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Adjusted Estimates of Worker Flows and Job Openings in JOLTS

Steven J. Davis, R. Jason Faberman, John C. Haltiwanger, and Ian Rucker

5.1 Introduction

The Job Openings and Labor Turnover Survey (JOLTS) is an innovative data program that delivers national, regional, and industry estimates for the monthly flow of hires and separations and for the stock of unfilled job openings. Analysts have seized on JOLTS data as a valuable source of insights about U.S. labor markets and an important new research tool for evaluating theories of labor market behavior. Recent studies draw on JOLTS data to investigate the cyclical behavior of hires and separations (Hall 2005); the Beveridge curve relation between unemployment and job vacancies (Valetta 2005; Fujita and Ramey 2007; Shimer 2007a); the connection between quits and employer recruiting behavior (Faberman and Nagypál 2007); and the relationship among vacancies, hires and employment growth at the establishment level (Davis, Faberman, and Haltiwanger 2006, 2009). Given the key roles played by job vacancies and worker flows in prominent search-based

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Ian Rucker was a bright young graduate student at the University of Maryland with a promising future. He died in May 2009 after he completed his work on this paper while working at the Bureau of Labor Statistics. He was a wonderful partner in research, and we will miss him. We thank Nathan Brownback for excellent research assistance and staff at the Bureau of Labor Statistics for much help with this project. We are also grateful to Robert Hall, Charlotte Mueller, John Wohlford, and the editors for helpful comments on an earlier draft. The views expressed in this paper are our own and do not reflect the opinions of the Bureau of Labor Statistics, the Federal Reserve Bank of Philadelphia, the Federal Reserve System, or their staffs.

theories of unemployment along the lines of Mortensen and Pissarides (1994), JOLTS will continue to attract keen interest from researchers.

In addition to notable virtues, the JOLTS program presents measurement issues that are imperfectly understood and not widely appreciated. Reasons for concern can be seen in three simple comparisons to other data sources. First, the aggregate employment growth implied by the flow of hires and separations in JOLTS consistently exceeds the growth observed in its national benchmark, the Current Establishment Statistics (CES) survey.[1] Cumulating the difference between hires and separations from 2001 to 2006 yields a discrepancy of 6.6 million nonfarm jobs. Second, JOLTS hires and separations are surprisingly small compared to similar measures in other data sources.[2] Third, the cross-sectional density of establishment growth rates shows much less dispersion in JOLTS than in data sources with comprehensive establishment coverage.[3]

These discrepancies arise, at least in part, from two aspects of JOLTS methodology. First, the JOLTS sample excludes establishment openings and very young establishments. Similar sample restrictions apply to many establishment surveys, but the consequences are more significant for the key statistics derived from JOLTS. To see this point, start with the observation that employees at new establishments have very short job tenures, which, in turn, are associated with very high separation rates.[4] Thus, the JOLTS sample systematically excludes a set of establishments with unusually high employee turnover. The volatility of employment growth rates is also extremely high at very young establishments, even after conditioning on size.[5] Greater volatility at the establishment level involves larger worker flows, as we show. In addition to these effects of JOLTS sample design on worker flows, new establishments surely account for a disproportionate share of job openings. Hence, the exclusion of new and very young establishments imparts a downward bias to both job openings and worker flows. It potentially affects cyclical patterns as well.

The second issue with JOLTS methodology involves adjustments for nonrespondents. Survey nonresponse rates are likely higher for establishments that exit or contract sharply. Compared to a randomly selected establishment, these establishments have high separation and layoff rates and low rates of hires and job openings. However, the JOLTS practice effectively imputes to nonrespondents the average rate among respondents in the same region-industry-size category. If the response rate is lower for exits and sharply contracting establishments, this imputation practice understates separations and overstates hires and job openings. It also imparts an upward

1. See Wohlford et al. (2003), Nagypál (2006), and Faberman (2005a).
2. See Faberman (2005a) and Davis, Faberman, and Haltiwanger (2006).
3. See Faberman (2005a).
4. See, for example, Mincer and Jovanovic (1981), Topel and Ward (1992), and Farber (1994).
5. See Davis and Haltiwanger (1999) and Davis et al. (2007).

bias to the employment change implied by the flow of hires and separations. Again, there are potentially important effects on cyclical patterns as well.[6]

In light of these measurement issues, we develop and implement a method for adjusting the published JOLTS estimates to more accurately reflect worker flows and job openings in the U.S. economy. Our method involves reweighting the cross-sectional density of employment *growth rates* in JOLTS to match the corresponding density in the Business Employment Dynamics (BED) data. The BED, which derives from administrative records in the unemployment insurance system, covers essentially all private-sector employers—including entrants, exits, and very young establishments. We apply the reweighted density of employment growth rates to calculate adjusted estimates for worker flows and unfilled job openings (i.e., vacancies). In doing so, we exploit the close cross-sectional relationship of worker flows and vacancy rates to the establishment-level growth rate of employment.[7]

To preview the main results, our adjusted measures of hires and separations exceed the published JOLTS estimates by about one-third. The adjusted layoff rate exceeds the published rate by more than 60 percent. Time series properties are also affected. For example, hires show more volatility than separations in the published statistics, but the reverse holds in the adjusted statistics. The impact of our adjustment methodology on estimated job openings is more modest, raising the average vacancy rate by about 8 percent. Our adjustments virtually eliminate the discrepancy between nonfarm private-sector employment growth in the CES or BED and the cumulative difference of hires and separations in JOLTS.

In terms of mechanics, our adjustments to the published JOLTS statistics can be understood by reference to two basic observations. First, the cross-sectional density of establishment growth rates in JOLTS data deviates systematically from the density in the underlying universe of establishment-level observations, as measured in the BED. Second, rates of worker flows and job vacancies vary greatly with establishment growth rates in the cross section. The cross-sectional relations are also highly asymmetric about zero. The underweighting of establishments with sharp negative growth rates in JOLTS yields an undercount of layoffs and an overstatement of the quit-layoff ratio. Correcting for this aspect of the JOLTS data substantially raises the average layoff rate and amplifies its variation over time.

6. In early 2009, following the conclusion of this research project, the BLS made substantial revisions to the published JOLTS statistics. The revisions reflected several of our suggestions and, consequently, resolve some of the issues noted in the following. For example, the revised JOLTS statistics now have net growth rates that are generally consistent with those derived from the CES. Revised worker flow rates are also higher, on average, though still below the magnitudes of the adjusted estimates in this chapter. The full details of the BLS revisions can be found at http://www.bls.gov/jlt/methodologyimprovement.htm. This study uses published data and microdata prior to the revisions.

7. For evidence, see Davis, Faberman, and Haltiwanger (2006, 2007) and section 5.3.

The more modest nature of our adjustments to the job openings rate reflects two opposing effects. The underweighting of establishments with sharp negative growth rates, which have low vacancy rates, imparts an upward bias to the published vacancy rate. The omission of births and very young fast-growing establishments imparts a downward bias. Our results indicate that the second effect dominates, on average, so that the adjusted vacancy rate exceeds the published rate.

The next section reviews certain aspects of the JOLTS sample design, JOLTS imputation and benchmarking methods, the BED data, and various measurement issues. Section 5.3 compares JOLTS data to other sources. Section 5.4 presents several striking patterns in the cross-sectional relationships of worker flows and job openings to employment growth. These cross-sectional relations play a major role in our adjustment method. They also shed new light on the cyclical behavior of labor market flows and unemployment, as stressed by Davis, Faberman, and Haltiwanger (2006). Section 5.5 sets forth our adjustment method and explains how we handle certain issues that arise in the implementation. Section 5.6 presents adjusted estimates for worker flows and job openings and compares them to the published JOLTS estimates. We conclude in section 5.7 with remarks about some broader implications of our results and several suggestions for improving JOLTS statistics.

5.2 Data Sources and Analysis Samples

Our study exploits BLS microdata from the Job Openings and Labor Turnover Survey (JOLTS) and the Business Employment Dynamics (BED) program.[8] This section reviews some important features of these two data sources, describes our analysis sample, and discusses a few measurement issues.

5.2.1 The Job Openings and Labor Turnover Survey

The published JOLTS statistics on worker flows and job openings derive from a sample of about 16,000 establishments per month. The JOLTS questionnaire elicits data on employment for the pay period covering the 12th of the month, the flow of hires and separations during the month, and the number of open job positions (vacancies) on the last business day of the month.[9] The JOLTS sample is stratified by major industry groups, four Census regions, and several establishment-size classes. JOLTS sample

8. See Clark and Hyson (2001) and Faberman (2005b) for information about the JOLTS program and Spletzer et al. (2004) for more information about the BED. Statistics derived from the JOLTS program are available at http://www.bls.gov/jlt/home.htm.

