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Labor Market Flows in the Cross Section and Over Time

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Abstract

Many theoretical models of labor market search imply a tight link between worker flows (hires and separations) and job gains and losses at the employer level. Partly motivated by these theories, we exploit establishment-level data from U.S. sources to study the relationship between worker flows and job flows in the cross section and over time. We document strong, highly nonlinear relationships of hiring, quit and layoff rates to employer growth in the cross section. We also evaluate how well various theoretical models and views fit the patterns in the data. Aggregate fluctuations in hires and layoffs are well captured by empirical specifications that impose a tight cross-sectional link between worker flows and job flows. Aggregate fluctuations in quits are not. Allowing the cross-sectional quit relationship to vary with aggregate conditions leads to a remarkable improvement in fit for quits and improves the fit for other worker flows as well. Overall, we find that incorporating the variation in the cross sectional distribution of job flows across employers has substantial explanatory power in accounting for aggregate worker flows relative to only taking into account standard aggregate labor market variables. Finally, we use our preferred statistical models – in combination with data on the cross-sectional distribution of establishment growth rates – to construct synthetic JOLTS-type measures of hires, separations, quits and layoffs back to 1990.

Keywords: worker flows, job flows, search and matching models, employment fluctuations, cyclicality of quits
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I. Introduction

Many theoretical models of labor market search carry strong implications for the relationship of worker flows (hires and separations) to job gains and losses at the employer level. Partly motivated by these theories, we exploit establishment-level data from U.S. sources to study the empirical relationship between worker flows and job flows in the cross section and over time. The evidence supports a hybrid view that incorporates aspects of several distinct theories of labor market dynamics. We also show that tracking the cross-sectional distribution of establishment growth rates, and applying simple models of cross-sectional behavior, greatly improves our ability to account for aggregate fluctuations in hires, quits and layoffs.

Previous work has not delivered a thorough and convincing explanation for the relationship between worker flows and job flows. One difficulty is that worker flow and job flow measures typically derive from different data sources, and are comparable only at high levels of aggregation. Even then, standard sources of data on these measures differ in scope, sampling frequency and other respects that hinder direct comparison. We overcome these difficulties by exploiting micro data from the Job Openings and Labor Turnover Survey (JOLTS). JOLTS data yield internally consistent measures of hires, separations, quits, layoffs, job creation and job destruction at the establishment and aggregate levels.

To deal with weaknesses in the JOLTS sample design, we rely on the comprehensive Business Employment Dynamics (BED) to track the cross-sectional distribution of establishment-level growth rates over time. We rely on JOLTS for hires, separations, layoffs and quits conditional on establishment growth rates. Combining JOLTS and BED data in this manner also enables us to construct synthetic data on worker flows back to 1990, nearly doubling the time-series length of JOLTS-type worker flow measures.

To guide our empirical work, we consider several theoretical models. Models in the spirit of seminal work by Mortensen and Pissarides (1994) (hereafter MP) imply a tight link between job flows and worker flows. Our empirical work assesses how closely models with these tight links fit the data. We also consider empirical specifications motivated by models that stress the role of search on the job, learning about match quality, firm profitability, and the impact of aggregate conditions on the propensity to quit. We evaluate alternative specifications in terms of their fit to cross-sectional patterns in the establishment-level data, their ability to generate the observed movements in aggregate worker flows, and their marginal explanatory power for aggregate worker flows after conditioning on aggregate variables.

Figures 1 and 2 plot our quarterly, seasonally adjusted time series for JOLTS-type worker flow measures, along with job creation and destruction rates from the BED.[1] All rates cover the nonfarm private sector and are expressed as a percent of employment. We define job creation as the sum of employment gains at new and expanding establishments as in Davis, Haltiwanger, and Schuh (1996). We define job destruction analogously. Figure 1 shows that job destruction and layoffs move together over time, while quits move counter to both. Job destruction and layoffs exhibit pronounced spikes in late 2008 and early 2009 and then decline in nearly parallel fashion. Figure 2 shows that job creation and hires rates decline from 2006, bottom out in 2009Q1, and then partly recover. The hiring rate moves much more than the job creation rate over this period. Our study explores the micro level sources of these aggregate movements.

[1] To conform to the BED sampling frequency, we cumulate monthly establishment-level JOLTS observations to the quarterly frequency. We then construct our aggregate JOLTS series by combining the cross-sectional relationships of worker flows to establishment-level growth rate in JOLTS micro data with employment growth rate distributions from the BED. This approach follows Davis, Faberman, Haltiwanger and Rucker (2010), and we describe it more fully in the text below. Worker flows prior to 2001Q3 in Figures 1 and 2 are synthetic data, constructed as described in Section IV.D below. The last three quarterly observations on hires, quits and layoffs in Figures 1 and 2 reflect certain measurement errors that we have corrected but have not yet received permission to release. Also, the JOLTS-based measures in Figures 1 and 2 and elsewhere in the current draft of this paper stop in 2010Q1, because we are awaiting permission to release the 2010Q2 data.

Looking across establishments, hiring and separation rates exhibit powerful elements of the "iron-link" behavior implied by MP-style search models. That is, hires are tightly linked to job creation, and separations are tightly linked to job destruction. When plotted as functions of establishment-level growth rates, hiring and separation rates exhibit nonlinear "hockey-stick" shapes. The hires relation is nearly flat to the left of zero growth (contracting employers) and rises more than one-for-one with employment growth to the right of zero (expanding employers), with a pronounced kink at zero. The separations relation is a mirror image of the hires relation. The hockey-stick shape for separations is starkly at odds with the simplifying assumption adopted in many search models of a uniform separation rate. Turning to the components of separations, both quits and layoffs rise with job destruction, but layoffs dominate the adjustment margin for rapidly contracting establishments. We also consider how the cross-sectional relations vary with aggregate conditions. As it turns out, the cross-sectional layoff relation is highly stable over time. In contrast, the cross-sectional quit relation varies markedly with aggregate conditions. Specifically, the quit relation shifts downward when aggregate conditions are weak, especially at contracting establishments.

Several theoretical models provide insight into the reasons for departures from an iron-link relationship between worker flows and job flows. Faberman and Nagypál (2009) consider a model of on-the-job search that delivers an "abandon-ship" effect at struggling employers. Firms vary in their idiosyncratic profitability and grow faster when more profitable. Because wages increase with firm profits in their model, workers at low-profitability firms are more likely to accept an outside offer. Consequently, quit rates decline with the idiosyncratic component of firm profitability. Barlevy (2002) considers a model with on-the-job search and a match-specific component of productivity. Because firms create fewer vacancies when aggregate conditions are weak, employed workers encounter better matches at a slower pace during recessions. As a result, workers tend to remain longer in poor matches, which Barlevy refers to as the “sullying” effect of recessions. In sum, Faberman and Nagypal highlight the role of cross-sectional variation in firm-level circumstances for quit rates, whereas Barlevy highlights the role of variation over time in aggregate conditions. Our evidence indicates that both effects are at work.

In Jovanovic (1979, 1985) and Moscarini (2005), gradual learning about match quality leads to a separations rate that declines with match tenure. Because more rapid growth involves a higher share of young matches, these models suggest that separations rise with the growth rate of expanding employers. Pries and Rogerson (2005) integrate elements of Jovanovic-style learning into an MP model. Separations occur because of job destruction, as in the MP model, and because of learning effects about match quality. Thus, the model of Pries and Rogerson generates elements of iron-link behavior in hires and separations while rationalizing a positive relationship between separations and growth at expanding employers. The data support this hybrid view of the cross-sectional relationship between hires, separations and employer growth.

Motivated by these theoretical ideas, we develop parsimonious statistical models of how worker flows vary in the cross section, and how the cross-sectional relations move over time. The statistical models serve three objectives. First, they provide guidance in evaluating, developing and calibrating theoretical models of labor market flows. Second, they allow us to investigate whether tracking the cross-sectional growth distribution adds much to our understanding of aggregate movements in labor market flows. Third, they yield a framework for constructing synthetic data on aggregate hires, separations, quits and layoffs in the period before the advent of JOLTS.

When we consider specifications that impose time-invariant relations of worker flows to employment growth rates in the cross section, the statistical models perform reasonably well in tracking the aggregate movements of the hires rate and the layoff rate. However, the same type of model fails miserably in tracking the aggregate behavior of quits. Consequently, it also fares poorly in accounting for the aggregate separations rate. When we move to a specification that allows the worker flow-employer growth relationships to vary with aggregate conditions, our ability to track aggregate quits and separations improves dramatically.

Our work in this paper has many antecedents. There is a large body of previous research on job flows and worker flows. We review research in this area in Davis and Haltiwanger (1999) and Davis, Faberman and Haltiwanger (2006). Labor market flows and job vacancies play central roles in modern theories of unemployment based on search and matching models. See, for example, Pissarides (2000), Rogerson, Shimer and Wright (2005) and Yashiv (2007) for reviews of work in this area. Models that treat hires as the outcome of a matching function carry implications for the relationship between hires and vacancies in the cross section and over time. We explore some of those implications in Davis, Faberman and Haltiwanger (2010).

The paper proceeds as follows. Section II discusses the conceptual underpinnings that guide our empirical work. We start with the model of Cooper, Haltiwanger and Willis (2006), which extends the basic MP model to multi-worker firms. We then consider models that endogenize the worker’s quit decision, as in Faberman and Nagypál (2008) and Barlevy (2002), and conclude with models of learning about match quality, such as Jovanovic (1979). Section III describes our data and empirical measures. Section IV presents our statistical models and investigates how well they account for worker flows in the cross section and over time. Section V constructs synthetic JOLTS-type data on worker flows, and Section VI concludes.

II. Conceptual Underpinnings

In thinking about worker flows and job flows, it is useful to begin with an identity:

$$e_{it} = e_{it-1} + h_{it} - l_{it} - q_{it}, \tag{1}$$

where e_{it} is employment at establishment i in period t and h, l and q denote hires, layoffs and quits. Separations are the sum of quits and layoffs. Theory provides guidance about how employers use hires, layoffs and quits to adjust employment and about the factors that lead to worker turnover in excess of employment changes. In what follows, we first consider search and matching models that involve an "iron link" between hires and job creation on the one hand and separations and job destruction on the other. We then consider theories that relax the iron link.

II.A. Models with an Iron Link

Every hire reflects a newly created job in the canonical search and matching model of Mortensen and Pissarides (1994), and every separation reflects a job that vanishes. That is what we mean by an iron link between worker flows and job flows. One goal of our study is to assess how well this iron link characterizes the data. However, the basic MP model has no role for multi-worker employers, an essential aspect of our empirical work. So we borrow from Cooper, Haltiwanger and Willis (2007, CHW) to illustrate the implications of the iron link in a multi-worker version of MP.[2]

Employers in the CHW model face common and idiosyncratic shocks and produce output according to a strictly concave function of the labor input. When hiring new workers, employers incur fixed and variable costs of posting vacancies. Workers separate for exogenous reasons, and some employers layoff additional workers subject to fixed and variable firing costs. Employers choose layoffs and vacancies – effectively, hires as well – to maximize the present discounted value of profits. Workers do not search on the job.

