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Abstract

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KEYWORDS: workplace liability, workplace injury

WAGE AND INJURY RESPONSE TO SHIFTS IN WORKPLACE LIABILITY

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This paper examines the impact of a monumental change in tort liability law, the Federal Employers' Liability Act (FELA) of 1908. This shift from common law, by changing the way injured workers were compensated and the compensating wage differentials for risk bearing, set the stage for workers' compensation and other no-fault systems. Focusing on the New Jersey railroad system, the authors examine three periods: the pre-FELA years of 1900–1908; 1909–11, when the FELA laws were the only changes in the common laws affecting some railroad workers; and 1912–16, when both FELA and workers' compensation laws affected railroad workers. They find that as liability shifted to railroad companies, accident rates fell for three occupational groups who worked outdoors, but rose for railroad "craft" employees (who worked indoors in shops). They also find that wages shifted for all four of the major occupational groups as predicted by their model.

One of the major tort liability changes of the twentieth century provides a natural experiment to measure the impact of a move away from common law. Ronald Coase has shown that in a competitive, zero-transactions-cost world, changes in liability rules would affect neither injury rates nor real wages (Coase 1960). The provision of actuarially fair insurance in such a world would simply result in a dollar for dollar reduction in compensating differentials for risk bearing. In a world of asymmetric information and non-zero transactions cost, however, there are various flies in the ointment—less than perfect experience rating in workers' compensation insurance, for example—that can lead to changes in either real or reported injury rates, and to changes in compensating differentials for risk bearing.

Alterations in liability rules can change which party can avoid accidents at least cost, and, as a consequence, also change both injury rates and wage differentials. Until the passage of the Federal Employers' Liability Act (FELA) of 1908, compensation for job injuries was settled by tort. Liability rules required employees seeking compensation to show that the employer was negligent. However, the vast majority of cases were settled out of court. FELA, one of the most important pieces of federal legislation of the Progressive Era, changed the dynamics of the system: railroads, the lower-cost avoider in the majority of cases, could now more readily be sued in court for damages, though FELA still imposed the proof-of-negligence require-

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A data appendix with additional results, and copies of the computer programs used to generate the results presented in the paper, are available from the first author at 183 FOB, Brigham Young University, Provo, UT, 84602 (richard_butler@byu.edu).

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ment on *interstate* railroad workers who wished to obtain compensation in court.

The passage of FELA was rapidly followed by the passage of no-fault workers' compensation laws, which covered the overwhelming majority of workers in the various states. Economists have exploited natural experiments generated by workers' compensation to examine how changes in benefits affect injury rates and compensating differentials, but there have been very few tests of the initial movement away from the common law. Although least-cost avoider models have been discussed extensively, empirical examination of this most important shift in injury liability in labor market history has been hampered by a want of detailed, clean data sets from the first decade of the last century.

Our data on four New Jersey railroads—with observations on a year-by-railroad-by-occupation basis—have a number of advantages for use in analyses testing various hypotheses about the shift from common law to FELA and workers' compensation insurance. Our data do not suffer from the aggregation problems that have affected data sets in some previous studies. Moreover, our data provide a natural experiment in which the passage of FELA and workers' compensation legislation can be taken as exogenous events. Our sample represents 2% of the 1.7 million railroad workers covered by FELA nationwide.[1] As workers' compensation laws only applied to those not involved in operating trains in interstate commerce, the majority of railroad workers were covered by FELA. Since railroad workers covered by workers' compensation represented a small fraction of all employees covered by workers' compensation in New Jersey at the time, conditions in the railroads were not likely to have had any important influence on the passage of New Jersey's workers' compensation act.

[1]Nationwide data come from Historical Statistics of the United States, Series Q 389-409. Our four-railroad sample was 36,037 (Annual Report, Bureau of Labor and Industries, Statistics of Labor and Industries, 1911), for data ending fiscal year June 1910. Total employment for all steam railroads in 1910 was 43,831; our four-railroad sample accounts for 82% of all New Jersey steam railroad workers.

Liability Changes: Theoretical Risk and Wage Adjustments

The Coase theorem implies that in the absence of transactions costs prohibiting negotiations between workers and firms, changes in workplace injury liability will not affect workplace injuries. All externalities are internalized and the optimal amount of safety is provided: either the least-cost avoider of accidents is liable and acts to prevent accidents whenever accident prevention is less costly than the accident itself, or those who are liable for the accident "bribe" the least-cost avoider to act as if he were liable. In such a Coasian world, changing liability has no effect on injuries or wages, except through possible wealth effects.

Even where bargaining is prohibitively expensive, the Coase analysis of liability has implications for optimal safety outcomes. Efficient safety can be achieved by assigning the liability to the least-cost avoider. Tort law before workers' compensation, that is, the "common law," has been interpreted to have operated in roughly this way. Under common law, the duty of employers was to provide their employees with a level of safety that a prudent person would provide. This meant providing a safe work environment: appropriate tools for the work, safety rules, and qualified co-workers. However, even when employers did not meet these standards, they would not be considered negligent if they could make one of three common law defenses:

1. *Fellow servant defense:* the employer was not liable if the injury was caused by a fellow worker.

2. *Assumption of risk defense:* the employer was not liable if the workplace was known to be especially risky, and the worker took a job despite this knowledge.

3. *Contributory negligence defense:* the employer was not liable if the worker could have avoided the consequences of the accident by taking ordinary precautions.

These common law defenses can be viewed as an attempt to assign liability on the basis of the least-cost safety provider discussed above. Such an interpretation was offered by Richard Posner (1972:44):

The fellow-servant rule, as the exception to Respondeat Superior is known, provides, in principle at least, a powerful instrument for industrial safety when combined with the rule making the employer liable for injuries inflicted on an employee through the negligence of a fellow employee if the employer was on notice of the fellow employee's habitual neglect or incompetence. The effect of the two rules is to give employees a strong incentive to report careless fellow workers to their supervisors.

Posner argued that the contributory negligence rule more directly encourages those who can most cheaply provide safety with an incentive to do so. He suggested that the assumption of risk rule allows workers with greater tastes for risk the chance to market those tastes (Posner 1972:45).

This common law, tort liability environment changed radically at the beginning of the twentieth century. The Federal Employers Liability Act (FELA) was enacted in 1908, modifying the common law defenses and making it easier for workers to sue for damages. Certain defenses under the common law doctrine were no longer considered viable options for avoidance of compensatory damages by the employer. Under FELA, the worker was still required to show negligence, but the employer could no longer claim the fellow servant defense, and the assumption of risk defense was greatly restricted, no longer holding if the employer violated a regulatory statute.[2] Also, complete contributory negligence was no longer possible. Instead, the amount awarded to the employee would be reduced proportionately with the employee's negligence in the resulting accident. Thus the standard shifted from contributory negligence to comparative negligence (Strauss 1994). This change in tort liability shifted more of the liability from railroad workers to railroad firms. Railroad workers engaged in interstate commerce were covered by FELA beginning in the second half of 1908, and the rest of New Jersey railroad workers were covered by workers' compensation insurance beginning in the second half of 1911. What was meant by "interstate commerce," and hence who was covered by FELA, however, remained controversial, and led to considerable uncertainty about which program applied throughout our sample period. It was not until a number of court cases clarified this issue starting in 1916 that interstate commerce coverage under FELA became more clearly defined. During our sample period, from 1900 to 1916, however, there was controversy about which railroad job categories were covered by FELA.

The establishment of the workers' compensation system in New Jersey also shifted some liability from railroad workers to the railroads. It did so, however, not by modifying tort rules, as FELA had done, but by establishing a no fault insurance system in which workers gave up their right to tort actions in return for guaranteed but limited payments. If the accident happened on the job, some medical costs associated with the accident were paid for, and lost wages were partially reimbursed, but there were no payments for pain and suffering. That is, the railroads were liable for all injuries suffered by their workers covered under workers' compensation law, but their liability was limited. Again, because the courts had not settled on definitive guidelines about who was covered under FELA, it was also somewhat unclear who was covered under the workers' compensation system. Both systems, however, shifted some of the liability for workplace injuries from railroad workers to the railroad companies.

New Jersey also passed a very weak Employers' Liability Act on September 1, 1909.[3] This Act was designed to temper the Fellow Servant and Contributory Negligence defenses, but did not affect the Assumption of Risk Doctrine (see Buffum 1992:128).[4]

[2]See Transportation Research Board (1994:17). Assumption of risk was completely eliminated in the late 1930s. We thank one of our referees for pointing this out.

[3]New Jersey's law did not include railroad workers (Fishback and Kantor 2000:251–54).

[4]The New Jersey law did limit assumption of risk in settings where the employer violated a statute or the worker reported a problem with machinery and later was injured before the machine was fixed. Before, the same worker would have been denied compensation on the grounds that he knew of the danger and still worked at the machine (U.S. Bureau of Labor Statistics 1914).

