.

Our approach re-estimates (1a) and (1b) using the firm panel. We include only variables available in both surveys. Additionally, when we include firm fixed effects, we must also drop the variables that are firm-invariant.[12] Table 5 shows that including firm fixed effects actually

[12] Variables that are unavailable in the 1980 data are: (log) applications per week, the part-time and temporary or seasonal status of the job, the union share

Table 5
Elasticity of recruiting outcomes with respect to the starting wage, 1980-82 EOPP panel.

Dependent Variable:	***ln (Vacancy Duration)***				***ln (Interviews per Week)***			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ln(Real Starting Wage)	0.477**	0.878**	0.538**	0.470**	−0.346**	−0.665**	−0.361**	−0.336**
	(0.092)	(0.174)	(0.133)	(0.155)	(0.075)	(0.132)	(0.086)	(0.100)
ln(Recruiting Effort per Week)			−0.776**	−0.763**			0.692**	0.701**
			(0.034)	(0.035)			(0.022)	(0.023)
Firm Fixed Effects?		Yes	Yes	Yes		Yes	Yes	Yes
Baseline Controls Included?	Yes	Yes[a]	Yes[a]	Yes[a]	Yes	Yes[a]	Yes[a]	Yes[a]
Additional Firm and Job Controls?				Yes				Yes
Additional Worker Controls?				Yes				Yes
R-squared	0.436	0.835	0.905	0.912	0.396	0.906	0.937	0.942

Notes: Estimates from authors' calculations using a merged panel of firms that responded to both the 1980 and 1982 EOPP surveys. All regressions are sample-weighted and include dummy variables for the starting month of the hire. See text for variables included in the baseline controls, firm and job controls, and worker controls. $N = 1922$. Standard errors are in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
[a] When firm fixed effects are used, the industry and metropolitan area dummies are excluded from the baseline controls.

increases the magnitude of the elasticities with respect to wages. The estimate of the elasticity of vacancy duration rises from 0.48 to 0.88, while the elasticity of interviews per week increases in magnitude from -0.35 to -0.65. Further, notice that the elasticity estimates in the specifications that exclude firm fixed effects are very similar to the analogous estimates in Table 4 (0.48 vs. 0.39, and -0.35 vs. -0.39, for vacancy duration and interviews, respectively). When we add both firm fixed effects and additional controls for firm, job, and worker characteristics, the estimated elasticities become smaller in absolute value. These estimates are also comparable to their counterparts in Table 4.

4.3. True duration dependence

Table 2 shows that vacancies that are filled in a week or less receive more applicants per week than vacancies that are filled after 2 weeks, which in turn receive more applicants per week than vacancies that are filled after a month. One interpretation of the observed duration dependence is that it is "spurious"—that is, duration dependence is due to the fact that the wage is negatively related to applications per week and positively related to the duration of the vacancy. This is the interpretation that lies behind the regression models in (1a) and (1b). Another interpretation of duration dependence is that it is "true"—that is, all else equal, firms receive fewer vacancies the longer a vacancy stays open.[13] Under this view, our estimated elasticity of the number of applications per week with respect to the wage conflates two channels. The first channel is the direct relationship between the wage and the number of applications received by a vacancy each week. The second channel is the indirect relationship between the wage and the number of applications that operates through the relationship between the wage and the duration of the vacancy. Here we attempt to isolate the direct channel.

We account for true duration dependence by imputing first-week values for applications, interviews, and recruiting effort under the assumption that these measures decline exponentially over the duration of the vacancy. We then use the imputed first-week values rather than the average-per-week values when re-estimating our model in (1a) and (1b) for applications and job interviews. Specifically, we assume that applications, job interviews, and recruiting effort follow the following process:

$$x_j(t) = \mu\alpha d(t)^{\alpha+1} e^{\varepsilon_j(t)},$$

where $x_j(t)$ represents the amount of applications, job interviews, or recruiting effort measured t days after vacancy j was posted, α is the parameter that determines the steepness of the exponential decline, μ is a scaling parameter, and $\varepsilon_j(t)$ is an error term.[14] The process can be estimated in log form using OLS on the following equation:

$$\text{In } x_j(t) = b_o + b_1 \text{ In } d(t) + \varepsilon_j(t). \tag{2}$$

Using this equation, we can account for duration dependence in the data by conditioning out $\hat{b}_1 \ln d(t)$, making our imputed first-week value of $\text{Inx}_j\ (t)$ equal to $\hat{b}_0 + \hat{\varepsilon}_j(t)$. We generate these estimates for the 1982 sample and re-estimate (1a) and (1b). Our results are in Table 6.

As expected, we find that—under the assumption of true duration dependence—the elasticities of the number of applications and the number of interviews per week with respect to the wage fall in magnitude. Indeed, in the most basic specification of the regression model, the elasticities of applications and interviews with respect to the wage fall to zero. In richer specifications of the regression model which include additional controls on firm, job, and worker characteristics, however, the elasticities fall in magnitude but remain negative and statistically significant.