The following law of motion links employment changes and worker flows in CHW:

$$e_{it} = (1-\overline{q})e_{it-1} + \eta(U_t, V_t)v_{it} - l_{it}\,, \tag{2}$$

[2] Other recent search-theoretic analyses with multi-worker firms include Elsby and Michaels (2008), Veracierto (2009), Fujita and Nakajima (2010), Schaal (2010) and Trapeznikova (2010).

where $\overline{q}$ is the quit rate, $\eta(U_t, V_t)$ is the job-filling rate, and v_{it} is the number of vacancies posted at the beginning of the period.[3] The job-filling rate derives from a standard matching function with constant returns to scale in the aggregate numbers of unemployed workers and vacant jobs. Period-*t* hires for the employer are $h_{it} = \eta(U_t, V_t) v_{it}$.

An employer in the CHW model operates in one of three regions each period, depending on the aggregate and idiosyncratic shock values: (i) positive vacancies and zero layoffs, (ii) zero vacancies and positive layoffs, or (iii) an inaction region with zero vacancies, no layoffs and no replacement hiring. Solving the model yields a stochastic equilibrium path for the cross-sectional distribution of employment changes, hires, quits and layoffs. The realized path depends in complex ways on the interaction of the aggregate and idiosyncratic driving forces and the key parameters of the revenue, cost and matching functions. Aggregate shocks shift the entire cross-sectional distribution of growth rates, while parameters governing adjustment costs and the variance of idiosyncratic shocks strongly influence its shape. Model-based outcomes exhibit an iron-link mapping of job flows to hiring, layoffs, and quits.

Figure 3 depicts the iron link. It shows the relationship of the hiring, layoff, and quit rates to employer growth rates in the cross section. There is a mass point with no hiring or layoffs at growth rate $-\overline{q}$. To the right of $-\overline{q}$, employers post vacancies and hire new workers. Employers in this range have zero layoffs, and hiring rises one-for-one with increases in employment. To the left of $-\overline{q}$, employers engage in no hiring and the layoff rate rises one-for-one with the rate at which the employer contracts.

Given the iron link relations illustrated in Figure 3, the cross-sectional distribution of employment growth rates fully determines aggregate hires and layoffs. This feature of the model has interesting implications. For example, modest recessions that shift the central tendency of the cross-

[3] We use uppercase letters for aggregate quantities and lowercase letters for establishment outcomes.

sectional distribution from positive values to a value near zero produce large drops in aggregate hires with relatively little increase in aggregate layoffs. In contrast, a deep recession that shifts much of the mass in the cross-sectional distribution across the kink point in Figure 3 produces a large jump in layoffs. Thus, the highly nonlinear micro relations in Figure 3 imply differential responses of hires and layoffs to mild and deep recessions. Below, we treat the aggregate implications of cross-sectional worker flow relations in a more formal manner.

II.B. Relaxing the Iron Link

There are several ways to relax the iron link feature of MP-style models. If we exogenously vary the quit rate in the CHW model, we obtain the implications shown in Figure 4. As the quit rate varies, the kink point moves and the layoff and hires relations shift accordingly. Specifically, a fall in the quit rate from $q(G_0)$ to $q(G_1)$ causes the cross-sectional hiring and layoff relations to shift rightward. That is, the fall in the quit rate creates an environment where employers require fewer hires when expanding and more layoffs when contracting to achieve a given growth rate. More generally, if the quit rate varies systematically with labor market slack, then so do the cross-sectional relations for hires and layoffs. This insight applies in more complex models as well.

Models with endogenous quit behavior deliver other interesting implications. As discussed in the introduction, the model of Faberman and Nagypál (2008) implies that quit rates decline with employer growth rates in the cross section. Workers are more likely to abandon struggling employers because they pay lower wages and cannot match outside offers from more profitable employers. Inspecting Figures 3 and 4, it is apparent that a nonlinear quit relation implies nonlinear relations for one or both of hires and layoffs as well. Somewhat paradoxically, weaker employers face greater needs for replacement hiring to offset, at least partly, a greater attrition rate. Thus, the model of Faberman and Nagypál can deliver a negative slope in the hires relation over some range. In the model of Barlevy

(2002), employers post fewer vacancies when aggregate conditions are weak. As a result, poorly matched employees encounter new job opportunities at a slower rate, and they quit less frequently. This implication of the Barlevy model provides an explanation for the downward shift in the quit rate in Figure 4 and the resulting shifts in the layoff and hiring relations.

Models that feature learning about match quality as in Jovanovic (1979) yield additional insights. Under weak conditions, these models imply that employment relationships dissolve at a rate that declines with match duration. A newly hired worker is more likely to quit because he learns a job is not to his liking, or to be fired because his employer learns he cannot perform. Naturally, the proportion of new employees tends to rise with an employer's expansion rate. Thus, learning about match quality can cause quits and layoffs to rise with the growth rate of employment at expanding employers. In addition, learning about match quality leads to additional separations at shrinking employers when recent replacement hires do not work out. More generally, learning about match quality implies that worker flows beget further worker flows, as stressed by Hall (1995), Pries (2004), and Pries and Rogerson (2005).

The lesson of this discussion is that the stark relations depicted in Figures 3 and 4 are too simple to fully capture the patterns in the data. Nevertheless, we think Figures 3 and 4 are useful starting points for two reasons. First, they provide a straightforward exposition of the links between worker flows and establishment-level growth in a prominent class of search models. We will investigate how closely the data conform to the relations exhibited in Figures 3 and 4. Second, our discussion provides guidance for formulating statistical models that relate worker flows to employer growth rates.

II.C. Aggregate Implications of the Iron Link and Relaxed Iron Link Relationships

The iron link specification of the worker flow-job flow relationship and its departures provide differing implications for the sources and nature of cyclical movements in aggregate worker flow and vacancy rates. To see this, consider the micro-level behavior of worker flows and vacancies as a function of establishment growth, *g*. In any period *t*, the aggregate worker flow rate will be a weighted average of its micro-level relationship with establishment growth, with the weights equal to the density of employment at establishments with a growth rate equal to *g*. Consider the aggregate hiring rate. It can be expressed as

$$H_t = \sum_g f_t(g) h_t(g), \tag{3}$$

where $h_t(g)$ is the mean hiring rate for establishments with a growth rate equal to *g* at time *t*, and $f_t(g)$ is the share of employment at establishments with growth *g* at time *t*. The key insight from this equation is that movements in the aggregate hiring rate can come from one of two sources: shifts in the micro-relationship between the hiring rate and establishment growth or changes in densities of employment across establishment growth rates. By definition, the latter are equivalent to shifts in the cross-sectional distribution of establishment-level growth rates.

It is important to emphasize that equation (3) is simply an accounting identity. That is, aggregate hires rate at time *t* can always be measured by taking the weighted average of establishment-level hires across the full range of growth rates. This will hold for all worker flow rates. Moving away from the accounting identity requires behavioral models of the micro level relationships between worker flows and growth.

Consider the CHW model where there exist iron link relationships between worker flows and establishment growth. Based on the type of identity in equation (3), the aggregate flows from the iron link relationships depicted in Figure 3 will be given by

$$\overline{H}_t = \sum_g f_t(g) \overline{h}(g),$$

$$\overline{L}_t = \sum_g f_t(g)\overline{l}(g), \text{ and} \tag{4}$$

$$\overline{Q}_t = \sum_g f_t(g)\overline{q} = \overline{q} \quad \forall t .$$

The iron link relationships of the CHW model have the stark implication that all movements in aggregate worker flows should come entirely from movements in the cross-sectional distribution of establishment growth. They also have the counterfactual implication that the aggregate quit rate is constant over time at $\overline{q}$.

As we relax the iron link relationships of the CHW model, Figure 4 illustrates that micro level relationships in equation (4) are no longer time-invariant. Denote the micro level relationships depicted in Figure 4 for hires, layoffs and quits as $\tilde{h}_t(g)$, $\tilde{l}_t(g)$, and $\tilde{q}_t$ respectively (where the time subscript on $\tilde{q}_t$ denotes that quits are time varying). The aggregate rates are defined analogously to (4) but replacing the hiring, layoff and quit functions with $\tilde{h}_t(g)$, $\tilde{l}_t(g)$, and $\tilde{q}_t$. In this specification, the cross sectional distribution of establishment-level growth rates will no longer be a sufficient statistic for movements in the aggregate hiring and layoff rates. So long as $\tilde{h}_t(g)$, $\tilde{l}_t(g)$, and $\tilde{q}_t$ are known, however, one will be able to account for the micro level sources of these movements. This general property will hold for any model where the empirical relationship of hiring, layoffs, and quits is known (i.e., can be derived from observable conditions).

As we move to further departures from the iron link specification, the aggregation from the micro level to the aggregate flow rates does not change but the interactions of the micro level growth relationships and the cross-sectional distribution become richer. For example, endogenizing the quit rate as in Faberman and Nagypál (2008) or Barlevy (2002) will introduce a nonlinear relationship between the quit rate and establishment growth (so that $q_t(g)$ will now depend on *g*) and consequently introduce additional nonlinearities in the relationships between hiring and establishment growth and layoffs and establishment growth. Introducing learning about match quality as in Jovanovic (1979) will enrich the micro-level relationships further.

III. Data and Measurement

For our analysis, we appeal to two data sources, the Job Openings and Labor Turnover Survey (JOLTS) and the Business Employment Dynamics (BED) data, both produced by the BLS. The JOLTS is a survey of roughly 16,000 establishments who each month report their employment, total hires during the month, total separations during the month, and number of vacancies open at the end of the month. Establishments report separations separately by quits, layoffs, and other separations (i.e., retirements, intra-firm transfers). For layoffs, the establishments are asked to identify involuntary separations initiated by the employer.[4] For quits, the establishments are asked to identify employees who left voluntarily (excluding retirements which are captured in the other separations category). The survey begins in December 2000 and is representative of all nonfarm employment.[5]

The BED data include longitudinally linked administrative records for all businesses covered under a state unemployment insurance system. As such, it is a virtual census of all establishments. The data are quarterly and include information on the employment and payroll of each establishment, as well as information on various establishment characteristics (e.g., industry, location, whether it is part of a multi- or single-unit firm.) The BLS uses the BED to publish quarterly statistics on private sector gross job creation and gross job destruction that date back to 1992, though microdata exists back to 1990.[6]

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[4] The JOLTS survey instructions for layoffs and discharges includes the following examples: layoffs with no intent to rehire, layoffs lasting more than 7 days, discharges res resulting from mergers, downsizing, or closings, firings or other discharges for cause, terminations of permanent or short-term employees, terminations of seasonal employees (whether or not they are expected to return next season)

[5] For more details on the JOLTS, see Clark and Hyson (2001) and Faberman (2008a). Davis, Faberman, Haltiwanger, and Rucker (2010) address several measurement issues inherent in an earlier version of the JOLTS data.

