NCCI Holdings, Inc.

NCCI RESEARCH BRIEF

August 2006

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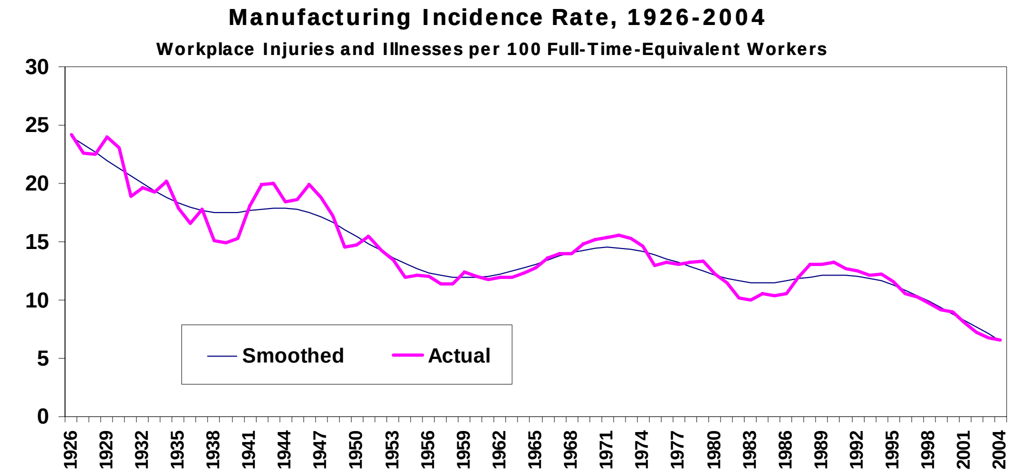
An Analysis of Factors Affecting Changes in Manufacturing Incidence Rates

Introduction

The incidence rate of manufacturing injuries (specifically, the number of cases per 100 full-time-equivalent employees) has been declining since the mid-1920s. As shown in Chart 1, the rate plummeted during the Great Depression era, spiked higher (and then lower) during the World War II (WW II) period, and then evidenced both a cyclical pattern as well as a mild downward trend through the early-to-mid-1990s.[1] Incidence rates then began declining rapidly, and they have shown no sign of reversing themselves through 2004.[2]

Chart 1



Source: U.S. Bureau of Labor Statistics and NCCI. The smoothing algorithm uses the Hodrick-Prescott filter with bandwidth set to 100

This paper analyzes the underlying factors driving the observed pattern of incidence rates. Following are the paper's key findings:

- To a large extent, the cyclical pattern of incidence rates is explainable by changes in the experience level of the workforce due to (a) the effects of the business cycle and (b) the impact of demographic changes
- In addition, other factors likely influenced incidence rate patterns during specific time periods, including:
  - Adoption of the Occupational Safety and Health Act (OSH Act) in 1970 and its ongoing impact
  - Implementation of the recommendations of the National Commission on State Workmen's Compensation Laws (released in 1972)
  - Possible underreporting of injuries to the Occupational Safety and Health Administration (OSHA) in the early 1980s, with a corrective surge later in that decade
  - The impact of globalization and technological change in creating a more competitive and productive workplace—developments that have paid added dividends in terms of reduced injury rates, especially since the 1990s
- Prospects for incidence rates in the near-term depend on the balance between factors that affect the experience level of the workforce and the extent to which ongoing efforts to increase productivity and drive down costs are reflected in further improvements in workplace safety

This paper is organized as follows:

- Discussion first focuses on a qualitative/graphical assessment of how changes in the experience level of the workforce impacts changes in manufacturing incidence rates through (a) the ups and downs of the business cycle and (b) demographic shifts in the sex and age composition of the workforce. This analysis covers the full period for which incidence rate data is available—1926 through 2004.
- Following that, models are presented that quantify the extent to which the experienced-worker effect (as reflected in the business cycle and demographic changes) explains changes in incidence rates since the late 1940s. (The Technical Appendix on page 10 provides full details of these models.)
- The final section looks at other factors that have affected (and in some cases are continuing to affect) incidence rates changes.

Key Role of the Experienced-Worker Effect

The Experienced-Worker Effect and the Business Cycle

To understand the relationship between incidence rate changes, the experienced-worker effect, and the business cycle, it is first necessary to understand the relationship between incidence rates and employment.

The Bureau of Labor Statistics (BLS) incidence rate series measures injuries and illnesses per 100 full-time-equivalent workers. This frequency rate can remain unchanged regardless of changes in employment, provided that the number of injuries varies directly with that exposure base. For example, a factory with four injuries and 100 employees has an incidence rate of 4.0. A doubling of employment and injuries would still leave the incidence rate at 4.0. Thus, a rise in the incidence rate means that injuries are increasing more rapidly than employment (or that employment is decreasing more rapidly than injuries). In contrast, the injury rate falls if injuries decrease faster than employment (or employment increases faster than the number of injuries).[3]

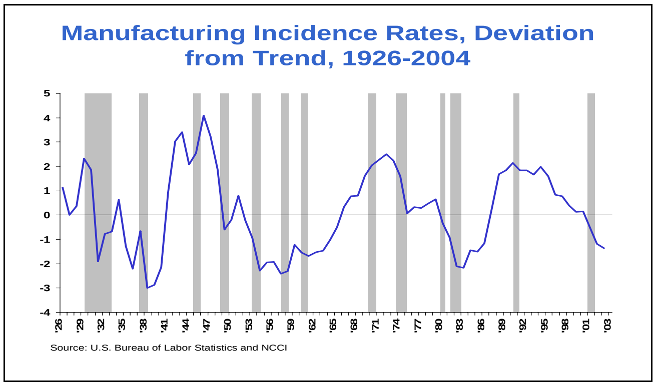
What the BLS found nearly 70 years ago was that changes in employment were associated with greater than proportional changes in injuries. That is, when the economy expanded and added jobs, injuries rose more rapidly than employment, with a resulting rise in frequency. When the economy was in recession, injuries tended to fall more rapidly than employment, and frequency declined.

According to the BLS, the primary factor explaining why incidence rates evidence this relationship over the business cycle is the experienced-worker effect. The agency described that effect as follows:

- As employment decreases, the frequency rate falls sharply as " . . . those most recently hired were laid off first. This generally left employed workers with long years of service. . . . Such workers were generally thoroughly familiar with job hazards and had developed safety habits which were carried from job to job."
- With the first decided increase in employment, the frequency rate rises sharply, because "increases in employment meant hiring of workers not accustomed to the hazards of their new jobs, or workers whose safety habits had been blunted through lengthy layoffs and financial worries and who, perhaps, were too eager to make a favorable showing."
- Subsequent increases in employment are accompanied by less decided increases in the frequency rate.
- Finally, as employment plateaus, the frequency rate turns downward "apparently because of the increasing skill and development of safety habits . . . of workers hired or rehired during the preceding year."[4,5]

The relationship between the business cycle and incidence rates is shown in Chart 2. The chart shows the "detrended" values for the incidence rate series, that is, the original data set minus the calculated trend (as shown in Chart 1). The shaded vertical areas on the chart are recession periods, as determined by the National Bureau of Economic Research. As seen in the chart, incidence rates have tended to rise and fall with the business cycle.[6]

Chart 2



That was certainly the case during the Great Depression era, a period of profound economic weakness, when the unemployment rate rose from 3.2% in 1929 to 8.7% in 1930 and to nearly 25% in 1933—and it was a still-high 17% in 1939.