5. Theory

The key empirical fact from the previous section is that jobs paying higher wages tend to receive fewer applications and tend to be filled more slowly than jobs paying lower wages. At first blush, this fact seems hard to reconcile with the popular view of a labor market in which firms post wages and workers direct their search based on that information. Indeed, why would a firm offer a higher wage if that means waiting longer to fill its vacancy? Similarly, why would a worker apply to a low-wage firm if that means competing with more applicants and, if hired, being paid a lower wage? In this section, we show that—if workers and jobs are heterogeneous (to a greater extent than what we can control for in the data) and the interaction of the worker's type and the job's type in production satisfies some reasonable assumptions—the equilibrium of a labor market in which firms post wages and workers direct their

of the firm's employees, and the veteran status and vocational training of the hire. Two-digit industry and metro area controls are excluded when firm fixed effects are included. Finally, when observable firm controls are included, we interact the turnover rate and the productivity category variables with survey year because the two are measured differently across the surveys.

[13] This is the view taken by, for example, van Ours and Ridder (1992) and Andrews et al. (2008).

[14] The specification is equivalent to the probability density function of a Pareto distribution with lower support equal to one, shape parameter α, and a scaling parameter μ.

Table 6
Elasticity of Recruiting Outcomes with Respect to the Starting Wage, Accounting for Duration Dependence in Recruiting Behavior.

Dependent Variable:	*ln (Applications, First Week)*			*ln (Interviews, First Week)*		
	(1)	(2)	(3)	(1)	(2)	(3)
ln(Real Starting Wage)	–0.042	–0.285**	–0.353**	–0.052	–0.246**	–0.291**
	(0.096)	(0.081)	(0.092)	(0.073)	(0.060)	(0.068)
ln(Recruiting Effort, First Week)		0.606**	0.615**		0.484**	0.495**
		(0.028)	(0.029)		(0.021)	(0.022)
Baseline Controls Included?	Yes	Yes	Yes	Yes	Yes	Yes
Additional Firm and Job Controls?			Yes			Yes
Additional Worker Controls?			Yes			Yes
R-squared	0.501	0.659	0.673	0.551	0.707	0.721

Notes: Estimates from authors' calculations using the 1982 wave of the EOPP survey. All regressions are sample-weighted and include dummy variables for the starting month of the hire. Applications, interviews, and recruiting effort are all imputed first-week values that assume each variable's reported value declines exponentially with vacancy duration. See text for details of the imputation methodology and for variables included in the baseline controls, firm and job controls, and worker controls. $N = 1238$. Standard errors are in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.

search is such that the wage paid by jobs is negatively correlated with the number of applications it attracts and the velocity at which it is filled.

5.1. Model

We use the model of Shimer (2005), which is a general model of directed search with two-sided heterogeneity. The labor market is populated by heterogeneous workers and heterogeneous firms.[15] In particular, there is a measure μ_j of workers of type $j = \{l, h\}$. Each one of these workers is unemployed and applies to only one job. A worker's payoff is equal to his labor income. There is also a measure v_i of firms of type $i = \{l, h\}$. Each one of these firms has one job. A firm's payoff is equal to its output net of the labor income it pays to its worker. To simplify the algebra, we assume that the measure of firms of type i is equal to 1, i.e., $v_l = v_h = 1$.

A firm of type i and a worker of type j produce $y_{ij} > 0$ units of output. A worker without a job produces zero units of output. Similarly, a firm without a worker produces zero units of output. We assume that $y_{ih} > y_{il}$ for $i = \{l, h\}$. That is, we assume that workers of type h are more productive than workers of type l when matched with either type of firm. Without loss of generality, we also assume that $y_{hh} - y_{hl} \geq y_{lh} - y_{ll}$. That is, we assume that the additional output produced by workers of type h relative to workers of type l is at least as large at firms of type h as it is at firms of type l .

Firms and workers come together according to a process of directed search. First, firms post wages. In particular, a firm posts wages (w_l, w_h) , where w_l is the wage the firm pays if it hires a worker of type l and w_h is the wage the firm pays if it hires a worker of type h . Second, workers observe the wages offered by different firms and choose where to apply. As is standard in directed search, we require that workers follow symmetric strategies, in the sense that all workers of type j apply to various jobs with the same probability. Third, firms observe the number and type of applicants. Given our assumptions on y_{ij} , all firms prefer workers of type h . If a firm receives some applications from workers of type h , it chooses one of these workers at random and hires him. If a firm receives no applications from workers of type h and some from workers of type l , it randomly chooses one of the type-l applicants and hires him. If a firm does receive any applications, it remains idle.

5.2. Social planner's problem

Proposition 2 in Shimer (2005) states that the equilibrium allocation of applications to firms in this setting is the same as the solution to the following social planner's problem. The objective of the social planner is to maximize aggregate output. The choice of the social planner is the probability p_{ij} with which a worker of type j applies to one of the jobs of type i . In the spirit of symmetric strategies, a worker of type j is equally likely to apply to any one of the jobs of type i . Therefore, given probabilities p_{ij} , the number of applications from workers of type j to a firm of type i is a Poisson random variable with average $q_{ij} = p_{ij}\mu_j / v_i$.