[6] For more details on the BED data, see Spletzer et al. (2004). The BLS does not publish job flow statistics for the earlier years because of issues related to administrative changes during the 1990-92 period. We employ methods identical to those used by Faberman (2008b) to address these issues.

We use a sample of JOLTS data that cover January 2000 through June 2010 and a sample of BED data that cover 1990Q2 through 2010Q2. Both cover all private sector employment. Due to data access restrictions, our BED sample excludes several U.S. states.[7] A key feature of our analysis is the interaction of the micro-level relationships of worker flows and establishment growth derived from the JOLTS data with the employment growth rate distributions derived from the BED. Consequently, we need to construct quarterly worker flow rates from the JOLTS data. In doing so, we require that establishments are observed in the JOLTS data for all three months of a quarter. This restriction reduces our sample by about 12 percent and produces slightly lower aggregate worker flow estimates than one would derive from the published JOLTS statistics, but it does not alter the cyclicality of the aggregate estimates. We also have to deal with several measurement issues related to the JOLTS data. These include accounting for sample weighting at a quarterly frequency, addressing timing differences in the measurement of worker flows and employment in the JOLTS data, and imputing worker flow estimates for opening and closing establishments (which are present in the BED data but not in our JOLTS sample). We detail how we deal with these issues in the appendix.

We use the BED data to calculate the cross-sectional distribution of establishment-level growth rates for each quarter. Since the BED data are the universe of all establishments, we do not have to deal with the issues related to sample weighting, timing, and establishment entry and exit noted for the JOLTS sample above. We measure the net employment change for a quarter as the difference between employment during the third month of the current quarter and employment during the third month of the previous quarter. We measure the employment growth rate as the net change divided by the same average employment measure as above. We also use the average employment measure when expressing

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[7] These states are Connecticut, Florida, Massachusetts, Michigan, Mississippi, New Hampshire, New York, Pennsylvania, and Wyoming. The patterns of job creation and destruction at the aggregate level from the BED that excludes these states closely mimics the analogous patterns from the published statistics that include these states.

worker flows as rates and when employment weighting worker flow or growth rates across groups of establishments.

Figure 5 shows the kernel density estimate of the cross-sectional distribution of establishment-level growth rates averaged across two periods in the sample: 2006Q1-2006Q4 and 2008Q3-2009Q2, while Table 1 summarizes the density of employment at expanding, contracting and stable establishments pooled over selected periods. The periods are chosen to roughly coincide with the recession and expansion periods of our sample. Figure 5 shows that the bulk of employment is at establishments who grew or contracted by less than 10 percent, or had no change in employment. Table 1 shows that this latter group accounted for roughly 15 percent of employment in 2006, and that this fraction rose slightly during the 2008-09 period. Establishments with employment changes of 10 percent or less account for roughly three-quarters of employment and establishments with employment changes of 30 percent or less account for about 90 percent of employment. As Figure 5 shows, there is a clear leftward shift of the growth rate distribution from 2006 to the 2008-09 period. This shift is most apparent at establishments either expanding or contracting by 10 percent or less. Table 1 shows that the fraction of employment at establishments expanding by 10 percent or less falls from 30.7 percent to 27.4 percent, while the fraction of establishments contracting by 10 percent or less rises from 28.0 percent to 30.8 percent. Such movements are characteristic throughout our sample period. In particular, recessions are generally periods where the fraction at expansions declines and the fractions at contractions or stable establishments increase.

IV. Accounting for Labor Market Flows

IV.A. Methodological Framework

One goal of our analysis is to assess how well the implications of standard models of labor market search and matching fit the data. To this end, we develop an empirical framework for estimating aggregate time-series derived from the worker-job flow relationships implied by the models discussed in Section II. We then assess how well these derived aggregate series fit the actual time-series of aggregate worker flow rates.

Our framework rests on estimating relationships between worker flows and establishment growth using regression specifications motivated by our theoretical models. We then interact these estimated relationships with the growth rate distributions derived from the BED data to produce an aggregate time series that we compare to the actual time series of aggregate worker flows.

We begin by estimating the mean worker flow rates for all establishments whose growth rate falls within some interval.[8] Note that this follows the identity relationship in equation (3). We use our quarterly JOLTS sample to estimate the employment-weighted mean rate for either hiring, layoffs, or quits by growth rate interval and quarter. Let $w_t(g)$ denote one of these rates for growth rate interval g during quarter t.

We estimate what we consider to be the "actual" estimate of aggregate worker flow rates by interacting the $w_t(g)$ from the JOLTS with the quarterly growth rate distributions derived from the BED data.[9] Let $f_t(g)$ denote the share of employment within growth rate interval g during quarter t. The aggregate estimate of each worker flow rate is then

$$W_t = \sum_g f_t(g) w_t(g) \,. \tag{5}$$

[8] We use 37 growth rate intervals that range from -200 percent to 200 percent and increase in size as the absolute value of the growth rate increases. These intervals include separate designations for establishments with growth rates of zero, -200 percent (exits) and 200 percent (entrants). We use intervals of varying length because of the sparse number of observations of establishments with extreme growth rates. Note that our JOLTS sample only includes continuous establishments, but we incorporate assumed worker flow rates for entrants and exits when we aggregate the micro-level relationships to the macro level.

[9] We regard the estimates of the "actual" flows using (5) as more reliable than the published estimates from JOLTS for the reasons discussed in detail in Davis, Faberman, Haltiwanger and Rucker (2010). Roughly speaking, equation (5) yields an *estimate* of the actual flow that accounts for entry and exit as well as for other sampling issues in JOLTS. It also provides a natural benchmark for our statistical models that follow, since all use the BED densities as weights in their aggregation.

We next turn to out statistical models of the micro level relations between worker flows and establishment growth. Our first specification is motivated by the iron link relationship of the CHW model (and related MP-style search models). It postulates that the micro-level relationships for hires, layoffs and quits are constant over time. We denote this as the fixed cross-sectional specification as we regress each micro flow rate on a set of dummy variables representing one of the growth rate intervals, $\alpha(g)$, that are fixed over time,

$$w_t(g) = \alpha(g) + \varepsilon_t^D(g). \tag{6}$$

Since they only depend on $\hat{\alpha}(g)$, the predicted values from this regression, $\hat{w}^D(g)$, will be constant across all quarters. We also depart somewhat from the CHW model in that, for the quit rate, it has the stark implication that $\hat{\alpha}(g) = \hat{\alpha}, \forall g$ but we allow these effects to vary by growth rate interval. Allowing such flexibility will permit this specification to capture nonlinearities such as the backward S-shape relationship implied by the FN model. It will not, however, allow for changes in the quit-growth relationship over time implied by the Barlevy (2002) model. We produce the aggregate time series implied from this model by replacing the actual worker flows in (5), $w_t(g)$, with $\hat{w}^D(g)$.

Our second specification is motivated by the models in Section 2 that relax the iron link relationships by allowing for cyclical variation in the quit-growth relationship, and subsequently in the hires-growth and layoffs-growth relationships. To account for such movements, we specify a regression of the form

$$w_t(g) = \alpha(g) + \beta_1 G_t^+ + \beta_2 G_t^- + \beta_3 \Delta G_t + \beta_4 JF_t + \varepsilon_t^B(g), \tag{7}$$

where G_t^+ is the aggregate net employment growth rate conditional on a positive rate, G_t^- is the aggregate net employment growth rate conditional on a negative rate, ΔG_t is an accelerator term that measures the change aggregate net employment growth rate, and JF_t is the aggregate job-finding rate of the unemployed.[10] We refer to this as our baseline specification since it allows for changes in the micro-level relationships over the business cycle in the most parsimonious way. It is flexible enough to capture the movements in hires, quits and layoffs depicted in Figure 4. We generate the aggregate worker flow rates predicted from this specification by replacing the actual worker flows in (5) with the predicted $\hat{w}_t^B(g)$ estimates obtained from (7).

Finally, further relaxations of the iron link relationship could include disproportionate shifts in the flow-growth relationships over time, as in Barlevy (2002). Therefore, we extend the baseline specification to include an interaction term between the aggregate net employment growth rate and job-finding rate and a set of class variables, $D(\tilde{g})$, that categorize the growth rate intervals into several groups,[11]

$$\begin{aligned} w_t(g) = \alpha(g) + \beta_1 G_t^+ + \beta_2 G_t^- + \beta_3 \Delta G_t + \beta_4 JF_t \\ + \delta_1 D(\tilde{g}) G_t + \delta_2 D(\tilde{g}) JF_t + \varepsilon_t^F(g) \end{aligned} . \tag{8}$$

Denote the predicted values from the flexible specification as $\hat{w}_t^F(g)$. The aggregate worker flows based on this specification replaces the actual worker flows in (5) with $\hat{w}_t^F(g)$.

IV.B. The Cross-Sectional Relationships of Worker Flows and Growth

Figure 6 presents the fixed cross-section estimates for hiring, total separation, layoff, and quit rates as a function of establishment growth. It allows a straightforward comparison to Figure 3. The top panel shows the relationships over a wide range of establishment-level growth and the bottom panel over a narrower range. Both panels are instructive since establishments with large changes (e.g.,

[10] We obtain the aggregate growth rate measures from the published Current Employment Statistics (CES) estimates of the BLS. The JOLTS survey is designed so that the difference between its aggregate hiring and separation rates is roughly equal to the CES aggregate net growth rate. We measure the job-finding rate as the fraction of unemployed who become employed from one month to the next, as measured in the Current Population Survey.

[11] The class variables aggregate the *g* growth rate intervals into five groups, with two dummy variables representing expansions or contractions of up to 10 percent of employment, respectively, two dummy variables representing $g < -10$ percent and $g > 10$ percent, respectively, and one dummy variable representing zero-growth.

establishment births and deaths) contribute disproportionately to flows but much of the cross-sectional employment-weighted distribution of establishment growth is, as seen in Figure 5, in a narrower range.

Both panels show that the hiring rate exhibits a strong, nonlinearly increasing relationship with growth at the establishment level. When interpreting the figure, keep in mind that the negative growth to the left of zero along the horizontal axis represents establishment-level job destruction and the positive growth to the right of zero represents establishment-level job creation. The hiring rate is positive but essentially constant for contracting establishments. The lower panel shows that even contracting establishments have a non-trivial hiring rate. The hiring rate is lowest for establishments for no employment change. It then increases nearly one-for-one with the job creation rate for expanding establishments. It is apparent from the lower panel that the slope of hires with respect to job creation is greater than one. Separation rates exhibit strong, nonlinearly decreasing relationships with growth, though there are notable differences between the relationships of its components (layoffs and quits).