Incidence rates also generally tracked the economy from the 1950s forward (the WW II-dominated 1940s is a special case, discussed in the next section). Interestingly, the sharp upward spike in the incidence rate series in the late 1980s, a period of economic expansion, may be more a reflection of data reporting issues (see discussion below) than changes in actual injuries and illnesses due to economic growth and its impact on experience levels.

The major exception in the post-WW II period is in the 1990s and into the current decade, when incidence rates trended markedly lower, even as the economy continued to expand (the reasons for this are treated at length below).

The Experienced-Worker Effect and Demographic Changes

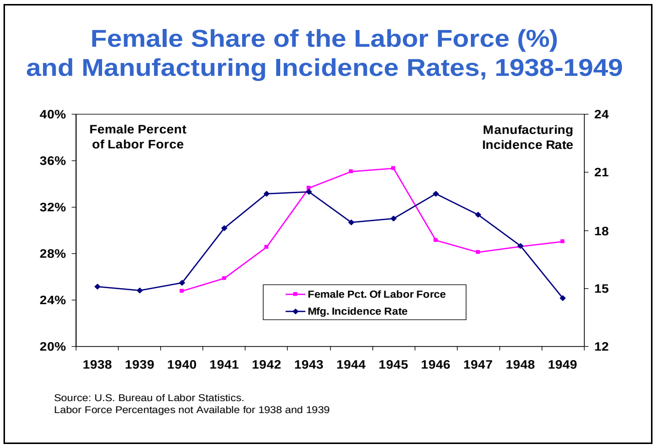
At the same time that experience levels were being affected by the business cycle, they were also being impacted by shifts in the gender and age composition of the workforce. Indeed, demographic factors appear to explain much of the broad swings in incidence rates from the WW II period to the present.

Changes in Gender Composition of the Workforce: World War II and Its Aftermath

Prior to the start of US involvement in WW II (in 1941), men made up the lion's share of the labor force, accounting for 75% of the total in 1940. In all likelihood, men held even a higher percentage of manufacturing jobs. With US entry into the war, there was a massive exiting of experienced male workers to the military—and a resulting sharp rise in the number and proportion of female workers. Many of these new workers were less trained than their male counterparts. Not surprisingly, as shown in Chart 3, the frequency of workplace injuries increased dramatically, from 15.3 per 100 full-time workers in 1940 to 20.0 in 1943. (That rise may also reflect the fact that the share of younger workers in the female labor force (those aged 14–19) increased from 10.7% in 1940 to 15.7% in 1943.)

The share of female workers kept rising through 1945, but by then, many of the replacement workers hired earlier were sufficiently experienced so that their incidence rates had likely declined to that of their male counterparts. (In that regard, females aged 14–19 declined as a share of the female labor force between 1943 and 1945—from 15.7% to 14.3%.) Thus, overall incidence rates leveled off in 1943 and declined a bit through 1945.

Chart 3



With the end of the war in 1945, soldiers (mostly men) began to return to their civilian jobs. Some retraining was likely needed, so incidence rates moved up again in 1946. They gradually declined thereafter, with the rate of decline quickening as overall experience levels returned to their more normal range. Indeed, by 1949, incidence rates were roughly at their pre-war levels.

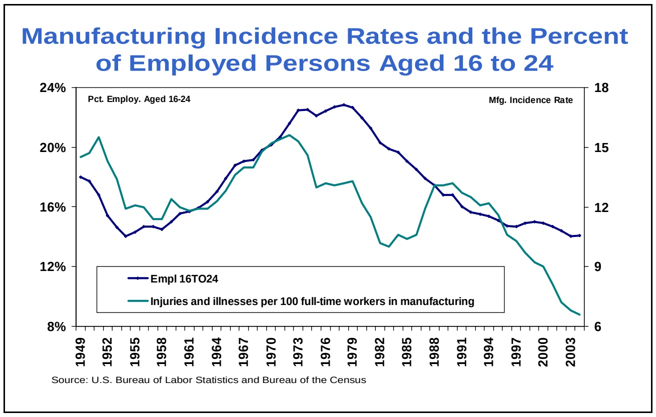
Changes in Age Composition of the Workforce: Key Role of Younger Workers

In investigating the relationship between experience on the job and incidence rates, NCCI's economists noticed that the sharp rise in incidence rates during the 1960s and early 1970s occurred just as the baby-boom generation was entering the workforce (the baby-boom generation reflects those born in the years just after the end of WW II). The percentage of persons in the labor force aged 16 to 24 rose from nearly 16% in 1961–1962 to 22% in 1972–1973, while the frequency of workplace injuries rose from just under 12 to 15.5. At no other period in modern history has the percentage of younger—and largely inexperienced—workers shown a similar surge.

The relationship between incidence rates and age seen in the 1960s is more than coincidence, and, indeed, as shown in Chart 4, changes in incidence rates have generally tracked the share of employed persons aged 16 to 24 over the period 1948 to date.

- ***The 1950s:***
  The share of younger (i.e., inexperienced) workers first declined rapidly and then stabilized. (The decline in the share of younger workers in the 1950s may be a reflection of the Great Depression era, when birth rates plummeted.)[7] Incidence rates also declined in that period, albeit erratically, as the economy also experienced a number of short-lived expansions and recessions that impacted experience levels.

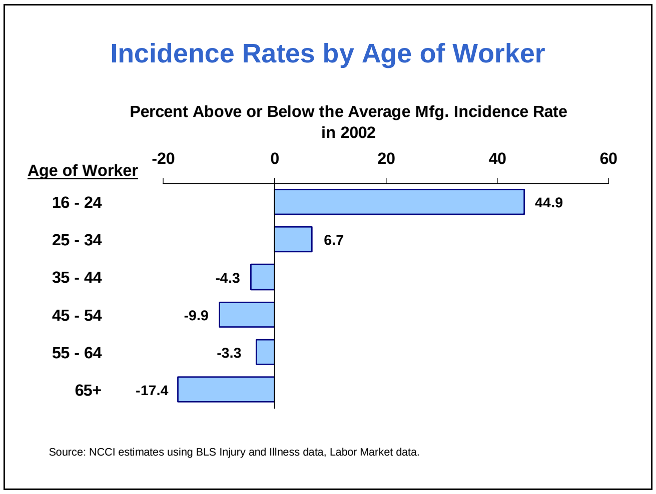
Chart 4



- ***The 1960s:***
  As previously discussed, this period experienced a surge in new and largely inexperienced workers over an extended period of years; their entry speeded by the demands of the booming economy.
- ***The 1970s:***
  Incidence rates generally drifted lower in the 1970s, as the baby boomers gradually became more experienced (and mature). Other factors also likely affected incidence rates in the period, including a severe recession in 1973 and 1974 and a brisk recovery beginning in 1975. OSHA may have also played a role in the downtrend (see discussion in the section focusing on the impact of OSHA on claims below).
- ***The 1980s:***
  At first look, the relationship between age and incidence rates does not appear to hold in the 1980s. Incidence rates then were initially flat before rising sharply, while the percentage of younger workers continued to decline. However, as noted earlier (and as discussed more fully below), the incidence rate data in the 1980s may have been affected by reporting issues rather than demographic factors.
- ***The 1990s and the Current Decade:***
  The correspondence between age and incidence rates returned in the 1990s, as the two series resumed their joint decline. However, factors in addition to the experienced-worker effect may be driving incidence rates since the mid-1990s, in light of the more pronounced decline in incidence rates seen then. A discussion of those factors is provided later.

