Application Flows

Steven J. Davis

and Brenda Samaniego de la Parra

+ Some Critical Remarks on the State of Macro-Labor Search Models and Analyses

IZA Workshop on The Role of Search and Matching in Macroeconomics: A Retrospective

19 November 2021

The authors received compensation from DHI Group, Inc. for developing and analyzing the DHI Database.

Grad school, circa early 1980s: Roaming the library stacks at Brown, perusing studies of unemployment

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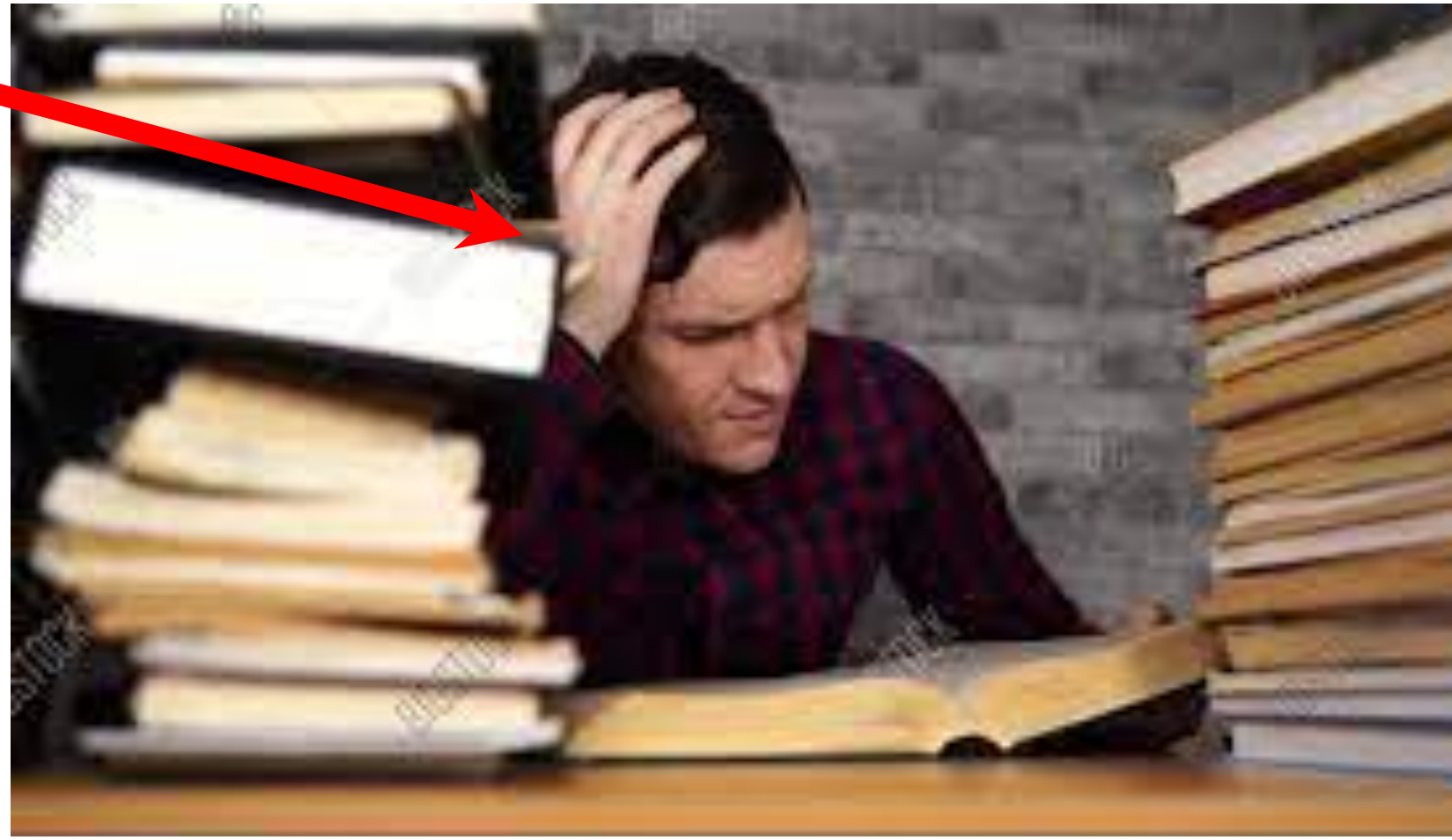

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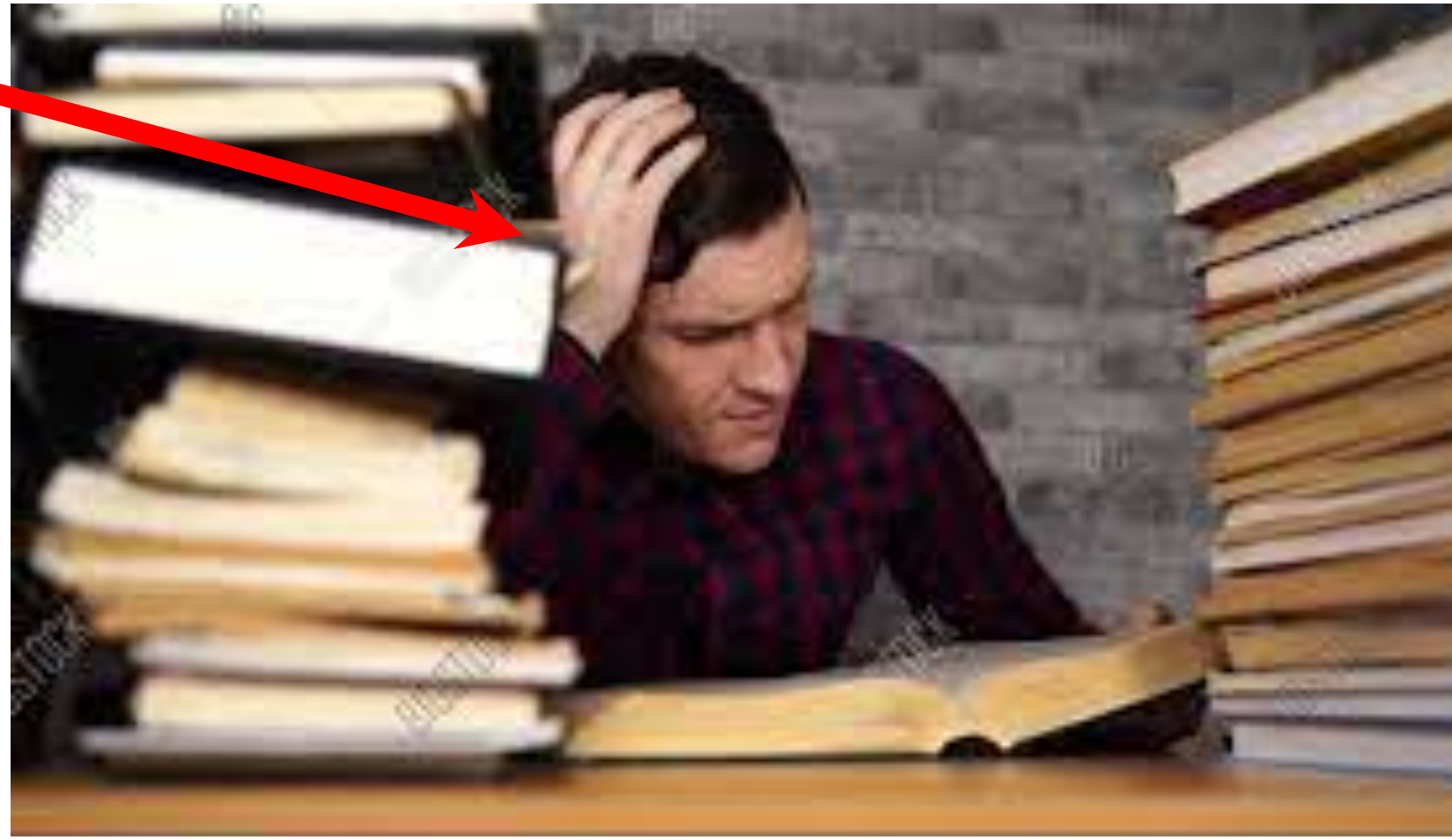

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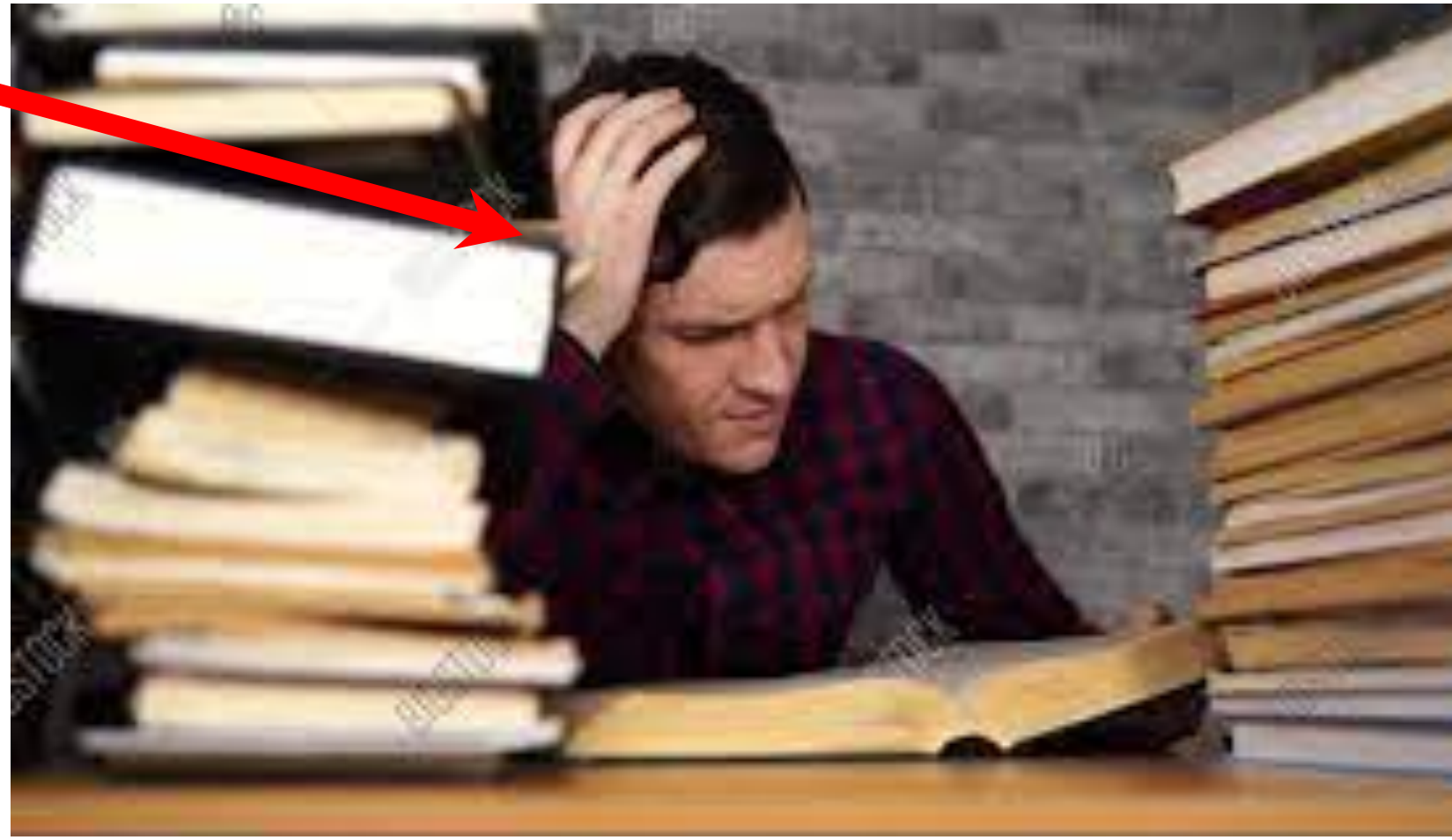
But more poorly dressed – as stipends were less generous back in the day.



