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Adjusted Estimates of Worker Flows and Job Openings in JOLTS

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Abstract
We develop and implement a method for adjusting the 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. To motivate our adjustments, we compare JOLTS data to other sources and document large differences with respect to aggregate employment growth, the cross-sectional density of establishment growth rates, and the magnitude of worker flows. We also discuss some concerns with the JOLTS methodology related to sample design and imputation practices.

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I. 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. Separations are broken down into quits, layoffs and discharges, and other separations. Recognizing its innovative features, researchers have seized on the JOLTS data as a valuable source of insights about U.S. labor markets. Recent research relies on JOLTS data to study the cyclical behavior of hires and separations, the Beveridge curve relationship between unemployment and job vacancies, and the relationship among vacancies, hires and employment growth at the establishment level.[1]

In addition to its notable virtues, there are some measurement issues for the JOLTS sample and estimates that are imperfectly understood and not widely appreciated. These measurement issues become transparent when one compares estimates from JOLTS to three types of other data sources. First, the employment growth implied by the flow of hires and separations in JOLTS consistently exceeds the growth observed in its national benchmark, the Current Establishment Survey (CES).[2] Cumulating the difference between hires and separations from 2001 to 2006 yields a discrepancy of 6.6 million jobs. Second, the rates of hires and separations in JOLTS are surprisingly small compared to similar measures in other data sources.[3] Third, the cross-sectional density of

[1] Hall (2005) relies partly on JOLTS data to study the cyclical behavior of hires and separations. Valetta (2005), Fujita and Ramey (2007) and Shimer (2007b) use JOLTS data to study the Beveridge Curve. Davis, Faberman and Haltiwanger (2006, 2007) and Faberman and Nagypál (2007) use JOLTS data to study the relationship among hires, vacancies and employment growth at the establishment level.
[2] See Wolford et al. (2003), Nagypál (2006) and Faberman (2005a).
[3] See Faberman (2005a) and Davis, Faberman and Haltiwanger (2006).

establishment growth rates shows much less dispersion in JOLTS than in otherwise comparable data sources with comprehensive establishment coverage.[4]

These patterns arise, at least in part, from two aspects of the methodology for producing the published JOLTS estimates. First, the JOLTS sample excludes establishment openings and very young establishments. This is a standard limitation of many establishment survey samples, but likely has a larger impact in this setting because employees at new establishments have very short job tenures, which, in turn, are associated with very high separation rates.[5] The volatility of employment growth rates is also extremely high at very young establishments, even after conditioning on size.[6] Greater volatility at the establishment level involves larger worker flows, as we show below. In addition to these effects on worker flows, new establishments surely account for a disproportionate share of job openings. Hence, the exclusion of new and very young establishments leads to an understatement of both job openings and employee turnover. It may affect cyclical patterns as well.

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

[4] See Faberman (2005a).
[5] See, for example, Mincer and Jovanovic (1981), Topel and Ward (1992), and Farber (1994).
[6] See Davis and Haltiwanger (1999) and Davis, Haltiwanger et al. (2007).

bias to the employment change implied by the flow of hires and separations. Again, there is clearly a potential impact on estimated cyclical patterns as well.

In this paper, we take a constructive approach to addressing these measurement issues by developing and implementing a method for adjusting the JOLTS estimates in a way that more accurately reflect worker turnover and job openings in the U.S. economy. We take as given that the JOLTS accurately represents aggregate employment *levels*, but because of the reasons we outline, not employment dynamics. 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 and includes entrants, exits and very young establishments. We apply the reweighted density of employment growth rates to calculate adjusted estimates for worker turnover and unfilled job openings. 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 worker turnover exceed the published JOLTS estimates by about one-third. The adjustment is particularly large for layoffs. In addition, the volatility of layoffs doubles, while the volatility of hires declines, making separations relatively more volatile than hires in the adjusted data. The reverse is true in the published statistics. The adjustments also remove the overstatement of growth implied by the cumulative difference of hires and separations relative to the CES employment change, but instead now understate growth relative to the CES – we hope to

[7] For evidence, see Davis, Faberman and Haltiwanger (2006, 2007) and Section III below.

understand this overstatement better in future work. The adjustment produces only a marginal change to the job openings rate, and leaves its volatility essentially unchanged.

The next section reviews certain aspects of the JOLTS survey, sample design, imputation practices and benchmarking methods. Section III compares several aspects of JOLTS data to other data sources and documents several large discrepancies. Section IV presents some striking patterns in the cross-sectional relationships of worker flows and job openings to employment growth. These cross-sectional relationships play an important role in our adjustment method. They also shed new light on the cyclical behavior of hires and separations. Section V sets forth our adjustment method and explains how we handle issues that arise in the implementation. Section VI presents our adjusted figures for worker flows and job openings and compares them to the published JOLTS estimates. We wrap up in Section VII with remarks about the broader implications of our results and additional suggestions for improving JOLTS statistics.

II. Data

II.A. The Job Openings and Labor Turnover Survey

We use data from two sources: the Job Openings and Labor Turnover Survey (JOLTS) and the Business Employment Dynamics (BED) data, both produced by the BLS.[8] The aggregate JOLTS estimates are the main focus of the paper. These estimates come from a sample of roughly 16,000 establishments. Each month, the BLS asks these establishments to report their employment, hires, separations and job openings. Employment is reported for the week including the 12th of the month. Hires and

[8] For more about the data see Clark and Hyson (2001) and Faberman (2005b) for the JOLTS and Spletzer et al. (2004) for the BED.

separations are reported as totals for the entire month, so one can consider them as flow measures of these statistics. Establishments are asked to report their separations in separate categories of quits, layoffs and discharges, and other separations (e.g., retirements). Job openings (i.e., vacancies) are reported as the number of existing open positions on the last business day of the month.[9] Consequently, one can consider the job openings data as a stock measure of vacancies.

Understanding the weighting and imputation methodology of the JOLTS is critical to understanding the potential biases of the aggregate worker flow and job openings estimates. The JOLTS data are weighted so that the employment levels within the survey's sample strata match the employment levels of identical strata within its benchmark data source, the Current Employment Statistics (CES) survey. These strata split the data by major industry, size class, and major geographic region. Simplifying the process somewhat, let E_i^C be total employment in sample cell i in the CES, and let e_{ik} be the employment of establishment k in sample cell i in the JOLTS.[10] The JOLTS sample weights for establishments in this cell will then be

$$\omega_{ik} = E_i^C \Big/ \sum_k e_{ik} \ .$$

This sample weight does not account for sample nonresponse (i.e., the failure of sample establishments to either respond to the survey, not the failure to respond to individual survey questions). Hence, the BLS applies a "nonresponse adjustment factor" to all of the weights within a sample cell. This factor scales up the weights within the cell

[9] The JOLTS job openings definition is fairly broad. It includes any position where the establishment is actively seeking a worker (where "actively seeking" can include anything from word-of-mouth networking to a formal vacancy posting) and the work can start within 30 days.

[10] The most prominent things this description omits are adjustments made for outliers and a separate treatment of establishments in the sample with certainty versus those who are randomly drawn. For more on the JOLTS estimation methodology, see Crankshaw and Stamas (2000).

so that its employment again matches the CES employment for that cell. Specifically, the nonresponse adjustment factor is

$$NRAF_{ik} = \sum_{k \in all} \omega_{ik} \Big/ \sum_{k \in used} \omega_{ik} \ ,$$

where "all" refers to all establishments originally sampled and "used" refers to the set of establishments that responded and were used in estimation.

In addition to nonresponse, the JOLTS sample weights are adjusted to account for the "benchmarking" of the CES estimates to administrative data from state unemployment insurance records.[11] These data represent the sample frame for both the CES and JOLTS data. The benchmarking is done each year to ensure that the CES employment levels match employment levels in the administrative data. To capture the adjustment this benchmarking does to the CES estimates, the JOLTS sample weight is adjusted by a "benchmark factor". Letting $\tilde{E}_i^C$ be the CES employment estimate in sample cell *i* after it is benchmarked to the administrative data, the benchmark factor is

$$BMF_{ik} = \tilde{E}_i^C \big/ E_i^C \ .$$

Putting this all together, the final JOLTS sample weight is

$$\theta_{ik} \quad = \quad w_{ik} \quad \times \quad NRAF_{ik} \quad \times \quad BMF_{ik} \, .$$

All elements of the JOLTS data (employment, hires, separations, job openings) are multiplied by their final sample weights to produce the aggregate JOLTS estimates.[12]

It is important to understand that neither the nonresponse adjustment nor benchmarking factors in the JOLTS undo the selection biases described above. We

[11] These administrative data are known as the Quarterly Census of Employment and Wages (QCEW). They are a virtual census of employment that includes all establishments covered under state unemployment insurance programs, about 98 percent of all paid employees. Independent contractors and unincorporated self-employed persons are out of scope for the QCEW, BED, CES and JOLTS.

[12] We focus on the final JOLTS estimates in this analysis including the benchmark adjustments.

expect that exits and large contractions are disproportionately nonrespondents. We also know that entrants and very young establishments are not in the JOLTS sample because of the lag time involved in compiling the administrative data and in drawing a new panel of randomly sampled establishments.[13] As we described earlier, the growth rates and worker flows of these establishments are, by definition, markedly different from the establishments who respond. The nonresponse and benchmark factors simply change the weights of the respondents to ensure that the JOLTS sample is representative in employment levels. Since the same weights are also applied to the worker flow and job openings, the JOLTS weighting approach implicitly imputes the average values of these statistics for the missing respondents in their sample cell. The weighting also makes no correction for missing entrants.[14] These facts imply that the JOLTS estimates likely miss a wide array of employment dynamics. Thus, it is possible for the JOLTS data to be representative of employment *levels* without necessarily being representative of employment *growth*.

