

The Establishment-Level Behavior of Vacancies and Hiring

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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 frequency of hires without a reported vacancy. The job-filling rate is counter cyclical, varies by a factor of three across major industry groups, declines steeply with employer size, and rises sharply with employer growth in the cross section. Our results also suggest that at least 36 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
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1. Introduction

In most 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 and industry, and how they move over time. To obtain a longer sample for time-series analysis, we supplement the JOLTS data with the Conference Board's Help Wanted Index and data on hires from the Current Population Survey. We

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.

show that the vacancy yield moves counter cyclically – in line with standard matching function specifications – but it rises with employer growth in the cross section.

We also establish other empirical regularities that search theories have yet to consider. First, many establishments hire workers during the month while reporting no job openings at the beginning of the month. Perhaps surprisingly, this pattern is more prevalent in industries with high worker turnover. Second, the vacancy yield declines steeply with employer size and varies by a factor of three across major industry groups. Third, the hires rate, the vacancy rate and the vacancy yield exhibit highly nonlinear relationships to employer 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. These cross-sectional relationships are essentially unchanged for new hires and vacancy yields, but not for the vacancy rate, when we control for establishment fixed effects.

We also develop an accounting framework that identifies the job-filling rate for vacant positions, the monthly flow of new vacancies, and the percentage of hires that occur without a recorded vacancy. 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. Our basic framework is readily adapted to accommodate hires without benefit of recorded vacancies (“passive recruiting”) and heterogeneity in job-filling rates among employers.

Applying the framework, we find large differences in the job-filling rate among industries and establishments and countercyclical movements in the fill rate over time. A version of the framework that allows for passive recruiting suggests that at least 36 percent of hires occur without a prior vacancy, as recorded in JOLTS. This fraction ranges from 28 to 41 percent in the four-year window covered by our JOLTS sample, and it varies across industries from a low of 17 percent in Government to nearly 60 percent in Construction and Natural Resources & Mining. We also find that the fraction of hires achieved by passive recruiting exhibits a highly nonlinear relationship to employer growth in the cross section.

Our study 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 show that the job-filling rate – a natural measure of vacancy productivity – varies systematically with the size, growth rate and worker turnover rate of employers. These empirical patterns provide a useful source of discipline in the specification and further development of search models. Our evidence related to passive recruiting raises several issues for search models. First, the sizable percentage of hires achieved by passive recruiting 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 passive recruiting 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, 2005a; 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 extends the accounting framework in two directions. First, we allow for passive recruiting – hires that occur without benefit of a reported vacancy. Second, we allow for heterogeneity in job-filling rates conditional on observable employer characteristics. The expanded versions of the stock-flow accounting framework identify additional features of vacancy and hiring behavior, and they illustrate the flexibility of our approach. Section 6 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 12th 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 January 2005. 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 372,288 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.

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 2004, whereas the Shimer series spans 1976 to 2004.³ 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.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

⁴ This approach to the HWI follows Abraham (1987) and Shimer (2005a), who discuss the measurement issues in detail.

hiring rates observed in other research (Faberman, 2006; Davis et al., 2006).⁵ With these caveats in mind, the figure shows that both hires and vacancies rise in booms and drop in recessions, with the latter being much more cyclically volatile.

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, Shimer, Fallick-Fleischman and HWI data to create three series, each measured as the flow of hires during month t divided by the stock of vacancies at the end of month $t-1$. The flow versus stock comparison is a major reason observed yields are greater than one (we discuss other potential reasons below). All three series appear countercyclical, though much of the movements in the vacancy yield seem driven by movements in the vacancy rate. Given a standard model of labor market search, a countercyclical vacancy yield is exactly what we would expect. 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

$$(1) \quad \frac{h}{v} = \mu \left(\frac{v}{u} \right)^{-\alpha}.$$

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.

⁵ Fujita and Ramey (2006a) argue that given the nature of measurement error associated with the CPS gross flow data that band pass filter techniques are more appropriate. In future drafts, we plan to explore the sensitivity of our results to the use of this alternative filtering technique.

Table 1 reports the cross-sectional evidence of hires, separations, vacancies, and the vacancy yield by major industry and establishment size class from our JOLTS sample. There is sizable variation in all variables across industries and across size classes. Of particular note are the variations across industry and size of the vacancy yield. 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, the vacancy yield tends to decrease with establishment size. Is it 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

To truly understand aggregate vacancies and hiring one must examine their behavior at the micro-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 with both unweighted and employment-weighted estimates. In the average month, only 12 percent of establishments (representing 54 percent of employment) report a vacancy. Figure 3 shows that, employment-weighted, even when establishments do report vacancies, they are often at very low rates and levels. Employment-weighted, the vacancy rate at the 90th percentile is 6 percent while the *number* of vacancies at this percentile is 58. Unweighted, the vacancy rate at the 90th percentile is 3 percent, while the number of vacancies is just one.

Much of this stems from the fact that only 18 percent of establishments (representing 64 percent of employment) report a hire in any given month, diminishing their need for a vacancy. Nevertheless, this cannot be the entire story. For instance, Table 2 shows that nearly 1 in 5 reported vacancies do not precede any hire in the following month, suggesting that the search process takes some time. Yet, 42 percent of hires occur at establishments where there was no vacancy reported going into the month, suggesting either that matches occur quickly or that some hires occur without a formal vacancy. 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 (i.e., highest reported hires and separations) also have the highest shares of observations with no reported vacancies. Consequently, these industries have the highest shares of hires without a previously reported vacancy. When establishments in these industries do have a vacancy, however, they are the most likely to

have that vacancy remain unfilled after a month. We explore possible explanations of these patterns in Section 4 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.⁶ 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 lies 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 increase with growth, but at a much slower rate than hires—establishments that grow by 30 percent have vacancy rates of just 5.6 percent. The most notable contrast with hires, however, is the relatively sharp discontinuity right around zero growth. Establishments with very small contractions average vacancy rates of 2.0 percent, while establishments with very small expansions average vacancy rates of 2.5 percent. Establishments with zero growth, though, have average vacancy rates of just 1.3 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

⁶ 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 that allows the true values to remain at and near zero.

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.

Figure 6 presents the employment-weighted probability of the discrete event that an establishment has a vacancy reported as a function of the growth rate. The relationship is highly nonlinear, with establishments with small employment changes being the most likely to report a vacancy. The probability of a vacancy decreases sharply in the magnitude of the change, though expanding establishments have a considerably higher probability than contracting establishments. While establishments with very small changes have a probability of a reported vacancy near 80 percent, those with no changes have a probability of only 22.7 percent. When we control for establishment effects, nearly all the nonlinearities disappear, though the probability remains increasing in growth and a much smaller discontinuity for zero-growth establishments still exists. This is consistent with the notion that different types of firms persistently use vacancies in different ways.

In Figure 7, 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 5.⁷ 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 for the first measure and a slight spike downwards for the second measure. The former stems from the sharp drop in vacancies posted in Figure 5. The latter reflects only the yield for establishments who reported a vacancy at the end of the previous month, so it suggests either that stable

⁷ It is not identical to this approach because the hires and vacancy rates have different denominators.

establishments tend to be less successful when posting vacancies or the more tautological conclusion that establishments that do not fill their vacancies by definition do not grow. 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 affect the relation between the vacancy rate and the probability of reporting a vacancy, they have very little effect on the relation of the vacancy yield to establishment growth.⁸

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 vacancy flows). Yet, other unobserved recruiting processes might explain the observed patterns, particularly the relationship between the vacancy yield and establishment growth. For example, variations in the yield could be driven by differences in vacancy durations (the inverse of the job-filling rate) 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 present a simple stock-flow accounting framework of vacancy and hiring flows. The framework is designed to pin down key parameters, unobservable in the data,

⁸ In Figure 7, 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 7.

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 θ). Later, we extend our framework to allow for hiring without any active recruiting as well as heterogeneity in fill and flow rates. We focus on identifying the average daily fill and flow rates without specifying a complete stochastic structure at the micro level. This is a reasonable starting point, but as will become clear, we believe the results imply micro-level behavior that calls for a richer specification of the underlying stochastic micro processes.

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 (θ_t) for a month consisting of τ days that are constant during the month but vary between months. Hires are simply the share of the vacancy stock from the previous day that is subsequently filled:

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

The stock of vacancies evolves along three dimensions. First, the flow of new vacancies increases the stock. Second, the number of hires during that day depletes the stock. Finally, an exogenous number of vacancies that close without ever being filled also deplete the stock. We denote this last variable by δ_t , and again assume a constant value during the month. The daily equation of motion for the vacancy stock is then

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

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 , τ days later. One can add up equation (3) over τ days and substitute back for $v_{s-1,t}$ to get the desired equation

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

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:

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

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 δ_t , we have two parameters to identify: f_t and θ_t . Equations (4) and (5) give us a two-equation system to exactly identify these parameters.

4.C. Estimation Approach

We estimate (4) and (5) using the aggregate hires and vacancy estimates constructed from our JOLTS sample, seasonally adjusted. 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).⁹ We let δ_t equal L_t/τ , where L_t is the layoff rate for month t . 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 exogenous job separation rate equal to the layoff rate. We solve the system numerically for each month to obtain estimates of f_t and θ_t , which provides us with a time-series of each parameter. 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 θ_t as an average daily flow *rate* for vacancies.

Figure 8 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 JOLTS data). The top row of Table 3 reports that the flow of vacancies average 3.4 percent of employment (compared to the stock's average of 2.4 percent), while the fill rate averages 5.5 percent of the previous day's stock. In the data, the stock of vacancies exhibit much greater cyclical movement than hires (see Figure 1).

⁹ In future drafts we will incorporate differences in the number of working days across months.

The results from the basic accounting framework suggest that the flow of vacancies is much less volatile than their stock, and that movements in the daily job-filling rate seem to account for much of the observed cyclical movement in the vacancy stock. During the 2001 recession, the job-filling rate rises from its low of 4.4 percent to a peak of 6.2 percent in mid-2002, and remains relatively high through the remainder of the period. This coincides with the relatively sharp, persistent decline in the vacancy stock, and represents a decrease in average vacancy duration from 23 days to 16 days.