The New Jersey Department of Labor and Industry did not believe that the Act changed much, writing, "No matter how the statute may be construed, the common law rights of an injured employee remain as they were before its enactment" (New Jersey 1909:164). Employers' liability was subsumed by the standard workers' compensation coverage in 1911, as it was in other states as they adopted workers' compensation laws.

Railroads also had their own "relief associations." The Pittsburgh Survey of 1907–8 provides strong evidence that the benefits under some of these schemes were better than those available at higher prices from private insurers. Pennsylvania Railroad actually had a higher replacement rate than New Jersey's workers' compensation law. Fishback and Kantor have studied both expected workers' compensation benefits and "relief" or "benefit" associations.[5] Some relief associations were described as being virtual conditions of employment (see Eastman 1910:183). If workers elected benefits under their relief association scheme, they gave up their right to sue their employer. Similarly, workers who elected to pursue their rights under common law gave up their claims to benefits under their company scheme. In our empirical work below, three of our four railroads had "relief" associations.[6]

If bargaining between railroad workers and employers is costless, then according to the Coase theorem, neither the initiation of FELA nor the initiation of workers' compensation should have changed the accident rate. If bargaining is costly and there is a shift in liability, accidents will rise or fall depending on whether the liability is shifted away from or toward the least-cost avoider of accidents: specifically, shifting some liability from workers to companies should increase accidents if workers are the least-cost avoiders, and reduce accidents if the railroad companies are the least-cost avoiders. Railroad workers at the turn of the twentieth century provide a natural experiment to examine significant modifications in workplace liability: there were few other confounding shifts in protective labor legislation, employee benefits, or tax legislation over the sample period;[7] railroad workers were one of the largest segments of the industrial work force; and railroads were relatively dangerous workplaces, with not only a high mean accident rate, but also considerable variation across railroads (see Table 2 below).

If a switch in liability leads to a change in workplace risk, wages ought to reflect those changes as well. Our theory of wage change given these changes in injury risk due to changes in the liability laws is relatively straightforward. We assume that the changes in injury rates reflect real changes in workplace risk rather than simply changes in reporting, so-called claims reporting moral hazard (Butler and Worrall 1991). This is not an innocuous assumption; if it does not hold, we will have to re-interpret our workers' compensation period shifters as representing shifts due to changes in the level of claims reporting, rather than (as we assume) changes

[5]For a panel of expected workers' compensation benefits by state from 1910 to 1930, see Fishback and Kantor (1998:118–19); for a panel of expected benefits as a percentage of annual earnings by state from 1910 to 1923, see Fishback and Kantor (1995:722–23); for a test for the impact of benefit or relief societies on compensating differentials, see Fishback and Kantor (1992); and for an examination of these societies for the coal mining industry, see Fishback (1987).

[6]The Pennsylvania RR, the Philadelphia and Reading RR, and the Delaware, Lackawana, and Western RR (Morris and Essex Division, and Sussex Railroad) had plans. We could find no plan for the Central Railroad of New Jersey. Relief and benefit funds, as well as descriptions of the plans, membership, and so on at the time of the introduction of FELA, can be found in *The Twenty-Third Annual Report of the Commissioner of Labor* (U.S. Department of Commerce and Labor 1908). It appears from the Report that the relief funds were mainly financed by workers' contributions, though they were usually jointly administered and often all the administrative costs, and any interest payments into the system, were funded by the railroads. FELA banned contracts that waived the right to sue in advance of an accident. Also, the ruling in 224 U.S. 603, 32 Sup. Ct. 589 states that the receipt of benefits from a relief fund under an agreement that such relief shall operate as a release from all claims for damages is not a bar to an action for injuries under FELA (U.S. Bureau of Labor Statistics 1914:2420–21).

[7]Congress did pass a corporate income tax of 1% on net incomes over $5,000 in 1909. The corporate income tax was repealed with the introduction of federal income taxes in 1916.

Table 1. All Injury Rates and Fatal Injury Rates (per million man days) for New Jersey Railroads, by Three-Year Periods.

					t-Statistics for Change	
Occupation	*Injury Type*	*Means for 1906–08*	*Means for 1909–11*	*Means for 1912–14*	*6–8 v. 9–11*	*9–11 v. 12–14*
Depot Workers	All Injuries	138.2	30.5	37.51	–3.00***	0.52
	Fatal Injuries	.5083	1.573	.9171	2.11**	–0.96
Trainmen	All Injuries	331.0	249.1	348.3	–1.19	2.48**
	Fatal Injuries	21.84	12.97	11.12	–2.11**	–0.67
Linemen	All Injuries	95.34	89.53	165.32	–0.29	2.08**
	Fatal Injuries	15.40	12.34	12.15	–1.00	–0.05
Crafts	All Injuries	167.2	218.0	305.1	1.00	1.32
	Fatal Injuries	1.601	2.916	1.042	1.19	–1.78*

These averages are for our four-railroad sample used below. Years reported are fiscal years, so, for example, the 1909 fiscal year begins on July 1, 1908, and runs through June 30, 1909. Hence, the middle column represents the FELA-only period, and the right-hand column represents the period in which both FELA and workers' compensation were applicable to railroad workers. The left-hand column shows results for the three-year period (1906–8) before either program took effect. All injury rates are measured as "injuries per day of work," and have been multiplied by one million (10E+6) for ease of comparison.

in the levels of risk bearing (however, see footnote 8 and Appendix B).

Elsewhere, we have argued that claims reporting moral hazard is important in a non-railroad context (Butler and Worrall 1991). According to Fishback and Kantor (2000, Appendix A), who examined other states, the reporting of nonfatal injuries among firms covered by workers' compensation spiked by a factor of two to ten after the institution of workers' compensation laws, with no concomitant change in fatal injury rates. We were concerned that there might be similar reporting problems in the railroad data. Table 1 illustrates the potential problem: between the FELA period of fiscal years 1909–11 and the workers' compensation/FELA period of fiscal years 1912–14 (three-year adjacent periods were chosen to make the means as comparable as possible), "all injuries" generally rose even though fatal injuries stayed relatively constant. However, none of the decreases in the fatal injury rates were statistically significant at the 5% level, and increases in the "all injuries" category of two of the four occupations (office workers and crafts) were statistically insignificant as well. Moreover, there was no doubling and quintupling in the all injuries category of the kind noted by Fishback and Kantor for the non-railroad sector.

Therefore, if these data suffer from the same kind of reporting bias as was present at the inauguration of the workers' compensation systems (which did not, at that time, cover railroads), at least the magnitude of the effect is several orders smaller. We also minimized the risk of reporting changes by analyzing data from the same four large railroad companies over the whole sample period. There is no reason to suppose that incentives to change reporting changed for these railroad companies in the way that they might have changed when workers' compensation replaced haphazard surveys of injuries with the administrative reports required in casualty insurance. Finally, if there is a reporting problem, it is not in the switch from the pre-FELA period to the FELA period: except for depot workers, the changes in fatal injury rates are highly correlated with, and of roughly the same magnitude as, changes in the overall injury rates.[8] So if reporting

[8]As one referee pointed out to us, amendments to the safety appliances acts (railroad safety laws) in 1909–10, and changes to procedures for reporting accidents in the same years, may have influenced reporting behavior. In Appendix B, we look at the difference between

changes drove any of our results, the period most likely to have been affected was the workers' compensation period (fiscal year 1912 and thereafter), and we would expect the shift in the wage/risk tradeoff during the transition to FELA (in fiscal year 1909) to differ qualitatively from the shift during the transition to workers' compensation (in fiscal year 1912).

Table 1 also indicates something else characteristic of railroad employment risk: the outdoor workers associated with train operations, which include trainmen (engineers, brakemen, conductors, and firemen) and linemen (principally track maintenance and track operations), had approximately five to ten times the fatal injury risk of depot and craft workers. Inter-occupational variation was not, however, as pronounced in injury risk as in fatal injury risk.

We model railroad employment risk by assuming that workers are risk-averse, mobile, and informed, and that each of our skilled groups has a reservation job in the manufacturing sector that has a lower wage but is also safe.[9] The workplace compensation/risk adjustments in the railroad sector must yield at least the same level of utility as the reservation job or the railroad workers will leave for the reservation job. Total compensation, consisting of both wages and expected liability payments for injury, is important to this tradeoff. Figure 1 shows the indifference curve for a risk-averse worker: as risk increases, larger compensation increments are required to hold a worker's utility constant.[10] An increase in risk requires a compensating increase in the risk premium, with small changes in additional risk requiring increasingly higher compensation. However, the higher premium will be accompanied by a decrease in the compensation intercept, in order to keep the worker on the same indifference curve.