The BLS does not publish incidence rates by age of worker, so researchers are unable to determine directly whether younger workers have exhibited higher incidence rates over time relative to older workers. However, since 1992, the BLS has collected data that show the *number* of injuries by age. NCCI economists have used that data, along with data on employment and hours by age of worker[8] (for all private industry workers), to estimate a proxy measure of incidence rates by age for 2002. The key finding confirmed the relatively adverse experience of younger workers—that younger workers (those aged 16 to 24) have incidence rates roughly 45% above the average of all workers, while older workers (those aged 35 and above) have below-average incidence rates (see Chart 5).

Chart 5



Quantifying the Experienced-Worker Effect

The preceding discussion suggests that changes in incidence rates can be explained by changes in the business cycle and the age composition of the workforce. To quantify that relationship, NCCI's economists developed models that relate changes in economic and demographic variables to changes in manufacturing incidence rates. The details of that analysis are provided in the Technical Appendix on page 10.

In brief, that modeling effort found a statistically significant relationship between percent changes in manufacturing incidence rates and percent changes in both the unemployment rate and the share of workers aged 16 to 24.

- The unemployment rate rises in periods of economic weakness and declines in periods of economic expansion. Declines in the unemployment rate would be expected to be accompanied by increases in incidence rates, all else being equal, since lower unemployment rates are reflective of increased hiring and reduced skill levels. In contrast, when the unemployment rate increases, those still on payrolls would tend to be the more experienced, so incidence rates would be expected to decline.
- The share of workers aged 16 to 24 is a proxy for the share of inexperienced workers in the workforce. This measure was seen to have the "best fit" of other potential candidates such as the share of older workers and an index derived from the spread between the share of younger and older workers.

A model that included real Gross Domestic Product (GDP) and the 16-to-24 age share as explanatory variables performed almost as well. Real GDP, of course, is the broadest measure of the goods and services produced in the economy and, along with the unemployment rate, is a key indicator of the business cycle. Unlike the unemployment rate, increases in real GDP are associated with increases in incidence rates. That is because an expanding economy results in increased hiring (which brings down average skill levels) as well as increases in overtime and capacity utilization, factors likely to result in a higher rate of workplace injuries.

Other Factors Affecting Incidence Rate Trends

A number of other factors, in addition to changes related to the experienced-worker effect, help to explain the short-term cyclicity and longer-term trend of the incidence rate series. A discussion of those factors follows:

OSHA's Impact on Incidence Rates in the 1970s and 1980s

A major change in national health and safety legislation occurred at the end of 1970, with the enactment of the OSH Act. Pressures for such legislation began to build in the 1960s, when organized labor reacted to (a) the conclusions of a 1965 report by the Public Health Service on technological dangers in the workplace and (b) the 1967 announcement of more than 100 radiation-related deaths among uranium mining workers. With manufacturing incidence rates moving sharply higher as well, the Johnson Administration, in 1968, proposed sweeping legislation that would have given the Secretary of Labor broad powers in the setting and enforcing of health and safety standards. The Johnson bill aroused strong reactions in Congress, and it never came to a vote.

However, the idea that some form of legislation was needed had taken hold, and the Nixon Administration put forward legislation of its own in August 1969. The final bill, which was adopted in December 1970, ended three years of legislative wrangling and provided for a separate commission to oversee standards set by the Labor Department.[9] The Act also established the National Commission on State Workmen's Compensation Laws. That Commission issued a report in 1972 that included recommendations for higher benefits, mandatory coverage, and unlimited medical care and rehabilitation benefits.[10] The National Commission's Report also included strong language that indicated that federalization of workers compensation should be considered if the states did not implement the "essential" recommendations of the Commission.

The question arises as to whether passage of the OSH Act (and the fallout from the National Commission's recommendations) had a discernable impact on the frequency of workplace injuries. More directly:

- Was the downtrend of incidence rates seen in the 1970s (and the uptrend in incidence rates after 1986) at least partly a reflection of OSHA?
- Did the benefit recommendations of the National Commission (and their implementation by the states) lead to an increase or decrease in claim frequency during this period?

Impact of OSHA on Incidence Rates

Econometric studies provide mixed results in terms of the efficacy of OSHA in reducing incidence rates.

Studies, conducted just a few years after the OSH Act took effect, showed little if any impact of the Act on either overall or lost-workday incidence rates (see, for example, Viscusi,[11] who focused on data from 1972–1975, and Smith, who examined data for 1973–1974[12]). The "newness" of OSHA and industry's reaction to it may have contributed to the lack of significant results in these studies.

A later analysis by Ruser and Smith[13] also showed no discernable OSHA impact. They used 1979–1985 establishment-based data to examine the effects of OSHA on workplace safety via (a) inspection effects (effects forced on employers after an inspection) and (b) deterrence effects (that is, the impact that the threat of OSHA inspections has on companies that are inspected or not inspected).[14] Based on 4,114 observations for establishments inspected by either federal or state OSHA compliance officers, the authors found no significant changes in injury rates within a year of the inspection, little evidence of a significant impact in the year following an inspection (except for firms with fewer than 100 employees), and no evidence of a deterrence effect (in terms of relating injury rates to the frequency of OSHA inspections).

Ruser and Smith did not control for the effect that changes in the business cycle can have on incidence rates—increasing them in expansions and reducing them in recessions. That may well have affected their results, given that during their 1979–1985 investigation period, there was a shift from expansion (in 1979) to severe recession (1980–1982) and back to expansion (in 1983–1985).

Indeed, in studies that included variables to control for the business cycle, OSHA was seen to have had a statistically significant (albeit small) impact in reducing incidence rate. For example:

- Viscusi[15] examined three different measures of industry risk levels in a sample of two-digit manufacturing industries for the period 1973–1983. In his study, risk was defined alternatively as the frequency of all injuries and illness, the frequency of injuries and illnesses involving lost work time, and the total number of days lost per 100 workers due to injury or illness. His study explicitly controlled for changes in the business cycle by including the percent change in manufacturing employment as an explanatory variable, along with variables measuring the frequency of OSHA inspections and assessed OSHA penalties. Viscusi found the strongest statistical relationship between lost workdays and prior-year OSHA inspections. However, the effect was not large, with OSHA's impact "in the range of 1.5% to 3.6% of the current lost-workday incidence rate." OSHA penalties were found to have no statistical relation to any measure of industry risk.

- Gray and Scholz[16] found that OSHA inspections where penalties were imposed induced a 22% decline in injuries in the inspected plants in the years following the inspection (Ruser and Smith's study did not distinguish between inspections with and without penalties). The Gray and Scholz study used a panel of 6,842 large manufacturing companies and covered the years between 1979 and 1985. It included control variables to account for the business cycle, including the percent change in employment and the percent change in hours. The authors hypothesized that inspections that impose a penalty appear to focus managerial attention on ways to reduce hazards in the workplace. The authors note that their results may overstate OSHA's impact since their data set included mainly large, intensively inspected firms. However, they also note that OSHA enforcement may have generalized deterrence effects, which could reduce incidence rates in small and medium-sized firms as well.

All this suggests that OSHA is likely to have been a factor in reducing incidence rates, although the agency's direct impact may be difficult to measure.