II.B. The Business Employment Dynamics Data

The fact that the JOLTS and CES use the administrative data as their sample frame is important for our purposes. The administrative data are virtually a census of all establishments that the BLS employs in several ways, including the tabulation of its BED statistics. The BED reports the gross job gains at opening and expanding establishments and the gross job losses at closing and contracting establishments calculated from

[13] The administrative data are compiled with an 8 month lag, with most of the lag involving the transfer of the data from the states to the BLS. Once an establishment appears in the administrative data, it would be at least 1 month before it could be randomly drawn for the JOLTS sample, giving a total lag of 9 months.

[14] Another way of making these points is to emphasize that business size, while related to business age, is an imperfect substitute for business age.

longitudinally-linked administrative data. The BED data are quarterly and cover the private sector. The job flow statistics are measured using the net employment growth rates at the establishment level. We use these establishment-level growth rates to construct cross-sectional density of establishment growth for each quarter. Using the BED data in this way provides us with a growth rate distribution from the universe of establishments that includes both entering and exiting establishments.

II.C. Sample and Measurement Concepts

We use a sample of JOLTS data from January 2001 to December 2006. Our sample of BED data covers the same period. Since the BED only has job flow estimates for private establishments, we restrict both data sets to the private sector. We use the JOLTS data to estimate worker flow rates (i.e., the hires rate, quits rate, layoffs rate and other separations rate) and the job openings rate as a function of establishment-level employment growth. We use both the JOLTS and BED data to estimate the cross-sectional densities of establishment growth. We calculate all rates (the growth rate, worker flow rates and the job openings rate) using the average of the current and previous periods' employment in the denominator. Measuring rates in this manner provides us with a symmetric growth rate bounded between -2 and 2 that gives an equal treatment of growth at entering and exiting establishments.[15]

There are timing differences between the measurement of employment and the worker flows in the JOLTS data. Furthermore, the sample weights for an establishment usually change from month to month. These issues can complicate our measurement of rates. To deal with this in a way that provides internally consistent estimates, we define

[15] See Davis, Haltiwanger and Schuh (1996) for more on this growth measure. The BED estimates use this growth rate measure in the published statistics of gross job gains and losses.

employment in the previous month as employment in month *m* less hires in month *m* plus separations in month *m*, or formally,

(1) $$e_{m-1} = e_m - h_m + s_m.$$

This approach guarantees that the change an establishment's change in employment will equal the difference between its hires and separations. We define $e_{m\text{-}3}$ (i.e., lagged quarterly employment) similarly when calculating the JOLTS quarterly growth rates. Changes in sample weights over the quarter complicate things a bit further, and we detail how we address this in the Appendix.

III. Comparing the JOLTS to other Data Sources

One issue with the aggregate JOLTS estimates is their overestimation of employment growth relative to the CES estimates. Figure 1 compares the growth rate of nonfarm employment in the JOLTS and the CES data. For the JOLTS, we measure the growth rate as the difference between the hires rate and the separations rate. For the CES, we measure it as the percent change in employment from one period to the next. We show the growth rates measured quarterly to reduce the noisiness observed in the monthly data. The growth rate in the JOLTS exceeds the rate in the CES in all but 3 quarters.

Figure 2 compares the evolution of employment in the CES 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 bolded line shows the cumulated difference from December of each year. The figure shows that the implied employment from the JOLTS data diverges from the CES estimates in nearly every year except 2005. This difference is a concern for several reasons. First, at 6.6 million jobs, the cumulative discrepancy amounts to 4.8 percent of the December 2006 CES employment estimate. Second, the persistent overstatement of net growth in the JOLTS relative to the CES data raises concerns about making inferences on cyclical movements in worker flows from the JOLTS estimates. Finally, as we described in the previous section, the JOLTS data are weighted so that their employment match CES employment levels within each sample cell for each month. That the employment level-to-employment level weighting approach produces such striking differences in what the hires and separations data imply about employment growth is puzzling.

A second issue with the aggregate estimates is that the magnitude of the JOLTS hires and separation rates appear considerably lower than comparable estimates in other data sources. For example, the monthly hires and separation rates over the survey's history average 3.4 and 3.3 percent of employment, respectively. Looking at comparable estimates generated from gross worker flow data from the Current Population Survey by Fallick and Fleischman (2004) over the same time period shows monthly averages of about 6.4 percent of employment for each.[16] In addition, quarterly accession and separation rates in matched employer-employee data are more than six times larger than monthly rates in JOLTS (Davis, Faberman and Haltiwanger, 2006).[17]

When one delves into the JOLTS microdata, a third measurement issue arises: the cross-sectional density of establishment growth in the JOLTS over-represents stable establishments. To see to what extent this affects the JOLTS growth rate distribution,

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[16] We use the Fallick-Fleischman estimates rather than estimates created by others using the CPS (e.g., Fujita and Ramey, 2006; Shimer, 2007a) because their estimates account for job-to-job transitions, and therefore are more comparable conceptually to the JOLTS worker flow measures.

[17] The employer-employee matched datasets have cumulative worker flows that are similar conceptually to the JOLTS measures, so in principle these estimates should be about three times larger, rather than six times larger, than the JOLTS monthly rates.

consider Figure 3. The figure depicts the quarterly growth rate distribution we estimate from JOLTS microdata along with the quarterly growth rate distribution from the BED.[18] As one can see, the JOLTS data has a considerably larger share of employment at establishments with no change in employment, and smaller shares of employment at establishments with large employment changes. In addition, the JOLTS data appear to have an asymmetry in the differences among smaller employment changes – there is a relatively greater difference with the BED data in the share of small employment increases than there is with the densities of small employment decreases.

Table 2 reports the cross-sectional distributions of growth for various cuts of the JOLTS and BED data, with densities reported over broad growth rate intervals. For the JOLTS data, we report the growth rate distributions three ways: the monthly growth rate distribution pooled over all private establishment observations, the monthly growth rate distribution of the sample of establishments from which we can calculate quarterly statistics, and the quarterly growth rate distribution from the same restricted sample. We report growth rate distributions from the BED two ways: pooled over all private establishment observations, and pooled over continuing establishments only. The distributions of monthly growth rates in the JOLTS data are very similar, suggesting that selection issues in our restricted sample are limited. The Table highlights the differences between the BED and JOLTS quarterly growth rate distributions – the JOLTS distribution has considerably more employment at establishments with changes of less

[18] Both distributions are employment weighted. The JOLTS distribution is also sample weighted. To create the quarterly JOLTS growth rates, we use a restricted sample of JOLTS data that requires establishments to have data for all three months of a quarter. We discuss this select sample in detail in the appendix. This restriction removes 11.2 percent of our sample's observations. If our hypothesis that more stable establishments are more likely to respond to a survey is true, then selection issues would potentially bias the quarterly JOLTS distribution towards an overrepresentation of stable establishments, though Table 2 suggests that any biases are likely small.

than 2 percent, while the BED has more employment at establishments of 5 percent or more. This is true even when controlling for the fact that the BED captures entrants and exits.

IV. Cross-Sectional Patterns in Worker Flows and Job Openings

Davis, Faberman, and Haltiwanger (2006) show that separations, particularly layoffs, are the relevant margin of employment adjustment for contracting establishments while hires are the relevant margin of adjustment for expanding establishments. They also show that these relationships fluctuate little over time. We replicate the relationships in Figures 4 and 5. The figures show a worker flow or job openings rate as a function of the establishment-level growth rate, measured using pooled monthly observations of all private establishments. To estimate these relations we calculate the mean values of each rate across a range of growth rate intervals.[19]

The hires rate, job openings rate, quits rate and layoff rate as a function of growth are shown in separate panels in Figure 4 (zoomed in to growth rates between -25 and 25 percent) and Figure 5 (the full range of growth). The hires rate is essentially constant for all contracting establishments, it is lowest for establishments with little to no growth, and increases almost linearly for expanding establishments. The job openings rate exhibits a similar pattern, but with a sharper decline for zero-growth establishments, and a less steep increase with growth among expanding establishments. The final two panels show the relations of the quits rate and layoffs rate, respectively, to establishment growth. Quits and layoffs essentially show the mirror-image of the relations hires and job openings

[19] We create these intervals so that so that they are relatively fine (intervals of 0.1 percent) close to zero, and increase in size (up to 5 percent intervals) as we move from zero to account for the sharp decline in the number of observations we have for the larger employment changes.

have with growth. Both rates are relatively flat for expanding establishments, are lowest among stable establishments, and increase with the size of the contraction among contracting establishments. Layoffs show a relatively linear increase, while quits increase rapidly for smaller contractions, and then begin to level off. Contractions greater than 16 percent have quit rates that hover around 12 percent of employment.[20]

The four panels of Figure 4 also illustrate that these relationships do not change much in high-growth versus low growth periods. The dotted lines in each panel represent the rate's relationship to growth during the 12 months of highest growth and 12 months of lowest growth, as measured by the aggregate net growth rates calculated from the JOLTS data.[21] As one can see, there is virtually no difference in these relations in either the high-growth or low-growth periods. The only notable differences are for the quit rates and vacancy rates among relatively large contractions (i.e., employment declines greater than 15 percent). These cross-sectional relationships are essentially constant over time.

Davis, Faberman and Haltiwanger (2006) find this result as well, and with further analysis, they conclude that most of the cyclical movements in the aggregate worker flow rates stem from shifts in the cross-sectional density of establishment growth. It is not surprising that the cross sectional density is potentially important, since by construction, an aggregate estimate is the result of the interaction between the cross-sectional density and the statistic's relationship to establishment growth. To see this, let X_t be the aggregate estimate of a worker flow or job openings rate at time t. Let i denote an interval along the range of growth rates between -2 and 2. Let $x_t(i)$ be the mean rate over growth interval i.