Both as a robustness check and to better gauge the cyclical movements in these parameters, we re-estimate the accounting framework using our adjusted CPS gross flows from Shimer (2005b) and adjusted Help Wanted Index data.¹⁰ The results are in Figure 9, with the JOLTS estimates included for comparison. For the longer time series, the striking pattern is the substantial variation in the job-filling rate, which increases considerably around cyclical downturns. Moreover, the variation in the job-filling rate is much greater than the variation in vacancy flows (the coefficient of variation for the job-filling rate is 0.24, compared to 0.04 for the vacancy flow rate). In terms of the overlap period with the JOLTS, the patterns are also broadly similar, with some subtle but potentially important differences. First, the JOLTS show a relatively more cyclical vacancy flow rate, most likely a consequence of the relatively more cyclical hiring rates in the JOLTS. Second, fill rates in both series rise during the 2001 recession, but the estimates from the JOLTS data are relatively slower to decline afterwards. This implies

¹⁰ For the CPS data, we use the employment-to-unemployment flow rate divided by τ , for our estimate of δ . 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 and our associated stock-flow accounting framework (e.g., the HWI is an index measured over the month, not as a stock)..

that, depending on the survey studied, cyclical increases in the job-filling rate have may high or low persistence.

In Section 3, we documented considerable variation in the use and yield of vacancies across industries and establishment size. The remainder of Table 3 presents estimates for the basic stock-flow model for these categories. Again, there is considerable variation across industries and size. 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. Across size classes, the vacancy flow and job filling-rates both tend to decrease with establishment size.

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 θ_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 θ 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 θ 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 10 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 $\tau \cdot \delta_t$). 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 7) stems from both sharply increasing vacancy flows (i.e., time aggregation) and sharply declining vacancy durations.

5. Extending the Basic Framework

5.A. Overview

Our basic accounting framework addresses the issue of time aggregation and permits us to estimate the time-series and cross-section variation in vacancy fill rates. However, the framework is not suitable for accounting for one of the key empirical patterns in the data – namely the high fraction of hires that occur at establishments that began the month without a reported vacancy. To address this issue, some form of heterogeneity in recruiting practices is required. We consider an extension of our basic framework that allows for heterogeneity in vacancy flows and permits hiring without a formal vacancy (i.e., “passive recruiting”). As an alternative, we consider another extension that allows for heterogeneity in vacancy flows and fill rates, but requires that all hires come from a formal vacancy.

5.B.1 Allowing for Passive Recruiting

Equations (4) and (5) tacitly assume that all hires must come from an active search process that includes a formal vacancy. In reality, hires often occur through social networking or other informal methods that do not necessarily involve active recruitment, or even a current job opening—many firms will create a position if a good enough worker comes along. Such hiring may exhibit considerable time-series and cross-sectional variation, and play a significant role in accounting for the observed increase in the vacancy yield with establishment growth. Such patterns would have a considerable impact on how we think about and model the worker search and recruitment process.

The following extension of our accounting framework captures the idea of hires without a vacancy while allowing for heterogeneity in vacancy flows. We define η_t as the average daily flow of hires without active recruitment during month t .¹¹ Note that the notion of such hires represents a significant departure from the standard assumptions of the search and matching literature, so there is little guidance on how to specify them. We let vacancy flows differ by whether or not an establishment started the month with a reported vacancy. The logic is that establishments that begin the month with a vacancy are likely to have different hiring dynamics in the subsequent month than those that do not. Let θ_t^P be the average daily vacancy flow for those who begin the month with at least one reported vacancy, and let θ_t^0 be the flow for those who begin the month with no reported vacancy.

The addition of these parameters makes the basic framework, in its current specification, underidentified. The additional information we bring to bear follows from empirical findings. Recall that most establishments report no vacancies and that these establishments account for 42 percent of all hires. By differentiating establishments along this margin, we are able to distinguish the subsequent hires and vacancies that occur among the two establishment groups in the JOLTS data. Exploiting this distinction provides us with the needed additional equations to exactly identify our framework and allow a numerical solution. Let H_t^P and v_t^P be the flow of hires and stock of vacancies, respectively, for month t for those establishments who began the month with at least one

¹¹ Note that it is not feasible with the information available to separately identify a flow of contacts without a vacancy and the rate at which these contacts get hired, so we identify only their product (i.e., the resulting hire).

reported vacancy, i.e., $v_{t-1} > 0$. Also, let H_t^0 and v_t^0 be the flow of hires and stock of vacancies, respectively, for month t for those establishments who began the month with no reported vacancy, i.e., $v_{t-1} = 0$. Then, for establishments with a positive stock of vacancies at the end of month $t-1$ equations (4) and (5) become

$$(4a) \quad v_t^P = (1 - f_t - \delta_t + \delta_t f_t)^\tau v_{t-1}^P + \theta_t^P \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1}, \text{ and}$$

$$(5a) \quad H_t^P = f_t v_{t-1}^P \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1} + f_t \theta_t^P \sum_{s=1}^{\tau} (\tau - s)(1 - f_t - \delta_t + \delta_t f_t)^{s-1} \\ + \tau(1 - \rho_t^0) \eta_t$$

where ρ_t^0 denotes the share of hires without active recruitment that occur at establishments with $v_{t-1} = 0$. For establishments with no vacancy reported at the end of $t-1$, equations (4) and (5) simplify to

$$(6) \quad v_t^0 = \theta_t^0 \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1}, \text{ and}$$

$$(7) \quad H_t^0 = f_t \theta_t^0 \sum_{s=1}^{\tau} (\tau - s)(1 - f_t - \delta_t + \delta_t f_t)^{s-1} + \tau \rho_t^0 \eta_t .$$

We can aggregate equations (4a) and (6), and (5a) and (7), respectively, to yield:

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

$$(5b) \quad H_t = f_t v_{t-1} \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1} + f_t \theta_t \sum_{s=1}^{\tau} (\tau - s)(1 - f_t - \delta_t + \delta_t f_t)^{s-1} + \tau \eta_t$$

where $\theta_t = \theta_t^P + \theta_t^0$ and $v_t = v_t^P + v_t^0$. By construction, $v_{t-1}^P = v_{t-1}$ and $v_{t-1}^0 = 0$.

Equations (4b) and (5b) are identical in structure to (4) and (5) from the basic model, save for the introduction of $\tau \eta_t$. The system (4b), (5b), (6) and (7) is a system of

four equations in five unknowns: $f_t, \theta_t, \theta_t^0, \eta_t,$ and ρ_t^0 .¹² To close the system we require an additional identifying assumption about the hires without a vacancy. It seems plausible that the propensity of such hires varies intrinsically across establishments. For evidence in support of this, return to Figure 6, which shows the probability of a vacancy as a function of employment growth. The inclusion of establishment fixed effects greatly alters this function, suggesting that some establishments regularly post vacancies, while others regularly do not. Yet, accounting for establishment fixed effects in the hires and vacancy yield relations to growth does little to alter their patterns. Accordingly, we consider different propensities of hiring without a vacancy via variations in ρ_t^0 . For our estimation here, however, we proceed with $\rho_t^0 = 1$, which implies that establishments with $v_{t-1} = 0$ are the only ones who hire without a vacancy. Figure 11 illustrates why we assume such an extreme value. As we increase ρ_t^0 , the values of f_t and θ_t also increase, but η_t decreases sharply, implying a smaller share of such hires. Further, $\rho^0 = 0.5$ yields the implausible result that most hires (81 percent) occur without active recruitment. Given the difficulty of formalizing the process for these types of hires (we are essentially trying to put structure on the unobserved heterogeneity of an unobserved variable), an assumption of $\rho_t^0 = 1$ proves useful because it provides us a lower-bound estimate of one of our main empirical findings: that hiring without active recruiting represents a common occurrence in the labor market matching process.

¹² The system (4a), (5a), (6) and (7) is an equivalent system. We use the system (4b), (5b), (6) and (7) since (4b) and (5b) closely resemble (4) and (5) and numerically we have found it easier to solve this latter system.

5.B.2 Results with Passive Recruiting

We next present the results from the passive recruiting framework. As before, we produce estimates for the aggregate time-series, for the industry and size cross-sections, for establishment growth rate intervals. We tabulate estimates of H_t , v_t , and v_{t-1} , as well as v_t^0 and H_t^0 , directly from the JOLTS microdata. Since our ability to identify this extension depends on estimates built from the microdata, we are precluded from producing a longer time-series with the CPS and HWI data. Our approach provides estimates of θ_t and θ_t^0 which in turn yield an estimate of θ_t^P .

The time-series and cross-section results for this passive recruiting framework are in Figure 12 and Table 4, respectively. On average, vacancy flow rates for those who began with a reported vacancy (2.7 percent) are considerably higher than for those who did not (1.4 percent), implying that establishments who begin the period without a vacancy are less likely to post one during the subsequent month. The mean job-filling rate is lower in this expanded framework (3.3 percent), leading to a higher mean duration rate (30 days). Surprisingly, even though we account for the intra-month flow of vacancies, introduce heterogeneity in vacancy use, and make the extreme assumption of $\rho_t^0 = 1$, the monthly rate of hires without a vacancy ($\tau \cdot \eta_t$) averages 1.2 percent of employment, representing 36 percent of all hires.

In Figure 12, vacancy flow rates for both types of firms drop slightly during the 2001 recession and gradually increase starting in mid-2003. The job-filling rate increases during the 2001 recession, but is less volatile than in the basic framework. Finally, hiring without a vacancy exhibits only modest variation over our sample period, and no clear cyclical pattern emerges. In Figure 13, however, we present estimates of the *fraction* of

hires without a vacancy (defined as $\tau \cdot \eta_t / H_t$) over the period. The fraction, albeit over a short time-series, appears to exhibit a countercyclical pattern, rising from 28 to 36 percent of total hiring during the 2001 recession, and then climbing to a peak of 41 percent in mid-2002 (a period when employment losses continued after the recession ended). The fraction remains relatively high through early 2004, though, several months after the labor market began to pick up.