OSHA Reporting Problems and the Rise in Incidence Rates in the Late 1980s

Incidence rates rose sharply in 1987 and 1988 (up 1.3 points and 1.2 points, respectively) after showing virtually no change in 1984 through 1986. Part of that rise may well have reflected the strong economy then. However, there is also some reason to speculate that the spurt was attributable to increased compliance with OSHA recordkeeping rules following a major recordkeeping scandal in 1986.

Here is some background. In late 1981, OSHA changed the way it used employer injury and illness records in its inspection programs. Under the new policy, OSHA compliance officers would perform a "records-only" check to determine if the lost-workday injury rate was below the national average. If so, the compliance officer would terminate the investigation. Unfortunately, this procedure resulted in abuses, and OSHA audits turned up numerous instances of significant underreporting of injuries and illnesses, many by major US corporations. The agency began issuing large fines for recordkeeping violations in the mid-1980s. The result of those penalties, in OSHA's words, was "an even greater awareness of, and sensitivity to, the injury and illness recordkeeping requirements among the safety and health community." (OSHA discontinued its records-only policy in 1989.[17])

Ruser and Smith suggest that the records-check program may have depressed incidence rates. They compared pre-1981 to post-1981 changes in reported injury rates across state and industry groupings for some 3,000 uninspected plants. They found a 5% to 14% decline in reported rates among plants that were potentially subject to the records-check procedure. Underreporting occurred just in those plants where the payoff for doing so was the largest—those in the "high-hazard" sector. The authors indicated that "none of the estimates suggested that underreporting was a problem in the low-hazard sector."[18]

Impact of the National Commission's Recommendations

The 1970 OSH Act created the National Commission because of concerns about the fairness and adequacy of the provisions of state workers compensation laws (especially as related to benefits). The Commission's report urged federalization of state workers compensation systems if the states did not significantly reform their systems by 1975.

The threat of federal takeover stimulated substantial compliance activity, with one estimate indicating that compliance with the Commission's recommendations increased from 36% to 64% by 1980.[19] Butler and Appel noted " . . . During the 1970s, the rate of real benefit increase more than doubled the rate of increase in either the 1960s or the 1980s. Workers compensation costs as a proportion of covered payroll roughly doubled from the mid-1960s to the mid-1980s".[20]

Increases in benefits can have differing impacts on employees and employers.

- For employees, added benefits will reduce the cost of an injury and may, therefore, provide an incentive for the employee to take fewer precautions to prevent an accident. In addition, higher benefits may increase the likelihood of an employee filing a workers compensation claim. Both of these "moral hazard" effects suggest higher benefits should increase claim frequency. (OSHA measures of frequency may not be as affected, however, since the reporting of injuries to OSHA would not be directly impacted by benefit changes.)
- For employers, added benefits increase the cost of workers compensation coverage. The higher cost may induce employers to become more safety conscious and increase outlays for training and job safety. This suggests that higher benefits may result in fewer accidents in years following the benefit increase.[21]

Butler provided a comprehensive review of the literature on the relationship between benefit increases and claim frequency. His research, published in 1994, cited studies by Chelius (in 1977 and 1983), Butler and Worrall (1983), Butler (1983), Bartel and Thomas (1982), Leigh (1985), Moore, and Viscusi (1990), and others. His overall conclusion, based on his research and that of others was that:

> “Virtually all empirical analyses of workers compensation find that claims frequency increases as workers compensation benefits increase. These studies suggest that a 10% increase in benefits is accompanied by a 4% to 10% increase in the frequency of claims (the average was about 6% across the various studies).”.[22]

Butler and Worrall’s 1983 study is especially of interest, as it focused on 1972–1978, a time frame immediately following the Commission’s report. The authors used data for 35 states, finding an average benefit elasticity of 0.4 (that is, a 10% increase in benefits resulted in a 4% increase in claim frequency). Interestingly, their elasticity estimates increased with injury severity—the elasticity for temp totals was a little less than 0.4, whereas the elasticity for major permanent partial claims was slightly over 1.0.[23]

In a 1997 article, Kaestner and Carrol explicitly allowed for the separate identification of the moral hazard and safety promotion effects of benefit changes. Their work (partly based on NCCI-supplied data) suggests that both effects are present but that the moral hazard effect tends to dominate.[24]

Globalization and the Decline in Incidence Rates Since the Early 1990s

As noted earlier, the breakdown of the manufacturing incidence rate series into its trend and cyclical components unveils a marked steepening in its trend rate of decline since 1990. The manufacturing sector is not unique in this regard, as the falloff in incidence rates is seen in all major industry and occupational groups.

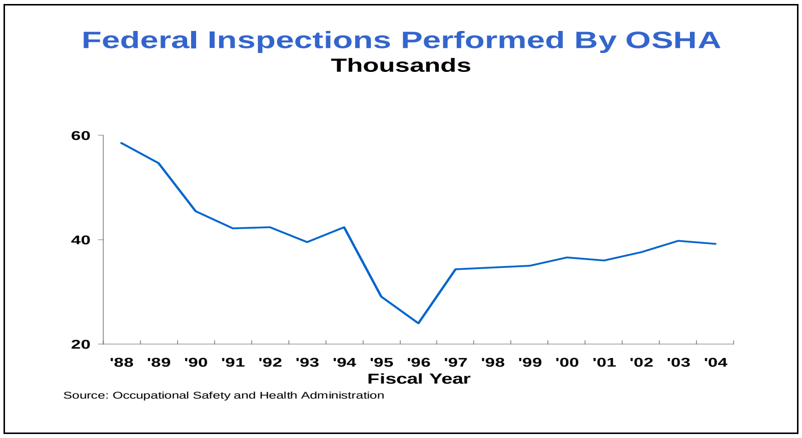
There appears to be no simple and all-inclusive explanation for the pervasive decline. For example, NCCI conducted tests adjusting BLS incidence rate data for shifts in the industrial and occupational mix during the 1990s (e.g., the decline in manufacturing employment as a percentage of total employment). Those tests indicated no significant relationships.[25] Changes in gender mix were also unable to explain the decline. That was also the case for changes in age distribution, although a small portion of the decline was seen to be attributable to the increasing share of older workers. Such persons, as previously discussed, tend to have below-average incidence rates.

NCCI further explored whether incidence rate changes could be explained by shifts in “part of body” injured, by event or cause of injury, and by the source of the injury. When the data was parsed by part of body, all major categories showed declines of over 30% between 1992/1993 and 1998/1999. That was also the case for “event or cause” of injury and “source” of injury (with the exception of transportation accidents and motor vehicles, where the decline was roughly 15%).[26]

Moreover, the decline does not appear to be due to increased underreporting. Coway and Svenson reported results of BLS and OSHA establishment audits performed in 1996. Preliminary findings suggested no increase in the rate of underreporting, either in total cases or lost work-time cases, from those found previously (total injury and illness cases were underreported by 11% vs. 10% in a 1986 audit). Decreases in reporting rates were observed in many states, but the degree of the reductions showed a wide variation. Moreover, the highest reductions were not concentrated in states or industries with higher initial rates.[27]

Finally, OSHA inspection activity did not increase materially in the 1990s and into the current decade. Although federal inspections have been edging higher in recent years, they are still well below their 1988 level (see Chart 6).

Chart 6



Although an all-inclusive explanation remains elusive, the marked decline in incidence rates since the 1990s may reflect the spillover effects of globalization, as US-based producers strove to examine every facet of their business processes to make them more productive and efficient.

