

# Workplace Injuries and Job Flows

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## **Abstract**

The growth rates of workplace injury and illness rates exhibit a negative (time-varying) mean and a pro-cyclical response to variations in economic activity, as they decline in recessions before rebounding (and overshooting) during economic recoveries. Using a structural time series model, it is shown that this business cycle behavior is driven by job flows. In recessions, the acceleration of job destruction increases the growth rate of workplace injury and illness incidence rate (which is indicative of moral hazard), while the slowdown in job creation depresses this growth rate by reducing the proportion of workers of short job tenure.

**Keywords:** Workplace injuries, job flows, moral hazard

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## 1. INTRODUCTION

There is compelling evidence for the growth rate of the workplace injury and illness incidence rate to drop during recessions and rise during economic recoveries (see, for instance, U.S. Department of Labor, 1994); this evidence will be confirmed below. At the same time, there is a widely held belief that layoffs (the magnitudes and rate of occurrence of which tend to peak in recessions) lead to spikes in workers compensation claims. For instance, Travelers (The Travelers Companies, 2008) states that “[i]t is a documented fact that workers compensation claims rise during impending layoffs. Some experts say that 40 to 50 percent of these claims are likely to be filed within six months of termination. Some, but not all, claims will have merit.” The following analysis attempts to reconcile these two opposing perceptions of the effect of an economic downturn on the growth rate of the reported workplace injury and illness incidence rate by studying how it is affected by changes in the rates of job creation and job destruction.

The analysis rests on data from the Bureau of Labor Statistics (BLS, [www.bls.gov](http://www.bls.gov)). The workplace injury and illness incidence rate—frequency, for short—is defined as number of cases per 100 full-time equivalent employees. Frequency is available on an annual basis for manufacturing since 1926, and for all private industry since 1972. Due to the manufacturing series being considerably longer, the analysis focuses on this industry; yet, for key hypotheses, evidence is provided for the private sector as well. The analysis proceeds in two steps. First, a state-space time series model is estimated for the (log) growth rate of frequency over the entire time period of available data; this model identifies the (geometric) mean rate of growth and the autoregressive process. Then, in a second step, the model is expanded to a structural (state-space) time series specification by introducing de-trended (log) growth rates of job flows as covariates; these covariates substitute for the autoregressive process for the time period for which they are available (1993-2007).

The analysis shows that both job creation and job destruction contribute to reported workplace injury and illness incidence rates. Job creation is related to an increase in the proportion of workers who are

inexperienced in their current job and, hence, more likely to sustain a workplace injury. Further, it is argued that the effect of job destruction originates in opportunistic behavior as employees affected by layoffs look to workers compensation for wage continuation. Evidence of moral hazard in workers compensation has previously been established by Krueger (1988, 1990) who showed that more generous benefits lead to greater participation in and utilization of workers' compensation programs. Another explanation for why layoffs contribute to workers' compensation claims points to the layoff "survivors," who may suffer from increased stress, anxiety, and depression (see, for instance, Noer, 1993, and The Travelers Companies, 2008). On the other hand, deteriorating labor market conditions may have a disciplining effect on workers, thus giving them an incentive not to contribute adversely to the employer's workers' compensation experience rating.<sup>1</sup>

In recessions, job creation plummets while job destruction soars; the former effect contributes to a decrease in the growth rate of workplace injury and illness incidence rates, whereas the latter works in the opposite direction. On net, the effect of job creation dominates quantitatively, thus generating the observed pro-cyclical behavior in the growth rate of workplace injury and illness incidence rates. Further, it is shown that the growth rate of frequency tends to overshoot during economic recoveries, although this effect is not common to all recessions.

The BLS data originate in industry level estimates of nonfatal work-related injuries and illnesses from the Survey of Occupational Injuries and Illnesses (SOII), as implemented in 1972 and enhanced (with the purpose of collecting more detailed case characteristics) in 1992. Pre-SOII workplace injury data is available for manufacturing, reaching back to the beginnings of the 20th century (see Bureau of Labor Statistics, 2008).

As a caveat, there is an ongoing discussion regarding the mismatch between BLS workplace injury and illness incidence rates and State workers compensation claim counts. In response to studies indicating that the BLS underreports nonfatal workplace injuries, the House Committee on Education and Labor (2008), on June 19, 2008, held a hearing titled "Hidden Tragedy: Underreporting of Workplace Injuries and Illnesses." The report to this hearing cites several academic studies, the underreporting estimates of which range from 33 percent to 69 percent. In the hearing, the BLS pointed out that a quality assurance survey it conducted in

2007 found that its survey of occupational injuries and illnesses captured accurately the information on employer OSHA (Occupational Safety and Health Administration, [www.osha.gov](http://www.osha.gov)) logs. Hence, the mismatch between BLS data (which are estimates, based on a survey) and (the population of) State workers compensation claim counts is mainly due to differences in reporting methodology between OSHA and the workers' compensation system. Whereas OSHA logs are maintained by the employer (which may have an incentive to underreport to avoid inspection; see Murray, 2008), a workers' compensation claim (some of which may be approved only with a multi-year lag or even be rejected) is filed by the employee. The following analysis relies on growth rates (as opposed to levels) and, hence, is insensitive to underreporting to the degree that such is time-invariant.

The following section presents a state-space time series model that isolates the (time-varying) mean rate of growth of the workplace injury and illness incidence rate and the autoregressive process around it. Then, in Section 3, by expanding the model to a structural time series specification, this autoregressive process is explained by the growth rates of job creation and destruction. Finally, Section 4 concludes.

## 2. A TIME SERIES MODEL OF WORKPLACE INJURY AND ILLNESS INCIDENCE RATES

This section determines the time series properties of the (logarithmic) growth rate of workplace injury and illness incidence rates for manufacturing, before repeating this analysis for all private industry. For manufacturing, the time series consists of annual observations that range from 1927 through 2007; for all private industry, the time frame is limited to 1973 through 2007.

Chart 1 displays the (logarithmic) workplace injury and illness incidence rates for manufacturing and all private industry, along with NBER (National Bureau of Economic Research, [www.nber.org](http://www.nber.org)) recession bars (which range from a mid-month peak of economic activity to a mid-month trough). The chart indicates close similarities between manufacturing and all private industry; the two trajectories share a negative trend, along with persistent deviations, during which the decline slows or temporarily reverses. Most interestingly, most of the decline in the incidence rate is due to an intra-industry improvement in workplace safety, as opposed to a

shift in relative employment (measured as a share in total private sector employment) toward less hazardous industries. For all private industry, Chart 2 displays for the time 1977-2000 the observed workplace injury and illness incidence rate, along with a hypothetical incidence rate that would have been observed had the private sector maintained the 1972 employment structure. By breaking down the private sector into nine industries based on SCI (Standard Industrial Classification), it is shown that only 15 percent of the incidence rate decline is due to a change in employment proportions. This finding agrees with a similar analysis by the U.S. Department of Labor (1994) for the time period 1973-1993, which finds that a mere 11 percent of the drop in the incidence rate in the private industry is due to structural change.

## 2.1 Time Series Modeling of the Manufacturing Industry

Chart 3 presents the (log) growth rate of the workplace injury and illness incidence rate for manufacturing only. This growth rate reveals an autoregressive process around a negative and potentially time-varying mean. The autoregressive process appears to be largely driven by the business cycle: the growth rate drops precipitously during recessions before rising sharply during the subsequent recovery. Second, the variance of the autoregressive process declines noticeably over time and, starting in the early 1960s, deviations from trend appear to become more persistent. The state-space model presented below accommodates these two properties of the data by treating the mean growth rate and the variance of the autoregressive process as time-varying. Further, the model allows for a change-point in the autoregressive parameter, thus accommodating a change in the persistence of deviations from trend.

The Bayesian model is a local level specification (see Durbin and Koopman, 2001) and builds on work by Rosenberg and Young (1999), as discussed by Congdon (2006), extended by a change-point for the autoregressive parameter,  $\rho$ . Below the equations of the model, starting with the measurement equation:

$$y_t = \mu_t + \varepsilon_t + e_t \tag{1a}$$

$$e_t \sim N(0, 1/\tau_e), \quad \tau_e \sim \text{Ga}(2, 0.001) \tag{1b}$$

$$\mu_t = \mu_{t-1} + \delta_{1,t} \cdot \nu_t, \quad t > 1 \tag{1c}$$

$$\delta_{1,t} \sim \text{Bern}(\eta_1), \eta_1 \sim \text{Beta}(1,17) \quad (1d)$$

$$v_t \sim \text{N}(0,1/\tau_v), \tau_v \sim \text{Ga}(2,0.001) \quad (1e)$$

$$\varepsilon_t = (\rho_1 \cdot \mathbf{I}_{t < cp} + \rho_2 \cdot \mathbf{I}_{t \geq cp}) \cdot \varepsilon_{t-1} + u_t, t > 1 \quad (1f)$$

$$\rho_i \sim \text{Beta}(1.3,1.3), i = 1,2 \quad (1g)$$

$$cp \sim \text{Cat}(p_1, \dots, p_T) \quad (1h)$$

$$(p_1, \dots, p_T) \sim \text{Dir}(1, \dots, 1) \quad (1i)$$

$$u_t \sim \text{N}(0, V_t) \quad (1j)$$

$$V_t = V_{t-1} \cdot \omega_t^{\delta_{2,t}}, t > 1, \omega_t \sim \text{Ga}(1,1) \quad (1k)$$

$$\delta_{2,t} \sim \text{Bern}(\eta_2), \eta_2 \sim \text{Beta}(1,17) \quad (1l)$$

The operators N, Ga, Bern, Beta, Cat, and Dir indicate the normal, gamma, Bernoulli, beta, categorical, and Dirichlet distributions, respectively; further, the operator  $\mathbf{I}_{(\cdot)}$  equals unity if the condition in the suffix is met, and is zero otherwise.

The level (i.e., the mean growth rate),  $\mu$ , and the variance of the autoregressive process,  $V_t$ , follow random walks with probabilistic innovations; the probabilities of these innovations are driven by Bernoulli distributions. The location of the change-point is governed by a categorical distribution, the prior of which is a Dirichlet distribution. Unlike Rosenberg and Young (1999) and Congdon (2006), a gamma prior is used for the precision  $\tau_v$ , instead of a pre-chosen value, although this makes no material difference to the estimation results. The model is estimated using Markov-chain Monte Carlo simulation with a burnin and sample size of 30,000 draws each; to mitigate possible autocorrelation in the Markov chains, of which there are three, only every tenth draw is collected, thus resulting in 9,000 draws for every posterior distribution.

Chart 4 displays the estimated level of frequency growth,  $\mu$ , along with the raw data. This mean rate of growth was nearly time-invariant for many decades before it started to drift down in the 1990s and stabilized at a new, lower level at around the year 2000. According to Boden and Ruser (2003), cost

containment reforms (enacted in the early 1990s in many U.S. states) were a major factor behind the drop in frequency growth during the 1990s.

Chart 5 exhibits the estimated autoregressive process; by definition, this process is centered on zero. Starting in the early 1960s, the autoregressive process reveals deviations from trend that last for about a decade; this pattern agrees with the spacing of the business cycles over the same period of time (when treating the 1980 and 1981/82 recessions as a single event).

Chart 6 displays the trajectory of the variance of the autoregressive process. This variance exhibits a precipitous decline in the first half of the 20th century that continued on at a slower pace in the following decades. It is worthy of note that this drop in variance sets in much earlier than the decline in variance in many macroeconomic series in the early 1980s, which is commonly referred to as the Great Moderation (see Bernanke, 2004).

Chart 7 shows kernel density estimates of the autoregressive coefficient,  $\rho$ , before and after the change-point. The mode of the distribution (here defined as the peak in density) equals 0.24 prior to the change-point, compared to 0.63 after the change-point; this means that prior to the change-point, only 24 percent of any systematic deviation from the mean repeated itself in the following year; after the change-point, it is 63 percent.

Chart 8 indicates the location of the change-point, by offering a graphical display of the posterior of the categorical distribution. The distribution peaks in the early 1960s, which agrees with the increase in persistence of deviations from the mean evident in Chart 3.

Appendix A offers two diagnostic charts of the estimated model. First, Chart A.1 displays a kernel density estimate of the residuals ( $\hat{\epsilon}_t$ ) of the measurement equations against the normal distribution; second, Chart A.2 presents autocorrelation functions for these residuals at various lag lengths. Neither diagnostic chart is indicative of model mis-specification.

After having isolated the autoregressive process, it is now possible to map it on the business cycle time line, as shown in Chart 9. Note that the BLS workplace injury and illness incidence data are observed annually; recessions, however, are not identically distributed on the calendar year axis. Hence, there is a degree of timing mismatch in this chart.<sup>2</sup> The “butterfly” specification of Chart 9 displays the (light and dark gray shaded) envelopes of the trajectories of the autoregressive process for every recession (starting with the Great Depression and ending with the 2001 recession); each trajectory starts 20 months prior to the onset of the recession and ends 36 months after the trough of economic activity. For the purpose of visualizing the magnitude of the recession impact, the trajectories are arranged such that the month of the trough (which does not count toward the length of the recession) is located on the zero vertical line. Further, each of the trajectories has been shifted vertically such that the estimated autoregressive component adopts the zero value at the month of the trough. As the median line in Chart 9 shows, the rate of growth of the workplace incidence and illness incidence rate drops by about 2.5 percentage points during the 20 months leading up to the trough, before bottoming out in sync with economic activity. During recoveries, this growth rate tends to overshoot its pre-recession level when rising by five percentage points, before giving up half of this increase and leveling off at the pre-recession value about 24 months after the trough.<sup>3</sup>

The (light and dark gray) envelopes in Chart 9 indicate a wide dispersion of the business cycle behavior of frequency growth.<sup>4</sup> Of particular interest is the Great Depression, which is indicated (up to the trough) by a dotted line. The recession-related drop in frequency growth during the Great Depression was the most extensive of all recessions, but because frequency growth is measured on an annual basis, it does not capture the dynamics of the Great Depression perfectly. For instance, industrial production (see Friedman and Schwartz, 1963, Chart 28) rose in early 1931, before the second banking crisis (March through August, 1931) gave rise to a renewed contraction of the economy. This temporary recovery in economic activity may explain the rise in frequency growth about two years prior to the end of the Great Depression, although monthly employment data in manufacturing point to deteriorating labor market conditions (Bureau of the Census, 1941, Table 401).