Both the layoff rate and the total separation rate exhibit a relationship to establishment growth that is a mirror-image of the hiring-growth relation. Separations increase nearly one-for-one with the job destruction rate for contracting establishments and are essentially constant for expanding establishments. The slope of separations with respect to job destruction is greater than one as is apparent from the lower panel. Layoffs also rise sharply with job destruction and essentially constant for expanding establishments. Establishments with zero growth have the lowest layoff and total separation rates. For sharply contracting establishments, layoffs dominate quits. However, for establishments with more modest contractions, quits are higher than layoffs. The quit rate is highest for contracting establishments, but rises with the job destruction rate until about a 30 percent quarterly contraction rate and then remains constant for establishments with larger contractions. The quit rate is also constant with respect to the job creation rate, albeit at a lower level. As with the other worker flows, the quit rate is lowest for establishments with zero growth. The quit rate is, however, higher for contracting establishments relative to expanding establishments. For ease of exposition, we do not show the patterns for other separations (i.e., retirements, intra-firm transfers) in the figure although they are part of total separations. They are very small on average (less than one percent of separations). We note that they increase somewhat with large contractions, but otherwise exhibit a constant rate with respect to growth.

The predictions of an iron link relation between worker flows and employer growth of the CHW and MP-style models are broadly supported by these fixed-effect estimates for hires and layoffs. Layoffs rise sharply with the size of a contraction and hires sharply with the size of an expansion. The positive hiring rates for contracting establishments and the positive layoff rates for expanding establishments are not strictly consistent with the iron link model, but the rates over these ranges are relatively small and relatively constant, and the latter feature is consistent with these models. Also, unlike Figure 3, the point of inflection of the "hockey sticks" for hires and layoffs is not centered at the average quit rate but at zero. As discussed in Section II, this pattern is potentially consistent with the iron link models that allow for stochastic behavior and/or heterogeneity in quits.

The quit-growth rate relationship is generally flat relative to the layoff-growth relationship, consistent with the CHW model, but there are clear and systematic departures from the strict prediction of a flat quit-growth relationship. Indeed, the relationship roughly has the backward S-shape predicted by the FN model. The rising portion of the backward S-shape for establishments with modest employment contractions is consistent with the "rats leaving a sinking ship" implication of the FN model. The backward S-shape relationship for quits also affects hiring and layoff behavior at establishments with small contractions. Hires rise with contractions just to the left of zero and layoffs do not rise as steeply as quits for mild net contractions.

We also evaluate how much of the variation in worker flow rates are captured by our statistical specifications in the previous section. As we show in the appendix, the fixed-cross section specification along does very well in accounting for the variation in worker flow rates across quarterly growth rate bins. Movements in the cross-sectional density of growth alone accounts for 98 percent of the variation of hiring and separation rates. It accounts for a slightly lower fraction of the variation in layoff rates (96 percent) and quit rates (85 percent).[12]

The hockey stick patterns reflect a common sense view of the relationship between workers and job flows that is inherent in the structure of MP-style models -- hires are tightly linked to job creation and layoffs are tightly linked to job destruction. However, it is important to emphasize that there is no mechanical relationship that generates these relationships. In this regard, we note the patterns in Figure 6 differ from the cross-sectional relationships found by Abowd, Corbel, and Kramarz (1999) using establishment data from France. They find that hiring is the primary margin of employment adjustment at the establishment level, even for contracting establishments. One reason for the difference may be differences in the nature of labor adjustment in France versus the U.S. It is also apparent that the assumption that some search and matching models make that separation rates are constant across employers is flatly at odds with the cross sectional patterns in the data. An open question is whether these nonlinear micro relationships matter for aggregate fluctuations. It is this question which is the primary focus of the remainder of the paper.

IV.C. Aggregate Behavior Implied by the Fixed Cross-Section Specification

While the estimates and fit of the fixed cross-sectional specification provide critical insights, our primary means of evaluating the success of any given specification is to consider how well it accounts for the observed aggregate fluctuations in the flow rates. Therefore, we compare the actual flows to the

[12] In the next draft of the paper, we will also include some additional exercises to quantify how much of the establishment-level variation in worker flows is accounted for by establishment-level variation in job flows.

aggregate flows implied from the fixed cross-section specification in (6). We estimate our specification for the hiring rate, the separation rate, as well as separation's and its component rates (layoffs, quits, and other separations) for completeness. The reported estimates use JOLTS establishments pooled across all quarters in our sample (2001Q1 – 2010Q1).[13]

The results of this exercise are plotted in Figure 7 (Figure 7 also includes results from other specifications that we discuss below). Each panel shows the actual aggregate rate (W_t) and the rate from the fixed cross-section specification ($\hat{W}_t^D$). The latter are labeled "implied by fixed cross-section relation". These findings imply that movements in the cross-sectional growth rate distribution interacting with the fixed cross-section relation do a fairly good job of predicting the aggregate movements in the hiring and layoff rates. The implied hiring rate from the fixed cross-section relation exhibits a much more modest decline in hires than actual hires in the 2008-2009 period. However, the fixed cross-section relation yields a notable increase in hires from 2009:1 through 2010:1. The layoff rate implied by the fixed cross-section relation more closely captures the actual rise in the layoff rate in this downturn.

The quit rate implied by the fixed cross-section relation tracks the actual quit rate poorly. Consequently, the fit of the aggregate separation rate is also poor. In fact, the quit rate series implied by the fixed cross-section relation is essentially a flat line for most of the period, and the specification predicts a counterfactual rise in the quit rate (and in the separation rate) during the 2008-09 downturn.

[13] We perform all of our exercises on seasonally unadjusted data and then seasonally adjust the aggregate time series of each exercise using the Census X-11 methodology. In addition, in this and subsequent exercises, we omit the first two quarters of the JOLTS sample (2001Q1-2001Q2) from the analysis. The JOLTS data have substantially fewer observations during these early quarters relative to the rest of the sample (2700 per quarter on average, compared to 6344 for the rest of the period), These quarters have relatively sparsely populated growth rate intervals, and consequently less precise estimates of the micro-level flow-growth relationships.

Table 2 quantifies what Figure 7 illustrates (like Figure 7, Table 2 includes results for other specifications that we discuss below).[14] The first column reports the standard deviation of the actual series for each of the worker flows. The second column reports the root mean squared error implied by the fixed cross-section alone as well as the correlation between actual and worker flows predicted from the fixed cross-section relation. The root mean squared error for the difference between the actual and implied hire series is 66 percent as large as the standard deviation of the hiring rate and the analogous root mean squared error for layoffs is about 59 percent as large as the standard deviation of the layoff rate. In addition, the correlation between actual and implied series is very high for both hires and layoffs (above 0.85). Consistent with Figure 7, these findings imply that the fixed cross-section relation model does a reasonable job of capturing the variation in hires and layoffs. The same conclusion does not hold for separations and quits. In both cases, the root mean squared error is large relative to the standard deviation of the actual series and the correlation between the implied and actual series is low. Since quit rates exhibit considerable movement over the sample period, the analogue of equation (3) for quits suggests that the micro-level relationship of quits with growth must vary over time. If these movements are simple functions of aggregate conditions, our baseline and flexible specifications will capture such fluctuations.

IV.D. Changes in the Cross-Sectional Relations over Time

Before proceeding to the analysis of the baseline and flexible specifications, we explore how the fixed cross sectional specification results vary over sub-periods. That is, instead of pooling over all quarters as in Figure 6, we estimate the fixed cross sectional specification separately for three selected periods: 2001Q2 – 2003Q1 (a relatively mild recession followed by a prolonged "jobless recovery"), 2006Q1 – 2006Q4 (an expansion period), and 2008Q3 – 2009Q2 (a deep recession). Note that the sub-

[14] As in Figure 7, Table 2 uses seasonally adjusted actual and predicted series. The patterns for Table 2 using not seasonally adjusted actual and predicted series is quite similar.

periods are defined over full years to account for any seasonal movements in the micro-level relationships. The results from this exercise are in Figure 8. We focus on differences between growth rates of -30 and 30 percent, which constitutes the bulk of the employment (about 90 percent of the distribution) at the quarterly frequency.

As one might expect from our results thus far, we observe relatively little change in the relationships between the hiring rate and growth and between the layoff rate and growth. There are some notable differences over time—the hiring rate is lower and the layoff rate is slightly higher during the 2008-09 recession, particularly at contracting establishments—but these changes are relatively small. These relatively modest shifts are broadly consistent with iron link specification in Figure 3.

The shifts in the quit-growth relationship, and to a lesser extent, the separation-growth relationship, over time are considerably more pronounced. The quit rate is lowest during the 2008-09 recession and highest during 2006. In addition, the differences are more pronounced for contracting establishments. Among expanding establishments, the difference in quit rates between 2006 and 2008-09 ranges between 1.5 and 2 percentage points. In comparison, establishments who contract by 10 percent have a difference of 2.3 percentage points and those who contract by 30 percent have a difference of over 10 percentage points. These large differences are not present in comparing 2006 to the 2001-2003 period suggesting that the severity of the 2008-2009 downturn is important for the cyclical patterns of quits. These patterns reinforce the finding that models with an iron link relation between worker flows and job flows cannot fully account for the observed movements aggregate worker flow rates. The systematic movements in these relations, however, suggest that our baseline and flexible form specifications should provide a better approximation of these aggregate fluctuations.

IV.E. Relaxing the Iron Link Specification

To evaluate the results from the baseline and flexible functional form specifications, we focus on the implied aggregate worker flows from each model. That is, we first estimate each model at the micro level using (7) and (8), respectively, and then generate the implied aggregate flows as we did with the fixed cross-section specification.

The time-series behavior of the worker flow implied by the baseline specification are overlaid with the series implied by the fixed cross-section specification and the actual aggregate series in Figure 7. Since it is practically identical to the baseline series, we refer the reader to the appendix for the time series patterns for our flexible specification. One can clearly see the improvement in fit for the hiring and quit rates, as the baseline series now accurately captures that large drop in hiring and quits observed in the actual series during 2008 and 2009 as well as the subsequent increases in hires (actual quits remain quite low in the 2009:1 to 2010:1 period and the baseline model is consistent with this pattern). [15]

There is less difference between the baseline specification and the fixed cross-section specification for the layoff rate, in part because shifts in the establishment growth rate distribution already accounted for a large fraction of the movements in the layoff rate. However, the baseline model captures more of the spike in layoffs in late 2008 and 2009, reflecting the shift away from quits and towards layoffs for contracting establishments as evident from Figure 8. By more accurately tracking quits and layoffs, the baseline model correctly predicts a declining and weakly procyclical total separations rate.