9. The JOLTS survey form instructs the respondent to report a job opening 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." Further instructions define "active recruiting"

observations are weighted so that the employment level for each industry-region-size cell matches employment for the corresponding cell in the much larger Current Employment Statistics (CES) survey. The sample frame for both JOLTS and CES derives from the Quarterly Census of Employment and Wages (QCEW), which essentially covers the universe of establishments with paid employees.[10]

Simplifying somewhat, let E_i denote total employment in cell i of the JOLTS sample frame, and let e_{ik} be employment at establishment k for the same cell.[11] The JOLTS sample weight for establishments in cell i is given by

$$\omega_{ik} = \frac{E_i}{\sum_{k \in \text{all}} e_{ik}},$$

where "all" refers to all sampled establishments that are in scope for the JOLTS survey. Here, we index ω by the establishment identifier k, even though all sampled establishments in cell i have the same sample weight. To construct the ω sample weights, the Bureau of Labor Statistics (BLS) relies on establishment-level employment data from the comprehensive QCEW. These data are available with a lag to the BLS and the JOLTS program.

The ω sample weights do not account for unit nonresponse, that is, the failure of a sampled establishment to respond to the JOLTS survey. Hence, the BLS applies a "nonresponse adjustment factor": an employment-based ratio adjustment that scales up the sample weights so that the resulting cell-level employment figure again matches the sample frame employment for that cell. Specifically, the nonresponse adjustment factor for cell i in month m is

$$\text{NRAF}_{m,ik} = \sum_{k \in \text{all}} \omega_{ik} e_{ik} \Big/ \sum_{k \in \text{used}(m)} \omega_{ik} e_{ik},$$

where "used(m)" refers to the set of establishments that respond to the survey in month m. Aside from the index set used(m), all quantities on the right side of this expression reflect past employment values in the QCEW, that is, prior to month m.

as "taking steps to fill a position . . . [that] may include advertising in newspapers, on television, or on radio; posting Internet notices; posting 'help wanted' signs; networking or making 'word of mouth' announcements; accepting applications; interviewing candidates; contacting employment agencies; or soliciting employees at job fairs, state or local employment offices, or similar sources." Job openings 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.

10. Independent contractors and unincorporated self-employed persons are out of scope for the QCEW, making them out of scope for the JOLTS, CES, and BED as well.

11. Our discussion in the text ignores outlier adjustments, sample rotation, and item nonresponse (as distinct from unit nonresponse). For more on the JOLTS estimation methodology, see Crankshaw and Stamas (2000).

The JOLTS sample weights are also adjusted over time to account for changes in CES employment estimates. These changes come in two forms. The first occurs each month because of regular BLS updates to the initial, preliminary CES estimates. The second occurs because of the annual "benchmarking" of CES estimates to the most recent data from the QCEW, which serves as the underlying population universe for both the CES and JOLTS. The benchmarking adjustment ensures that the final CES (and JOLTS) employment estimates are consistent with the administrative data in the QCEW.

The JOLTS program accounts for each of these benchmark adjustments in a similar manner. Each month, a "benchmark factor" is calculated for each establishment in the sample. This factor involves another employment-based ratio adjustment, one that constrains the JOLTS employment estimate to match the CES employment estimate for each sample cell. To construct the benchmark adjustment factor, let $\hat{E}_{m,i} \equiv \Sigma_k \text{NRAF}_{m,ik}\omega_{ik}e^J_{m,ik}$ be the initial (prebenchmark) JOLTS employment estimate for cell i, where $e^J_{m,ik}$ is the month m employment level for employment establishment k in cell i according to JOLTS. Also, let $E^C_{m,i}$ be the month m CES employment estimate for sample cell i. The benchmark adjustment factor for sample cell i in month m is

$$\text{BMF}_{m,ik} = \frac{E^C_{m,i}}{\hat{E}_{m,i}}.$$

Putting all this together, the final JOLTS sample weight for cell i in month m is

$$\theta_{m,ik} = \omega_{ik} \times \text{NRAF}_{m,ik} \times \text{BMF}_{m,ik}.$$

All survey response data in the JOLTS program are multiplied by these final sample weights to produce the published statistics on worker flows and job openings. Hereafter, references to the "weight" or "adjusted weight" refer to the JOLTS final sample weight.

At this point, it is essential to recognize that the nonresponse and benchmark adjustments do not address the sources of bias identified in the introduction. These adjustments ensure that sample-weighted JOLTS employment totals match CES employment totals at the cell level, but they do *not* ensure unbiased estimates for worker flows and job openings. In fact, the omission of establishment openings and very young establishments means that the JOLTS sample is unrepresentative in key respects that relate to worker flows and job openings. The administrative data that feed into the JOLTS sample frame are compiled with a lag of eight months or more, mostly due to the time it takes to transfer data from the states to the BLS. Once an establishment is captured by the QCEW, it takes at least one more month before it can be selected for the JOLTS sample. In sum, it takes at least nine months in the best-case scenario before a new establishment becomes available for inclusion in the JOLTS sample.

We have also suggested that JOLTS nonresponse rates are higher among establishments that exit or contract sharply. This nonresponse pattern, coupled with the current JOLTS procedure for handling unit nonresponse, also causes the JOLTS sample to be unrepresentative in key respects that relate to worker flows and job openings. We do not offer direct evidence that unit nonresponse rates are higher for establishments that exit or contract sharply, but sections 5.3 and 5.4 show that the JOLTS sample substantially underweights rapidly contracting establishments. Regardless of exactly why this type of underweighting occurs, it leads to a systematic bias in JOLTS-based estimates of worker flows and job openings.[12]

5.2.2 The Business Employment Dynamics Data

The BED data are essentially a longitudinal version of the QCEW. Hence, like the QCEW, the BED is a universe data set with comprehensive establishment coverage. In particular, it captures exits, entrants, and continuing establishments, including very young ones. The BLS relies on the BED to produce quarterly statistics on gross job gains and losses.[13] We use the BED to obtain the cross-sectional density of employment growth rates for the universe of private-sector establishments. We then adjust the cross-sectional density of employment growth rates in JOLTS to conform to the corresponding BED density. The main complication that arises in practice involves a difference in sampling frequency. The BED uses employment data for the third month of each calendar quarter, whereas JOLTS contains monthly observations.

5.2.3 Analysis Sample and Measurement Concepts

We consider a sample of JOLTS data from January 2001 to December 2006. We limit attention to private-sector establishments because the BED is restricted to the private sector. We rely on JOLTS data to estimate how worker flows and job openings vary with employment growth in the cross section of establishments. We calculate rates for employment growth, worker flows, and job openings using the average of current and previous period employment in the denominator. Measuring rates in this manner yields an employment growth rate measure that is symmetric about zero and bounded

12. In general, a sample that is representative with respect to levels, such as employment, need not be representative with respect to changes, such as employment growth rates. Worker flows and job openings are much more closely related to employment changes than employment levels. Hence, the benchmarking and nonresponse adjustments that constrain JOLTS employment totals to match sample frame employment do not ensure unbiased estimates of worker flows and job openings. See the recent National Academy of Sciences report by Haltiwanger, Lynch, and Mackie (2007) for additional discussion of the distinction between samples optimized for levels and samples optimized for changes.

13. These statistics are available at http://www.bls.gov/bdm/.

between –2 and 2. It also affords an integrated treatment of entering, exiting, and continuing establishments.[14]

As we remarked earlier, the JOLTS employment measure pertains to the payroll period covering the 12th of the month, whereas JOLTS hires and separations are flows during the month. This timing difference and the month-to-month changes in establishment-level sample weights complicate our adjustment methods. To deal with these complications, it is useful to compute lagged employment values that are consistent with current-month JOLTS values for employment, hires, and separations. We calculate this internally consistent measure of lagged employment as

$$e^{\mathrm{IC}}_{m-1} = e^{J}_{m} - h_m + s_m, \tag{1}$$

where h_m and s_m denote hires and separations during month m, and we have suppressed cell and establishment identifiers.

We use e^{IC}_{m-1} when calculating growth rates from $m-1$ to m. This approach ensures that an establishment's employment change equals the difference between its hires and separations and does so in a way that preserves reported hires and separations, a key focus of our study. It also allows us to calculate flow rates entirely from current month data, eliminating the need to restrict the sample to observations with consecutive months of reporting. We use the same approach for e^{IC}_{m-3} when calculating quarterly growth rates. See the appendix for an explanation of how we treat sample weight changes within the quarter when computing quarterly growth rates.

5.3 JOLTS Data Compared to Other Sources

Figure 5.1 compares the growth of nonfarm employment in JOLTS and CES data. For JOLTS, we measure the growth rate as the hires rate minus the separations rate. For the CES, we use the percent change in employment from one period to the next. We show quarterly growth rates because they are less noisy than monthly data. As seen in figure 5.1, the JOLTS-based measure of employment growth exceeds the CES measure in twenty-one of twenty-four quarters.

Figure 5.2 compares the evolution of CES employment to the cumulative change implied by hires minus separations in JOLTS. The thin line shows the cumulated difference between hires and separations from December 2000, and the bold lines show the cumulated difference from December of each year. Figure 5.2 demonstrates that the employment path implied by JOLTS data diverges upward relative to the CES path in each year except 2001. The divergence is large in four out of six years, and the cumulative discrepancy of 6.6 million jobs amounts to 4.8 percent of the December 2006 CES employment figure. The cumulative discrepancy is smaller but still sizable

14. See Davis, Haltiwanger, and Schuh (1996) for more on this growth measure. The BED program uses this growth rate measure in its published statistics for gross job gains and losses.