Chart 10 isolates from Chart 9 the business cycle trajectories of the past three recessions (again treating the 1980 and 1981/82 recessions as a single event). Only during the recovery from the 1980-82 recession, frequency growth (temporarily) overshot its pre-recession level. During the recovery from the 2001 recession, frequency growth climbed slowly back to its pre-recession level, whereas the 1990/91 recession had comparatively little impact on frequency growth. As Ritter (1994) and Faberman (2006) demonstrate, job creation varies greatly across recoveries; this observation is confirmed in Chart 11, which displays the rates of job creation (and destruction) from 1947 through 2004. Job creation in manufacturing recovered vigorously following the 1980-1982 recession, but started declining after a brief increase following the 1990/91 recession, and recovered very little in the wake of the 2001 recession. In Section 3, it will be argued that the business cycle behavior of workplace injury and illness rates is primarily driven by the rate of job creation.

## **2.2 Time Series Modeling of All Private Industry**

The data for the growth rate of the workplace injury and illness incidence rates of all private industry is confined to the time period 1973 through 2007. Hence, when applying the time series model from Section 2.1 to this shorter series, no change-point in the autoregressive parameter ( $\rho$ ) is allowed; all other properties of the model remain in place.

Chart 12 displays the (logarithmic) growth rates of the workplace injury and illness incidence rates for all private industry; the vertical axis of the chart is on the same scale as its manufacturing equivalent (Chart 3), for the purpose of comparison. The mean rate of growth exhibits a behavior comparable to the manufacturing sector, except that its decline appears less pronounced.

Chart 13 presents the business cycle behavior of frequency growth for all private industry, as it manifests itself in the autoregressive process; the vertical axis is on the same scale as Chart 10, its manufacturing equivalent.<sup>5</sup> The 1980-82 and 1990/91 recessions both exhibit a drop in frequency growth,

followed by overshooting during the subsequent recovery. The 2001 recession has comparatively little effect on the growth rate of the workplace injury and illness incidence rate.

### 3. RELATING WORKPLACE INJURIES TO JOB FLOWS

As discussed, this analysis attempts to reconcile two competing hypotheses of the effect of an economic downturn on the growth rate of the workplace injury and illness incidence rate by studying how this measure is affected by changes in the rates of job flows. The economics of job creation and job destruction has been studied extensively (among others) by Davis, Faberman, and Haltiwanger (2006), Davis, Haltiwanger, and Schuh (1996), and Ritter (1994) for the U.S. economy and, for the economy of the Commonwealth of Massachusetts, by Bradbury (1999). A primary focus of the research on job creation and destruction is the dynamics of job flows during recessions. As Davis, Haltiwanger, and Schuh (1999, p. 11) point out, “important aspects of economic behavior and performance are likely to vary with rates of job creation and destruction.” For instance, an acceleration of job creation comes with a shortening of the length of service with the current employer as workers switch jobs, come out of unemployment or (re)join the work force. Table 1, Panel A, shows that around 30 percent of all reported workplace injuries in the manufacturing industry are associated with workers who have been with their current employer for less than one year. No data is available for the job tenure of employees in manufacturing, but for the total private sector (Table 1, Panel B), in 2006, the proportion of total employees with a job tenure of less than one year is about 11 percentage points lower than the proportion of injured employees in the same tenure category. Further, according to the BLS, as of January 2006, the median tenure in manufacturing runs at 5.5 years, compared with only 3.6 years in the private sector overall, thus suggesting that the mentioned 30 percent of injured employees greatly exceeds the proportion of total employees with a length of service of less than one year.

There are several publicly available data sets on job flows. This study uses primarily the Business Dynamics data from the BLS, which is available on a calendar year basis (unlike the Business Dynamic Statistics of the Census Bureau, which is as of March 12). The BLS data set, which reaches back to the third

quarter of 1992, is based on the Quarterly Census of Employment and Wages (QCEW), thus encompassing essentially the entire establishment population. Job gains and losses are defined as net changes in employment by establishment, where “[a]n establishment is defined as an economic unit that produces goods or services, usually at a single physical location, and engages in one or predominantly one activity” ([www.bls.gov/news.release/cewbd.tn.htm](http://www.bls.gov/news.release/cewbd.tn.htm)); thus, a firm may have multiple establishments. Gross job gains for the manufacturing sector (for instance) is obtained by adding up changes in employment across all establishments in manufacturing that report employment increases; similarly, gross job losses are arrived at by aggregating over all establishments with reductions in employment. Gross job gains (losses) are differentiated by expansions at existing (contractions at continuing) establishments and openings (closings) of establishments.

The impact of job creation and destruction is analyzed in a structural time series model, which is obtained from model (1) by adding a linear regression component to the measurement equation (see Durbin and Koopman, 2001):

$$y_t = \mu_t + \sum_k (\beta_k \cdot \bar{x}_{k,t}) + e_t, \quad \beta_k \sim N(0, 0.001) \quad (1a')$$

The covariates substitute for the autoregressive process for the time period for which these covariates are available. In order to keep the covariates from affecting the estimated mean rate of growth (the level,  $\mu_t$ ), these variables are centered on zero. This model specification may be viewed as two models, one being applied for the time period 1927-1992, and one to the time period 1993-2007; these two models are estimated simultaneously and have in common only the variance of the error term of the measurement equation and the process that drives innovations to the state variable  $\mu_t$ .

There are two alternative sets of covariates. First, there is a set of two covariates, which are the (log) growth rates of job creation and job destruction. Second, there is a set of four covariates, which consist of the (log) growth rates of job creation at expanding and new establishments (expansions and openings, respectively) and of job destruction at continuing and discontinuing establishments (contractions and closing,

respectively). Like the rate of frequency growth, the covariates are annual numbers; these annual growth rates of job flows were calculated from non-seasonally adjusted Q4 (fourth quarter) numbers.<sup>6</sup> The covariates are de-trended (centered on zero) by subtracting their mean for the observed time period, thus assuming stationarity for the rate of growth over the period of 15 annual observations.

Although the covariates cover only one recession, they do include the time of the Asian Crisis, which started in July 1997 with the devaluation of the Thai baht and culminated in August 1998 with the Russian default on domestic debt and the ensuing collapse of Long-Term Capital Management (LTCM) the following month. The most significant effect of the Asian crisis on North America was its negative effect on commodities prices (OECD, 1999), thus causing declines across the spectrum of Producer Price Indexes (PPI), ranging from All Commodities to Finished Goods. As will be shown below, the Asian Crisis had little effect on the growth rates of job creation and destruction overall, but impacted profoundly the growth rates of job creation at openings and job destruction at closings.

Chart 14 shows the growth rates of job creation and destruction for the available time period 1993-2007. There is no discernible impact of the Asian crisis on job flows, but a marked effect of the 2001 recession—while the growth rate of job creation tumbles, the growth rate of job destruction soars. During the recovery from the 2001 recession, the growth rate of job creation rises only mildly above its mean; this is consistent with the sluggish job creation evident in Chart 11.

Chart 15 presents the posterior distributions for the regression coefficients. For both coefficients, the bulk of the probability mass is to the right of the zero value, thus indicating that the growth rates of job creation and destruction both contribute to frequency growth. For an increase in the growth rate of job creation by 1 percentage point, frequency growth increases approximately by 0.37 percentage points.<sup>7</sup> As job creation slows in recession, frequency growth drops; during recoveries, when job creation accelerates, frequency growth increases. The link between job creation and job frequency is work experience, as illustrated in Table 1. When fewer jobs are created, the proportion of inexperienced employees drops, thus depressing frequency growth. This interpretation of the business cycle sensitivity differs from the explanation

offered in Personick (1997), who argues that frequency drops in recessions because the most inexperienced workers are laid off first, thus lengthening the average time of service with the current employer. Although the “last hired, first fired” argument may be an important aspect, the evidence provided above points to slowing job creation, not accelerated job destruction, as the main source for the lengthening job tenure.

Further, Chart 15 shows that an increase in the growth rate of job destruction by 1 percentage point increases frequency growth by about 0.27 percentage points. Thus, when the economy goes into recession and job destruction soars, the positive relation between frequency growth and job destruction counteracts the (also positive) relation between frequency growth and job creation. The effect of job creation dominates in magnitude, thus causing frequency growth to behave pro-cyclically.

The established relation between the incidence rate of workplace injury and illnesses and job destruction is indicative of opportunistic behavior. This finding is consistent with Krueger (1988), who provides evidence for moral hazard when showing that a 10 percent increase in workers’ compensation benefits is associated with a 7.1 percent rise in participation in workers’ compensation programs. On the other hand, it may be argued that if the growth of job destruction occurs primarily in branches of manufacturing with low frequency growth, then the relation between frequency growth and accelerated job destruction is an artifact of structural change in manufacturing. This argument of structural change will be addressed below when discussing the empirical evidence for all private industry; although the Business Dynamic Statistics of the Census Bureau offers a breakdown of expansions and openings by industry, there is no differentiation within manufacturing. Hence, only by studying all private industry it is possible to distinguish between structural change and moral hazard as two alternative explanations for the presented empirical findings.

The second set of covariates breaks down job creation into expansions (at existing establishments) and openings; similarly, job destruction is divided into contractions (at continuing establishments) and closings. Because the bulk of job creation and destruction occurs at expanding and contracting establishments (respectively), the chart of the growth rates of these two job flow measures resembles closely

the one for overall job creation and destruction (Chart 14) and, hence, is not shown. Instead, Chart 16 displays the growth rates of job creation at openings and job destruction at closings. Most interestingly, for the displayed time period, the growth rates of these two measures are positively correlated, whereas the growth rates of overall job creation and destruction (shown in Chart 14) are negatively correlated. As Gelman and Hill (2007) argue, Bayesian models, due to the use of prior distributions, are powerful in isolating the effects of variables even in the presence of high collinearity. Further, the growth rates for openings and closings respond strongly to the Asian Crisis; both growth rates rise sharply above the mean in 1997, before falling short of the mean by about the same magnitude in the following year.

The estimated posterior distributions of this second set of covariates are shown in Charts 17 and 18. Whereas the estimated impact for expansions is similar to the one for job creation overall, the posterior distribution for openings is approximately centered on zero (with little dispersion, which indicates that the model succeeded in estimating the parameter with high precision). This finding suggests that jobs added through openings are safer than those added at existing establishments, possibly because new workplaces are safer by design or because openings are over-presented in branches of manufacturing where frequency growth is below average. Here again, due to lack of data, only by studying all private industry (in the next section) it is possible to discern the cause of the difference in impact between expansions and openings. For diagnostic purposes, Chart A.3 displays autocorrelation functions at various lag lengths of the residuals of the measurement equation of the estimated model for the time period during which the covariates substituted for the autoregressive process; there is no indication that the covariates did not succeed in explaining the business cycle behavior of frequency growth.

It may be argued that new openings had insufficient time to generate reported workplace injuries (in spite of the data being annual). Thus, the model is re-estimated using a growth rate of job creation at openings that is calculated from Q2 (instead of Q4) numbers. The posterior distributions, which are displayed in Chart 19, differ very little to the original estimates (which are shown in Chart 17).

### 3.2 Structural Time Series Modeling of All Private Industry

The analysis of the effect of job flows on the incidence rate of workplace injuries and illnesses is now repeated for all private industry. As mentioned, the growth rate of frequency is available from 1973 on. The posterior distributions for the first set of covariates (growth rates of job creation and destruction) are displayed in Chart 20. Similar to manufacturing (Chart 15), there is strong evidence in support of a positive relation between the growth rates of frequency and of job destruction. On the other hand, contrary to manufacturing, there is only mild evidence for a positive relation between frequency growth and job creation. The reason for the weak impact of job creation becomes apparent when studying the posterior distributions of the second set of covariates, as displayed in Chart 21 (expansions and openings) and Chart 22 (contractions and closings). As Chart 21 shows, the effect of expansions on frequency is similar to what has been established for manufacturing (Chart 17), but the impact of openings is very different. Whereas for manufacturing, the posterior distribution for openings was centered on zero, there is strong evidence that for all private industry, the relation between the growth rates of frequency and job creation at openings is negative. For contractions and closings, as shown in Chart 22, the posterior distributions are similar to those in manufacturing, thus indicating the presence of moral hazard.

As mentioned, it may be argued that the positive relation between the growth rates of frequency and job destruction and the negative relation between the growth rates of frequency and job creation at openings are artifacts of structural change in the economy. For instance, if the growth of job destruction occurs primarily in industries with below-average frequency growth, then the relation between the two variables is positive, yet such positive relation does not constitute evidence of moral hazard. Similarly, if the growth of job creation at openings occurs primarily in industries with below-average frequency growth, then the relation between the two variables is negative, thus generating data that is observationally equivalent to workplaces at openings being safer than comparable workplaces at expansions.

Chart 23 displays a scatterplot for the growth rates of frequency and of job destruction. The displayed growth rates are by industry (Agriculture, Forestry and Fishing; Mining; Construction;

Manufacturing; Transport and Public Utilities; Wholesale Trade; Retail Trade; Finance, Insurance and Real Estate; and Services; these industries add up to the private sector) and centered on the calendar year median across industries; the gray line indicates the LOESS scatterplot smoother. The scatterplot provides no compelling evidence for the growth of job destruction disproportionately affecting industries of low frequency growth; this finding supports the hypothesis that the established empirical evidence originates in moral hazard.

Chart 24 presents a scatterplot for the growth rates of frequency and job creation at openings. As the chart shows, there is no evidence for a negative relation between these two growth rates, thus indicating that new workplaces are safer by design.