The results by industry and establishment size are in Table 4. The expanded framework does particularly well in highlighting the differences in recruitment across these categories. For example, high turnover industries such as Resources, Construction, Retail, and Leisure and Hospitality still tend to have higher fill rates, but the disparity is considerably less. These industries also tend to have high vacancy flow rates, regardless of whether a vacancy was reported at the end of the previous month. The most notable variation across industries, though, is in the rates and *fractions* of hiring without a vacancy. High-turnover industries have the highest rates of such hires, while industries such as Government, Health & Education, and Information have the lowest. Similarly, Resources and Construction tend to have the highest fractions of their hires come from without a vacancy (59 and 58 percent, respectively), while Government and Health & Education have the lowest shares of such hires (17 and 22 percent, respectively). This further reinforces the notion that different sectors use vacancies as a recruitment tool in very different ways, and that hiring without active recruitment is an important part of the matching process. The evidence also suggests that the degree to which an establishment uses a vacancy to attract workers is decreasing in the amount of turnover its industry regularly incurs.

An open question is whether the magnitudes of hiring without vacancies are plausible across industries. While we argue above that the ranking across industries is sensible, the finding that even Government and Health and Education have substantial shares of workers hired without vacancies raises some questions about plausibility. Taken at face value, these industries, which are known to have formal and time intensive recruiting procedures, manage to hire a substantial fraction of workers without vacancies. As we noted, however, the conversion of temporary help or short-term contract workers to permanent employees, opportunistic hiring of unexpected good matches, and hiring for positions that start more than 30 days into the future are not part of the JOLTS job openings definition. Our view is that while the prevalence of these occurrences may vary from sector to sector, they remain relatively common occurrences across all industries.

Across size classes, the job-filling rate decreases somewhat with size, but not nearly as much as the basic model implied. Vacancy flow rates among establishments with $v_{t-1} > 0$ decreases with size in a similar manner to the vacancy flow rate in the basic model, but the flow rate among establishments with $v_{t-1} = 0$ appears to be independent of size. Hires without a vacancy as well as their share of total hires, however, both decrease significantly with establishment size.

Figure 14 illustrates the micro net growth results for the passive recruiting framework. We use the same estimation approach across growth rate intervals as we did with the basic framework. The results are similar to before (Figure 10) in that all parameters increase nonlinearly with growth, remaining essentially constant for contracting establishments, declining for zero-growth establishments, and then increasing considerably for expanding establishments. The vacancy flow rate for establishments

with $v_{t-1} > 0$ exhibits the greatest increase with growth among expanding establishments, while the vacancy flow rate for establishments with $v_{t-1} = 0$ as well as the rate of hires without a vacancy increase at roughly the same rate. We find it interesting that the rate of hires without a vacancy systematically increases with establishment growth. If one takes our results at face value, then this suggests that passive recruiting is not a constant flow to be added to a model, but instead is a process dependent on the performance of and intensity of idiosyncratic shocks incurred by individual firms.

5.C. Heterogeneity in Job-Filling Rates

The finding that many establishments hire workers without a reported vacancy at the beginning of the month and exhibit different hiring patterns than those establishments with reported vacancies motivated our extended framework with passive recruiting. Consequently, the results of this framework suggested that hiring without a vacancy constitutes a substantial fraction of total hires. An alternative explanation, however, is to permit heterogeneity in both job-filling and vacancy flow rates.¹³ It may be that establishments that hire without a previously reported vacancy just have different flow and fill rates than establishments with some prior vacancy.¹⁴

We consider another extension of our accounting framework to explore the potential role of heterogeneity in this context. We characterize this alternative version with the following equations:

$$(4a)' \quad v_t^p = (1 - f_t - \delta_t + \delta_t f_t)^\tau v_{t-1}^p + \theta_t^p \sum_{s=1}^{\tau} (1 - f_t - \delta_t + \delta_t f_t)^{s-1}$$

¹³ We thank Eva Nagypal for suggesting this version of the extended accounting framework.

¹⁴ Note that this is one of several alternative specifications one could use to extend our basic framework. For example, one could envision a framework and allowed quits to affect the propensity to post a vacancy, as with the model of Fujita and Ramey (2006b).

$$(5a)' \quad H_t^P = f_t^P v_{t-1}^P \sum_{s=1}^{\tau} (1 - f_t^P - \delta_t)^{s-1} + f_t^P \theta_t^P \sum_{s=1}^{\tau} (\tau - s)(1 - f_t - \delta_t + \delta_t f_t)^{s-1}$$

$$(6)' \quad v_t^0 = \theta_t^0 \sum_{s=1}^{\tau} (1 - f_t^0 - \delta_t + \delta_t f_t^0)^{s-1}$$

$$(7)' \quad H_t^0 = f_t^0 \theta_t^0 \sum_{s=1}^{\tau} (\tau - s)(1 - f_t^0 - \delta_t + \delta_t f_t^0)^{s-1} .$$

Like with the passive recruiting framework, we have a system of four equations and four unknowns that we can solve numerically. Figure 15 and Table 5 present the time-series and cross-sectional results for this alternative framework. To generate the observed hiring and vacancies among the two establishment groups, this specification generates job-filling and flow rates that are 16.0 percent and 3.9 percent, respectively, for the establishments with $v_{t-1} = 0$, compared to 3.3 and 1.4 percent, respectively, for establishments with $v_{t-1} > 0$. Establishments in the first group have considerable hires, so in the absence of other adjustment mechanisms, both the fill rate and the flow rate must be high for this group. Figure 15 also shows that most of the time-series variation in the job-filling rate occurs among establishments who begin without a reported vacancy.

We find the patterns by industry and size especially revealing for this alternative specification. For industries such as Construction and Natural Resources, the fill rate exceeds 25 percent per day so the average duration of a vacancy for such establishments is less than four days. Even for industries like Government and Health & Education the fill rates for such establishments are 11 and 12 percent respectively so the implied vacancy durations are under 10 days. While a rapid filling of vacancies might be plausible for the Construction and Natural Resource industries – a construction site needs more workers today, posts the vacancies today and they are filled virtually immediately –

it seems less plausible for the Government and Health & Education industries, where the process of recruiting is arguably much more formal and time intensive.

Figure 16 illustrates the results as a function of establishment growth. This framework suggests that establishments growing between 25 and 30 percent fill over 60 percent of their vacancies within a day. This is another aspect of this framework that leads us to believe that one needs some form of heterogeneity in recruiting practices (as in the passive recruiting framework) to account for the empirical patterns in the data.

6. 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 fill rate for reported job openings, and the mean number of days required to fill an open job. The flow of new vacancies is considerably

less volatile than the vacancy stock, according to our basic accounting framework, and the job-filling rate is countercyclical.

When we extend the accounting framework to accommodate passive recruiting, we estimate that at least 36 percent of hires occur without benefit of a vacancy. This fraction varies greatly by industry and employer size. Allowing for passive recruiting reduces the estimated volatility of the job-filling rate and suggests roughly similar contributions of the fill rate, the vacancy flow rate, and passive recruiting to time variation in the hires rate. We also consider a version of the framework that allows for heterogeneity in job-filling rates conditional on employer size and industry. This extension also has merit in our view, but fill-rate heterogeneity alone yields some implausible results. For example, the magnitudes of certain job-filling rates in this version of the framework imply implausibly short vacancy durations.

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 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.

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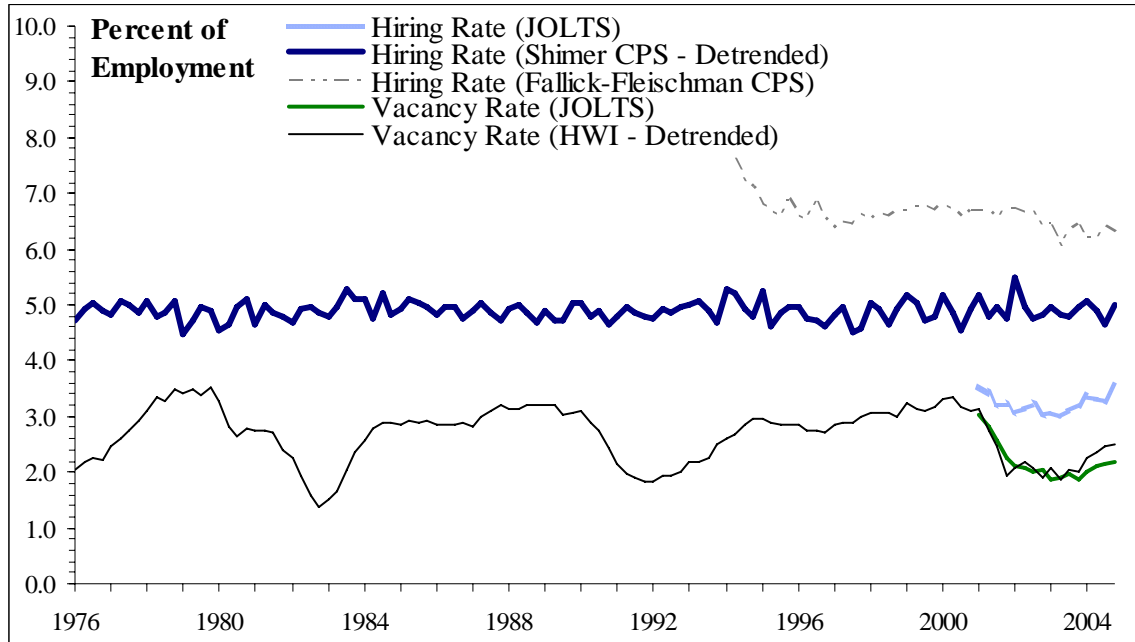
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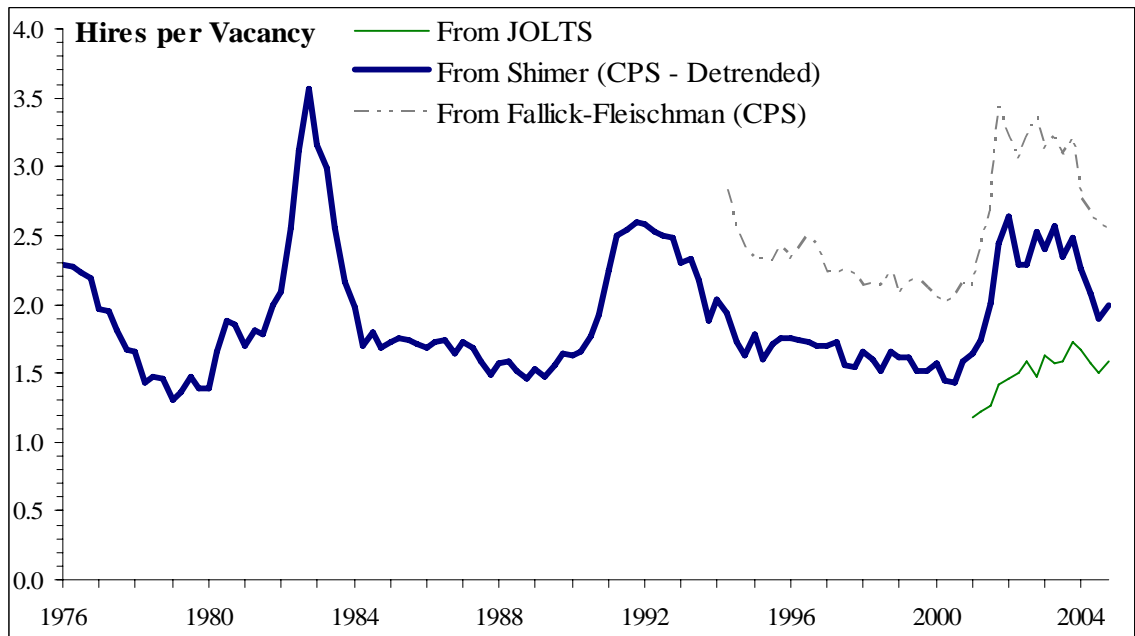
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Figure 1. Hires from CPS Gross Flows and Vacancies from Help Wanted Data