Although US businesses have always faced competition from abroad, the realities of the globalization of the world economy began to hit home in force in the 1990s. Imports as a percentage of gross domestic purchases increased from 8.4% in 1990 to 14.2% in 2005, a rise in the import share percentage of 70%. Moreover, US-based firms found themselves competing against far-lower-cost producers abroad. Imports from China, for example, increased from 5.8% of total US imports in 1994 to 14.4% in 2005.

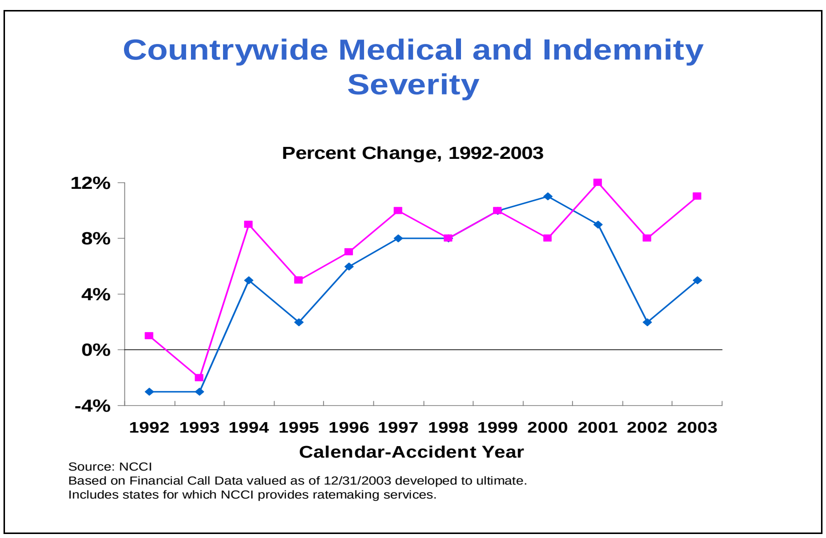
In this environment, management was under intense pressure to boost worker productivity and reduce the overall cost structure. Such efforts brought with them an important dividend—a safer workplace. Indeed, examples abound of how business efforts to boost productivity and reduce costs by changing work processes and employing new technology contributed to a safer work environment:[28]

- Wal-Mart made changes in its inventory handling that increased efficiency and reduced costs—in part through reduced ladder climbing and lifting.
- Ligon Brothers boosted productivity and sharply cut back injuries by installing conveyors that reduced bending and by moving welding stations closer to the conveyors to reduce reach.
- Textron trained its employees in ergonomic problem-solving skills, reducing its musculoskeletal injury rate by 90%.
- Toyota redesigned the "rear spoiler" installation process, radically reducing task times. Medical and workers compensation expenditures also declined (in part because of the reduction in reaching and assuming awkward positions).
- Honda redesigned its fender finishing operation using a newly designed positioner that reduced cycle times by 50%. The new process reduces lifting, reaching, and awkward postures. No injuries have occurred with the new equipment.

More generally, the increasingly widespread application of innovations such as advanced robotics, availability of cordless tools, and ergonomically designed machinery and work processes appears to be making a difference in workplace incidence rates. In addition, advances in computer technology and software design, as well as an increasingly computer-literate workforce, have brought computer-aided (and potentially safer) processes to every corner of the factory floor and office.

Although pressures from globalization appear to be a major factor underlying many of the safety-generating changes in the workplace, such changes may also have been motivated, at least in part, by the rapid increases in workers compensation costs that occurred during this period. Workers compensation benefits rose near or at double-digit rates in the late 1980s and into the 1990s, with benefit costs in 1992 running at more than twice those in 1985—$45.7 billion vs. $22.3 billion (measured in 1985 dollars, this increase was nearly 63%, to $35 billion in 1992).[29] Rising indemnity and medical severity costs during the 1990s and into the current decade only added to the financial pressure facing employers and their insurers (see Chart 7).

Chart 7



Clearly, there have been many forces at work driving down incidence rates since the early 1990s. Quantifying those factors remains a major challenge to researchers interested in the dynamics of the workers compensation system.

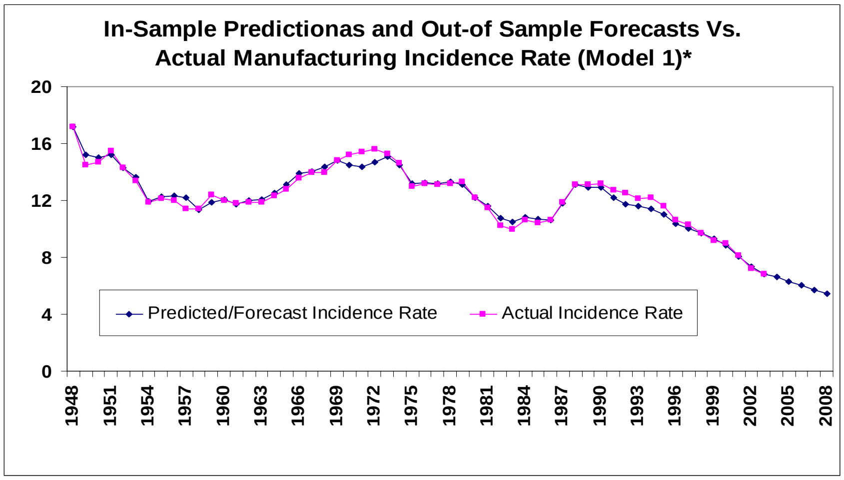
Prospects and Conclusions

The analyses presented in this paper indicate that changes in domestic economic conditions (as measured by changes in the unemployment rate or real GDP) and shifts in the share of younger workers are statistically significant explanatory variables in a "local level" model of manufacturing incidence rates. The paper also suggests that US businesses' reaction to increasing global competition may be an important factor in explaining the downward trajectory of incidence rates since the early 1990s.

Latest economic forecasts at the time of writing this paper call for continued economic expansion through 2009 (five years from the last observed data point), with unemployment rates stabilizing at about 4.8%—down slightly from their 5.2% average in 2005—and real GDP growth continuing at roughly its 3% trend rate. At the same time, the share of younger workers is projected to stop declining and to remain essentially unchanged at 14%.[30] Both of these factors suggest some upward pressure on incidence rates. Global competition, meanwhile, is likely to remain intense (continuing to place pressure on US industry to increase productivity—suggesting ongoing improvements in workplace safety and downward pressure on incidence rates.

An estimate of the impact of these various forces on the future direction of manufacturing incidence rates is shown in Chart 8. The chart indicates a continued decline in incidence rates through 2009, albeit at a somewhat slower rate than in 2002–2008. The incidence rate forecasts incorporate separate forecasts of both economic and demographic factors and are based on the models described in the Technical Appendix.[31] Because the forecasts of economic variables are subject to substantial error—especially regarding cyclical turning points—the projections shown here are best viewed as extensions of the current trajectory.

Chart 8



Technical Appendix

In quantifying the relationship between manufacturing incidence rates and measures of the business cycle and workplace demographics, several issues needed to be addressed, including the choice of explanatory variables, the time period for the analysis, and the modeling techniques to be employed.

Choice of Explanatory Variables

In terms of variables reflecting the business cycle, prior research by Smith provides an excellent starting point. He related changes in the manufacturing incidence rate to changes in the unemployment rate, finding a statistically significant relationship between the two for the period 1948 through 1969.[32]

The unemployment rate (the percentage of the labor force that is unemployed) rises in periods of economic weakness and declines in periods of economic expansion. Changes in it are reflective of changes in skill levels, since the first hired are typically the first fired. Declines in the unemployment rate would be expected to be accompanied by increases in incidence rates, all else being equal, since lower unemployment rates are reflective of increased hiring and reduced skill levels. In contrast, when the unemployment rate increases, those still on payrolls would tend to be the more experienced, so incidence rates would be expected to decline.