[20] In unreported results, we also find that the other separations rate rises with the size of a contraction, but much less so, ranging from about 0.3 percent for the smallest contractions to 7.4 percent for the largest contractions.
[21] When ranking the months by their growth rate, we use the seasonally unadjusted data. The unadjusted data generally have much larger variations in growth over time, so are better suited for this exercise.

The panels in Figure 4 and 5 illustrate these mean rates as a function of the growth rate intervals. Finally, let $f_t(i)$ be the share of employment at establishments with a growth rate in interval *i*. The cross-sectional density of growth is simply the representation of these shares over the full range of growth rates. In any given period, the aggregate estimate is

$$(2) \qquad X_t = \sum_i x_t(i) f_t(i) .$$

Thus, changes in the aggregate estimate can come from one of two sources: through changes in the relationship to establishment growth (the *x*'s), or through changes in the cross-sectional density of growth (the *f*'s). The interesting finding emphasized in Davis, Faberman and Haltiwanger (2006) is that most of the variation in the aggregate flows stem from variation in the cross sectional density of growth over time.

Given the measurement issues we outlined in Section II, one might worry that selection and nonresponse may affect shifts in the cross-sectional density in addition to affecting its shape, and through this channel affect the cyclicality of the aggregate statistics in addition to their magnitudes. In Figure 6, we compare shifts in the cross-sectional density of quarterly growth rates in the BED data (upper panel) to the density of quarterly growth in the JOLTS (lower panel). We group the data into high-growth and low-growth groups using the six highest- and six lowest-growth quarters, as ranked in the BED data.[22] We also note the locations of the 10th and 90th percentiles of each distribution – as one could guess, the leftmost bar for each percentile is associated with the low-growth distribution. In both data sources, the distributions are shifted more

[22] We again use the restricted sample of JOLTS data described in the previous section to produce the quarterly growth rate distributions. As we did earlier, we use the seasonally unadjusted data to create the distributions and rank the aggregate growth rates. In the BED, the mean growth rate is 2.6 percent in the high-growth group and -2.0 percent in the low-growth group. We use the same quarters in both the JOLTS and BED growth groups, even though these may not rank as the highest (lowest) growth quarters in the JOLTS data, to keep the comparison consistent.

toward expanding establishments in the high-growth quarters and contracting establishments in low-growth quarters. Unlike the BED data, the JOLTS data have a notably larger employment density at zero-growth establishments during the low-growth quarters. Both JOLTS distributions have their employment density more concentrated among smaller employment changes, relative to their BED counterpart. Finally, the differences in the 10th percentile and the 90th percentile between the high- and low-growth distributions suggest that the BED data have larger shifts in their growth rate distribution than the JOLTS when moving from the high-growth to the low-growth quarters, particularly among the contracting establishments at the 10th percentile. This suggests that the JOLTS data understate the time-series movements in the growth rate distribution, and thus likely understate the cyclical movements of worker flows.

V. A Method for Adjusting the Published JOLTS Estimates

Above, we showed that the cross-sectional relationships of the worker flow and job openings rates to establishment growth have strong, nonlinear relations that vary little over time. We also showed that the cross-sectional distribution of growth appears to over-represent establishments with little to no growth, and appears to understate shifts in the distribution in going from high-growth to low-growth periods. In this section, we attempt to address these issues by creating adjusted time-series of the aggregate worker flow and job openings rates. The adjusted estimates use the establishment-level relationships coupled with a monthly growth rate distribution that is adjusted to be consistent with the distributions of the BED data, including their measures of entry and exit.

A. Creating a Series of Growth Rate Distributions

The first step is to create a series of adjusted growth rate distributions. In replacing the employment densities of the JOLTS distribution with the densities from the BED distribution, two complicating issues arise. First, the BED data capture entering and exiting establishments, while the JOLTS data do not. Adding entry and exit, of course, extends the tails of the distribution and since the sum of all densities in any distribution must sum to one, this affects the densities throughout the entire distribution. Second, the BED data are quarterly while the JOLTS data are monthly. We ideally want a use monthly version of the BED for our exercise. Since quarterly data are lower frequency, they will reflect cumulative employment changes. When establishments have an employment change in the same direction in consecutive months, or when multiple establishments have at least one employment change during different months this naturally yields greater employment changes at the quarterly frequency. Some employment changes may be transitory, though, and may reverse themselves within the quarter and thus not be reflected at the quarterly frequency.

We start with the BED distribution. We use discrete growth rate intervals in our exercise and consequently describe our distributions using the discrete notation from equation (2). This representation portrays our adjustment as a re-weighting of the cross-sectional relationships to establishment growth, which, given our focus on the JOLTS sampling and weighting in this paper, is an appropriate way to think about this exercise.

Let $f_t^B(i)$ be the employment density of establishments with a growth rate in interval *i* in the BED data at quarter *t*. Keep in mind that the employment densities are summed over a symmetric growth rate bounded over the range [-2, 2], where exits have a growth rate of -2 and entrants have a growth rate of 2.[23] Let $f_t^J(i)$ be the employment density of establishments with a quarterly growth rate in interval *i* in the restricted sample of JOLTS establishments with three monthly observations during quarter *t* (see the Appendix for details of this sample.) Finally, let $f_{m,t}^J(i)$ be the employment density of establishments with a monthly growth rate in interval *i* during month $m \in \{1, 2, 3\}$ of quarter *t* in the same restricted sample of JOLTS.[24]

Our first step is to adjust the BED growth rate distribution to account for differences in frequency (i.e., quarterly versus monthly). This is where the restricted sample of JOLTS data is necessary. We use the quarterly and monthly JOLTS densities to create an adjustment factor. For any given interval *i*, we define the monthly frequency adjustment as

$$\delta_{m,t}(i) = \frac{f_{m,t}^J(i)}{f_t^J(i)}. \tag{3}$$

In practice, we find that permitting this factor to vary over the full time-series produces a noisy adjustment that is susceptible to sampling bias, particularly at the tails of the distribution. Thus, for each month of the year, we instead use $\delta_m(i)$, which takes the ratio of the monthly density averaged across the 6 yearly observations of that month to the quarterly density averaged across the 6 yearly observations of that quarter. This averaging removes the time-series variation in the month-to-quarter relationship from one

[23] For our estimation, we use growth rate intervals that are relatively fine close to zero-growth (with a minimum range of 0.0025 just to the left and right of zero) and relatively wide close to the entry and exit boundaries (with a width of 1 adjacent to each boundary). We also separate entrants, exits and zero-growth establishments into their own distinct intervals. In all, we separate the range of growth into 37 intervals.

[24] The JOLTS distributions (both quarterly and monthly) only contain continuous establishments. Therefore, $f^J(-2) = f^J(2) = 0$ in all periods.

month to the next, but preserves both the quarterly variation over the entire period and the over-the-month variation within each year. [25]

Our next step is to apply the adjustment to the quarterly BED employment densities. To be consistent, we only want to apply the adjustment to the employment densities of continuous establishments, so we renormalize the BED employment densities for these establishments, making the adjusted monthly density for growth rate interval *i*

(4) $$\tilde{f}_{m,t}(i) = \delta_m(i)\left(\frac{f_t^B(i)}{1 - f_t^B(-2) - f_t^B(2)}\right).$$

Keep in mind that $f_t^B(2)$ is the employment density of entering establishments and $f_t^B(-2)$ is the employment density of exiting establishments in the BED data at quarter *t*. Also, note that since $\delta_m(i)$ is a multiplicative adjustment of the BED data, it will generally be the case that $\sum_i \tilde{f}_{m,t}(i) \neq 1$. Consequently, we must normalize the densities by this sum to get a distribution that sums to one.

The final step is to add entry and exit back into the distribution for each month. In doing so, we divide up the densities of employment at entering and exiting establishments and apply one-third to each month of the quarter. In doing so, we make some implicit assumptions, the most obvious being that entry and exit occurs at a constant rate throughout the quarter. The less obvious assumption is that we rule out time aggregation issues. In other words, we ignore the possibility that establishments might both enter and exit within the quarter, which would imply that the sum of the monthly entry (exit) densities exceed the quarterly entry (exit) density. Given the startup costs of an

[25] We plan to explore richer characterizations of the mapping between the quarterly and monthly growth rate distributions in future drafts.

establishment and the logistics and time needed to enter a state's unemployment insurance system (i.e., the requirement to appear as an entrant in the BED), we believe this is a reasonable assumption. The employment densities at entering and exiting establishments in our final adjusted series are $\hat{f}_{m,t}(2) = f_t^B(2)/3$ and $\hat{f}_{m,t}(-2) = f_t^B(-2)/3$, respectively. To obtain the final adjusted densities for continuous establishments, we normalize $\tilde{f}_{m,t}(i)$ as described above. We also have to adjust these densities one more time to account for the addition of entry and exit. For -2 < *i* < 2, the final, adjusted monthly employment density is

(5) $$\hat{f}_{m,t}(i) = \left(1 - \tfrac{1}{3}[f_t^B(-2) + f_t^B(2)]\right)\left(\frac{\tilde{f}_{m,t}(i)}{\sum_i \tilde{f}_{m,t}(i)}\right).$$

The final adjusted distribution has all the desirable properties for our exercise. The distribution is well-behaved in that it sums to one. For any month, it preserves the distribution we observe in the BED data (i.e., the universe of establishments for the JOLTS sample), but incorporates an adjustment for comparing the monthly versus quarterly frequencies. Finally, it accounts for establishment entry and exit.

One can interpret our exercise in the spirit of benchmarking to Census or administrative data, a standard practice in statistical methods in use at the U.S. statistical agencies. What is novel about our benchmarking is that it uses the cross-sectional distribution of establishments to benchmark to employment *growth* rather than to employment *levels*. Such benchmarking, however, is appropriate for the JOLTS since its estimates are flow rather than stock measures of labor market phenomena.

