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THE ECONOMIC EFFECTS
OF LIABILITY RULES
ON RAILROAD EMPLOYEE ACCIDENTS:
1890-1970

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Abstract

This paper examines the impact of various legal changes in employer liability and safety standards affecting railroads during the period 1890-1970 with respect to two competing hypotheses--the efficient markets hypothesis and the transaction costs hypothesis--which offer distinct testable implications. The results indicate that workers generally perceived the danger of their employment and accepted lower real wages in exchange for greater safety. However, this paper finds support for the transactions cost hypothesis, as employers failed to take advantage of the great gains from safety improvements. Various theories explaining this phenomena are entertained, including the possibility that workers only perceived the safety of the industry (rather than individual railroads) resulting in the provision of safety being a public good among railroads. The various changes in federal law between 1893 and 1926 overcame this problem.

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1. INTRODUCTION

Working for a railroad at the turn of the century was an extremely dangerous occupation. The Interstate Commerce Commission's Third Annual Report in 1889 indicated that the chance of a brakeman dying a natural death was one out of five and the average life expectancy of a switchman was a mere seven years. With such horrifying statistics, one might surmise that there would have been

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tremendous pressures on the railroads to increase the safety of their workplace. Nonetheless, for most of the nineteenth century, neither statutory provisions for safety nor effective remedies at common law existed to promote workers' safety.

At the end of the nineteenth century and the beginning of the twentieth century some changes, both statutory and in common law, were made which remained essentially unaltered until 1970. As a consequence, a study of railroad accidents during this transition period affords the economist a rare opportunity to test various competing theories about the markets for risk and the effect of the common law on industrial behavior. We take up this study here.

2. A CONCISE HISTORY OF RAILROAD ACCIDENT LAW

Before 1837, there are no recorded cases of employees seeking damages from their employers for an injury or death. In part, this lack of judicial precedent may be explainable by the lack of prevalence and seriousness of industrial accidents at that time.

In 1837 an important English case, *Priestly v. Fowler*, 150 Eng. Rep. 1030 (1837), considered a work-related lawsuit by a worker against his employer and adopted the *fellow servant rule*, also known as the doctrine of common employment, which held that an employer could not be held liable for accidents if a fellow employee was at fault. In 1842, the fellow servant rule was first adopted in the United States in a famous Massachusetts decision, *Farwell v. Boston & Worcester Railroad*, 45 Mass. 49 (1842). In this case, a fellow employee was negligent and the court subsequently held that the plaintiff could not bring an action against the employer – only a stranger to the firm could successfully sue the employer for the negligence of a worker. Because most fellow employees had little resources and hence were judgment proof, such a defense greatly helped employers avoid liability for workplace accidents at the cost of the injured worker.

Beyond the defense of the fellow servant rule, the railroad (as well as other employers) had two other defenses in common law during this time period: assumption of risk and contributory negligence. The doctrine of *assumption of risk* allowed employers to avoid liability if it could be shown that the employee knowingly assumed the risk of the activity. The defense, predicated on classical theories of freedom of contract, provided an easy escape for a negligent employer if the dangers of the particular employment were generally known.¹ The doctrine of *contributory negligence* barred an employee from recovery whenever the employer could demonstrate that the employee was partially at fault. This harsh doctrine

¹See, for example, *St. Louis Cordage v. Miller*, 126 F. 496 (1903).

effectively shielded the employer from liability in many circumstances as employees often contributed to the accident in one way or another.

The three defenses taken together – fellow servant rule, assumption of risk, and contributory negligence – insulated the railroads from legal exposure for work-related accidents. Many scholars of railroads have indicated that these defenses manifested themselves as a laxness “in developing safety measures for their employees.”²

Nonetheless, the railroad industry did invest in new technologies which would have the effect of reducing workplace accidents. In 1887, the Master Car Builders Association (MCBA) developed the Janney automatic coupler, which became the MCBA industry standard in 1889.³ Additionally, the industry worked on improving brakes in the 1870s and 1880s, which culminated in the invention of the air brake by Westinghouse.

In 1887, Congress established the Interstate Commerce Commission (ICC) to regulate the railroads engaged in interstate traffic. From 1890 until 1970, six major changes in the legal environment occurred which plausibly affected railroad safety: The Safety Appliance Act (SAA), the Hours of Service Act, the Federal Employers’ Liability Act (FELA), the Railroad Labor Act (RLA), the Power Brake Law, and the Locomotive Inspection Law.⁴

In part a response to the staggering loss of life involved in employee accidents on the railroad (in 1893, for example, 2727 workers lost their lives in railroad accidents), the ICC promulgated the Safety Appliance Act on March 2, 1893.⁵ The SAA required power driving-wheel brakes, automatic couplers, grab irons, and

²Robb and Lustig [1968], p.143.

³See, for example, Haines [1897, pp. 38-61] and Overbey [1982, pp. 17-18] for a discussion of the development.

