The Establishment-Level Behavior of Vacancies and Hiring

April 2008

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Abstract

Search models are widely applied to the study of unemployment, worker turnover, wage dispersion and other labor market phenomena. These models afford a central role to the concept of a job vacancy, but most of the evidence on vacancies is confined to aggregate outcomes. In contrast, we study vacancies, hires and vacancy yields (success rates in generating hires) at the establishment level using the BLS Job Openings and Labor Turnover Survey, a large representative sample of U.S. employers. We show that the vacancy yield moves counter cyclically but rises with employer growth in the cross section. We also develop a stock-flow accounting framework that identifies the average job-filling rate for vacant positions, the monthly flow of new vacancies, and the fraction of hires outside of this basic framework. The job-filling rate is counter cyclical, increases steeply with establishment turnover and rises sharply with employer growth in the cross section. Our results also suggest that at between 16 and 22 percent of hires occur without a prior vacancy, as recorded in JOLTS. We argue that these findings raise several issues for the treatment of vacancy data and worker recruitment in models of labor market search.

Keywords: vacancies, job openings, hiring, labor market search, establishment data
JEL Codes: D21, E24, J60

We thank Eva Nagypál, Rob Shimer, Mike Pries, Shigeru Fujita and seminar participants at the University of Maryland, the Wharton School, the Bureau of Labor Statistics, the Federal Reserve Banks of Kansas City, New York, and Philadelphia and several conferences for many helpful comments. We thank Bruce Fallick, Charles Fleischman and Rob Shimer for providing CPS data on gross worker flows. We thank Marios Michaelides and Nathan Brownback for excellent research assistance. The views expressed are solely those of the authors and do not necessarily reflect the official positions or policies of the U.S. Bureau of Labor Statistics, the U.S. Bureau of the Census or the views of other staff members.
1. Introduction

In most recent models of labor market search, firms must post costly vacancies to attract job seekers.¹ This assumption often takes the form of a matching function that requires job-seeking persons and posted vacancies to produce hires. Despite their central role in search models, few empirical studies consider vacancies at the employer level. In practice, the role of vacancies likely differs among the various methods employers use to identify, meet, recruit and hire workers. These methods include bulk screening of applicants who respond to help-wanted advertisements, informal recruiting through social networks, opportunistic hiring of attractive candidates, impromptu hiring of unskilled workers in spot labor markets, and the conversion of temp workers and independent contractors into employees. The role of vacancies is also likely to vary with labor market conditions and the characteristics of employers and recruits.

In this study, we examine vacancies, hires and vacancy yields at the establishment level using the BLS Job Openings and Labor Turnover Survey (JOLTS), a large representative sample of U.S. employers. The vacancy yield is the flow of realized hires per reported job opening. Using JOLTS data, we explore how the hires rate, the vacancy rate and the vacancy yield vary with employer growth in the cross section, how they differ by employer size, turnover and industry, and how they move over time. To obtain a longer sample for time-series analysis, we supplement the JOLTS data with the

¹ This description fits random search models such as Pissarides (1985) and Mortensen and Pissarides (1994), directed search models such as Moen (1996), wage-posting models such as Acemoglu and Shimer (2000), and on-the-job search models such as Burdett and Mortensen (1998) and Nagypal (2005). The precise role of vacancies differs among these classes of models. See Mortensen and Pissarides (1999), Rogerson, Shimer and Wright (2005) and Yashiv (2006) for reviews of research in this area.
Conference Board’s Help Wanted Index and data on hires from the Current Population Survey.

We begin our analysis by generating basic facts relating the aggregate and establishment level behavior of hires and vacancies. We show that the vacancy yield moves counter cyclically – in line with standard matching function specifications. We find that the vacancy yield declines steeply with employer size, increases steeply with turnover, and varies by a factor of three across major industry groups. A novel set of findings emerge from the establishment-level behavior. We find highly nonlinear relationships between the hires rate, the vacancy rate, and the vacancy yield with establishment net growth in the cross section. Among contracting establishments, the relationship of all three measures to employer growth is essentially flat. Among expanding establishments, all three measures rise steeply with employer growth. Stable establishments with no employment change have the lowest values of all three measures. The finding that the vacancy yield rises sharply with expanding establishments is interesting since it contrasts with the inverse relationship between the vacancy yield and net growth at the aggregate level.

Another novel set of findings from the establishment-level data emerge when we examine the distribution of vacancy postings across establishments and the relationship between this distribution and the patterns of hires. We show that there is a large fraction of employment at establishments with zero vacancies posted at the beginning of the month. Many of these establishments hire workers over the course of the month so that such zero initial vacancy establishments account for about 42 percent of hires. This
pattern varies considerably over time, and is more prevalent in establishments and industries with high worker turnover.

The basic facts from the aggregate and establishment-level data are interesting but caution must be used in interpreting the findings in terms of standard macro labor models. For example, it is tempting to interpret the vacancy yield (hires divided by initial vacancies) as the job filling rate in standard models. Supporting this temptation, the aggregate vacancy yield is countercyclical consistent with the prediction that the job filling rate derived from a matching function should be countercyclical. However, the stock flow issues and associated time aggregation issues imply that it is essential to translate the basic facts into measures that are consistent with the concepts in standard models. To accomplish this translation, we develop a stock flow accounting framework that identifies the job-filling rate for vacant positions and the monthly flow of new vacancies. The accounting framework treats JOLTS data on the monthly flow of new hires and the stock of vacancies at month’s end as observed outcomes of daily processes for new vacancies and new hires. By cumulating the daily processes to the monthly level, we account for time aggregation and uncover several interesting quantities not directly observed in JOLTS.

Applying the framework, we find that the job-filling rate is countercyclical with respect aggregate growth but is positively related to establishment-level growth. We also find that the job filling rate varies systematically with the industry, establishment size and establishment turnover rate. We find that the flow of posted vacancies is procylical with respect to aggregate growth and is also positively related to establishment-level growth.
We also find that the vacancy posting flow varies systematically with the industry, establishment size and establishment turnover.

The differences in correlations with aggregate net growth and establishment net growth with the job filling and vacancy posting flows are striking. These patterns on the job filling and vacancy posting flows along with the other patterns we detect can be read as an effort to partly unpack the “black box” nature of the matching function (Petrongolo and Pissarides, 2001), especially with respect to recorded vacancies. We believe these empirical patterns should provide a useful source of discipline in the specification and further development of search models where vacancies play an important role.

However, we take our analysis one step further as we provide an estimate of the fraction of hires that seemingly occur outside the standard matching function framework. That is, our job filling and vacancy posting rates can be used to generate an estimate of the fraction of hires that should be accounted for by establishments that by chance find themselves with zero vacancies at the beginning of the month. A steady-state approximation of this estimate given the estimated flow and fill rates is that establishments that begin the month with zero vacancies should account for about 20 percent of hires. However, the data show that establishments that begin the month with zero vacancies account for about 42 percent of hires. These findings imply that 22 percent of hires occur outside of the standard matching function framework, which, taken literally imply that these hires occur without a vacancy (at least of the type recorded in JOLTS). This fraction of hires outside the standard framework varies across industries and decreases sharply with establishment size.
Both the main findings on job filling and flow rates as well as the steady state
approximation estimate of the hires outside the framework are based on the simple
accounting stock-flow framework that does not take full advantage of the establishment
level distributions we observe in the data. To obtain more rigorous estimates of our
findings, we also develop and apply a richer stochastic version of our stock-flow
framework to the establishment data using a Simulated Method of Moments approach.
By construction, this version is able to account for the stochastic nature of job posting
and job filling as well as some of the heterogeneity at the micro level. This more rigorous
framework largely confirms our findings on job filling and vacancy flow rates. We also
find that the more rigorous framework yields an estimate that about 26 percent of hires
should occur from establishments that being the month with zero vacancies. This
estimate implies that about 16 percent of hires in the data are outside the standard
framework.

Our evidence related to hiring outside of our basic framework raises several issues
for search models. First, its sizable percentage points to the value of models that
incorporate multiple recruiting channels, not all of which involve formal vacancies.
Second, cyclical variation in the relative importance of different recruiting channels leads
to biased estimates of matching function parameters, as carefully analyzed by Sunde
(2007). Third, models that ignore time variation in the prevalence of recruiting through
nonstandard methods are likely to yield misleading inferences in other respects when fit
to data on employment, wages, vacancies and unemployment.