B. Creating the Adjusted Estimates

At this point, calculating the adjusted worker flow and job openings estimates is straightforward. Let uppercase $X_{m,t}$ represent one of the aggregate worker flow or job openings rate estimates during month m of quarter t – i.e., hires ($H_{m,t}$), quits ($Q_{m,t}$), layoffs and discharges ($L_{m,t}$), other separations ($R_{m,t}$), or job openings ($V_{m,t}$). Let lowercase $x_{m,t}(i)$ be the mean value of this worker flow or job opening rate for growth rate interval i during the same month. We estimate these rates from the full sample of monthly JOLTS data. This sample only covers continuous establishments, so we must make some assumptions on the value of these rates for entering and exiting establishments. The table below lists these assumptions.

Assumptions on Entry and Exit Values

	$h_{m,t}(i)$	$q_{m,t}(i)$	$l_{m,t}(i)$	$r_{m,t}(i)$	$v_{m,t}(i)$
Entrants (i = 2)	2	0	0	0	0.382
Exits (i = -2)	0	0.124	1.802	0.074	0

We assume that entrants have only hires while exits have quit and other separation rates that are are equal to their average rates at continuous establishments with the largest contractions. The layoff rate accounts for the remainder of the separations, making its assumed value 2 minus the sum of the other two rates. There is no binding constraint on the vacancy rate for these establishments. We assume that exits have no vacancies. For entrants, there are two sets of unobserved vacancies we must deal with. Vacancies will likely exist at the end of an entrants' first month. For these vacancies, we assume that their rate is equal to the end-of-month vacancy rate at continuous establishments with the largest expansions, scaled to account for the hires-to vacancies ratio and the amount of hiring in excess of growth that occurs in this group, giving an average rate of 17.4

percent. Vacancies will likely also exist prior to the establishment's entry (i.e., the vacancies used to attract the first employees). These vacancies would not be captured by an establishment survey because the establishment does not exist when they are posted. [26] We assume that these beginning-of-month vacancies equal the lagged vacancy rate at the largest expansions, again scaling for the hires-vacancy ration and hiring in excess of growth. This yields an average rate of 20.8 percent. The vacancy rate we use for entrants is the sum of these rates.

Taking these assumptions into account and applying our adjusted densities gives an aggregate estimate of

$$\hat{X}_{m,t} = \sum_i x_{m,t}(i)\,\hat{f}_{m,t}(i)\,. \tag{6}$$

That is, we sum up the mean rates multiplied by the adjusted employment density over all growth rate intervals to obtain the aggregate estimate for each month. We then seasonally adjust the aggregate rates using the Census X-12 technique.

VI. Adjusted Statistics for Hires, Layoffs, Quits and Job Openings

The summary of our results is in Table 3. The left column reports the means and standard deviations of the worker flow and job openings rates for the private sector from the published JOLTS statistics. The right column reports the means and standard deviations of our adjusted estimates. The bottom panel of the table lists notable relative volatilities in the published and adjusted estimates.

The most striking result of our adjustment is the dramatic increase in the hires and separations rates. Both rates increase by about one-third, with the hires rate increasing

[26] This suggests that JOLTS may benefit from retrospective questions for entrants about their pre-entry activity, but it is not the only survey. (e.g., adding restrospective questions about initial investment in the Annual Capital Expenditures Survey, ACES).

from 3.8 to 4.9 percent and the separations rate increasing from 3.7 to 5.0 percent. Much of the increase in the separations rate comes from a large increase in the layoffs rate, which rises by nearly two-thirds from 1.4 percent to 2.3 percent. There is also a notable rise in the quits rate, but it is much smaller. The job openings rate exhibits a relatively small increase, from 2.7 percent to 2.9 percent.

The monthly volatilities of these rates also change with our adjustment. The standard deviation of the hires rate declines while the standard deviation of the separations rate increases. These changes reduce the relative volatility of hires to separations by more than half, with separations, not hires, becoming the more volatile worker flow. The increase in the volatility of the separations rate is driven almost entirely by an increase in the volatility of the layoffs rate. The time-series variation of job openings, quits and other separations changes little with the adjustment. Consequently the relative volatility of quits to layoffs also declines by about half, and the relative volatility of hires to job openings declines, but not as dramatically. The relative volatility of job openings to unemployment, a statistic of much attention in the labor search and matching literature, shows essentially no change.[27]

Figure 7 compares the time-series movements of the adjusted and published JOLTS estimates of the hires rate, job openings rate, quits rate and layoffs rate. The differences in magnitude between the published and adjusted estimates for the hires and layoffs rates persist throughout the sample period. Like the published estimates, the adjusted hires rate shows a decline during the 2001-03 period, but show less of an increase from 2004 on. The adjusted layoffs rate shows a relatively larger increase during the 2001 recession, and then exhibits a gradual but steady decline thereafter. The

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

published layoffs rate is essentially flat until 2006. The adjusted quits rate and job openings rate have time-series patterns that are essentially the same as the patterns of the published estimates. In Figure 8, we compare the movements of the adjusted quits and layoffs rate. The quits rate exhibits its sharpest decline during 2001, right when the layoffs rate is high. The two remain essentially flat and about equal in magnitude in 2002 and 2003. They then diverge from mid-2004 on, with the quits rate gradually increasing and the layoffs rate gradually falling.

One aspect of the JOLTS estimates that our adjustment does not address well is the estimated aggregate growth rate implied from the hires and separations rates. The published statistics imply an average monthly growth rate of 0.08 percent. The corresponding growth rate in the CES is about 0.04 percent. Our adjusted estimates, however, predict a larger decline, implying an average monthly growth rate of -0.10 percent. We suspect that some of this may stem from sampling error issues at the tails of the growth rate distribution, and in future drafts, we plan to address this issue. For now, we note that the potential exists for this underestimation of aggregate growth to affect the volatility of the adjusted worker flow estimates, but its affect on the magnitudes should be relatively small (in theory, it should not alter adjustments by more than 0.14 percent.)

VIII. Concluding Remarks

The JOLTS data have proven to be an invaluable resource in understanding labor market dynamics and in evaluating theories of labor market search. As a relatively new source, the JOLTS has measurement issues that are not well understood or fully appreciated. In this paper, we highlight two issues observable in the published JOLTS statistics: an overstatement of aggregate employment growth and an understatement of worker flows. We also show that JOLTS oversamples relatively stable establishments, does not capture entry and exit, and does not capture very young establishments. In each respect, there is a tendency to miss establishments undergoing large changes. Large changes imply large worker flows and, for large positive changes, high job openings.

We address these issues by using the BED growth rate distribution to re-weight the cross sectional relationships observed in the JOLTS micro data. This approach yields a representative growth rate distribution because the BED data are a virtual census of all establishments. The adjustment yields a modest increase in the job openings rate and little change in the relative volatility of vacancies to unemployment. In contrast, the adjustment has a major impact on estimated worker flows. The adjusted hires and separations rates exceed the published rates by one-third. Moreover, the adjustment alters the quit-layoff mix of separations, and it substantially raises the volatility of separations relative to hires.

While measurement issues are the main focus of this paper, our admittedly preliminary findings have potentially important 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, 2007a). However, we find that using a representative growth rate distribution to estimate worker flows substantially increases the variability of separations relative to hires. In fact, according to our preliminary results in Table 3, separations are more variable than hires in the period covered by JOLTS.

Our study also highlights an important issue for estimating worker flows at the BLS and other statistical agencies. For the purpose of estimating these flows, it is not sufficient to ensure that surveys are representative in levels, as is the case with the CES and many other establishment surveys. One must also ensure that the survey is representative of the underlying growth rate distribution. Appealing to representative administrative data such as the BED can help greatly in this respect, as can methods that account for entry, exit and the dynamics of very young establishments.

As a final note, our estimation has the potential to aid in the estimation of worker flows and job openings further back than the start of the JOLTS. One could combine historical administrative records with recent data on the cross-sectional relations linking worker flows and job openings to establishment growth rates in order to construct estimated historical series on worker flows and job openings. Such an endeavor would greatly expand the time-series dimension of data for the study of labor market dynamics.

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Appendix

A. Calculating Quarterly Flows and Growth Rates

Changes in JOLTS sample weights from month to month create an issue in measuring quarterly growth rates in the JOLTS data. In comparing the JOLTS and BED data, we want to have consistent quarterly measures of the JOLTS data, but the changing sample weights complicate this. To deal with this, we define the quarterly flows as the sum of their monthly weighted values divided by the weight of the latest month. Formally, letting $x_{m,t}$ be one of the worker flow measures at month *m* of quarter *t* for an establishment and letting $\theta_{m,t}$ be the establishment's sample weight at *m*, the quarterly flow measure is

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

This measure has the useful property that the only weight needed to make the quarterly statistics representative (whether they be in levels or in rates) is $\theta_{m,t}$. To maintain consistency, we use the employment level of the last month of the quarter along with the quarterly measures of hires and separations to calculate the previous quarter's employment analogously to equation (1) in the text.