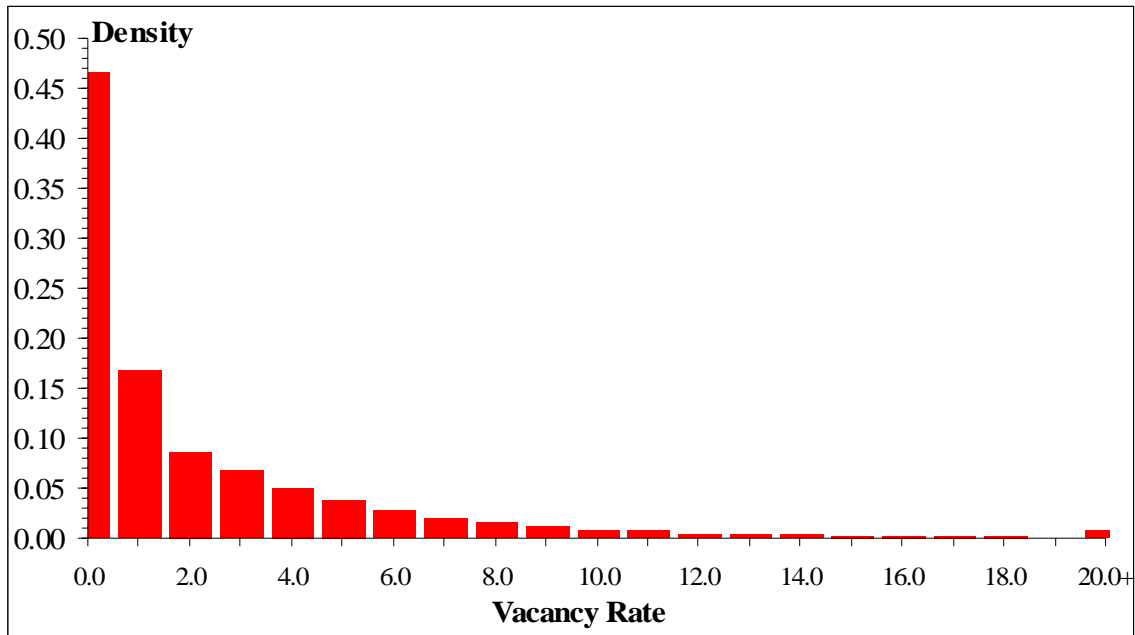
Notes: Hires estimates are from CPS gross flows data as tabulated by Shimer (2005, for 1976-2004 series) and Fallick and Fleischman (2004, for 1994-2004 series). Vacancy estimates come from the Help Wanted Index of the Conference Board. Shimer and HWI estimates are detrended using an HP filter with smoothing parameter of $\lambda = 10^5$. See above references and text for more details.

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

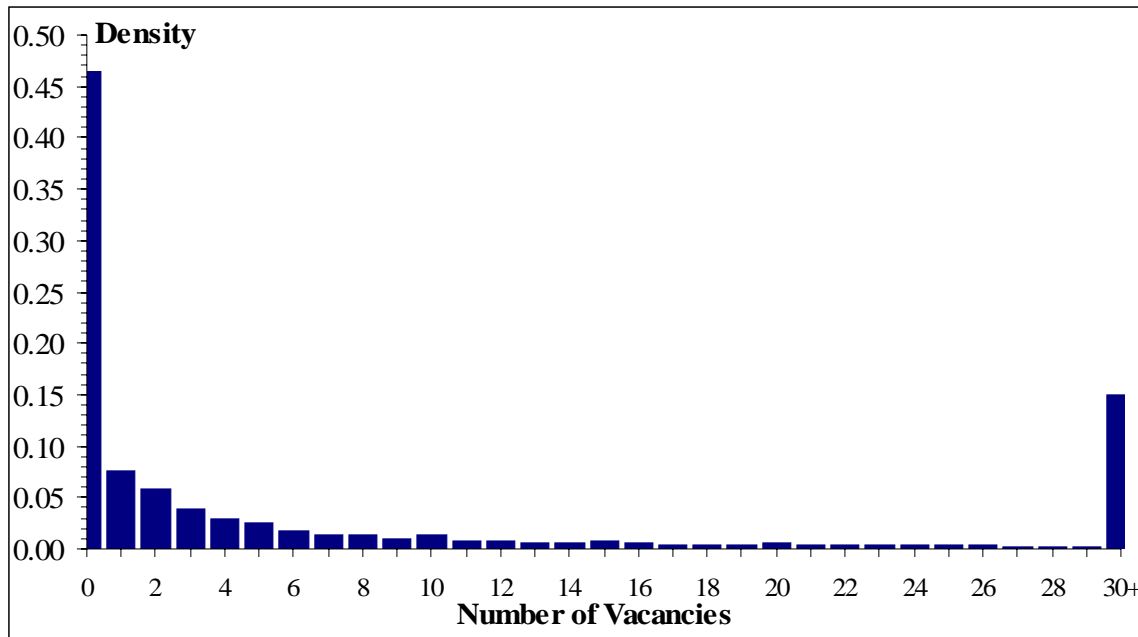


Notes: Hires estimates are from CPS gross flows data as tabulated by Shimer (2005, for 1976-2004 series) and Fallick and Fleischman (2004, for 1994-2004 series). Vacancies estimates come from the Help Wanted Index of the Conference Board. Shimer and HWI estimates are detrended using an HP filter with 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)

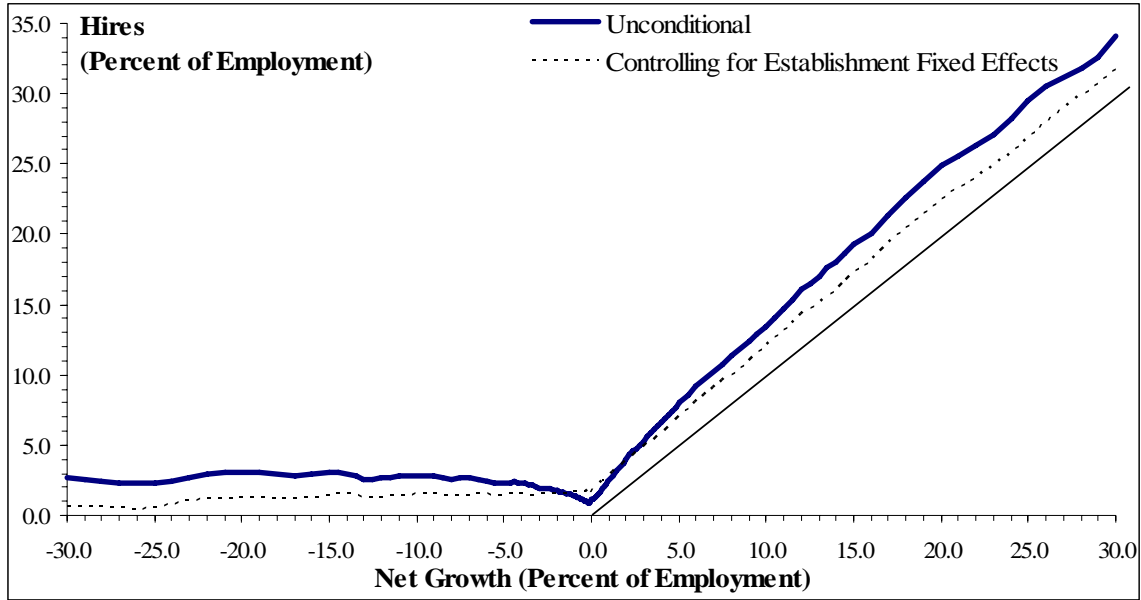


(b) Vacancy Levels (Number of Vacancies)