Our study also has clear roots in previous empirical research on vacancy behavior.
The pioneering work of Abraham (1983, 1987), and Blanchard and Diamond (1989) uses
the Help Wanted Index (HWI) to proxy for vacancies, and many other studies follow the same approach. The Help Wanted Index yields sensible patterns at the aggregate level (Abraham, 1987; Blanchard and Diamond, 1989; and Shimer, 2005a), but its design cannot accommodate a firm-level analysis. Several recent studies exploit aggregate and industry-level JOLTS data on hires, separations and vacancies (e.g., Hall, 2005a; Shimer, 2007; Valetta, 2005). Earlier studies by Holzer (1994) and Cunningham (1998) consider vacancy behavior in small samples of U.S. employers. Coles and Smith (1996), Yashiv (2000) and Sunde (2007) exploit vacancy data from centralized registers of job openings in Britain, Israel and Germany, respectively.

The paper proceeds as follows. The next section discusses our data sources. Section 3 documents several patterns in the time-series and cross-sectional behavior of vacancies and hires. Section 4 introduces our basic stock-flow accounting framework and fits it to the data. We show how to recover monthly estimates for the unobserved flow of new vacancies, the job-filling rate, and the mean vacancy duration. Section 5 analyzes a steady-state approximation of the accounting framework to obtain its implied fraction of hires outside of the basic stock-flow specification. Section 6 applies a stochastic version of our framework to simulated establishment data using a Simulated Method of Moments approach. Section 7 concludes with a summary of our main contributions and some remarks about directions for future research.

2. Data Sources

We exploit micro data from the Job Openings and Labor Turnover Survey (JOLTS), which samples about 16,000 establishments per month. Respondents report hires and separations during the month, employment in the pay period covering the 12\textsuperscript{th}
of the month, and job openings at month’s end. They also report quits, layoffs and
discharges, and other separations (e.g., retirements). The JOLTS commences in
December 2000, and our sample continues through December 2006. We drop
observations that are not part of a sequence of at least two consecutive observations for
the same establishment. This restriction enables a comparison of hires in the current
month to vacancies at the end of the previous month, an essential element of our analysis.
The resulting sample contains 577,268 observations, about 93 percent of the full sample
that the BLS uses for published JOLTS statistics. We have verified that our sample
restriction has little effect on aggregate estimates of vacancies, hires and separations.2

For our purposes, it is important to consider exactly how job openings (vacancies) are defined and measured in JOLTS. The survey form instructs the respondent to report a vacancy when “A specific position exists, work could start within 30 days, and [the establishment is] actively seeking workers from outside this location to fill the position.” The respondent is then asked to report the number of such vacancies existing on “the last business day of the month.” Further instructions define “active recruiting” as “taking steps to fill a position. It may include advertising in newspapers, on television, or on radio; posting Internet notices; posting ‘help wanted’ signs; networking or making ‘word

2 There is a broader selection issue in that the JOLTS is not designed to capture most establishment births
and deaths, which may be why our sample restriction has little impact on aggregate estimates. Another
issue is the potential impact of JOLTS imputations for item nonresponse, on which we rely. See Clark and
Hyson (2001), Clark (2004) and Faberman (2005) for detailed discussions of JOLTS. Finally, in related
work (Davis, Faberman and Haltiwanger (2008)) we have explored measurement concerns that have been raised about JOLTS estimates of net employment growth rates (JOLTS yields a higher net growth rate than estimates from the Current Establishment Survey) and the magnitude of the hires and separations rates in JOLTS (JOLTS appears to be low relative to alternative estimates). We find in this work that relative to the universe distribution of establishment-growth rates that the JOLTS sample has lower dispersion of establishment-growth (even neglecting the contribution of entry and exit) and especially on the job destruction side. We suggest and develop a benchmarking adjustment to the universe distribution that ameliorates the measurement concerns that have been raised. It is beyond the scope of the current paper to consider or incorporate the type of adjustments we have suggested in this other work. We note however that for the measures and moments that we focus on in this paper that the patterns are largely robust to our suggested adjustment of the published JOLTS data.
of mouth’ announcements; accepting applications; interviewing candidates; contacting employment agencies; or soliciting employees at job fairs, state or local employment offices, or similar sources.” Vacancies are not to include positions open only to internal transfers, promotions, recalls from temporary layoffs, or positions to be filled by temporary help agencies, outside contractors, or consultants.

Given the survey instructions, there are several ways for a hire to occur without benefit of a reported vacancy. First, the new job starts more than thirty days after the recruitment period, as in the market for economics professors. Second, the employer hires someone it previously engaged as an independent contractor, consultant or temp worker (leased from a temporary help agency) while foregoing any active recruiting as defined by JOLTS. Third, the hire otherwise occurs without benefit of active recruiting efforts. For example, an employer might create a new position to hire an attractive candidate who suddenly becomes available or known. And, of course, hires can occur without benefit of a reported vacancy because respondents fail to comply carefully with the survey instructions. In Section 5 below, we show how to use JOLTS data to estimate the frequency of hires without a reported vacancy.

Turning to measurement mechanics, we calculate an establishment’s net employment change in month $t$ as its reported hires in month $t$ minus its reported separations in $t$. We then subtract this net change from its reported employment in $t$ to obtain employment in $t−1$. This procedure ensures that the hires, separations and employment measures in the current month are consistent with our employment measure for the previous month. To express hires, separations and employment changes at $t$ as rates, we divide by the simple average of employment in $t−1$ and $t$. The resulting growth
rate measure is bounded, symmetric about zero and has other desirable properties, as discussed in Davis, Haltiwanger, and Schuh (1996). We measure the vacancy rate at \( t \) as the number of vacancies reported at the end of month \( t \) divided by the sum of vacancies and the simple average of employment in \( t - 1 \) and \( t \). The vacancy yield in \( t \) is the number of hires reported in \( t \) divided by the number of vacancies reported at the end of \( t - 1 \).

We supplement the JOLTS with other sources that yield longer time series for aggregate outcomes. To obtain hires and separations, we rely on two related sources of data on gross worker flows, both of which derive from the Current Population Survey (CPS). First, using data from Shimer (2005b), we compute the aggregate hires rate at \( t \) as the gross flow of persons who transit from jobless status in \( t - 1 \) (unemployed or out of the labor force) to employed status in \( t \) divided by employment at \( t \). We detrend the resulting hires rate using a Hodrick-Prescott filter with a smoothing parameter of 10\(^5\). This filter removes low-frequency movements in the series, including movements induced by CPS design changes, and it facilitates a comparison to the Help Wanted Index described below. Second, using data from Fallick and Fleischman (2004), we compute the aggregate hires rate as the sum of gross flows from joblessness to employment and direct job-to-job transitions. Thus, the Fallick-Fleischman data yield a more inclusive measure of the hires rate. However, their series runs from 1994 to 2007, whereas the Shimer series spans 1976 to 2007.\(^3\) Both series are quarterly averages of monthly values.

The Conference Board’s Help Wanted Index (HWI) is a monthly measure of help-wanted advertising volume in a sample of U.S. newspapers. The HWI has significant shortcomings as a proxy for vacancies, but it is the only vacancy-related measure for the U.S. economy that provides a long, high-frequency time series. We detrend the HWI

\(^3\) Direct job-to-job transitions by workers cannot be identified under the pre-1994 CPS design.
using the same HP filter as before, then rescale the deviations to match the mean JOLTS vacancy rate in the overlapping period.\textsuperscript{4} We use the detrended rescaled HWI in the first month of each quarter as a proxy for the vacancy rate and match it to the CPS-based hires rates in the same quarter. The HWI-based vacancy proxy closely tracks the JOLTS vacancy rate in the overlapping period.

3. Aggregate and Establishment-Level Patterns

3.A. Aggregate Patterns

The period covered by our JOLTS sample spans the onset of a recession and its recovery. The recession officially lasted from March to November 2001, but employment losses continued through mid-2003. Based on the publicly-available JOLTS data (see also Davis et al., 2006), hires and vacancies, as well as quits, dip during the recession and remain low afterwards. The vacancy rate undergoes the largest decline. When employment growth picks up again in mid-2003, hires, vacancies, and quits follow. Layoffs rise during the recession and decline thereafter. They remain relatively flat through mid-2003, then begin another, more gradual, decline.

