National Council on Compensation Insurance, Inc.

Impact of the Economy on Workers Compensation Insurance

Business Cycle Behavior of Bureau of Labor Statistics Workplace Injury and Illness Incidence Rates

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Questions Addressed

- What properties characterize the behavior of the rate of growth of BLS (Bureau of Labor Statistics) workplace injury and illness incidence rates?
  - Of what magnitude is the trend rate of growth, and how persistent is this trend rate?
  - Of what magnitude are deviations from trend, and how persistent are these deviations?
    - Has the magnitude of deviations changed over time?
    - Has the persistence of these deviations changed over time?
  - To which degree does the business cycle explain deviations from trend?

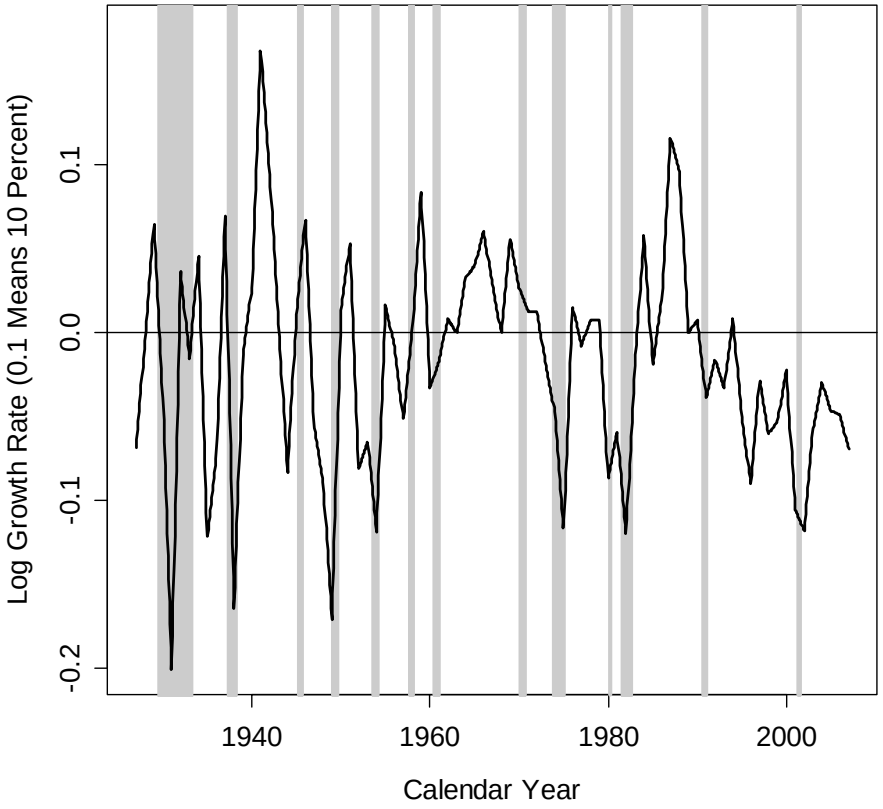
Road Map

- A time series model is applied to an annual series of the (logarithmic) growth rate of BLS manufacturing injury and illness incidence rates
  - This series of growth rates ranges from 1927 through 2007
- Subsequently, this time series model is expanded to a *structural* (time series) model by adding (two alternative sets of) covariates
  - These covariates are available only from 1993 onward

Caveat

- "BLS occupational injury and illness numbers come from the BLS annual Survey of Occupational Injuries and Illnesses," which "captures data from Occupational Safety and Health Administration (OSHA) logs of workplace injuries and illnesses maintained by employers" (www.bls.gov/iff/)
- A 2006 study published in the *Journal of Environmental Medicine* documented "missing cases in individual firms, as determined by comparisons between BLS and state workers compensation data" (www.bls.gov/iff/)

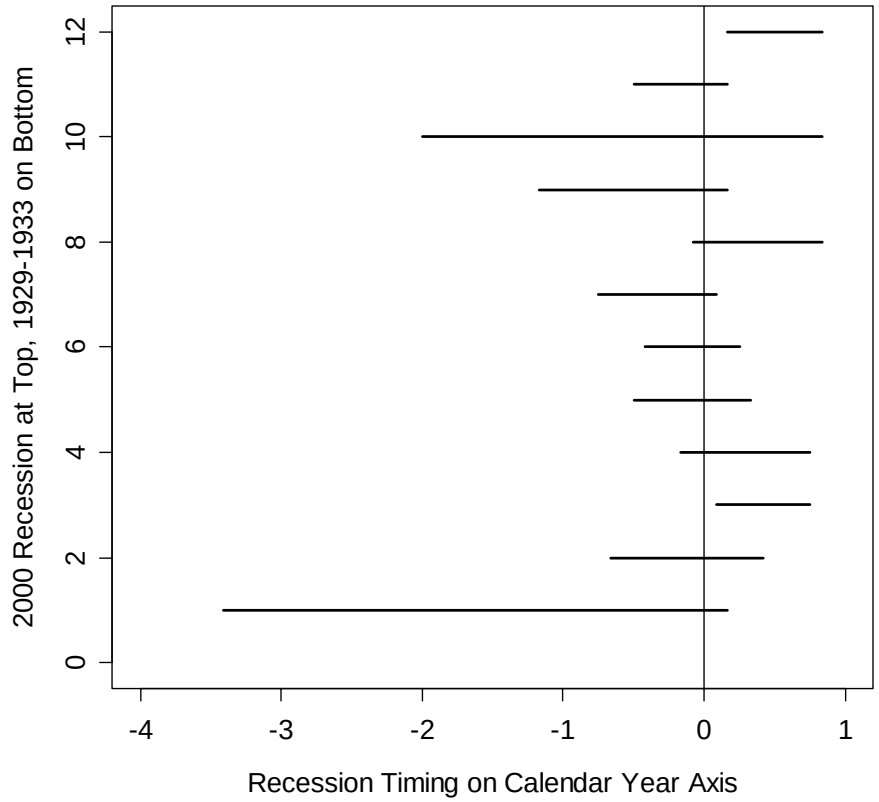
Growth Rate of BLS Workplace Injury and Illness Rates, 1927-2007



- The growth rate of workplace injury and illness rates drops sharply during recessions and rises sharply during recoveries
- Since the early 1960s, there is a decline in variance and an increase in the persistence of the deviations from the (potentially time-varying) mean

Note: Manufacturing only; time frame: 1927-2007; National Bureau of Economic Research (NBER, www.nber.org) recessions indicated by gray bars.