What Did I Learn?

Before the advent of search theory, and especially before World War II, economists lacked a sound conceptual framework for thinking about frictional unemployment and its determinants – let alone an explicit theory of frictional unemployment as an equilibrium phenomenon.

At some point, I discovered/was introduced to the exciting work in search theory by McCall, Diamond, Mortensen, Pissarides, and others.

The **First** Paper I Ever Refereed

JOURNAL ARTICLE

Short-Run Equilibrium Dynamics of Unemployment, Vacancies, and Real Wages

Christopher A. Pissarides

The American Economic Review
Vol. 75, No. 4 (Sep., 1985), pp. 676-690 (15 pages)
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This paper, Chris's related work, Dale Mortensen's work on search theory (with and without Chris) and Peter Diamond's work on search theory (on his own and with others) greatly influenced my early thinking about unemployment and labor market dynamics.

A Tremendous Intellectual Achievement

The work of Diamond, Mortensen, Pissarides and others in developing coherent equilibrium theories of frictional unemployment and related phenomena (labor market flows, wage dispersion, etc.) is a tremendous intellectual achievement.

The 2010 Nobel Prize in Economic Sciences was well deserved.

Building on DMP foundations, later research has pushed equilibrium search theory in an astonishing variety of fruitful directions. Mortensen and Pissarides (1994 RESTUD) and its descendants became workhorse models in the analysis of unemployment fluctuations and other phenomena.

Reasons for Dissatisfaction

Still, I see reasons to be dissatisfied with the current state of (a) theorizing about macro-labor phenomena from a search and matching perspective and (b) quantitative and policy analyses that rest on leading equilibrium search models.

The next slides summarizes, baldly and without nuance, three criticisms of the macro-labor search literature. The first two criticisms are not entirely new, but I aim to advance them in a more compelling and forceful manner. To do so, I will draw on my work with Brenda Samaniego de la Parra in “Application Flows.” I will also draw on other works and data sources.

Three Criticisms of Leading Macro-Labor Search Models

They presume that employers (and workers) follow sequential search strategies.

- Available evidence mostly says otherwise
- Neither sequential nor non-sequential decision making dominates as a search strategy across all settings.
  - See, for example, Gal, Landsberger and Levykson (1981), Burdett and Judd (1983), Morgan (1983), Morgan and Manning (1985), and Gautier (2002),
- Theory also says that the distinction between sequential vs. non-sequential search matters for outcomes.

Three Criticisms of Leading Macro-Labor Search Models

They largely neglect the role of intermediaries: staffing firms, recruitment firms, placement agents, and meeting platforms.

- Evidence says intermediaries play a large and growing role in search, recruitment, screening, matching, and hiring.
- Theory and evidence provide ample reasons to think that intermediaries affect the search process and its outcomes.

Three Criticisms of Leading Macro-Labor Search Models

There are few efforts (none?) to investigate whether directed search models actually explain the empirically observed directions of search.

- For example, to what extent can we explain non-randomness in application flows to vacancy postings using offer wages and other variables that theory stresses as instruments for directing search by jobseekers?

Outline of What's to Come

I. Rich new database that links employers, vacancy postings, applications & applicants
II. New facts about search & hiring behavior
III. Remarks about implications for theory and how we think about search and matching in the labor market.

The DHI Vacancy and Application Flow Database

Source of Raw data: From Dice.com, an online platform for posting vacancies and attracting applications.

Analysis Data: Developed from the raw data by Brenda and me.

Employer-side clients: (a) organizations that directly hire their own workers, (b) recruitment firms that solicit applicants for third parties, and (c) staffing firms that hire workers for lease to others.

Vacancy postings: Mainly in technology sectors, software development, other computer-related occupations, engineering, financial services, business and management consulting, and a variety of other jobs that require technical skills.

High volume, granularity and frequency:

- 125 million applications to 7.5 million postings from 5+ million applicants from 2012 to 2017. 57,000 employer-side clients.
- Second-by-second tracking of postings and applications, with identifiers for employer-side clients and applicants
- Employer side: Name, industry, size, vacancy ID, job description, city of job, compensation (if posted) and more
- Applicant side: Applicant ID, location, current job title, date-time stamp of applications and more
- 3,600 job titles with ≥ 100 distinct postings
- Broader functional categories (software developer, project manager, business analyst, etc.) and skill categories (Javascript, Oracle, Linux, etc.) that we construct from job descriptions.

Two Application Modes: Email and URL

- For each posting, the employer-side client decides whether job seekers submit applications via email on the Dice platform 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.
- We pool these two application modes for most aspects of our analysis. We separate them when the distinction is critical.

More about the Dice.com Platform, 1

The Pricing of Vacancy Postings

- Clients typically face a positive (shadow) price to keep a posting in active status and visible to job seekers.
- Pricing on other platforms can yield many “stale” postings.

The Job-Seeker Experience

- Can browse postings by job title, job location, company name, skill requirements and other job characteristics.
- Browsing does not require registration, but job seekers must register before applying for a job via the Dice.com platform.
- 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.

More about the Dice.com Platform, 2

Applicant Quality Control

- High-quality applicant pools are an important part of the Dice.com value proposition to employer-side clients.
- DHI relies on client complaints and other information to identify bad actors who engage in bad behaviors.
  - Example: A third party misrepresents itself to submit an application for a posting that accepts only first-party applicants.
- DHI uses machine-learning methods to develop rules for screening bad actors and bad behaviors. After verifying a rule does not generate false positives, DHI implements the rule to block “bad” applications.
- Our dataset excludes blocked applications.

Standard versus “Long-Duration” Postings

80% of postings at the level of a Job ID exhibit the following pattern:

a) Client posts a vacancy on the DHI site
b) Most applications arrive within a week after posting
c) Client permanently removes the vacancy posting within one month after first posting.

For Job IDs that fit the standard pattern, we interpret each one as a unique posting for a single opening.

Standard versus “Long-Duration” Postings, 2

- Other Job IDs do not conform to this pattern; instead, they remain online for many weeks or months, and applications flow in over time.
- Based on our examination of the data and our conversations with DHI staff, the vast majority of these “long-duration” postings reflect direct hire clients with ongoing hiring needs for certain jobs and recruiting and staffing firms that more or less continuously seek applicants for certain types of jobs

Standard versus “Long-Duration” Postings, 3

How We Proceed

- If gap between a posting’s first active date-time and its last active date-time is > 31 days, we regard it as a “long-duration” posting.
- We “slice” each long-duration posting into multiple postings, one for each calendar month it’s active.
- We consider standard postings only in much of our analysis, so as to focus on single-position openings.

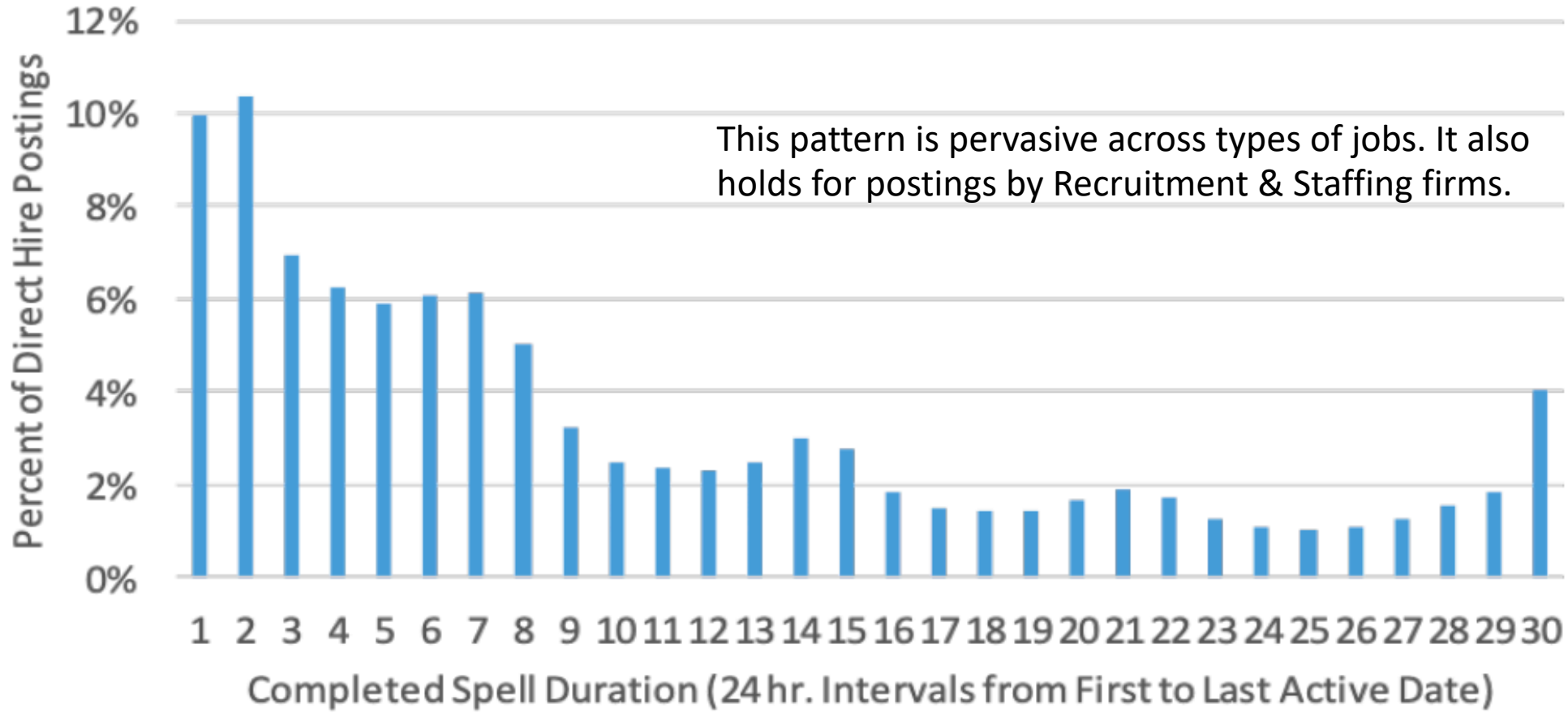
Facts about Search & Hiring Behavior

1. ***Posting*** durations are much shorter than ***vacancy*** durations.
2. Job seekers target new vacancy postings.
3. Intermediaries play huge roles on both the employer-side and worker-side of platform.
4. Posting durations are insensitive to market tightness.
5. Application flows are highly uneven across vacancy postings:
   - Most postings attract few applicants; typical applicant competes with many other applicants.
   - The flows are neither random nor directed in ways stressed by received theoretical models.
6. Platform functionality greatly affects the volume and distribution of application flows to postings.