Formally, the social planner's problem is

$$\max_{q_{ij}} \sum_{i=\{l,h\}} \left[(1 - e^{-q_{ih}})y_{ih} + e^{-q_{ih}}(1 - e^{-q_{il}})y_{il}\right], \tag{3}$$

subject to

$$q_{lj} + q_{hj} = \mu_j, \quad \text{for} \quad j = \{l, h\} \tag{4}$$

Let us briefly explain the objective function in (3). There is a measure 1 of firms of type i . A firm of type i receives at least one application from a worker of type h with probability $1 - e^{-q_{ih}}$. In this case, the firm hires the worker of type h and produces y_{ih} units of output. A firm of type i does not receive any application from a worker of type h , but at least one application from a worker of type l with probability $e^{-q_{ih}}(1 - e^{-q_{il}})$. In this case, the firm hires a worker of type l and produces y_{il} units of output. In any other case, the firm does not have any applicants and its output is 0. The constraint (4) is an aggregate feasibility constraint for each worker type j . There is a measure 1 of firms of type i and each of them receives q_{il} applicants of type l and q_{ih} applicants of type h . The constraint (4) states that the measure of applicants of type j received by all firms is equal to the measure μ_j of workers of type j .

Shimer (2005) proves that the first order conditions of the planner's problem are both necessary and sufficient for optimality. The first order conditions are given by

$$e^{-q_{ih}} e^{-q_{il}} y_{il} \leq \phi_l \quad \text{and} \quad q_{il} \geq 0, \quad \text{for} \quad i = \{l, h\} \tag{5}$$

$$e^{-q_{ih}}\left[y_{ih} - (1 - e^{-q_{il}})y_{il}\right] \leq \phi_h \text{ and } q_{ih} \geq 0, \text{ for } i = \{l, h\} \tag{6}$$

where ϕ_j is the Lagrange multiplier on (4) and the two pairs of inequalities in (5) and (6) hold with complementary slackness.

The optimality condition (5) is easy to understand. The left-hand side is the marginal benefit of increasing q_{il} . An increase in q_{il} raises the probability that a firm of type i receives at least one application from a worker of type l by $e^{-q_{il}}$. The value of receiving at least one application from a worker of type l is given by $e^{-q_{lh}} y_{ll}$, which is the probability that the firm does not receive any application from a worker of type h times the output produced by a worker of type l . The right-hand side is the marginal cost of increasing q_{il} , which is the Lagrange multiplier on

[15] In the model, we refer to firms and jobs interchangeably, as every firm has only one job. However, the model is really about jobs and not firms.

the aggregate resource constraint for workers of type l. The optimality condition (5) then states that the marginal benefit of increasing q_{il} must be at most equal to the marginal cost, and must equal the marginal cost if q_{il} is strictly positive.

The optimality condition (6) is also easy to understand. The left-hand side is the marginal benefit of increasing q_{ih}. An increase in q_{ih} raises the probability that a firm of type i receives at least one application from a worker of type h by $e^{-q_{ih}}$. The value of receiving at least one application from a worker of type h is given by $y_{ih}-(1-e^{-q_{il}})y_{il}$, which is the difference between the output y_{ih} produced by the firm with an h-worker minus the output $(1-e^{-q_{il}})y_{il}$ that the firm could have produced if it had received no applications from h-workers. The right-hand side is the marginal cost of increasing q_{ih}, which is the Lagrange multiplier on the resource constraint for workers of type h. The optimality condition (6) then states that the marginal benefit of increasing q_{ih} must be at most equal to the marginal cost, and must equal the marginal cost if q_{ih} is strictly positive.

Now, let us conjecture that the solution to the social planner problem is interior. Later we will find parametric conditions under which this conjecture is correct. At an interior solution, the ratio between the left-hand side of (6) and the left-hand side of (5) for $i=l$ equals the ratio between the left-hand side of (6) and the left-hand side of (5) for $i=h$. This equality can be written as

$$\frac{y_{lh}-y_{ll}}{y_{ll}e^{-q_{ll}}}=\frac{y_{hh}-y_{hl}}{y_{hl}e^{-q_{hl}}}. \tag{7}$$

Using the resource constraint (4), we can solve (7) with respect to q_{ll} and q_{hl} and obtain

$$q_{ll}=\frac{\mu_l}{2}+\frac{1}{2}\left[\log\left(\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\right)-\log\left(\frac{y_{hl}}{y_{ll}}\right)\right], \tag{8}$$

$$q_{hl}=\frac{\mu_l}{2}-\frac{1}{2}\left[\log\left(\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\right)-\log\left(\frac{y_{hl}}{y_{ll}}\right)\right]. \tag{9}$$

The above expressions imply that a firm of type l receives more applicants of type l than a firm of type h if and only if $(y_{hh}-y_{hl})/(y_{lh}-y_{ll})$ is greater than y_{hl}/y_{ll}.