Calendar Year Timing of U.S. Recessions, Starting with Great Depression



- Recessions do not all line up the same way on the calendar year axis
  - This matters because the BLS workplace injury and illness rates are *annual* data

Note: Recession ends in calendar year to the right of the vertical line at zero; 1980/1981 recessions are treated as *one* recession; final recession (#12): 2001.

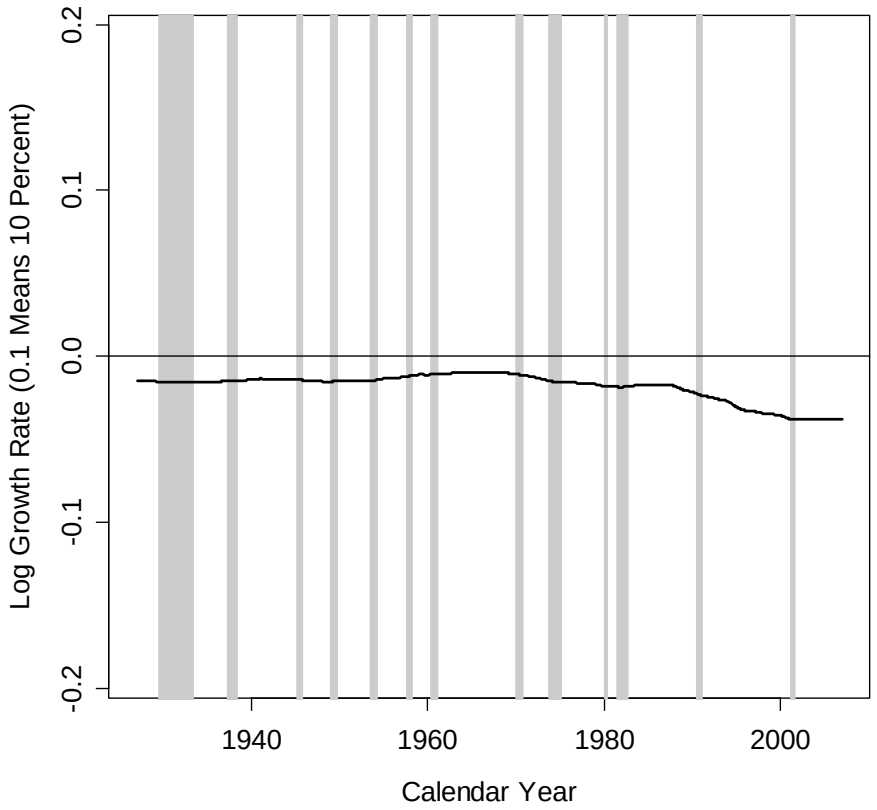
State-Space Time Series Model Without Covariates

- The observed growth rate of the BLS incidence rate consists of three parts
  - The level (i.e., trend)
    - The level (trend) is allowed to vary over time (i.e., may "change states")
  - An AR(1) process (i.e., mean-reverting process)
    - The variance of the AR(1) process may change states
    - The AR(1) coefficient ("rho") may have a (*one*) change-point
  - White noise

Estimation

- The time series model and the structural model are estimated using MCMC (Markov-chain Monte Carlo simulation)
  - We use WinBUGS 1.4.3 with R2WinBUGS in R
  - We employ gamma priors for the precisions
  - We run three Markov chains
  - The time series model uses 200,000 iterations per chain, after a burn-in of the same length—we use every tenth draw
  - The structural model uses 20,000 iterations per chain, of which we use every tenth draw

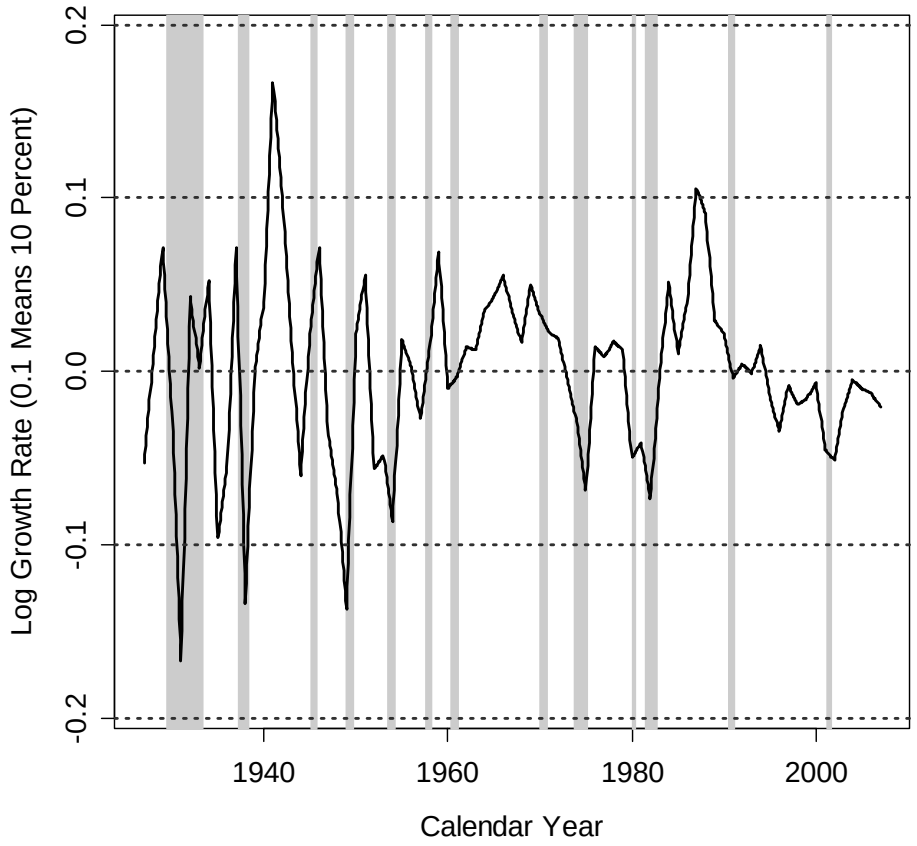
Estimated Level



- The trend rate of growth of workplace injury and illness rates has been negative since the 1920s
- Between the late-1980s and 2000, this (negative) trend growth rate has drifted down, but has since stabilized at a new level

Note: Manufacturing only; time frame: 1927-2007;
NBER (www.nber.org) recessions indicated by gray bars.