Unfortunately, there are no data on total compensation—and in the presence of overlapping liability programs with several occupations and the uncertainty of coverage as discussed above, it would be virtually impossible to calculate expected liability benefits for each occupational cohort for each year. We measure wages, which is the difference between total compensation and expected benefits. Any change lowering expected benefits would increase wages, holding compensation constant. Assume expected injury benefits are a linear function of risk and that changes in liability are represented, generically, as a FELA effect (a dummy variable taking the value of 1 after liability changes):

$$\text{(1)} \quad \text{expected injury benefits} = \delta_0 + \delta_1\text{Risk} + \delta_2\text{FELA} + \delta_3(\text{FELA} * \text{Risk}).$$

Here δ_1 is positive, as the riskiest occupations and locations are most likely to bring tort actions, and the likelihood of a successful action may also increase with risk. If these risk/benefit effects do not decrease after FELA takes effect, δ_3 is nonnegative, lowering the wage/risk tradeoff and reinforcing the equilibrium pictured in Figure 1. If FELA reduces risk, then expected benefits will not increase after FELA becomes effective, *ceteris paribus*, so $\delta_2 \leq 0$, and the wage intercept may have to rise to maintain the reservation utility pictured for total compensation in Figure 1. This type of adjustment, in which benefits increase with risk and but fall at the imple-

results for all injury rates and fatal injury rates for trainmen and linemen (as reflected in Table 1, there were rarely fatalities for depot workers or craftsmen). If there were a reporting bias, it would be reflected in the all injury rate results but not in the fatal injury rate results: the true coefficients (fatal rates) would tend to be more negative than the upwardly biased all injury rates (in the all injury rate regression). The results presented in Appendix B do not show much of a difference in coefficients between fatal and all injury rates except for the workers' compensation period for linemen, which indeed goes from positive to negative. Whatever reporting bias exists in our data seems to be relatively minor.

[9]We emphasize that we model the representative worker with these assumptions. We feel that these simplifying assumptions, which lead to well-defined predictions, are appropriate given our research focus, but obviously they abstract from hedonic and self-selection models based on varying tastes for risks across workers.

[10]We are very grateful to a referee who caught a crucial error in our earlier exposition of this model, and suggested the development below, which vastly aided in the interpretation of our empirical results.

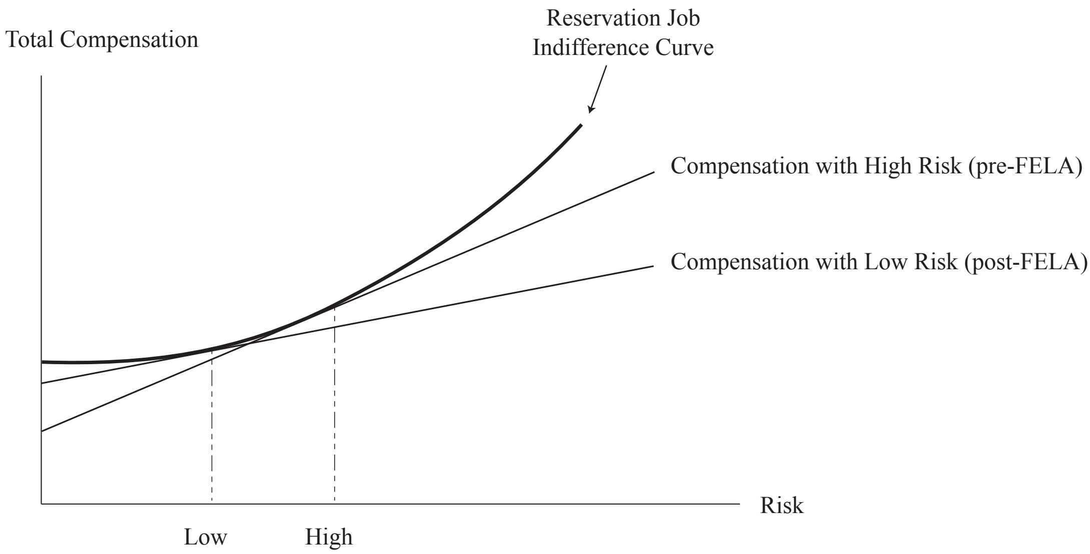

Figure 1. Compensation Adjustment with Constant Reservation Utility.

mentation of FELA, is pictured in Figure 2, showing how a decrease in benefits after FELA yields, in our reservation wage model, an upward intercept shift in the wage/risk line following the implementation of FELA.

Thus, when FELA lowers risk, both the intercept for total compensation and the intercept for wages would shift up, and the risk differential with respect to total compensation (and wages)[11] would shift down. Note that theory is ambiguous about whether real wages will rise or fall after the implementation of FELA. In terms of Figure 2, this depends on the height of the dashed wage line in Figure 2 at low risk, with the height of the dashed wage line at high risk which is nearly equal as drawn (actually wages fell slightly as drawn), but could rise or fall depending on variations in the benefit/risk function when liability changes. Real total compensation (not counting the utility value of reduced risk) falls, but real wages can rise or fall.

Hence, if the injury rate fell when FELA was implemented, we would expect to see an offsetting change in the structure of wages. As the risk fell from high to low, competition would have changed the wage structure so that the compensating wage (the slope) would have fallen. The opposite is expected to have happened if the change in liability increased the risk. Moreover, it is possible—also as indicated in Figure 2—that the compensating wage shift would appear to overcorrect for risk after FELA and yield a negative wage/risk tradeoff. Indeed, we observe such shifts in our data below.[12]

[11]This assumes that δ_3 in equation (1) is not sufficiently negative to reverse the slope after FELA is enacted—a highly unlikely result, it seems to us.

[12]Our theory of competitive wage and compensation differentials hinges on the existence of a reservation job, but this assumption is not necessarily correct, and it may be that railroad workers wound up on a different level of utility after FELA. As Fishback and Kantor (2000) found, unionized workers experience much smaller decreases in wages in response to increases in post-injury benefits than do nonunion workers. Many railroad workers were unionized. Kim and Fishback (1993) also found that squeezes in wage distributions caused by more unionization and arbitration reduced the compensating wage differential for accident risk.

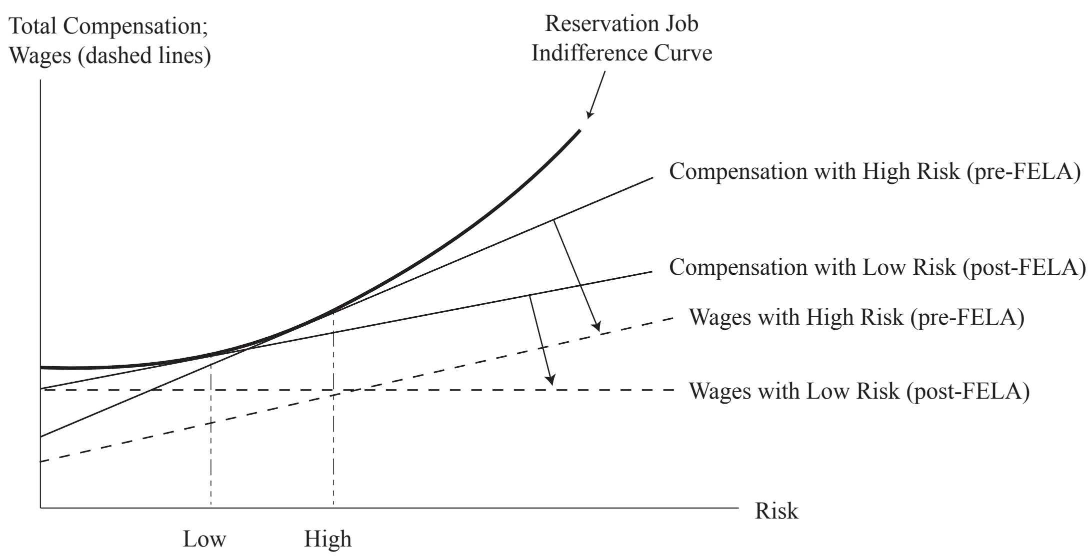

Figure 2. Benefit and Compensation Changes with FELA-Induced Risk Changes.

Prior Evidence

Prior empirical evidence on how a change in workplace liability laws affects injury rates and wages comes from analyses of other data drawn from roughly the same sample period as our analysis: the early 1900s, when liability for industrial injuries shifted first from common-law negligence to modified negligence under employer liability laws, and then shifted again to strict liability under workers' compensation (for non-railroad workers). In the Posner/Landes model (Posner 1972; Landes and Posner 1987), when there are substantial transactions costs and relatively low accident prevention costs for workers, shifting more liability to employers will induce a decline in industrial safety, as an assumption of this model is that workers are the least-cost avoiders of accidents. However, the first empirical analysis of these changes (Chelius 1976) found evidence at odds with the Posner/Landes model of accidents under tort law—evidence inconsistent, in particular, with the assumption that workers were the least-cost avoiders of accidents. Chelius used the U.S. Bureau of the Census's *Vital Statistics* series on accidental deaths caused by non-motor-vehicle machinery in 26 states from 1900 to 1940 as a proxy for industrial safety. He found that machinery deaths decreased both with the enactment of employer liability laws, most of which sought to limit the scope of the fellow servant doctrine, and with the switch to the strict liability of workers' compensation. Though Chelius did all he could with these aggregated state data, machinery-related deaths also include those in the home and agricultural sectors, and there are obvious measurement problems at this level of aggregation, especially given changes in safety technology.

