Application Flows

Steven J. Davis*  Brenda Samaniego de la Parra+

*UChicago Booth School of Business and the Hoover Institution

+UC Santa Cruz

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Outline

I. Rich, new database that links employers, vacancy postings, applications and applicants.

II. New facts about employer and worker search behavior, and the role of online job boards.

III. Implications for theoretical modelling.
   - Intermediaries play a huge role in the matching process.
   - Employer search is non-sequential.
   - Application flows depart greatly from a random assignment model.
   - The unevenness of application flows remains even after conditioning for various job and employer characteristics.
Raw data from DHI Group, Inc. Our data derive from the Dice.com online job board.

Employer-side clients: (a) Direct hire, (b) Recruitment Firms, and (c) Staffing Firms.

Postings are mainly in technology, software development, and other computer-related occupations, engineering, financial services, business and management consulting, and other jobs requiring technical skills.
The DHI Vacancy and Application Database

High volume, granularity and frequency

- 125 million applications to 7.5 million postings from 5+ million applicants and 57,000 employer-side clients in the US from 2012 to 2017.

- Includes information on:
  - employers’ industry and size,
  - job postings’ daily time online, job title description, location, compensation (if posted) and more.
  - applicants’ IP address (location), (current/desired) job title.
New Facts on Search Behavior

1. Posting durations are short, much shorter than vacancy durations.

2. Job seekers target new postings for applications, strikingly so.

3. Large, growing role for labor market intermediaries.

4. Posting durations decrease in slack labor markets, but the effect is tiny.

5. Application flows are highly uneven across postings
   - Many vacancies attract very few applicants,
   - The typical applicant competes with many other applicants,
   - Low mean-to-variance application flow ratios, even within narrowly defined job and employer categories.

6. Platform functionality greatly affects the volume and distribution of application flows to postings.
1. Short Posting Duration

- 20% of all standard postings are active for 48 hours or less.
- Half of all standard postings last one week or less.

Direct Hire Clients Total Posting Duration (First to Last Active Date-Time)
2. Job Seekers Target Younger Postings

Applications Distribution by Posting Age at Time of Arrival

![Bar chart showing the distribution of applications per vacancy day, by age. The x-axis represents the number of days since posting (24-hour intervals), and the y-axis represents the percent of applications. The chart shows a concentration of applications in the first few days.](chart.png)
3. Large, growing role for intermediaries

- 80% of all applications on Dice.com involve an employer-side or worker-side intermediary, or both.

**Figure:** Percent with intermediaries on at least one side of the market
4. Posting Duration Falls with Tightness, as Measured by Application Flows per Posting, But the Elasticity is Tiny

\[ \ln(\text{duration}_{s,t}) = \alpha_0 + \alpha_1 \ln(\text{daily_apps}_{s,t}) + \alpha_2 \ln(\text{daily_apps}_{s,t-1}) + \ldots + \epsilon_{s,t} \]

where \( \bar{X}_{s,t} = \frac{\sum x_j}{\sum j \in s,t} \) and \( j \) denotes vacancy postings.

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Log Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>( \ln(\text{daily_apps}) )</td>
<td>-0.040***</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
</tr>
<tr>
<td>( \text{L1 ln(daily_apps)} )</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
</tr>
<tr>
<td>( \text{L2 ln(daily_apps)} )</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>( \text{L3 ln(daily_apps)} )</td>
<td>0.016***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>( \text{Constant} )</td>
<td>2.242***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
</tr>
<tr>
<td>( \text{Observations} )</td>
<td>2,664</td>
</tr>
</tbody>
</table>

Notes: The standard deviation for log daily applications across skillXtime groups is 1.11.
5. Highly Uneven Distribution of Application Flows

Application Volume in First 14 Days (336 Hours) since Posting

- Mean = 11.53
- Median = 4.0
- Std. Dev. = 28.22

Applications Received in First 14 Days (24 Hrs. Intervals)

(a) Direct Hire
5. Highly Uneven Distribution of Application Flows

- The distribution of application flows in the DHI data strongly departs from random allocation.
- Overdispersion and excess share of postings with zero applications holds even when controlling for an extensive battery of vacancy and employer characteristics.