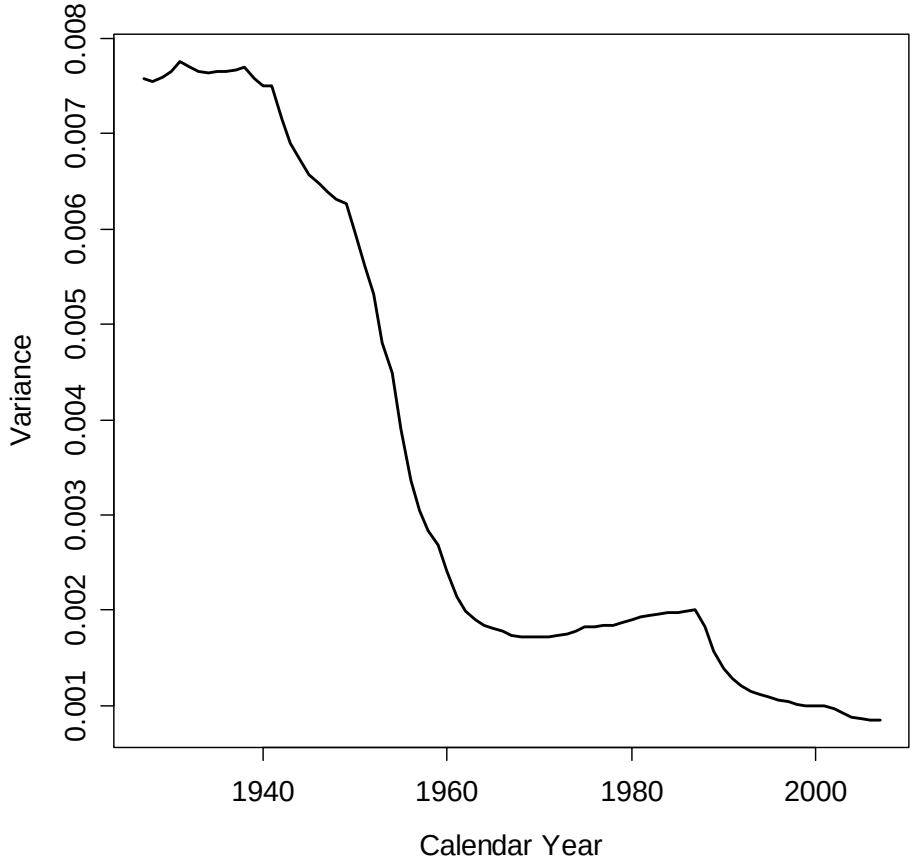
Estimated Autoregressive Process



- The business cycle (i.e., changes in economic activity) manifests itself in the autoregressive process
- Such autoregressive process is net of trend and the white noise of the measurement equation

Note: Manufacturing only; 1927-2007;
NBER (www.nber.org) recessions indicated by gray bars.

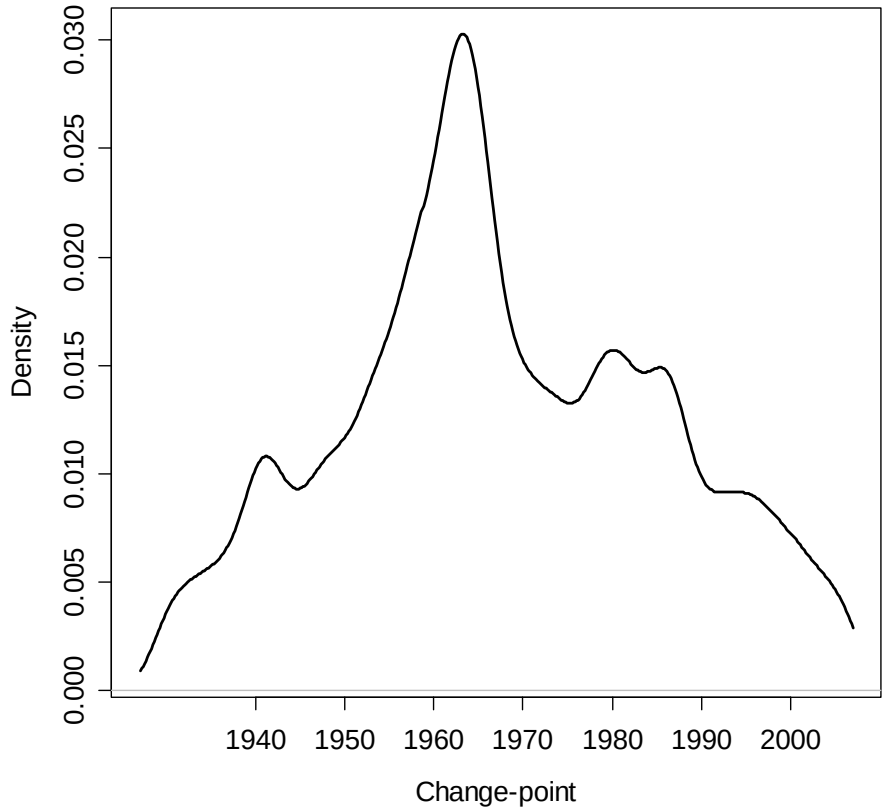
Estimated Variance of Autoregressive Process



- The variance of the autoregressive process has decreased sharply over time, thus indicating that deviations from trend have become smaller