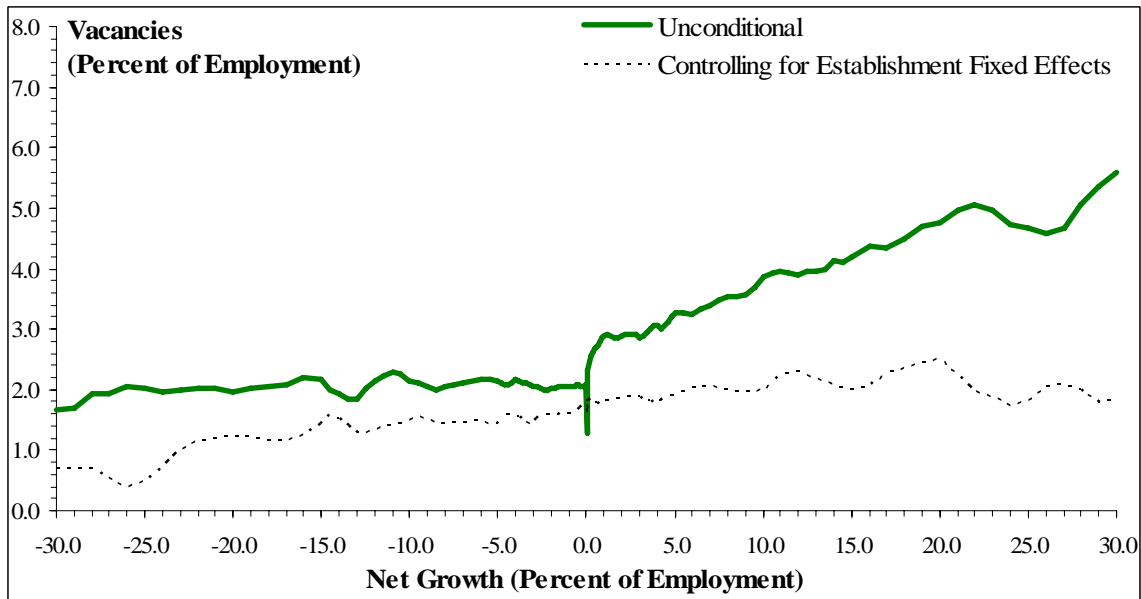
Note: Figures display the employment-weighted distribution of vacancy rates (upper panel) and vacancy levels (lower panel) across pooled monthly establishment observations from our JOLTS sample.

Figure 4. Hires Rate as a Function of Establishment Employment Growth



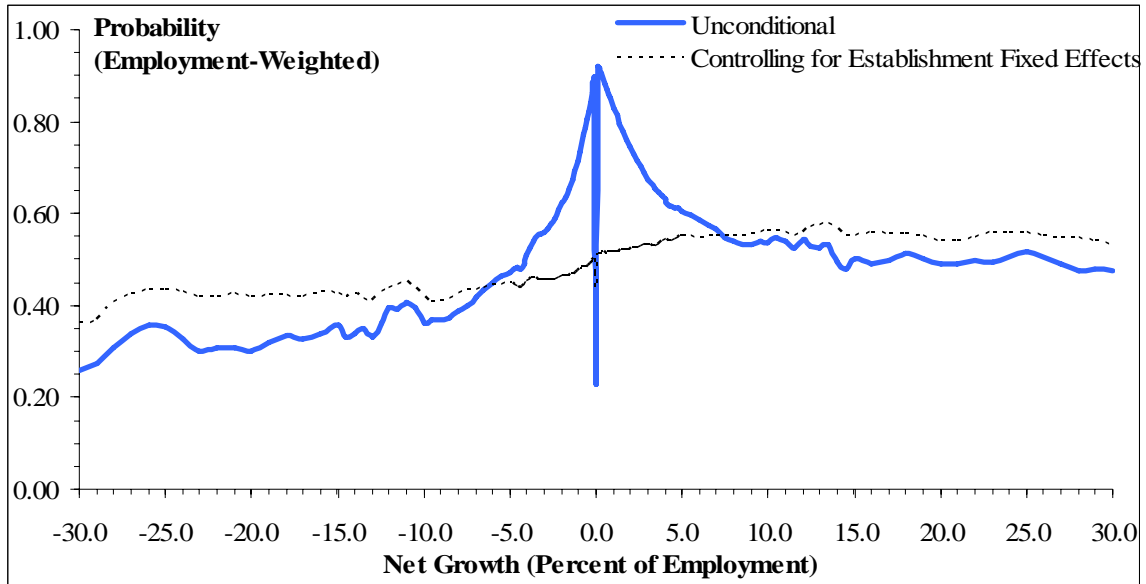
Note: The solid line represents the mean hires rate for fine intervals over the range of growth rates. The dashed line represents the mean hires rate conditional on establishment fixed effects. The thin line represents the 45-degree line from the origin. We derive our estimates from the pooled monthly 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



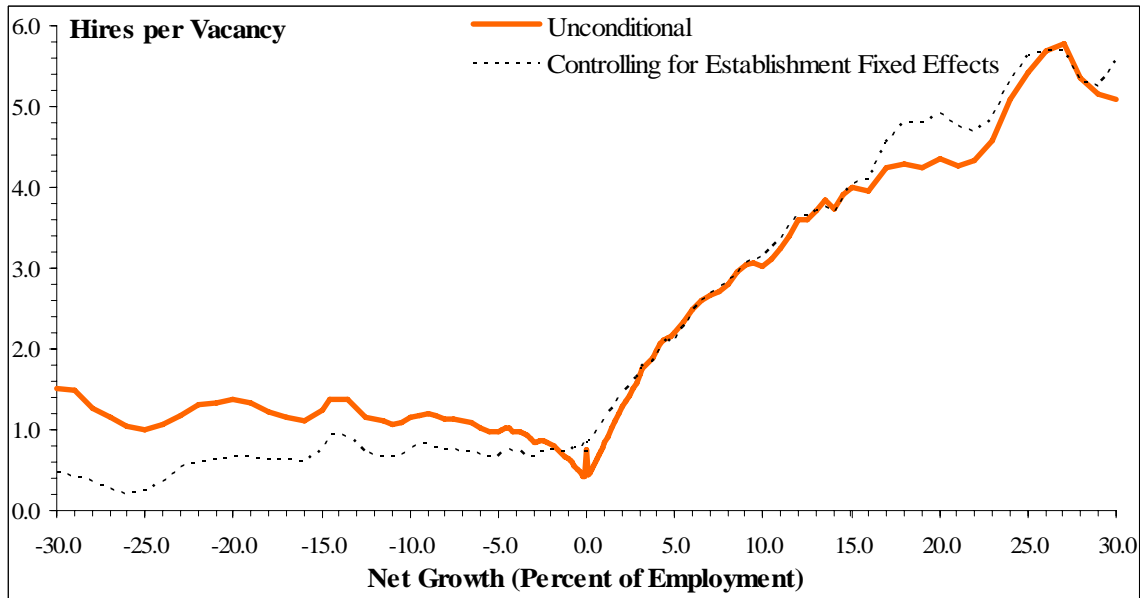
Note: The solid line represents the mean vacancy rate (measured at the end of the previous month) for fine intervals over the range of growth rates. The dashed line represents the mean vacancy rate conditional on establishment fixed effects. We derive our estimates from the pooled monthly establishment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

Figure 6. Probability of a Reported Vacancy as a Function of Establishment Employment Growth, Employment-Weighted



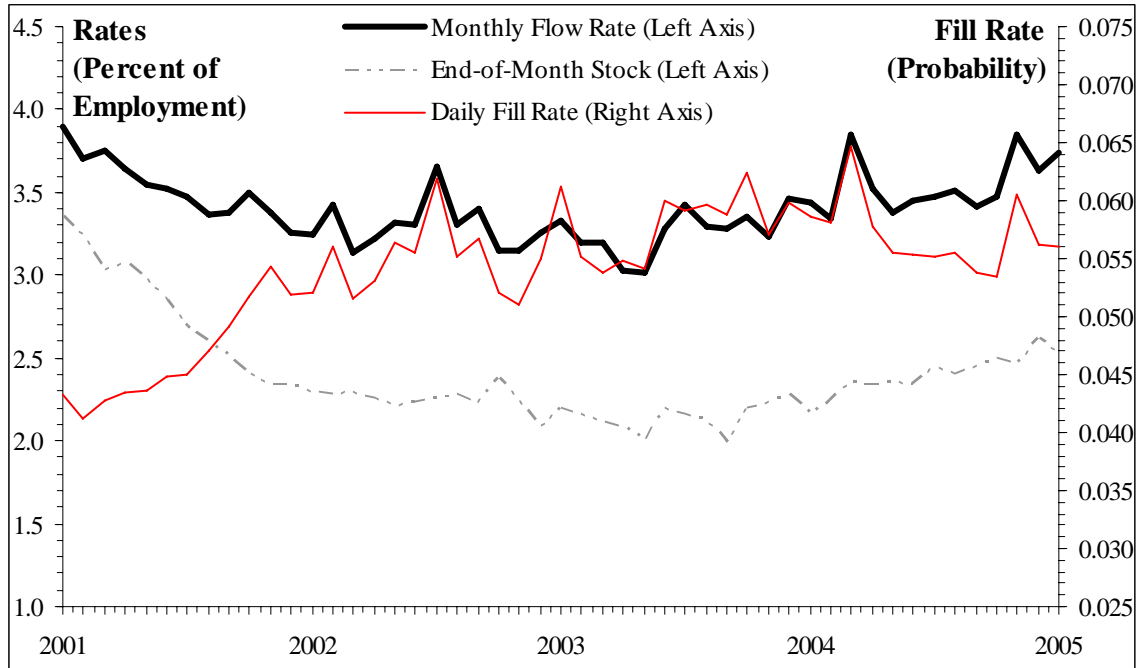
Note: The solid line represents the probability of a vacancy (measured at the end of the previous month and weighted by employment) for fine intervals over the range of growth rates. The dashed line represents the probability conditional on establishment fixed effects. We derive our estimates from the 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 7. Vacancy Yield as a Function of Establishment Employment Growth