Another potential explanatory measure, albeit less directly reflective of employment conditions, is real Gross Domestic Product (GDP)—the value of the goods and services produced in the economy. Real GDP is a key indicator used by economists in determining cyclical turning points, and many macroeconomic series are highly correlated with GDP, including employment and the unemployment rate. This study also develops models using real GDP as an explanatory variable, since it captures the full dynamic of the economy.

Both the unemployment rate and real GDP have the benefit of having substantial history, with both series being available on a consistent basis from the late 1940s. Other potential explanatory variables, such as the capacity utilization rate or labor turnover—while perhaps equally appealing candidates—have far less history (especially in the case of turnover measures, where data is not available prior to 2000).

For the demographic variable, we selected the share of younger workers—those aged 16 to 24. This variable had the strongest explanatory power among other potential candidates such as the share of older workers and an index derived from the spread between the share of younger and older workers.

Time Period

The models developed in this study utilize incidence rate data from 1948 through 2004—a time span of 57 years. We excluded the Great Depression era of the 1930s and the WW II period, not because such periods are inconsistent with the experienced-worker effect (as demonstrated earlier, such is clearly not the case) but because those periods were unique in history and (hopefully) unlikely to be repeated. The exclusion of the WW II period is especially warranted because incidence rates during that period were driven by the temporary needs of the war, rather than more fundamental and longer-term factors. Also, from a practical perspective, consistent data for the explanatory variables are not available prior to the late 1940s.

Model Specification

The percent change in manufacturing incidence rates follows a random walk, in that the first difference of the series is stationary. The mean of the first differences is close to zero, also suggesting that there is no drift. Under these circumstances, the statistical process generating the incidence rate series can be characterized by the following "local level" unobserved components (UC) model:

$$y_t = \theta_t + \varepsilon_t \qquad (1)$$
$$\theta_t = u_t \qquad (2)$$
$$u_t = u_{t-1} + \eta_t \qquad (3)$$

where:

y_t is the observed value of the variable of interest (i.e., the rate of growth of the manufacturing incidence rate)

θ_t is the unobserved (actual) trend in that variable

ε_t is the measurement error of this trend (white noise), normally distributed, with zero mean and variance σ_ε^2

u_t is the "level" of the variable of interest

η_t is the innovation to this "level," normally distributed with 0 mean and variance σ_η^2

As specified, this model does not recognize a causal relationship that might exist between the manufacturing incidence rate and the set of explanatory variables discussed above (e.g., the unemployment rate and the share of workers aged 16–24). However, the model can be expanded to a "structural time series" (STS) model, to include such variables. Following Evans and Schmid:

$$y_t = \theta_t + \gamma * x_t + \varepsilon_t \qquad (4)$$
$$\theta_t = u_t \qquad (2)$$
$$u_t = u_{t-1} + \eta_t \qquad (3)$$

where:

x_t is an explanatory variable and

γ is a regression parameter

The regression parameter γ is time-invariant. It is assumed that the variable X_t is measured without error and that the relation depicted in the model is time-invariant. Evans and Schmid note that these are standard assumptions in linear regression models.[33]

Results of Alternative Model Runs

Two models of the form described in equation (4) above were tested using the STAMP software. STAMP was especially designed for estimating UC and STS models.[34]

- The dependent variable in both models is the first difference in the logarithm of the manufacturing incidence rate (LDMIR).

All explanatory variables in Model 1 have the conceptually correct sign and are statistically significant, with t-values above 2.0. The R^2 of .65 indicates that 65% of the variation around the random walk is explained by the model. In Model 2, the coefficient on the employment share variable is just under being statistically significant. The R^2 in Model 2 is also .65

The significance of the employment share variable in the unemployment rate model (Model 1) and the marginal significance of it in the GDP model (Model 2) may partly reflect the greater collinearity between employment share and real GDP (correlation coefficient of .35) than between employment share and the unemployment rate (correlation coefficient of –.23).

The results of the alternative model runs are shown in the following table:

	Trend	LDUNR	LDGDP	LDEMPSH	DUM	R^2
Model 1	–0.0507	–0.1410	—	0.6144	0.1007	.647
***t* value**	(–3.03)	(–5.99)	—	(2.66)	(4.01)	
Model 2	–0.0920	—	1.2724	0.469	0.1058	.653
***t* value**	(–4.93)	—	(6.19)	(1.92)	(4.28)	

- In Model 1, the set of explanatory variables includes the unemployment rate and the share of workers aged 16–24, both expressed in log-difference form (LDUNR and LDEMPSH).
- In Model 2, the log-difference in real GDP (LDGDP) is substituted for the unemployment rate series.
- Both models also include an indicator (or “dummy”) variable (DUM) to account for the previously noted spike in incidence rates in 1987 and 1988. DUM was set to 1 in those two years and 0 in all other periods.
- The Kalman Filter technique and Maximum Likelihood estimation were used in all cases.

Charts 9a and 9b show the fitted/actual and regression diagnostics for Model 1, while Charts 10a and 10b show similar plots for Model 2. The diagnostics are similar in both models. The correlograms, in the upper left corners, show autocorrelations in the residuals at lag lengths 1 through 5. The correlations are small, supporting the assumption that the measurement errors are independently distributed. The QQ plots, in the upper right corners, indicate that there is no statistically significant skewness (i.e., lack of symmetry) or excess kurtosis (thicker than normal tails). The bottom left panels show the cumulative sum of the residuals. The sums are within the error cone, suggesting an absence of positive serial correlation. The cumulative sum of squared residuals in the bottom right panels indicate some mild heteroskedasticity.

Chart 9a
Model 1: Log-Difference Manufacturing Incidence Rates vs. Log-Difference Unemployment Rate, Log-Difference Employment Share Aged 16–24, and Dummy (1987–1988 = 1, Else 0)