Time frame: 1927-2007

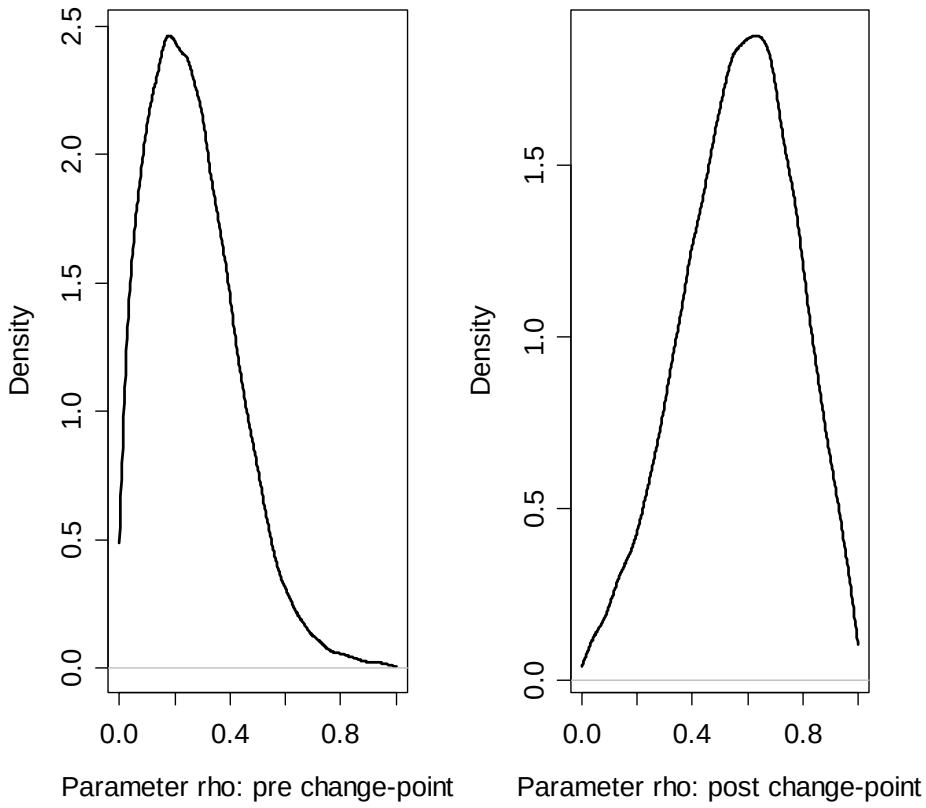
Posterior Distribution of Changepoint of Autoregressive Coefficient



- The autoregressive coefficient rho, which gauges the degree of persistence of deviations from trend, has a change-point in the early 1960s

Note: Prior distribution is a beta distribution: B(1.3,1.3) on the interval [1927,2007]; mode: 1963

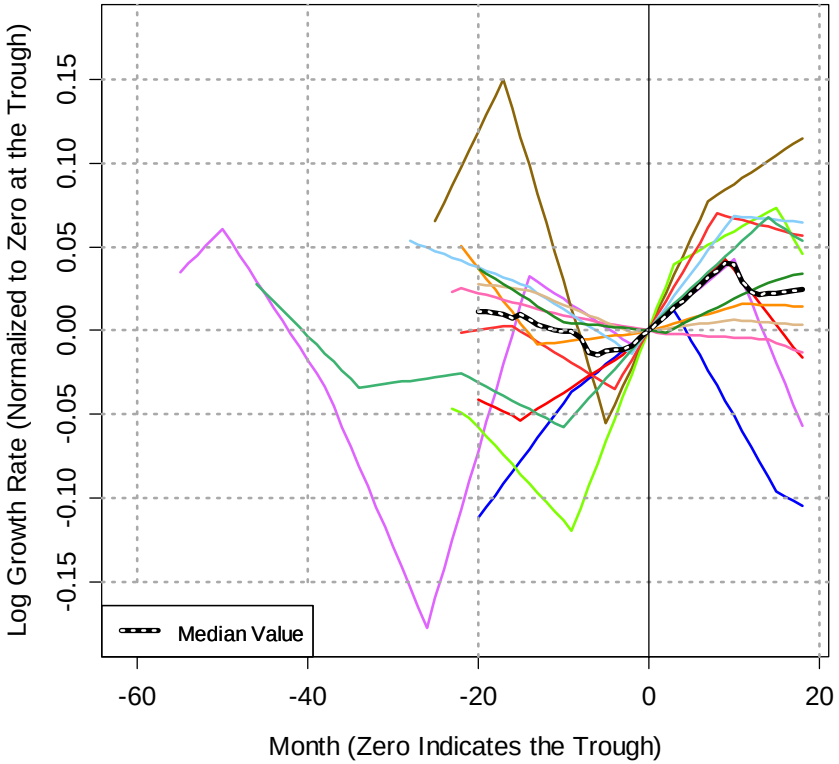
Estimated Autoregressive Coefficients (Pre and Post Changepoint)



- The degree of persistence of deviations from trend, as measured by the autoregressive coefficient rho, has increased over time
- At the same time, such deviations from trend tend to be smaller, as argued above

Note: Pre-change-point AR(1) coefficient to the left (mode: 0.18); post-change-point AR(1) coefficient to the right (mode: 0.63); prior: B(1.3,1.3)