Figure 1 depicts the behavior of hires and vacancies from the CPS gross flow data and the Help Wanted Index back to 1976. The figure depicts both the Shimer and Fallick-Fleischman hires series. Note that the latter hires are greater in magnitude because they include job-to-job transitions. Note also that HP filtering removes a secular decline in

\textsuperscript{4} This approach to the HWI follows Abraham (1987) and Shimer (2007), who discuss the measurement issues in detail.
hiring rates observed in other research (Faberman, 2006; Davis et al., 2006). With these caveats in mind, the figure shows that vacancies rise in booms and drop in recessions, and appear much more cyclically volatile than hires. The hires measures from the CPS appear somewhat acyclical, though the hires measure from the JOLTS shows a decline during the 2001 recession and a recovery thereafter.

One major focus in this paper is on the vacancy yield. Figure 2 depicts the time-series of the aggregate vacancy yield estimated using the JOLTS, CPS and HWI data to create three series, each measured as the flow of hires during month $t$ divided by the stock of vacancies from month $t-1$. The flow versus stock comparison is a major reason the observed yields are greater than one (we discuss other potential reasons below). All three series appear countercyclical, though most movement in the CPS-HWI vacancy yield measures is driven by movement in the vacancy rate. In the JOLTS data, both hires and vacancies fall during the 2001 recession, but since vacancies fall further, the vacancy yield exhibits a qualitatively similar, albeit less pronounced, pattern as the other measures. Given a standard model of labor market search, a countercyclical vacancy yield is exactly what we would expect (neglecting the stock-flow and time aggregation issues to come). To see this, let hires stem from a constant returns to scale matching function that has the stocks of vacancies and unemployed ($u$) as its arguments:

$$h = \mu v^{1-\alpha} u^\alpha,$$

where $\mu > 0$ and $0 < \alpha < 1$. Rearranging, we get

$$\frac{h}{v} = \mu \left( \frac{v}{u} \right)^{-\alpha}.$$

另外一个需要注意的警告来源是Fujita和Ramey（2006a）认为，由于测量误差的性质，CPS的毛流量数据提出了带通滤波技术更适合。
With equation (1), it is straightforward to see that the vacancy yield \((h/v)\) is a decreasing function of labor market tightness \((v/u)\). In the data (using the unemployment rate from the CPS and the Shimer hires rate) the correlation between these two measures (in logs) is -0.89, while the correlation between the (log) vacancy yield and the (log) unemployment rate is 0.64. Using the monthly JOLTS data, the correlations are -0.83 and 0.82, respectively.

Table 1 reports the cross-sectional evidence of hires, separations, vacancies, and the vacancy yield by major industry, establishment size class, and establishment turnover quintile (where turnover is measured as the sum of the hires and separations rates) from our JOLTS sample. There is sizable variation in all variables across industries, across size classes, and across turnover quintiles. Of particular note are the variations within each category of the vacancy yield. High turnover establishments tend to have the high vacancy yields. The bottom panel clearly shows this to be the case. In addition, industries such as Construction and Resources (Natural Resources and Mining) have yields that are several times larger than those in Health & Education and Government. Similarly, both turnover and the vacancy yield tend to decrease with establishment size. Could it be that certain industries and establishment sizes are more efficient at matching workers to jobs? Perhaps. A more likely explanation, however, is that there are institutional differences across these groups in how they recruit and attract workers. For example, establishments in construction and resources may regularly recruit workers from a select labor pool for repeated short-term work, reducing their need for a vacancy (as defined in the data) to attract workers. On the other hand, establishments in education, health and government may have regulatory constraints that require them to undergo a formal search process for
any new employee. Such differences have important theoretical implications because they suggest that the standard assumption that firms must post a costly vacancy to attract a worker may be true in some industries (and size classes) more than others.

3.B. The Establishment-Level Behavior of Vacancies

We now turn to examining the behavior of vacancies at the establishment-level. The JOLTS data are the first timely, representative data source that allows such an examination. Consequently, it is useful to know basic micro-level evidence on the frequency, intensity, and variability of vacancy posting. We present that evidence here.

First, one must realize that at the monthly frequency, reported vacancies are relatively rare. Table 2 illustrates this point. In the average month, only 55 percent of employment is at establishments that report a vacancy. Figure 3 shows that even when establishments do report vacancies, they are often at very low rates and levels. Employment-weighted, the vacancy rate at the 50th percentile is less than 1 percent, while the number of vacancies at this percentile is just one. At the 90th percentile, the rate is 6 percent while the number of vacancies is 63.6

Similarly, only 65 percent of employment is at establishments who report at least one hire in any given month, so the need for a vacancy at the monthly frequency may not be that great. Nevertheless, this cannot be the entire story. For instance, Table 2 shows that 42 percent of hires occur at establishments where there was no vacancy reported going into the month, suggesting either that many matches occur quickly or that some hires occur without a formal vacancy. Table 2 also shows that even at the establishment

6 In unreported results, we find that establishments reporting at least one vacancy make up only 12 percent of all establishments. We also find that, across establishments rather than employment, the vacancy rate at the 90th percentile is 3 percent, while the number of vacancies is just one.
level, vacancies appear relatively persistent—only 18 percent of vacancies are at establishments without at least one vacancy reported in the previous month. One facet of recruiting patterns is their variation across industries and establishment size. Table 2 shows that there are considerable differences in the frequency of hiring and vacancies across both industries and size classes. Perhaps counterintuitively, industries with the greatest worker turnover also have the highest shares of observations with no reported vacancies. Consequently, these industries have the largest shares of hires and largest share of end-of-month vacancies without a previously reported vacancy. The results by turnover quintile show the same pattern. We explore possible explanations of these patterns in Sections 5 and 6 below.

3.C. Hires, Vacancies, and Establishment Growth

We next explore the establishment-level relationships of hires and vacancies to employment growth. Previous research has clearly shown that there is a wide distribution of growth rates at the establishment level at any point in time (e.g., Davis, Haltiwanger, and Schuh, 1996). In addition, labor market search theories suggest that the extent of an establishment’s employment change is a signal of the intensity of an idiosyncratic shock. Finally, other research has shown that the hiring dynamics related to micro-level employment growth can be quite complex (Abowd, Corbel, and Kramarz, 1999; Davis, Faberman, and Haltiwanger, 2006). As such, examining the relation of hiring and vacancy posting to employment growth can provide insight on how their behavior varies with the extent of such shocks.

Using our pooled sample of JOLTS microdata, we estimate weighted-mean values of the hires rate, vacancy rate and vacancy yield for growth rate intervals that increase
with the magnitude of the change. The intervals are relatively fine (0.1 percent) close to zero and increase to 5 percent intervals near the extremes; zero-growth establishments have their own distinct interval. The infrequent occurrences of large changes coupled with the relatively small size of the JOLTS sample necessitate the non-uniform interval spacing. We take a semi-parametric approach to estimating the mean values by regressing the variable of interest on a set of dummies for each growth rate interval. This allows us to estimate the vacancy and hires relations to growth while controlling for other factors, notably establishment fixed effects.

Figures 4 and 5 illustrate our results for the hiring rate and vacancy rate, respectively. Both rates increase with growth, though both relations are nonmonotonic. The hires relation must satisfy some portion of an adding-up constraint, since net growth is the difference between hires and separations. Consequently, the minimum for the hires rate is the horizontal axis for non-positive growth and the 45-degree line for positive growth. Hiring lies above the minimum for all growth rates. Rates hover around 3 percent of employment for contracting establishments then decline as one approaches zero. Establishments with no net employment changes have an average hires rate of 1.1 percent. Hiring at expanding establishments increases proportionally with growth, and is several percentage points above the 45-degree line for all values. Interestingly enough, inclusion of establishment fixed effects does little to alter the observed pattern. Vacancy rates mostly follow the same pattern, with rates at contracting establishments generally averaging 2 percent regardless of the magnitude of the contraction. Vacancy rates

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7 For all figures that depict estimates as a function of net growth, we focus on the -30 to 30 percent range, as greater magnitudes have a large decline in the number of observations used in estimation, and consequently a large decline in statistical precision. Furthermore, in each figure we smooth our estimates using a centered, 5-interval moving average for all intervals save for those at and near zero, which retain their true values.
increase with growth, but at a much slower rate than hires—establishments that grow by 30 percent have vacancy rates of just 4.8 percent. The most notable contrast with hires, however, is the relatively sharp discontinuity right around zero growth. Establishments with very small contractions (less than 1 percent) have average vacancy rates of 2.2 percent, while establishments with very small expansions average vacancy rates of 2.7 percent. Establishments with zero growth, though, have average vacancy rates of just 1.4 percent, but note that this group includes both idle establishments and establishments whose separations offset hires, so it may simply be that stable but high-turnover establishments tend to use vacancies less often. When we control for establishment effects, much of the nonlinearities in the vacancy-growth relation disappear, which is consistent with this hypothesis.