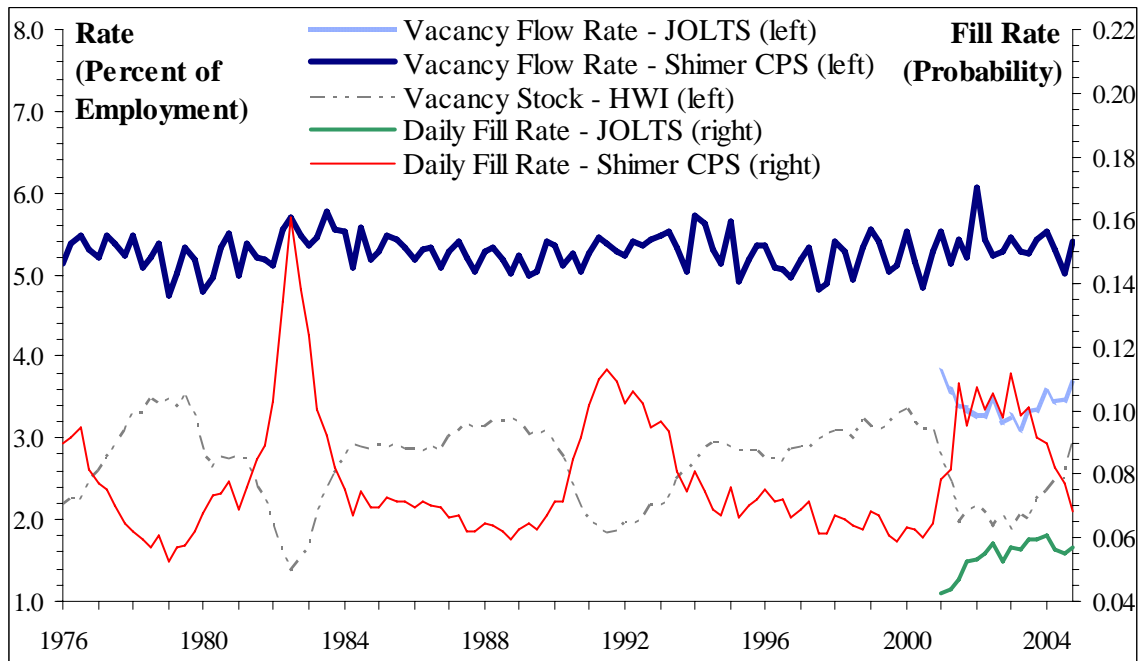
Note: In each panel, the solid line represents the number of hires in month t per vacancy reported at the end of month $t-1$ for fine intervals over the range of growth rates. The dashed line represents the number of hires per vacancy conditional on establishment fixed effects. In the upper panel, we 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 8. Basic Framework Monthly Estimates, JOLTS Data



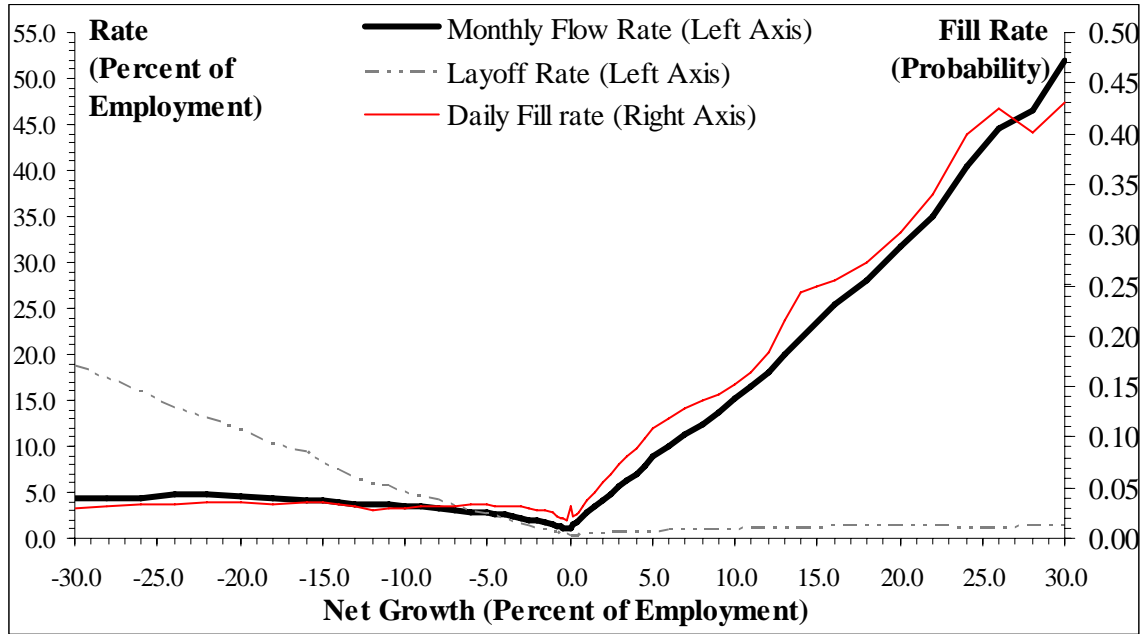
Notes: Results are from our basic accounting framework estimation using hires and vacancy rates tabulated from JOLTS microdata. See text for details.

Figure 9. Basic Framework Monthly Estimates, JOLTS, CPS and HWI Data



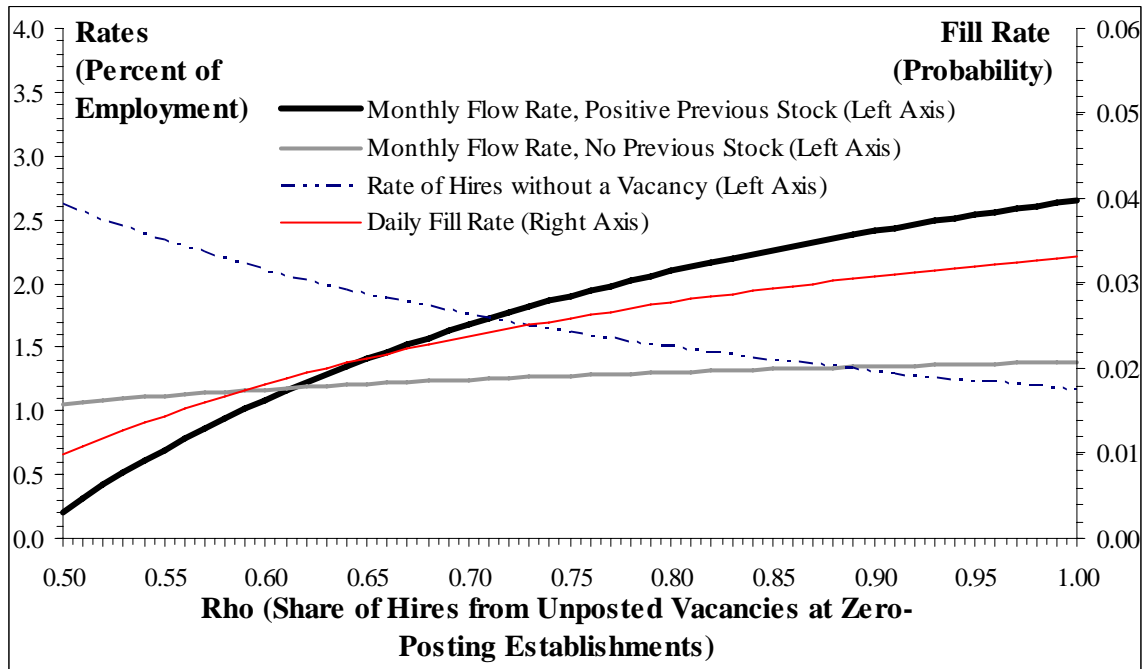
Notes: Results are from our basic accounting framework estimation using hires and vacancy rates tabulated from detrended estimates of CPS gross flow data (hires) and HWI data (vacancies). JOLTS estimates are identical to those in the previous figure. See text for details.

Figure 10. Basic Framework Estimates as a Function of Establishment Growth



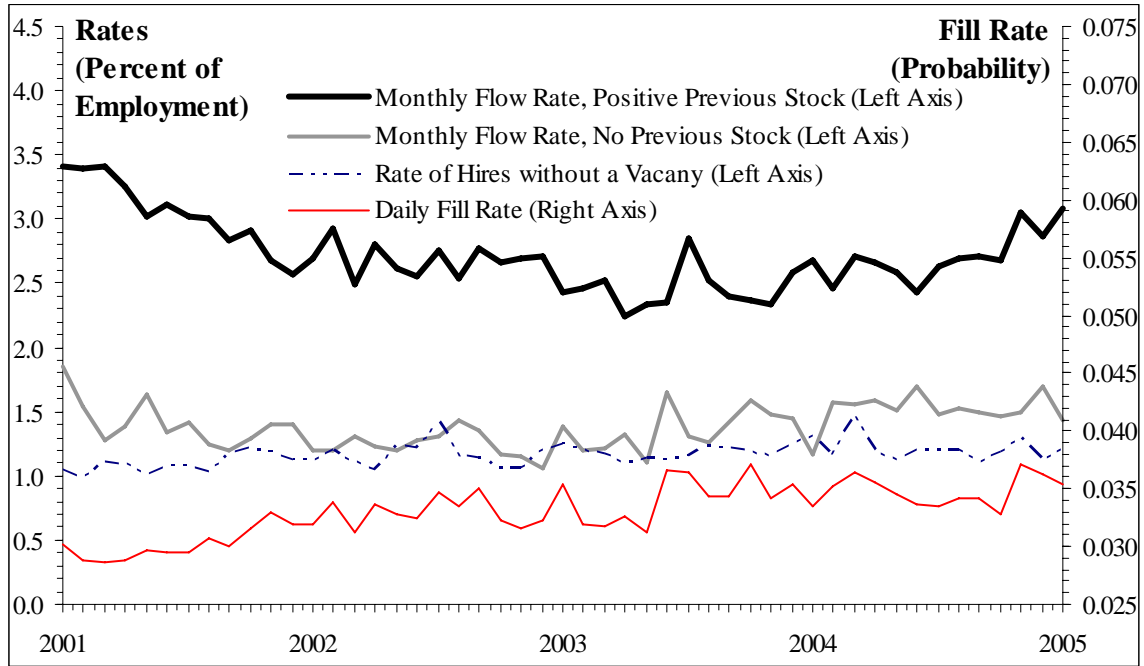
Notes: Results are from our basic accounting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.