#### 4. CONCLUSION

The nonfatal workplace injury and illness incidence rates in manufacturing and the private sector have experienced steep declines over their respective recorded histories. By 2007, the incidence rate for the private sector had dropped to 40 percent of its 1972 value (which is the first value on record). It was shown (for the period 1977-2000) that only 15 percent of this decline is due to structural change in the economy; the remaining 85 percent are due to workplaces being safer by design.

There is a “the dog that did not bark” issue to the behavior the growth rate of the injury and illness incidence rate during recessions. This growth rate does not drop because of the jobs that are destroyed (which lengthens the average job tenure if short-tenured workers are overrepresented in layoffs) but because of the jobs that are not created. This explanation of the cause of frequency growth differs from the interpretation put forward in Personick (1997).

There is an important difference between jobs created at existing establishments (expansions) and jobs created at openings. Whereas an acceleration of job creation through expansions increases frequency growth, a quickening of job creation through openings has the opposite effect for the private sector and no effect for manufacturing. This finding suggests that workplaces at openings are safer than the average existing



workplace, thus pointing to new establishments as an important avenue toward safer workplaces.

The established positive relation between the growth rates of the workplace injury and illness incidence rate and job destruction points to moral hazard, as laid-off workers have an incentive to use the workers' compensation system as a social safety net. Although the evidence was established for aggregate data only, the finding agrees with evidence of moral hazard in the workers' compensation system established by Krueger (1988, 1990) at the level of individual claims.

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<sup>1</sup> Experience rating in workers' compensation adjusts the (future) insurance premium to an employer's past claims experience, thus functioning as an updating of beliefs about this employer's loss distribution; for an introduction to the actuarial foundations of experience rating, see Dorweiler (1934). See also Ruser (1985) who establishes a link between experience rating and safety incentives.

<sup>2</sup> Appendix B displays a chart that lines up past recessions, as they pertain to this analysis, on the calendar year time axis.

<sup>3</sup> By definition, the recovery-related increase must equal the original, recession-related decrease, which is approximately the case within a recovery period of 24 months. Note that for the 1957/58 recession, a post-trough time period longer than 24 months overlaps with the 1960/61 recession.

<sup>4</sup> The 1945 recession, which coincided with war veterans rejoining the workforce, is an outlier. Here, the growth rate rises steeply going into recession, before dropping sharply several months after the trough. Removing this recession from Chart 6 has little effect on the displayed median value, however.

<sup>5</sup> The 1973-75 recession is not included, because the available data do not fully capture the 12-month pre-recession period.

<sup>6</sup> Published BLS rate of job creation and job destruction at openings and closings are rounded to a degree where many annual values for the growth rate come up as zeros. The author is grateful to the BLS for providing data before rounding.

<sup>7</sup> The rates of growth in frequency and job flows are measured as log differences. For small changes, these log differences (when multiplied by 100) are approximately equal to percentage changes. Generally, a log difference (log rate of growth) of  $x$  translates into a change of  $(\exp(x)-1)\times 100$  percent.

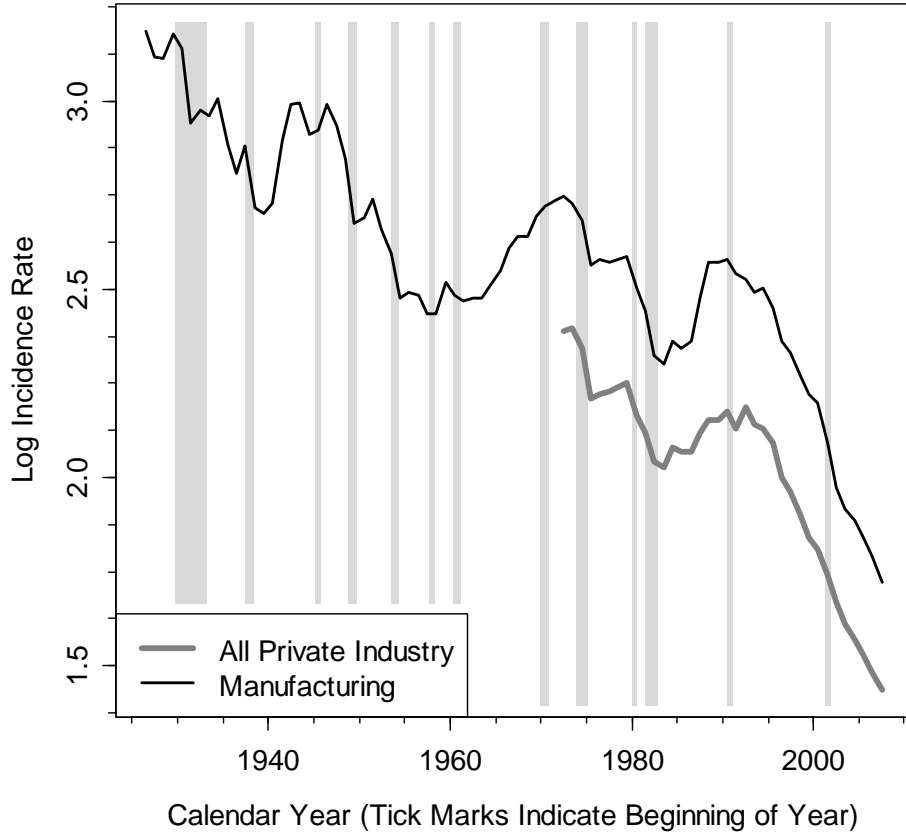
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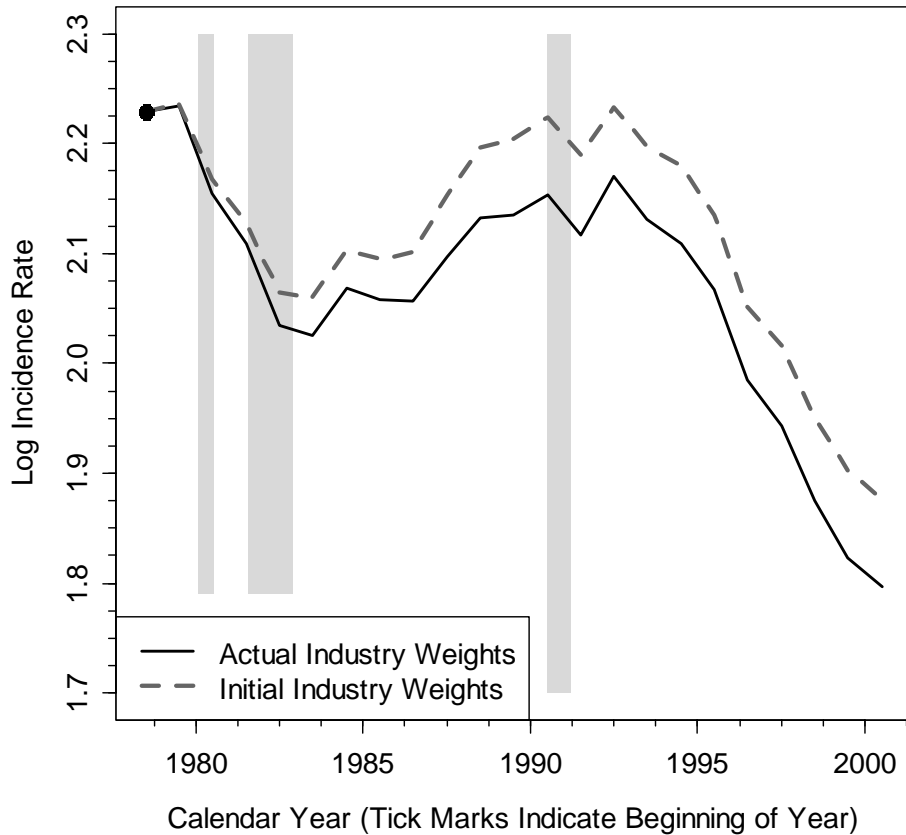
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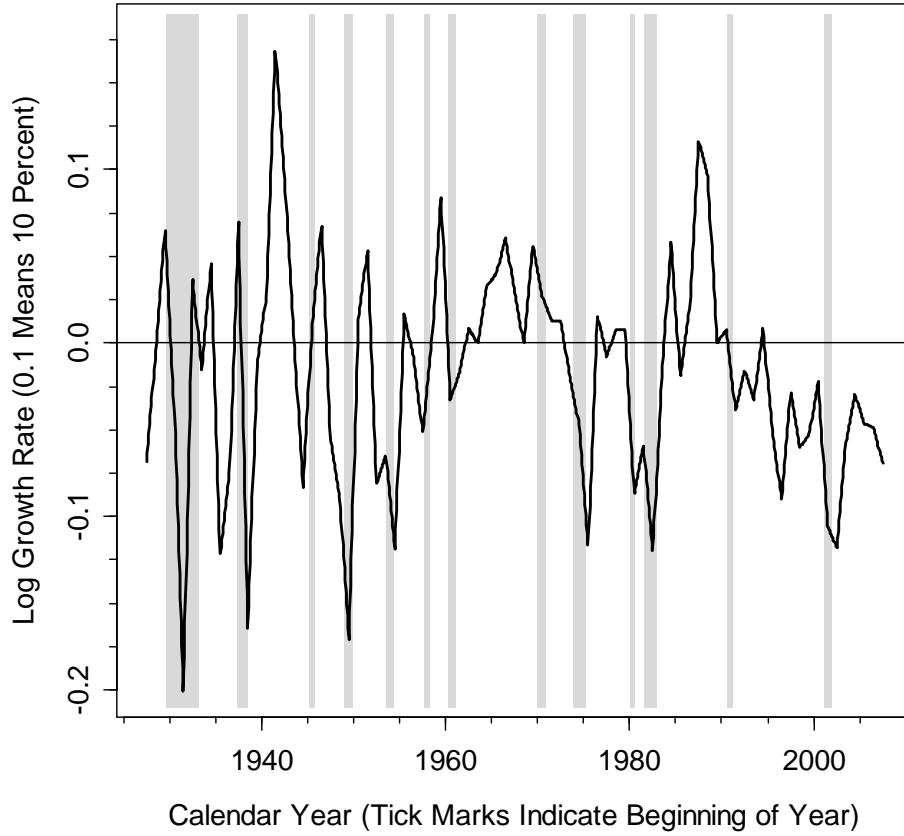
**Chart 1: Workplace Injury and Illness Incidence Rate.** Manufacturing: 1926-2007; All Private Industry: 1972-2007. Data source: BLS; recession information: NBER.



**Chart 2: Workplace Injury and Illness Incidence Rate with Structural Change Isolated.** All Private Industry: 1977-2000. Frequency is calculated as employment-weighted average across industries: Agriculture, Forestry and Fishing, Mining, Construction, Manufacturing, Transport and Public Utilities, Wholesale Trade, Retail Trade, Finance, Insurance and Real Estate, and Services; these industries add up to the private sector. The industry classification rests on SIC (Standard Industrial Classification), which confines the data set to the pre-2002 time window. Data source: BLS (Bureau of Labor Statistics), [www.bls.gov](http://www.bls.gov); recession information: NBER.

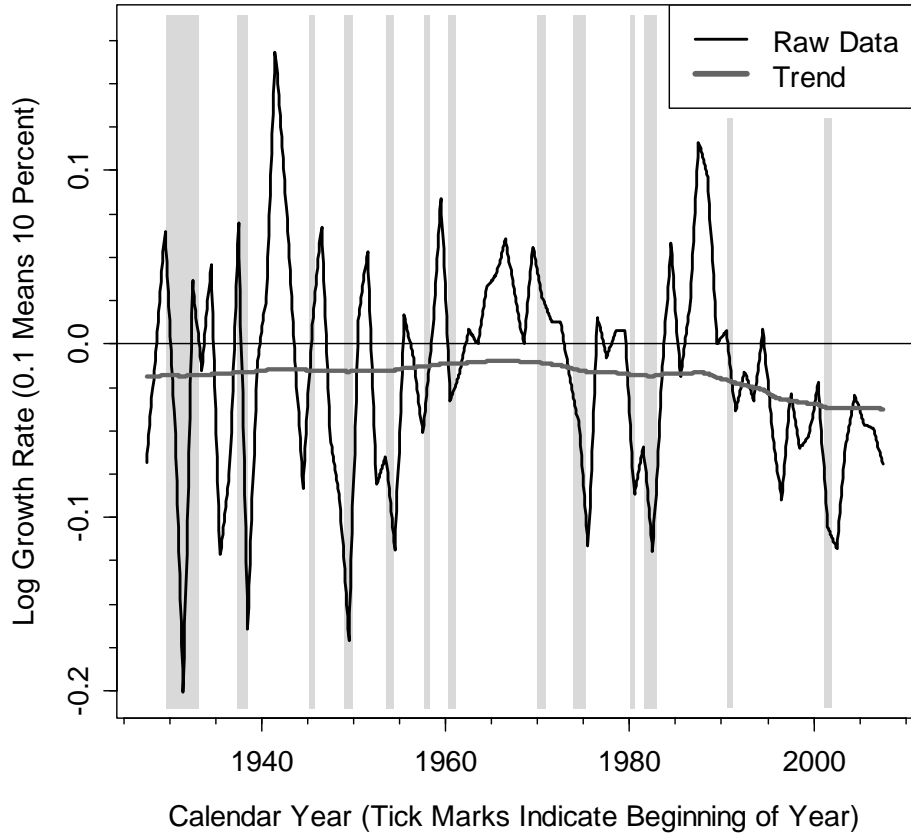


**Chart 3: Growth Rate of the Workplace Injury and Illness Incidence Rates for Manufacturing.**  
1927-2007. Data source: BLS; recession information: NBER.