In Figure 6, we present the vacancy yield as a function of establishment-level growth. To show this relationship, total hires divided by total vacancies reported within each growth rate interval; this is similar to dividing the hires rate function in Figure 4 by the vacancy rate function in Figure 5.\(^8\) We find that among contracting establishments, vacancy yields are constant at about one hire per vacancy. There is a discontinuity for zero-growth establishments, with a slight spike upwards. This stems from the sharp drop in vacancies posted in Figure 5. Among expanding establishments, the vacancy yield increases considerably with the growth rate, with expansions in the 25-30 percent range having over five hires per vacancy. Interestingly, even though establishment fixed effects

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\(^8\) It is not identical to this approach because the hires and vacancy rates have different denominators.
affect the relation between the vacancy rate and growth, they have very little effect on the relation of the vacancy yield and growth.\(^9\)

Since hires are a flow and vacancies are a stock in the JOLTS data, one may be quick to attribute our findings entirely to time aggregation—i.e., high-yield establishments are simply establishments with higher (unobservable) vacancy flows. Yet, other unobserved recruiting processes might explain the relationship between the vacancy yield and establishment growth. For example, variations in the yield could be driven by differences in vacancy durations or heterogeneity in the propensity to attract workers without active recruiting. Consequently, we move next to an accounting framework of worker recruitment that attempts to disentangle these potential underlying processes.

### 4. A Stock-Flow Accounting Framework for Hires and Vacancies

**4.A. Overview**

We now develop a straightforward stock-flow accounting framework of vacancy and hiring flows. The framework is designed to pin down key parameters, unobservable directly in the data, that describe the search and recruitment process while addressing the inherent time aggregation issues of comparing stock and flow data. Namely, we seek to identify the average daily fill rate of vacancies (denoted by \(f\)), and account for time aggregation by estimating the average daily vacancy flow (denoted by \(\theta\)). In subsequent sections, we study the steady-state properties of the framework to see what they imply

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\(^9\) In Figure 6, we use the data on all observations and construct the figure as noted. An alternative approach would be to construct the vacancy yield at the micro level and then aggregate, which would inherently condition on the establishment having positive vacancies at the beginning of the month. We find that this alternative approach yields very similar patterns to those reported in Figure 6.
about hires outside the scope of our basic framework and then develop a stochastic simulation of the model at the establishment level.

4.B. Basic Accounting Framework

Let $h_{s,t}$ denote the number of hires on day $s$ during month $t$, and $v_{s,t}$ denote the number of vacancies on day $s$ during month $t$. We assume a daily fill rate ($f_t$) and vacancy flow ($\theta_t$) that are constant during the month but vary between months. We assume each month consists of $\tau$ workdays. Hires are simply the share of the vacancy stock from the previous day that is subsequently filled:

$$h_{s,t} = f_t v_{s-1,t}.$$  \hfill (2)

Each day, the stock of vacancies evolves along three dimensions. First, an inflow of new vacancies increases the stock. Second, hires during that day deplete the stock. Finally, an exogenous number of vacancies close without ever being filled, also depleting the stock. We denote this last variable by $\delta_t$, and again assume a constant value during the month.

The daily equation of motion for the vacancy stock is then

$$v_{s,t} = ((1 - f_t)(1 - \delta_t))v_{s-1,t} + \theta_t.$$  \hfill (3)

Next, we need to sum up equations (2) and (3) into monthly measures, as this is what we observe in the data. For vacancies, we would like to relate their stock at the end of month $t - 1$, $v_{t-1}$ to their stock at the end of the following month, $v_t$, $\tau$ days later. One can add up equation (3) over $\tau$ days and substitute back for the daily $v_{s-1,t}$ to get the desired equation

$$v_t = (1 - f_t - \delta_t + \delta_t f_t) v_{t-1} + \theta_t \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1}.$$  \hfill (4)

The first term on the right depicts the original stock after depletion by hires and closings. The second term represents the total monthly flow of vacancies, similarly depleted. Hires
reported in the data are a flow measure. As such, we wish to add up the daily equation for
hires, so that so that the monthly flow is \( H_t = \sum_{s=1}^{\tau} h_{s,t} \). Substituting (3) into (2), and (2)
into the monthly sum, and then substituting back for \( v_{s-1,t} \) to the beginning of the month
yields the following:

\[
(5) \quad H_t = f_t v_{t-1} \sum_{s=1}^{\tau} \left(1 - \delta_t - \delta_t f_t \right)^{s-1} + f_t \theta_t \sum_{s=1}^{\tau} \left(\tau - s \right) \left(1 - \delta_t - \delta_t f_t \right)^{s-1}.
\]

The first term on the right represents hires from the original stock, while the second term
represents hires from the total monthly flows. Given an exogenous \( \delta_t \), we have two
parameters to identify: \( f_t \) and \( \theta_t \). Equations (4) and (5) give us a two-equation system to
exactly identify these parameters.

4.C. Estimation Approach

The parameters of the basic framework in (4) and (5) can be estimated using the
publicly available JOLTS estimates of hires and vacancies, which we do with the
published data through June 2007. As a robustness check (that also has the benefit of a
longer time series), we present the results using the CPS gross flow and HWI data. We let
\( H_t \) be total hires during month \( t \), \( v_t \) be the vacancies reported at the end of month \( t \) and \( v_{t-1} \)
be the vacancies reported at the end of month \( t-1 \). For simplicity, we assume all months
have \( \tau = 26 \) working days (the average number of days per month less Sundays and
major holidays). We let \( \delta_t \) equal \( L_t / \tau \), where \( L_t \) is the layoff rate for month \( t \).10 This
assumption states that vacancies close without being filled at a rate proportional to the
daily layoff rate. This is analogous to assumptions in the labor search literature that set an

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10 When we use the CPS gross flow data, we set \( \delta_t \) equal to the employment-to-unemployment flow, as a
fraction of employment divided by \( \tau \).
exogenous job separation rate equal to the layoff rate. We solve the system numerically for each month to obtain estimates of $f_t$ and $\theta_t$, which provides us with a time-series of each parameter. We also produce estimates by industry, size class and turnover quintile using the average hires and vacancy rates within each category. We can calculate the average vacancy duration (in days) as $1/f_t$ and the monthly flow rate of vacancies as $\tau \cdot \theta_t$.

4.D. Aggregate Results

We begin with the time-series results for our basic framework. To make the results more easily comparable to the results reported in section 3, we scale our flow estimates (which are in levels) by employment in month $t$. The scaling has no effect on estimates of $f_t$, but it allows one to interpret $\theta_t$ as an average daily flow rate for vacancies.

Figure 7 shows the movements of the monthly vacancy flow rate (measured as $\tau \cdot \theta_t$) and the daily fill rate ($f_t$), as well as the beginning stock of vacancies, $v_{t-1}$ (measured directly from the data) using the published JOLTS estimates. Over the period, the monthly flow of vacancies average 3.4 percent of employment (compared to the stock’s average of 2.4 percent), while the fill rate averages 5.0 percent of the previous day’s stock. In the data, the stock of vacancies exhibit greater cyclical movement than hires (see Figure 1). The results from the basic accounting framework suggest that the vacancy flow is less cyclically volatile than the vacancy stock. Movements in the daily job-filling rate instead seem to account for much of the cyclical movement in the vacancy stock. During the 2001 recession, the job-filling rate rises from its low of 4.0 percent to a peak of 6.1 percent in early 2004, and then declines steadily through the remainder of the period to 4.3 percent. This coincides with the relatively sharp, persistent decline and
subsequent rise in the vacancy stock, and represents a fluctuation in average vacancy
duration that ranges between 16 and 25 days.

Both as a robustness check and to better gauge the cyclical movements in these
parameters, we apply our accounting framework to the adjusted CPS gross flow data
from Shimer (2005b) and Fallick and Fleischmann (2004) in conjunction with the Help
Wanted Index data. The results are in Figure 8, with quarterly means of the JOLTS
results included for comparison. The top panel shows the movements in the job-filling
rate, while the lower panel shows the movements in the vacancy flow rate. For the longer
time series, the striking pattern is the substantial variation in the job-filling rate, which
increases considerably around cyclical downturns. During the 2001 recession, and its
subsequent prolonged downturn, all three data sources show a job-filling rate that rises
during the downturn and falls afterwards. The two series based on CPS data, though,
show sharper movements than the serried based on the JOLTS data. This implies that,
depending on the survey studied, cyclical increases in the job-filling rate have may high
or low persistence. The vacancy flow rates estimated for the two CPS series appear
highly volatile. The vacancy flow rate from the longest available time series declines
during each recession, but overall the cyclical movements of the flow rate from the CPS
data seems less stark, particularly during the overlap period with the JOLTS data.