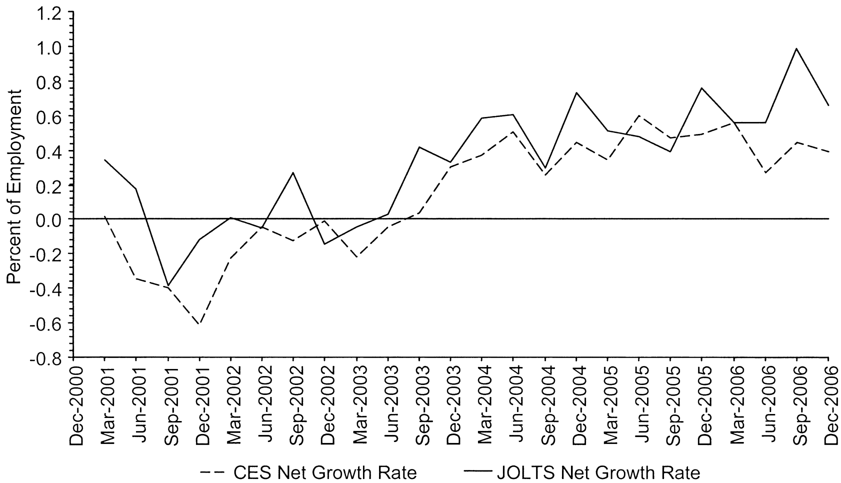


Fig. 5.1 CES and JOLTS employment growth rates compared

Notes: Figure depicts the quarterly net employment growth rates calculated from the JOLTS and CES data. The JOLTS growth rate is measured from the difference in total hires and total separations for each quarter. The CES growth rate is measured from the net change in employment levels between the third month of each quarter. Both rates are calculated using the average of the current and previous quarter's employment in the denominator.

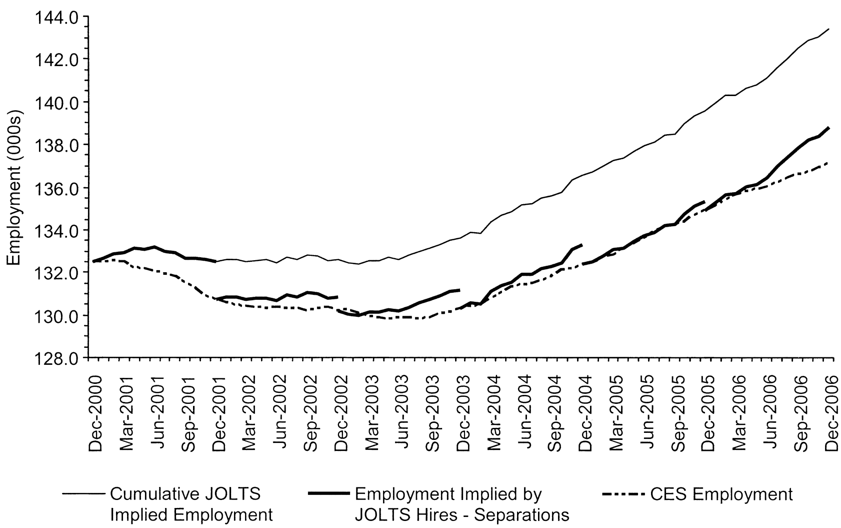


Fig. 5.2 CES employment path compared to cumulated differences between hires and separations in JOLTS

Notes: Figure depicts the employment levels implied from the JOLTS hires and separations data and reported in the CES data. The JOLTS level is reported two ways: as an accumulation of the difference between hires and separations each month (added to the December 2000 total) and as the accumulation over each year of the survey, added to the beginning-of-year employment level.

in the private sector at 3.0 million jobs, or 2.6 percent of December 2006 CES employment.[15]

Figure 5.2 also confirms that the sample weight adjustments that constrain JOLTS employment levels to match CES levels do not ensure consistency of employment changes, as calculated from hires and separations.

Turning to another issue, JOLTS statistics for worker flows are much smaller than comparable statistics produced from other sources. The published JOLTS statistics for hires and separations average about 3.3 percent of employment per month. Monthly hires and separations computed from Current Population Survey (CPS) data on gross worker flows are nearly twice as large, as reported in table 5.1. In addition, monthly analogs to quarterly accessions and separations computed from administrative wage records are at least twice as large as monthly hires and separations in JOLTS (Davis, Faberman, and Haltiwanger 2006). Current Population Survey gross flows and administrative wage records present their own measurement issues, and there are reasons to suspect that both sources overstate worker flows, but the much smaller magnitude of JOLTS worker flows warrants a closer inspection of the underlying data.

Delving into the microdata reveals that the JOLTS sample overweights stable establishments with small employment changes. To develop this point, table 5.2 compares cross-sectional distributions of employment growth rates in JOLTS and BED data. For the BED, table 5.2 summarizes the distribution of quarterly growth rates in the full universe and in a subset restricted to continuous units. A "continuous unit" in, say, the second quarter of 2003 is one with paid employees in both March and June. For JOLTS, the table summarizes three related objects: the distribution of monthly growth rates for all private-sector establishments, the distribution of monthly growth rates for a sample restricted to establishments with employees in all three months of the quarter, and the distribution of quarterly growth rates for the same restricted sample. This restriction yields a JOLTS sample that is directly comparable to the BED subset with continuous units.[16] Note that the full and restricted JOLTS samples yield similar monthly growth rate distributions.

Table 5.2 reports large differences between the BED and JOLTS cross-

15. Wohlford et al. (2003) point to education (mostly in State and Local Government) and temporary help (part of Professional and Business Services) as the main sources of the JOLTS-CES divergence. Using published JOLTS data, we confirm that the employment path implied by JOLTS hires and separations exhibits an especially large divergence from the CES employment path in Professional and Business Services. The cumulative discrepancy for this industry group is 3.6 million jobs, or 20.5 percent of the industry's December 2006 CES employment value. Education, Health, and Leisure and Hospitality also exhibit large cumulative discrepancies in the same direction. There are large cumulative discrepancies in the opposite direction in Construction (1.1 million jobs, 14.8 percent of employment) and Manufacturing (1.1 million jobs, 7.5 percent of employment). In short, several major industry groups show big cumulative discrepancies over the 2001 to 2006 period.

16. Recall that we construct internally consistent measures of lagged employment using current-quarter JOLTS data for hires, separations, and employment. In particular, if an estab-

Table 5.1 **Average monthly worker flows as a percent of employment, 2001–2006**

	Hires rate	Separations rate
JOLTS, published statistics	3.4	3.3
CPS gross flows, Fallick-Fleischman	6.4	6.4

Source: The statistics on Current Population Survey (CPS) gross flows are from Fallick and Fleischman (2004), as updated at http://www.federalreserve.gov/pubs/feds/2004/200434/200434abs.html.

Notes: Table entries report mean monthly rates for hires and separations from January 2001 to December 2006. CPS hires and separations include employment-to-employment flows. JOLTS = Job Openings and Labor Turnover Survey.

Table 5.2 **Cross-sectional growth rate distributions, 2001–2006**

	JOLTS			BED	
	Monthly		Quarterly	Quarterly	
Growth rate interval	Full sample	Restricted sample	Restricted sample	All observations	Continuous observations
–2.0 (exits)				0.7	
(–2.0, –0.20]	1.6	1.5	4.3	7.5	7.6
(–0.20, –0.05]	7.1	7.0	13.2	16.5	16.7
(–0.05, –0.02]	7.9	7.8	9.5	9.6	9.7
(–0.02, 0.0)	14.7	14.6	11.6	7.6	7.8
0.0	33.6	34.1	17.1	15.4	15.7
(0.0, 0.02)	16.5	16.6	13.1	7.9	8.0
[0.02, 0.05)	9.2	9.1	11.7	9.9	10.0
[0.05, 0.20)	7.9	7.8	15.1	16.7	16.9
[0.20, 2.0)	1.6	1.5	4.5	7.5	7.6
2.0 (entrants)				0.7	

Notes: Table entries report employment shares for the indicated establishment growth rate intervals in Job Openings and Labor Turnover Survey (JOLTS) and Business Employment Dynamics (BED) microdata from 2001 to 2006. Calculations on JOLTS data make use of the JOLTS final sample weights described in section 5.2.1. Each column in the table reports results for a different data set or sample. See the text for a detailed explanation of how the data sets and samples differ.

sectional growth rate distributions. For example, 24.8 percent of the mass in the JOLTS restricted sample falls in the open interval from 0 to 5 percent, compared to only 18.0 percent for the BED subset with continuous units. Similarly, 21.1 percent of the mass in the JOLTS restricted sample lies in the

lishment has employees in all three months of the current quarter, we calculate its growth rate using reported employment for the current quarter and the internally consistent measure of previous quarter employment. Thus, the restricted JOLTS sample captures establishments that operate continuously from the last month of the previous quarter to the last month of the current quarter. The JOLTS sample restriction removes 11.2 percent of the observations on a sample-weighted basis and a much smaller percentage when we further weight by size.

open interval from 0 to negative 5 percent, compared to only 17.5 percent for BED continuous units. The excess mass in the interval (–5.0, 5.0) for the restricted JOLTS sample amounts to 11.8 percent of employment relative to the BED subset with continuous units and 12.6 percent relative to the full BED. These results establish two important points: first, the JOLTS sample substantially overweights relatively stable establishments. Second, the overweighting of stable establishments does not arise mainly from the fact that births are out of scope for the JOLTS sample frame. That is, the JOLTS sample substantially overweights stable establishments relative to the BED even when we restrict attention to continuous units.