At an interior solution, the left-hand side of (5) for $i=l$ equals the left-hand side of (5) for $i=h$. This equality can be written as

$$e^{-(q_{ll}+q_{lh})}y_{ll}=e^{-(q_{hl}+q_{hh})}y_{hl}. \tag{10}$$

Using (8), (9) and the resource constraint (4), we can solve (10) with respect to q_{lh} and q_{hh} and obtain

$$q_{lh}=\frac{\mu_h}{2}-\frac{1}{2}\log\left(\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\right), \tag{11}$$

$$q_{hh}=\frac{\mu_h}{2}+\frac{1}{2}\log\left(\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\right). \tag{12}$$

The above expressions imply that a firm of type h receives more applicants of type h than a firm of type l, since—by definition—a firm of type h has more to gain from producing with a type-h worker rather than with a type-l worker than a firm of type l does, i.e., $y_{hh}-y_{hl}>y_{lh}-y_{ll}$.

Finally, we can use (8)-(9) and (11)-(12) to find conditions under which the solution to the social planner's problem is interior. In particular, the necessary and sufficient conditions for $q_{ij}>0$ for $i=\{l,h\}$ and $j=\{l,h\}$ are given by

$$\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\in(e^{-\mu_h},e^{\mu_h}), \tag{13}$$

$$\frac{y_{hh}-y_{hl}}{y_{lh}-y_{ll}}\in\frac{y_{hl}}{y_{ll}}(e^{-\mu_l},e^{\mu_l}). \tag{14}$$

5.3. Market decentralization

In equilibrium, firms of type i offer wages (w_{il},w_{ih}) that attract an average of q_{il} applications from workers of type l and an average of q_{ih} applications from workers of type h, where q_{il} and q_{ih} are the same queue lengths as in the solution to the planner's problem. Shimer (2005) shows that the wages (w_{il},w_{ih}) offered by firms of type i are

$$w_{il}=\frac{e^{-q_{il}}q_{il}}{1-e^{-q_{il}}}y_{il}, \tag{15}$$

$$w_{ih}=\frac{e^{-q_{ih}}q_{ih}}{1-e^{-q_{ih}}}\left[y_{ih}-(1-e^{-q_{il}})y_{il}\right]. \tag{16}$$

Let us explain the above expressions for the equilibrium wages. Start with (15). If a worker of type l applies to a firm of type i, he is hired with probability $e^{-q_{ih}}(1-e^{-q_{il}})/q_{il}$ and, conditional on being hired, he earns the wage w_{il}. The worker's expected payoff from applying to a firm of type i must be equal to the worker's maximized payoff from applying anywhere else. In a directed search model, this is equal to ϕ_l, the value of the worker to the social planner, because firms compete for workers . Eq. (6) tells us that ϕ_l is equal to the marginal social value of increasing q_{il}, i.e. $e^{-q_{ih}}e^{-q_{il}}y_{il}$. From these observations, it follows that the equilibrium wage w_{il} is given by (15).

Next, consider (16). If a worker of type h applies to a firm of type i, he is hired with probability $(1-e^{-q_{ih}})/q_{ih}$ and, conditional on being hired, he earns the wage w_{ih}. The worker's expected payoff from applying to a firm of type i must be equal to the worker's maximized payoff from applying anywhere else, ϕ_h. Eq. (6) tells us that ϕ_h is equal to the marginal social value of increasing q_{ih}, i.e., $e^{-q_{ih}}[y_{ih}-(1-e^{-q_{il}})y_{il}]$. From these observations, it follows that the equilibrium wage w_{ih} is given by (16).

5.4. Wages, applications, and job-filling rates

We now want to find a set of conditions for the parameters that describe the production process under which a firm of type h receives fewer applications, has a lower job-filling probability, and pays higher wages than a firm of type l. To carry out this task, it is useful to represent the production process with the tuple $(y_{ll},\delta_l,\rho_y,\rho_\delta)$, where δ_l denotes $y_{lh}-y_{ll}$, ρ_y denotes the ratio y_{hl}/y_{ll} and ρ_δ denotes the ratio $(y_{hh}-y_{hl})/(y_{lh}-y_{ll})$. Given $(y_{ll},\delta_l,\rho_y,\rho_\delta)$, one can recover the tuple $(y_{ll},y_{lh},y_{hl},y_{hh})$ as $y_{lh}=y_{ll}+\delta_l$, $y_{hl}=y_{ll}\rho_y$, and $y_{hh}=y_{ll}+\delta_l\rho_\delta$.

A firm of type h receives, on average, $q_{hl}+q_{hh}$ applications. A firm of type l receives, on average, $q_{ll}+q_{lh}$ applications. Using (8)-(9) and (11)-(12), we can express the ratio between $q_{hl}+q_{hh}$ and $q_{ll}+q_{lh}$ as

$$\frac{q_{hl}+q_{hh}}{q_{ll}+q_{lh}}=\frac{\mu_l+\mu_h+\log\rho_y}{\mu_l+\mu_h-\log\rho_y}. \tag{17}$$

The above expression implies that $q_{hl}+q_{hh}<q_{ll}+q_{lh}$ if and only if $\rho_y<1$. That is, a firm of type h receives fewer applications than a firm of type l if and only if a firm of type h produces less output with an l-worker than a firm of type l does.