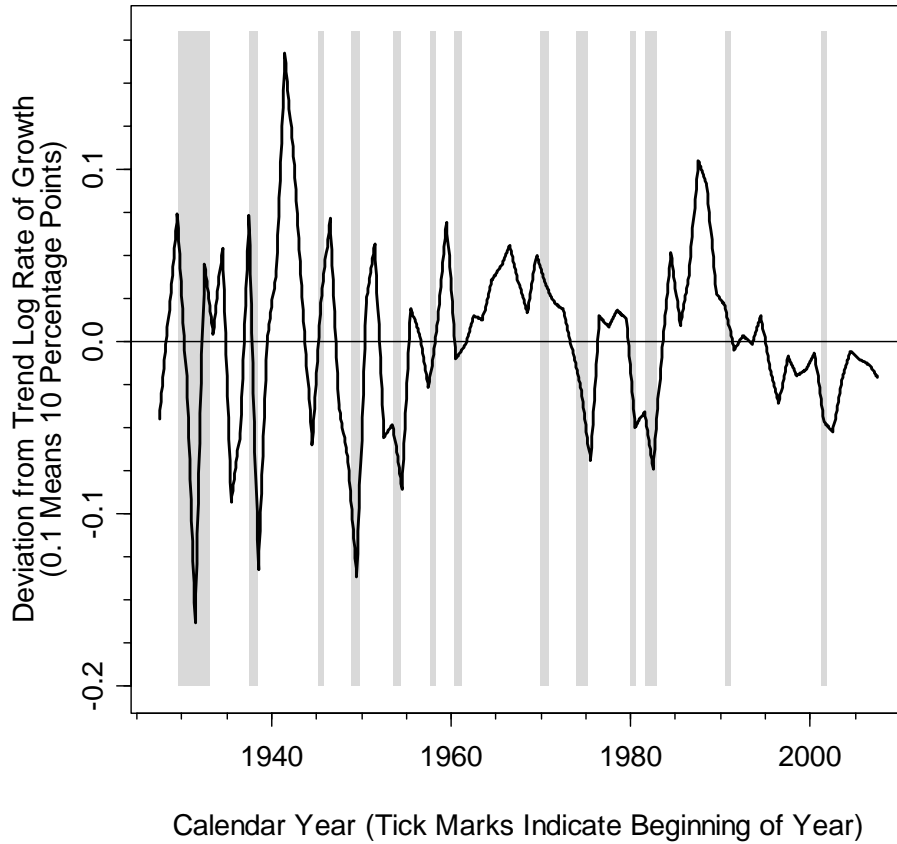




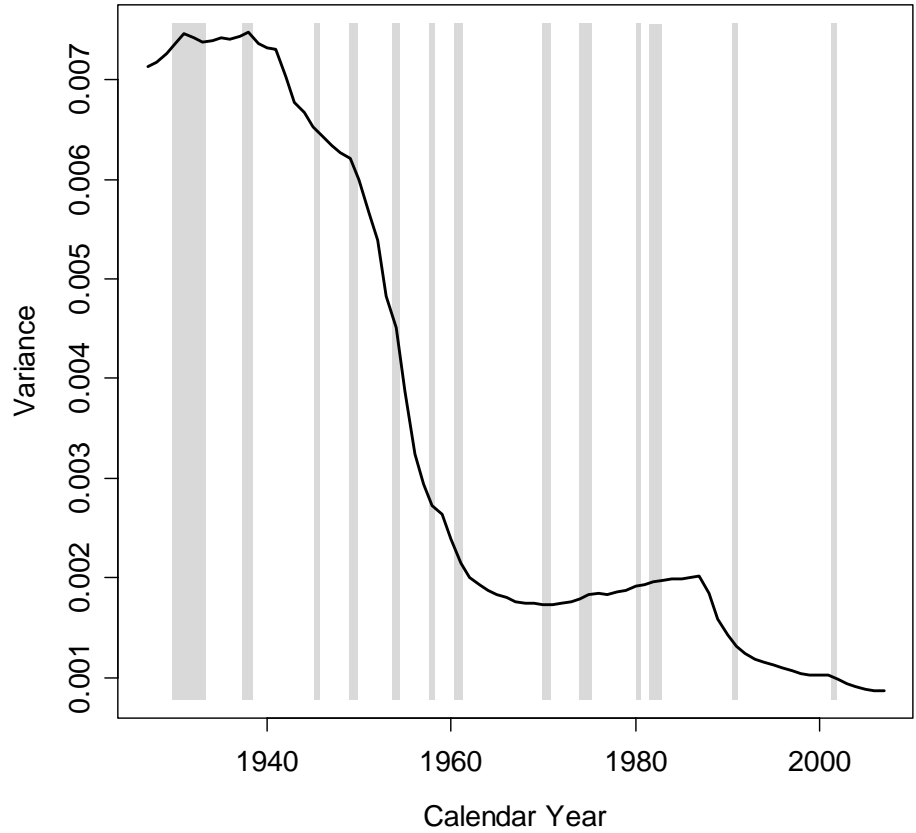
**Chart 4: Estimated Mean Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing.** 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Data source: BLS; recession information: NBER.



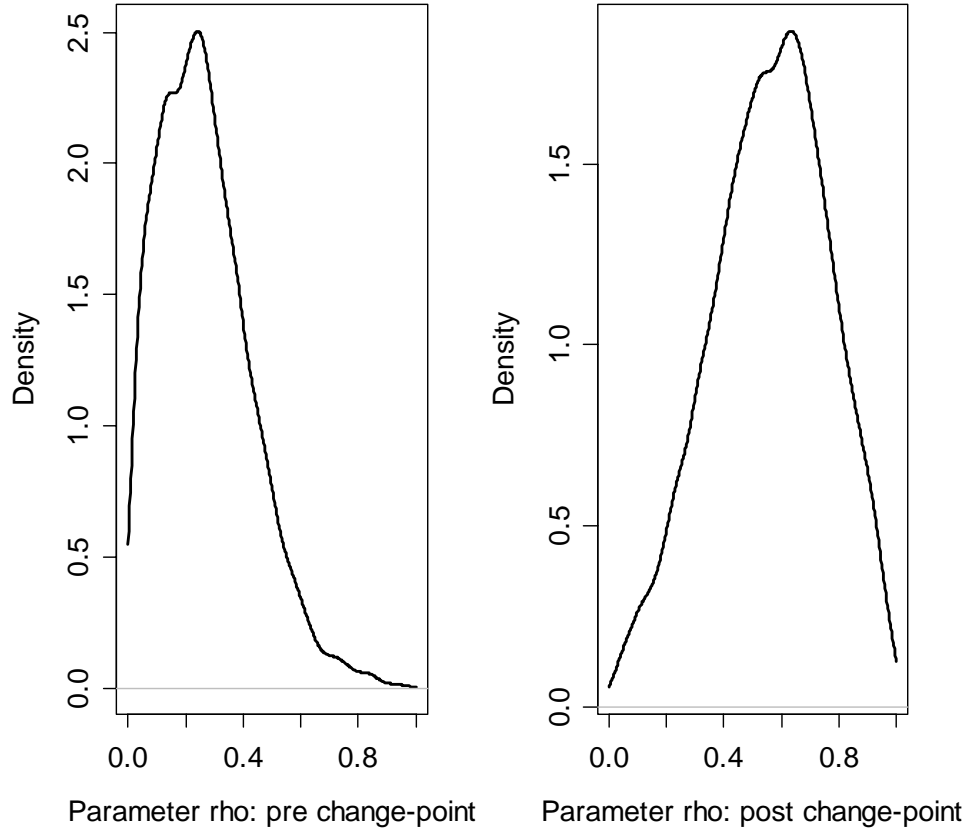
**Chart 5: Autoregressive Process in the Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing.** 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Data source: BLS; recession information: NBER.



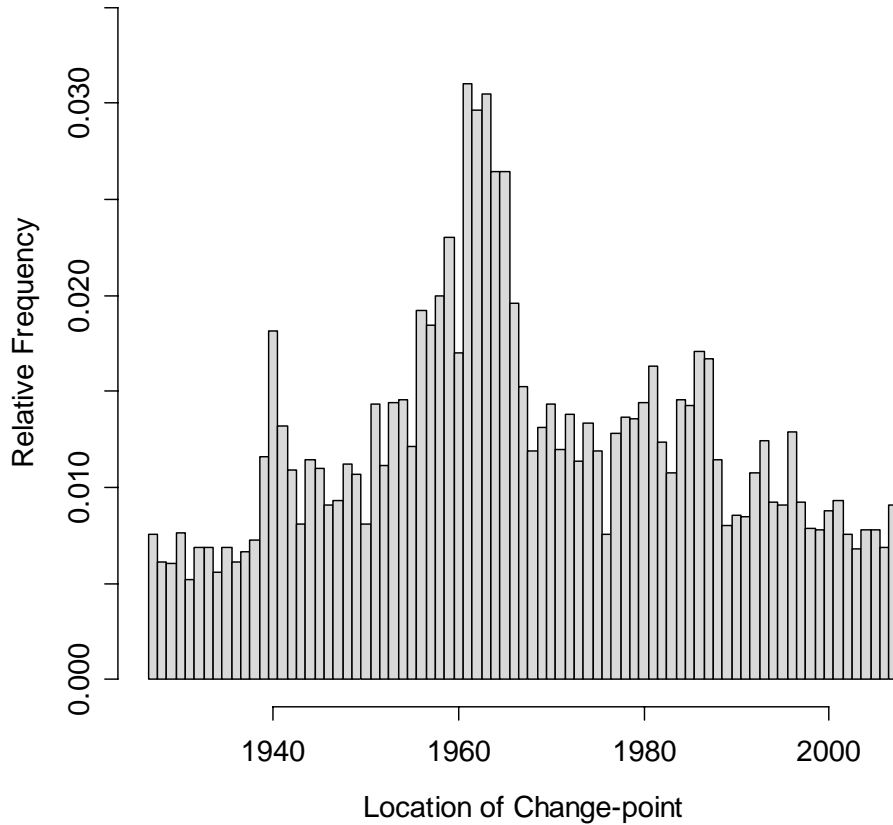
**Chart 6: Variance of Autoregressive Process in the Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing.** 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Data source: BLS; recession information: NBER.



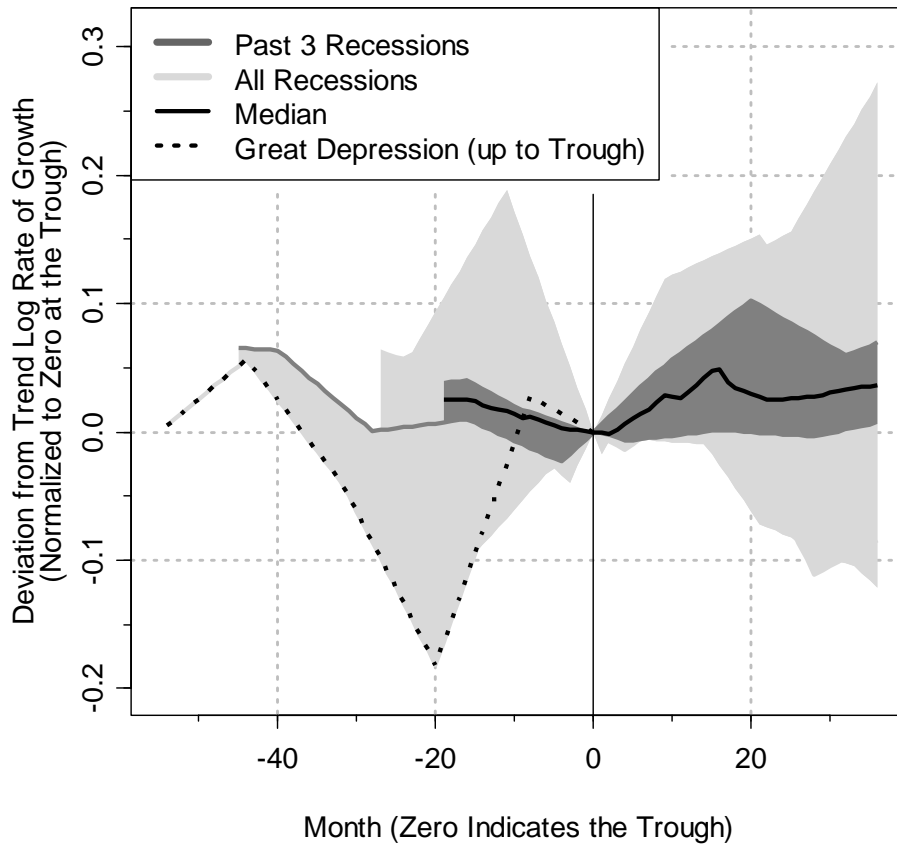
**Chart 7: Autoregressive Coefficients in the Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing, 1927-2007.** Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Modes: 0.24 (prior to change-point); 0.63 (after change-point). Data source: BLS; recession information: NBER.



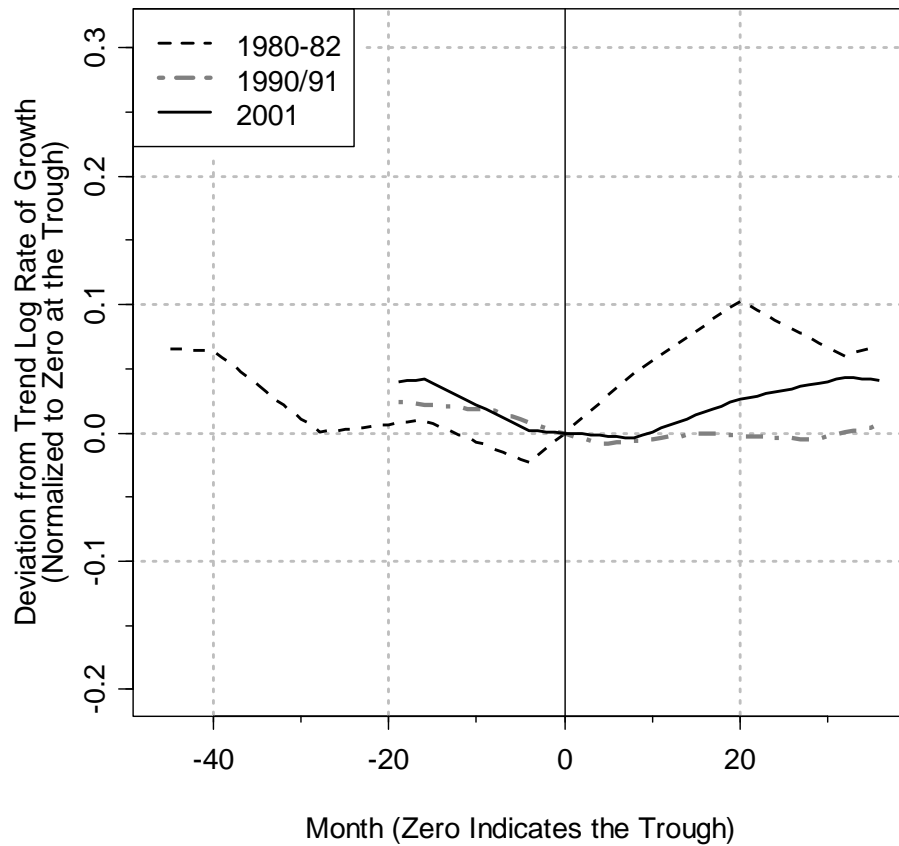
**Chart 8: Kernel Density Estimate of Posterior Distribution of Change-point in the Autoregressive Coefficient of the Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing, 1927-2007.** Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Mode: 1961. Data source: BLS.