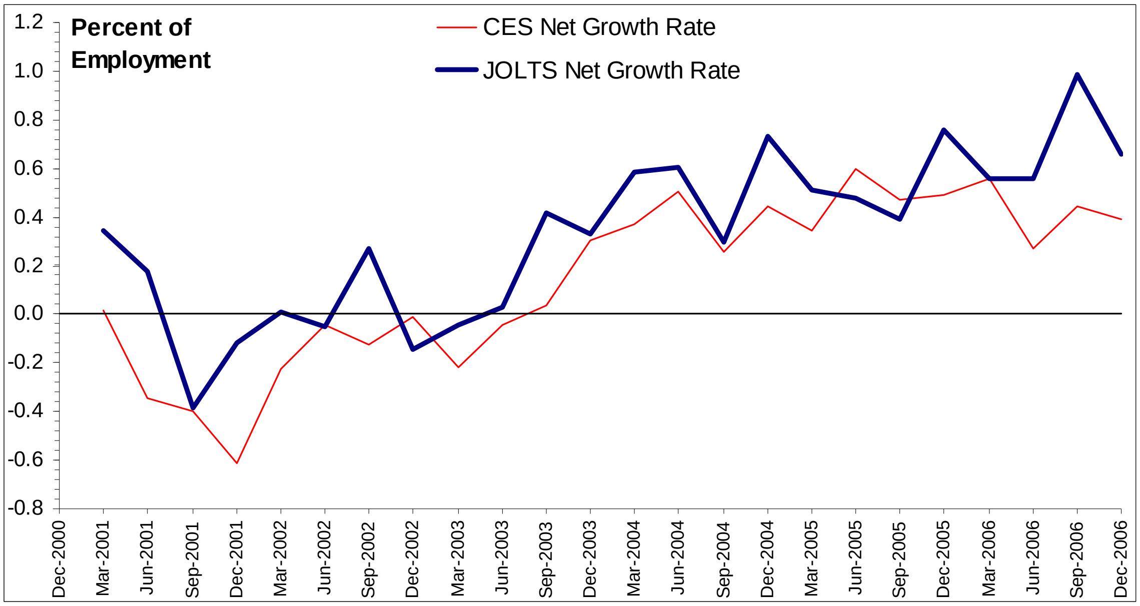
B. Creating a Sample of Quarterly JOLTS Data

To create a quarterly JOLTS growth rate distribution, we need a restricted sample of JOLTS data that requires establishments to have data for all three months of a quarter. This restriction removes that are not part of three consecutive months of data for a quarter. For example, the first quarter includes January-March. If an establishment only had data for February, March and April, those observations would be removed because even though we have three months of data, the data do not cover a full quarter. Note that this restriction does not remove an entire establishment, only those observations of an establishment that do not cover a full quarter. So, if an establishment had data from February through June, we would exclude its February and March observations, but include its April, May and June observations for the second quarter.

The restriction removes 11.2 percent of our sample's observations. If our hypothesis that more stable establishments are more likely to respond to a survey is true, then the selection would potentially bias the quarterly JOLTS distribution towards an overrepresentation of stable establishments. A potential bias would only affect our exercise through $\delta_{m,t}(i)$, the ratio of the monthly to quarterly employment densities for a given growth rate interval in the restricted JOLTS sample. In this case, the bias would only be an issue if selection affected the relative densities of the data at the monthly and quarterly frequency. To see this, let $\delta^*_{m,t}(i) = f^{*J}_{m,t}(i) \big/ f^{*J}_{t}(i)$ be the true value of $\delta_{m,t}(i)$. The extent to which $\delta_{m,t}(i)$ is biased can be measured by $B = \delta^*_{m,t}(i) \big/ \delta_{m,t}(i)$. B will be > (<) 1 as $f^{*J}_{m,t}(i) \big/ f^{J}_{m,t}(i) > (<) \; f^{*J}_{t}(i) \big/ f^{J}_{t}(i)$. In words, the ratio is upwards (downwards) biased when the ratio of the actual to restricted monthly density is greater than (less than) the ratio of the actual to restricted quarterly density. When $B = 1$, there is no bias because the differences in the monthly and quarterly densities offset, preserving their relative difference.

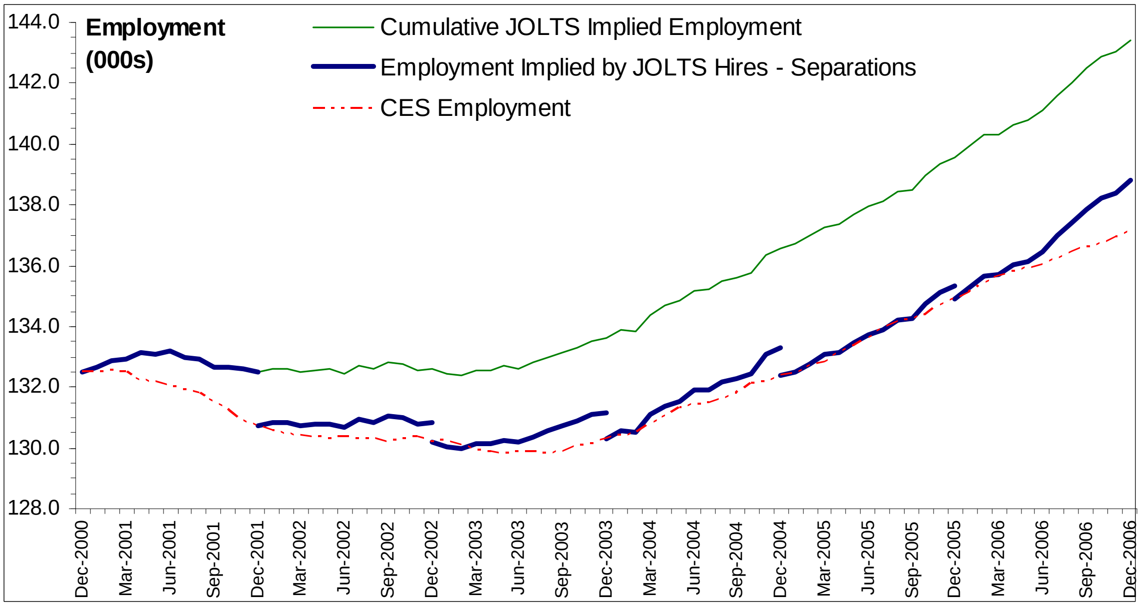
We actually know $f^{*J}_{m,t}(i)$, which is the monthly JOLTS density from the unrestricted data. Unfortunately, we cannot determine $f^{*J}_{t}(i)$, the unrestricted quarterly density. If we could, we wouldn't need the restricted sample in the first place. Thus, we cannot identify the extent of any potential bias. We also cannot even sign the direction of the bias, in part because the identity that the densities must sum to one ensures that if the bias for some growth intervals was positive, it would have to be negative for other intervals. While we cannot quantify the bias, we want to acknowledge it as a potential issue for our quarterly-to-monthly adjustment.

Figure 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.

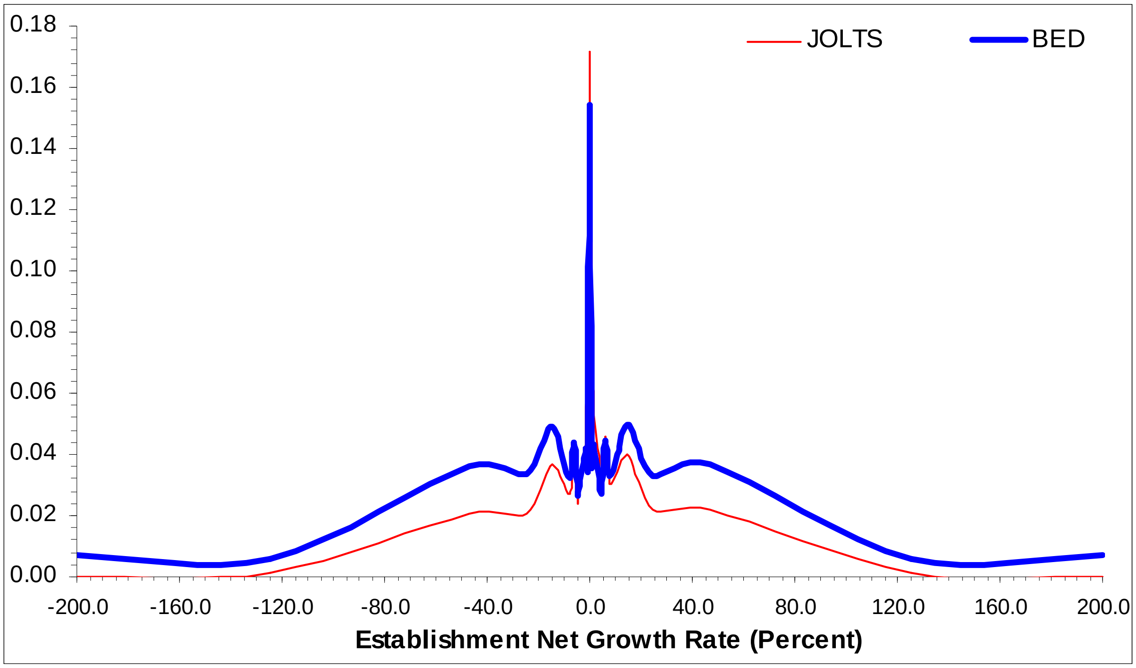
Figure 2. CES Employment Path Compared to Cumulated Differences between Hires and Separations in JOLTS