Figure 5.3 illustrates the first point graphically by comparing smoothed histograms of quarterly growth rate distributions in JOLTS and the BED. It is apparent to the naked eye that the JOLTS sample substantially overweights stable establishments.[17] Stable establishments are likely to have smaller worker flows, a conjecture that we verify in the next section.

5.4 Cross-Sectional Patterns in Worker Flows and Job Openings

Figures 5.4 and 5.5 show how worker flows and job openings vary with employment growth rates in the cross section of establishments. To construct these figures, we pool monthly JOLTS data from 2001 to 2006 for private-sector establishments. We group the roughly 572,000 observations into growth rate bins, calculate employment-weighted mean outcomes in each bin, and plot the resulting relationships. We use narrow bins close to zero (width of 0.001, or 0.1 percent) and progressively wider bins as we move away from zero into thinner parts of the distribution. We also allow for a mass point at 0. Figure 5.4 shows the relationships over the full range of growth rate outcomes, and figure 5.5 zooms in to monthly growth rates from –25 to 25 percent. Figure 5.5 also shows cross-sectional relations for the twelve months with the highest or lowest growth rates of aggregate employment.[18] The pattern for separations, not shown, is closely approximated by the sum of quits and layoffs.[19]

17. The overweighting of stable establishments in figure 5.3 and table 5.2 is not caused by our use of hires and separations to measure previous-period employment when calculating JOLTS-based measures of the employment growth rate. This point can be seen by inspecting figure 5 in Faberman (2005a), which shows that the employment-weighted growth rate distribution in the JOLTS sample is extremely similar whether we compute growth rates using the reported value of lagged employment or the imputed value based on the identity linking employment changes to hires and separations. Figure 5 in Faberman also shows that the JOLTS sample substantially overweights stable establishments relative to the BED for both approaches to the calculation of employment growth rates in the JOLTS sample.

18. When ranking the months by aggregate growth rates, we do not seasonally adjust the data. The unadjusted data have much larger variations in growth over time so are better suited for this exercise.

19. The other separations rate (not shown) rises with the contraction rate from about 0.3 percent of employment per month for mild contractions to 7.4 percent for the largest contractions.

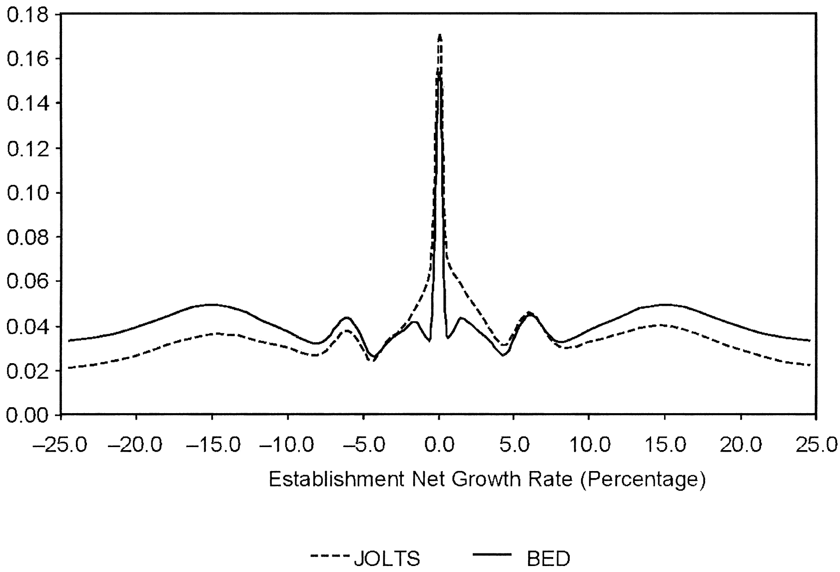


Fig. 5.3 Cross-sectional densities for establishment growth rates, 2001–2006

Notes: The densities are constructed as smoothed histograms of quarterly employment growth rates using establishment-level observations in JOLTS (restricted sample) and BED (all observations) from 2001Q1 to 2006Q4. Histograms are constructed over the full growth rate distribution, but the figure zooms in on growth rates from –25 to 25 percent per quarter. Histogram bins are narrower for smaller growth rates and allow for mass points at growth rates of –2.0 (exit), 0 (no change), and 2.0 (entry).

Figures 5.4 and 5.5 document several key results:

1. Hires dominate the employment adjustment margin for expanding establishments. The hires rate is lowest for establishments with little or no growth, essentially unrelated to growth for contracting establishments, and rises almost linearly with the growth rate for expanding establishments.

2. Separations dominate the adjustment margin for contracting establishments. Quit, layoff, and separation rates are also lowest for establishments with little or no growth, and they rise sharply with the contraction rate.

3. Layoffs dominate the adjustment margin for rapidly contracting establishments.

4. The job openings rate is lowest for stable establishments. It rises in both directions moving away from zero, more so for expanding establishments.

5. The cross-sectional relations are remarkably stable with respect to aggregate employment growth, especially for hires and layoffs. Conditional on establishment growth, quits occur more frequently when aggregate employment grows more rapidly. This cyclical aspect of quit behavior shows up mainly at contracting establishments.

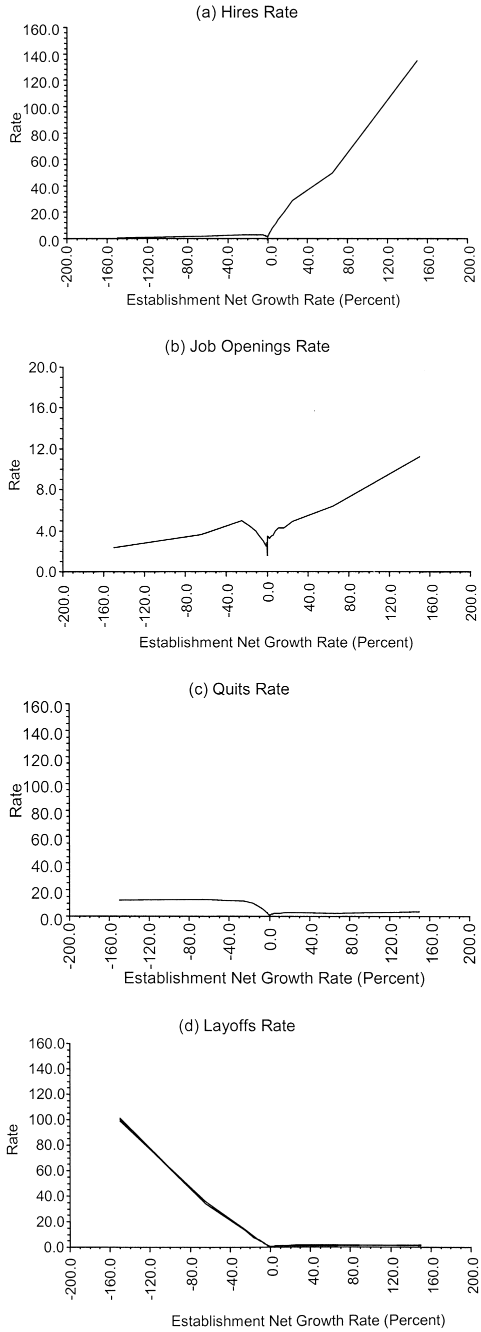


Fig. 5.4 Cross-sectional relationships of worker flows and job openings to establishment growth rates, monthly JOLTS data from 2001 to 2006, full range of growth rates