In Section 3, we documented considerable variation in the use and yield of
vacancies across industries, establishment size and establishment turnover rates. Table 3
presents results from our basic framework for these categories. The results are based on
estimates of hires and vacancies tabulated from pooled JOLTS data from our sample.

11 In interpreting the results for this longer time period, we suggest appropriate caution since the timing and
frequency of the data do not quite match the JOLTS measures and our associated stock-flow accounting
framework (e.g., the HWI is an index measured over the month, not as a stock).
Again, there is considerable variation across industries, size and turnover rates. The model suggests that Resources, Construction and Retail Trade, i.e., the industries with the highest worker turnover and lowest incidence of vacancies, have the highest vacancy flow and job-filling rates. Industries with the lowest turnover and vacancy rates, Government and Education & Health, have the lowest rates of both. Vacancy flow and job filling-rates tend to decrease with establishment size, and increase with establishment turnover.

4.E. Results by Establishment Growth

One of the most novel aspects of studying hiring and vacancy behavior with the JOLTS data is our ability to study their patterns at the establishment-level, particularly when we relate these patterns to variations in establishment growth. In section 3, we showed highly nonlinear but increasing relationships of hires, vacancies, and the vacancy yield to growth. These relationships generally proved robust to controlling for establishment fixed effects, but it was unclear whether the patterns were the result of time aggregation or unobserved processes of recruiting. To get at this question, we estimate our basic framework using hires and vacancy data tabulated from pooled JOLTS microdata for detailed growth rate intervals that are identical to those used to the empirical analysis. We use current and lagged observations of each establishment (where the growth rate in the current month determines which growth rate interval the observation goes into) to obtain $H_t$, $v_t$, and $v_{t-1}$. We use these estimates to estimate average values of $f_t$ and $\theta_t$ within each growth rate interval.

The underlying conceptual model for this approach postulates that structural heterogeneity exists within the joint distribution of $f$ and $\theta$ at the micro level.
Specifically, suppose that establishments receive systematically different draws from this joint distribution. This would create a distribution of employment growth across establishments. Using our stock-flow framework, we can recover estimates of the average $f$ and $\theta$ draws within each growth rate interval. In this respect, we are not positing a causal relationship between net growth and our model parameters, but rather an equilibrium relationship across a distribution of growth rates that would emerge from a model with an underlying distribution of structural heterogeneity.

Figure 9 illustrates our basic framework estimates across establishment growth rates. We present the daily fill rate, the monthly vacancy flow rate, and the layoff rate (obtained directly from the JOLTS data and defined in the framework as $\tau \cdot \delta_r$). We show the layoff rate to highlight its strong declining relation to establishment growth. Both the fill rate and the vacancy flow rate increase nonlinearly with growth, with essentially flat rates among contracting establishments that decline somewhat near zero-growth and then rise sharply for expanding establishments. The increase for the vacancy flow rate and the job-filling rate are similar, and are comparable to the empirically observed increases in the hires rate and vacancy yield. Overall, our estimates suggest that the observed increasing relationship between the vacancy yield and growth (Figure 6) stems from both sharply increasing vacancy flows, suggesting that time aggregation plays a nontrivial role, and sharply declining vacancy durations, suggesting an underlying relationship between job-filling rates and establishment growth.
5. The Stock-Flow Framework in Steady State

Another novelty of our stock-flow framework is the ability to use a steady-state approximation to analyze properties beyond the job-filling and vacancy flow rates.\(^{12}\) Namely, by characterizing the steady-state of the hires and vacancy processes much in the same way that Shimer (2007) characterizes steady-state unemployment and appealing to some of the establishment-level results we presented earlier, we can infer what the framework implies about one of the more interesting establishment-level statistics: the fraction of hires where there is no previously reported vacancy.

In steady-state, hires and vacancies are constant at both the daily and monthly frequencies. We can apply this to equations (2) and (3), and appeal to the fact that monthly hires will be \(H = h \cdot \tau\), to get the steady-state characterization of \(f\) and \(\theta\),

\[
f = \frac{H}{\nu},
\]

\[
\theta = (f + \delta - f\delta)\nu.
\]

We can then use equations (6) and (7) to obtain the monthly steady-state values of the job-filling and vacancy flow rates by substituting in \(H_t, \nu_t,\) and \(\delta\) from the aggregate JOLTS estimates.\(^{13}\) When we do so, we get values of \(f_t\) and \(\theta_t\) that are nearly identical to those calculated numerically in the previous exercise. The mean job-filling rate is 5.0 percent in the basic exercise and 5.1 percent in the steady-state exercise. The mean vacancy flow rate is 3.4 percent in the both exercises.\(^{14}\)

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\(^{12}\) We thank Rob Shimer for suggesting the exercises in this section.

\(^{13}\) For this exercise we use (seasonally adjusted) hires, vacancy and layoff rates for nonfarm employment estimated from our microdata sample, rather than the published statistics, so that its results are consistent with the subsequent exercise, which uses the fraction of employment at establishments where \(v_{t,1} = 0\), which is also estimated from the microdata, in its calculations.

\(^{14}\) The finding that the steady state approximation yields reasonable estimates of fill and flow rates at the aggregate and broad aggregate level should not be used to imply it holds well in all applications. Indeed, a
Using the steady-state values of $f_t$ and $\theta_t$, we can also calculate the steady-state number of hires that come from the “flow” vacancies, i.e., from the $\tau \theta_t$ vacancies that are posted during the month. This statistic will be equal to the second term on the right-hand side of from equation (5),

$$H^0_t = f_t \theta_t \sum_{s=1}^{\tau} (\tau - s)(1 - f_t - \delta_t + f_t \delta_t)^{s-1}.$$

In Section 3, we showed that in the data, on average, 41.6 percent of hires were at establishments with no vacancies reported at the beginning of the month. Using equation (8) along with the fraction of employment at establishments with no vacancy from the data (which we denote as $e_t^0$), we can calculate the same fraction of hires implied by the steady-state approximation as

$$\tilde{H}^0_t = e_t^0 H^0_t / H_t.$$

This estimate represents the amount of hires without a prior reported vacancy the stock-flow attributes to time aggregation (i.e., the posting and filling of vacancies between reporting periods). An estimate close to the 41.6 percent observed in the data would suggest that time aggregation accounts for most of what we observe in the data, and that the basic stock-flow framework of hiring and vacancies is a sufficient way to characterize the recruiting process of establishments. A smaller fraction would suggest recruiting practices outside of the basic stock-flow framework are at play. These practices could include, but are not limited to, hiring without the use of a vacancy.

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quick check shows that it does not hold as well in estimating the fill rate variation across establishments. For example, in Figure 10 we report the estimates of the fill rates by net establishment growth. For an establishment with net growth of 20 percent, Figure 10 shows that the daily fill rate is estimated to be approximately 0.20. Using the steady state approximation for this net growth rate bin instead yields a fill rate estimate of 0.18. This pattern of slightly underestimating the fill rate for rapidly growing establishments using the steady state approximation holds over a wide range of establishment growth rate bins where the establishment growth rate exceeds 10 percent.
Our results are in Figure 10 and the last column of Table 3. Figure 10 shows the monthly series for two statistics, the fraction of hires at establishments with $v_{t-1} = 0$ observed in the data, and the same fraction implied by the steady-state approximation of our stock-flow framework. The difference between the actual and implied series is stark. In the data, hires at establishments without a previously reported vacancy average 41.6 of all hires, but in the model, they only represent 19.7 percent of all hires, less than half of what we observe in the data. Interestingly, both the actual and implied fractions exhibit considerable time-series variation. In the data, the fraction varies between 32 and 48 percent, and appears highest during the 2001-03 period, when the labor market experienced sluggish growth. While the fraction implied by the steady-state exercise is notably lower, its time-series behavior generally is essentially the same. These facts suggest two things. First, time aggregation explains only a portion of the observed hiring without a previous vacancy observed in the data, and second, the fraction of hires without a prior reported vacancy varies substantially over time, perhaps cyclically. These results suggest that understanding fluctuations in hiring and recruiting requires a better understanding of what the unaccounted-for fraction represents.