Table: Departure from Random Application Allocation: Direct Hire Postings

<table>
<thead>
<tr>
<th></th>
<th>DHI Data</th>
<th>Random</th>
<th>ZINB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Mean</td>
<td>11.8</td>
<td>11.8</td>
<td>18.8</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>28.6</td>
<td>3.4</td>
<td>28.6</td>
</tr>
<tr>
<td>Percent with 0 applications</td>
<td>18.9</td>
<td>0.0008</td>
<td>18.9</td>
</tr>
<tr>
<td>Percent with 1 application</td>
<td>12.1</td>
<td>0.0089</td>
<td>8.1</td>
</tr>
<tr>
<td>Ratio of Median to Simple Mean</td>
<td>0.34</td>
<td>1</td>
<td>0.39</td>
</tr>
</tbody>
</table>

ZINB models parameters are estimated to minimize the squared sum deviations from the data’s simple mean, standard deviation, and share of postings with zero applications. The resulting mean ($\mu$), overdispersion ($\theta$), and inflated zero probability ($p$) parameters are $\mu=18.9$, $\theta=2.2$, and $p=0.005$. 
6. Changes in Platform Functionality

- In Dec. 2014, DHI implemented several changes that facilitated job seekers search and application process, specially for EMAIL applications.

![Average Applications per Job Seeker](chart.png)
6. Changes in Platform Functionality

- The platform change also included allowing employers to browse through job seekers’ resumes and “nudge” them to apply to their job postings.
- Smaller employers benefited more from the platform change.

![Applications per Vacancy Day by Employer Size](chart.png)
Concluding Remarks

- **Stages of the Hiring Process**
  - Non-sequential search and Stock-flow matching
    - Short-lived postings with longer vacancy duration.
    - Heavy bunching of applications shortly after posting.
    - Job seekers bunch applications in 7-day intervals.

- **Job Seeker Behavior**
  - Huge role for intermediaries.
    - 80% of applications in 2016 involved an intermediary on at least one side of the market.
    - Platform functionality has an important role for the volume and distribution of applications.

- **Tiny effects of anticipated labor market tightness on posting duration.**
  - Procyclical vacancy duration likely reflects variation in the selection phase, rather than in meeting rates.
Concluding Remarks

- Our empirical findings are hard to reconcile with sequential search models and models that feature random search.

- Strong motivation for models where job seekers and employers contact multiple partners, with mediation from intermediaries, before making decisions about whether, and with whom, to initiate an employment relationship.
Theoretical Implications: Stages of the Hiring Process

Mean Duration from Date of First Posting to Start of Employment = 56.2 Calendar Days

Pre-Posting Decision-Making by Employer

Job Openings and Labor Turnover Survey

DHI Database

Posting Commences

Screening, Selection, and Recruitment = 30.8 Days

Posting Ends

Recruitment Event

Survey of Consumer Expectations (NY Fed)

First Date of Employment

Ongoing Employment Relationship

Mean Vacancy Duration = 40.2 Calendar Days (Davis et al. (2013) and DHI Hiring Indicators)

Mean Start Lag Duration = 16.2 Days (Crane et al., 2016)

Mean Posting Duration = 9.4 Days (this paper)

Application bunching: 45% arrive within 48 hours after vacancy posting
Clients typically face a positive (shadow) price to keep a posting in active status and visible to job seekers (reputational costs from responsiveness + opportunity cost of other postings).

DHI also offers different screening services and applicant quality control.
Other pricing methods can yield many “stale” postings.

Post Jobs and View Talent Solutions at a Glance

Get Tech Talent Faster and Easier through Dice

- **Single Job Post** $395
- **Two Job Posts** $325 each, save $140 total (18%!)
- **Three Job Posts** $305 each, save $270 total (23%!)
- **5-10 Job Posts** $250 each, save $725 – $1,450 total (up to 37%!)