A firm of type h fills its vacant job with an h-worker with probability $(1-e^{-q_{hh}})$ and with an l-worker with probability $e^{-q_{hh}}(1-e^{-q_{hl}})$. Overall, a firm of type h fills its vacant job with probability $(1-e^{-(q_{hl}+q_{hh})})$. Similarly, a firm of type l fills its vacant job with probability $(1-e^{-(q_{ll}+q_{lh})})$. Using (8)-(9) and (11)-(12), we can express the ratio between the job-filling probability for a firm of type h and the job-filling probability for a firm of type l as

$$\frac{1-e^{-(q_{hl}+q_{hh})}}{1-e^{-(q_{ll}+q_{lh})}}=\frac{1-e^{-(\mu_l+\mu_h+\log\rho_y)/2}}{1-e^{-(\mu_l+\mu_h-\log\rho_y)/2}}.$$

The above expression implies that $1-e^{-(q_{hl}+q_{hh})}<1-e^{-(q_{ll}+q_{lh})}$ if and only if $\rho_y<1$. That is, a firm of type h has a lower job-filling probability than a firm of type l, and hence a longer vacancy duration, if and only if a firm of type h produces less output with an l -worker than a firm of type l .

The average wage paid by a firm of type i is

$$w_i = \alpha_i w_{ih} + (1 - \alpha_i) w_{il},$$

where α_i is the probability that the worker hired by the firm is of type h and $1-\alpha_i$ is the probability that the worker hired by the firm is of type l . That is, α_i is

$$\alpha_i = \frac{1 - e^{-q_{ih}}}{1 - e^{-(q_{il} + q_{ih})}}.$$

We can express the difference between the average wage paid by a firm of type h and the average wage paid by a firm of type l as

$$w_h - w_l = \alpha_l (w_{hh} - w_{lh}) + (1 - \alpha_l)(w_{hl} - w_{ll}) + (\alpha_h - \alpha_l)(w_{hh} - w_{hl}).$$

The above decomposition implies that $w_h > w_l$ if: the probability that the worker hired by an h -firm is of type h is higher than the probability that the worker hired by an l -firm is of type h , i.e. $\alpha_h > \alpha_l$; an h -firm offers higher wages than an l -firm, i.e. $w_{hh} \geq w_{lh}$ and $w_{hl} \geq w_{ll}$; and an h -firm offers a higher wage to a worker of type h than to a worker of type l , i.e. $w_{hh} > w_{hl}$.

The ratio between the probability that the worker hired by an h -firm is of type h , α_h , and the probability that the worker hired by an l -firm is of type h , α_l , is given by

$$\frac{\alpha_h}{\alpha_l} = \frac{1 - e^{-q_{hh}}}{1 - e^{-(q_{hl} + q_{hh})}} \cdot \frac{1 - e^{-(q_{ll} + q_{lh})}}{1 - e^{-q_{lh}}}. \tag{18}$$

The right-hand side of (18) is certainly greater than 1 if $q_{hh} \geq q_{lh}$ and $q_{hl} + q_{hh} \leq q_{ll} + q_{lh}$. From (11) and (12), it follows that $q_{hh} \geq q_{lh}$ because $(y_{hh} - y_{hl})/(y_{lh} - y_{ll}) = \rho_\delta \geq 1$. From (17), it follows that $q_{hl} + q_{hh} \leq q_{ll} + q_{lh}$ if and only if $\rho_y \leq 1$. Therefore, a sufficient condition for $\alpha_h > \alpha_l$ is $\rho_y < 1$. That is, if an h -firm produces less output with a worker of type l than an l -firm, the probability that the worker hired by an h -firm is of type h is higher than the probability that the worker hired by an l -firm is of type h .

From (15), the ratio between the wage offered by an h -firm to a worker of type h , w_{hh} , and the wage offered by an l -firm to a worker of type l , w_{lh} , is given by

$$\frac{w_{hh}}{w_{lh}} = \left(\frac{1 - e^{-q_{lh}}}{q_{lh}} \right) \cdot \frac{q_{hh}}{1 - e^{-q_{hh}}}. \tag{19}$$

The first term on the right-hand side of (19) is $(1 - e^{-q_{lh}})/q_{lh}$, which is the probability that a worker of type h applying to an l -firm gets hired. The second term on the right-hand side of (19) is $q_{hh}/(1 - e^{-q_{hh}})$, which is the inverse of the probability that a worker of type h applying to an h -firm gets hired. Since $q_{hh} \geq q_{lh}$, an h -firm receives more applications from workers of type h than an l -firm and, consequently, a worker of type-h is more likely to be hired if he applies to a firm of type l than to a firm of type h . Therefore, $w_{hh} \geq w_{lh}$.