1. Short Posting Durations

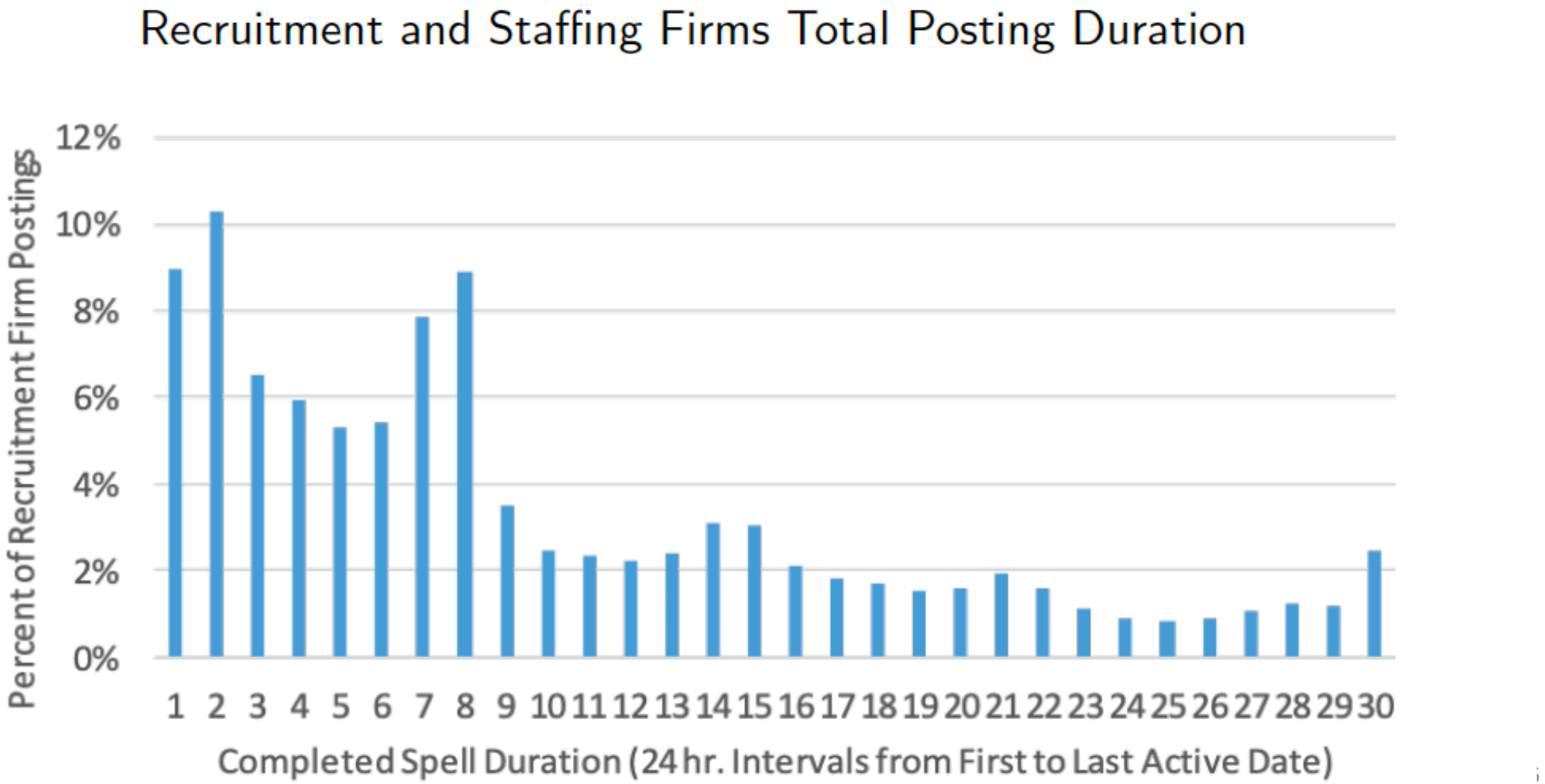
- 20% of all standard postings are active for 48 hours or less.
- Half of all standard postings last one week or less.

Direct Hire Clients Total Posting Duration (First to Last Active Date-Time)



This pattern is pervasive across types of jobs. It also holds for postings by Recruitment & Staffing firms.

Short Posting Durations -- Recruiting & Staffing Firms



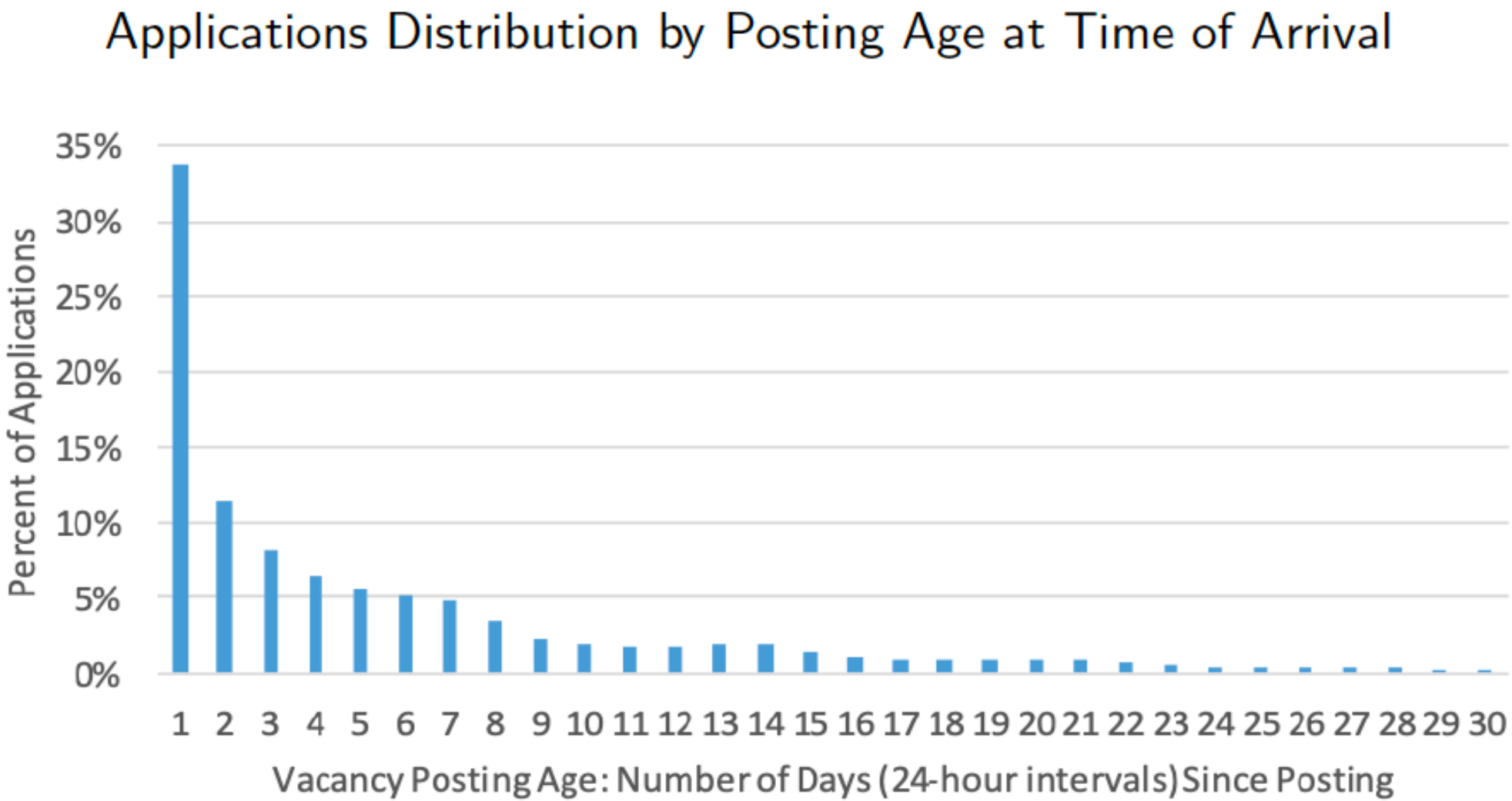
Summary Stats for Completed Posting Durations, in Days

January 2012 to June 2017		Percentile				
	Mean	10	25	50	75	90
All Standard Postings	9.80	0.91	2.66	6.78	14.70	25.12
All Job Titles with at Least 100 Standard Postings	9.80	0.91	2.67	6.79	14.71	25.13
Selected Job Types						
Developer	8.80	0.84	2.16	6.25	13.38	22.29
Project Manager	9.51	1.00	2.96	6.80	13.93	23.62
Business Analyst	9.30	0.91	2.57	6.66	13.80	23.61
Help / Support Desk	10.35	1.00	3.25	7.00	15.64	25.80
Software Engineer	12.96	1.31	4.72	10.63	20.90	29.08
Systems Administrator	11.36	1.05	3.63	8.00	17.59	27.54
Technician	9.35	0.89	2.69	6.60	13.75	24.62
Data Analyst	10.12	1.00	3.02	7.00	15.05	25.08
Database Administrator	9.81	0.94	2.77	6.77	14.58	25.41
Programmer	11.45	1.03	3.64	7.92	18.02	28.10
Quality Assurance Tester	7.83	0.83	1.79	5.45	11.01	20.58
Sales	11.89	0.81	3.23	9.66	18.70	28.16
Electrical Engineer	12.69	1.68	4.96	10.78	19.85	28.87
Mechanical Engineer	12.01	1.20	4.39	9.62	18.90	28.41
Finance Consultant	7.91	0.59	2.12	5.31	10.46	21.64

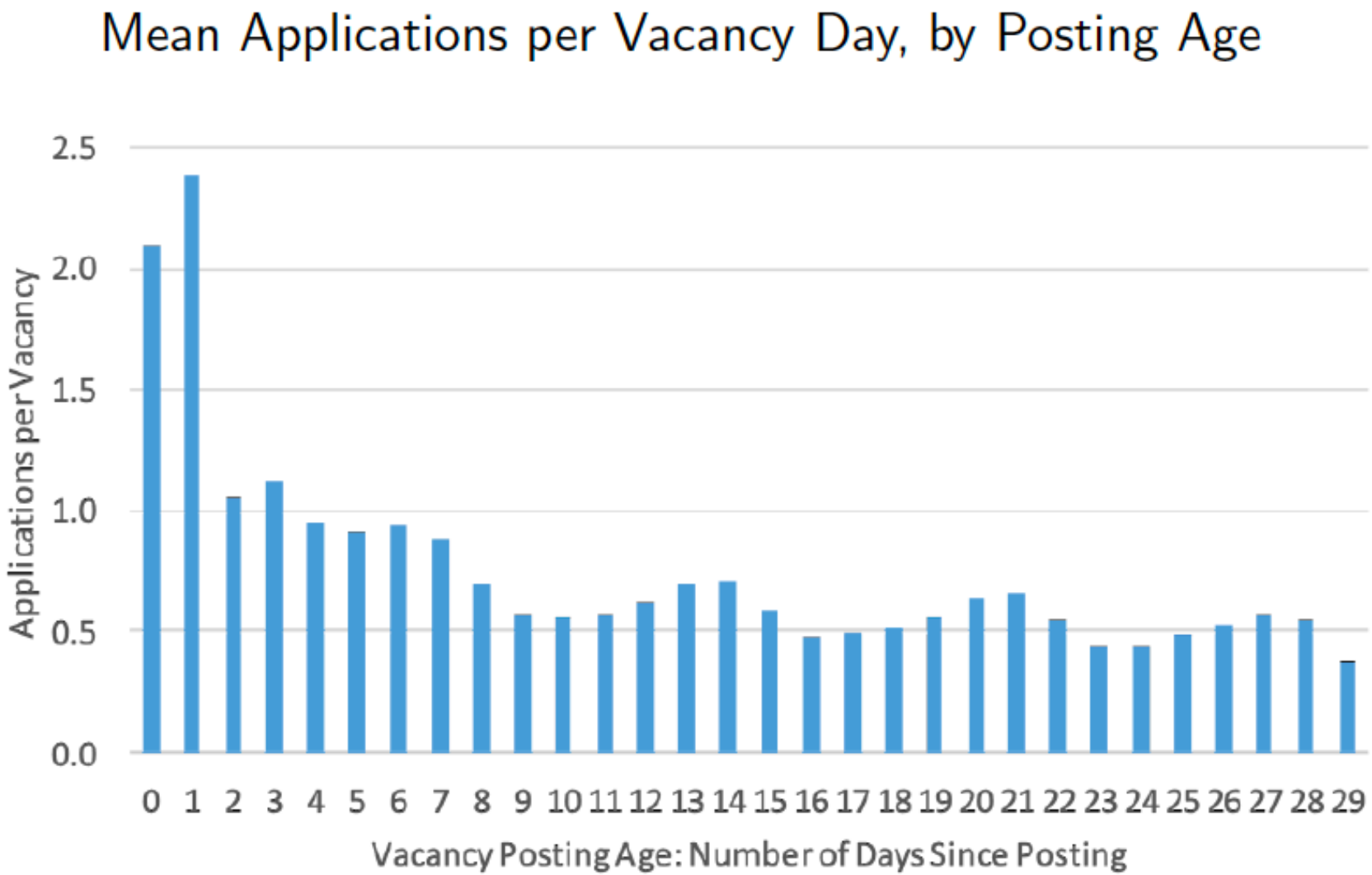
Short "Meeting" Phase, Much Longer "Selection" Phase

- The mean ***posting*** duration for single-position openings is only 9.4 days.
- In contrast, the mean ***vacancy*** duration for comparable jobs in the Job Openings and Labor Turnover Survey (JOLTS) is more than four times as long.
- Thus, the "meeting" phase of the hiring process, during which employers solicit and accept applications, is much shorter than the "selection" phase, which entails screening and interviewing applicants, selecting one for a job offer, extending an offer, negotiating terms, and waiting for an accept/reject decision.