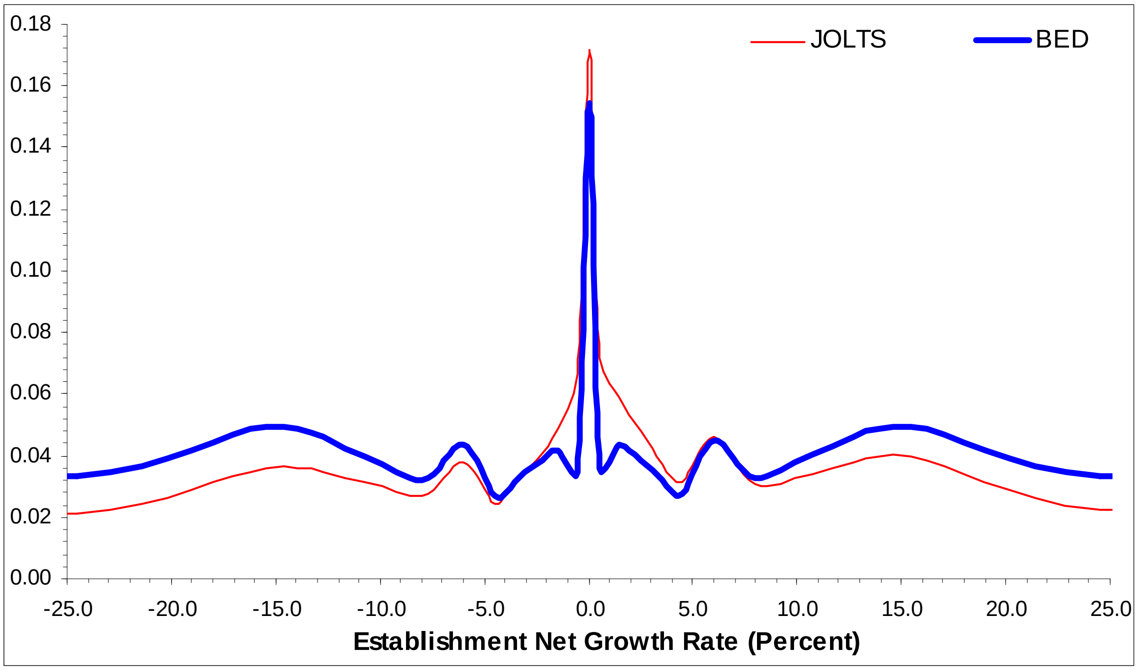
Notes: Figure depicts the employment levels implied from the JOLTS hires and separations data and reported in the CES data. The JOLTS level is reported two ways: as an accumulation of the difference between hires and separations each month (added to the December 2000 total) and as the accumulation over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

Figure 3. Cross-Sectional Quarterly Growth Rate Densities, JOLTS and BED Data

(a) Full Range of Growth Rates



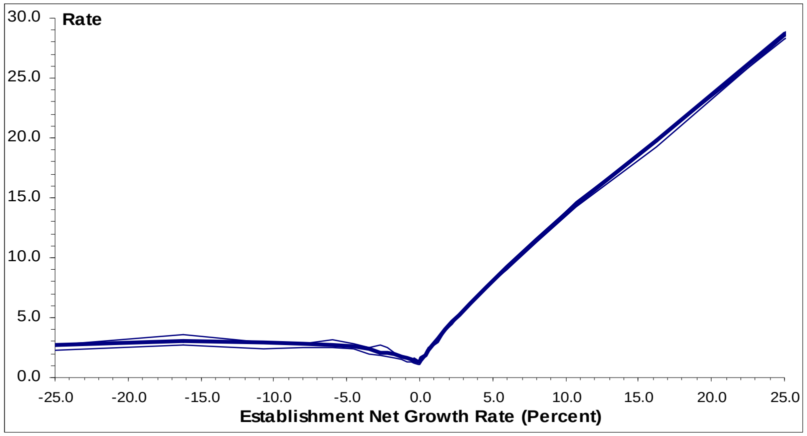
(b) Growth Rates Between -25 and 25 Percent



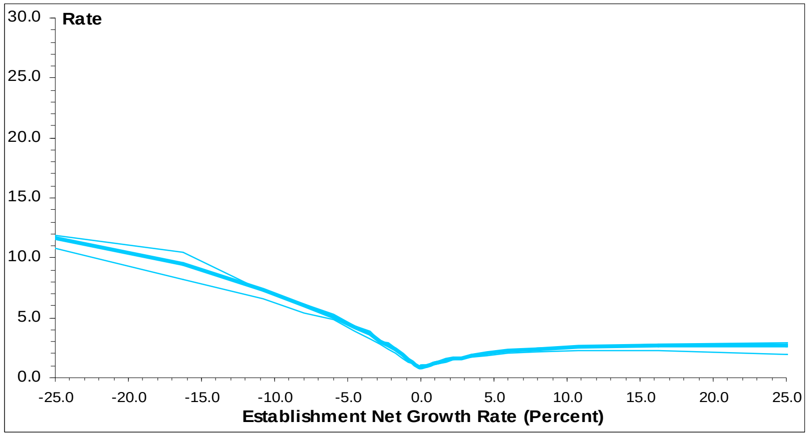
Notes: Figures depict the densities of employment at establishments with quarterly a growth rate in a specified interval. The distributions are of all observations in the BED and the sample of JOLTS data restricted to establishments with three months of data for a given quarter for 2001Q1 – 2006Q4 (see text for details).

Figure 4. Cross-Sectional Relationships of Worker Flows and Job Openings to Establishment Growth Rates, JOLTS Data, Zoomed in to Growth Between -25 and 25 Percent

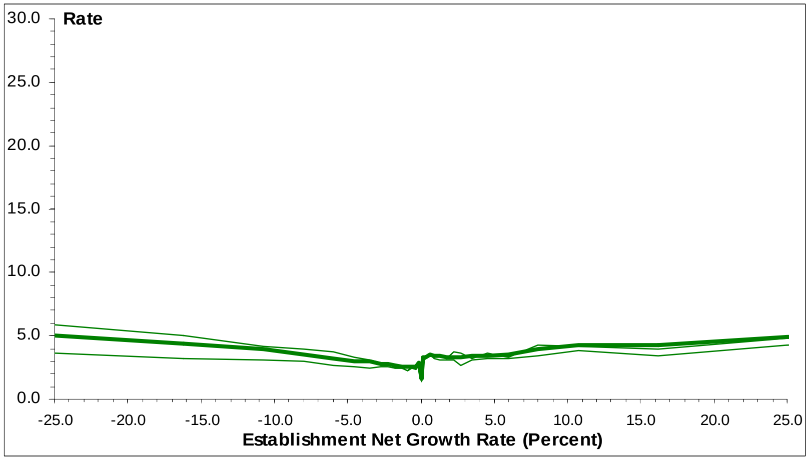
(a) Hires Rate



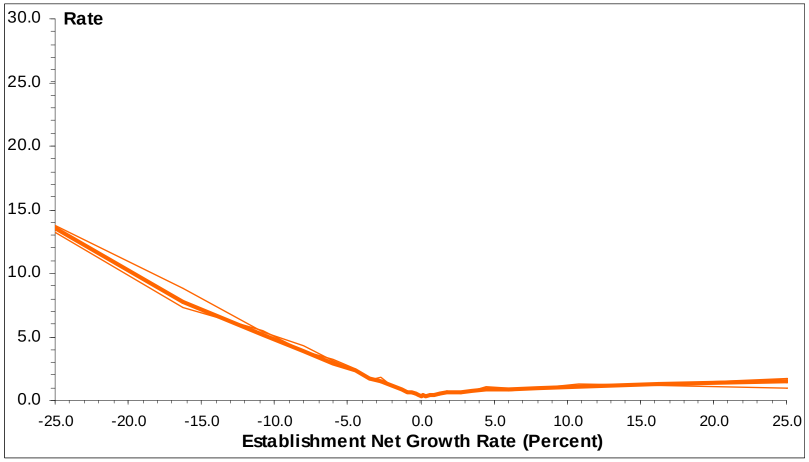
(c) Quits Rate



(b) Job Openings Rate



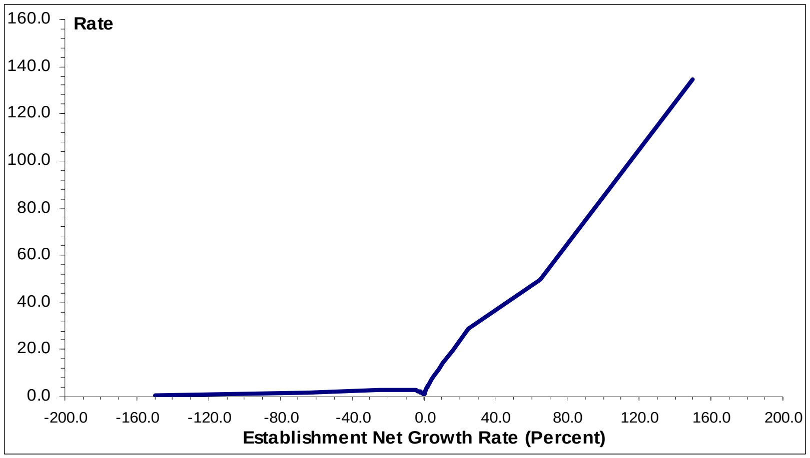
(d) Layoffs Rate



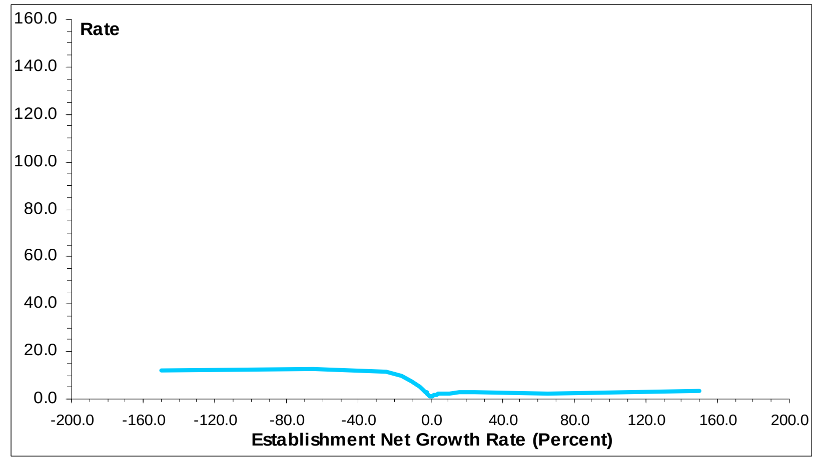
Notes: Each panel illustrates a worker flow or job openings rate as a function of the establishment-level employment growth rate. These rates are estimated as the means of variable-length growth rate intervals. Thick lines represent means pooled over all observations. Thin lines represent means pooled over the 12 months of JOLTS data with either the high or lowest aggregate growth rates.