The last column of Table 3 reports the percent of hires “outside the framework”, which we measure as the difference (in absolute terms) between the fraction of hires without a prior vacancy observed in the data and the fraction implied by the stock-flow framework. There is notable variation in this statistic across industries, though the patterns differ from what we observed in the data, as reported in Table 2. The statistic declines with establishment size, similar to the trend observed in the data, but varies little across turnover quintiles.
We can think of the percentage of hires outside our framework as a residual that reflects the consistency of three statistics in the data: the vacancy yield, the hires rate, and the fraction of hires without a prior vacancy. We find that this residual calculation tends to be large for an industry, for example, if the industry has a low vacancy yield (and thus a low estimated job-filling rate) and a relatively high fraction of hires without a prior vacancy. Compare and contrast the Finance, Insurance, and Real Estate (FIRE) and Government industries. Both have relatively low hires rates and vacancy yields, as shown in Table 1, but the fraction of hires without a prior vacancy in FIRE is nearly double that in Government (Table 2). The similar hires rate and vacancy yield yield similar job-filling and vacancy flow rates for the two industries, and as a result, the time-aggregation components implied for each industry are roughly similar. However, since the fraction of hires without a prior vacancy is much larger for FIRE, this industry ends up with a considerably larger residual percentage of hires outside of the basic framework. In contrast, Construction is the industry with the largest fraction of hires without a prior vacancy, but it also has the highest vacancy yield and a high hires rate. As a result, the stock-flow model predicts that a large fraction of its hires at establishments without a reported vacancy is due to time aggregation, so its residual percentage of hire outside the framework is relatively low.

Across turnover categories, we essentially see a constant residual percentage—both vacancy yields and the fraction of hires without a prior vacancy increase with turnover. This produces a time aggregation component that increases proportionately as well, which in turn produces the near-constant residual component. Conversely, the residual component declines sharply with size, even though vacancy yields, hires rates
and the fraction of hires with no prior vacancy all decline with size as well. The
difference here, with respect to the turnover results, is that the yield and hires rate do not
decline nearly as sharply as the fraction of hires without a prior vacancy (which falls by
almost a factor of 10). As a result, the residual percentage of hires outside the framework
exhibits a declining trend with size.

Overall, our basic stock-flow framework can only account for about 47 percent of
the observed hires at establishments without an initial vacancy. What accounts for the
remainder? Some of the difference may be due to heterogeneity. The basic framework
essentially assumes a constant job-filling and vacancy flow rate for all establishments,
and as Table 3 shows, there is clearly heterogeneity in these statistics across several
dimensions of the data. Nevertheless, even within industries, size classes, turnover
categories, and even growth rates, there still exists a substantial fraction of these hires
unaccounted for by the time aggregation in the basic framework. A more straightforward
explanation, albeit one that does not conform with canonical models of labor market
search, is that these hires occurred without the use of vacancies.

Before drawing this conclusion, we note that the results on hires outside the
framework are based on a steady state approximation that in turn is based on a version of
the stock flow model that does not take full advantage of the heterogeneity we observe at
the establishment level. In addition, while the basic framework equations are consistent
with aggregation of micro units into the aggregate equations (4) and (5), the calculations
of all the results in Table 3 are not based on stochastic micro framework that presumably
underlies (4) and (5). In the next section, we remedy these limitations of the analysis so
far by analyzing the implications of a stochastic micro version of the stock-flow
framework where we can incorporate key aspects of the underlying distributions in the establishment-level data.

6. A Stochastic Micro Simulation of the Stock-Flow Framework

The basic stock-flow framework by construction matches the aggregate hiring and vacancy rates observed in the data, but in doing so, it imposes strict assumptions on the establishment dynamics that underlie these rates. For instance, the framework implicitly assumes that vacancies occur at all establishments at some constant rate, and are subsequently filled at yet another constant rate throughout each period. As we have shown, this characterization is appealing because it permits estimating these rates using readily available data, but given our access to the establishment data, a richer characterization is possible. Namely, if we treat the daily flow and fill rates from the basic model as stochastic arrival rates as is standard in the search literature, we can generate a variety of the framework’s simulated moments that we can then compare to what we observe in the data. That is, if we interpret the vacancy flow, $\theta$, as the likelihood that a vacancy will be posted on a given day, and the job-filling rate, $f$, as the probability that a posted vacancy will be filled on any given day, then we can generate a micro-level distribution of hires and vacancies using an establishment-based simulation of the basic framework.

The objective of this micro stochastic simulation is not simply to provide a robustness check but also to take into account key aspects of the heterogeneity at the micro level. In particular, we conduct this micro simulation in a manner that matches the size distribution of employment and the size distribution of vacancy rates. It is clear from Tables 1 and 2 that many dimensions vary by size class including hires rates, vacancy
yields and the distribution of hires at establishments that begin the month with zero
vacancies. To accomplish this in the simulation of the stochastic model, we first generate
data of 30,000 establishments, each with an initial employment level and number of
vacancies. To match the size distribution, we assign each establishment into one of the
six size class categories listed in Tables 1-3 based on the share of total establishments
each category represents in the data, and assign each establishment the mean employment
level for that size class. To match the vacancy rate distribution by size class, we draw an
initial number of vacancies for each simulated establishment from the distribution of
beginning-of-month vacancies observed in the data by size class. To keep track of an
establishment’s employment growth throughout the month, we assume a worker
separates with probability $s$, which we set equal to the average separation rate observed
within the data for the simulated establishment’s size class. Finally, we assume an
unfilled vacancy closes with probability $\delta$, which we set equal to the average layoff rate
within the simulated establishment’s size class, divided by $\tau$ days.\(^{15}\)

Given the distribution of simulated establishments and an initial guess for $f$ and $\theta$,
we simulate the evolution of hires and vacancies over $\tau$ days for each establishment using
micro based equations (2) and (3). From this we can generate the aggregate monthly hires
rate ($H_t$) and the end-of-month vacancy rate ($v_t$) from the simulated data. We then choose
the optimal $\hat{f}$ and $\hat{\theta}$ using a Simulated Method of Moments approach that minimizes the
distance between the simulated and actual hires and vacancy rates at the aggregate level.
Since we have two parameters and two moments, the system is exactly identified.

\(^{15}\) As before, we assume $\tau = 26$ days.
We perform the SMM estimation separately on the simulated data within each size class, and we take the weighted average of these results as our aggregate estimates. While the aggregate hires and vacancy rates are the only moments we use in our SMM estimation, the micro-level nature of the simulation allows us to calculate several other establishment-level moments implied by the estimation, including the simulated versions of the moments listed in Table 2.

Our results are listed in Table 4. As one can see, even though in the SMM estimation we use the initial distribution of simulated microdata as opposed to aggregate estimates, the estimated job-filling and vacancy flow rates are nearly identical to those obtained from the basic stock-flow framework across all size classes and for total nonfarm employment. Thus, one conclusion is that the solution of our basic model from aggregated data yields robust estimates of the job filling and vacancy flow rates at the aggregate level. The fourth and fifth columns of the Table list what the estimation predicts for two of the moments listed in Table 2. For comparison, we list the moments from the actual data in brackets underneath each estimate. As with the basic framework, the stochastic micro-simulation consistently under-predicts the fraction of hires that occur at establishments without a previously reported vacancy, albeit to a lesser degree. For all establishments, the model predicts that time aggregation should produce 25.6 percent of hires occurring at establishments with no prior vacancy. This is higher than the 19.7 percent observed with the basic framework estimation, but is still much lower than the 41.6 percent observed in the data. The model’s under-prediction holds within each size category. Interestingly, the micro-simulation over-predicts the fraction of end-of-month vacancies at establishments with no beginning-of-month vacancies, which is analogous to
saying that it under-predicts the establishment-level persistence of vacancies observed in the data. Again, the pattern holds within each size category.

The final column of Table 4 lists the percent of hires outside of the stock flow framework. It is equal to the difference between the reported estimate and the term in brackets in the fourth column, and is comparable to the same statistic tabulated for the basic framework and listed in last column of Table 3. For all establishments, the stochastic micro-simulation predicts that 16 percent of hires lie outside the stock-flow framework, a smaller estimate than the one implied by the basic framework, but nonetheless a large fraction representing nearly 1 out of every 6 hires. The main point to take away from this exercise is that even with an micro-based approach that accounts for heterogeneity in establishment size and the micro-level distribution of initial vacancies, we still get the result that a sizeable fraction of hires occur outside of a standard stock-flow framework of worker recruitment.