2. Job Seekers Target Younger Postings



Job Seekers Target Younger Postings (2)



3. Intermediaries Dominate Employer-Worker Meeting Activity on Both Sides of Dice.com, Itself an Intermediary

Joint Distribution of Applications over Employer-Side and Worker-Side Types, January 2015 to July 2017

	1st Party Applications	3rd Party Applications	Not Classified
Direct Hire	12%	22%	3%
Recruitment & Staffing Firms	20%	39%	4%

Only 12% of all applications involve job seekers who apply on their own behalf to employers who hire on their own behalf.

Who Generates 3rd-Party Applications?

1. Staffing agencies that lease their employees to other firms submit applications in response to postings.
   - Even when staffing firms pay hourly, they have incentives to market their (leased) employees. That's how they generate (a) fees charged to employers and (b) markups on what they pay their employees.
   - Employer-side clients on Dice.com can explicitly allow or disallow such "corporation-to-corporation" applications in their postings.
2. Placement agents that respond on behalf of individuals seeking jobs that meet particular criteria.

Vacancy Durations Are Highly Sensitive to Tightness

- Previous research establishes that ***vacancy durations*** lengthen with tightness, as measured by the ratio of openings to job seekers. See Davis, Faberman and Haltiwanger (2012, 2013), Crane et al. (2016), Gavazza, Mongey and Violante (2018), Leduc and Liu (2020), Mongey and Violante (2020), and Mueller et al. (2021).
- This empirical regularity confirms a central prediction of search models in the mold of Pissarides (1985, 2000) and Mortensen and Pissarides (1994).

Are Posting Durations Sensitive to Tightness?

- But previous research is largely silent about which aspects of search and matching account for cyclical movements in ***vacancy durations***.
- Because tighter labor markets bring a slower pace of applicant arrivals in MP models, it is natural to hypothesize that the meeting phase of vacancy spells is longer in tight markets and shorter in slack ones.
- To test this hypothesis, we treat posting spells in the Dice.com data as coterminous with the meeting phase of vacancy spells. Specifically, we investigate how ***posting durations*** vary with labor market slack.

Are Posting Durations Sensitive to Tightness?

Hypothesis: Employers extend (shorten) posting durations when labor markets get tighter (slacker).

- Test using cell-level data on posting durations and slack for 48 skill categories crossed with 71 calendar months.
- Skill categories: “Java,” “Oracle,” “SAP,” “Systems,” etc.
- Slack = # of Dice.com jobseekers who apply to 1 or more jobs in the cell divided by the # of postings in the cell.

4. The Slack Effect on Posting Durations Is Tiny

Panel A. Main Regressions

Dependent Variable: ln(Mean Duration of Postings in Skill Category *j* in Month *t*)

	(1)	(2)	(3)	(4)	(5)	(6)
ln(Job Seekers/Postings)	-0.039***	0.027***			0.013	0.044***
	(0.003)	(0.005)			(0.008)	(0.008)
ln(Applications/Postings)			-0.030***	0.009**	-0.039***	-0.017***
			(0.002)	(0.004)	(0.006)	(0.006)
Constant	2.34***	2.28***	2.37***	2.28***	2.22***	2.15***
	(0.003)	(0.011)	(0.005)	(0.012)	(0.012)	(0.015)
Observations	3,408	3,408	3,408	3,408	3,408	3,408
R-squared	0.64	0.74	0.64	0.74	0.64	0.74
Within R-squared	0.05	0.01	0.06	0.001	0.06	0.01
Fixed Effects	Skill	Skill & Time	Skill	Skill & Time	Skill	Skill & Time

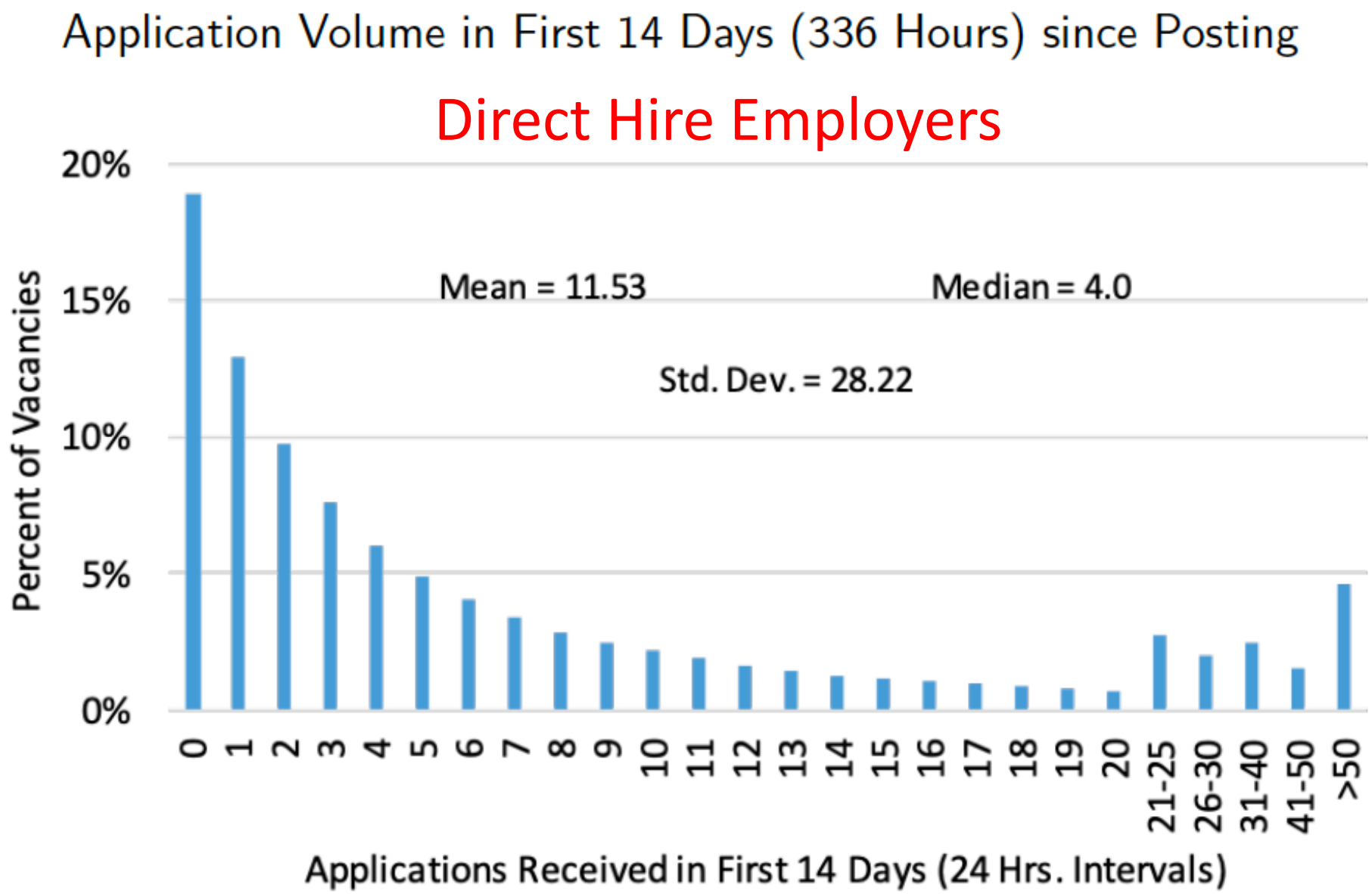
4. The Slack Effect on Posting Durations Is Tiny

- The time-series standard deviation of the log slack measure, averaged over skill categories, is 0.45.
- Thus, the fitted regression in Column (1) implies that a two standard deviation increase in log slack shrinks posting durations by 2(0.45)(0.039) = 3.5 log points, or one-third of a day when evaluated at the mean posting duration of 9.4 days.
- For perspective, U.S. vacancy durations rose from 18.6 days in July 2009 (the first month after the Great Recession) to 39.3 days in September 2018.
- Clearly then, slack effects on ***posting durations*** in the Dice.com data do not explain the sensitivity of ***vacancy durations*** to slack shown in previous work.

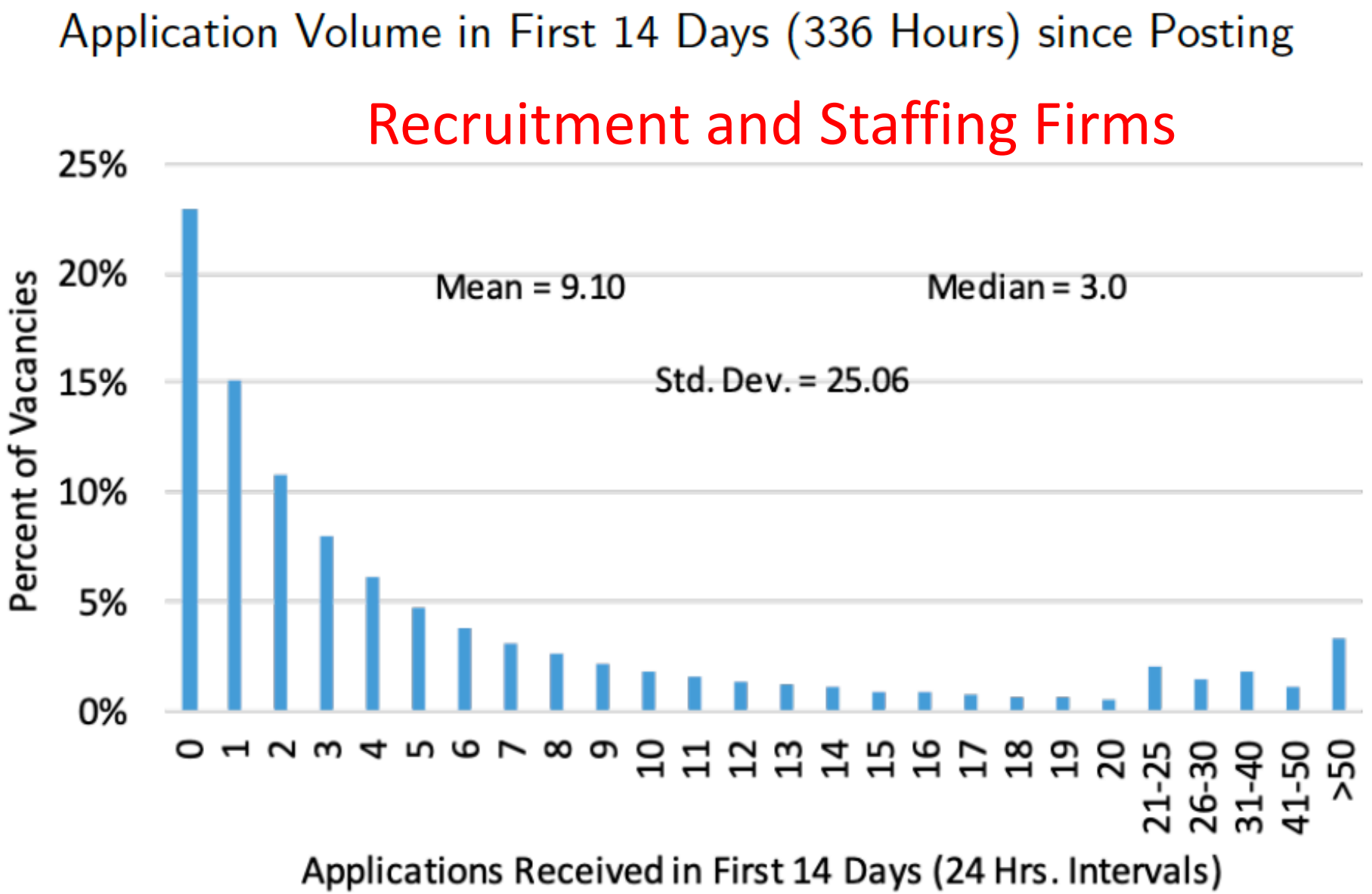
The Tiny Slack Effect Is Robust to:

1. Inclusion of common time effects as controls.
2. Letting slack affect posting durations with a lag.
3. Using an alternative slack measure motivated by models with workers who can submit multiple applications at the same time and employers that collect a pool of applicants before interviewing some of them.
   - Examples: Albrecht et al. (2006), Galenianos and Kircher (2009), Kircher (2009), Albrecht et al. (2020), and Cai et al. (2021).
   - Slack (alternative) = Applications per posting in the cell.
4. Defining labor markets by job functions, MSAs or MSAs-by-skill categories.

5. Highly Uneven Distribution of Application Flows



Highly Uneven Distribution of Application Flows



Applications Per Vacancy Posting, Completed Spells, Standard Postings from January 2012 to December 2017

How it looks to employers and recruiters: Many postings attract no or few applicants.

		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
Job Titles with 100+ Postings	5,396,822	11.03	90.58	3	40
Job Titles with 1,000+ Postings	5,189,803	11.11	91.60	3	41
Frequently Appearing Combinations of Skills and Job Functions	5,362,744	11.03	90.72	3	40
Selected Job Functions					
DEVELOPER	1,248,269	15.98	143.36	3	76
ENGINEER	669,690	7.46	65.49	2	30
ADMINISTRATOR	408,444	10.30	59.29	4	32
ANALYST	345,556	9.76	68.12	3	32
ARCHITECT	299,085	5.90	32.66	2	17

Typical Applicant Competes Against Many Others

How it looks to job seekers

		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
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5. Application Flows Are Highly Non-Random

Red rectangles: Targeted moments for indicated model

	DHI Data	Binomial (i.e., Random Assignment)	Negative Binomial	Zero-Inflated Negative Binomial
Simple Mean	11.8	11.8	11.8	18.8
Standard Deviation	28.6	3.4	28.6	28.6
Percent with 0 applications	18.9	0.0008	48.1	18.9
Flow-Weighted Mean	81.1	12.8	81.1	62.2
Ratio of Flow-Weighted to Simple Mean	6.9	1.1	6.9	3.3

Using data on all Standard Postings by Direct Hire clients. NB model collapses to large-sample version of Binomial when overdispersion parameter equals 0.

Non-Randomness in Application Flows

- Models with segmented markets and/or directed search predict a non-random flow of applications to postings.
- They suggest we can explain departures from randomness using observable aspects of postings that segment markets and direct applications flows within them:
  - Compensation, job location, firm size, job title, job function, direct hire indicator, employer fixed effects, …
- Empirical Questions: How well can we explain departures from randomness with these observables? With offer wages, in particular, which are stressed as direction-inducing instruments in models of competitive search?

Modelling Non-Randomness in Application Flows

Empirical Approach:

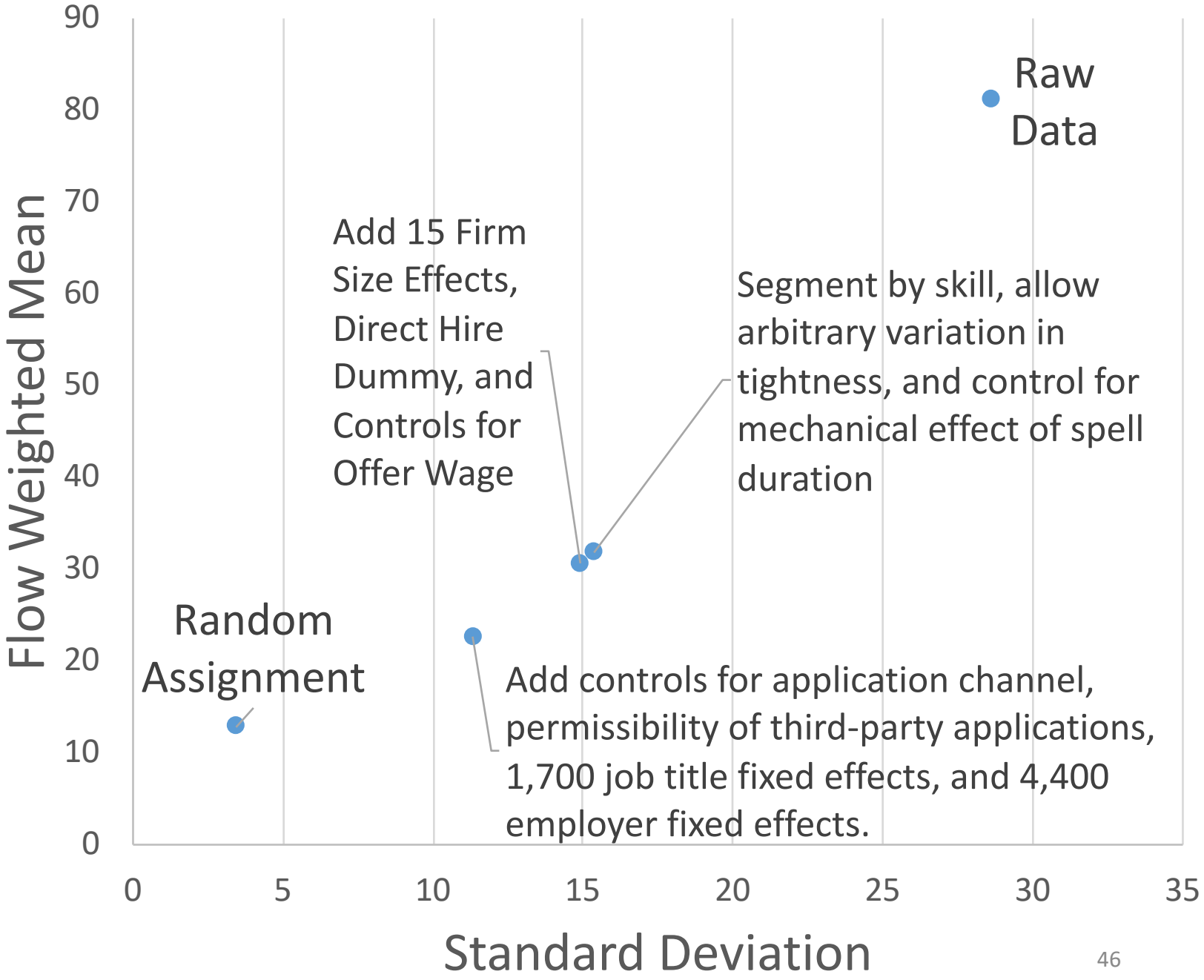
- Binomial model has one parameter for probability that any given application flows to any given vacancy posting.
- Generalize as follows: Let flow direction probability be a flexible function of (many) observables, add free parameter to handle high share of postings with no applicants, and include an over-dispersion parameter to quantify the (conditional) departure from randomness.

→ A regression analog to Zero-Inflated Negative Binomial

- Fit this flexible model separately by skill category.

5. Application Flows Are neither Random nor Directed in Ways Stressed by Theory

"Random Assignment" reports moments implied by binomial model with simple mean set to 11.8 apps per posting. Other data points report moments implied by plugging estimated over-dispersion parameter for indicated model into negative binomial with simple mean set to 11.8.



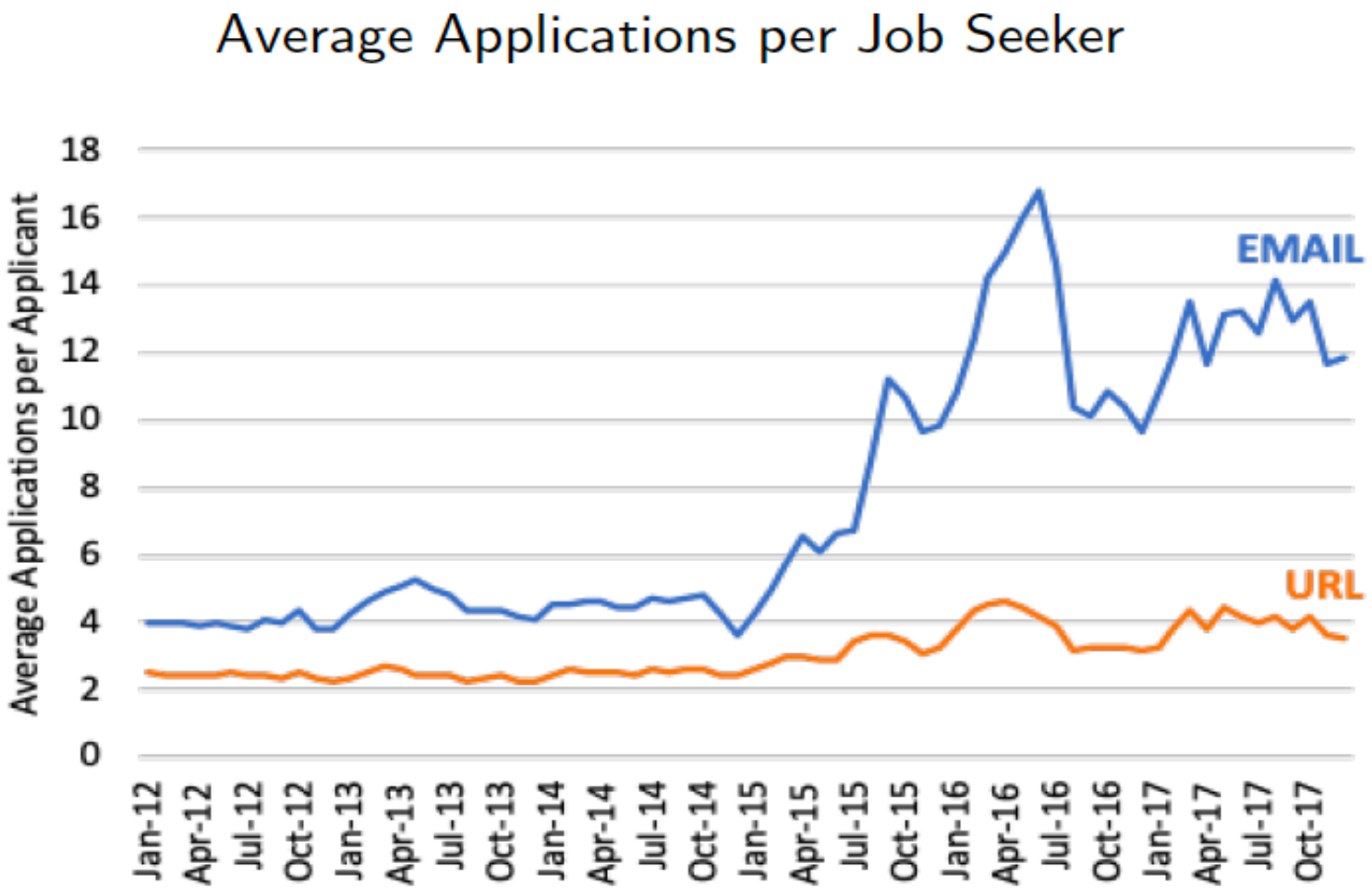
6. Platform Functionality Matter for the Volume and Distribution of Applications to Postings