From (15) and (16), the ratio between the wage offered by an h -firm to a worker of type h , w_{hh} , and the wage offered by an h -firm to a worker of type l , w_{hl} , is given by

$$\frac{w_{hh}}{w_{hl}} = \frac{\epsilon(q_{hh})[y_{hh} - y_{hl} + e^{-q_{hl}} y_{hl}]}{\epsilon(q_{hl}) y_{hl}} \geq \frac{\epsilon(q_{hh}) \rho_\delta \delta_l}{\epsilon(q_{hl}) \rho_y y_{ll}}. \tag{20}$$

where $\epsilon(q) = e^{-q} q/(1 - e^{-q})$ is the elasticity of the job-filling probability $1 - e^{-q}$ with respect to q , and the inequality follows from the fact that $e^{-q_{hl}} y_{hl} \geq 0$. After substituting q_{hl} and q_{hh} with (9) and (11), we find that the right-hand side of (20) is greater than 1 if and only if

$$\delta_l > \frac{\epsilon[(\mu_l - \log\rho_\delta + \log\rho_y)/2]}{\epsilon[(\mu_h + \log\rho_\delta)/2]} \cdot \frac{\rho_y y_{ll}}{\rho_\delta}. \tag{21}$$

Therefore, $w_{hh} \geq w_{hl}$ if δ_l is greater than the right-hand side in (21). That is, an h -firm offers a higher wage to a worker of type h than to a worker of type l if—for given ratios ρ_y and ρ_δ —the difference between the output produced by an l -firm with a worker of type h and with a worker of type l is high enough.

Finally, the ratio between the wage offered by an h -firm to a worker of type l , w_{hl} , and the wage offered by an l -firm to a worker of type l , w_{ll} , is given by

$$\frac{w_{hl}}{w_{ll}} = \frac{\epsilon(q_{hl}) y_{hl}}{\epsilon(q_{ll}) y_{ll}}. \tag{22}$$

After substituting q_{ll} and q_{hl} with (8) and (10), we find that the right-hand side of (22) is greater than 1 if and only if

$$\frac{\epsilon[(\mu_l + \log\rho_\delta - \log\rho_y)/2]}{\epsilon[(\mu_h - \log\rho_\delta + \log\rho_y)/2]} \leq \rho_y. \tag{23}$$

Let $f(\rho_y)$ denote the value of ρ_δ for which the left-hand side of (23) equals ρ_y . Then, for all $\rho_\delta \geq f(\rho_y)$, condition (28) is satisfied and $w_{hl} \geq w_{ll}$. That is, a worker of type l is offered a higher wage by an h -firm than by an l -firm if the ratio between the extra output produced by a worker of type h at an h -firm and at an l -firm is greater than $f(\rho_y)$. Notice that, $f(1) = 1$ and that $f(\rho_y)$ is strictly decreasing with respect to ρ_y .

We can now summarize our findings by stating the following theorem.

Theorem. : *Let the production process be described by the tuple* $(y_{ll}, \delta_l, \rho_y, \rho_\delta)$ *with* $y_{ll} > 0$, $\delta_l > 0$, $\rho_y > 0$, *and* $\rho_\delta \geq 1$ *: (i) In equilibrium, the queue lengths* $(q_{ll}, q_{lh}, q_{hl}, q_{hh})$ *are strictly positive if and only if* $\rho_\delta \in (e^{-\mu_h}, e^{\mu_h})$ *and* $\rho_\delta \in \rho_y(e^{-\mu_l}, e^{\mu_l})$ *; (ii) In equilibrium, firms of type h pay strictly higher wages, attract strictly fewer applicants and have a strictly lower job-filling probability than firms of type l if* $\rho_y < 1$, $\rho_\delta \geq f(\rho_y)$ *, and* δ_l *is high enough.*

The theorem above is illustrated in Fig. 2. The necessary and sufficient conditions for an interior equilibrium are $\rho_\delta \in (e^{-\mu_h}, e^{\mu_h})$ and $\rho_\delta \in \rho_y(e^{-\mu_l}, e^{\mu_l})$. The lightly-shaded blue area denotes the region of parameters (ρ_y, ρ_δ) where the conditions for an interior equilibrium are satisfied. The necessary and sufficient condition for firms of type h to receive fewer applications and have a lower job-filling probability than firms of type l is $\rho_y < 1$. The sufficient conditions for firms of type h to pay higher wages than firms of type l are $\rho_y < 1$, $\rho_\delta \geq f(\rho_y)$ and δ_l large enough. The heavily-shaded gray area denotes the region of parameters (ρ_y, ρ_δ) where the equilibrium is interior, firms of type-h attract fewer applicants, have a lower job-filling probability, and pay higher wages (for some δ_l high enough).

The theorem shows that the empirical observation that firms paying higher wages receive fewer applications and take longer to fill their vacancies is not at all inconsistent with a view of the labor market in which firms post wages and workers direct their search based on these wages. The first key assumption is that workers are heterogeneous.[16] First, consider the side of the firm. If workers were all identical, a firm would only offer higher wages if that meant attracting more applicants and filling its vacancies faster. If workers are heterogeneous, however, a firm could offer higher wages not because they attract more applicants but because they attract a better pool of applicants. Now, consider the side of the workers. If workers were identical, they would prefer to apply more frequently to high-wage jobs than to low-wage jobs. However, if workers are heterogeneous, this need not be true. High-quality workers still prefer to apply more frequently to high-wage jobs than to low-wage jobs, as their chances of being hired only depend on the number of applications from other high-quality workers. In contrast, low-quality workers may apply less frequently to high-wage jobs than to low-wage jobs because, at high-wage jobs, there are so many more high-quality

[16] More precisely, the assumption is that workers are heterogeneous in some dimension that is not observable to us from the EOPP data (i.e., some dimension not captured by education, experience, or age).