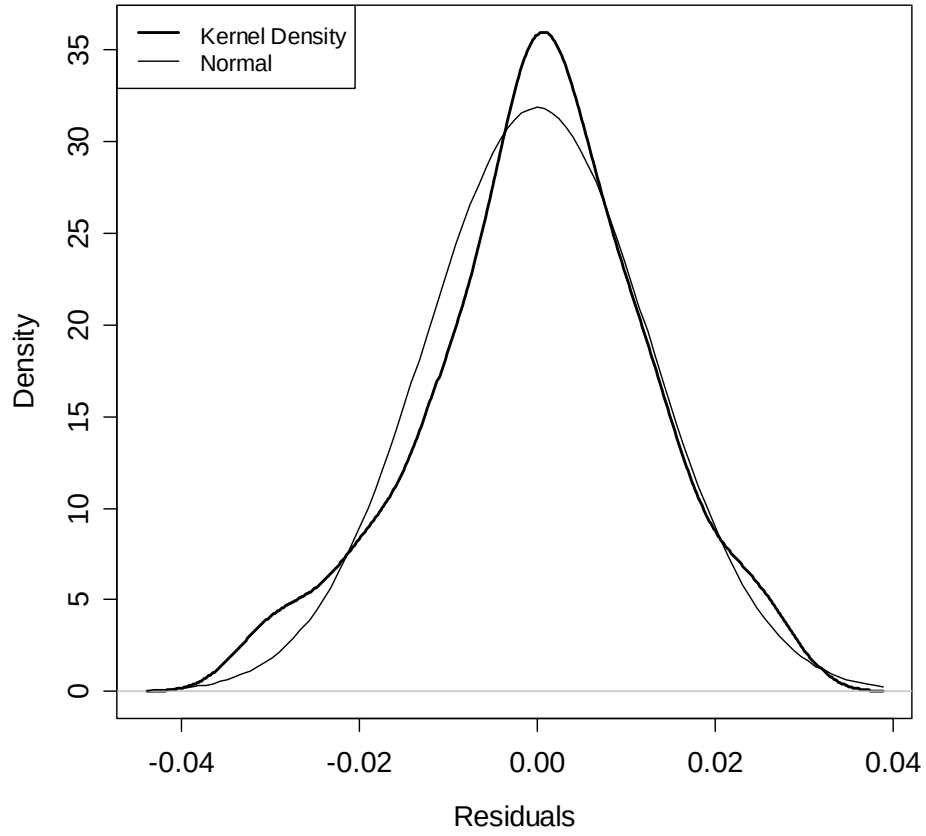
Incidence Growth Rate During Recessions, Starting with Great Depression



- Recessions tend to cause a decline in the growth rate of the workplace injury and illness incidence rate
- Three to nine months prior to the trough of the recession (i.e., the onset of the expansion), this growth rate starts to rise sharply

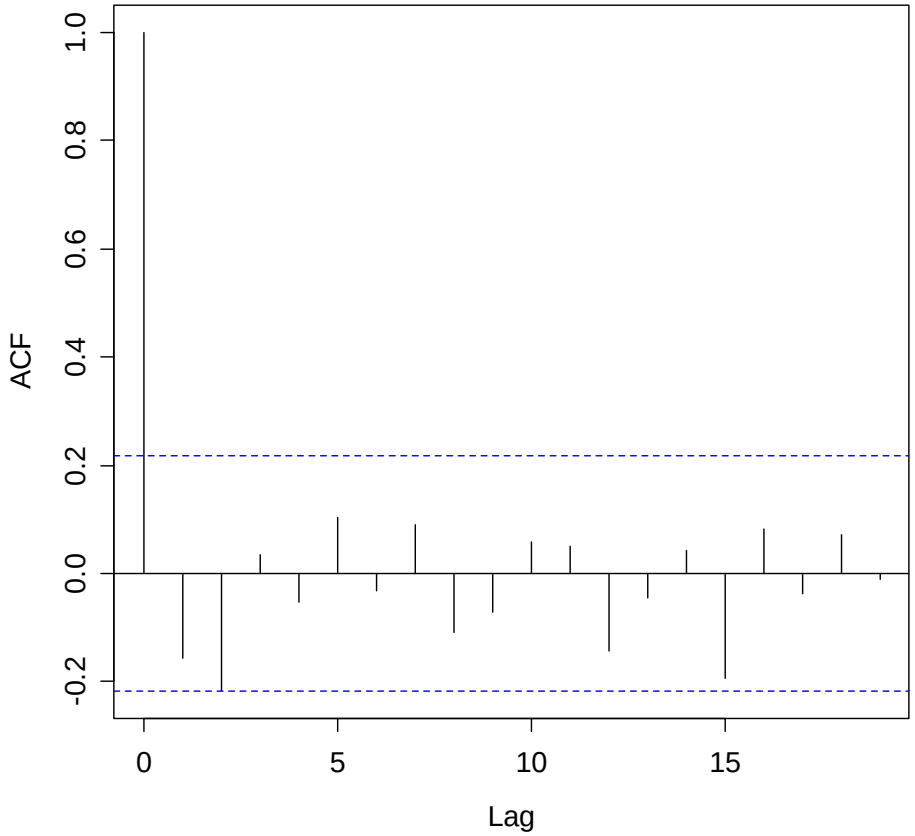
Note: The chart rests on the autoregressive process. Lines start 12 months prior to the onset of the recession and end 18 months after the trough (i.e., end of the recession); 1980/1981 recessions are treated as *one* recession

Diagnostics: Kernel Density Estimate of Residuals



- The residuals of the measurement equation are close to normal

Diagnostics: Autocorrelation Plot of Residuals



- There is no indication of serial correlation in the residuals of the measurement equation beyond the incorporated AR(1) process

State-Space Time Series Model With Covariates, *cont'd.*

- Starting in 1992, (quarterly) rates of job creation and job destruction are available from the BLS
  - The rates are based on the QCEW (Quarterly Census of Employment and Wages)
  - Job gains and losses are defined as net changes in employment *by establishment*
    - "An 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."

      Source: http://www.bls.gov/news.release/cewbd.tn.htm

State-Space Time Series Model With Covariates, *cont'd.*

- Adding up changes in employment across all establishments in manufacturing that report employment increases delivers the gross job gains for the manufacturing sector
  - Similarly, aggregating over all establishments with reductions in employment delivers the gross job losses
- Gross job gains (losses) are differentiated by…
  - expansions at existing (contractions at continuing) establishments and…
  - openings (closings) of establishments

State-Space Time Series Model With Covariates, *cont'd.*

- The time series model is expanded to a structural model by adding as covariates annual (logarithmic) growth rates of job creation and job destruction rates
  - The annual growth rates are calculated from fourth-quarter (not seasonally adjusted) values
  - Further, these growth rates are centered on zero (for the purpose of de-trending)
    - That way, the *level* of the original model retains its interpretation as the trend rate of growth