Key changes to the Dice.com platform in December 2014:

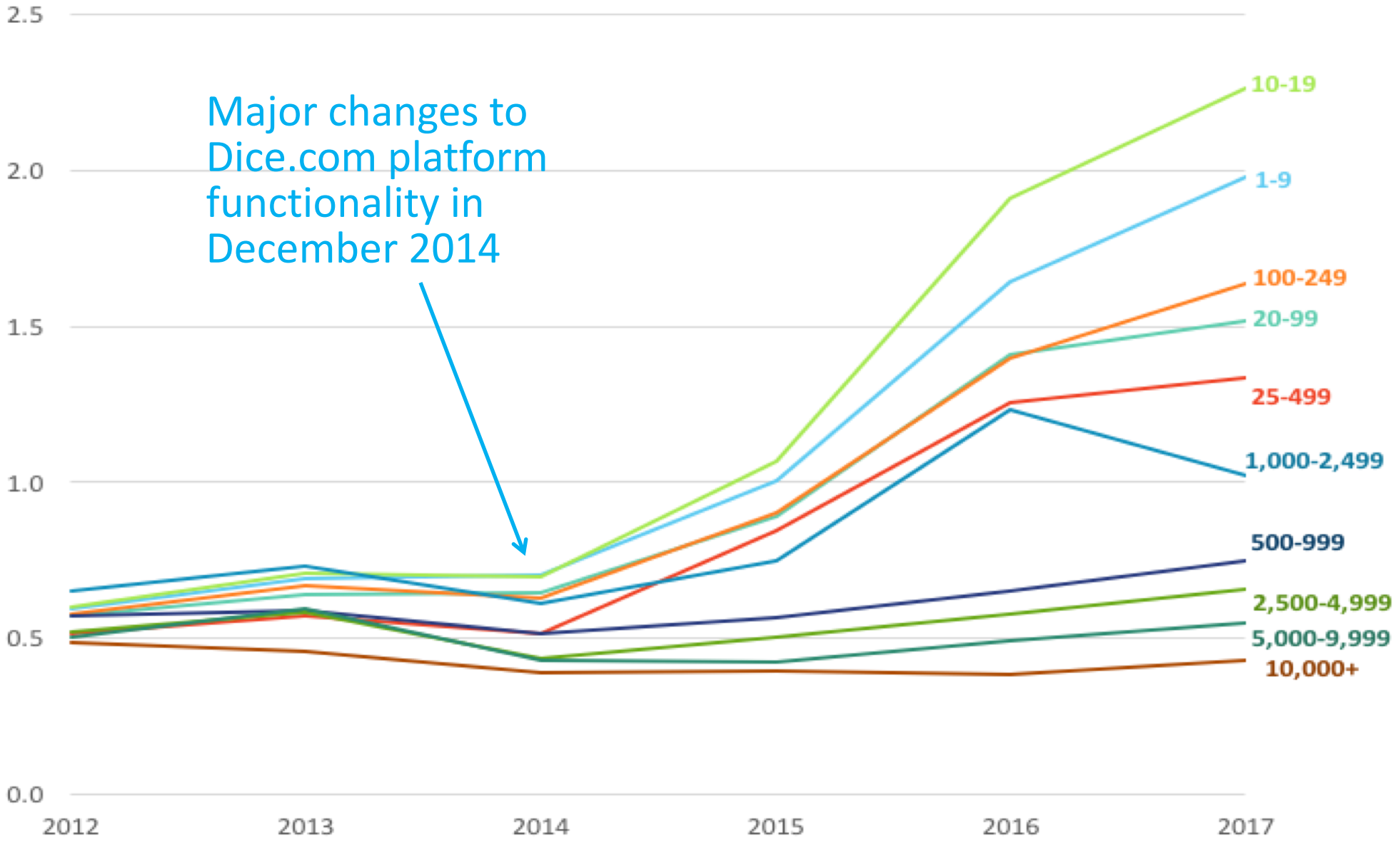
1. DHI streamlined the registration and application process for job seekers.
2. It improved the search engine available to job seekers.
3. It enabled employer-side clients to search over registered jobseekers on Dice.com and solicit applications from particular individuals.
4. It removed information from Dice.com postings that, in some cases, had facilitated applications off platform.

6.Changes in Platform Functionality

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



Applications per Vacancy-Day by Firm Size, Annual Averages, Standard Postings by Direct-Hire Employers



More Evidence on Intermediaries

1. 80% of all applications on Dice.com involve an employer-side or worker-side intermediary, or both. Dice is also an intermediary.
2. Staffing firms take on recruiting, screening, and matching functions that would otherwise occur inside their client firms.
3. Adding client reassignments to hires and separations, the worker reallocation rate of staffing firms is 11.5 times that of other firms. On this basis, Houseman and Heinrich (2015) estimate that staffing firms account for 18.5% of all worker reallocation, inclusive of client reassignments, in 2011.
4. Our extrapolations from BLS payroll data: **The staffing-firm share of worker reallocation in the U.S. economy rose from 11% in 1990 to 21% in 2018.**

More Evidence on Intermediaries

5. This inference accords with independent evidence on the disappearance of short-duration employment relationships and secular fall in the measured pace of worker reallocation. See Davis et al. (2010), Hyatt and Spletzer (2013, 2017), Davis and Haltiwanger (2015), and Crump et al. (2019). What once appeared in standard sources as short-duration employment relationships and between-employer transitions now occurs inside staffing firms.
6. Firms that specialize in headhunting, talent sourcing, screening & other recruitment services also play a large and growing role.
   - CareerBuilder.com, Indeed.com, Monster.com and Upwork, among others, have evolved from simple job boards to multi-faceted online platforms that supply talent-sourcing, screening, and recruitment services.
   - Professional networking platforms like LinkedIn and data analytics firms like Burning Glass have also evolved to offer sourcing, screening, and recruitment services.
   - G2, a peer-to-peer business review site, offers ratings and descriptions for more than 150 of the “Best Recruitment Agencies.

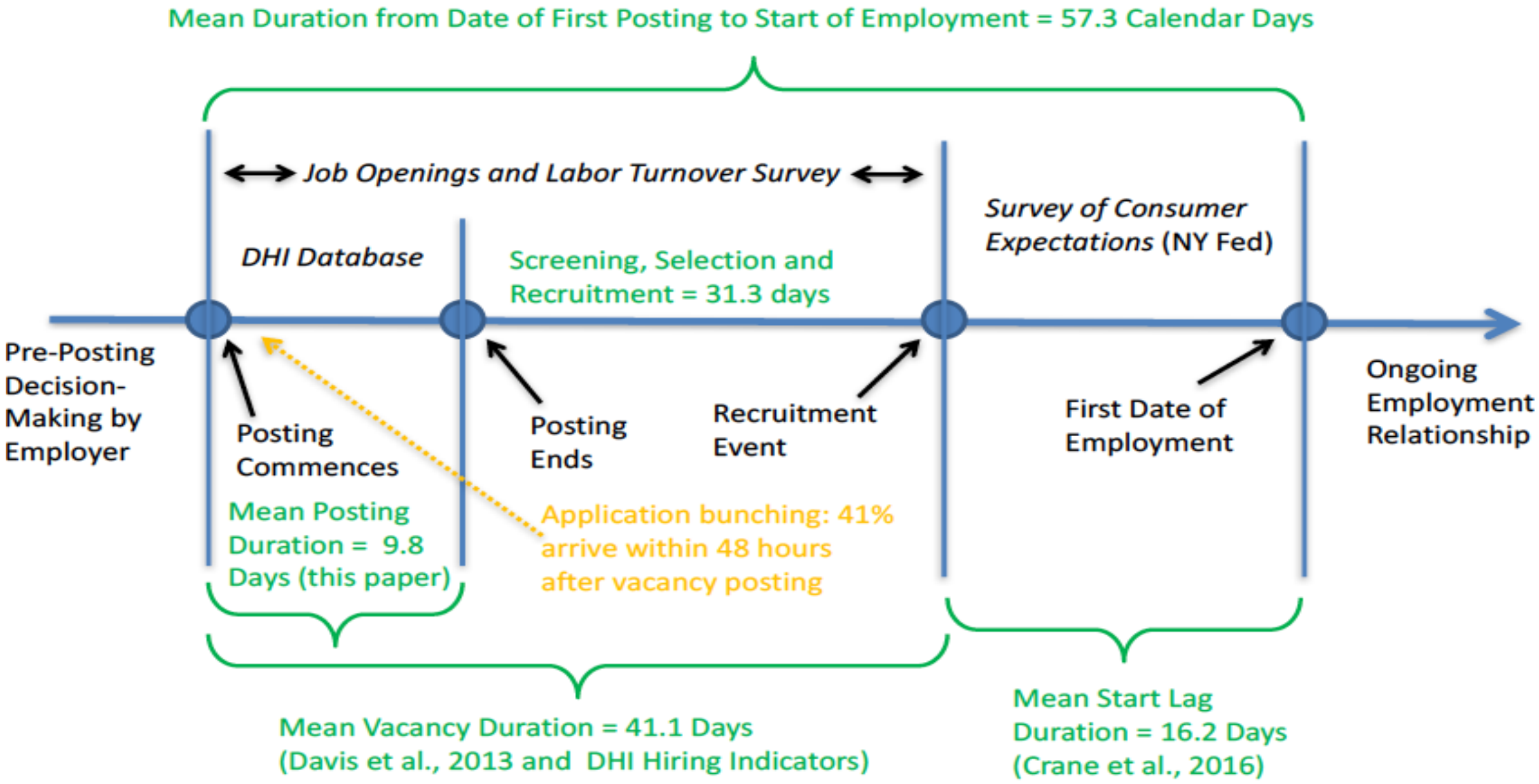
Staffing and Recruitment Firms Affect Matching and Labor Market Outcomes

1. When scale economies in search, recruitment and screening are important, intermediaries can lower the costs of finding prospective workers, assessing their skills, hunting for suitable jobs, and identifying high-quality matches.
2. Their high-volume market engagement gives them better information about job availabilities, suitable workers, potential matches, and likely match quality.
3. Horton (2017) studies a field experiment in which oDesk (later known as Upwork) offered algorithm-based recommendations to employers. The recommendations raised the success rate in forming matches by 20 percent in technical job openings, with no apparent evidence that other matches were crowded out.
4. Staffing and recruitment firms also have reputational incentives to supply high-quality information and recommendations, in line with Stanton and Thomas (2016).
5. Finally, because of their capacity to quickly gather a pool of suitable applicants, recruitment firms increase the appeal of non-sequential search, which also matters for labor market outcomes.