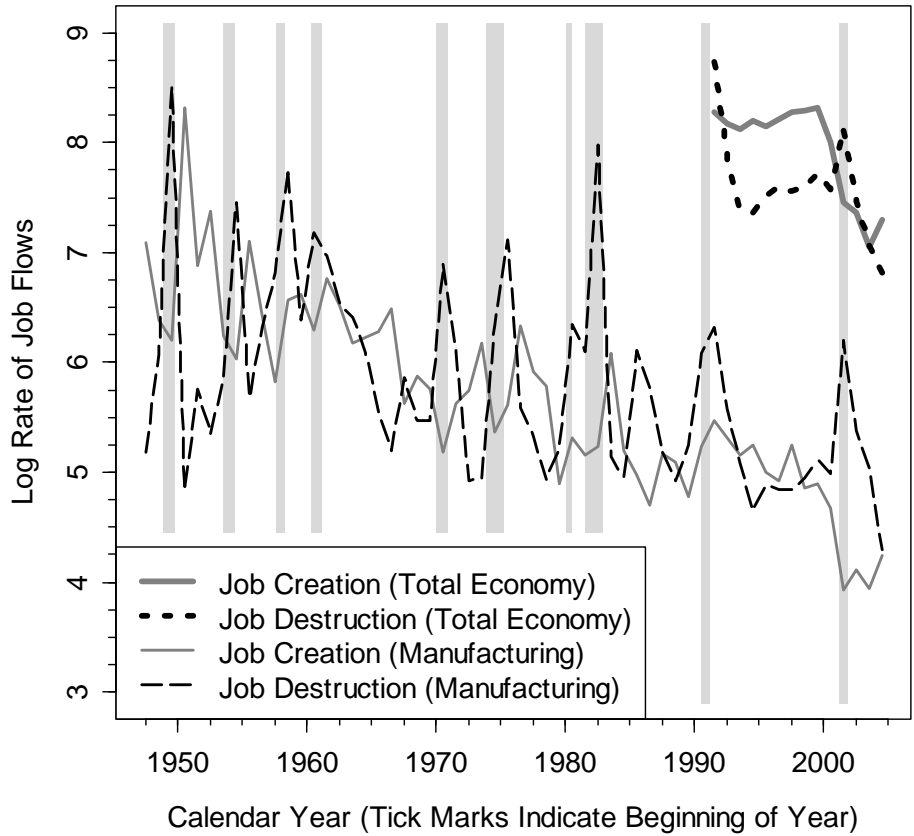
**Chart 9: Business Cycle Behavior of the Growth Rate of the Workplace Injury and Illness Incidence Rate for Manufacturing.** 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The displayed business cycle behavior rests on the estimated autoregressive process. The light gray area is the envelope of the trajectories during the 12 recessions since (and inclusive of) the Great Depression (treating the 1980 and 1981/82 recessions as a single event). Each trajectory starts twelve months prior to the recession and ends 36 months after the trough; the month of the trough does not count toward the length of the recession. The dark gray area is the envelope of the past three recessions (again treating the 1980 and 1981/82 recessions as a single event). For illustration, up to month the trough, the Great Depression is broken out as a dotted line. Data source: BLS; recession information: NBER.



**Chart 10: Business Cycle Behavior of Growth Rate of the Workplace Injury and Illness Incidence Rates for Manufacturing.** 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The displayed business cycle behavior rests on the estimated autoregressive process. Each trajectory starts twelve months prior to the recession and ends 36 months after the trough; the month of the trough does not count toward the length of the recession. Displayed are the past three recessions. Data source: BLS; recession information: NBER.

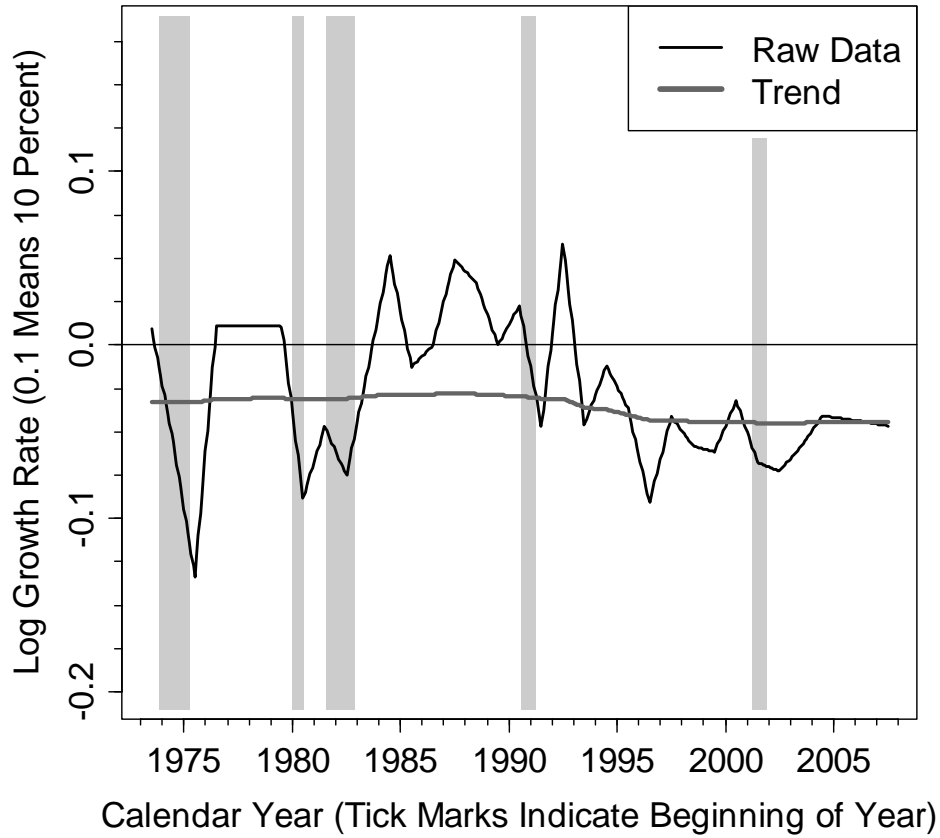


**Chart 11: Rates of Job Creation and Job Destruction for Manufacturing (1947-2004) and the Total Economy (1991-2004).** Annual numbers are geometric means of quarterly data for the calendar year. Data source: Davis, Faberman, and Haltiwanger (2006); recession information: NBER.

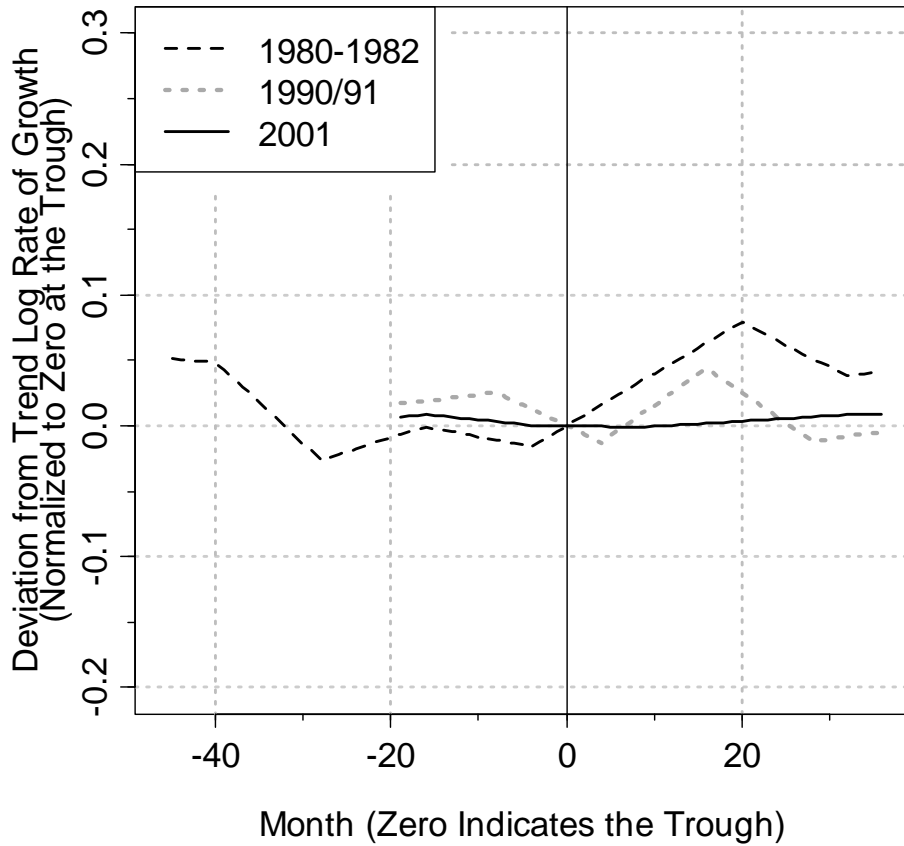




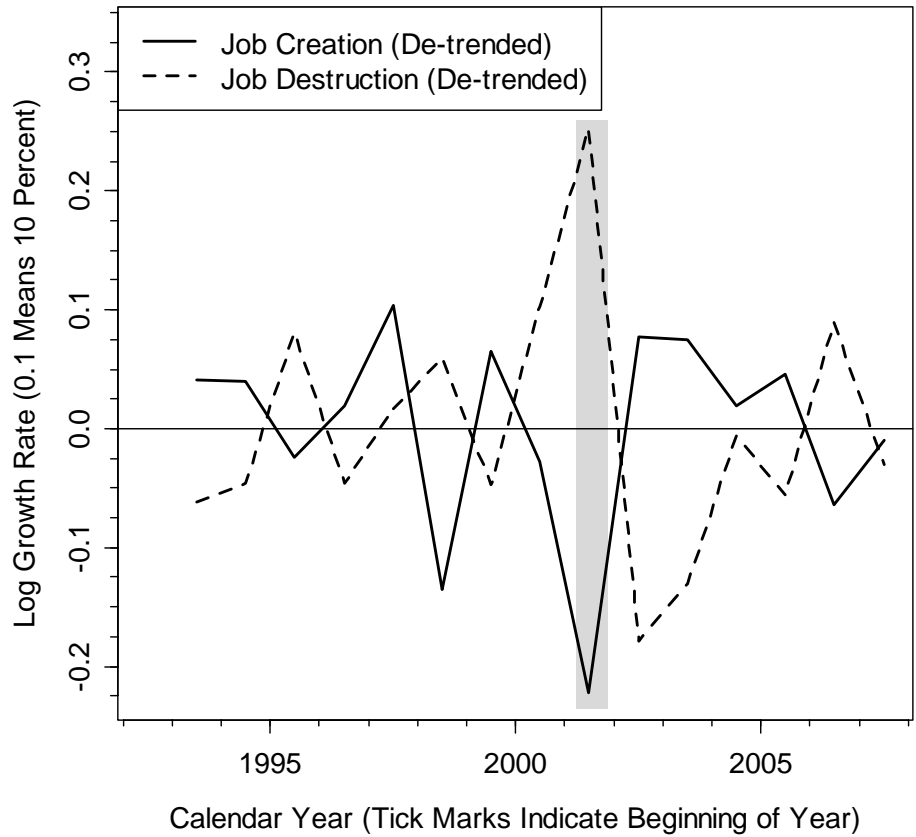
**Chart 12: Estimated Mean Growth Rate of Workplace Injury and Illness Incidence Rates for All Private Industry, 1973-2007.** Estimates are from a local level model with time-varying variance of the autoregressive process. Data source: BLS; recession information: NBER.



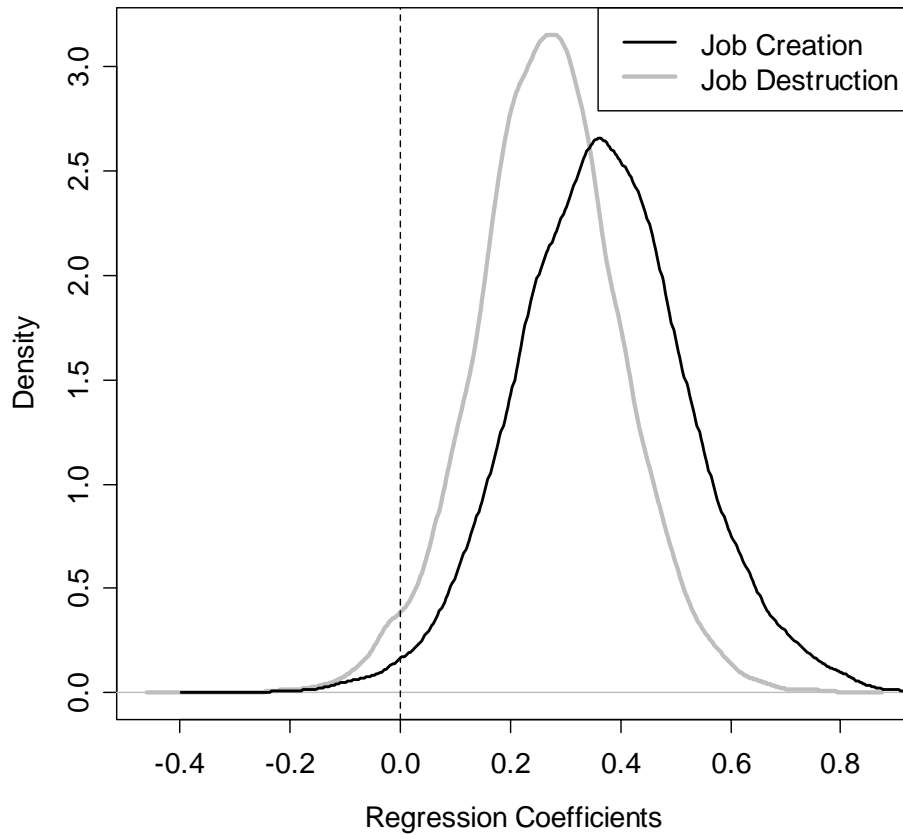
**Chart 13: Business Cycle Behavior of Growth Rate of Workplace Injury and Illness Incidence Rates for All Private Industry.** 1973-2007. Estimates are from a local level model with time-varying variance of the autoregressive process. The displayed business cycle behavior rests on the estimated autoregressive process. Each trajectory starts twelve months prior to the recession and ends 36 months after the trough; the month of the trough does not count toward the length of the recession. Data source: BLS; recession information: NBER.