Analyzing aggregate trends in railroad employee deaths from 1890 to 1970, Stole (1994) found death rates fell when FELA was enacted in 1908, after controlling for the enactment of other railroad employment–related legislation and a time trend. He interpreted this as a rejection of the "efficient market" hypothesis, that is, a rejection of the Landes/Posner model of optimally evolved common laws. One explanation for Stole's finding is that railroad companies were lower-cost accident avoiders than railroad workers. Stole makes this argument, but also suggests that there may have been a market failure—namely, misperception of risk by workers—that was partially corrected by the change in liability. Because of technological changes, analyzing the trend of fatal injuries over nearly a century places a heavy interpretative burden on Stole's data, particularly when aggregate railroad fatality rates exhibit pronounced variation around a steady long-term decline. Although Stole did not discuss trends in non-fatal injuries, it is interesting to note that they increased sharply immediately after the enactment of FELA, while fatalities fell.

Buffum (1992) used aggregate data to test for the effects of FELA on fatalities in the railroad industry over the years 1888–1940. Since he did not have disaggregated data at the state level, he could not test for the impact of various state workers' compensation laws. He did, however, control for virtually all of the major pieces of railroad safety legislation over the sample period. Like Stole, Buffum found that FELA had a strong negative effect on railroad fatalities.

In a careful study designed to handle the aggregation problem and obtain cleaner estimates of workplace safety, Fishback (1987) used coal mine data to examine fatal death rates from 1903 to 1930 in 23 leading coal mining states. Contrary to the findings of Chelius and Stole, and in support of the Posner/Landes model, Fishback reported that the death rate rose both after the implementation of employer liability laws and after the implementation of workers' compensation laws.

In this paper, we further narrow the scope of empirical inquiry to a single industry in a single state, and follow the accident, occupation, and wage trends over several years. In particular, we focus on the New Jersey railroad system for eight years before implementation of FELA (fiscal years 1900–1908), through three years when the FELA laws were the only changes in the common laws (fiscal years 1909–11) affecting some railroad workers, and then for five years during which both FELA and workers' compensation laws affected railroad workers (fiscal years 1912–16).

Sample and Injury Rate Regressions

The New Jersey Department of Labor and Industries reported information on steam railroad companies offering passage between cities within New Jersey from 1900 to 1916 in their annual reports. Initially in 1900, seven steam railroads ran over 1,600 miles of track, employed over 31,000 workers, and reported over 1,500 injuries, including 100 fatalities. By 1916, 13 companies ran over 2,100 miles of track, employed over 49,000 workers, and reported over 3,500 injuries, including 121 fatalities. The overall injury rate rose more than proportionally with employment in railroads, injuries more than doubled, and employment rose by 58%, while fatalities rose at a rate below that of employment. The dangers of railroad employment were generally recognized, however, even at the beginning of the sample period. As noted in the 1900 Labor report, "The dangers of railroad employment are generally understood to be great, but few understand just how great.... The astonishing significance of these figures is that for every seven trainmen employed ... one must expect to lose his life or to suffer bodily injury each year" (p. 230). The 1900 report also noted that employment on the railroads was more permanent than most other employment, and the wages were relatively high.

We picked the 1900 to 1916 sample not only because it provides the relevant liability information with eight years of data both before and after the enactment of FELA, but also because it is bounded by significant labor law changes that affected railroad employees. The most important regulatory development affecting workers at the start of the sample period was the 1893 enactment of the Safety Appliance Act, which required railroads to employ recent technological advances in air brakes and couplers. The railroads were given until 1898 to comply with the new standards, and could be awarded extensions, but it is safe to say that by 1900, safety changes induced by the law would have been fully implemented. At the other end of our sample period was the 1916 amendment of the Hours of Service Act to limit a working day to eight hours, legislation that substantially changed the working conditions of railroad workers in New Jersey, who, in our sample period, worked an average of 10.5 hours a day.[13]

A number of railroad companies started operations in 1912–13, concurrent with the implementation of workers' compensation. In order to avoid sample selection problems, we restricted the analysis to the four largest New Jersey Steam Railroads, all of which operated throughout the entire sample period: Central Railroad of New Jersey, the Morris and Essex Railroad (MERC), the Pennsylvania Railroad Company (PENN), and the Philadelphia and Reading Railroad Company (PRRC). Railroad workers were classified by detailed occupation, and by the company for which they worked during the respective fiscal years.[14] The data analyzed were for employees in various occupations ranging from depot men handling freight, to the trainmen who operated the trains (engineers, firemen, brakemen, and conductors), to those who worked on the tracks (switchmen, flagmen, engine-wipers, and construction workers), to those in the shop crafts who built and maintained the equipment (blacksmiths and boilermakers, for example). A residual category of telegraph operators and division supervisors/foremen was not included in the analysis.[15]

Wages were adjusted for inflation, using 1967 dollars, and calculated on a daily basis, derived from the ratio of the aggregate amount paid in wages to the aggregate number of days employed.[16] As can be seen from Table 2, daily pay varied substantially across work groups: trainmen (1909–11) had the highest average daily pay, at $11.78; craft workers made nearly $3 per day less than trainmen; depot men earned a dollar less than craft workers; and at the bottom of the pay scale were linemen, who earned $6.10 per day. Average hours employed per day were also observed, and varied little among those working outdoors: depot workers, trainmen, and linemen all worked slightly more than 10 hours per day. Only the indoor workers, those in the craft shops, varied from this pattern, averaging less than 10 hours a day (9.7 hours). This distinct break in hours between outdoor and indoor workers suggests technological differences that are also reflected in the trend of injuries over the sample period.

Besides dummy variables for railroad companies, individual railroad occupations, and the change in the liability laws, several control variables were appended to the model. From an extensive reading of the annual labor logs, we created a railroad strike variable specific to each railroad company in each year. These strikes were mostly by low-skilled labor gang crews or freight men, often seeking small increases in their daily wages. The reports indicate that most of the labor crews were Italian immigrants, and that their strikes were rarely successful in securing the wage increase they sought. Since these strikes were always prominent, and frequently disruptive of railroad traffic, it is not unreasonable to suspect that they might have affected the wages of other workers besides laborers.

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[13]The Hours of Service Act became effective in 1908. It limited a work shift to 16 hours. (See Buffum 1992:148.)

[14]The fiscal year ran from July 1 to June 30.

[15]There were no uniform reporting requirements across firms or over time with regard to occupational groupings, so there were marked variations across our sample. We and our research assistants spent three months trying various aggregations to maximize the number of occupational cells while minimizing the number of missing values. For example, boilermaker (in Shop Crafts) is sometimes lumped with other occupations, and sometimes listed alone. When we had missing values in the data set, it was most often because a railroad's reported occupational groupings in one year became too aggregated (though less aggregated in the year before and the year after), and we chose to leave it as a missing observation rather than arbitrarily break the occupational aggregate into subgroups. Hence, we tried to maintain as disaggregated a classification as we could, subject to having the same categories available across railroad companies over time. In the end, we used the following number of aggregated occupations (one of these categories was always the "other" in these occupational groupings): 5 groups in Depot Workers, 4 groups in Trainmen, 6 groups in Linemen, and 6 groups for Shop Craft Workers.

[16]We used days as the time frame rather than hours or years because most of the railroad workers were paid by the day (see Licht 1983:132–33).

A CPI closer to the period studied (1900–1916) might have been desirable, but we do not think that our use of the 1967 benchmark is likely to affect our results.

Table 2. Sample Means: New Jersey's Four Largest Steam Railroad Companies.

	Depot Workers		*Trainmen*		*Linemen*		*Craft Workers*	
Period	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
1900–1908 Means								
Real Daily Wage	7.2028	32.1696	10.4394	52.4170	6.0311	45.3052	8.0863	18.4547
All Injuries/Day	0.000106	0.0031	0.000298	0.0060	0.000108	0.0024	0.000146	0.0036
1909–1911 Means								
Real Daily Wage	7.7613	40.6382	11.7813	64.3836	5.8942	23.6629	8.9908	21.2510
All Injuries/Day	0.000030	0.000963	0.000249	0.0030	0.000089	0.0020	0.000218	0.0051
1912–1916 Means								
Real Daily Wage	7.3921	31.7518	12.8644	77.5275	6.368	25.6608	8.0633	21.9895
All Injuries/Day	0.000076	0.0056	0.000345	0.0039	0.00016	0.0042	0.000283	0.0055
1900–1916 Means								
Log(Real Daily Wage)	1.9815	2.9968	2.4069	5.4343	1.7818	5.0860	2.1352	2.7259
Real Daily Wage	7.3632	33.7204	11.4848	65.9520	6.1009	37.1656	8.5351	21.7519
All Injuries/Day	0.000083	0.0038	0.000303	0.0051	0.000121	0.0031	0.000203	0.0046
Average Hours	10.1240	17.4138	10.8059	18.5887	10.3929	17.8570	9.7014	22.5106
Number of Employees	810.3208	8,861.42	648.2296	7,967.22	1,348	190,10.85	612.4427	5,748
Employees-Squared	875,994.85	1,526,408	561,872.76	1,359,3972	2,483,721	53,298,172	461,551	6,902,594
Number of Strikes	0.6800	21.0229	0.9266	24.1674	0.8738	26.6003	0.6230	20.7084
U.S. Passenger Mi. (b.)	28.1065	116.0982	28.1939	128.4616	27.1222	145.2956	28.0721	117.0832
FELA Dummy	0.1719	7.1391	0.2016	8.4927	0.1719	8.7938	0.1946	7.7392
BOTH Dummy	0.3403	8.9645	0.3195	9.8702	0.2765	10.4242	0.3109	9.0487
FELA*All Injuries	5.248E–6	0.000454	0.000050	0.0025	0.000015	0.0011	0.000042	0.0027
BOTH*All Injuries	0.000026	0.0031	0.000110	0.0039	0.000046	0.0029	0.000088	0.0039
MERC RR	0.2250	7.9006	0.1395	7.3358	0.2040	9.3922	0.2169	8.0569
PENN RR	0.5322	9.4400	0.5453	10.5399	0.5260	11.6373	0.5231	9.7638
PRRC RR	0.0114	2.0120	0.0052	1.5356	0.0064	1.8640	0.0025	0.9775
Sample Size	211		179		190		215	

Source: New Jersey Bureau of Labor and Industries, *Annual Reports, Classification of Persons Employed on the Steam Railroads in New Jersey,* various years.