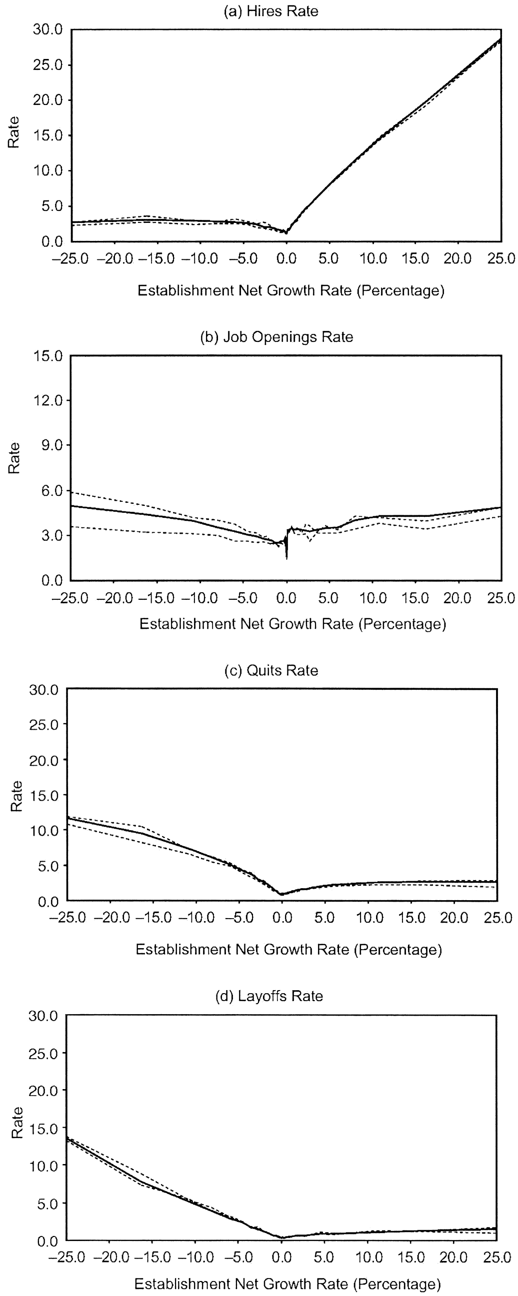


Fig. 5.5 Cross-sectional relationships of worker flows and job openings to establishment growth rates, monthly JOLTS data from 2001 to 2006, zoomed in on growth rates from –25 and 25 percent

Notes: Thick lines are constructed from the full 2001 to 2006 sample. Thin lines are constructed from samples restricted to the twelve months with the highest or lowest growth rate of aggregate employment. The upper thin lines typically correspond to the high-growth sample.

These results have important implications for JOLTS-based estimates of worker flows and job openings.[20] It is evident from figures 5.4 and 5.5 that the overweighting of stable establishments in the JOLTS sample imparts a downward bias in estimated hires, separations, quits, layoffs, and job openings. Less obviously, the bias is likely to vary systematically with aggregate employment growth. To see this point, consider the layoff rate and recall our earlier discussion of nonresponse adjustments in the JOLTS program. Suppose that nonresponse rates are higher among rapidly contracting establishments. Because rapidly contracting establishments are more prevalent in downturns, higher nonresponse rates among these establishments also has a greater effect on the estimated aggregate layoff rate in downturns. In other words, the published JOLTS statistics understate the amplitude of cyclical fluctuations in the layoff rate.

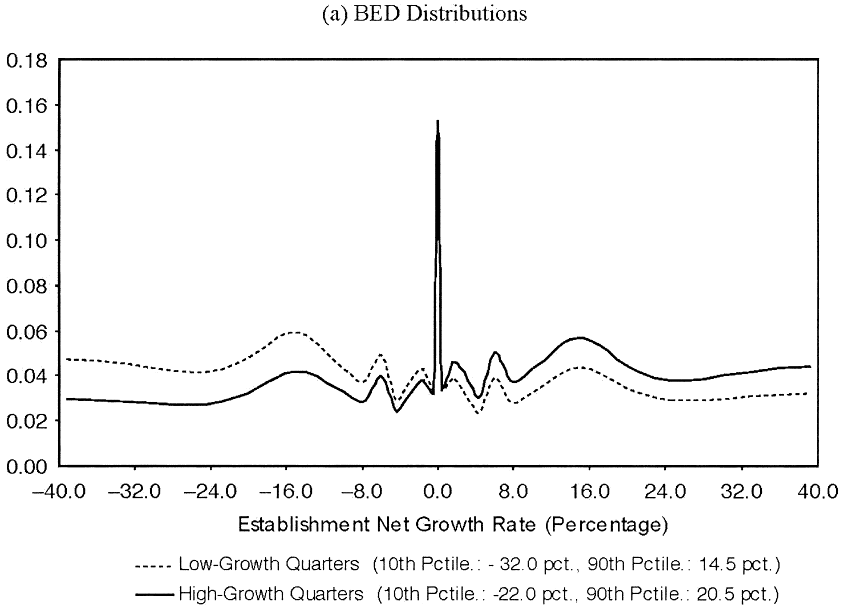
Figure 5.6 confirms a key element of this cyclical bias story. As in figure 5.3, figure 5.6 shows smoothed histograms of quarterly establishment growth rates using JOLTS and BED data. However, we now plot separate histograms for quarters with high and low growth in aggregate employment. Figure 5.6 shows that the overweighting of stable establishments in the JOLTS sample is more serious in downturns, that is, quarters with low aggregate growth. The BED-JOLTS difference in the 90-10 growth rate differential is 18.0 percentage points in high-growth quarters as compared to 20.3 percentage points in low-growth quarters. Moreover, the cyclical variation in the BED-JOLTS discrepancy is concentrated among contracting establishments: the BED-JOLTS difference in the 50-10 growth rate differential rises from 10.5 percentage points in high-growth quarters to 15.0 percentage points in low-growth quarters. This cyclical pattern in the BED-JOLTS discrepancy, coupled with the cross-sectional layoff relation shown in figures 5.4 and 5.5, implies that JOLTS understates the amplitude of aggregate layoff fluctuations.

Figures 5.4 and 5.5 also suggest a constructive approach to adjusting JOLTS-based estimates of worker flows and job openings. In particular, if we use the universe data in the BED to obtain the distribution of establishment growth rates, we can apply the cross-sectional relationships in figures 5.4 and 5.5 to obtain more accurate estimates for worker flows and job openings. The next section of the chapter formalizes this idea and sets forth the details.

5.5 A Method for Adjusting the Published JOLTS Estimates

Partition the range of establishment growth rates into bins indexed by b, allowing for mass points at –2 (exits), 0 (no change), and 2 (entry). Let

20. In related work (Davis, Faberman, and Haltiwanger 2006), we argue that the cross-sectional relations in figures 5.4 and 5.5 also have important implications for the cyclical behavior of unemployment.



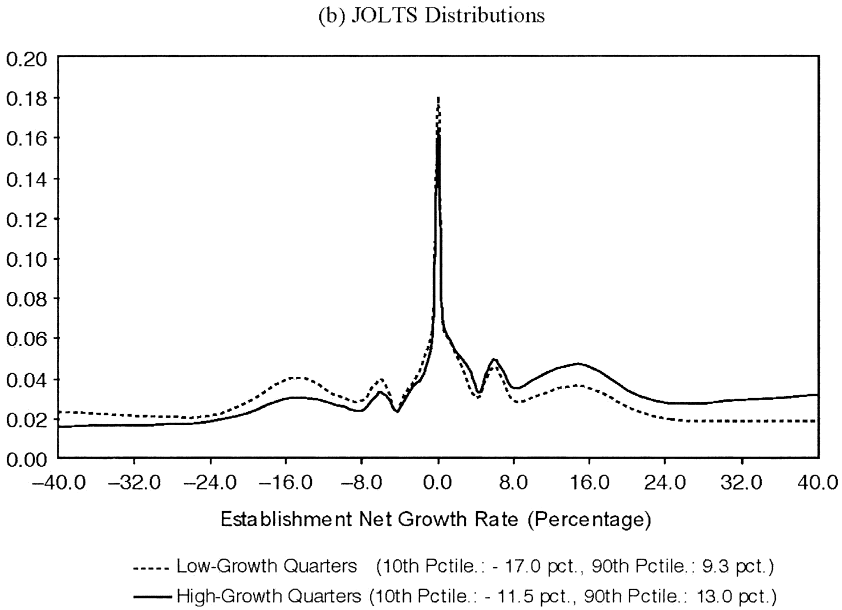


Fig. 5.6 Quarterly growth rate distributions in high- and low-growth quarters, JOLTS and BED data

Notes: Figures depict employment densities at establishments with quarterly growth rates within a given interval in the BED (top panel) and a restricted panel of JOLTS data (bottom panel; see text for details of restriction) for 2001Q1 to 2006Q4. The distributions are split into the six quarters of highest growth and six quarters of lowest growth, based on their seasonally unadjusted aggregate growth rates in the BED. Vertical lines represent the growth rates at the 10th (shaded lines) and 90th (dashed lines) percentiles of the distribution, with the leftmost of each pair associated with each low-growth distribution.

$f_m(b)$ be the month m share of employment for establishments with growth rates in bin b, and let $x_m(b)$ denote the employment-weighted mean rate of hires, separations, layoffs, quits, or job openings for the bin. Express the corresponding month m aggregate rate as

$$X_m = \sum_b x_m(b) f_m(b). \tag{2}$$

Sections 5.3 and 5.4 show that the JOLTS sample is not representative with respect to the $f_m(b)$ values. As a result, the current JOLTS program yields biased estimates for the estimated X_m values, that is, for published statistics on worker flows and job openings. We address this problem by relying on the BED to adjust the JOLTS $f_m(b)$ values. We then combine the adjusted $f_m(b)$ weights with JOLTS estimates for the $x_m(b)$ values, that is, the bin-specific rates of worker flows and job openings. We rely on other information for the x_m (exit) and x_m (entry) values, which the JOLTS sample does not provide.