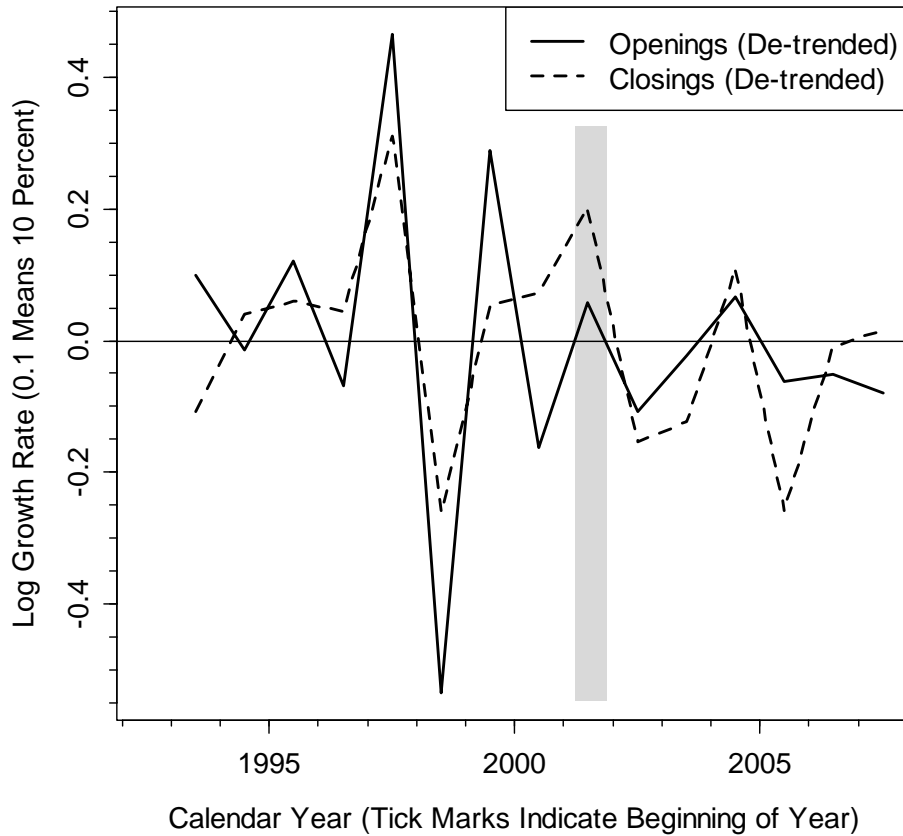
**Chart 14: Growth Rates of Job Creation and Destruction, Manufacturing.** 1993-2007. Annual growth rates are calculated from Q4 numbers. The log growth rates are de-trended by centering them on their mean. Job creation and destruction data are at the level of the establishment and based on the Quarterly Census of Employment and Wages. Data source: BLS; recession information: NBER.



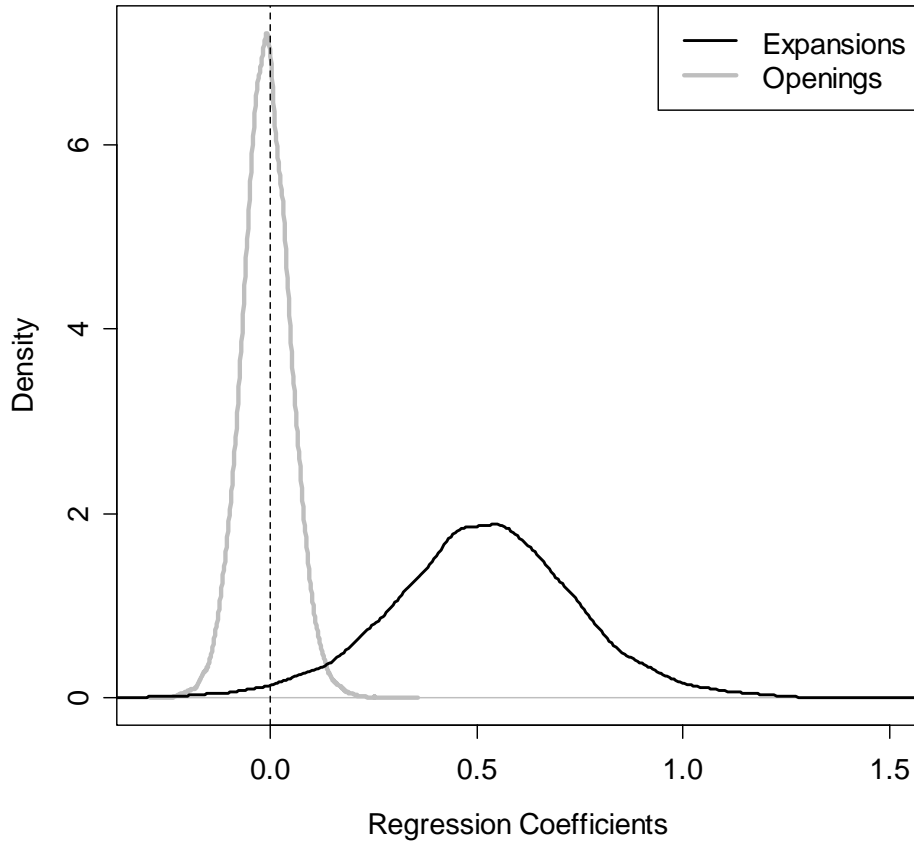
**Chart 15: Posterior Distributions of Regression Coefficients of Job Creation and Destruction for Manufacturing.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The model is estimated for the time period 1927-2007; for the period 1993-2007, the annual log growth rates of job creation and job destruction substitute for the autoregressive process; all covariates are calculated from Q4 numbers. Means: 0.367 (creation); 0.268 (destruction). Data source: BLS.



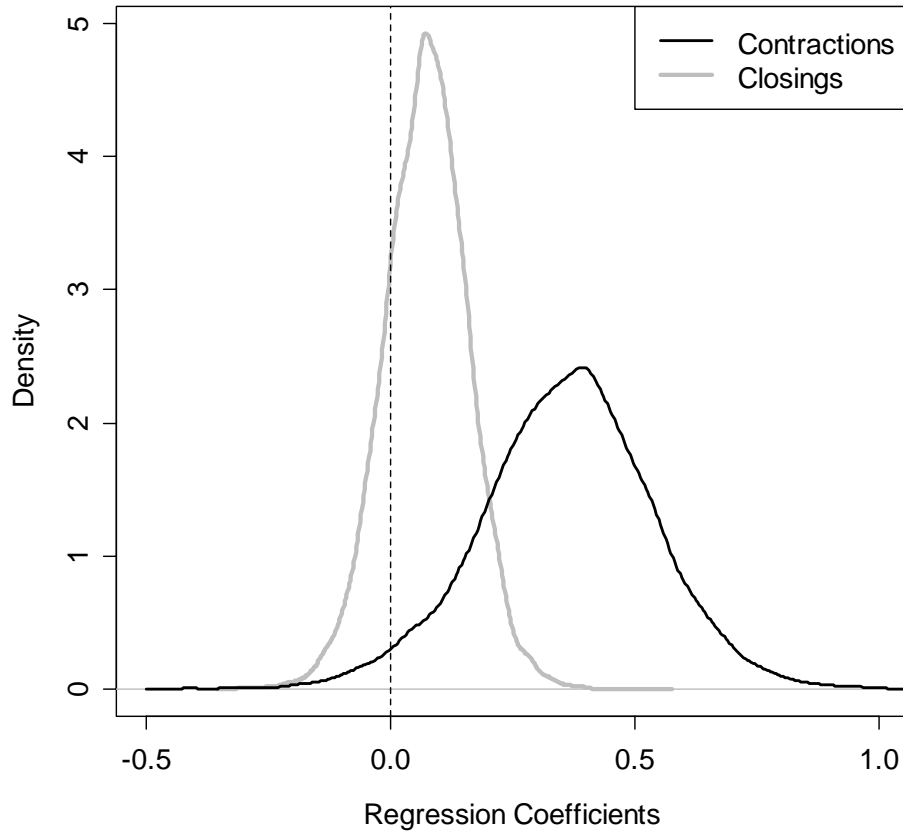
**Chart 16: Growth Rates of Job Creation through Openings and Destruction through Closings, Manufacturing.** 1993-2007. Annual growth rates are calculated from Q4 numbers. The log growth rates are de-trended by centering them on their mean. Job creation and destruction data are at the level of the establishment and based on the Quarterly Census of Employment and Wages. Data source: BLS; recession information: NBER.



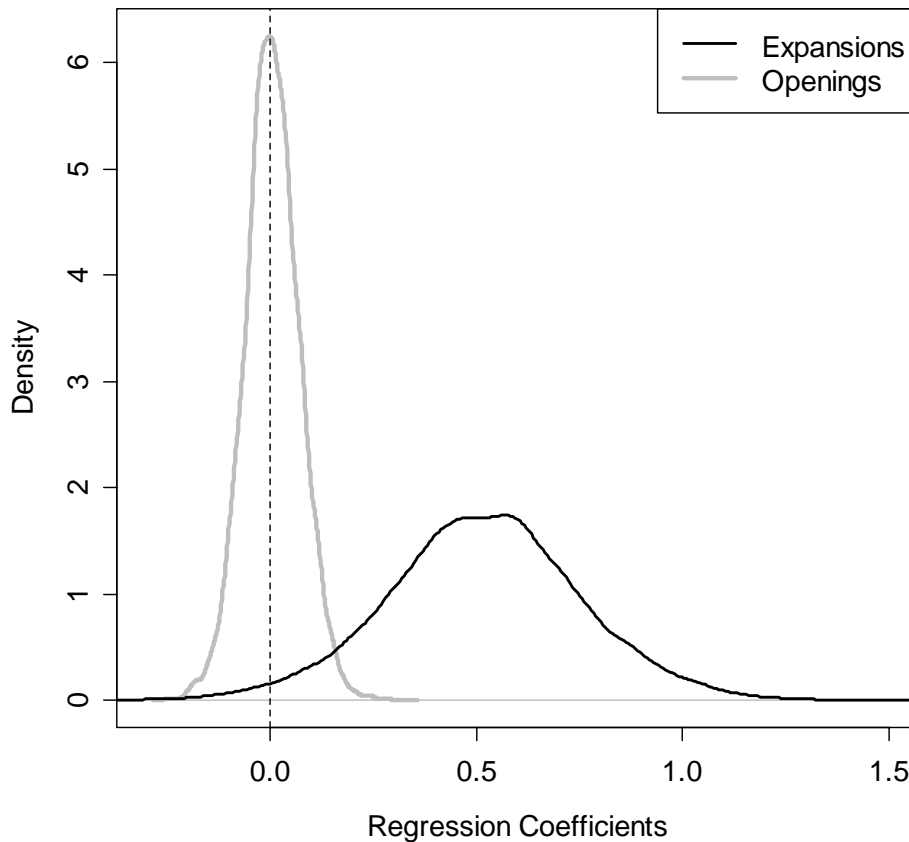
**Chart 17: Posterior Distributions of Regression Coefficients of Expansions and Openings for Manufacturing.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The model is estimated for the time period 1927-2007; for the period 1993-2007, four covariates substitute for the autoregressive process. The covariates are the annual log growth rates of job creation at (1) expanding and (2) opening establishments, and job destruction at (3) contracting and (4) closing establishments; all covariates are calculated from Q4 numbers. Means: 0.517 (expansions); -0.010 (openings). Data source: BLS.



**Chart 18: Posterior Distributions of Regression Coefficients of Contractions and Closings for Manufacturing.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The model is estimated for the time period 1927-2007; for the period 1993-2007, four covariates substitute for the autoregressive process. The covariates are the annual log growth rates of job creation at (1) expanding and (2) opening establishments, and job destruction at (3) contracting and (4) closing establishments; all covariates are calculated from Q4 numbers. Means: 0.361 (contractions); 0.074 (closings). Data source: BLS.