As measures of output, four variables, each aggregated to the annual, U.S. railroad industry, were tried in the models: passenger miles, freight miles, revenue per passenger mile, and revenue per freight mile.[17] These variables turned out to be somewhat collinear in our data set. Because tests of statistical significance indicated that the passenger miles variable provided the best statistical fit, we retained it in all of our models. Including the other variables did not change any of our results. The passenger mile variable, expressed in billions of miles, is roughly the same across all occupational groups, any difference arising from differences in the distribution of workers over time (the means and standard deviations in Table 2 are weighted by the number in each detailed occupational group). Other variables measuring the within-state differences between manufacturing and railroad employment had no effect on the estimates.

Finally, the results were robust to the way injuries were measured and to the way we treated heteroskedasticity in the model. Tables 3 and 4 present weighted least squares estimates using the number in each (detailed) occupational group as the weight,[18] also

[17]We used the National Bureau of Economic Research data. See www.nber.org/databases/macrohistory/contents/chapter03.html.

[18]As we are using averages for each railroad, year, and occupational group, the variance will be (inversely)

Table 3. Railroad Injury Rates When Liability Changes: Four Railroads, Weighted Least Squares with T-Statistics Calculated Using White's Robust Standard Errors.

Variable	*Depot Workers*	*Trainmen*	*Linemen*	*Crafts*
Constant	–0.00057638	–0.00011340	–0.00046121	–0.00027315
	(–1.00)	(–0.34)	(–2.24)	(–2.21)
Average Hours	0.00006293	0.00002389	0.00003482	–0.00000964
	(1.27)	(1.10)	(2.10)	(–1.85)
Number of EEs	–6.93359E–7	–8.1148E–7	1.268983E–7	6.249154E–7
	(–4.82)	(–1.66)	(1.41)	(2.23)
EEs-Squared	3.47143E–10	2.95327E–10	–1.7089E–11	–1.937E–10
	(4.60)	(1.66)	(–0.56)	(–0.88)
Number of Strikes	0.00002823	–0.00000499	0.00000311	–0.00000236
	(.75)	(–0.43)	(0.53)	(–0.31)
Passenger Miles	0.00001012	0.00001090	0.00000186	–0.00000182
	(1.99)	(1.31)	(0.99)	(–0.60)
FELA Only	–0.00009409	–0.00013083	–0.00000559	0.00006289
	(–1.86)	(–1.66)	(–0.27)	(2.12)
BOTH	–0.00010086	–0.00006858	0.00004427	0.00009357
	(–1.60)	(–.73)	(1.69)	(2.75)
MERC	–0.00000961	–0.00017166	0.00008140	0.000002481
	(–0.38)	(–2.53)	(3.97)	(0.69)
PENN	0.00023572	0.00017811	0.00013706	0.00014989
	(2.03)	(1.47)	(5.41)	(3.25)
PRRC	0.00010862	–0.00018975	0.00008167	0.00027362
	(1.87)	(–1.23)	(1.76)	(1.75)
Joint Test for FELA, BOTH	1.79	5.04***	2.52*	4.13**
Joint Test for Railroad Effect	1.89	2.50*	9.88***	7.49***
Joint Test for Job Types	5.82***	20.53***	9.32***	11.11***
R-Squared	.391	.525	.600	.621
Sample Size	211	179	190	215

Source: New Jersey Bureau of Labor and Industries, *Annual Reports, Classification of Persons Employed on the Steam Railroads in New Jersey,* various years.

Dummy variables for jobs were also included in the specification, but their individual coefficients are not reported in the Table.

MERC: Morris and Essex Railroad; PENN: the Pennsylvania Railroad Company; PRRC: the Philadelphia and Reading Railroad Company.

employing White's robust standard errors. Estimates using OLS and standard errors clustered at the railroad level were very similar to those reported in Tables 3 and 4, as were estimates using just weighted least squares. The injuries reported in Tables 3 and 4 are on a daily basis, all injuries per year divided by the number of days worked per year; measuring them on an hourly basis or an annual basis instead yields the same general results. Fatal injuries were also included in the data, and showed a pattern of coefficients similar to that exhibited by all injuries (as well as by the subset of non-fatal injuries; see footnote 8 and Appendix B).

Methodology

As suggested by the discussion in the first section of this paper, there are at least three alternative models of how FELA could affect accident rates. In the frictionless Coasian world, bargaining between employees and employers ensures that FELA will not affect injuries or wages. In an empirical wage regression of this Coasian world, the coefficient on

proportional to the number of workers in each of our cells, as noted in Theil (1971:250).

a FELA dummy variable (FELA = 1 starting in 1908 to capture shifts in employer liability) in an injury rate equation,[19] and the FELA coefficient and the coefficient on a "FELA*injury" interaction variable (to capture shifts in injury risk) in the wage equation, should both be statistically insignificant. This model is not supported in any of the work cited above, or in our results reported below.

Because of insufficient empirical support for the frictionless "Coase" model, Stole (1994) and Fishback (1987) presented two empirical "transactions costs" models of industrial injuries as alternatives. Stole's "employer liability" model assumes that railroad companies can provide safety at lower cost than can railroad workers because of, for example, intrinsic safety technology that only the railroad controls. FELA modifications would be expected to decrease the injury rates, with an accompanying adjustment in the wage structure: an increase in the intercept and a lowering of the compensating risk premium in wages (the "FELA*injury" coefficient will be negative). The Posner/Landes "worker liability" model assumes workers are the least-cost avoiders of injuries. Hence, shifting injury liability away from them through the enactment of FELA should increase injury avoidance costs, raising both workplace injury risk and the compensating risk premium in wages (the "FELA*injury" coefficient will be positive, and the wage intercept will shift up during FELA).

Table 3 models the overall injury rate by broad occupational group, using the variables discussed above. To control for scale differences in safety technology, the number of employees (EEs) and the number of employees squared (EE-squared) are included in the model along with the variables discussed earlier. A number of results suggest that the indoor/outdoor distinction is useful for railroad job types. As demand for labor increased, whether measured by passenger-miles or hours of work, the injury rate rose for outdoor workers—depot men, trainmen, and linemen—but fell for indoor workers, those in crafts. That there was a difference in safety technology is most evident, however, in the signs of the FELA and FELA/workers' compensation (BOTH) variables. The variable BOTH indicates the period following the second half of 1911 during which both FELA and workers' compensation were in effect for railroad workers, depending on occupation. For all three outdoor worker groups (the first three columns on the left-hand side), the accident rate fell as FELA shifted the liability from the worker to the firm, suggesting that railroads were the least-cost avoider of accidents. Indoor workers, that is, craft workers, exhibit the opposite sign: as FELA was implemented, accidents rose rather than fell. For craft occupations, it appears that workers were the least-cost accident avoiders.[20] This might explain why the empirical findings of Fishback, Chelius, and Stole differ from ours: to the extent that the coal miners in the Fishback samples are like the indoor workers in the railroads, shifts away from worker liability increase workplace risk. Fishback and Kantor argued convincingly that monitoring costs differ across industries (2000:79–82), and the ability to control moral hazard and monitor safety behavior varied across the occupational groups we consider in our sample as it did in Fishback and Kantor's.

Note that the shift in joint FELA/workers' compensation rules (the FELA and BOTH effects are measured relative to the pre-liability-shift period, 1900–1908) generally exhibits the same pattern as the FELA shift did. Accident rates for depot men and trainmen drop as they did in the FELA shift, although the

[19]We also tested to see if there was any impact of the 1906 FELA, which was declared unconstitutional in 1907. We found that the 1906 Act had no statistically significant impact on fatal or non-fatal injury rates. This could be due to the short duration of the law, which was amended to pass constitutional muster. Fishback has pointed out that there can be a lag in the impact of a law. Studies like ours may be picking up some of the impact of the 1906 Act with the 1908 variable.