Figure 5. Cross-Sectional Relationships of Worker Flows and Job Openings to Establishment Growth Rates, JOLTS Data, Full Range of Growth Rates

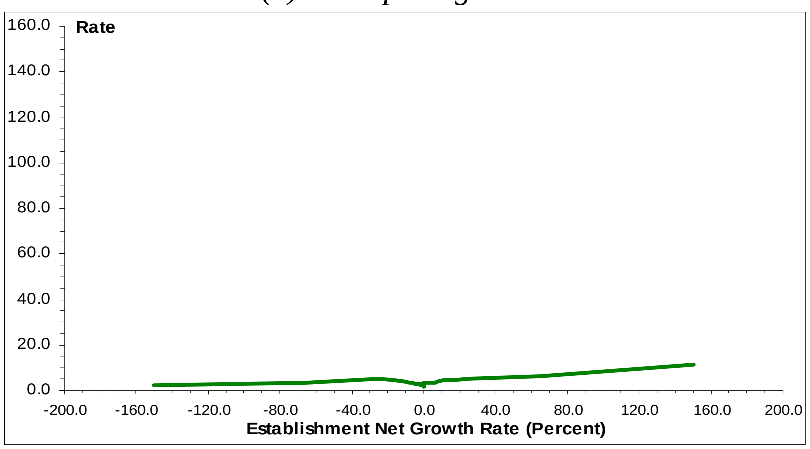
(a) Hires Rate



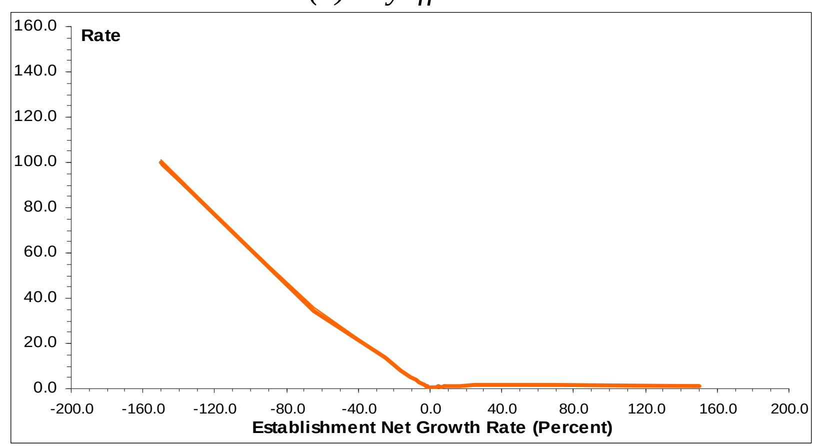
(c) Quits Rate



(b) Job Openings Rate



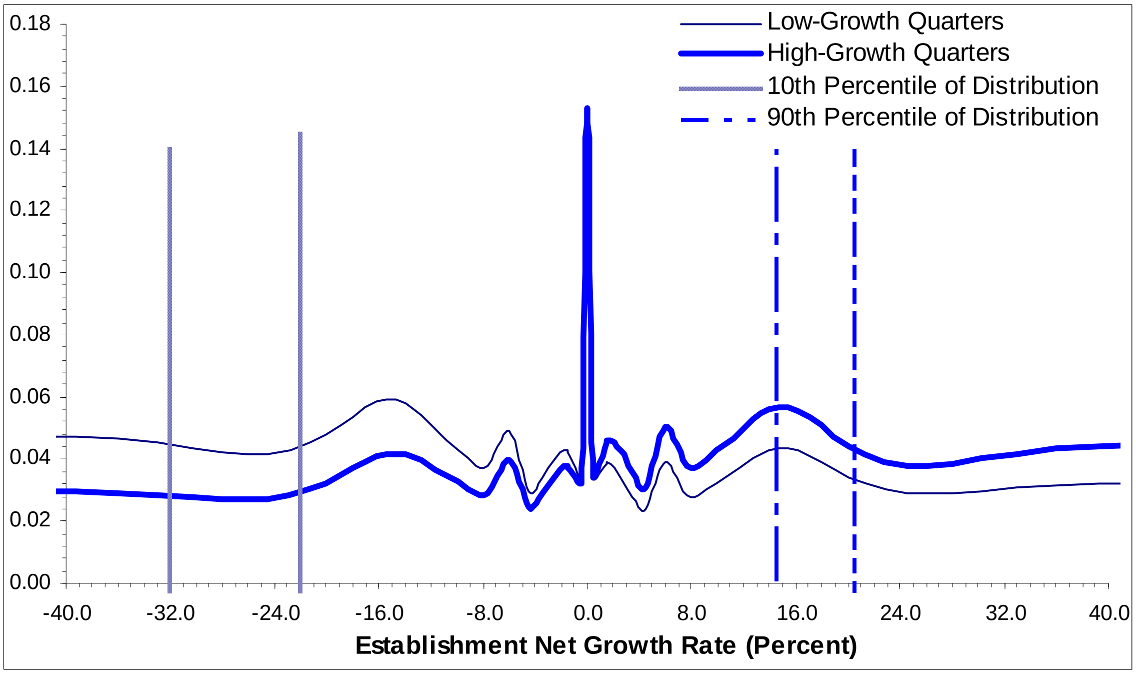
(d) Layoffs Rate



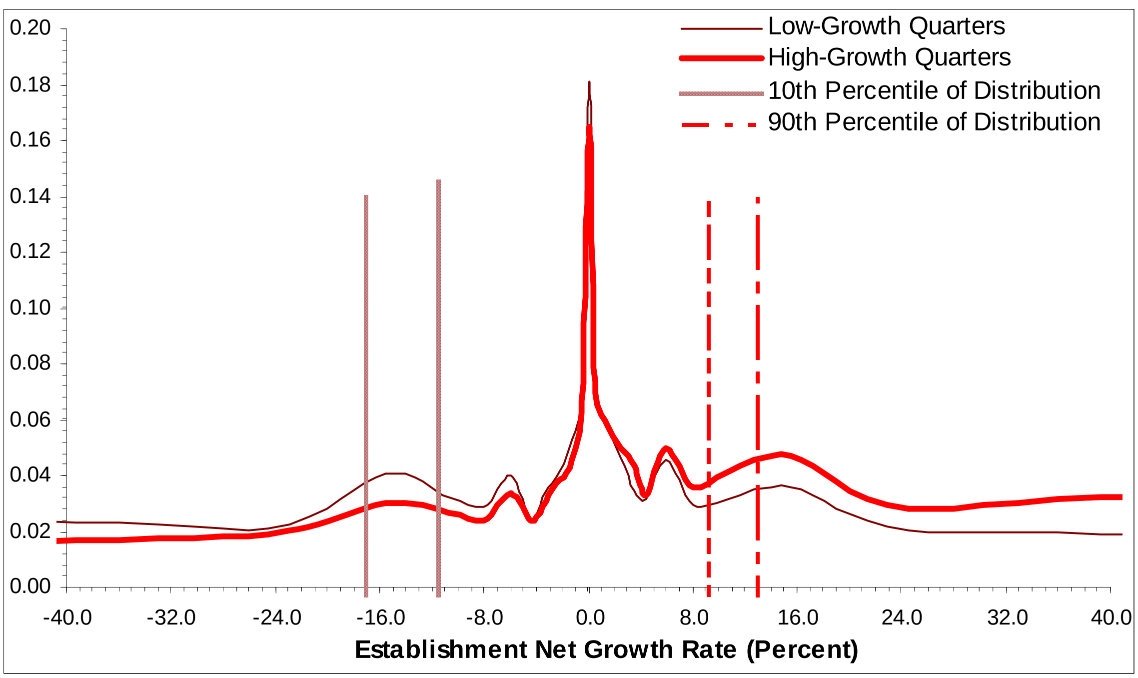
Notes: Each panel illustrates a worker flow or job openings rate as a function of the establishment-level employment growth rate. These rates are estimated as the means of variable-length growth rate intervals.

Figure 6. Quarterly Growth Rate Distributions in High- and Low-Growth Quarters, JOLTS and BED Data