Figure 11. Passive Recruiting Framework Estimates as a Function of ρ^0



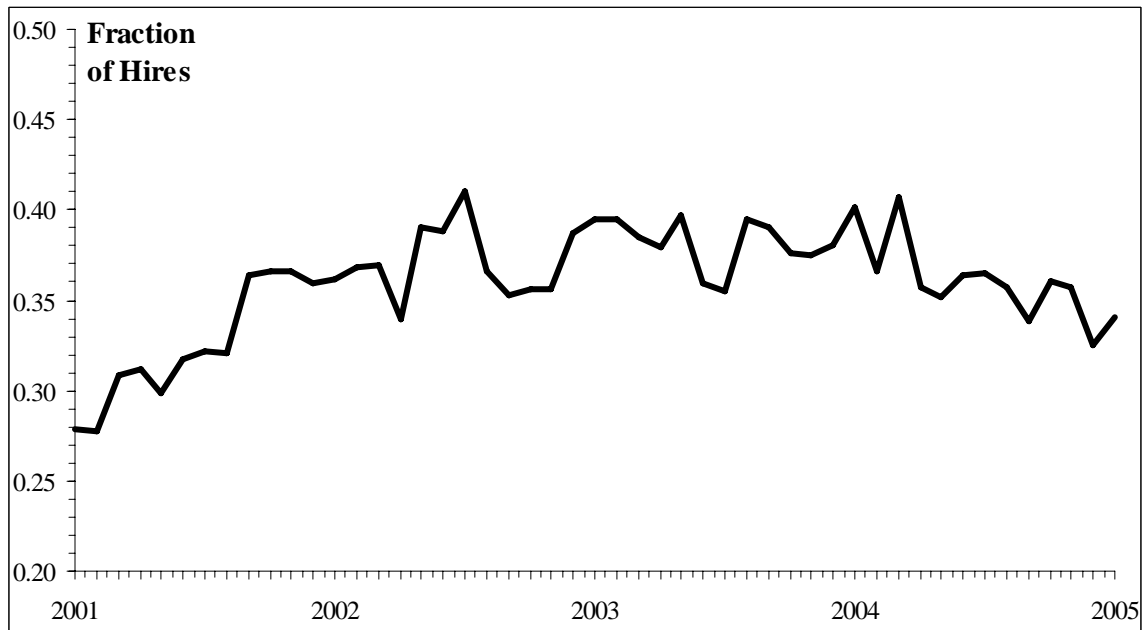
Notes: Estimates are parameters from our passive recruiting framework over a range of ρ^0 in the interval [0.5,1.0]. Estimates use hires and vacancy rates at the mean of their monthly values. See text for details.

Figure 12. Passive Recruiting Framework, Monthly Estimates



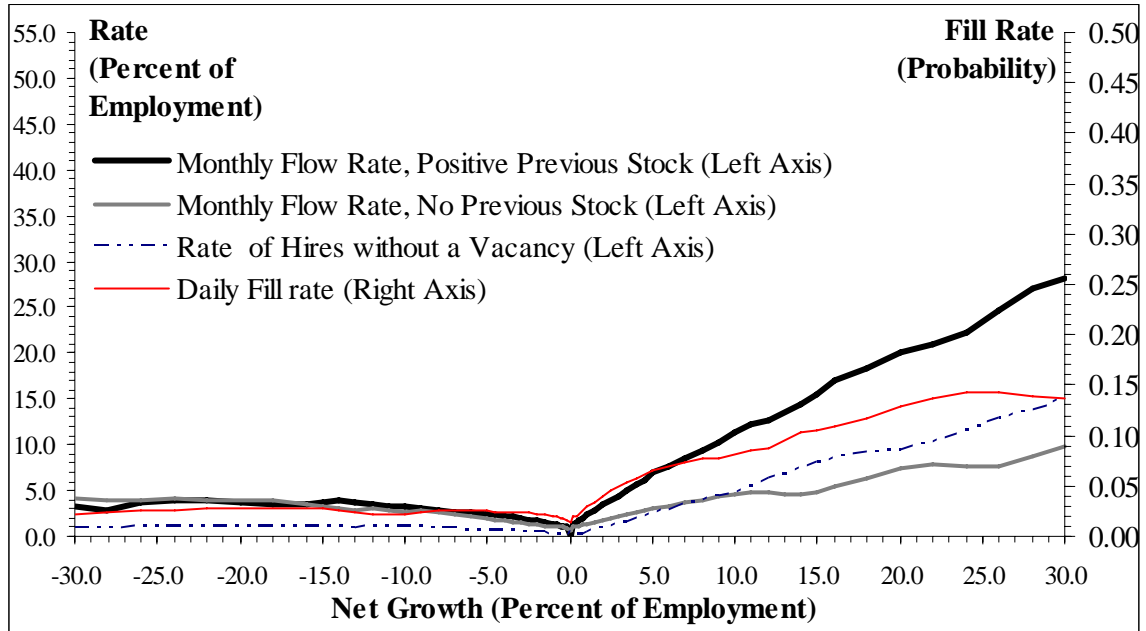
Notes: Results are from our passive recruiting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details.

Figure 13. Passive Recruiting Framework, Monthly Fraction of Hires without a Vacancy



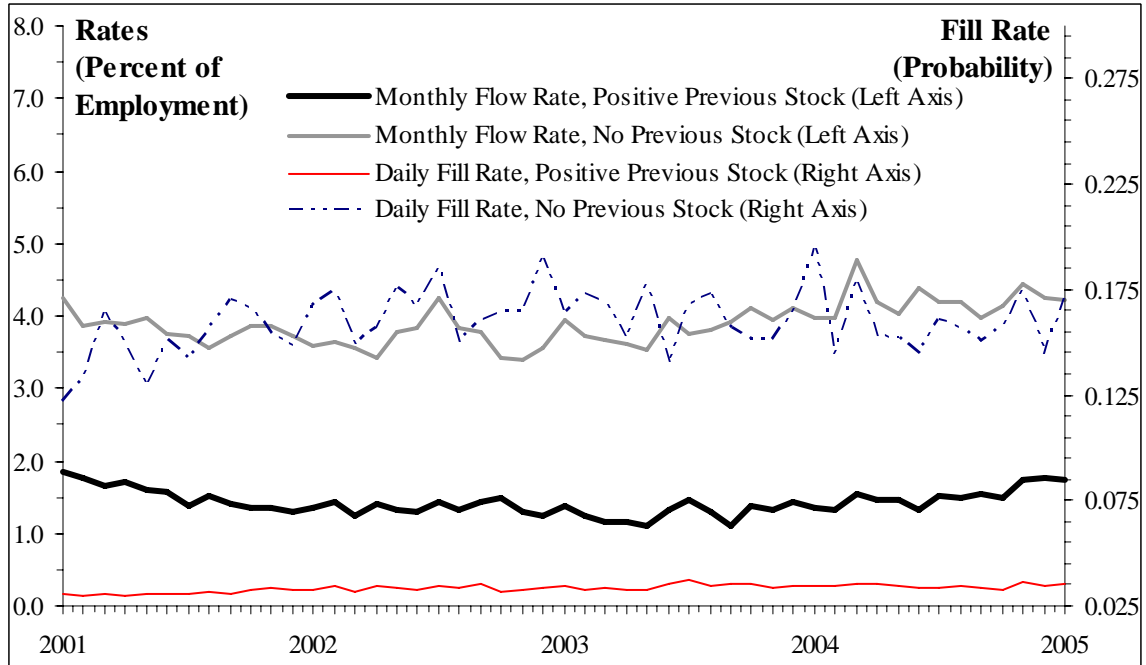
Notes: Figure depicts the fraction of hires without a vacancy as estimated with our passive recruiting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details. The fraction is defined as $\tau\eta_t/H_t$.

Figure 14. Passive Recruiting Framework, Estimates as a Function of Establishment Growth



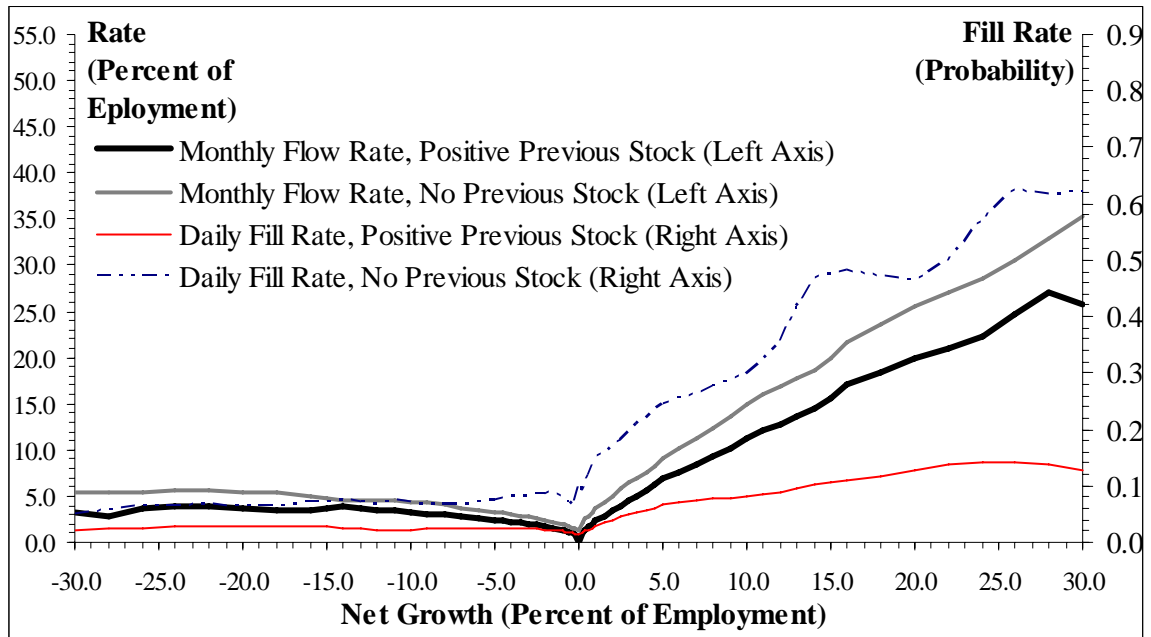
Notes: Results are from our passive recruiting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details. Estimates are smoothed using a centered, 5-interval moving average, with a discontinuity allowed at zero.