[15] Figure 7 also highlights that the predicted baseline series exhibits less month-to-month noise in the worker flows compared to the actual series. In that respect, it is not clear that the objective for the models is to exactly produce the actual series since the latter is subject to sampling error in a manner that the predicted models, because of their reliance on administrative data for movements in their growth rate distributions, may mitigate.

The third and fourth columns of Table 2 reports the root mean squared error from the difference between the actual and implied baseline and flexible specification worker flow series, respectively, as well as the correlation between actual and worker flows predicted from each model. The baseline specification provides a substantial improvement in fit on these dimensions for all worker flow rates. The root mean squared error decreases substantially for all worker flow rates and the correlation of actual series with all implied flows is above 0.92. The improvement in fit for the quit rate is remarkable. The root mean squared error falls by nearly three-quarters and the correlation between the actual and predicted series increases from 0.105 to 0.969 when moving from the fixed cross-section to the baseline specification. In all cases, the flexible specification adds modest improvement in fit over the baseline specification. There are very modest decreases in the root mean squared error (most notably for quits and layoffs) but no improvements in correlations for any of the series.

The results for the baseline model, in particular, provide support for the view that relaxing the iron link relationships to account for aggregate conditions, as depicted in Figure 4, provides a reasonably accurate accounting of movements in the aggregate hiring, layoff, and quit rates. Put differently, the results suggest that by knowing the shape *and cyclical movement* of the micro-level relationships between hires, layoffs, quits and establishment growth, along with movements in the cross-sectional distribution of establishment growth, one can account for almost all of the variation in aggregate worker flow rates. This is especially true for the aggregate quit rate, where movements in the cross-sectional density of growth alone account for a tiny fraction of its cyclical behavior.

We now turn to an overall assessment of the importance of accounting for the interaction of the micro-level relationships with the variation in the cross sectional density of employer growth rates for aggregate worker flow fluctuations. Table 3 presents results that quantify the importance of taking the cross sectional distribution of establishment growth rates into account. Column 1 of Table 3 shows the

R-squared from regressing the aggregate flows on the aggregate net growth rate and job-finding rate terms that are included in the baseline specification. Column 2 of Table 3 shows the R-squared from adding as a regressor $\hat{W}_t^D$, the aggregate rate predicted from the fixed cross-section specification.[16] We also report in parentheses the p-value for this additional regressor. Variation in $\hat{W}_t^D$ is entirely driven by variation in the cross sectional distribution of growth rates. As such, the difference in the R-squared between the two columns provides a metric of the additional explanatory power obtained from taking into account such variation.

Column 1 shows that a substantial fraction of the variation in the aggregate worker flows is accounted for by the aggregate growth rate and job-finding rate terms. This is not surprising since all of the worker flows have pronounced cyclical patterns. The highest R-squared value is for the quit rate, which is also not surprising given how much adding the aggregate variables to our statistical model improved the fit of the quit rate. Column 2 shows the additional explanatory power from including $\hat{W}_t^D$ as an additional regressor. For hires, separations, quits, and layoffs there is substantial explanatory power gained by accounting for the variation in the cross sectional distribution of establishment growth rates. For hires, and layoffs it adds over an additional 17 percentage point increase in the R-squared and for separations it adds a 34 percentage point increase. While still significant, the addition of $\hat{W}_t^D$ in the quit rate specification only increases the R-squared by 3 percentage points.

[16] Note that we have also considered a version of Table 3 where we use $\hat{W}_t^B$ and obtain virtually the same results. This is not surprising even though the baseline specification yields superior results in Table 2 and Figure 7. In the exercise for Table 3, we have also included as independent regressors the aggregate variables we use in the baseline specification so the additional explanatory power from the aggregate variables in the baseline series has already been accounted for.

V. Synthetic Data on Worker Flows

A byproduct of our analysis is the ability to use our framework to generate estimates of aggregate worker flow rates out of sample. Specifically, given out-of-sample data on quarterly growth rate densities, $f_t(g)$, and aggregate employment growth, G_t, and job-finding rates, JF_t, one can use the estimates derived from our framework to create an synthetic series of the aggregate worker flow rates. The approach is clear once one refers back to our baseline specification. Once we obtain the coefficient estimates from the regression in (7), we can generate the predicted values, $\hat{w}_t^B(g)$, for a time series as far back as we have data on G_t and JF_t. Then, given the aggregation with the actual cross sectional distribution of establishment growth rates, we can generate an aggregate time series of worker flow rates for as far back as we have data on $f_t(g)$.[17]

We employ exactly this approach. We use our baseline specification, since it provided the best fit of the actual estimates in the previous section. We use the same employment growth rate and job-finding rate series that we used in the baseline specification and the quarterly growth rate distributions from the BED for $f_t(g)$. The latter only go back to 1990Q2, so this is the start date for our predicted series.

One can observe these series in Figures 1 and 2. Figure 1 presents the synthetic estimates of the quit rate and layoff rate overlaid with the BED job destruction rate. It is striking the degree to which the layoff rate and job destruction rate track each other. Both spike sharply during the 1990-91 recession, exhibit a moderate but prolonged rise during the 2001 recession, and rise sharply in 2008-09. The predicted quit rate is strongly procyclical, exhibiting sharp declines at the onset of all three recessions. Figure 2 shows the behavior of the synthetic series for the hiring rate overlaid with the aggregate job creation rate from the BED data. Hiring and job creation track each other closely. Both

[17] In the next draft of the paper, we will consider some tests of out of sample forecasts using within sample variation. The within sample time series period is too short to split the sample and explore how well the forecasting model for part of the sample performs in the remaining part of the sample. However, by exploiting spatial variation by region we can conduct such out of sample forecast tests.

exhibit a mild decline during the 1990-91 recession, a moderate decline during the 2001-03 downturn, and a precipitous drop during the 2008-09 recession. Of the two, the hiring rate is more cyclically volatile.

Taken at face value, the estimates worker flow rates in Figures 1 and 2 provide a rich perspective on the changes in the secular and cyclical dynamics of worker and job flows over the last couple of decades. It is evident that the U.S. labor market exhibited more dynamism in the 1990s with a higher pace of worker and job flows than in the post-2000 period. Especially notable is the difference in the boom of the second half of the 1990s relative to the boom of the 2004-2006 period. Job creation, hires and quits are notably higher in the second half of the 1990s relative to the 2004-2006 period.

As a check of the validity of our synthetic estimates, we compare the behavior of our layoff rate series to two measures that should, in theory, exhibit similar behavior: the inflows into unemployment, as measured by the Current Population Survey (CPS), and initial unemployment insurance (UI) claims. We focus on layoffs for this purpose since these latter series are readily available and should in principle be closely related to the JOLTS (actual and synthetic) layoff series. Both the layoff and UI claims series represent the involuntary separation of a worker from a job and most moves from employment to unemployment are due to a layoff rather than a quit (see Elsby, Hobijn, and Sahin, 2009).

Figure 9 plots our synthetic layoff rate series along with the job destruction rate from the BED, the CPS unemployment inflow rate, and the UI initial claims rate. The latter two are measured as quarterly sums and their rates represent percentages of employment. The figure shows that the behavior of the layoff series matches the behavior of the unemployment data reasonably well. All three series exhibit strong countercyclical behavior and exhibit sharp spikes during each of the three recessions of the sample period. The most notable departure is that the two unemployment series appear to exhibit a greater decline than the layoff series during the expansion periods, though this occurs during both the within-sample and earlier out-of-sample periods.

VI. Concluding Remarks

We integrate the relatively new JOLTS and BED data at the establishment-level to study the relationship between worker flows and job flows in the cross section and over time for the U.S. To put structure on the empirical analysis, we begin with models that imply a tight link between job flows and worker flows in the spirit of the seminal work by Mortensen and Pissarides (1994). Consistent with these models, we show that hires and layoffs exhibit powerful, highly nonlinear relationships to employer growth in the cross section. We also find evidence that quits exhibit nonlinear relationships to employer growth in the cross section consistent with models that allow for endogenous quits. For example, quits are higher at contracting compared to expanding establishments.

We develop a statistical framework for evaluating how well various models and views fit the patterns in the data. Aggregate fluctuations in hires and layoffs are well captured by empirical specifications that impose a tight cross-sectional link between worker flows and job flows. Aggregate fluctuations in quits are not. Allowing the cross-sectional quit relationship to vary with aggregate conditions leads to remarkable improvement in fit and improvements in the fit for other worker flows. Overall, we show that taking into account the variation in the cross sectional distribution of job flows across employers has substantial explanatory power in accounting for aggregate worker flows relative to only taking into account standard aggregate labor market variables.

The strong procyclicality of aggregate quits helps reconcile the differences in the cyclical volatility of aggregate worker and job flows. Hires are much more volatile than job creation in the aggregate over time. In a cyclical downturn, there is a decline in hires associated with the decline in job creation but there is an additional decline in hires associated with the decline in quits. In this respect, the procyclicality of quits drives a wedge in the relationship between hires and job creation. The strong procyclicality of quits also helps reconcile the differences in cyclicality between job destruction and separations. The evidence shows that job destruction and layoffs are tightly linked in the cross section and strongly countercyclical in the aggregate over time (consistent with MP models). However, the procyclicality of quits largely offsets the countercylicality of layoffs so that aggregate separations are roughly acyclical.

We take advantage of the tight fit of our statistical models along with historical BED data to construct synthetic JOLTS-like measures of hires, separations, layoffs and quits back to 1990. In this way, we nearly double the length of the time series on hires, separations, layoffs and quits available for analysis in future research. While not the focus of the current analysis, one immediate observation that emerges from these extended series is that the U.S. labor market was much more dynamic in the 1990s relative to the post 2000 period, with a much higher pace of worker and job flows in the 1990s. Other sources of data also identify a strong secular decline in the pace of worker and job churning activity. See Davis et al. (2006, 2010). Investigating the sources of the secular decline in the pace of job and worker reallocation activity in recent decades is an important area for future research.