Theorizing about Intermediaries

1. Despite their prevalence and likely effects on labor market outcomes, theorizing about staffing and recruitment firms is scarce – especially in the form of equilibrium models that speak to frictional unemployment, job-finding rates, job creation incentives, vacancy durations, and wage dispersion.
2. In an early effort, Bull et al. (1987) show that recruitment firms can diversify idiosyncratic risks by sampling over a greater number of job candidates, thereby letting employers fill vacancies more quickly and with greater assurance.
3. Biglaiser (1993) models the role of "middlemen" who specialize in quality assessment and re-sell acquired goods at a premium. Although he considers goods markets, his middlemen perform functions similar to those of staffing firms.
4. Gautier (2002) models how intermediaries reduce duplicative screenings, thereby lowering aggregate screening costs and mitigating congestion externalities. Both recruitment and staffing firms perform screening functions akin to those of the intermediaries in Gautier's model.
5. Stanton and Thomas (2016) stress the quality certification role of the outsourcing intermediaries on oDesk.com, adapting a model of Tervio (2009). They develop evidence that these intermediaries improve allocative efficiency and raise the wages of high-quality inexperienced workers.
6. Arnosti et al. (2015): Meeting cost reductions due to the rise of online platforms can lower welfare by raising screening costs.

A Quantitative Sketch of Stages in the Hiring Process:



Alternative Employer Search Strategies

Sequential Search Strategy: Employer screens each applicant on arrival and immediately offers a job if expected match surplus > 0. Factors that favor a sequential strategy include**:**

- Low applicant arrival rate
- High cost of screening another applicant
- Absence of scale economies in screening

Non-Sequential Search Strategy: Employer gathers a pool of applicants, screens the pool, selects one or more, then extends job offer(s). Factors that favor a non-sequential strategy include:

- High applicant arrival rate
- Bunching of applications shortly after posting
- Scale economies in screening applicants

1. We are not the first to argue that much hiring behavior is inconsistent with sequential search. In a small sample of 1900 Dutch establishments with 670 vacancies, Van Ours and Ridder (1992) find that almost all hires take place from a pool of applicants formed shortly after vacancy posting.
2. Van Ommeren and Russo (2008) reject the hypothesis of sequential search by Dutch employers who rely on advertising or employment agencies to recruit workers, which constitute nearly half the hires in their sample. When they consider vacancies filled through social networks (e.g., employee referrals), they cannot reject the hypothesis of sequential search by employers.
3. Guertzgen and Moczall (2020) report that 3/4ths of hires originate from a non-sequential search process in a large, representative sample of German employers.

4. Application bunching shortly after posting favors a non-sequential search strategy, whereby an employer first collects a batch of applications, then screens them and potentially selects one (or more) for an offer.

- See Gal, Landsberger and Levykson (1981), Morgan (1983) and Morgan and Manning (1985)
- Application bunching is prominent in our data: 41% of applications arrive within 48 hours of posting, and 56% arrive within 96 hours.
- Thus, observed applicant behavior favors non-sequential employer search, according to theory. And we find evidence of non-sequential employer search.

5. Labor market intermediaries arise partly to exploit scale economies in screening and matching. The prominence of employer-side intermediaries on Dice.com suggests that scale economies are important. That, according to theory, also weighs in favor of non-sequential search strategies by employers.
6. Non-sequential employer search creates incentives for job seekers to also adopt a non-sequential strategy, applying to many job openings at the same time.
   - Non-sequential employer search creates a delay between application and employer's selection of a recruit. Thus, it makes sense for job seekers to apply to multiple job openings simultaneously while awaiting call-backs and offers, unless applications themselves are very costly to submit.
   - We find evidence (not shown here) that many job seekers engage in this form of non-sequential search. See, also, Abbring and Van Ours (1994).

How Non-Sequential Search Matters

1. Many workers bargain with prospective employers before accepting a job (Hall and Krueger, 2012).
   - An employer strengthens its bargaining position by gathering a pool of qualified applicants before negotiating with a prospective hire.
   - Likewise, job seekers strengthen their positions when a non-sequential search strategy yields multiple options.
   - Thus, non-sequential search influences negotiated wage outcomes, which in turn affect search incentives, recruiting behavior, and job creation incentives.

How Non-Sequential Search Matters

2. Non-sequential search injects distinct forces into the determination of equilibrium outcomes.

- Chade and Smith (2009): Suppose job seekers can submit multiple applications while awaiting news about callbacks and offers, can take at most one job, and run the risk of no offers. This search problem has aspects of portfolio choice in that the number *and* mix of vacancies to which the job seeker applies affect his expected payoff.
- It is not generally sufficient to rank order vacancies by expected payoffs and then optimize over the number of applications. Instead, when jobs differ enough in attractiveness and offer probabilities, and if costs per application are not too high, the optimal non-sequential strategy is to apply to a mix of highly attractive and not-so-attractive jobs while foregoing jobs in the middle.
- Galenianos and Kircher (2009) integrate this portfolio choice perspective into an equilibrium model of directed search with wage posting. In their model, job seeker appetites for both “risky” job openings (high wage, low offer probability) and “safe” ones (low wage, high offer probability) support equilibrium wage dispersion with homogenous agents. The number of simultaneous applications per job seeker determines the extent of equilibrium wage dispersion and, hence, the types of jobs that emerge in equilibrium.

How Non-Sequential Search Matters

3. Constrained inefficient outcomes also emerge in several other equilibrium models with non-sequential search by job seekers. Examples include Gautier (2002), Albrecht et al. (2003, 2006) and Gautier and Moraga-Gonzalez (2005).
4. As later work shows, the (in)efficiency of the directed search equilibrium depends on details of the environment. See Kircher (2009), Gautier and Holzner (2016), Wolthoff (2018), and Wright et al. (2019).
5. Extra screening costs that applicants impose on employers are another potential source of inefficiency when job seekers search in a non-sequential manner.

Concluding Remarks

The search and matching process, as documented here and in other recent research, differs sharply from the process embedded in leading theoretical models. In particular:

- Employer-side search is non-sequential in nature.
- Worker-side search also exhibits important aspects of non-sequential behavior.
- Staffing agencies, Recruitment firms, placement agents and commercial platforms play a huge and growing role in the search and matching process.
- Worker-side search is neither random nor directed in ways stressed by received theory.

Our evidence provides strong motivation for greater attention to models with non-sequential search, whereby job seekers and employers contact multiple potential partners before making decisions about whether, and with whom, to initiate an employment relationship.

- In contrast, leading equilibrium models of the search and matching process presume sequential search behavior.

Likewise, our evidence calls for greater attention to the role of commercial, for-profit labor market intermediaries in the search and matching process and the equilibrium outcomes they produce.

- Platform design can greatly affect the volume of meetings (as (measured by applications per posting), their distribution over employers, and the matches that occur (Horton's work).

To my knowledge, there is little work that investigates whether whether directed search models actually explain the empirically observed directions of search.

- Our evidence for the Dice.com says that offer wages play little role in directed applications to postings.

Data Availability

- Our micro data are available for use by other researchers. Contact Steve or Brenda for information about the access protocol.
- For a detailed description of the database, see "The DHI Vacancy and Application Flow Database: Record Layouts, Variable Descriptions, and Summary Statistics" by Davis and Samaniego de la Parra, February 2019.

Extra Slides

Distributions by Full/Part Time Schedule

	Raw Postings	Applications
Full-Time	44.9%	45.7%
Part-Time	4.1%	4.9%
No Time Schedule Specified	53.9%	53.3%

Columns sum to more than 100% because some postings are for a job that can be full-time or part-time.

Percent Distributions by Firm Type, Direct Hires Only

Jan. 2012 to July 2017	Privately Held	Publicly Listed	Govt.	Other
Employer-Side Clients	93.5	3.5	2.9	0.1
Raw Job Postings	91.6	7.7	0.6	0.0
Applications	92.1	7.2	0.7	0.0

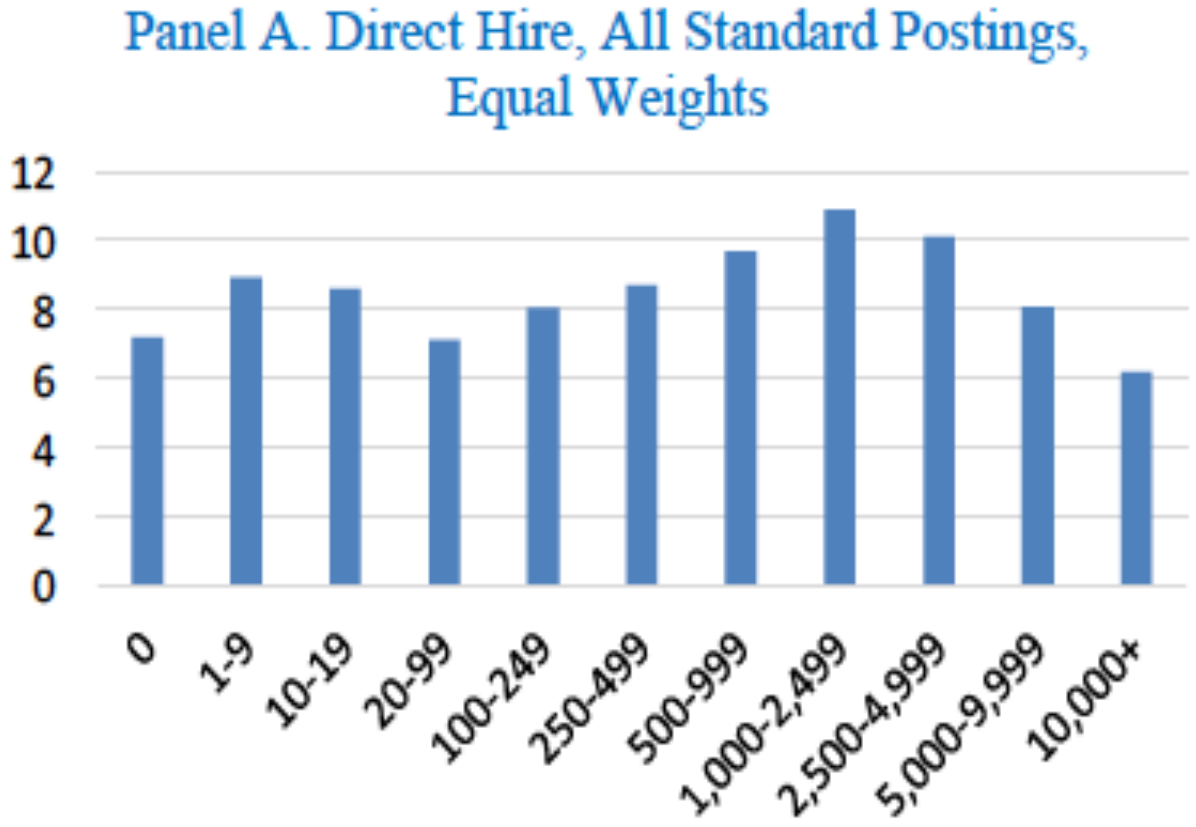
Percent Distributions by Firm Size, Direct Hires Only			
Employer Size	*Clients*	*Raw Job Postings*	*Applications*
0 Employees	11.8	16.7	14.5
1-9	20.3	19.2	21.7
10-11	8.1	6.4	6.7
20-99	22.9	21.7	20.3
100-249	12.3	7.6	8.0
250-499	7.3	6.0	6.3
500-999	5.7	2.3	2.9
1,000-2,499	4.9	3.2	4.2
2,500-4,999	2.6	2.5	3.4
5000-9,999	1.6	2.9	3.1
10,000+	2.4	11.6	8.8