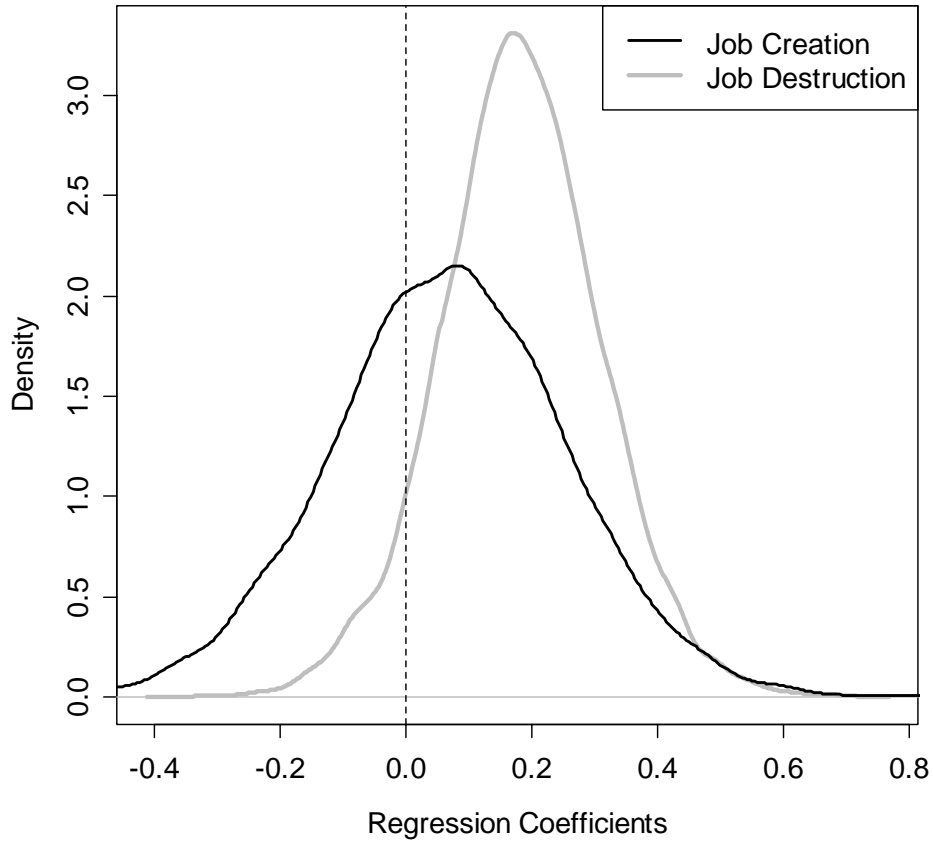


**Chart 19: Posterior Distributions of Regression Coefficients of Expansions and Openings for Manufacturing, Openings Lagged.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The model is estimated for the time period 1927-2007; for the period 1993-2007, four covariates substitute for the autoregressive process. The covariates are the annual log growth rates of job creation at (1) expanding and (2) opening establishments, and job destruction at (3) contracting and (4) closing establishments. All covariates (growth rates) are calculated from Q4 numbers, except for the covariate representing opening establishments, which rests on Q2 numbers (for the purpose of introducing a half-year lag). Means: 0.519 (expansions); 0.005 (openings). Data source: BLS.

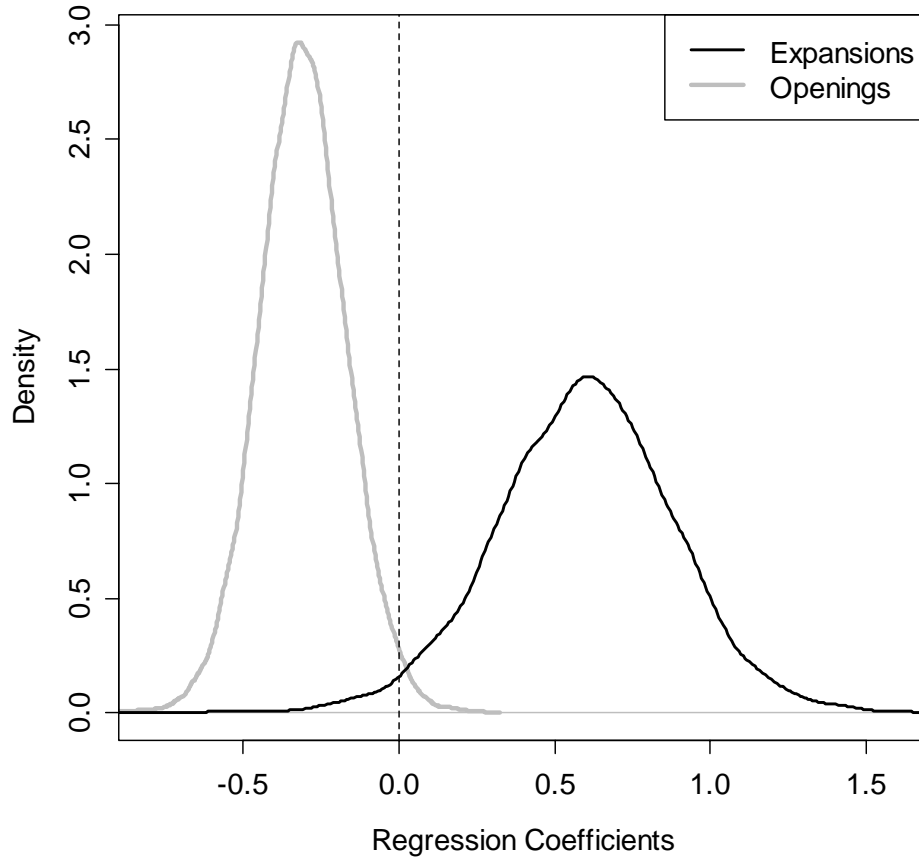




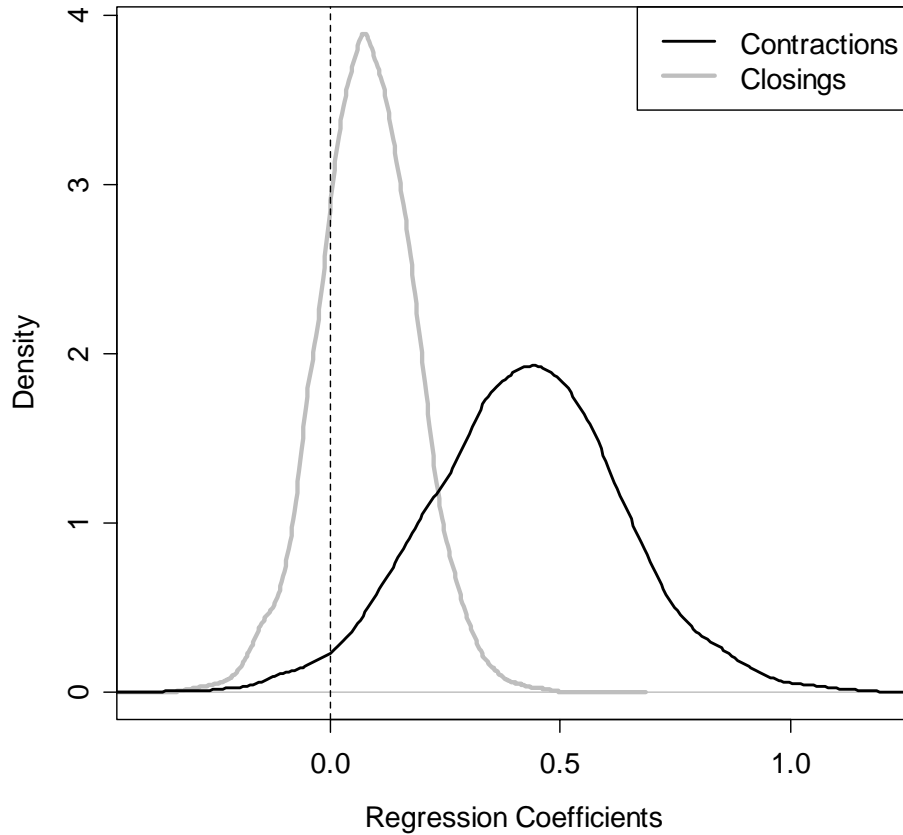
**Chart 20: Posterior Distributions of Regression Coefficients of Job Creation and Destruction for All Private Industry.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process. The model is estimated for the time period 1973-2007; for the period 1993-2007, the annual log growth rates of job creation and job destruction substitute for the autoregressive process; all covariates are calculated from Q4 numbers. Means: 0.068 (creation); 0.183 (destruction). Data source: BLS.



**Chart 21: Posterior Distributions of Regression Coefficients of Expansions and Openings for All Private Industry.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process. The model is estimated for the time period 1973-2007; for the period 1993-2007, four covariates substitute for the autoregressive process. The covariates are the annual log growth rates of job creation at (1) expanding and (2) opening establishments, and job destruction at (3) contracting and (4) closing establishments; all covariates are calculated from Q4 numbers. Means: 0.598 (expansions); -0.307 (openings). Data source: BLS.

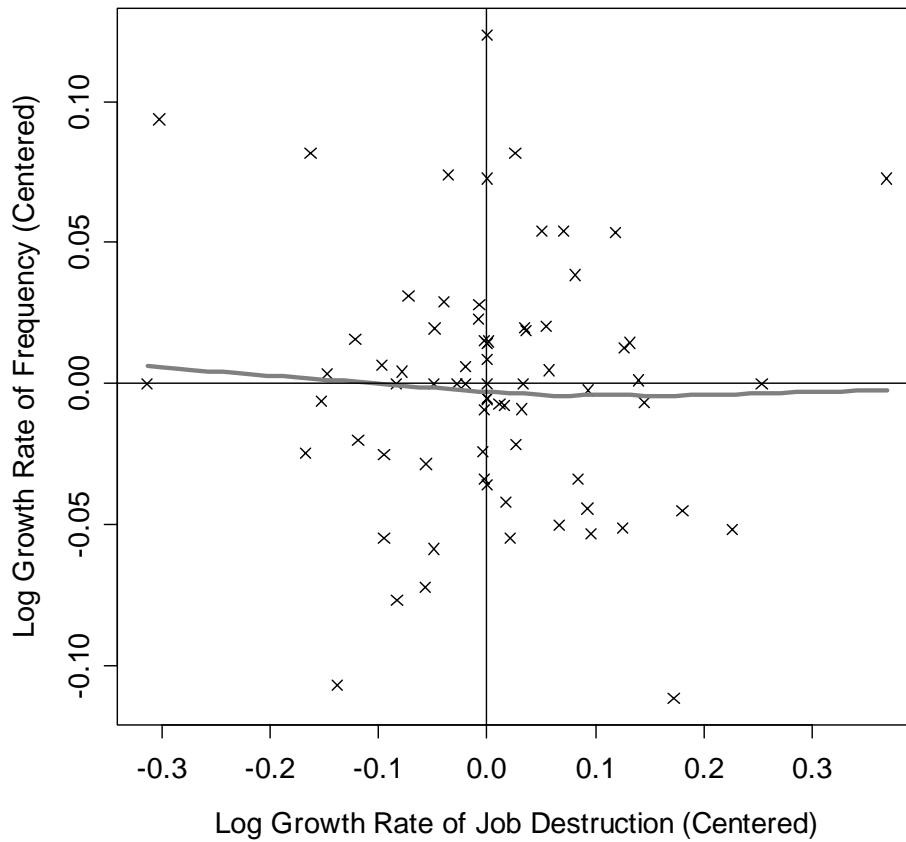


**Chart 22: Posterior Distributions of Regression Coefficients of Contractions and Closings for All Private Industry.** Estimates are from a local level structural time series model with time-varying variance of the autoregressive process. The model is estimated for the time period 1973-2007; for the period 1993-2007, four covariates substitute for the autoregressive process. The covariates are the annual log growth rates of job creation at (1) expanding and (2) opening establishments, and job destruction at (3) contracting and (4) closing establishments; all covariates are calculated from Q4 numbers. Means: 0.425 (contractions); 0.080 (closings). Data source: BLS.



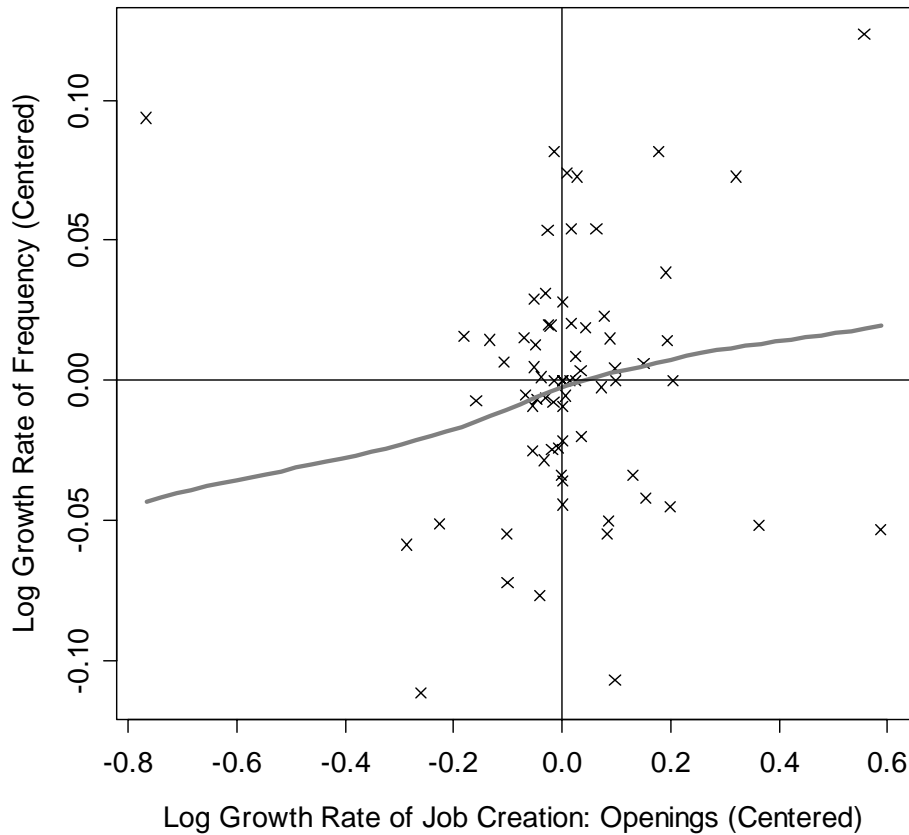
**Chart 23: Growth Rates of Frequency and Job Destruction for All Private Industry. 1993-2002.**

Frequency growth rates and growth rates of job destruction are by industry: Agriculture, Forestry and Fishing, Mining, Construction, Manufacturing, Transport and Public Utilities, Wholesale Trade, Retail Trade, Finance, Insurance and Real Estate, and Services; these industries add up to the private sector. The industry classification rests on SIC (Standard Industrial Classification), which confines the data set to the pre-2002 time window. All values are centered on the calendar year median across industries. Job flows are as of March 12. The scatterplot smoother (gray line) is LOESS (Cleveland, Gross and Shyu, 1992) with a unit smoothing parameter. Data source: BLS (frequency) and Census Bureau (job flows).