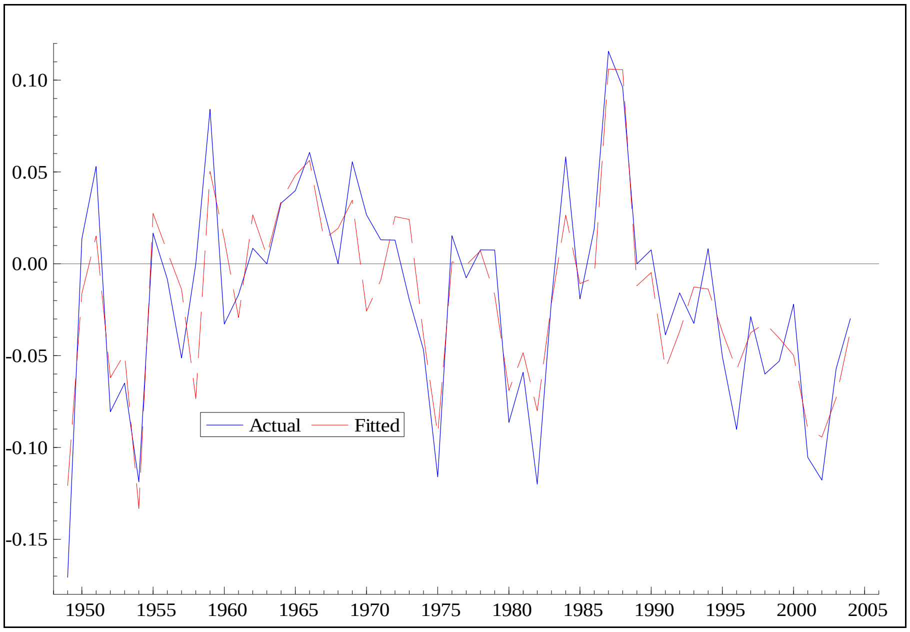


Chart 9b
Model 1 Regression Diagnostics

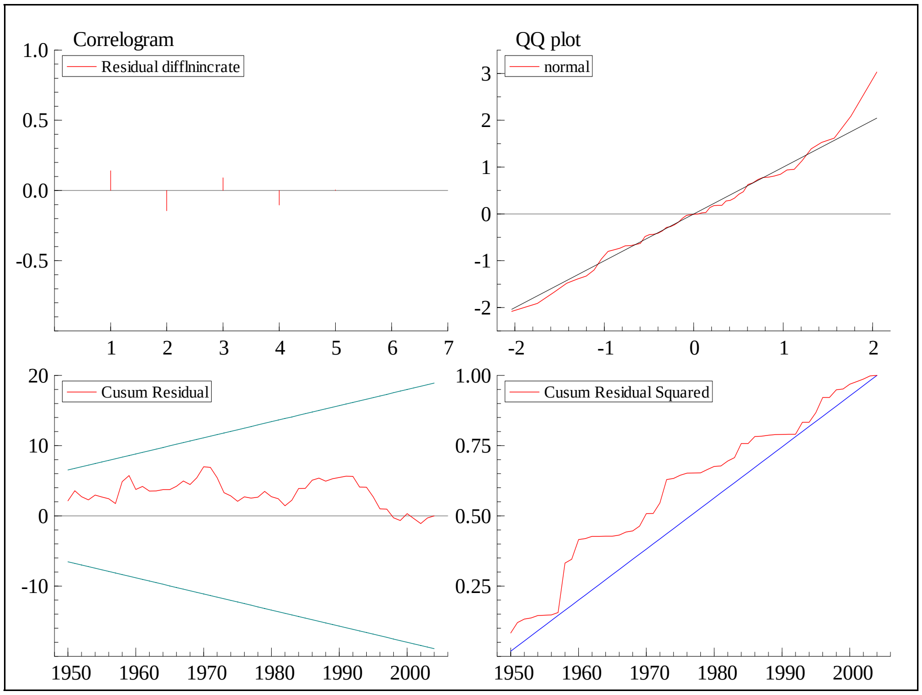


Chart 10a
Model 2: Log-Difference Manufacturing Incidence Rates vs. Log-Difference Real GDP, Log-Difference Employment Share Aged 16–24, and Dummy (1987–1988 = 1, Else 0)

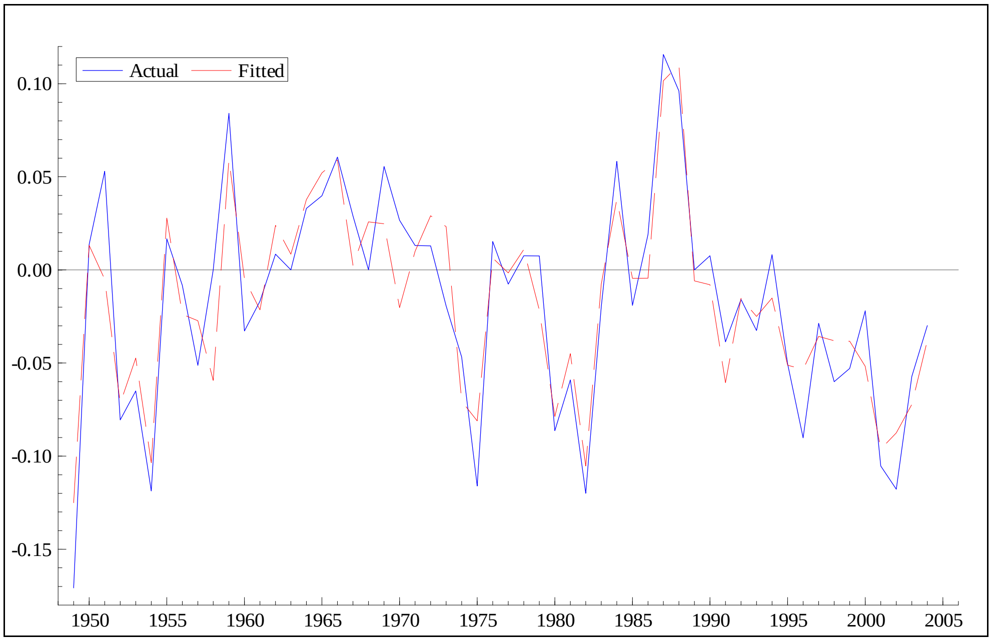
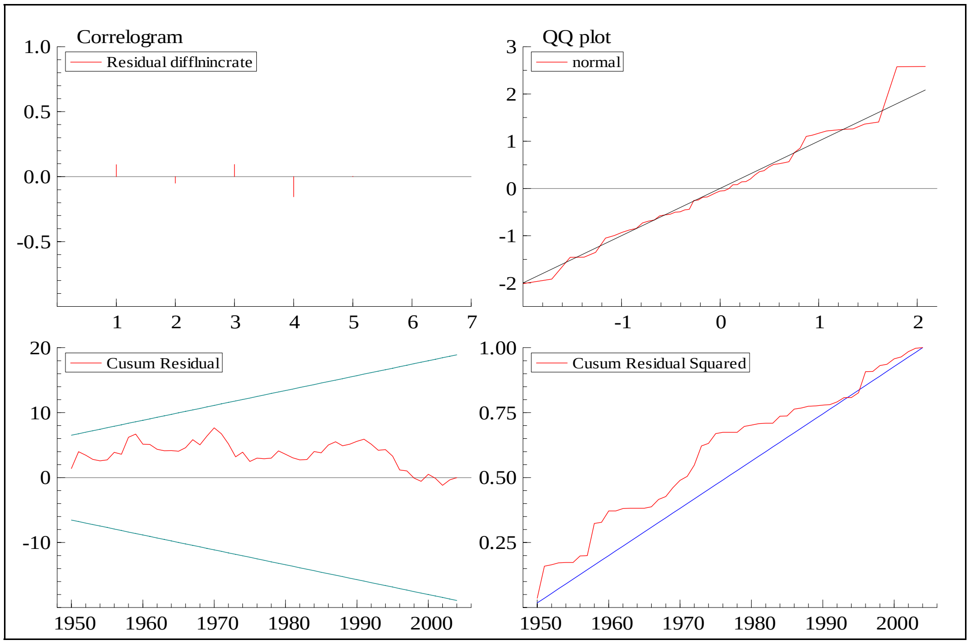


Chart 10b
Model 2 Regression Diagnostics



ENDNOTES

[1] The trend in Chart 1 is calculated using unobserved components modeling. For those desiring additional information on this methodology, a good starting point is: Andrew Harvey, Siem Jan Koopman, and Neil Shephard, *State Space and Unobserved Component Models, Theory and Applications,* Cambridge University Press, 2004.