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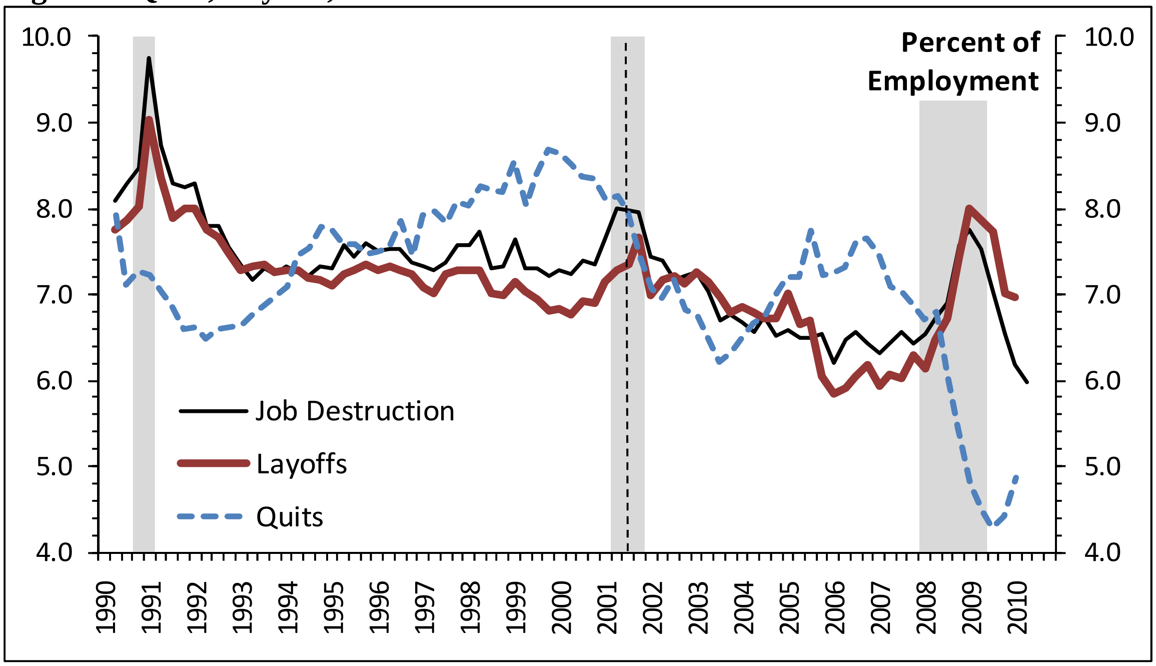
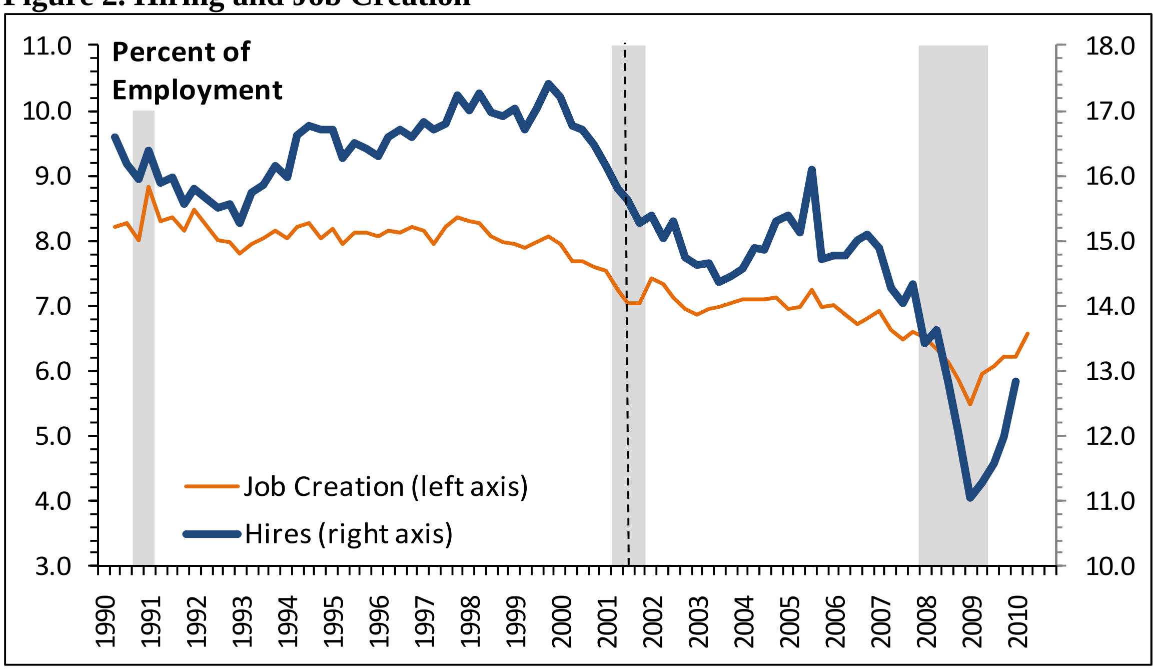
Figure 1. Quits, Layoffs, and Job Destruction



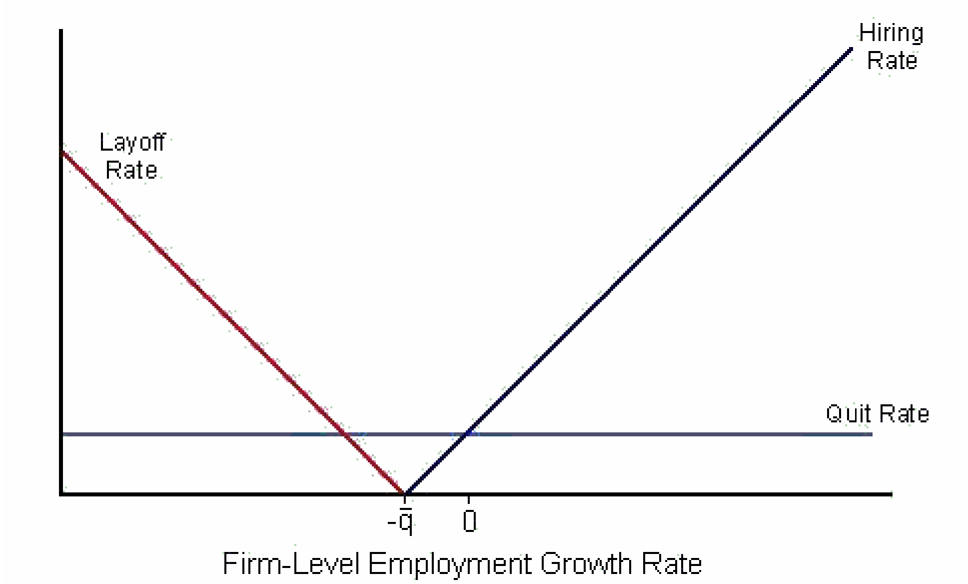
Sources: Quit and layoff rates (2001Q3 – 2010Q2) are authors' calculations using JOLTS establishment microdata weighted to an aggregate value for each quarter using growth rate densities from the BED. Job destruction rates (1990Q2 – 2010Q2) are authors' tabulations directly from the BED data. All estimates are seasonally adjusted. All rates are percentages of employment. Backcasted estimates of the quit and layoff rates are included to the left of the dashed vertical line.

Figure 2. Hiring and Job Creation



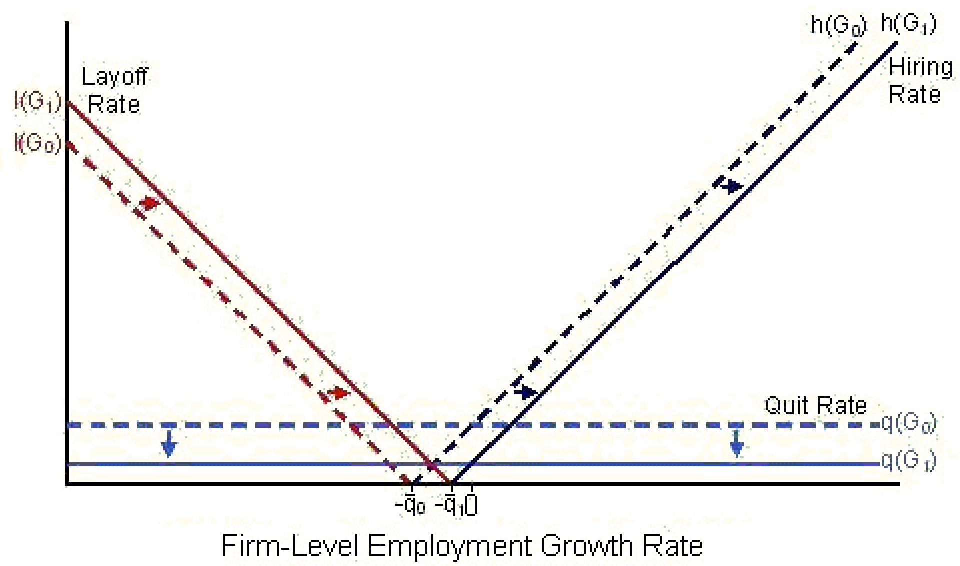
Sources: Hiring rates (2001Q3 – 2010Q2) are authors' calculations using JOLTS establishment microdata weighted to an aggregate value for each quarter using growth rate densities from the BED. Job creation (1990Q2 – 2010Q2) rates are authors' tabulations directly from the BED data. All estimates are seasonally adjusted. All rates are percentages of employment. Backcasted estimates of the hiring rate are included to the left of the dashed vertical line.

Figure 3. Implied Worker Flows from a Search Model with Multi-Worker Firms, Constant Exogenous Quit Rate



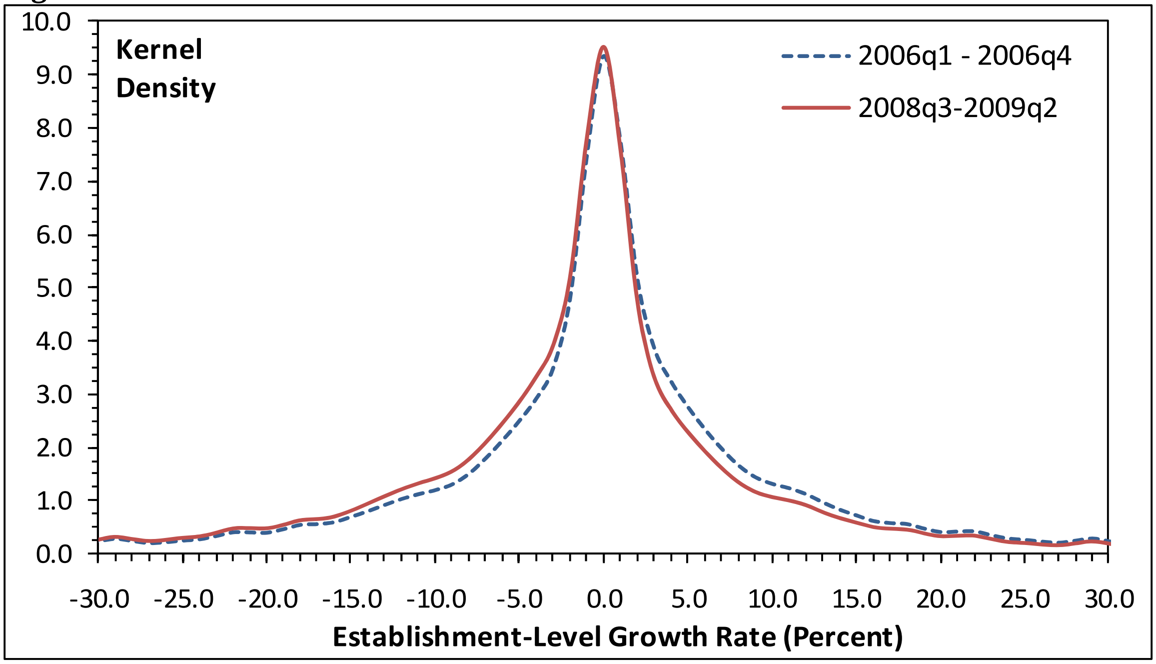
Notes: The figure depicts hiring, layoff, and quit rates as a function of the firm-level quit rate for a search model with multi-worker firms and a constant, exogenous quit rate, $\overline{q}$, faced by all firms. See text for model details.