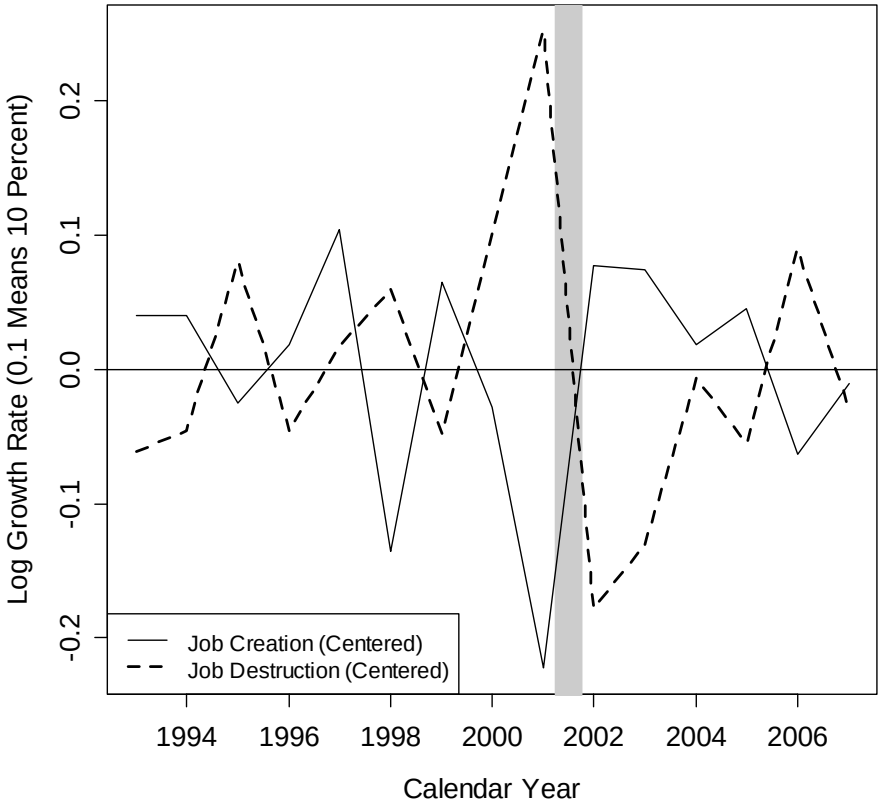
State-Space Time Series Model With Covariates, *cont'd.*

- Because there are only 15 observations (1993-2007) available, (the posterior distributions of) two parameters of the original model are fed into the structural version—these two parameters are the level (i.e., trend) and the variance of the measurement error (white noise)
  - First, there is no benefit in re-estimating the level based on a shorter series
  - Second, by retaining the variance of the measurement noise from the original model, the structural model is less prone to overfitting

State-Space Time Series Model With Covariates, *cont'd.*

- When feeding posteriors of the original model into the structural model, we approximate the (innumerable) population of draws from the respective posterior by a total of 60,000 iterations (from the three Markov chains)
  - By means of such approximation, we can draw with (instead of without) replacement from these posteriors at every updating step of the Markov-chain Monte Carlo simulation of the structural model
    - The structural model draws 6,000 times from these posteriors

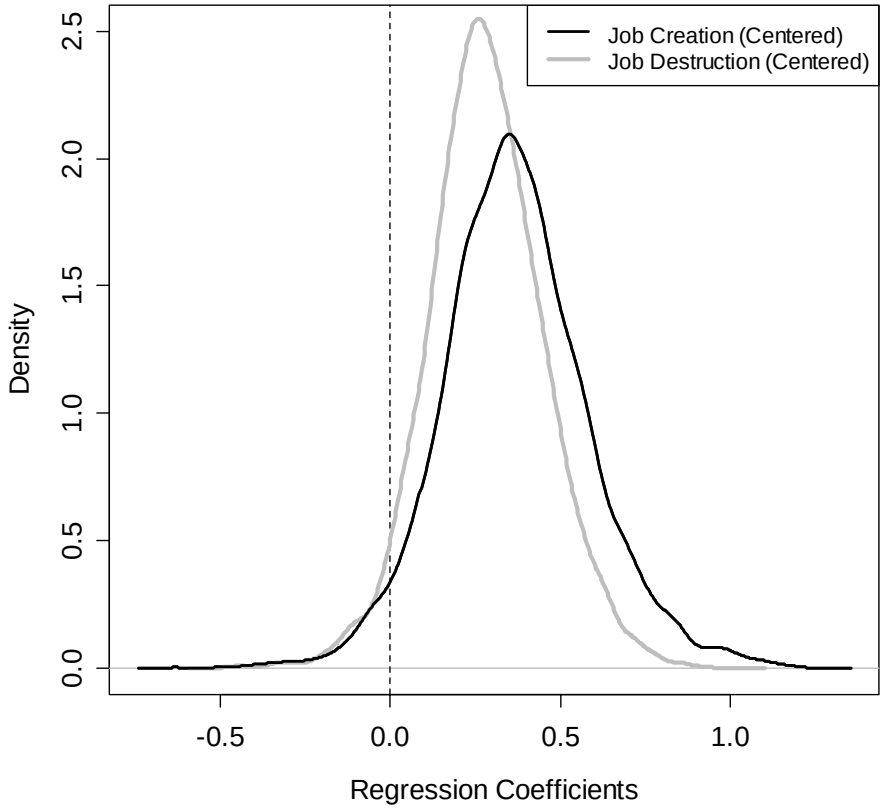
Job Creation and Job Destruction, Two Covariates



- At the onset of a recession, job creation slows and job destruction quickens
- See also Steven J. Davis, John C. Haltiwanger, and Scott Schuh (1998) *Job Creation and Destruction*, Cambridge (MA): MIT Press

Note: 1993-2007; annual growth rates are calculated from not seasonally adjusted fourth-quarter numbers