In principle, this approach to adjusting JOLTS-based statistics on worker flows and job openings is easy to implement. The main complication in practice arises from the need to use *quarterly* BED data to adjust the *monthly* growth rate distributions in the JOLTS data. Readers who are uninterested in the details of this mapping between BED and JOLTS data can safely skip section 5.5.1 and resume the text in section 5.5.2.

5.5.1 Adjusting the JOLTS Monthly Growth Rate Distributions

Some additional notation will be helpful. It will also be useful in this section to distinguish between quarters, indexed by t, and months, indexed by m. Let $f_t^B(b)$ be the employment density of continuous BED establishments with quarter-t growth rates in bin b. Let $f_t^J(b)$ be the employment density of establishments with a quarter-t growth rate in bin b, using the restricted JOLTS sample with three monthly observations in quarter t. Finally, let $f_{m,t}^J(b)$ be the employment density of establishments with a monthly growth rate in bin b during month m of quarter t in the restricted JOLTS sample. We use narrow growth rate bins near zero (width of 0.25 percent), progressively wider bins as we move away from zero to thinner parts of the distribution, and allow for mass points at –2, 0, and 2. The resulting partition involves thirty-seven bins, although the JOLTS restricted sample and the continuous BED data contain no observations in the entry and exit bins.

After allocating the data to growth rate bins, the next step is to map the quarterly growth rate densities for BED data to consistent monthly growth rate densities. We use JOLTS data to model the mapping from quarterly to monthly densities, and we then apply the fitted mapping to obtain estimated monthly BED growth rate densities. After some experimentation with parametric and nonparametric methods, we settled on a simple regression model. Specifically, for each bin b, we fit a regression of the form

(3) $$f^J_{m,t}(b) = \alpha(b) + \sum_{n \in \mathrm{Top}N(b)} \beta_n(b) f^J_t(b) + \varepsilon_{m,t}(b)$$

to seventy-two monthly observations from 2001 to 2006, where $\alpha(b)$ is a bin-specific constant, the $f^J_t(b)$ are quarterly densities, $\beta_n(b)$ is a regression coefficient that varies across five groupings of growth rate bins (two to the left of zero, two to the right of zero, and one that includes only zero), $\varepsilon_{m,t}(b)$ is an error term, and Top$N(b)$ is a set of N quarterly growth rate bins that varies with b.[21]

To select the bins in Top$N(b)$, we compute the mapping from quarterly growth rate bins to monthly growth rate bins in JOLTS data pooled over the entire sample from 2001 to 2006. For each monthly bin b in the pooled sample, this mapping gives the fraction of mass derived from the quarterly bins. We then identify the N quarterly bins that contribute the most mass to monthly bin b to form the set Top$N(b)$ for that b. We use $N = 5$ in our reported results but obtained similar results for values up to $N = 10$.[22]

Next, we construct three monthly counterparts for each quarterly BED density by substituting the BED density values into the right side of equation (3) along with estimated parameters in the ordinary least squares (OLS) regressions (3) fit to JOLTS data. These substitutions yield

(4) $$\tilde{f}_{m,t}(b) = \hat{\alpha}(b) + \sum_{n \in \mathrm{Top}N(b)} \hat{\beta}_n(b) f^B_t(b),$$

which, after rescaling to ensure that the adjusted densities sum to 1, is our mapping from quarterly BED densities for continuous units to the corresponding monthly densities.

As a final step, we append entry and exit mass points to the estimated monthly distributions. We take a simple approach and set the monthly entry and exit rates to one-third of their values in the full BED distribution for the quarter. This approach involves two assumptions: first, that entry and exit rates are constant during the quarter and, second, that establishments do not enter and exit in the same quarter. One could relax these assumptions and improve upon this approach, but they are adequate for present purposes.

In a slight abuse of notation given our previous definition of $f^B_t(b)$, let f^B_t(entry) and f^B_t(exit) denote the entry and exit mass point values in the full BED for quarter t. Then we can write the estimated monthly growth rate densities as follows:

21. Allowing the β coefficients to vary by individual growth rate bin yields noisy estimates because of sparsely populated bins, particularly at the tails of the growth rate distribution. After some experimentation, we set the boundary for the two bins to the left and to the right of zero at $\pm$ 9 percent.

22. The choice of N has little effect on the magnitude or time series volatility of our adjusted worker flow rates and vacancy rates. However, alternative choices of N imply different paths for cumulative employment growth over the six-year sample period. The choice of $N = 5$ minimizes the absolute difference of cumulative employment growth between the adjusted JOLTS figures and the BED.

$$(5)\qquad \hat{f}_{m,t}(\text{entry}) = \frac{f_t^B(\text{entry})}{3} \quad \text{and} \quad \hat{f}_{m,t}(\text{exit}) = \frac{f_t^B(\text{exit})}{3}; \quad \text{and}$$

$$\hat{f}_{m,t}(b) = \left[1 - \frac{f_t^B(\text{entry})}{3} - \frac{f_t^B(\text{exit})}{3}\right]\tilde{f}_{m,t}(b), \text{ otherwise.}$$

These equations describe our mapping from the BED growth rate distribution for quarter t to the corresponding monthly distributions.

Our method for obtaining equation (5) does not capture time variation in the monthly densities within a quarter. To address this shortcoming, one could estimate a richer regression specification (3) with covariates that capture within-quarter movements in the shape and location of the aggregate employment growth rate density. This approach could be implemented with any data source that provides monthly observations on the distribution of employment growth rates. We leave such refinements for future work.

5.5.2 Calculating the Adjusted Estimates

Henceforth, we suppress the quarterly index t except when needed for clarity. To calculate adjusted rates for worker flows and job openings, we apply equation (2) by combining the $\hat{f}_m(b)$ values in equation (5) with JOLTS-based estimates for the $x_m(b)$. For continuous units, we estimate the $x_m(b)$ values using the bin-specific employment-weighted mean rates for worker flows and job openings in month m, which we denote by $\hat{x}_m(b)$.

The JOLTS data do not provide estimates for worker flows and job openings in the entry and exit bins. For these bins, we use the values in table 5.3.

We obtain these values as follows. For exits, we assume no job openings or hires in the exit month, and we set quits and other separations to their average rates in the bin with the most rapidly contracting continuous establishments. These assumptions yield the values reported in the second row. For entrants, we assume no separations in the entry month, which implies a hires rate of 2. This assumption is conservative in the sense that understates the level of worker flows at entrants. There are two sources of job openings not captured by the JOLTS sample design. First, some entrants have job openings at the end of their first month in operation. Second, new employers seek workers before they begin operations. For the first source, we use the end-of-month vacancy rate in the bin with the most rapidly growing continuous establishments, scaled to match the hires-to-vacancies ratio and the amount of hiring in excess of growth in the bin. This source yields a vacancy rate equal to 17.4 percent. For the second source, we set (beginning-of-month) vacancies to the lagged vacancy rate in the bin with the fastest-growing continuing establishments, again scaling for the hires-vacancy ratio and hiring in excess of growth. This source yields a vacancy rate of 20.8

Table 5.3 **Rates for entry and exit bins**

Bin	Hires	Quits	Layoffs	Other separations	Job openings
b = entry	2	0	0	0	0.382
b = exit	0	0.124	1.802	0.074	0

percent. Summing these two sources yields the figure for job openings in the top row.[23]

As a final step, we make an adjustment for sampling variability in our bin-specific estimates. Sampling variability is a significant concern in the tails of the growth rate distribution over continuous establishments. For example, the (–2.0, –1.0) and (1.0, 2.0) bins are quite wide, yet very few establishments in the JOLTS sample fall into these bins in a given month. In such cases, the bin-specific estimates can vary widely within a wide interval based on realized outcomes at very few establishments. To address this issue, we adjust the within-bin means for all but the zero bin (which is a mass point and, thus, immune to this form of variability) so that the implied difference between hires and separations equals the mean growth rate for the same bin in the BED. The appendix provides details.

Putting the pieces together, our adjusted estimates for worker flows and job openings in month m are given

$$\hat{X}_m = \sum_b a_m(b)\hat{x}_m(b)\hat{f}_m(b), \tag{6}$$

where the $\hat{f}_m(b)$ are the mass values in the reweighted monthly growth rate density given by equation (5), the $\hat{x}_m(b)$ are the JOLTS-based bin-specific means for worker flows and job openings, and the $a_m(b)$ are the adjustments for sampling variability. We seasonally adjust the estimated $\hat{X}_m(b)$ using the Census X-12 technique.

5.6 Adjusted Statistics for Hires, Layoffs, Quits, and Job Openings

Table 5.4 reports adjusted estimates for worker flows and job openings in the U.S. private sector and compares them to published JOLTS statistics. The adjusted worker flows are much larger than the published estimates. Hires and separations are about 5 percent of employment per month according to the adjusted estimates, as compared to 3.7 or 3.8 percent in the published statistics. The adjusted layoff rate, at 2.3 percent of employment per month,

23. This discussion suggests that the JOLTS program would benefit from retrospective questions about preentry job openings for new establishments. A similar point applies to other establishment surveys that seek to capture activities that are correlated with entry. For example, it would be helpful to add retrospective questions about initial investments for entrants in the Annual Capital Expenditures Survey.