Figure 4. Implied Worker Flows from a Search Model with Multi-Worker Firms, Time-Varying Exogenous Quit Rate



Notes: The figure depicts hiring, layoff, and quit rates as a function of the firm-level quit rate for a search model with multi-worker firms and a exogenous quit rate, $\overline{q}$, that varies with aggregate conditions, *G*, and is faced by all firms. See text for model details.

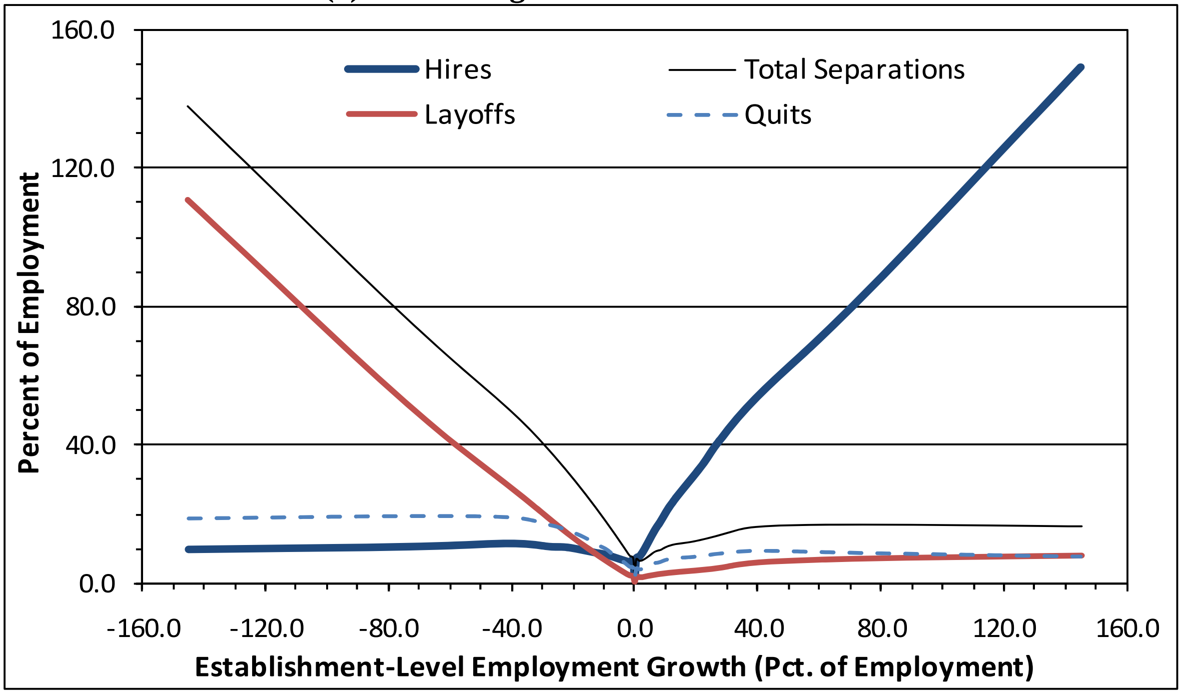
Figure 5. The Cross-Sectional Distribution of Establishment-Level Growth Rates



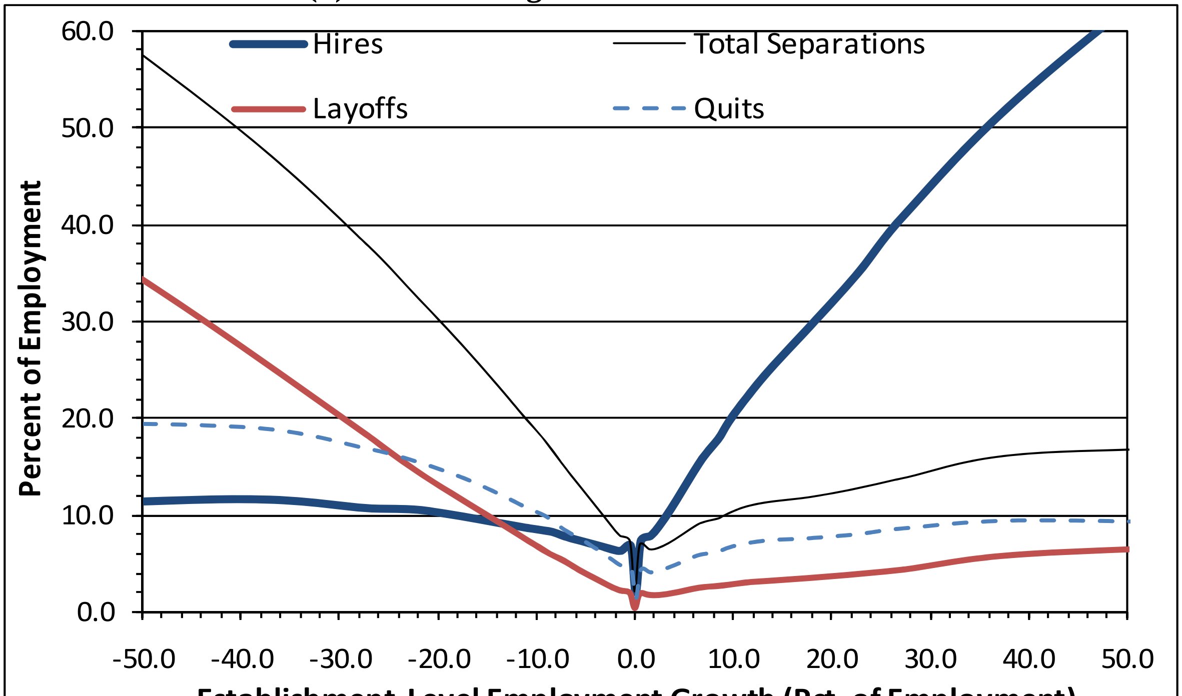
Source: Authors' tabulations using BED establishment data. Estimates are employment-weighted kernel density functions of establishment-level growth rates. The "2006" densities are pooled over 2006Q1-2006Q4 and the "2008-09" densities are pooled over 2008Q3-2009Q2.