[20]One referee argued that these results may be counter-intuitive: to the extent that indoor jobs provide a more stable working environment and more opportunity for close supervision than outdoor jobs do, they will be more susceptible to employer control; hence, for indoor jobs, the railroad company will be the least-cost avoider. We leave the matter of least-cost avoider as an empirical issue, and let the data speak for themselves.

Table 4. Railroad Worker Wages When Liability Changes: Weighted Least Squares with White's Robust Standard Errors (t-statistics); Adding EE and EE-Squared.

	Depot Workers		*Trainmen*		*Linemen*		*Crafts*	
Variables	*Log Wages*	*Wages*	*Log Wages*	*Wages*	*Log Wages*	*Wages*	*Log Wages*	*Wages*
Constant	2.168506	9.193796	2.210304	9.251786	1.75842	7.091711	1.799926	5.799381
	(8.19)	(5.03)	(18.64)	(6.53)	(6.21)	(3.44)	(24.34)	(8.99)
Average Hours	–.0337917	–.2793581	.0065156	.0637674	–.0076411	–.1452879	–.0026244	–.030568
	(–1.79)	(–2.15)	(0.76)	(0.61)	(–0.33)	(–0.85)	(–0.56)	(–0.70)
Employees	.0003236	.0018726	–.0001189	–.0001002	.0001443	.0014432	–.0000455	–.0001776
	(2.46)	(2.05)	(–1.03)	(–0.06)	(1.70)	(2.43)	(–0.35)	(–0.16)
Employees Sq.	–1.81e-07	–1.11e-06	2.33e-08	–3.57e-07	–3.69e-08	–3.44e-07	6.29e-08	4.45e-07
	(–2.08)	(–1.83)	(0.49)	(–0.55)	(–1.63)	(–2.24)	(0.70)	(0.63)
Number of Strikes	–.0090539	–.0638487	.0121755	.1823498	–.0012064	.0026232	–.0026647	–.0193492
	(–1.12)	(–1.09)	(2.11)	(2.54)	(–0.13)	(0.04)	(–0.48)	(–0.42)
Passenger Miles	–.002678	–.0168007	.0079711	.0724107	.0054711	.0226854	.0114639	.0905733
	(–0.78)	(–0.67)	(4.35)	(3.31)	(1.68)	(0.97)	(7.09)	(6.79)
Injury/Day	426.7834	2,818.938	74.90213	849.2356	1,194.164	9,669.962	11.13881	–40.20159
	(2.61)	(2.49)	(2.65)	(2.87)	(4.74)	(4.88)	(0.29)	(–0.12)
FELA Only	.1295789	.9658731	.041773	.8690666	.0758551	.6179342	–.0166796	–.1359652
	(4.59)	(4.73)	(1.51)	(2.24)	(1.56)	(1.82)	(–0.86)	(–0.77)
FELA*Injury	–539.8039	–5,070.718	83.69288	–39.16986	–899.7338	–6,963.397	98.97176	1,053.646
	(–1.74)	(–2.25)	(0.88)	(–0.03)	(–3.14)	(–3.37)	(1.99)	(2.38)
BOTH	.1097682	.7735687	.1411787	2.498632	.0915497	.6131995	–.0785827	–.6585411
	(3.01)	(2.96)	(3.83)	(5.04)	(1.76)	(1.63)	(–3.54)	(–3.42)
BOTH*Injury	–409.4398	–2,810.177	–62.66869	–2,535.938	–1,019.763	–7,768.345	163.6294	1,608.969
	(–2.39)	(–2.36)	(–0.52)	(–1.74)	(–3.87)	(–3.84)	(4.16)	(4.73)
MERC	–.0988582	–.6421529	.0041221	.2867311	–.1309837	–.8230826	–.1022875	–.8911428
	(–4.91)	(–4.33)	(0.16)	(0.85)	(–4.42)	(–3.90)	(–3.53)	(–3.62)
PENN	–.044296	–.2047424	.1094951	1.186399	–.0286386	–.4914215	–.0702374	–.7317249
	(–1.30)	(–0.82)	(4.75)	(4.24)	(–0.87)	(–2.02)	(–2.53)	(–3.01)
PRRC	–.1186984	–.8988071	.1874195	2.615482	.0009863	.1324619	–.2320608	–1.85428
	(–2.99)	(–3.07)	(3.74)	(4.29)	(0.01)	(0.15)	(–3.16)	(–3.43)
F: Injury/Day	3.35**	3.34**	2.59*	2.98**	8.13***	8.71***	11.32***	13.92***
F: FELA Vars	10.56***	11.43***	4.77***	6.13***	5.00***	5.69***	2.02	3.10**
F: BOTH Vars	5.58***	5.48***	17.41***	23.79***	7.53***	7.48***	9.81***	11.71***
F: Railroads	10.90***	9.66***	29.24***	35.61***	6.77***	5.40***	6.34***	7.15***
F: Job Types	97.10***	65.25***	408.50***	321.56***	7.71***	8.54***	31.73***	33.52***
R-Squared	.6703	.8256	.9348	.9235	.7284	.7410	.6186	.7137
Sample Size	211	211	179	179	190	190	215	215

Source: New Jersey Bureau of Labor and Industries, *Annual Reports, Classification of Persons Employed on the Steam Railroads in New Jersey,* various years.

Dummy variables for job types were also included in the specification but are not reported in the table. The standard errors are robust, calculated for clustering within each railroad. Weights were number of workers within each railroad/occupation/year cohort. We report F-statistics in the bottom rows from weighted least squares regressions with White's robust variance correction.

MERC: Morris and Essex Railroad; PENN: the Pennsylvania Railroad Company; PRRC: the Philadelphia and Reading Railroad Company.

accident rate for linemen increases slightly. Again, there is a statistically significant accident rate increase in the BOTH period for railroad workers in the craft occupations. It appears that the source of the liability change matters less than the shift itself does: workers' compensation was important because it brought no-fault accident insurance with limited liability for the firm, FELA because it eased the way for workers to sue employers. This suggests that those who argue that the tort system generated better safety incentives than did workers' compensation are wrong: the incentives seem similar, whenever the least-cost avoidance technology is similar.

Wage Shifts Following the Liability Change

Table 4 shows the results from a hedonic wage equation, where the risk and hours of work determine the wages. The R-squares for these models are relatively high, with between two-thirds and 90% of the variation in wages being explained by the model. The coefficients on the railroad dummy variables at the bottom of the table indicate that the Central Railroad of New Jersey (our omitted railroad in these specifications) paid more than the other railroads for depot workers, linemen, and craft workers, but less for trainmen. Passenger miles, an index of demand conditions, has the expected positive sign for all occupational groups except depot workers. The average hours and number of employees coefficients are often statistically insignificant and have mixed signs.[21] Omitting these variables does not change any of our results. The injury/day coefficients, which are positive and statistically significant for all groups except craft workers, indicate compensating wages for injury risk in the pre-FELA period for all outdoor workers.

As discussed above, liability rules changed twice during the period: first in mid-1908 with the introduction of FELA, and then in mid-1911 with the implementation of workers' compensation in New Jersey. To capture the intercept/slope shift in the wage structure for the first, FELA shift, we include the variables "FELA only" and "FELA*injury/day." For shifts when both laws are in effect, we include "BOTH" and "BOTH*injury/day." The F tests at the bottom of Table 4 indicate that compensating wages and shifts in compensating wages are jointly statistically significant (except for FELA shifts for craft workers in the log wage specification). Respectively, the results indicate that the compensating wages for injury risk are statistically significant (first F-test), that the FELA shift variables are jointly significant (second F-test), and that the BOTH shift variables are jointly significant (third F-test).

All outdoor workers exhibited declines in their injury rates with the enactment of FELA in 1908, as indicated by the negative coefficients for the FELA variable in the three left-hand columns in Table 3. As risk falls, wages are predicted to shift up in intercept and down in slope, which is exactly what is observed in five of the six left-hand specifications, the only exception being the "FELA*injury" shift in the log-wage specification for trainmen, which is (insignificantly) positive rather than, as predicted, negative. A further test of our theory is the behavior of wages for craft workers. Given that injury risk actually rose for this group in 1908 with the enactment of FELA, we would expect to observe a wage shift for craft workers just the opposite of that for outdoor workers, with a fall in intercept and a rise in slope. This is exactly what we observe. This is also what we observe for craft workers when their injury rates were lower in the BOTH period: relative to the pre-FELA period, the wage intercept shifted down and the wage slope variables shifted up. Finally, consistent with the theory as illustrated in Figures 1 and 2, depot workers in the post-FELA period and trainmen in the post–workers' compensation period (in the wage regression, though not the log-wage regression) exhibit a downward-sloping wage/risk tradeoff, even though the

[21]We added employees and employees squared to the analysis as scale measures (for technology, just as in the injury rate regression), but were concerned that they might be interpretable as endogenous factors in a supply and demand model as well as hours of work. Their omission from the model does not appreciably alter either the signs or the statistical significance of our variables of interest. These tables are available upon request.

total compensation relationship may be positive as indicated in Figure 2. None of these results were sensitive to the introduction of controls for workers' compensation benefit payments.[22]

Outdoor workers exhibited a fairly consistent set of changes in the workers' compensation period: as indicated in Table 3, linemen exhibit a statistically insignificant increase in injury rates in the BOTH period, while depot workers and trainmen have lower injury rates than in the pre-FELA period. However, all three groups exhibit wage shifts in the BOTH period consistent with their injury rates having fallen. Linemen may have considered the experience of other outdoor workers when they assessed their own information concerning risk, and there may have been sufficient substitution between linemen and the other groups, for example depot men, for their wages to change in the same way.