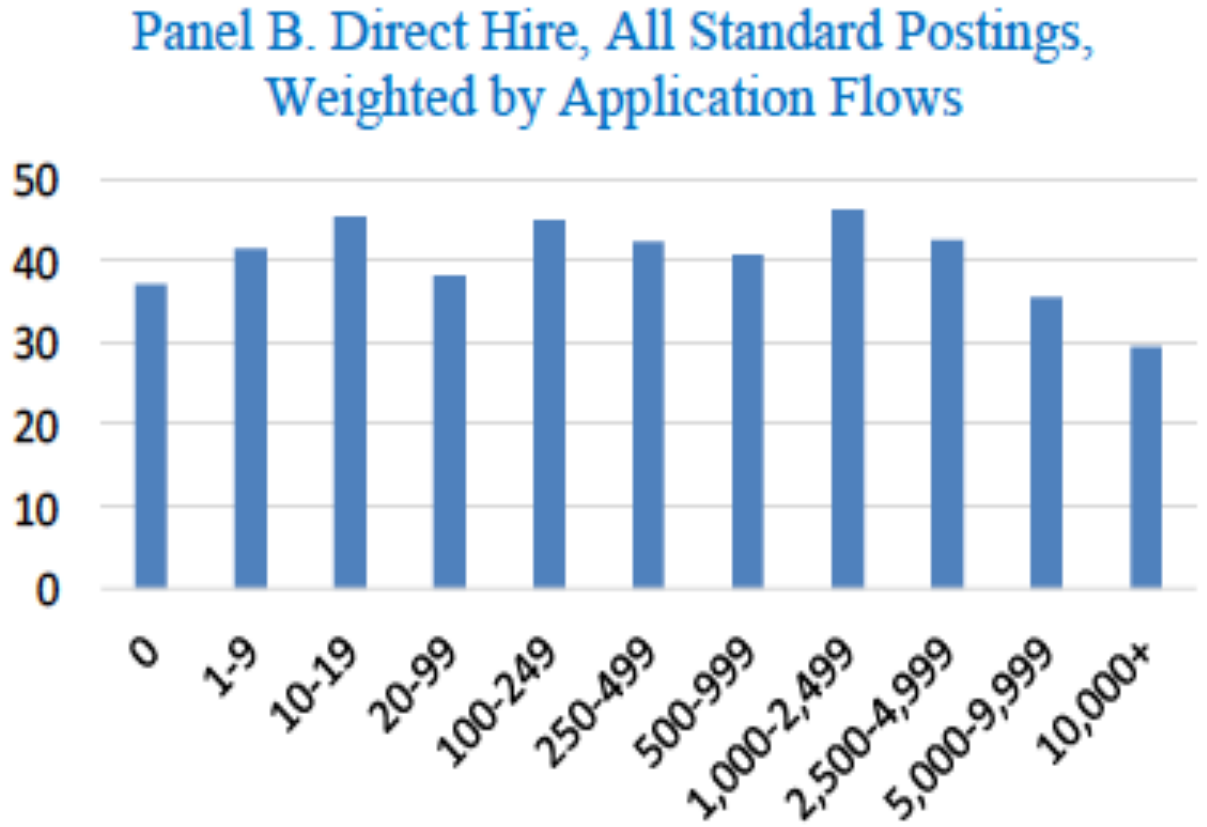
Table 4. Summary Statistics for Frequently Posted Job Titles in the DHI Database

January 2012 to November 2016

(1) Minimum Posting Frequency	(2) Number of Job Titles	(3) Share of Job IDs	(4) Share of Vacancy IDs	(5) Share of Applications
250 Job IDs	1,580	66.6%	66.3%	73.6%
100 Job IDs	3,680	70.7%	70.2%	76.9%
50 Job IDs	7,122	73.8%	73.1%	76.9%

Figure 3. Mean Applications per Vacancy by Employer Size





Applications Per Completed Posting Spell
54 Software-Related Skill Categories

		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
Standard Postings with Frequently Required Skills	3,097,722	11.8	102.3	3	45
Selected Skills					
COBOL	10,248	18.1	46.2	11	31
HADOOP	19,022	28.8	111.1	10	78
SSIS	6,341	26.7	120.0	9	79
INFORMATICA	30,106	20.7	91.4	9	51
ABAP	2,222	17.0	52.7	9	35
ETL	42,649	20.6	90.2	8	53
COGNOS	17,749	13.4	45.9	7	29
SQL	98,961	18.9	100.8	6	60
SAP	200,146	11.3	38.1	6	24
SALESFORCE	58,242	20.3	105.0	5	73

		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
BIGDATA	**16,364**	**15.0**	**61.4**	**5**	**42**
ORACLE	190,389	12.0	60.2	5	33
JAVA	318,005	21.0	196.9	4	114
DOTNET	195,973	18.3	165.8	4	96
IOS	22,535	16.9	74.9	4	60
SHAREPOINT	56,903	11.5	55.3	4	36
DATA	149,481	10.9	53.3	4	32
SAS	16,528	9.7	34.6	4	23
WINDOWS	44,251	8.60	37.87	4	22
HYPERION	12,342	8.49	27.68	4	19
LOTUS	2,797	5.55	13.54	4	10
USER INTERFACE	49,310	26.4	199.5	3	149
LINUX	41,383	10.6	72.4	3	48
MOBILE	38,349	10.4	63.7	3	39
C	67,934	9.37	81.87	3	30
UNIX	23,898	8.00	52.75	3	28
TIBCO	12,598	7.46	28.87	3	18
WEBSPHERE	19,996	7.30	35.58	3	21

		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
SYSTEMS	**263,608**	**7.18**	**41.24**	**3**	**21**
SOA	9,560	6.91	34.92	3	17
DATABASE	65,311	6.64	38.56	3	18
PEOPLESOFT	59,869	6.21	25.00	3	14
ABINITIO	6,070	5.63	24.83	3	13
PYTHON	16,702	10.3	50.8	2	37
JEE	10,886	10.3	101.6	2	56
CLOUD	27,347	9.8	86.9	2	41
NET	5,782	9.6	62.9	2	40
NETWORK	170,200	9.47	76.71	2	43
FINANCE	8,760	8.63	63.88	2	32
WEB	107,092	7.96	82.23	2	42
CISCO	20,067	6.52	66.72	2	27
PHP	23,850	6.48	34.10	2	23
SOFTWARE	205,712	6.45	45.97	2	21
DRUPAL	7,142	6.30	29.77	2	22

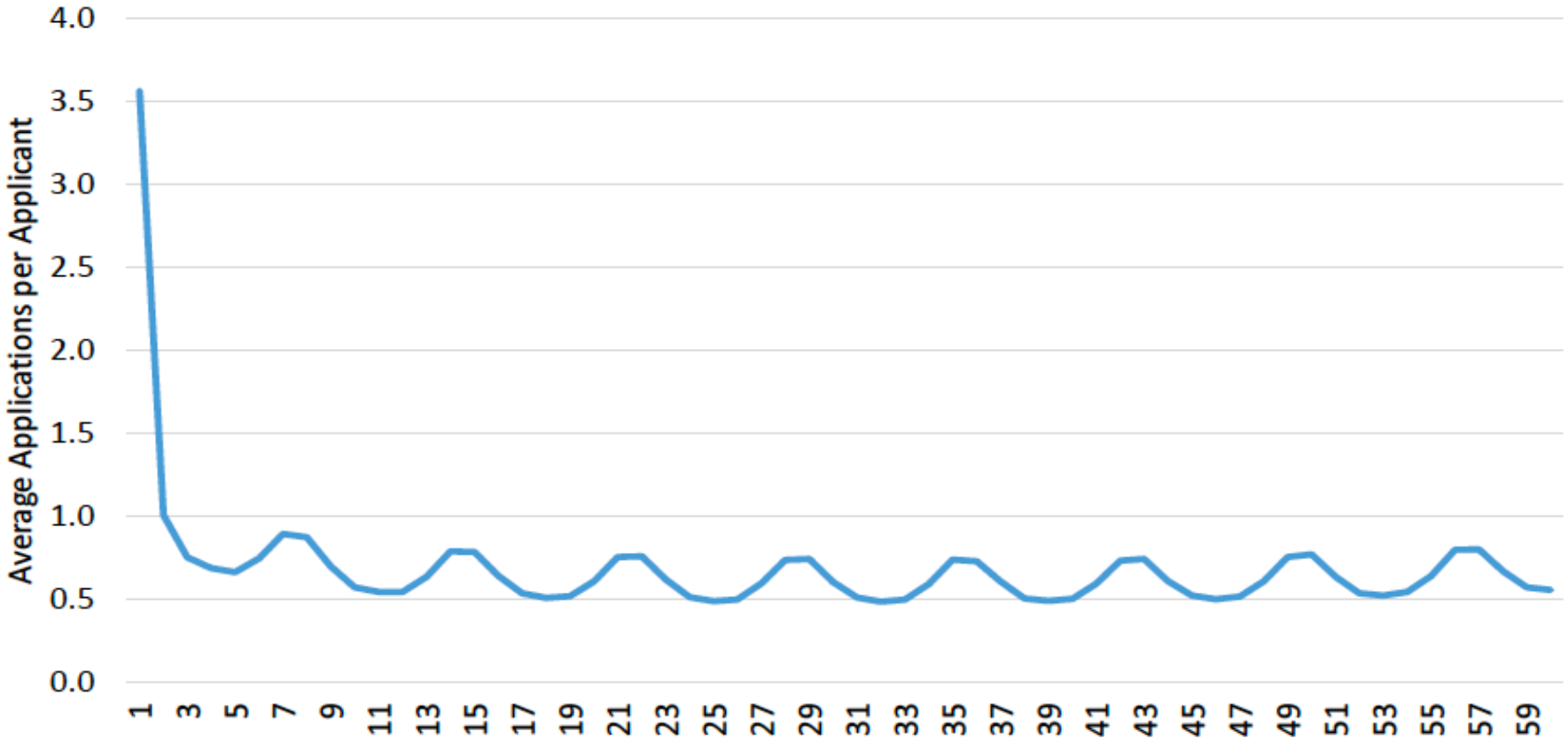
		Mean Applications per Completed Spell		Median Applications per Completed Spell	
	(1)	(2)	(3)	(4)	(5)
	No. of Postings	Equal Weights	Application Weighted	Equal Weights	Application Weighted
VISUALBASIC	**11,497**	**6.22**	**43.99**	**2**	**17**
USER EXPERIENCE	20,221	5.81	49.19	2	18
IBM	21,383	5.64	29.86	2	16
APPLICATIONS	109,415	5.24	29.81	2	15
SECURITY	100,852	4.56	25.25	2	12
PERL	4,361	4.49	31.37	2	12
SOLUTION	44,042	4.48	22.78	2	11
DELPHI	861	3.95	15.04	2	8
MATLAB	502	3.60	15.53	2	8
RUBY	11,908	5.58	40.11	1	24

More on Sequential vs. Non-Sequential Search

- The non-sequential perspective has been overshadowed by theories in the mold of Diamond (1982), Mortensen (1982), Pissarides (1985) and Mortensen and Pissarides (1994), which postulate sequential search by employers and workers.
- Prevailing treatments of frictional unemployment, job-finding rates, vacancy dynamics, wage dispersion with search frictions, and job creation incentives in settings with search frictions have been dominated by the sequential search perspective.
- Leading examples include Burdett & Mortensen (1998), Pissarides (2000), Postel-Vinay & Robin (2002), Mortensen (2003), Hall (2005), Shimer (2005), Hornstein, Krusell and Violante (2011) and Davis, Faberman & Haltiwanger (2013).

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.

Job Seekers

Figure: Job Seekers Distribution by Search Spell Duration