7. Concluding Remarks

This paper examines the establishment-level behavior of vacancies and hires in a large monthly sample of U.S. employers, supplemented by aggregate data for a longer time period. We introduce the concept of the vacancy yield, a measure of success in generating hires. We show that the vacancy yield is countercyclical, consistent with standard search theory. We also find large differences by industry and employer size in vacancy yields, vacancy rates, and the propensity to hire without a reported vacancy, and we document strong nonlinear relationships of hires, vacancies, and the vacancy yield to establishment-level growth rates in the cross section.
To help interpret these patterns, we develop a simple stock-flow framework that accounts for time aggregation and identifies other interesting quantities. The framework treats JOLTS data as the observed monthly outcomes of daily processes for new vacancies and hires. Cumulating the daily processes to the monthly level, and making use of JOLTS data, the accounting framework delivers estimated values for the unobserved monthly flow of new vacancies, the job-filling rate for reported job openings, and the mean number of days required to fill an open vacancy. The flow of new vacancies appears less cyclically volatile than the vacancy stock, according to our basic accounting framework, while the job-filling rate is countercyclical. It is the latter pattern that is directly relevant in terms of standard search models since it is the job filling rate after taking into account stock-flow and time aggregation issues that corresponds to the job filling rate of standard models. Our finding that it is countercyclical is consistent with standard matching functions. Our finding that at the micro level that the job filling rate is sharply increasing in net establishment growth is a novel finding that contrasts with decreasing relationship at the aggregate level (i.e., the aggregate job filling rate decreases with net aggregate growth).

When we examine a steady-state approximation of our accounting framework, we estimate that 22 percent of hires occur outside of the framework, perhaps without benefit of a vacancy. This fraction accounts for time aggregation in the data and varies greatly by industry, employer size and establishment turnover. When we push the data further with a stochastic micro-simulation, our estimate of hires outside of the stock-flow accounting framework falls to 16 percent. This estimate accounts for time aggregation as well as
several sources of heterogeneity in the microdata, strengthening the argument that this residual may represent hiring that occurs without the benefit of a vacancy.

The empirical patterns we document provide a useful guide to the further development of search models. For example, Faberman and Nagypál (2006) show that a model with search on the job and productivity heterogeneity among firms can deliver a positive relationship between the job-filling rate and employer growth rates in the cross section. Other aspects of our results call for a bigger departure from received search models – in particular the substantial fraction of hires that are outside the standard matching framework. In this respect, our evidence strongly suggests that the role of vacancies in the recruiting process varies systematically by industry, employer size and employer growth. Similarly, the evidence suggests that at least some employers rely heavily on recruiting channels that are not captured in the JOLTS measure of job openings.
References


Figure 1. Hires from CPS Gross Flows and Vacancies from Help Wanted Data


Figure 2. Aggregate Vacancy Yield (Hires per Vacancy), CPS and HWI Data

Notes: Hires estimates are from CPS gross flows data as tabulated by Shimer (2005, for 1976-2004 series) and Fallick and Fleischman (2004, for 1994-2004 series). Vacancies estimates come from the Help Wanted Index of the Conference Board. Shimer and HWI estimates are detrended using an HP filter with smoothing parameter of $\lambda = 10^5$. The JOLTS yield is calculated using the quarterly average of the monthly hires rate. See above references and text for more details.
Figure 3. Distribution of Establishment-Level Vacancies, Employment-Weighted

(a) Vacancy Rates (Percent of Employment)

(b) Vacancy Levels (Number of Vacancies)

Note: Figures display the employment-weighted distribution of vacancy rates (upper panel) and vacancy levels (lower panel) across pooled monthly establishment observations from our JOLTS sample.
Figure 4. Hires Rate as a Function of Establishment Employment Growth

![Hires Rate Graph]

**Note:** The solid line represents the mean hires rate for fine intervals over the range of growth rates. The dashed line represents the mean hires rate conditional on establishment fixed effects. The thin line represents the 45-degree line from the origin. We derive our estimates from the pooled monthly establishment observations of our JOLTS sample. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.

Figure 5. Vacancy Rate as a Function of Establishment Employment Growth

![Vacancy Rate Graph]

**Note:** The solid line represents the mean vacancy rate (measured at the end of the previous month) for fine intervals over the range of growth rates. The dashed line represents the mean vacancy rate conditional on establishment fixed effects. We derive our estimates from the pooled monthly establishment observations of our JOLTS sample. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.
Figure 6. Vacancy Yield as a Function of Establishment Employment Growth

Note: In each panel, the solid line represents the number of hires in month $t$ per vacancy reported at the end of month $t-1$ for fine intervals over the range of growth rates. The dashed line represents the number of hires per vacancy conditional on establishment fixed effects. In the upper panel, we measure the ratio as all hires in each interval divided by all vacancies in each interval, while in the lower panel, the ratio is the number of hires per vacancy only for establishments that report at least one vacancy. We derive our estimates from the pooled monthly establishment observations of our JOLTS sample. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.

Figure 7. Basic Framework Monthly Estimates, JOLTS Data, January 2001 – June 2007

Notes: Results are from our basic accounting framework estimation using hires and vacancy rates tabulated from published JOLTS data. See text for details.
Figure 8. Basic Framework Monthly Estimates, JOLTS, CPS and HWI Data

(a) Job-Filling Rates

(b) Monthly Vacancy Flow Rates

Notes: Results are from our basic accounting framework estimation using hires and vacancy rates tabulated from detrended estimates of CPS gross flow data (hires) and HWI data (vacancies). JOLTS estimates are identical to those in the previous figure. See text for details.
Figure 9. Basic Framework Estimates as a Function of Establishment Growth

Notes: Results are from our basic accounting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.

Figure 10. Fraction of Hires at Establishments with No Prior Vacancy Reported

Notes: The figure illustrates the monthly fraction of all hires at establishments that report no vacancies at the end of the previous month. It includes the actual fraction tabulated from the JOLTS microdata and the fraction implied from an analysis of our basic stock-flow framework in steady-state. See text for details.
Table 1. Hires, Separations and Vacancies by Industry, Size and Turnover

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<td>Second Quintile</td>
<td>1.3</td>
<td>1.2</td>
<td>2.6</td>
<td>0.5</td>
<td>15.1</td>
</tr>
<tr>
<td>Third Quintile</td>
<td>2.4</td>
<td>2.2</td>
<td>2.9</td>
<td>0.8</td>
<td>15.1</td>
</tr>
<tr>
<td>Fourth Quintile</td>
<td>4.5</td>
<td>4.3</td>
<td>3.1</td>
<td>1.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Fifth Quintile (highest turnover)</td>
<td>13.5</td>
<td>13.0</td>
<td>4.4</td>
<td>3.1</td>
<td>15.1</td>
</tr>
</tbody>
</table>

Notes: Estimates are tabulated from our sample of JOLTS microdata. Rates are as defined in the text.
Table 2. Establishment-Level Hires and Vacancy Statistics by Industry, Size and Turnover