Effect of Job Creation and Job Destruction, Two Covariates



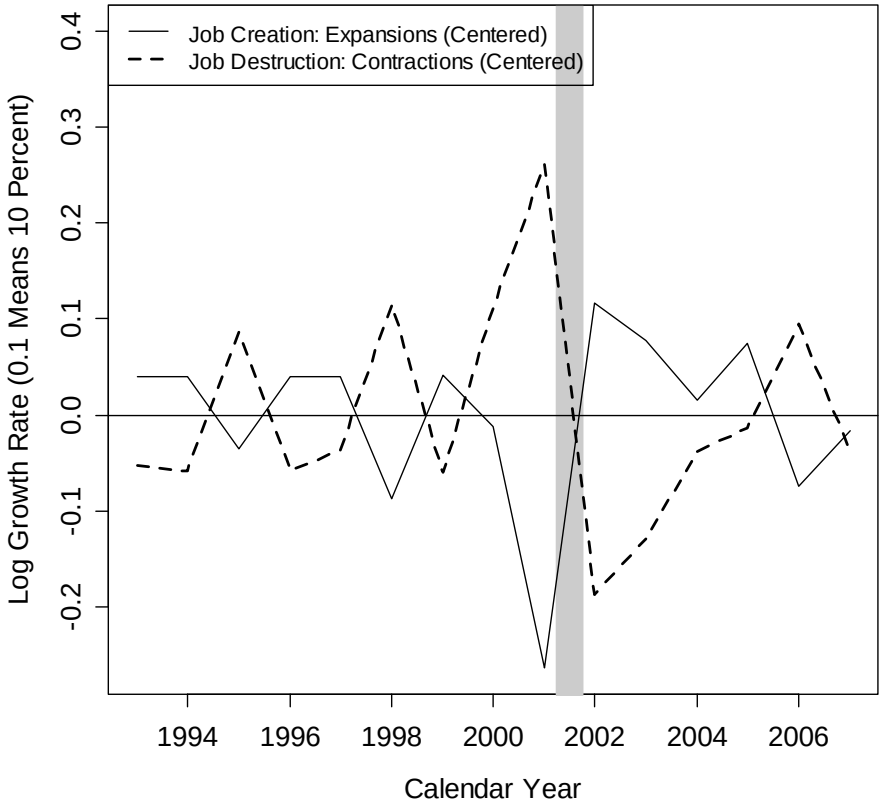
Note: Prior distributions are normal with expected values of zero and precisions (inverses of the variances) of 0.001

- Faster job creation is associated with an increase in the growth rate of the workplace injury and illness incidence rate
  - Evidence provided by the BLS relates higher incidence rates to shorter job tenure
- Faster job destruction also increases the growth rate of the workplace injury and illness incidence rate
  - This finding is indicative of *moral hazard* (opportunistic behavior)

The State-Space Time Series Model With Covariates, *cont'd.*

- We now re-estimate the structural model using a set of four (instead of two covariates)
  - The growth rate of job creation is replaced by growth rates of job creation at…
    - existing establishments (expansions) and…
    - new establishments (openings)
  - The growth rate of job destruction is replaced by growth rates of job destruction at…
    - continuing establishments (contractions) and…
    - closing establishments

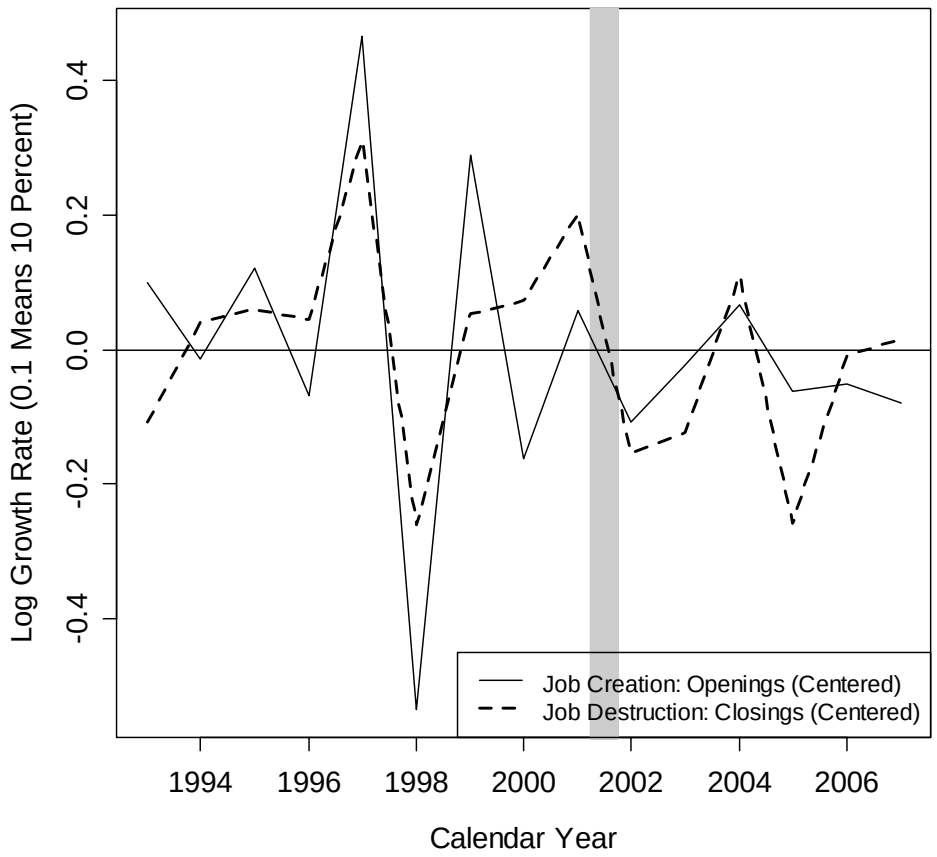
Job Creation and Job Destruction: Expansions and Contractions



- Job creation by means of expansion of existing establishments and job destruction by means of contraction at continuing establishments make up the bulk of total job creation and destruction
  - Hence, this chart resembles the one for total job creation and destruction shown above

Note: 1993-2007; annual growth rates are calculated from not seasonally adjusted fourth-quarter numbers