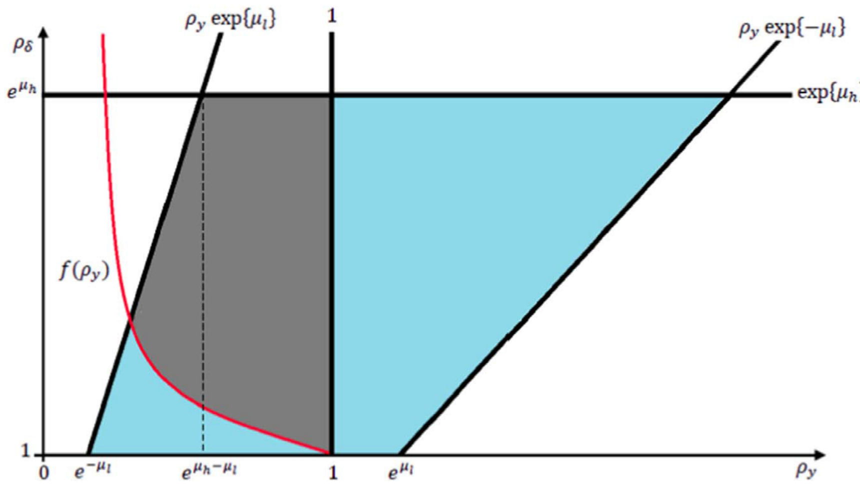

Fig. 2. Wages, applications, and vacancy filling by relative output differences.

applicants that their chances of being hired are much lower. If this second effect is strong enough, the overall number of workers applying to high-wage jobs may be lower than at low-wage jobs.

The second key assumption is that jobs are heterogeneous and the interaction between their type and the worker's type satisfies some particular conditions.[17] These conditions are spelled out in the theorem and they all have a simple intuition. The condition $\rho_\delta \geq 1$ means that jobs of type h have more to gain than jobs of type l by employing high-quality workers than low-quality workers. In turn, this implies that jobs of type h will offer higher wages than jobs of type l to high-quality workers and they will attract more of them. The condition $\rho_y < 1$ means that jobs of type h produce less output than jobs of type l when employing low-quality workers. In turn, this implies that jobs of type h will attract fewer applicants of type l and fewer applicants overall. The condition $\rho_\delta \geq f(\rho_y)$ guarantees that jobs of type h will have to pay low-quality workers more than jobs of type l. Finally, the condition that δ_l is high enough guarantees that high-quality workers are paid more than low-quality workers, even though low-quality workers are hired with lower probability.

The assumptions of the model are quite natural. The assumption that the workers and the jobs participating in any particular labor market are heterogeneous beyond what is observable in the EOPP seems hard to dispute. The assumptions about the interaction between jobs' and workers' types in production are also quite natural. They basically say that there are some "sensitive" jobs and some "regular" jobs. The productivity of sensitive jobs is more responsive to the quality of the workers manning them than the productivity of regular jobs and the productivity of sensitive jobs manned by low-quality workers is lower than the productivity of regular jobs. Our explanation for the fact that jobs paying higher wages attract fewer applicants and take longer to be filled is based on the existence of jobs' and workers' heterogeneity that is not observable in the EOPP. However, if one had data that contained information about the job type, one would recover the standard positive relationship between wages, applicants, and job-filling rates. For instance, using data that identifies jobs as sensitive or not, one would find that—controlling for the type of job—firms that pay higher wages do attract more applicants and fill their vacancies more quickly. Indeed, this is exactly what Marinescu and Wolthoff (2015) find when they control for the exact job title, a much more nuanced variable than an occupational code. Similarly, if one could average out the heterogeneity between different types of jobs, one would recover the standard positive relationship between wages, applicants and job-filling rates. For instance, averaging out the firm's wage across sensitive and regular jobs, one would find that firms with a high average wage attract more applicants and fill vacancies faster. Indeed, this is what Banfi and Villena-Roldán (2015) and Ketterman, Mueller, and Zweimueller (2016) find.

[17] More precisely, the assumption is that firms and jobs are heterogeneous in some dimension that is not captured by the characteristics available in the EOPP survey.

6. Conclusions

In this paper we used the EOPP survey to study the relationship between the wage paid to the worker filling a vacancy, the duration of the vacancy, the number of applications attracted by the vacancy each week, and the number of candidates interviewed for the vacancy each week. We found that, within a particular labor market, the wage is positively related with the duration of the vacancy and negatively related with both the number of applications and the number of interviews per week. We found these relationships to be robust to the addition of all controls for observed characteristics of the job, firm, and worker. We then argued that these findings do not contradict the common theory of the labor market where firms post wages and workers direct their search based on these wages. We made this point using the general directed search framework of Shimer (2005). We showed that jobs that are "sensitive"—in the sense that they are especially responsive to the worker's quality and are especially unproductive when manned by low-quality workers—pay higher wages, attract fewer applicants, and take longer to fill. The seeming paradoxical finding is easily explained by the fact that, while these jobs attract fewer applicants overall, they attract a pool of applicants of higher quality.