Table 5.4 **JOLTS summary statistics, published and adjusted statistics**

	Published statistics	Adjusted statistics
Monthly means (monthly and quarterly standard deviations)		
Hires rate (H)	3.78	4.99
	(0.25, 0.23)	(0.17, 0.16)
Separations rate (S)	3.70	4.96
	(0.18, 0.16)	(0.21, 0.20)
Quits rate (Q)	2.06	2.36
	(0.17, 0.17)	(0.17, 0.15)
Layoffs and discharges rate (L)	1.40	2.29
	(0.09, 0.07)	(0.16, 0.15)
Other separations rate (R)	0.24	0.31
	(0.03, 0.02)	(0.07, 0.05)
Job openings rate (V)	2.71	2.94
	(0.39, 0.38)	(0.36, 0.34)
Unemployment rate (U)	5.29	
	(0.57, 0.58)	
Quarterly relative volatilities		
$\sigma(H)/\sigma(S)$	1.47	0.80
$\sigma(Q)/\sigma(L)$	2.35	1.00
$\sigma(H)/\sigma(V)$	0.61	0.47
$\sigma(V)/\sigma(U)$	0.66	0.59

Notes: Table lists the noted monthly statistics from the publicly available Job Openings and Labor Turnover Survey (JOLTS) estimates and the adjusted estimates (see text for details). Standard deviations of the monthly data, followed by the quarterly means of the monthly data (or third-month values in the case of the vacancy and unemployment rate), are in parentheses below each mean. Relative volatilities are the ratios of the quarterly standard deviations of the listed estimates. The period covers January 2001 to December 2006. The unemployment rate comes from the Current Population Survey.

is nearly two-thirds greater than the published layoff rate.[24] Our adjustments also lead to a higher quit rate. The adjusted job openings rate is 2.9 percent of employment per month compared to 2.7 percent for the published rate. Clearly, reweighting the cross-sectional growth rate density to conform to the BED, and capturing the role of entry and exit has a major impact on the estimated levels of worker flows and job openings.

Table 5.4 also shows that the adjustments substantially alter the time series properties of JOLTS statistics.[25] Focusing on quarterly data, the adjustments lower the variability of hires by about one-third, roughly double the

24. To understand the large upward adjustment in the layoff rate, recall that layoffs are disproportionately concentrated in establishments that exit or contract sharply (figures 5.4 and 5.5). These establishments are heavily underweighted in the JOLTS sample, as documented in table 5.2.

25. Given the limitations of our data and methods, we think our adjustments produce more reliable evidence for quarterly than for monthly fluctuations. For this reason, table 5.3 reports standard deviations of monthly and quarterly values, and the lower panel focuses on volatility statistics in quarterly data. However, the upper panel suggests that the choice between quarterly and monthly data matters little in this regard.

variability of layoffs and modestly reduce the variability of job openings. The quarterly standard deviation of hires is 47 percent greater than that of separations in the published data but 20 percent smaller in the adjusted data. Quits are more than twice as variable as layoffs in the published data but equally variable in the adjusted data.[26] The relative volatility of hires to job openings declines by about one-quarter. The relative volatility of job openings to unemployment, a statistic that receives much attention in the search and matching literature, declines by about 10 percent.[27]

Figure 5.7 shows that sizable level differences between published and adjusted estimates persist throughout the 2001 to 2006 period. The decline in the layoff rate after the middle of 2003 is noticeably larger in the adjusted data. Figure 5.8 shows that adjusted quits exceed layoffs in the relatively strong labor market of 2005 and 2006 but are otherwise very similar in magnitude.

As we remarked in the preceding, the cumulative employment growth implied by the flow of hires and separations in JOLTS exceeds employment growth in the CES and the BED. Our adjustments largely eliminate this discrepancy. The published JOLTS statistics imply an average monthly growth rate of 0.08 percent for private-sector employment. The corresponding growth rate in the CES is about 0.04 percent and the monthly analog of the BED growth rate is 0.03 percent. Our adjusted estimates imply a mean growth rate of 0.03 percent. This is in line with the monthly BED growth rate, the appropriate comparison because it is the rate our adjustment is constructed to reproduce. It is also quite close to the CES growth rate.

5.7 Concluding Remarks

JOLTS data are a valuable resource for understanding labor market dynamics and for evaluating theories of unemployment and worker turnover. They also present measurement issues that are not well understood or fully appreciated. A key point is that the JOLTS sample overweights relatively stable establishments with low rates of hires and separations and underweights establishments with rapid growth or contraction. The unrepresentative nature of the JOLTS sample with respect to the cross-sectional density of employment growth rates matters because hires, quits, layoffs, and job openings vary greatly with establishment growth rates in the cross section. As a result, the current JOLTS program produces downwardly biased estimates for worker flows and job openings. The extent of bias varies systematically with the growth rate of aggregate employment.

26. A careful inspection of figure 5.5 suggests that the impact of our adjustments on the relative volatility of hires and separations, or quits and layoffs, would be somewhat smaller if we extended the regression specification (3) to capture time variation in the cross-sectional relations.

27. For example, see Shimer (2005), Gertler and Trigari (2005), and Hagedorn and Manovskii (2007).

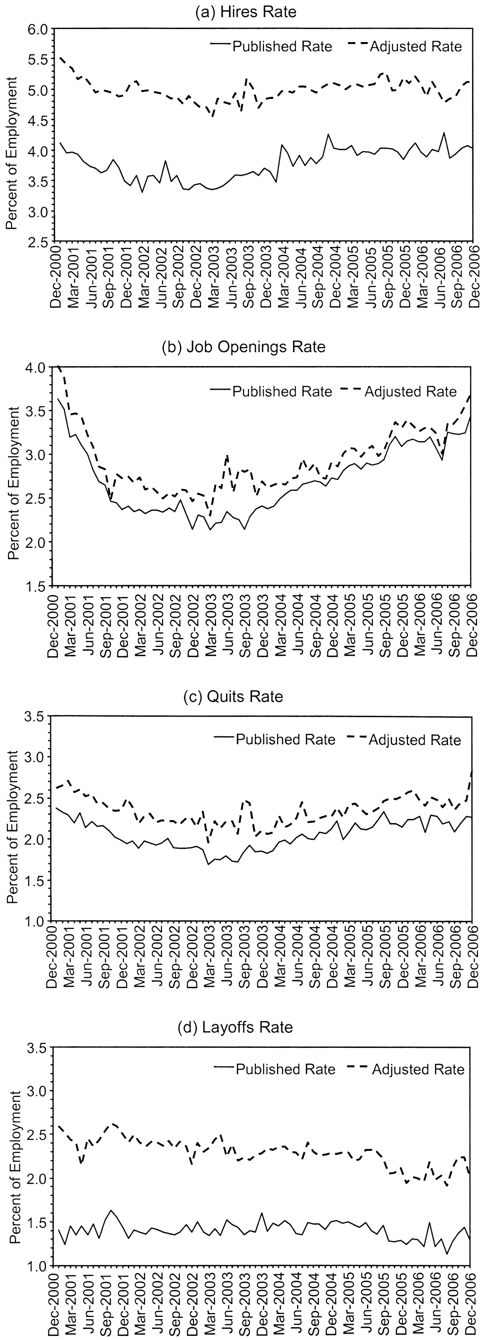


Fig. 5.7 Adjusted and published estimates of JOLTS worker flows and job openings

Notes: Each panel illustrates a worker flow or job openings rate, seasonally adjusted, from the published JOLTS statistics (dashed line) and our adjusted estimates (solid line). See text for details of the adjustment.

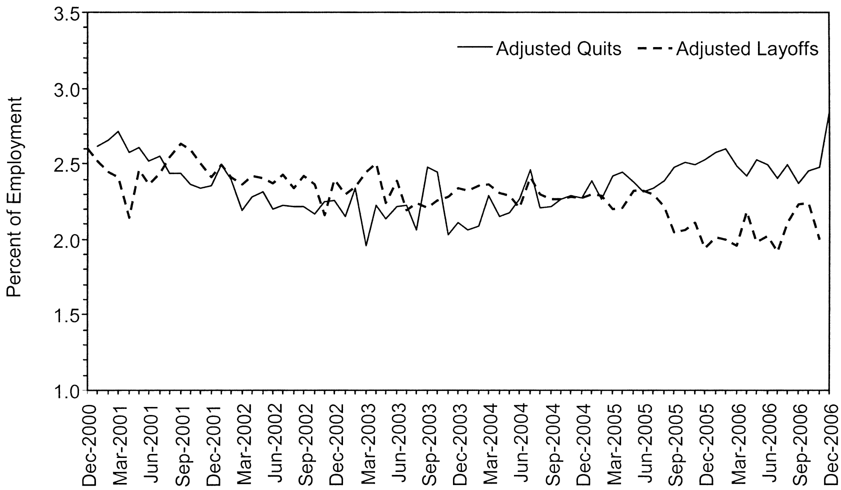


Fig. 5.8 Adjusted quit and layoff rates, JOLTS data

Notes: The figure illustrates the quit rate and layoff rate, seasonally adjusted, from our adjusted estimates. See text for details of the adjustment.