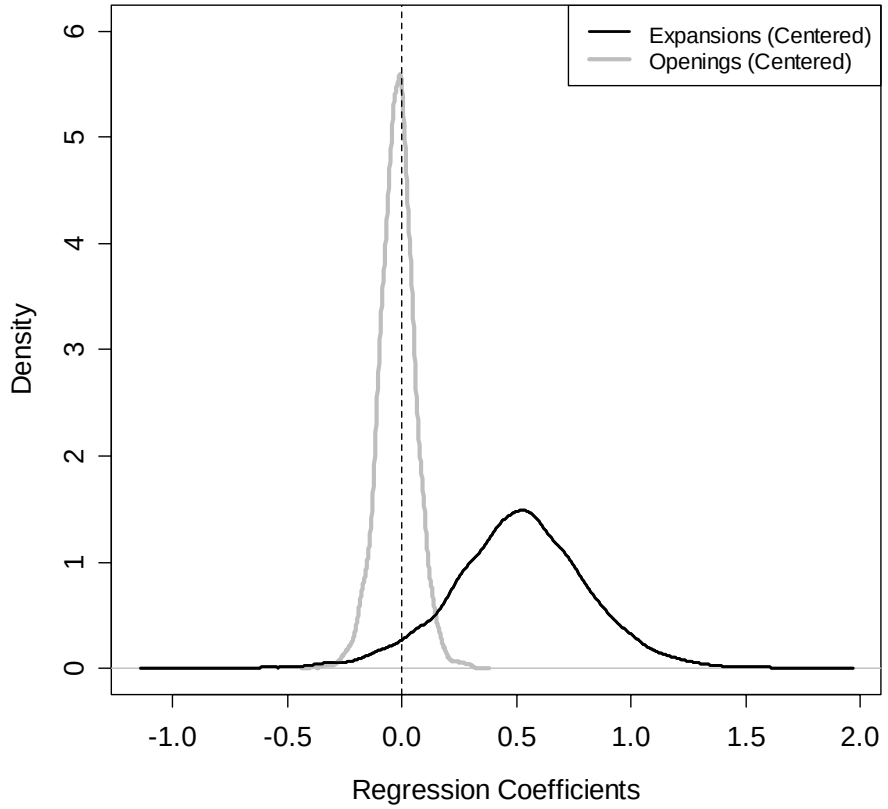
Job Creation and Job Destruction: Openings and Closings



- There was significant job creation and destruction through openings and closings during the 1997/1998 Asian Crisis
  - This crisis was characterized by sweeping currency realignments and a sharp drop in commodities prices (in U.S. dollar terms)

Note: 1993-2007; annual first differences are calculated from not seasonally adjusted fourth-quarter numbers

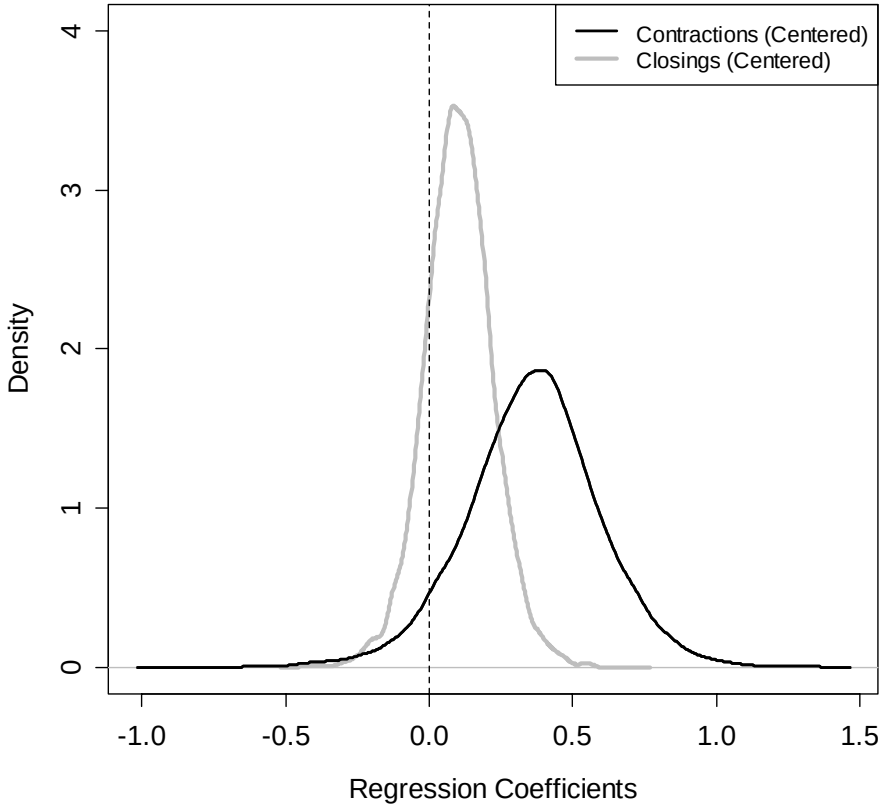
Effect of Job Creation and Job Destruction: Expansions and Openings



Note: Prior distributions are normal with expected values of zero and precisions (inverses of the variances) of 0.001

- Faster job creation due to expansions at existing establishments leads to an increase in the growth rate of the workplace injury and illness incidence rate
  - As mentioned, evidence provided by the BLS relates higher incidence rates to shorter job tenure
- Faster job creation that arises from the opening of new establishments leaves the growth rate of the workplace injury and illness incidence rate unaffected
  - Possibly, new establishments provide for safer workplaces than expansions of existing locations

Effect of Job Creation and Job Destruction: Contractions and Closings



Note: Prior distributions are normal with expected values of zero and precisions (inverses of the variances) of 0.001

- Faster job destruction due to contractions of continuing establishments leads to an increase in the growth rate of the workplace injury and illness incidence rate
- Faster job destruction as caused by closings of establishments also increases the growth rate of the workplace injury and illness incidence rate
- Again, these two findings are indicative of *moral hazard* (opportunistic behavior)

Conclusions

- The (negative) trend rate of growth of workplace injury and illness incidence rates shows a high degree of persistence
- Between the mid-1980s and 2000, this (negative) trend growth rate has drifted down, but has since stabilized at a new level
- Since the early 1960s, deviations from the (negative) trend rate of growth are smaller and more persistent than they were previously

Conclusions, *cont'd.*

- Accelerated job destruction (as happens at the onset of recessions) causes the growth rate of the workplace injury and illness rate to increase
  - This effect is observed for contractions at continuing establishments and for closings
- Accelerated job creation (as happens during recoveries) also causes the growth rate of the workplace injury and illness rate to increase
  - Although this holds for total job creation, such effect is not observed for openings of new establishments

Conclusions, *cont'd.*

- On net, recessions tend to cause a decline in the growth of the workplace injury and illness incidence rate
- Similarly, on net, recoveries from recessions come with an increase in the growth of the workplace injury and illness incidence rate
- These two net effects are driven by slowing job creation in recessions and accelerated job creating during recoveries
  - The effect of job creation outweighs the effect of job destruction