Request info about packages with résumé search

**Single Post, $395**
- Promote your job post on Dice and within 3000 partner sites for 30 days
- Gain exposure to our 1.5 million monthly tech professional visitors

Post Job Now
Job Seeker Experience

- Can browse postings by job title, job location, company name, skill requirements and other job characteristics.
- Must register before applying for a job.
- Job seekers submit applications at no charge.
- By supplying enough information, job seekers can include their profiles in a database searchable to employer-side clients.
Application Channels

- For each posting, employers decide whether job seekers submit applications directly via the Dice platform (email) or via an external URL operated by the client or a third party.
- For email applications, we see the number of completed applications. For URL applications, we see how often job seekers click through to the external URL.
Recruitment and Staffing Firms Total Posting Duration

Percent of Recruitment Firm Postings

Completed Spell Duration (24 hr. Intervals from First to Last Active Date)
Job Seekers Target Younger Postings (2)

Mean Applications per Vacancy Day, by Posting Age

Davis and Samaniego de la Parra

Application Flows

Back
Highly Uneven Distribution of Application Flows

Application Volume in First 14 Days (336 Hours) since Posting

Percent of Vacancies

Mean = 9.10
Median = 3.0
Std. Dev. = 25.06

Applications Received in First 14 Days (24 Hrs. Intervals)

(i) Recruitment and Staffing Firms

Back
## Highly Uneven Distribution of Application Flows

### Table: Departure from Random Application Allocation: Recruitment and Staffing Firm Postings

<table>
<thead>
<tr>
<th></th>
<th>DHI Data</th>
<th>Random</th>
<th>ZINB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Mean</td>
<td>9.3</td>
<td>9.3</td>
<td>15.9</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>25.6</td>
<td>3.1</td>
<td>25.5</td>
</tr>
<tr>
<td>Percent with 0 applications</td>
<td>22.9</td>
<td>0.0091</td>
<td>22.9</td>
</tr>
<tr>
<td>Percent with 1 application</td>
<td>15.1</td>
<td>0.0850</td>
<td>8.9</td>
</tr>
<tr>
<td>Ratio of Median to Simple Mean</td>
<td>0.32</td>
<td>1</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Moments implied by the ZINB model vs. DHI data

The graph illustrates the comparison between the model implied moments and the DHI data. The x-axis represents the Dispersion Parameter ($\theta$), while the y-axis shows the Standard Deviation and Share of Postings with Zero Applications.

- **Model Implied Standard Deviation**
- **DHI Data Standard Deviation**
- **Model Implied Simple Mean**
- **DHI Data Simple Mean**
- **Model Implied Share of Postings with Zero Applications**
- **DHI Data Share of Postings with Zero Applications**

A vertical line at $\theta = 2.24$ indicates the dispersion parameter that minimizes the sum of deviations from the DHI data.
Figure: Job Seekers Distribution by Search Spell Duration
Job Seekers

Mean Applications per Active Job Seeker by Spell Duration at the Time of Application

Note: Active job seekers are those users that submit at least one more application in a future date within the same search spell. This figure excludes job seekers that only submit one application.
Allocating Applications to Vacancy Postings: Zero-Inflated Negative Binomial Model

- **ZINB Model**: excess zeros are generated through a separate process that can be modeled independently from the distribution of positive applications.