(a) BED Distributions



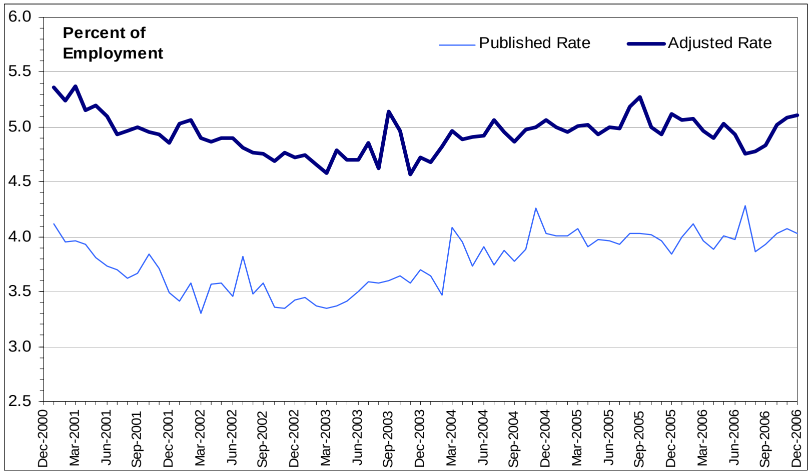
(b) JOLTS Distributions



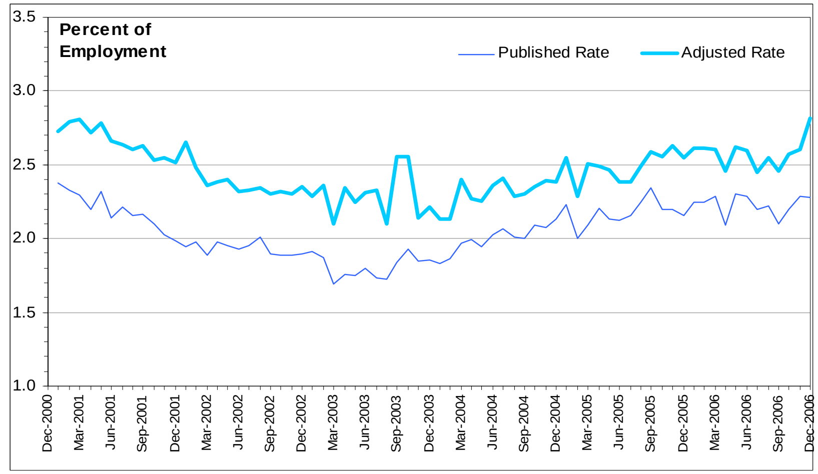
Notes: Figures depict employment densities at establishments with quarterly growth rates within a given interval in the BED (top panel) and a restricted panel of JOLTS data (bottom panel, see text for details of restriction) for 2001Q1 – 2006Q4. The distributions are split into the 6 quarters of highest growth and 6 quarters of lowest growth, based on their seasonally unadjusted aggregate growth rates in the BED. Vertical lines represent the growth rates at the 10^{th} (shaded lines) and 90^{th} (dashed lines) percentiles of the distribution, with the leftmost of each pair associated with each low-growth distribution.

Figure 6. Adjusted and Published Estimates of JOLTS Worker Flows and Job Openings

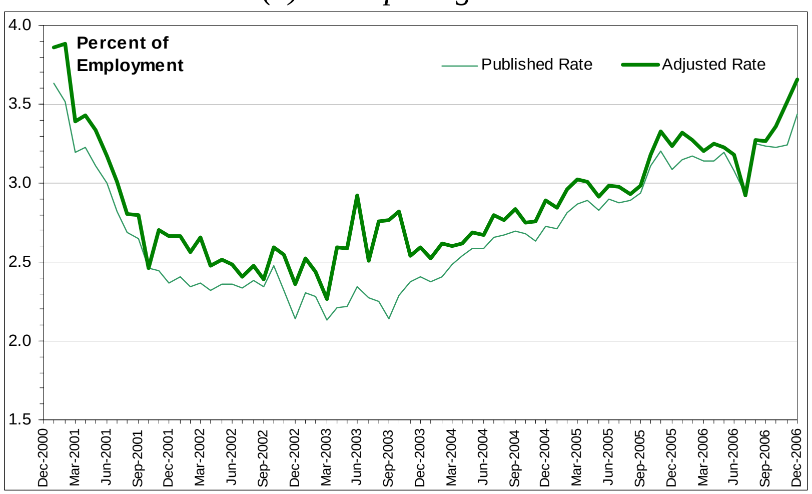
(a) Hires Rate



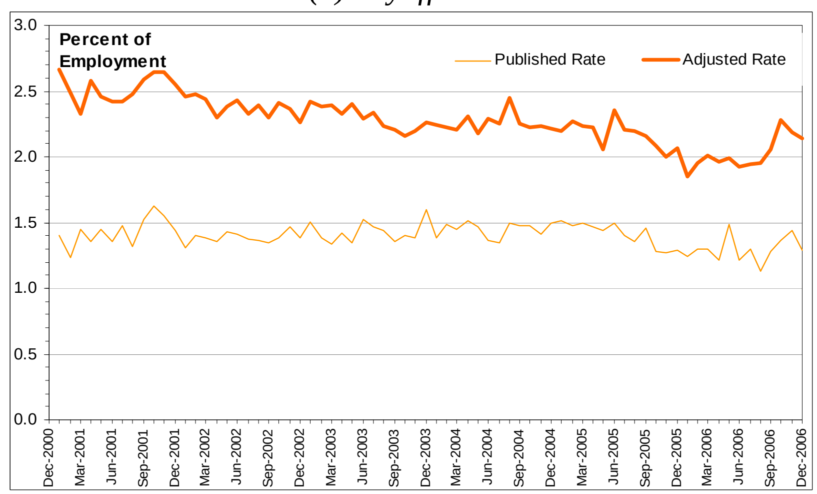
(c) Quits Rate



(b) Job Openings Rate

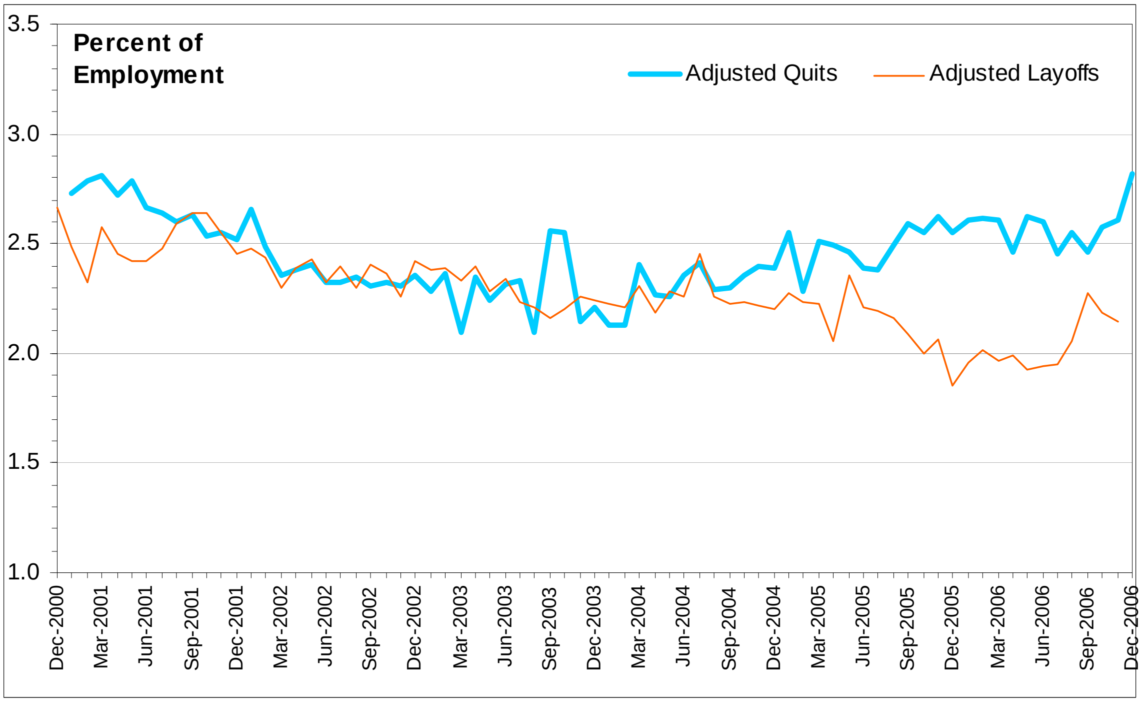


(d) Layoffs Rate



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.

Figure 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.

Table 1. Monthly Worker Flows in JOLTS and CPS Gross Flows Compared

	Hires Rate	**Separations Rate**
JOLTS Published Statistics	3.4	3.3
CPS Gross Flows, Fallick-Fleischman	6.4	6.4

Note: The table reports the mean hires and separations rates from the JOLTS published data and from the updated data of Fallick and Fleischmann (2004) over the January 2001 – December 2006 period. The CPS gross flow measure of hires includes all flows into employment, including employment-to employment flows, while the CPS gross flow measure of separations includes all flows out of employment, including employment-to employment flows.

Table 2. Growth Rate Distributions Compared, JOLTS and BED

Growth Rate Interval	*Monthly, All Obs.* (JOLTS)	*Monthly, Select Sample* (JOLTS)	*Quarterly, Select Sample* (JOLTS)	*Quarterly, All Obs.* (BED)	*Quarterly, Continuous Obs. Only* (BED)
-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	---

Note: The table reports the densities of employment at establishments with an employment growth rate within the specified interval. The columns represent different samplings of the JOLTS and BED data at either the quarterly or monthly frequency, as noted. The JOLTS "select sample" is a sample of establishments with observations for all three months within a given quarter – see text for more details.

Table 3. JOLTS Summary Statistics, Published and Adjusted Statistics

	Published Statistics	Adjusted Statistics
Means (Standard Deviations)		
Hires Rate (*H*)	3.78 (0.25)	4.94 (0.17)
Separations Rate (*S*)	3.70 (0.18)	5.04 (0.26)
Quits Rate (*Q*)	2.06 (0.17)	2.45 (0.17)
Layoffs and Discharges Rate (*L*)	1.40 (0.09)	2.27 (0.18)
Other Separations Rate (*R*)	0.24 (0.03)	0.31 (0.05)
Job Openings Rate (*V*)	2.71 (0.39)	2.88 (0.36)
Unemployment Rate (*U*)	5.29 (0.57)	---
Relative Volatilities		
$\sigma(H)/\sigma(S)$	1.38	0.65
$\sigma(Q)/\sigma(L)$	1.86	0.96
$\sigma(H)/\sigma(V)$	0.65	0.47
$\sigma(V)/\sigma(U)$	0.68	0.64

Notes: Table lists the noted monthly statistics from the publicly available JOLTS estimates and the adjusted estimates from our counterfactual exercise (see text for details). Standard deviations of the monthly data are in parentheses below each mean. Relative volatilities are the ratio of the variances of the listed estimates. The period covers January 2001 – December 2006. The unemployment rate comes from the Current Population Survey.