Overall, our simple model of wage shifts receives considerable support from the data. An interesting question is whether these shifts made any difference to railroad workers' real wage income, once the level of risk is taken into account. As discussed above, real wages could have risen, fallen, or remained unchanged even if total compensation fell as risk fell. We estimate wage changes by holding all other variables constant at their sample mean (the mean taken over the whole sample period), examining only those changes in injury rates and wages specifically associated with changes due to FELA and FELA/workers' compensation (BOTH). Let the contribution of all other variables (that is, all variables other than the injury rate and shift variables) be denoted as $Z\gamma$, which we again hold constant before and after the liability changes, as we only want to calculate the influence of the liability changes *per se* on wages; then the pre-FELA wage expression is given as

$$(2) \qquad \text{WAGE}^{\text{PRE-FELA}} = \beta_0^{\text{PRE-FELA}} + Z\gamma + \beta_1^{\text{PRE-FELA}}(\text{injury/day})^{\text{PRE-FELA}};$$

that is, this is the predicted wage if all other variables are held constant at their sample mean and weighted by their estimated coefficients, while the PRE-FELA injury rate and coefficient are applied. Then the POST-FELA predicted wage would, by this accounting, be

$$(3) \qquad \text{WAGE}^{\text{POST-FELA}} = \beta_0^{\text{PRE-FELA}} + Z\gamma + \beta_1^{\text{POST-FELA}}(\text{injury/day})^{\text{POST-FELA}}.$$

We can decompose wage changes before and after FELA, for example, using our modified version of the regression decomposition formula, not to look for disparities, but to calculate and test for changes in the real wages of railroad workers:

$$(4) \qquad \text{WAGE}^{\text{POST-FELA}} - \text{WAGE}^{\text{PRE-FELA}} = (\beta_0^{\text{POST-FELA}} - \beta_0^{\text{PRE-FELA}}) + \beta_1^{\text{PRE-FELA}}(\text{INJURY}^{\text{POST-FELA}} - \text{INJURY}^{\text{PRE-FELA}}) + (\beta_1^{\text{POST-FELA}} - \beta_1^{\text{PRE-FELA}})\text{INJURY}^{\text{POST-FELA}}.$$

The $(\beta_0^{\text{POST-FELA}} - \beta_0^{\text{PRE-FELA}})$ term is the coefficient on the FELA dummy variable—that is, it is the change in coefficient associated with the pre-FELA period/post-FELA period transition. The $(\beta_1^{\text{POST-FELA}} - \beta_1^{\text{PRE-FELA}})$ term is the "FELA∗injury/day" interaction coefficient, representing the change in the compensating wage differential when going from the pre-FELA period to the post-FELA period. Taking the change in injury risk and the post-FELA level of risk—($\text{INJURY}^{\text{POST-FELA}}$

[22]We controlled for the introduction of workers' compensation in two ways. Benefits were zero before fiscal year 1912, and nearly constant thereafter. Therefore, benefits will be nearly collinear with the BOTH dummy variable, except that there was also a noticeable change in workers' compensation payments. Including the 1913 shift as a dummy variable in addition to the 1911 shift variable (BOTH) had no impact on the other reported coefficients; the 1913 shift was statistically significant only in the linear wage specification for craft workers. In addition, all specifications included the expected benefit series found in Fishback and Kantor (2000:175). We found that its inclusion in our models had relatively little impact on the reported results. This is unsurprising both because (a) New Jersey was a relatively low benefit state and our sample is composed of relatively high-wage workers and (b) there was very little variation in the real workers' compensation benefit in New Jersey. Indeed, the Pearson correlation between BOTH and New Jersey workers' compensation benefits was .88, and real benefits (in 1967 dollars) varied between a low of \$30.57 and a high of \$31.59 (and were, of course, zero before 1911). That is, controlling for the expected real level of workers' compensation benefits had no impact on the results reported in Table 4.

– $\text{Injury}^{\text{PRE-FELA}}$) and $\text{Injury}^{\text{POST-FELA}}$—from the means in Table 2 and treating them as fixed changes in real wages after the liability shift can be tested as a linear restriction given in the right-hand side of equation (4). A similar expression is readily derived (replace BOTH superscripts for FELA superscripts) for the real wage shift when both liability schemes were in force.

We cannot reject the null hypothesis of no change in real wages for linemen or craft workers, for either the FELA period or the BOTH period. Linemen's real wages fell between 1% and 3%, a statistically insignificant change, as did craft workers' wages in the BOTH period, while craft workers' wages rose by less than 1% in the FELA period, again statistically insignificant. Depot workers and trainmen, on the other hand, experienced statistically significant increases in their real wages. Log-wage specifications indicate that depot workers and trainmen experienced real wage increases of 6–8% during each of the two periods of liability shift.

Except for the wage specification for trainmen, we found no statistically significant and negative shift in real wages. This would be an anomalous finding for our theory if we were measuring total compensation, as in Figure 1. As our theoretical predictions shown in Figure 2 make clear, however, it is important to distinguish between total compensation and wage compensation when dealing with liability changes involving changes in the expected value of non-wage benefits, in particular, expected injury benefits. Positive real wage changes, even after a switch in liability that lowers risk, are consistent with our model.

As noted above, technology, monitoring cost, and the potential for moral hazard differ across occupational groups. Outdoor workers may not have as much control over their environment, and the potential for moral hazard may be lower. In such a case, firms may need more resources to establish liability in the face of exogenous unobservable factors. When there is a shift in liability rules, firms may save on transactions cost because they do not have to establish liability. The trainmen group, the most frequently and severely injured, are the most likely to benefit from the reduction in transactions cost. Craft workers have more control, and with the introduction of workers' compensation, they do not have to be as careful (it was during the workers' compensation period that their wages fell by 3%, though the decrease was statistically insignificant). Transactions cost rises for the firm, and craft workers share that cost.

Conclusion

The passage of FELA in 1908 and workers' compensation in 1911 clearly shifted more of the liability for railroad injuries to the employers. In a world with substantial transactions costs, this shift could either increase or decrease the real level of safety depending on whether the worker or the railroad company was the least-cost avoider of the injuries. Posner/Landes have argued that railroad workers were the least-cost avoiders of accidents in nineteenth-century America, and that this was reflected in the evolution of common law. Hence, FELA's shift of injury liability to railroad companies should have increased industrial accidents. Earlier empirical research showed mixed results, however. Fishback (1987) found that death rates rose in coal mines when a similar shift in liability to employers occurred. On the other hand, Stole (1994) found that U.S. aggregate fatality rates trended downward after 1908, and a panel data study conducted by Kim and Fishback (1993) also noted a substantial decrease in fatalities following enactment of FELA.

Using a more detailed data set for railroads than previous research has employed, we have analyzed the changes in injury rates and wages for several railroads in New Jersey from 1900 to 1916. Consistent with Chelius (1976) and Stole (1994), we find that accident rates fell for three of the four occupational groups when liability shifted to the railroads. For the fourth group, craft workers who worked indoors in shops, we find that accident rates rose with the shift in liability, consistent with Fishback (1987). Our results indicate that for outdoor jobs the railroad companies were the least-cost avoider of accidents, while for indoor jobs the railroad workers were the least-cost avoider. The compensating differentials generated are consistent with this story, and Fishback's monitoring cost–moral hazard argument is consistent with our data.