We develop and implement an adjustment method to address these issues. Our method reweights the cross-sectional density of employment *growth rates* in JOLTS to match the corresponding density in comprehensive BED data. In addition, our method supplements JOLTS data on worker flows and job openings at continuing establishments with estimates for worker flows and job openings at entering and exiting establishments. Our adjustments have a large effect on JOLTS-based estimates. Adjusted hires and separations exceed the published statistics by about one-third. Layoffs are much larger and much more variable in the adjusted statistics, and they account for a bigger share of separations.

There are several steps that the BLS can undertake to improve the JOLTS sample and JOLTS-based statistics. First, as part of a regular program to monitor the JOLTS sample, the BLS should compare the cross-sectional densities of employment growth rates in JOLTS data to the corresponding densities in the BED or other comprehensive source. Because of lags in the availability of administrative records that feed into the BED, it is not feasible to reweight the JOLTS density to conform to the BED as part of a real-time monthly production process. It is feasible to reweight the JOLTS density to conform to the growth rate distribution in the monthly CES, as adjusted for systematic differences between the CES and comprehensive sources in historical data.

Second, the BLS should explicitly incorporate adjustments for worker flows and job openings at establishments that are outside the JOLTS sample frame. The BLS already models the effects of entry and exit in its CES employment estimates. Adapting and extending BLS models to capture the effects of entry and exit on hires, separations, and job openings is entirely feasible using information available from JOLTS, BED, and CES data. It would also be useful to conduct special surveys with retrospective questions about worker flows and job openings at new establishments, including questions about the number of job openings before an entrant began operations. Information obtained from this type of survey would provide a strong basis for imputing worker flows and job openings to new establishments as part of a monthly production process.

Third, the BLS should investigate the potential payoff from sample stratification on establishment age and from corrections for the exclusion of very young establishments from the JOLTS sample frame. As discussed in the introduction, young establishments have unusually high worker flows, even after conditioning on establishment size. Our adjustment method does not directly address this source of downward bias in JOLTS-based estimates for hires and separations.[28] We suspect that very limited sample stratification on establishment age and simple corrections for the exclusion of very young establishments would go a long way to address this source of bias because hires and separations decline very rapidly with establishment age initially but then flatten out. Here as well, special surveys could provide a reliable basis for imputing worker flows and job openings to young establishments that are underweighted or excluded from the JOLTS sample frame.

Fourth, the BLS should carefully investigate how the unit nonresponse rate varies with the establishment growth rate in the JOLTS sample. In this regard, it is essential to evaluate the nonresponse rate throughout the entire distribution of growth rates. Suppose, for example, that the response rate is very high, on average, but is smaller in certain parts of the growth rate distribution. This type of nonresponse pattern leads to biased estimates for aggregate worker flows and job openings because these measures vary greatly with establishment growth rates in the cross section. Determining whether, and how, the unit nonresponse rate varies with the establishment growth rate is a straightforward exercise. It can be carried out by matching JOLTS micro data to data from the BED or other comprehensive source and then directly computing nonresponse rates as a function of the establishment growth rate. Having obtained this function, it would be a simple matter to adjust JOLTS-based estimates of worker flows and job openings for unit nonresponse rates that vary with the establishment growth rate.

Another potential issue in JOLTS data is respondent error—the propensity of establishments to misreport their true number of hires, separations, or job openings to the BLS. Wohlford et al. (2003) and Faberman (2005a)

28. Our adjustment method relies on JOLTS data to provide unbiased estimates for $\hat{x}(b)$ in equation (6). However, the underweighting of younger establishments in JOLTS data imparts a downward bias to the $\hat{x}(b)$ estimates.

express concerns about respondent error as a source of bias in JOLTS-based statistics. The methods we develop in this paper do not address respondent error. Thus, this chapter should be viewed as part of a broader effort to better understand and improve JOLTS-based statistics.

While measurement issues are our main focus in this chapter, our findings have implications for the broader study of labor market dynamics. In this regard, some authors have interpreted data on the relative volatility of separations and hires as favoring a hires-driven view of recession (Hall 2005; Shimer 2007b). We find that using a representative growth rate distribution to estimate worker flows substantially increases the variability of separations relative to hires—so much so that separations are more variable than hires according to our adjusted estimates.

The adjustment method we introduce in this chapter is potentially useful in other settings as well, and these settings are relatively easy to identify. In particular, when the outcome measure of interest varies with micro growth rates in the cross section, it is important to evaluate whether the sample produces a representative cross-sectional growth rate distribution. If the sample is not representative in this respect, and if the outcome variable varies systematically with growth rates in the cross section, then sample means of the outcome variable are biased. That is the essence of the problem in the JOLTS sample that we consider in this chapter. Analogous problems potentially arise in surveys of capital investment and disinvestment because investment outcomes differ systematically between declining and growing businesses.

Finally, we note that our adjustment method can be applied to "backcast" worker flows and job openings before the period covered by the JOLTS sample. In particular, one could combine historical data on the cross-sectional distribution of establishment growth rates from the CES, BED, or other source with JOLTS-based data on the cross-sectional relations displayed in figures 5.4 and 5.5 to construct historical time series for worker flows and job openings. Such an endeavor would greatly expand the time series dimension of data available for the study of labor market dynamics.

Appendix

Calculating Quarterly Flows and Growth Rates

In comparing JOLTS and BED data in table 5.2 and figures 5.3 and 5.6, we need a consistent measure of quarterly growth rates. There is an issue of how to measure quarterly growth rates in the JOLTS data because JOLTS sample weights change from month to month. To deal with this issue, we measure quarterly flows as the sum of weighted monthly values divided by the weight for the last month in the quarter:

$$x_t = \frac{\theta_{m,t}x_{m,t} + \theta_{m-1,t}x_{m-1,t} + \theta_{m-2,t}x_{m-2,t}}{\theta_{m,t}},$$

where x_t is the quarterly rate for quarter t, $x_{m,t}$ is the monthly rate for month m in quarter t, $\theta_{m,t}$ is the weight for month m in quarter t, and we have suppressed the index for establishments. When computing the internally consistent measure of lagged quarterly employment analogous to equation (1) in the main text, we use the level of employment in the last month of the quarter together with the quarterly measures of hires and separations defined in the preceding.

Adjusting the Bin-Specific Estimates for Sampling Variability

The sampling-variability adjustment factor for the estimate $\hat{x}_{m,t}(b)$ is given by

$$a_{m,t}(b) = \frac{n_t^B(b)}{[h_{m,t}(b) - s_{m,t}(b)]},$$

where $n_t^B(b)$ is the mean net growth rate for bin b in quarter t in the BED data, and h and s denote rates of hires and separations, respectively, in the JOLTS data. This adjustment factor constrains the resulting mean net growth rate in bin b in the adjusted JOLTS data to equal the mean net growth rate in the corresponding bin in the BED data. It would be better to impose this constraint using CES rather than BED data; however, the CES micro data were not available to us for this project.

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Comment Robert E. Hall

Though this chapter presents itself as a technical treatise on correcting some serious biases in the Job Openings and Labor Turnover Survey (JOLTS), it actually has important lessons for labor mobility and aggregate labor-market fluctuations. I've learned a lot over the years from the Davis-Haltiwanger team and appreciate the relentless pressure that they, especially Steve, have applied to me to correct my ways.

In this literature, there is something called the "hiring-driven view." According to this view, firms adjust employment mainly by varying their hiring rates. Separation rates are constant. Research on JOLTS has voided this view, which never had any factual support and is not an intrinsic part of the Hall-Shimer position on aggregate fluctuations. The hiring-driven view is an incorrect extrapolation from the correct proposition that separations, in the aggregate, are close to a constant fraction of employment.

The team's work with JOLTS demonstrates a simple proposition: firms raise employment by increasing hiring and cut employment by increasing layoffs or other separations. The micro relation between employment growth and hires has a beautiful kink right at zero—see panel A of figure 5.4 in the chapter. The layoff rate has a similar kink (panel D of figure 5.4). Interestingly, the quit rate also has a kink (panel C of figure 5.4). Workers figure out that it is time to quit when firms downsize or their employers take actions that make them decide to quit.

I have a particular interest in aggregate fluctuations. Now that I'm fully indoctrinated by the Davis-Haltiwanger team, my view is that aggregate fluctuations have little effect on the separation rate and large effects on the job-finding rate. This view is validated by this chapter and the body of Davis-Haltiwanger research.

Panel D of figure 5.7 shows the layoff rate in the corrected JOLTS. It shows no particular bulge during the large decline in employment in the recession that began in early 2001. There is a small spike associated with 9/11. The explanation for the large role of layoffs in contractions at the firm level and the complete unimportance of layoffs in aggregate contractions is simple: aggregate employment contractions are tiny, in the range of

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