Figure 15. Fill Rate Heterogeneity Framework, Monthly Estimates



Notes: Results are from our fill rate heterogeneity accounting framework using hires and vacancy rates tabulated from JOLTS microdata. See text for details.

Figure 16. Fill Rate Heterogeneity Framework, Estimates as a Function of Establishment Growth



Notes: Results are from our fill rate heterogeneity 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.

Table 1. Hires, Separations and Vacancies by Industry and Size, JOLTS Data

	h_t	s_t	v_t	h_t / v_{t-1}	Employment Share
<i>Nonfarm Employment</i>	3.2	3.1	2.2	1.3	---
<i>Major Industry</i>					
Natural Resources & Mining	3.1	3.1	1.1	2.4	0.5
Construction	5.3	5.5	1.3	3.3	5.2
Manufacturing	2.2	2.7	1.4	1.5	11.6
Transport, Wholesale & Utilities	2.5	2.6	1.6	1.4	8.1
Retail Trade	4.3	4.2	1.9	2.0	11.4
Information	2.1	2.3	2.0	0.9	2.5
Finance, Insurance & Real Estate	2.2	2.1	2.0	1.0	6.1
Professional & Business Services	4.1	3.8	2.9	1.2	12.3
Health & Education	2.7	2.3	3.3	0.7	12.5
Leisure & Hospitality	6.1	5.9	2.8	1.9	9.2
Other Services	3.2	3.1	1.9	1.4	4.1
Government	1.5	1.2	1.8	0.8	16.5
<i>Establishment Size Class</i>					
0-9 Employees	3.1	3.2	1.4	1.6	12.1
10-49 Employees	3.9	4.0	1.9	1.8	23.1
50-249 Employees	3.8	3.7	2.2	1.5	28.4
250-999 Employees	2.9	2.8	2.4	1.1	17.0
1,000-4,999 Employees	2.0	1.9	2.7	0.7	13.3
5,000+ Employees	1.5	1.3	2.3	0.6	6.1

Notes: Estimates are tabulated from our sample of JOLTS microdata. Rates are as defined in the text.

Table 2. Distribution of Hires and Vacancies by Industry and Size, JOLTS Data

	Percent of Employment with $h_t = 0$	Percent of Employment with $v_{t-1} = 0$	Percent of Establishments with $h_t = 0$	Percent of Establishments with $v_{t-1} = 0$	Percent of h_t with $v_{t-1} = 0$	Percent of v_{t-1} with $h_t = 0$
<i>Nonfarm Employment</i>	35.9	46.5	81.6	87.6	42.3	18.7
<i>Major Industry</i>						
Natural Resources & Mining	44.8	65.0	83.8	91.1	65.1	30.8
Construction	47.4	75.2	82.1	92.3	67.7	33.3
Manufacturing	34.8	46.4	73.2	84.4	43.3	15.8
Transport, Wholesale & Utilities	45.6	54.0	85.8	89.6	43.3	29.6
Retail Trade	44.0	61.0	77.6	87.7	49.7	22.4
Information	34.5	38.1	80.1	83.1	34.9	21.0
Finance, Insurance & Real Estate	45.0	50.2	87.9	90.9	41.6	22.8
Professional & Business Services	36.3	43.4	85.7	89.1	32.3	16.8
Health & Education	27.6	31.7	81.2	83.8	25.4	11.0
Leisure & Hospitality	33.6	55.6	66.4	81.8	48.6	16.6
Other Services	61.5	70.8	88.8	90.4	54.3	48.6
Government	22.4	25.7	76.8	75.7	20.6	12.9
<i>Establishment Size Class</i>						
0-9 Employees	87.6	92.3	91.7	94.7	77.5	62.8
10-49 Employees	60.9	75.2	65.9	78.7	61.1	35.5
50-249 Employees	29.3	45.7	33.1	50.0	37.3	14.1
250-999 Employees	13.3	20.6	14.5	22.4	17.7	5.2
1,000-4,999 Employees	4.7	8.3	5.5	9.5	6.9	1.4
5,000+ Employees	1.7	7.5	1.6	6.6	7.1	1.0

Notes: Estimates are tabulated from our sample of JOLTS microdata.

Table 3. Basic Accounting Framework Results by Industry and Size Class, JOLTS Data

	Daily Fill Rate f_t	Monthly Flow Rate $\tau \cdot \theta_t$	Duration (Days) $1/f_t$
<i>Nonfarm Employment</i>	0.055	3.4	18.3
<u><i>Major Industry</i></u>			
Natural Resources & Mining	0.105	3.3	9.5
Construction	0.148	6.1	6.8
Manufacturing	0.061	2.4	16.4
Transport, Wholesale & Utilities	0.059	2.7	16.9
Retail Trade	0.083	4.6	12.0
Information	0.039	2.1	25.8
Finance, Insurance & Real Estate	0.040	2.3	25.2
Professional & Business Services	0.050	4.4	19.8
Health & Education	0.029	2.7	34.3
Leisure & Hospitality	0.078	6.5	12.8
Other Services	0.058	3.4	17.3
Government	0.032	1.6	30.9
<u><i>Establishment Size Class</i></u>			
0-9 Employees	0.069	3.4	14.5
10-49 Employees	0.075	4.2	13.4
50-249 Employees	0.063	4.0	15.8
250-999 Employees	0.045	3.0	22.2
1,000-4,999 Employees	0.028	2.0	36.0
5,000+ Employees	0.025	1.6	40.1

Notes: Estimates are tabulated from our sample of JOLTS microdata.

Table 4. Framework with Passive Recruiting Results by Industry and Size Class, JOLTS Data

	Daily Fill Rate f_t	Flow Rate $\tau \cdot \theta_t$, $v_{t-1} > 0$	Flow Rate $\tau \cdot \theta_t$, $v_{t-1} = 0$	Rate of Hires without a Vacancy $\tau \cdot \eta_t$	Fraction of Hires w/o a Vacancy $\tau \cdot \eta_t / h_t$
<i>Nonfarm Employment</i>	0.033	2.7	1.4	1.2	0.36
<u><i>Major Industry</i></u>					
Natural Resources & Mining	0.039	2.1	0.8	1.8	0.59
Construction	0.055	4.5	1.6	3.1	0.58
Manufacturing	0.036	1.9	0.8	0.8	0.37
Transport, Wholesale & Utilities	0.036	2.2	1.1	0.9	0.35
Retail Trade	0.048	3.8	1.9	1.7	0.39
Information	0.026	1.5	1.4	0.6	0.28
Finance, Insurance & Real Estate	0.024	1.7	1.0	0.8	0.36
Professional & Business Services	0.035	4.1	1.7	1.1	0.26
Health & Education	0.022	2.4	1.2	0.6	0.22
Leisure & Hospitality	0.044	5.2	2.5	2.4	0.40
Other Services	0.030	2.5	1.4	1.4	0.45
Government	0.026	1.4	0.8	0.3	0.17
<u><i>Establishment Size Class</i></u>					
0-9 Employees	0.019	NA*	1.1	2.3	0.71
10-49 Employees	0.034	3.1	1.5	2.0	0.52
50-249 Employees	0.041	3.6	1.5	1.2	0.30
250-999 Employees	0.037	2.8	1.3	0.4	0.15
1,000-4,999 Employees	0.025	1.9	1.3	0.1	0.05
5,000+ Employees	0.023	1.4	1.6	0.1	0.05

Notes: Estimates are tabulated from our sample of JOLTS microdata. * The estimate of the vacancy flow rate for this group is imprecise and inconsistent (i.e., less than zero), mostly likely a consequence of the very small share of activity in this category (very small firms with positive vacancies) thus we suppress its result.

Table 5. Fill Rate Heterogeneity Framework Results by Industry and Size Class, JOLTS Data

	Daily Fill Rate $f_t,$ $v_{t-1} > \mathbf{0}$	Flow Rate $\tau \cdot \theta_t,$ $v_{t-1} > \mathbf{0}$	Daily Fill Rate $f_t,$ $v_{t-1} = \mathbf{0}$	Flow Rate $\tau \cdot \theta_t,$ $v_{t-1} = \mathbf{0}$
<i>Nonfarm Employment</i>	0.033	1.4	0.159	3.9
Natural Resources & Mining	0.039	2.1	0.280	3.6
Construction	0.055	4.5	0.260	5.7
Manufacturing	0.036	1.9	0.185	2.7
Transport, Wholesale & Utilities	0.036	2.2	0.144	2.8
Retail Trade	0.048	3.8	0.161	4.6
Information	0.026	1.5	0.106	2.9
Finance, Insurance & Real Estate	0.024	1.7	0.126	2.6
Professional & Business Services	0.035	4.1	0.140	4.3
Health & Education	0.022	2.4	0.120	3.1
Leisure & Hospitality	0.044	5.2	0.173	6.9
Other Services	0.030	2.5	0.132	3.4
Government	0.026	1.4	0.113	1.8
0-9 Employees	NA*	NA*	0.153	3.6
10-49 Employees	0.034	3.1	0.161	4.2
50-249 Employees	0.041	3.6	0.166	4.1
250-999 Employees	0.037	2.8	0.154	3.3
1,000-4,999 Employees	0.025	1.9	0.097	2.7
5,000+ Employees	0.023	1.4	0.075	2.7

Notes: Estimates are tabulated from our sample of JOLTS microdata. * The estimate of the job-filling and vacancy flow rates for this group are imprecise and inconsistent, mostly likely a consequence of the very small share of activity in this category.