**Chart 24: Growth Rates of Frequency and Job Creation at Openings for All Private Industry.**

1993-2002. Frequency growth rates and growth rates of job creation at openings are by industry: Agriculture, Forestry and Fishing, Mining, Construction, Manufacturing, Transport and Public Utilities, Wholesale Trade, Retail Trade, Finance, Insurance and Real Estate, and Services; these industries add up to the private sector. The industry classification rests on SIC (Standard Industrial Classification), which confines the data set to the pre-2002 time window. All values are centered on the calendar year median across industries. Job flows are as of March 12. The scatterplot smoother (gray line) is LOESS (Cleveland, Gross and Shyu, 1992) with a unit smoothing parameter. Data source: BLS (frequency) and Census Bureau (job flows).



**Table 1: Distribution of Nonfatal Injury and Illnesses by Length of Service with the Current Employer.** Panel A: Manufacturing; Panel B: All Private Industry; Employment by length of service is as of January. Manufacturing employment is not available by length of service. Proportions may not add up to 1 due to rounding. Data source: BLS.

Panel A: Manufacturing

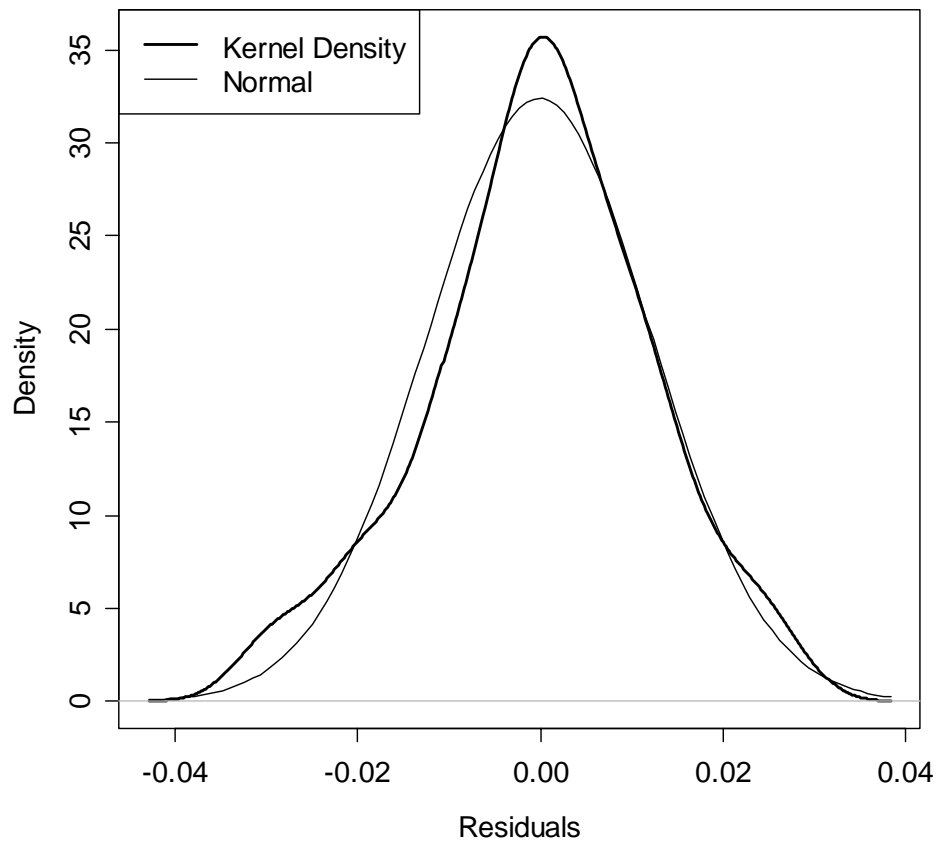
| Length of Service | Proportion of Injuries and Illnesses |       |       |       |       |
|-------------------|--------------------------------------|-------|-------|-------|-------|
|                   | 2003                                 | 2004  | 2005  | 2006  | 2007  |
| Less than 1 Year  | 0.237                                | 0.290 | 0.307 | 0.311 | 0.300 |
| 1 to 5 Years      | 0.325                                | 0.311 | 0.287 | 0.297 | 0.311 |
| 5 Years or More   | 0.435                                | 0.396 | 0.402 | 0.386 | 0.382 |
| Not Reported      | 0.003                                | 0.003 | 0.004 | 0.006 | 0.007 |

Panel B: All Private Industry

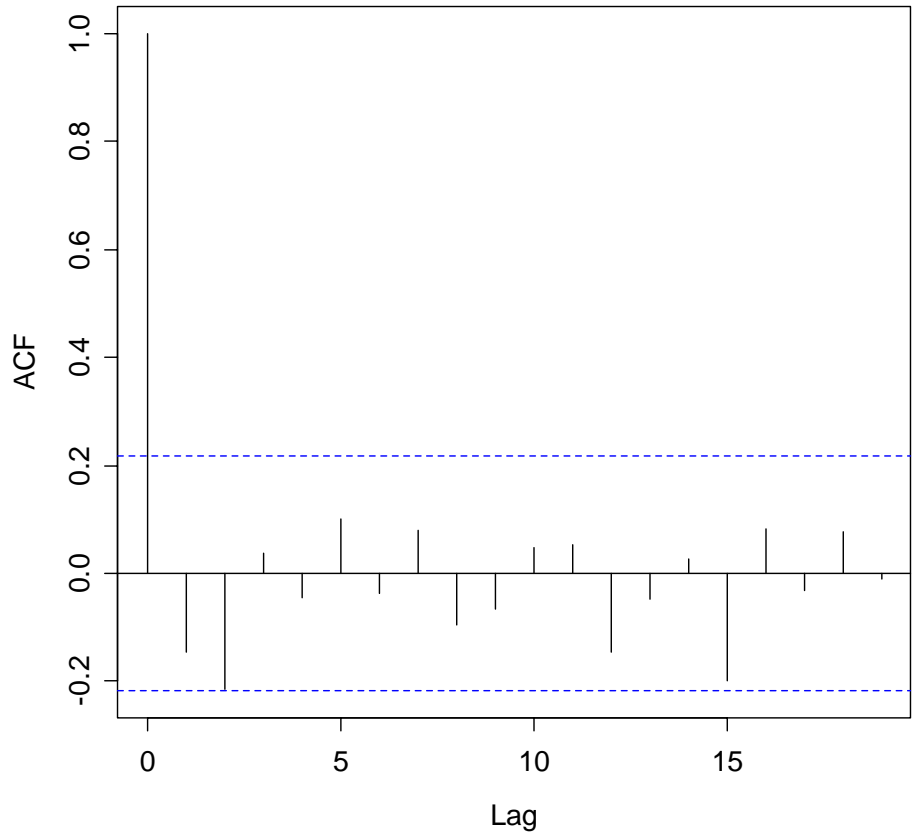
| Length of Service | Proportion of Injuries and Illnesses |       |       |       |       | Proportion of Employment |       |
|-------------------|--------------------------------------|-------|-------|-------|-------|--------------------------|-------|
|                   | 2003                                 | 2004  | 2005  | 2006  | 2007  | 2006                     | 2008  |
| Less than 1 Year  | 0.321                                | 0.334 | 0.347 | 0.352 | 0.338 | 0.244                    | 0.229 |
| 1 to 5 Years      | 0.366                                | 0.355 | 0.338 | 0.334 | 0.348 | 0.291                    | 0.299 |
| 5 Years or More   | 0.306                                | 0.304 | 0.306 | 0.305 | 0.302 | 0.465                    | 0.472 |
| Not Reported      | 0.007                                | 0.007 | 0.008 | 0.009 | 0.012 | ---                      | ---   |

## Appendix A

**Chart A.1: Kernel Density of Residuals of Measurement Equation.** Manufacturing, 1927-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. Data source: BLS.

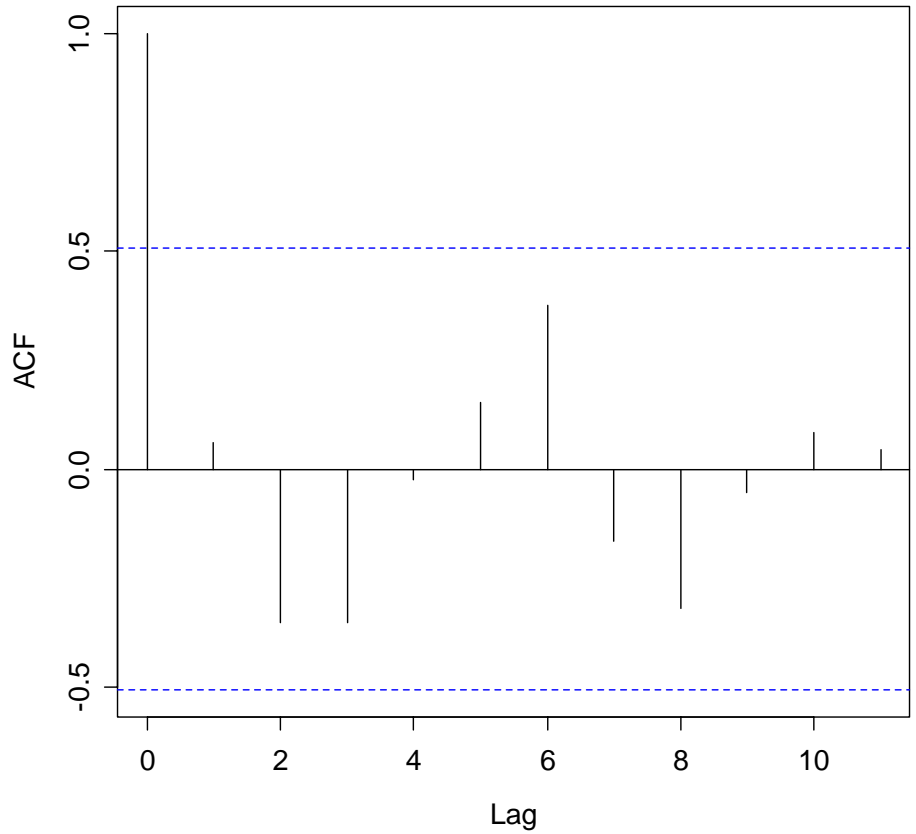


**Chart A.2: Autocorrelation Functions of the Residuals of the Measurement Equation.** Manufacturing, 1926-2007. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter. The dashed lines indicate an approximate 95 percent confidence interval. Data source: BLS.

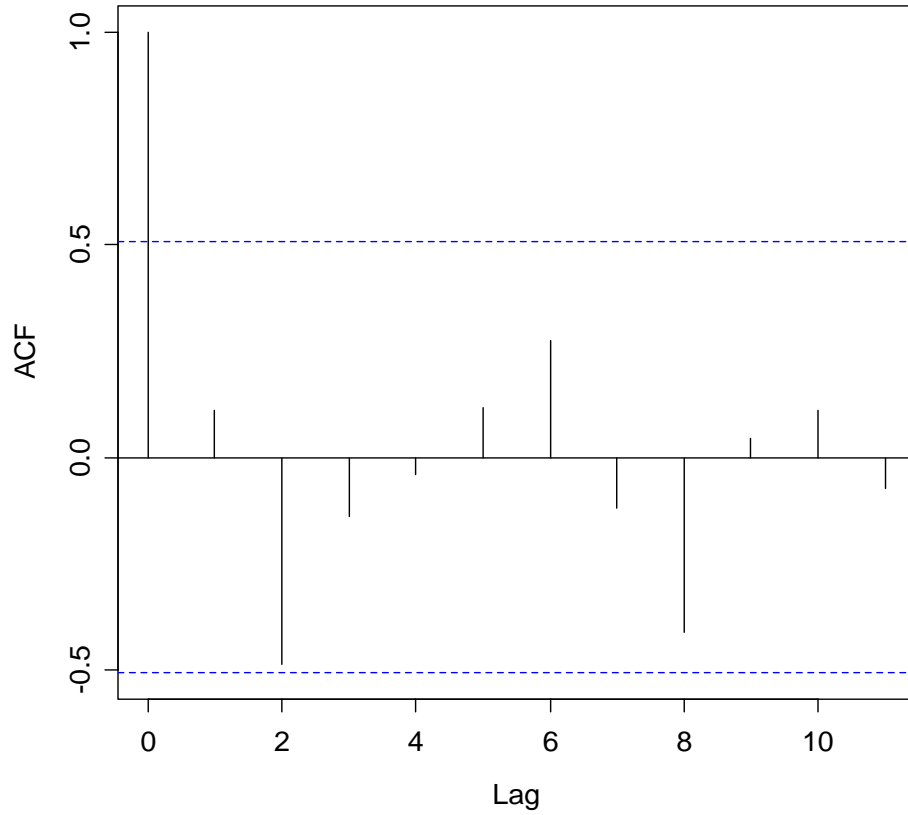




**Chart A.3: Autocorrelation Functions of the Residuals of the Measurement Equation for the Time Period for which the Set of Two Job Flow Covariates Substitute for the Autoregressive Process (1993-2007).** Manufacturing. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter, 1927-2007. The dashed lines indicate an approximate 95 percent confidence interval. Data source: BLS.



**Chart A.4: Autocorrelation Functions of the Residuals of the Measurement Equation for the Time Period for which the Set of Four Job Flow Covariates Substitute for the Autoregressive Process (1993-2007).** Manufacturing. Estimates are from a local level model with time-varying variance of the autoregressive process and a change-point in the autoregressive parameter, 1927-2007. The dashed lines indicate an approximate 95 percent confidence interval. Data source: BLS.



## Appendix B

**Chart B.1: Timing of U.S. Recessions on the Calendar Year Axis.** 1929-2001. The lines are arranged on the time axis such that they end within 12 months to the right of the zero vertical line. The 1980 and 1981/82 recessions are lumped into a single event. The bottom line indicates the Great Depression; the top line represents the 2001 recession. Data source: NBER.