Figure 6. Worker Flow Rates as a Function of Establishment-Level Growth

(a) Wide Range of Establishment-Level Growth

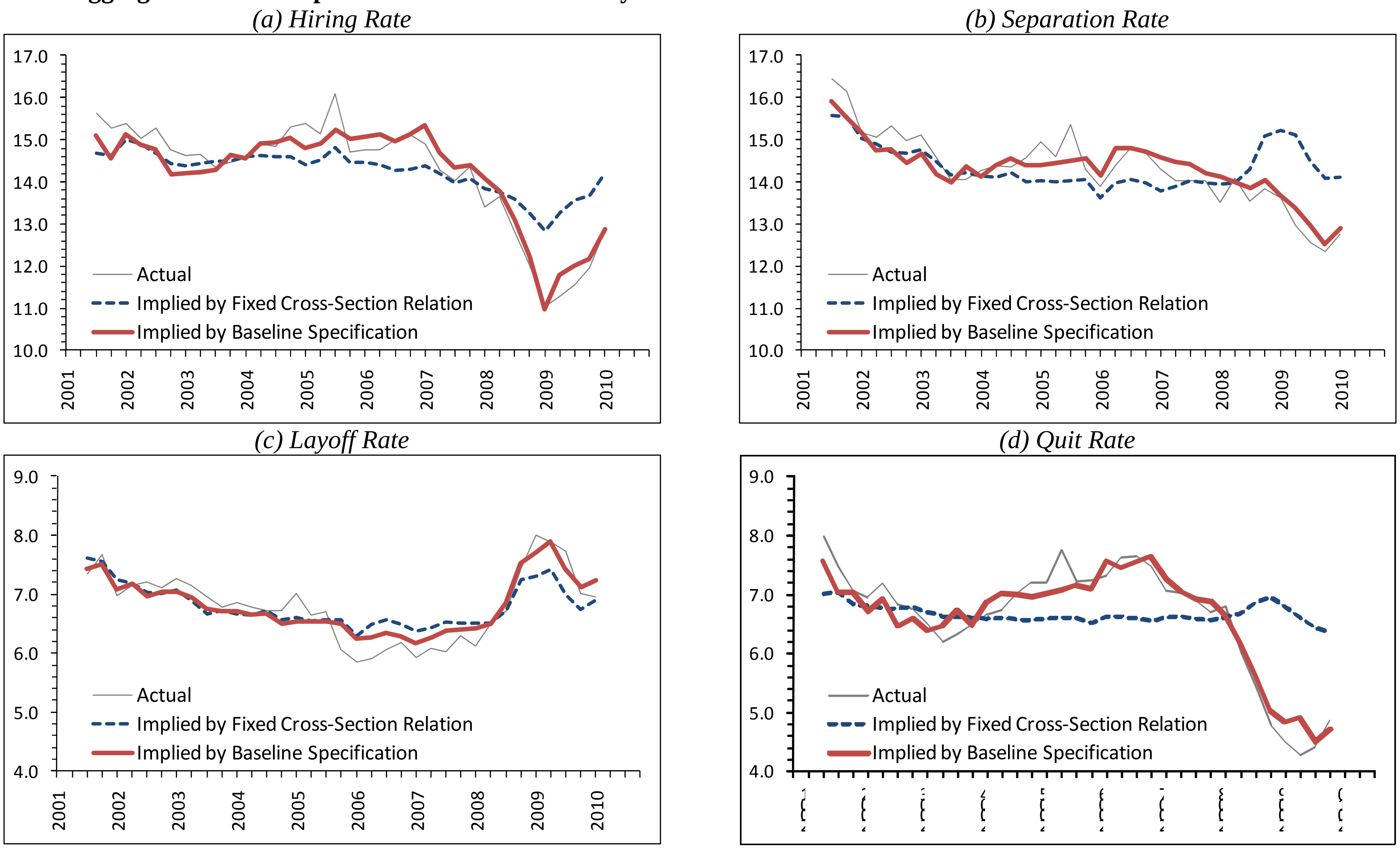


(b) Narrow Range of Establishment-Level Growth



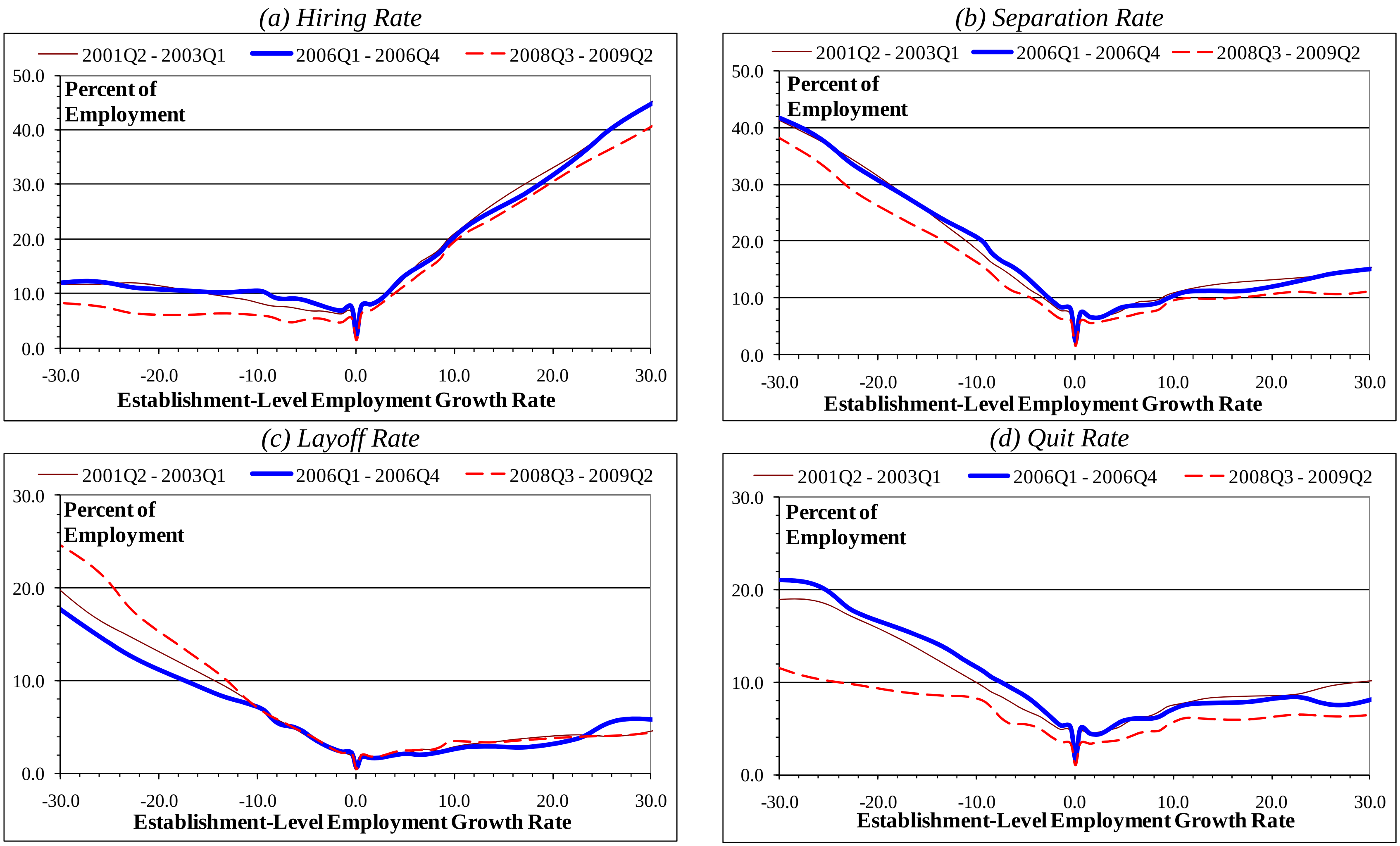
Source: Authors' calculations using JOLTS establishment data pooled over 2001Q1 – 2010Q1. Estimates are employment-weighted averages of the establishment-level growth rates within intervals that increase in width with the absolute value of the growth rate. Save for the endpoints and zero growth point, estimates are smoothed using a 3-bin moving average.

Figure 7. Aggregate Flows Compared to Flows Generated by Alternative Statistical Models



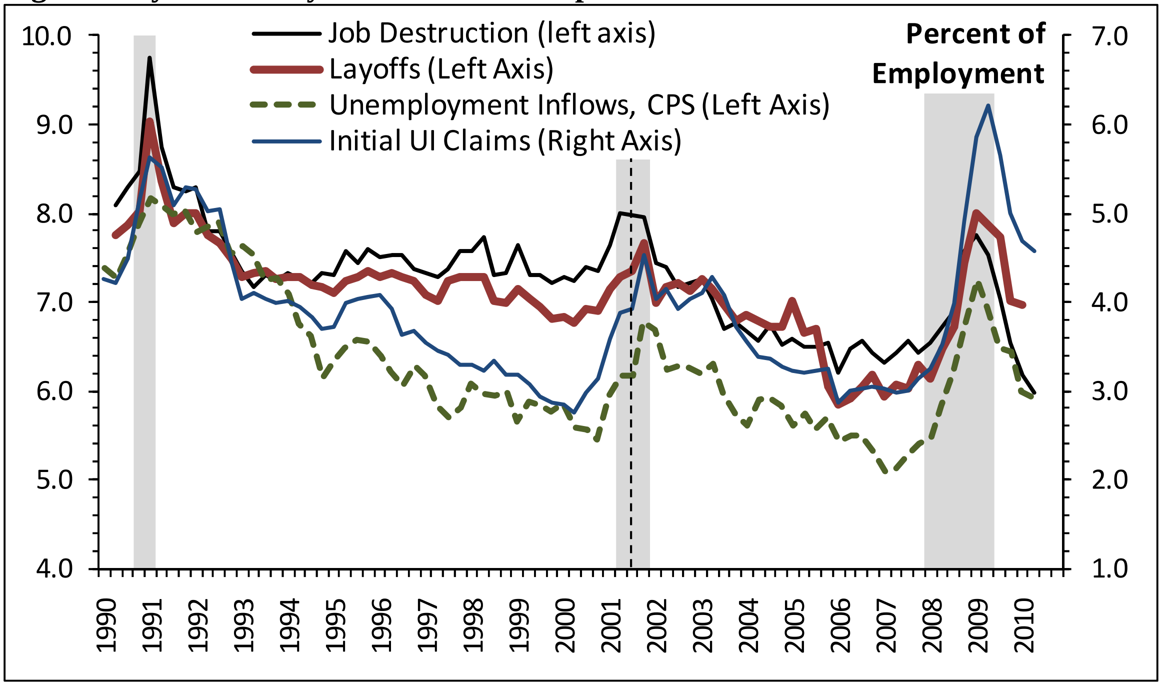
Source: Authors' calculations using estimates of worker flow-growth and vacancy-growth relationships derived from the JOLTS establishment data interacted with growth rate densities derived from BED data for 2001Q3 – 2010Q1. See text for details of the methodologies. Estimates are seasonally adjusted.

Figure 8. Worker Flows and Vacancies as a Function of Establishment-Level Growth, Selected Periods



Source: Authors' calculations using JOLTS establishment data pooled over the listed periods. Estimates are employment-weighted averages of the establishment-level growth rates within intervals that increase in width with the absolute value of the growth rate. Save for the zero growth point, reported estimates are smoothed using a 3-bin moving average.

Figure 9. Synthetic Layoff Estimates Compared to Other Job Loss Data



Sources: Layoff rates (2001Q3 – 2010Q2) are authors' calculations using JOLTS establishment microdata weighted to an aggregate value for each quarter using growth rate densities from the BED. Prior to 2001Q3 (to the left of the dashed vertical line), layoff rates are a synthetic series based on our baseline statistical model of worker flows (see text for details). Job destruction rates are authors' tabulations directly from the BED data. Unemployment inflow rates are calculated from the CPS. Initial unemployment insurance claims rates are from published statistics. All estimates are seasonally adjusted. All rates are percentages of employment.

Table 1. Changes in the Cross-Sectional Distribution of Establishment-Level Growth Rates over Time, Selected Years

Fraction of Employment at…	1991	1998-99	2001q2-2003q1	2006	2008q3-2009q2
Establishments with Contractions > 10%, including Closings	16.0	14.0	14.5	12.6	14.0
Establishments with Contractions ≤ 10%	27.4	26.9	29.3	28.0	30.8
Establishments with No Net Change	14.3	13.9	14.8	15.5	16.1
Establishments with Expansions ≤ 10%	27.4	30.0	28.0	30.7	27.4
Establishments with Expansions >10%, including Openings	14.8	15.2	13.4	13.2	11.6

Source: Authors' tabulations using BED establishment data pooled over the listed years. Estimates are the share of employment at establishments that expanded, contracted, or had no net employment change, on average, during the quarters of the listed years.

Table 2. Root Mean Squared Error and Correlations with Actual Series from Alternative Models

	Actual Std Deviation	Implied by Fixed Cross-Section	Implied by Baseline Specification	Implied by Flexible Specification
		Root Mean Squared Error from Actual - Implied		
Hiring Rate	1.306	0.866	0.379	0.378
Separation Rate	0.891	0.869	0.444	0.366
Quit Rate	0.990	0.986	0.266	0.246
Layoff Rate	0.589	0.348	0.230	0.218
		Correlation of Implied with Actual		
Hiring Rate		0.921	0.961	0.958
Separation Rate		0.358	0.927	0.922
Quit Rate		0.105	0.969	0.968
Layoff Rate		0.856	0.933	0.932

Notes: Table reports the root mean squared error (top panel) and correlation of actual with the predicted series (bottom panel) for each of the within sample predicted series for the alternative models. See the text for details of the estimation and aggregation methodologies.

Table 3. Fit of Regressions of Worker Flows on Aggregate Employment Growth and Implied Series from Fixed Cross-Section Relation

	Actual Rate on Aggregate Growth Variables	Actual Rate on Growth Variables and Fixed Cross-Section Relation Series
Private Employment		
Hiring Rate	0.787	.960 [.000]
Separation Rate	0.534	.906 [.000]
Quit Rate	0.923	.957 [.000]
Layoff Rate	0.640	.869 [.000]

Notes: The first column of the table reports the R-squared values from the regression of the actual aggregate estimate of each rate on the four aggregate growth rate terms from our baseline specification. The second column of the table reports the R-squared values from the regression of the actual rate on the four growth rate terms and the aggregate series implied from the fixed cross-section relation specification, along with the *p*-value on the coefficient on the fixed cross section relation rate. For both regressions, T = 35 over 2001Q3 – 2010Q1. See text for details of the estimation and aggregation methodologies.