Appendix A
Listing of Occupations Included in "Job" Categories

Depot	*ShopCraft*	*OperatingCraft*	*Other*
General Officer	Machinist	Engineman	Telegraph-Dispatcher
Other Officer	Carpenter	Fireman	Other Employee
Agent	Other Shopman	Conductor	Floating Equip.
Other Station Man	Carbuilder	Other Trainman	Telegraph-Operator
Clerk	Carbuilder/Carpenter	Other Trackman	Supply Dept/Oth. Employees
Baggageman	Machinist/Blacksmith/ Boilermaker	Brakeman	Division-Superintendent
Agent/Asst. Agent	Blacksmith	Trackman	Office Supply Dept.
Baggageman/Clerk/ Depot Man	Boilermaker	Trackman/ Construction	Foreman
Asst. Agent	Blacksmith/Boilermaker	Construction	
Other Depot Man	Blacksmith/Boilmaker/ Carbuilder	Switchman/Flagman/ Watchman	
Agent/Asst. Agent/Clerk	Blacksmith/Boilermaker/ Carbuilder/Shopman	Switchman/Flagman/ Enginewiper/Yardman	
Baggageman/Depot Man		Switchman/Flagman/ Watchman/Yardman	
Baggageman/Station Man/ Depot Man		Switchman	
Baggageman/Station Man		Flagman	
		Enginewiper	
		Switchman/Flagman/ Enginewiper	
		Brakeman/Flagman	
		Switchman/Watchman	

Appendix B
Railroad Injury Rates When Liability Changes: Four-Railroad Sample, Weighted Least Squares with White's Heteroskedastic Standard Errors—All Injuries and Fatal Injuries

	Trainmen		*Linemen*	
Variables	*Injuries/Day*	*Fatalities/Day*	*Injuries/Day*	*Fatalities/Day*
Constant	–0.00011340	–0.00002037	–0.00046121	–0.00003889
	(–0.34)	(–.92)	(–2.24)	(–1.71)
Average Hours	0.00002389	0.00000252	0.00003482	0.00000369
	(1.10)	(1.82)	(2.10)	(2.25)
Total Employees	–8.1148E-7	–5.23377E-8	1.268983E-7	–1.8788E-9
	(–1.66)	(–2.02)	(1.41)	(–.26)
Employees Sq.	2.95327E-10	1.25617E-11	–1.7089E-11	1.50206E-12
	(1.66)	(1.31)	(–0.56)	(.64)
Number of Strikes	–0.00000499	–6.07557E-9	0.00000311	–0.00000102
	(–0.43)	(–.01)	(0.53)	(–1.15)
Passenger Miles	0.00001090	7.198089E-7	0.00000186	2.824652E-7
	(1.31)	(1.35)	(0.99)	(.75)
FELA Only	–0.00013083	–0.00000958	–0.00000559	–0.00000305
	(–1.66)	(–1.91)	(–0.27)	(–.67)
BOTH	–0.00006858	–0.00001119	0.00004427	–0.00000536
	(–0.73)	(–1.87)	(1.69)	(–1.11)
MERC	–0.00017166	–0.00000339	0.00008140	0.00000826
	(–2.53)	(–.67)	(3.97)	(2.76)
PENN	0.00017811	0.00001371	0.00013706	0.00001008
	(1.47)	(2.19)	(5.41)	(3.24)
PRRC	–0.00018975	–0.00000686	0.00008167	–0.00000120
	(–1.23)	(–.58)	(1.76)	(–.28)
Joint Test for FELA,BOTH	5.04***	1.89	2.52*	0.73
Joint Test for Railroad Effect	2.50*	1.73	9.88***	5.13***
Joint Test for Job Types	20.53***	8.73***	9.32***	3.97***
R-Squared	.525	.324	.600	.172
Sample Size	179	179	190	190

Dummy variables for occupations were also included in the specification but their individual coefficients are not reported in the table.

MERC: Morris and Essex Railroad; PENN: the Pennsylvania Railroad Company; PRRC: the Philadelphia and Reading Railroad Company.

REFERENCES

Buffum, David R. 1992. "Workmen's Compensation: Passage and Impact." Ph.D. diss., University of Pennsylvania.

Butler, Richard J., and John D. Worrall. 1991. "Claims Reporting and Risk Bearing Moral Hazard in Workers' Compensation." *Journal of Risk and Insurance*, Vol. 58 (June), pp. 191–204.

Chelius, James R. 1976. "Liability for Industrial Accidents: A Comparison of Negligence and Strict Liability Systems." *Journal of Legal Studies*, Vol. 5 (June), pp. 293–309.

Coase, Ronald. 1960. "The Problem of Social Cost." *Journal of Law and Economics*, Vol. 3 (October), pp. 1–44.

Douglas, Paul H. 1930. *Real Wages in the United States, 1890–1926.* Boston: Houghton Mifflin.

Eastman, Crystal. 1910. *Work Accidents and the Law.* New York: Charities Publication Committee.

Fishback, Price V. 1987. "Liability Rules and Accident Prevention in the Workplace: Empirical Evidence from the Early Twentieth Century." *Journal of Legal Studies,* Vol. 16 (June), pp. 305–28.

____. 1992. *Soft Coal, Hard Choices: The Economic Welfare of Bituminous Coal Miners, 1890 to 1930.* New York: Oxford University Press.

____. 1998. "Operations of 'Unfettered' Labor Markets: Exit and Voice in American Labor Markets at the Turn of the Century." *Journal of Economic Literature*, Vol. 36, No. 2 (June), pp. 722–65.

Fishback, Price V., and Shawn Everett Kantor. 1992. "'Square Deal' or Raw Deal? Market Compensation for Workplace Disamenities, 1884–1903." *Journal of Economic History,* Vol. 52 (December), pp. 826–48.

____. 1995. "Did Workers Pay for the Passage of Workers' Compensation Laws?" *Quarterly Journal of Economics,* Vol. 110, No. 3 (August), pp. 713–42.

____. 1996. "The Durable Experiment: State Insurance of Workers' Compensation Risk in the Early Twentieth Century." *Journal of Economic History*, Vol. 56 (December), pp. 809–36.

____. 1998. "The Political Economy of Workers' Compensation Benefit Levels, 1910–1930." *Explorations in Economic History*, Vol. 35 (April), pp. 109–39.

____. 2000. *A Prelude to the Welfare State: The Origins of Workers' Compensation.* Chicago: University of Chicago Press.

Hobbs, Clarence W. 1939. *Workmen's Compensation Insurance.* New York: McGraw-Hill.

Kantor, Shawn Everett, and Price V. Fishback. 1996. "Precautionary Saving, Insurance, and the Origins of Workers' Compensation." *Journal of Political Economy*, Vol. 104, No. 2 (April), pp. 419–42.

Kim, Seung-Wook, and Price V. Fishback. 1993. "Institutional Change, Compensating Differentials, and Accident Risk in American Railroading, 1892–1945." *Journal of Economic History,* Vol. 3 (December), pp. 796–823.

Landes, William, and Richard A. Posner. 1987. *The Economic Structure of Tort Law.* Cambridge, Mass.: Harvard University Press.

Licht, Walter. 1983. *Working for the Railroad: The Organization of Work in the Nineteenth Century.* Princeton, N.J.: Princeton University Press.

McCahan, David. 1929. *State Insurance in the United States.* Philadelphia: University of Pennsylvania Press.

National Commission on State Workmen's Compensation Laws. 1973. *Compendium on Workmen's Compensation.* Washington, D.C.: Government Printing Office.

New Jersey Bureau of Labor and Industries. 1901–1916. *Annual Reports, 23rd–38th.* Camden, N.J.: S. Chew & Sons.

____. 1917. *Thirty-Eighth Annual Report.* Trenton, N.J.: MacCrellish & Quigley.

Posner, Richard A. 1972. "A Theory of Negligence." *Journal of Legal Studies,* Vol. 1 (January), pp. 29–96.

Rees, Albert. 1961. *Real Wages in Manufacturing, 1890–1914.* Princeton, N.J.: Princeton University Press.

Schwartz, Victor E., and Liberty Mahshigian. 1986. "The Federal Employers' Liability Act: a Bane for Workers, a Bust for Railroads, a Boon for Lawyers." *San Diego Law Review,* Vol. 23 (January-February), pp. 1–15.

Shavell, Steven. 1987. *The Economic Analysis of Accident Law.* Cambridge, Mass.: Harvard University Press.

Stole, Lars. 1994. "The Economic Effects of Liability Rules on Railroad Employee Accidents, 1890–1970." Working paper, Graduate School of Business, University of Chicago.

Strauss, Peter L. 1994. "On Resegregating the Worlds of Statute and Common Law." *Supreme Court Review,* Annual, pp. 429–540.

Theil, Henri. 1971. *Principles of Econometrics.* New York: John Wiley & Sons.

Transportation Research Board. 1994. "Compensating Injured Railroad Workers under the Federal Employers' Liability Act." *Transportation Research Board Special Report 241.* Washington, D.C.: National Academy Press.

U.S. Bureau of the Census. 1975. *Historical Statistics of the United States, Colonial Times to 1970.* Washington, D.C.: Government Printing Office.

U.S. Bureau of Labor Statistics. 1914. *Labor Laws of the United States with Decisions of Courts Relating Thereto.* Bulletin No. 148, Vol. 2. Washington, D.C.: Government Printing Office.

U.S. Commissioner of Labor. 1908. *Workmen's Insurance and Benefit Funds in the United States.* Washington, D.C.: Government Printing Office.

Viscusi, W. K. 1978. "Wealth Effects and Earnings Premiums for Job Hazards." *Review of Economics and Statistics,* Vol. 60, No. 3 (August), pp. 408–16.

White, Halbert. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimation and a Direct Test for Heteroskedasticity." *Econometrica*, Vol. 48, No. 4 (July), pp. 817–38.

Wolman, Leo. 1924. *Growth of American Trade Unions, 1880–1923.* New York: National Bureau of Economic Research.