\[
\Pr (A_j = a) = \Pr (\text{views}_j = 0) \times 0 + \Pr (\text{views}_j > 0) \times \Pr (A_j = a|\text{views}_j > 0)
\]

\[
L = \begin{cases} 
\sum_{j=1}^{V} \left\{ \ln(p_j) + (1 - p_j) \left( \frac{1}{1+ \frac{e^{x_j^t \beta}}{\theta}} \right) \right\}, & \text{if } A_j = 0 \\
\sum_{j=1}^{V} \left\{ \ln(p_j) + \ln\Gamma (\theta + A_j) - \ln\Gamma (A_i + 1) - \ln\Gamma (\theta) + \theta \ln \left( \frac{1}{1+ \frac{e^{x_j^t \beta}}{\theta}} \right) + A_j \ln \left( 1 - \frac{1}{1+ \frac{e^{x_j^t \beta}}{\theta}} \right) \right\}, & \text{if } A_j > 0
\end{cases}
\]

- As \( \theta \to 0 \) \( \text{PDF} (A_j) \to \text{Poisson} \left( \frac{A}{V} \right) \)
### Table: Dispersion Estimation

<table>
<thead>
<tr>
<th>Skill Category</th>
<th>Apps. per Vac.</th>
<th>Time</th>
<th>Employer Type, Size &amp; wage</th>
<th>3rd party &amp; App Channel</th>
<th>State FE</th>
<th>Job title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA</td>
<td>10.9</td>
<td>1.44</td>
<td>1.38</td>
<td>1.11</td>
<td>0.74</td>
<td>0.62</td>
</tr>
<tr>
<td>JAVA</td>
<td>21.3</td>
<td>1.87</td>
<td>1.80</td>
<td>1.25</td>
<td>0.90</td>
<td>0.81</td>
</tr>
<tr>
<td>ORACLE</td>
<td>12.3</td>
<td>1.30</td>
<td>1.28</td>
<td>1.16</td>
<td>0.79</td>
<td>0.64</td>
</tr>
<tr>
<td>SAP</td>
<td>11.5</td>
<td>1.12</td>
<td>1.11</td>
<td>1.01</td>
<td>0.71</td>
<td>0.68</td>
</tr>
<tr>
<td>NETWORK</td>
<td>9.6</td>
<td>1.93</td>
<td>1.70</td>
<td>1.30</td>
<td>0.80</td>
<td>0.74</td>
</tr>
<tr>
<td>SECURITY</td>
<td>4.6</td>
<td>1.50</td>
<td>1.37</td>
<td>1.15</td>
<td>0.59</td>
<td>0.51</td>
</tr>
<tr>
<td>SQL</td>
<td>18.5</td>
<td>1.46</td>
<td>1.34</td>
<td>0.92</td>
<td>0.67</td>
<td>0.63</td>
</tr>
</tbody>
</table>

All estimates are statistically different from zero at 1% significance levels. All specifications control for posting duration.
### Negative Binomial Parameter Estimates

<table>
<thead>
<tr>
<th></th>
<th>DH</th>
<th>Wage Dummy</th>
<th>3rd party</th>
<th>URL</th>
<th>EMAIL</th>
<th>Dispersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill</td>
<td>0.20***</td>
<td>0.05***</td>
<td>1.06***</td>
<td>0.10***</td>
<td>28.52***</td>
<td>28.41***</td>
</tr>
<tr>
<td>+ Time</td>
<td>0.22***</td>
<td>0.08***</td>
<td>0.72***</td>
<td>-0.09***</td>
<td>33.63***</td>
<td>33.44***</td>
</tr>
<tr>
<td>+ State</td>
<td>0.22***</td>
<td>0.08***</td>
<td>0.73***</td>
<td>-0.09***</td>
<td>26.95***</td>
<td>26.75***</td>
</tr>
<tr>
<td>+ Job Title</td>
<td>0.26***</td>
<td>0.06***</td>
<td>0.71***</td>
<td>-0.11***</td>
<td>27.04***</td>
<td>26.85***</td>
</tr>
<tr>
<td>+ Employer</td>
<td>0.24***</td>
<td>0.02***</td>
<td>0.90***</td>
<td>-0.03***</td>
<td>21.73***</td>
<td>21.37***</td>
</tr>
</tbody>
</table>

All specifications include skill and employer size FE. We also control for posting duration (in 24-hour intervals from first to last posting date-time).