References

Andrews, Martin, J., Bradley, Steve, Stott, Dave, Upward, Richard, 2008. Successful employer search? An empirical analysis of vacancy duration using micro data. Economica 75, 455–480.

Banfi, Stefano, Villena-Roldán, Benjamín, 2015. Do High-wage Jobs Attract more Applicants? Directed Search Evidence from the Online Labor Market. University of Chile, mimeo.

Barron, John M., Berger, Mark C., Black, Dan A., 1997. Employer search, training, and vacancy duration. Econ. Inq. 35 (1), 167–192.

Barron, John M., Bishop, John, Dunkelberg, William C., 1985. Employer search: the interviewing and hiring of new employees. Rev. Econ. Stat. 67 (1), 43–52.

Belot, Michele, Kircher, Philipp, Muller, Paul, 2015. Providing advice to job seekers at low cost: an experimental study of on-line advice. Mimeo.

Brenčič, Vera, 2012. Wage posting: evidence from job ads. Can. J. Econ. 45 (4), 1529–1559.

Burks, Stephen V., Cowgill, Bo, Hoffman, Mitchell, Housman, Michael, 2015. The value of hiring through employee referrals. Q. J. Econ. 130 (2), 805–839.

Burdett, Kenneth, Cunningham, Elizabeth J., 1998. Toward a theory of vacancies. J. Labor Econ. 16 (3), 445–478.

Burdett, Kenneth, Shi, Shouyong, Wright, Randall, 2001. Pricing and Matching with Frictions. J. Political Econ. 109 (2001), 1060–1085.

Davis, Steven J., Faberman, R. Jason, Haltiwanger, John C., 2013. The establishment-level behavior of vacancies and hiring. Q. J. Econ. 128 (2), 581–622.
Galenianos, Manolis, 2014. Hiring through referrals. J. Econ. Theory 152, 304–323.
Ioannides, Yannis M., Loury, Linda Datcher, 2004. Job information networks, neighborhood effects, and inequality. J. Econ. Lit. 42, 1056–1093.
Hall, Robert E., Krueger, Alan B., 2012. Evidence on the incidence of wage posting, wage bargaining, and on-the-job search. Am. Econ. J.: Macroecon. 4 (4), 56–67.
Holzer, H., 1987. Hiring procedures in the firm: Their economic determinants and outcomes, National Bureau of Economic Research Working Paper no. 2185.
Holzer, Harold J., Katz, Lawrence F., Krueger, Alan B., 1991. Job queues and wages. Q. J. Econ. 106, 739–768.
Kaas, Leo, Kircher, Philipp, 2015. Efficient firm dynamics in a frictional labor market. Am. Econ. Rev. 105 (10), 3030–3060.
Ketterman, Andreas, Mueller, Andreas, Zweimueller, Josef, 2016. How firms fill vacancies: evidence from linked vacancy-worker data. Columbia University, mimeo.
Marinescu, Ioana, Ronald Wolthoff. Opening the black box of the matching function: the power of words. mimeo (2015).
Menzio, Guido, Shi, Shouyong, 2010. Block recursive equilibria for stochastic models of search on the job. J. Econ. Theory 145 (4), 1453–1494.
Menzio, Guido, Shi, Shouyong, 2011. Efficient search on the job and the business cycle. J. Political Econ. 119, 468–510.
Menzio, Guido, Telyukova, Irina, Visschers, Ludo, 2016. Directed search over the life cycle. Rev. Econ. Dyn. 19, 38–62.
Moen, Espen, 1997. Competitive search equilibrium. J. Political Econ. 105 (2), 385–411.
Montgomery, James D., 1991. Equilibrium wage dispersion and interindustry wage differentials. Q. J. Econ. 106, 163–179.
Pallais, Amanda, Sands, Emily G., 2016. Why the referential treatment? Evidence from field experiments on referrals. J. Political Econ. 124 (6), 1793–1828.
Peters, Michael, 2012. Non contractible heterogeneity in directed search. Econometrica 78, 1173–1200.
Schaal, Edouard. Uncertainty and Unemployment. mimeo (2015).
Shi, Shouyong, 2001. A Directed search model of inequality with heterogeneous skills and skill-biased technology. Rev. Econ. Stud. 69, 467–491.
Shimer, Robert. Contracts in a frictional labor market. mimeo (1996).
Shimer, Robert, 2005. The assignment of workers to jobs in an economy with coordination frictions. J. Political Econ. 113 (5), 996–1025.
Sicilian, Paul, 1995. Employer search and worker-firm match quality. Q. Rev. Econ. Financ. 35, 515–532.
Topa, Giorgio, 2011. Labor markets and referrals. Handb. Social. Econ. 1, 1193–1221.
Van Ours, Jan, Ridder, Gert, 1992. Vacancies and the recruitment of new employees. J. Labor Econ. 10, 138–155.
Wolthoff, Ronald, 2014. Applications and Interviews: firms' Recruiting Decisions in a Frictional Labor Market. University of Toronto, mimeo.