<table>
<thead>
<tr>
<th></th>
<th>Percent of Employment with $h_t = 0$</th>
<th>Percent of Employment with $v_{t-1} = 0$</th>
<th>Percent of $h_t$ with $v_{t-1} = 0$</th>
<th>Percent of $v_t$ with $v_{t-1} = 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonfarm Employment</strong></td>
<td>34.8</td>
<td>45.1</td>
<td>41.6</td>
<td>17.9</td>
</tr>
<tr>
<td><strong>Major Industry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Resources &amp; Mining</td>
<td>40.1</td>
<td>59.2</td>
<td>57.8</td>
<td>22.5</td>
</tr>
<tr>
<td>Construction</td>
<td>46.3</td>
<td>73.7</td>
<td>67.2</td>
<td>36.3</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>33.0</td>
<td>43.3</td>
<td>41.3</td>
<td>15.4</td>
</tr>
<tr>
<td>Transport, Wholesale &amp; Utilities</td>
<td>43.2</td>
<td>51.2</td>
<td>41.5</td>
<td>20.2</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>39.4</td>
<td>59.3</td>
<td>49.1</td>
<td>30.5</td>
</tr>
<tr>
<td>Information</td>
<td>32.6</td>
<td>34.3</td>
<td>29.5</td>
<td>13.7</td>
</tr>
<tr>
<td>Finance, Insurance &amp; Real Estate</td>
<td>44.6</td>
<td>48.8</td>
<td>40.3</td>
<td>16.9</td>
</tr>
<tr>
<td>Professional &amp; Business Services</td>
<td>34.7</td>
<td>41.9</td>
<td>31.9</td>
<td>14.8</td>
</tr>
<tr>
<td>Health &amp; Education</td>
<td>27.5</td>
<td>31.6</td>
<td>26.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Leisure &amp; Hospitality</td>
<td>33.1</td>
<td>54.2</td>
<td>47.7</td>
<td>25.6</td>
</tr>
<tr>
<td>Other Services</td>
<td>61.6</td>
<td>70.6</td>
<td>54.5</td>
<td>30.9</td>
</tr>
<tr>
<td>Government</td>
<td>21.6</td>
<td>25.7</td>
<td>20.2</td>
<td>7.8</td>
</tr>
<tr>
<td><strong>Establishment Size Class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9 Employees</td>
<td>87.0</td>
<td>91.6</td>
<td>76.9</td>
<td>43.2</td>
</tr>
<tr>
<td>10-49 Employees</td>
<td>60.0</td>
<td>73.6</td>
<td>60.3</td>
<td>33.3</td>
</tr>
<tr>
<td>50-249 Employees</td>
<td>27.7</td>
<td>43.6</td>
<td>36.5</td>
<td>16.5</td>
</tr>
<tr>
<td>250-999 Employees</td>
<td>11.9</td>
<td>18.7</td>
<td>17.3</td>
<td>6.2</td>
</tr>
<tr>
<td>1,000-4,999 Employees</td>
<td>3.7</td>
<td>7.1</td>
<td>6.3</td>
<td>2.4</td>
</tr>
<tr>
<td>5,000+ Employees</td>
<td>1.1</td>
<td>8.8</td>
<td>8.0</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Turnover Category</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Turnover</td>
<td>100.0</td>
<td>85.2</td>
<td>--</td>
<td>27.7</td>
</tr>
<tr>
<td>First Quintile (lowest turnover)</td>
<td>20.7</td>
<td>22.5</td>
<td>18.2</td>
<td>7.6</td>
</tr>
<tr>
<td>Second Quintile</td>
<td>12.3</td>
<td>22.6</td>
<td>19.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Third Quintile</td>
<td>11.8</td>
<td>28.4</td>
<td>25.9</td>
<td>10.8</td>
</tr>
<tr>
<td>Fourth Quintile</td>
<td>12.1</td>
<td>38.4</td>
<td>35.6</td>
<td>18.5</td>
</tr>
<tr>
<td>Fifth Quintile (highest turnover)</td>
<td>12.0</td>
<td>49.0</td>
<td>49.2</td>
<td>27.4</td>
</tr>
</tbody>
</table>

Notes: Estimates are tabulated from our sample of JOLTS microdata.
Table 3. Basic Framework Results by Industry, Size and Turnover

<table>
<thead>
<tr>
<th>Nonfarm Employment</th>
<th>Daily Fill Rate $f_t$</th>
<th>Monthly Flow Rate $\tau \cdot \theta$</th>
<th>Duration (Days) $1/f_t$</th>
<th>Percent of $h_t$ Outside Framework#</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.050</td>
<td>3.4</td>
<td>20.0</td>
<td>21.8</td>
</tr>
</tbody>
</table>

| Major Industry       |                        |                                         |                         |                                     |
|----------------------|------------------------|-----------------------------------------|-------------------------|                                     |
| Natural Resources & Mining | 0.078                  | 3.1                                     | 12.8                    | 24.5                                |
| Construction         | 0.121                  | 5.4                                     | 8.3                     | 16.0                                |
| Manufacturing        | 0.052                  | 2.3                                     | 19.3                    | 22.0                                |
| Transport, Wholesale & Utilities | 0.052                  | 2.7                                     | 19.1                    | 18.5                                |
| Retail Trade         | 0.073                  | 4.5                                     | 13.7                    | 16.7                                |
| Information          | 0.031                  | 2.2                                     | 32.0                    | 18.9                                |
| Finance, Insurance & Real Estate | 0.034                  | 2.3                                     | 29.0                    | 24.1                                |
| Professional & Business Services | 0.049                  | 4.6                                     | 20.4                    | 13.9                                |
| Health & Education   | 0.028                  | 2.7                                     | 35.4                    | 17.0                                |
| Leisure & Hospitality| 0.069                  | 6.3                                     | 14.6                    | 19.1                                |
| Other Services       | 0.053                  | 3.3                                     | 18.8                    | 22.6                                |
| Government           | 0.032                  | 1.6                                     | 31.4                    | 12.1                                |

| Establishment Size Class |                        |                                         |                         |                                     |
|--------------------------|------------------------|-----------------------------------------|-------------------------|                                     |
| 0-9 Employees            | 0.061                  | 3.3                                     | 16.5                    | 32.0                                |
| 10-49 Employees          | 0.066                  | 4.0                                     | 15.2                    | 22.3                                |
| 50-249 Employees         | 0.059                  | 4.0                                     | 17.1                    | 15.6                                |
| 250-999 Employees        | 0.041                  | 3.1                                     | 24.1                    | 10.1                                |
| 1,000-4,999 Employees    | 0.026                  | 2.1                                     | 37.9                    | 4.4                                 |
| 5,000+ Employees         | 0.026                  | 1.7                                     | 38.9                    | 5.7                                 |

| Turnover Category        |                        |                                         |                         |                                     |
|--------------------------|------------------------|-----------------------------------------|-------------------------|                                     |
| No Turnover              | ---                    | ---                                     | ---                     | ---                                 |
| First Quintile (lowest turnover) | 0.011                  | 0.4                                     | 87.9                    | 15.3                                |
| Second Quintile          | 0.019                  | 1.3                                     | 52.8                    | 15.1                                |
| Third Quintile           | 0.030                  | 2.4                                     | 32.8                    | 17.3                                |
| Fourth Quintile          | 0.054                  | 4.6                                     | 18.4                    | 17.8                                |
| Fifth Quintile (highest turnover) | 0.114                  | 14.0                                    | 8.7                     | 15.3                                |

Notes: Estimates are tabulated from our sample of JOLTS microdata.
#: Estimates come of the fraction of hires outside of the basic framework come from a steady-state approximation. See text for details.
### Table 4. Stochastic Micro Simulation Results by Size

<table>
<thead>
<tr>
<th>Establishment Size Class</th>
<th>Employment Share ( f_i )</th>
<th>Daily Fill Rate ( \tau )</th>
<th>Monthly Flow Rate ( \theta_i )</th>
<th>Percent of ( h_t ) with ( v_{t-1} = 0 )</th>
<th>Percent of ( v_t ) with ( v_{t-1} = 0 )</th>
<th>Percent of ( h_t ) Outside Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 Employees</td>
<td>0.121</td>
<td>0.062</td>
<td>3.4</td>
<td>46.6</td>
<td>75.7</td>
<td>30.3</td>
</tr>
<tr>
<td>10-49 Employees</td>
<td>0.232</td>
<td>0.065</td>
<td>4.0</td>
<td>[60.3]</td>
<td>64.1</td>
<td>20.5</td>
</tr>
<tr>
<td>50-249 Employees</td>
<td>0.283</td>
<td>0.058</td>
<td>4.1</td>
<td>[36.5]</td>
<td>37.8</td>
<td>13.7</td>
</tr>
<tr>
<td>250-999 Employees</td>
<td>0.171</td>
<td>0.041</td>
<td>3.1</td>
<td>[17.3]</td>
<td>13.8</td>
<td>9.4</td>
</tr>
<tr>
<td>1,000-4,999 Employees</td>
<td>0.130</td>
<td>0.026</td>
<td>2.1</td>
<td>[6.3]</td>
<td>4.3</td>
<td>4.0</td>
</tr>
<tr>
<td>5,000+ Employees</td>
<td>0.064</td>
<td>0.026</td>
<td>1.7</td>
<td>[8.0]</td>
<td>3.4</td>
<td>6.2</td>
</tr>
<tr>
<td><strong>Weighted Average of Size Class Results</strong></td>
<td><strong>0.051</strong></td>
<td><strong>3.4</strong></td>
<td><strong>25.6</strong></td>
<td><strong>35.1</strong></td>
<td><strong>15.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Notes: Estimates are tabulated from our sample of JOLTS microdata using a simulated method of moments estimation of our accounting framework. Numbers in brackets represent the listed fraction’s value from the data.*