[2] The Bureau of Labor Statistics made a substantial number of significant recordkeeping changes relating to the collection of incidence rate data for 2002 and 2003. The 2002 changes were designed to produce more useful data, simplify recordkeeping for employers, and facilitate use of computers and telecommunications technology for OSHA recordkeeping purposes. Some of the changes appear likely to result in a decline in the number of recordable cases, although that is not uniformly the case. Matters were complicated further with the 2003 data because of the conversion of the BLS incidence rate series to a NAICS basis from the prior SIC basis.

[3] This example was adapted from "Changes in Injury Frequency Rates and Employment in Manufacturing, 1936–1941," *Monthly Labor Review,* May 1943, p. 949.

[4] This example was adapted from "Changes in Injury Frequency Rates and Employment in Manufacturing, 1936–1941," *Monthly Labor Review,* May 1943, p. 949.

[5] Other economic developments during the business cycle, in addition to changes in experience levels, also affect incidence rates. For example, as expansions mature, the work week lengthens, additional work shifts are added, and overtime hours increase. All of this takes a toll in terms of worker fatigue. In addition, as capacity utilization rates tighten in the face of rising demand pressures, machinery may be operated above its design capacity and older (and potentially less safe) equipment may be brought online. Safety procedures may be degraded to meet production quotas. The workplace, as a result, simply becomes less safe.

Many of the reasons why frequency tends to decline in recessions reflect a reversal of those other factors that pushed up frequency during economic expansions. In addition, layoffs tend to lag behind reductions in operating rates during economic downturns (largely because shedding trained workers is generally viewed as a last resort). The combination of excess workers and reduced injuries due to slower operating rates implies a lower incidence rate of injuries (since the denominator of the BLS incidence rate series is a reflection of total hours worked by full-time workers).

[6] The turning points do not line up exactly with the shaded areas because recession periods are developed using monthly and quarterly data, while the data in the chart reflects annual averages.

[7] Birth rates (live births per 1,000 population) averaged 25.0 in the 1920s. They dropped sharply in the 1930s, to an average of 19.2. Birth rates edged up a bit in the 1940–1945 period (to an average of 21.0) and then soared with the end of WW II to an average of 24.8 between 1946 and 1950.

[8] The calculation uses private industry hours, since hours by age in manufacturing are not available.

[9] A detailed history of OSHA is provided in Judson MacLaury, "The Job Safety Law of 1970: Its Passage was Perilous," US Department of Labor, Office of the Assistant Secretary for Policy, March 3, 2005.

[10] See *"The Report of the National Commission on State Workmen's Compensation Laws,"* July 1972. John F. Burton, Jr., Chairman.

[11] W. Kip Viscusi, "The Impact of Occupational Safety and Health Regulation," *Bell Journal of Economics,* Vol. 10, 1979, pp. 117–140.

[12] Robert S. Smith, "The Impact of OSHA Inspections on Manufacturing Incidence Rates," *Journal of Human Resources,* Vol. 14, 1979, pp. 145–170.

[13] John W. Ruser and Robert S. Smith, "Reestimating OSHA's Effects—Have the Data Changed?," *Journal of Human Resources,* Vol. 26, No. 2 (1991), pp. 212–235.

[14] Ruser and Smith, *Ibid.* The threat of inspections is proxied by the inspection intensity, that is, the number of inspections per establishment. The premise is, according to the authors, that "An increase in inspection intensity increases the probability that an establishment violating a standard will be detected and cited. This increases the marginal benefits of added safety and will increase an establishment's equilibrium safety level. In contrast to the specific inspection effect, the deterrence effect occurs in all establishments, inspected and uninspected alike." p. 229.

[15] W. Kip Viscusi, "The Impact of Occupational Safety and Health Regulation. 1973–1983," *Rand Journal of Economics,* Vol. 17, No. 4, Winter 1986, pp. 567–580.

[16] Wayne B. Gray and John T. Scholz, "Does Regulatory Enforcement Work? A Panel Analysis of OSHA Enforcement," *Law and Society Review,* Vol. 27, No.1 (1993), pp. 177–214.

[17] *Federal Register,* February 2, 1996, Vol. 61, Number 23, p. 4031 (Compliance Section).

[18] John W. Ruser and Robert. S. Smith, "The Effect of OSHA Records-Check Inspections on Reported Occupational Injuries in Manufacturing Establishments," *Journal of Risk and Uncertainty,* Vol. 1, No. 4, 1988. p. 433.

[19] H. Allen Hunt and Rochelle V. Habeck, "New Hope for Workers' Compensation Programs," *Employment Research,* W.E. Upjohn Institute for Employment Research, Fall 1994, p. 1.

[20] Richard J. Butler and David Appel, "Benefit Increases in Workers Compensation," *Southern Economic Journal,* Vol. 56, No. 3. (January 1990), p. 604.

[21] These relationships are discussed in Robert Kaestner and Anne Carroll, "New Estimates of the Labor Market Effects of Workers Compensation Insurance," *Southern Economic Journal,* Vol. 63, No. 3 (January 1977), pp. 635–651.

[22] Richard J. Butler, "Economic Determinants of Workers Compensation Trends," *The Journal of Risk and Insurance,* Vol. 62, No. 3 (September 1994), p. 385.

[23] Richard J. Butler and John D. Worrall, "Workers Compensation Benefits and Injury Claims in the Seventies," *The Review of Economics and Statistics,* Vol. 65, No. 4 (November 1983), pp. 580–589.

[24] Robert Kaestner and Anne Carroll, *op. cit.*

[25] Christopher Poteet and Tony DiDonato, "Analyzing the Decline in Claim Frequency," *Workers Compensation Issues Report,* Spring 2001, National Council on Compensation Insurance, pp. 29–35.

[26] National Council on Compensation Insurance, "Searching for the Factors Driving the Change in Frequency With Special Interest in the Decline of the 1990s," Presentation to the Annual Issues Symposium, Research Breakout Session, May 10, 2002.

[27] Hugh Conway and Jens Svenson, "Occupational Injury and Illness Rates, 1992–1996: Why They Fell," *Monthly Labor Review,* November 1998, pp. 36–58.

[28] Case studies from Wal-Mart based on conversation with John Leyenberger, Divisional Risk Control Director at Wal-Mart. Other studies from the Humantech, Inc. Web site: www.humantech.com.

[29] National Academy of Social Insurance, *Workers' Compensation: Benefits, Coverage and Costs,* 1997–1998.

[30] The unemployment rate forecast is from Economy.com (its October 2005 model run). The forecast of the share of workers aged 16–24 is based on Census Bureau population projections and analyses by NCCI.

[31] The forecasts were developed using the specification in Model 1 in the Technical Appendix on page 10. Model 1 relates the log-difference in the manufacturing incidence rate to log-difference in the unemployment rate and the share of workers aged 16–24.

[32] Robert S. Smith, "Intertemporal Changes in Work Injury Rates," *Proceedings of the 25th Annual Meeting of the Industrial Relations Research Association,* 1972, pp.167–174.

[33] Jon Evans and Frank Schmid, *"Estimating Trend Rates of Growth of Workers Compensation Severities with the Kalman Filter,"* draft paper for publication in the Winter 2006 edition of the Casualty Actuarial Society *Forum,* pp. 4–6.

[34] Siem Jan Koopman, Andrew Harvey, Jurgen A. Doornik, and Neil Shephard, *"Stamp, Structural Time Series Analyser, Modeller and Predictor,"* Timberlake Consultants Press, London, 1999.