⁴All of these acts only affected interstate commerce so it is important to keep in mind the importance of state regulation as well. Nevertheless, the federal laws certainly provided a strong impetus for state regulation, as well as indicated current trends in state regulation. Additionally, during this time period, two other laws were passed which are worth noting. The Accident Reports Act of 1910 required railroads to make accurate, detailed, and specific reports of all accidents or face steep penalties. [May 6, 1910, 36 Stat. 350, codified at 45 U.S.C. §§38-43 (1982).] Although the railroads had been reporting deaths and injuries for both workers and passengers to the ICC since 1890, this Act elicited more detailed information and increased the costs for overlooking accidents. As a consequence we might expect an under-reporting of accidents, particularly non-fatal accidents, prior to 1910. Finally, in the fall of 1970, Congress passed new comprehensive safety regulations designed to greatly improved the safety of the railroads. [October 16, 1970, 84 Stat. 971, codified at 45 U.S.C. §§421-444 (1982).] Given that we are our interested only in accidents occurring between 1890 and 1970, it is implausible that any real effects occurred during the period under study from this latter law.

⁵27 Stat. 532, codified at 45 U.S.C. §§1-7 (1982).

standardized height for drawbars. Consequently, the recent advances in couplers and air brakes were required by law. Additionally, the Act eliminated the assumption of risk defense by employers if an accident was caused by violations of the law.

There appears to be some disagreement among scholars as to the effect of the SAA legislation. Friedman [1985, p.480] indicates in a footnote that the railroads were given until January 1, 1898 to comply and the ICC could grant extensions, suggesting that the law was lax in its requirements on the railroads. Overbey [1982, p.18], however, argues that the act was largely unnecessary, as the railroads had already begun using the Janney coupler and air brakes.⁶ Later in 1903, the Safety Appliances Act was amended to improve the enforcement of the original act.⁷ Additional amendments in 1910 also served to improve enforcement, as well as to require hand brakes on most rail cars.⁸ The essence of the Safety Appliance Act, however, remains in the original legislation enacted in 1893.

The Hours of Service Act was enacted on March 4, 1907 and provided varying limitations on the length of time an employee could work.⁹ Most importantly, an employee was limited to shifts of less than 14 hours in length. The Act was significantly amended in 1916 to limit a work day to 8 hours.¹⁰ Presumably, a better rested workforce had the affect of reducing employee accidents.

The Federal Employers' Liability Act was a remarkable change from the status quo.¹¹ The act imposed greater liability on railroad employers for workplace accidents. The original FELA made no distinction between *intrastate* and *interstate* commerce, and so was declared unconstitutional by the Supreme Court in the *Employers' Liability Cases*, 207 U.S. 463 (1908). In response to the Courts decision, President Roosevelt called upon Congress to enact a strengthened FELA, albeit restricted to interstate commerce.¹²

Shortly after the Supreme Court declared the act unconstitutional, Congress followed Roosevelt's request and enacted the Federal Employers' Liability Act of 1908.¹³ The new and improved FELA increased the railroad's liability for worker

⁶ "In 1893, the young ICC required by law the use of air brakes and automatic couplers on all trains engaged in interstate service. As with other standards of this period, federal and state regulation followed the lead of national railroad organizations, serving primarily as an incentive for laggard companies to move up to standards set up by better-run railroads."

⁷ March 2, 1903, 32 Stat. 943, codified at 45 U.S.C. §§8-10 (1982).

⁸ April 10, 1910, 36 Stat. 298, codified at 45 U.S.C. §§11-16 (1982).

⁹ 34 Stat., codified at 45 U.S.C. §§61-66 (1982).

¹⁰ September 3, 1916, 39 Stat. 721, codified at 45 U.S.C. §§65-66 (1982).

¹¹ June 11, 1906, 34 Stat. 232.

¹² 42 Congressional Record 1347 (1908).

¹³ April 22, 1908, 35 Stat. 65, codified at 45 U.S.C. §§51-60 (1982). The new Act withstood a

accidents by great magnitudes. More importantly, FELA codified the common law action of negligence against an employer, and it eliminated the railroad's defenses of the fellow servant rule and contributory negligence. Now common employment could not be used as a defense, and a worker that was found contributorily negligent would have his award reduced proportionately but not eliminated entirely. Additionally, the Act eliminated assumption of risk defenses whenever the cause the accident could be traced to a statutory violation by the railroad. Thus, although the Act did not eliminate assumption of risk as a defense, it curtailed its use somewhat. An amendment to FELA in 1939 had the affect of completely eliminating the assumption of risk defense in cases where the employer was negligent.¹⁴ Finally, FELA explicitly refused to acknowledge any terms in contracts between railroads and workers which attempted to avoid the effect of the Act. The workers were not free to contract around the Act's provisions. Thus, even though FELA was a statutory change, it had the affect of radically altering the application of common law to suits between railroads and their workers.

The Railroad Labor Act of 1926 was enacted to prevent strikes which could have a crippling impact on the U.S. economy.¹⁵ The RLA allowed labor to organize and provided for arbitration of disputes. In turn, the Act instituted mechanisms designed to prevent strikes from ever occurring. Although the RLA is not a safety-related act, it arguably increased employee safety by providing a forum for discussing and improving work conditions.

The Power Brake Law¹⁶ and the Locomotive Inspection Law¹⁷ were promulgations by the ICC in the late 1950s that improved safety standards and strengthened the ICC's enforcement. The former authorized the "ICC to prescribe rules, standards, and instructions for the installation, inspection, maintenance, and repair of power or train brakes." The latter was an act "to promote the safety of employees and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto." Taken together, these two acts represent a greater commitment by the ICC to increase railroad safety. Nonetheless, these acts represent little more than improved enforcement of previous acts (e.g., the Safety Appliance Act) which introduced far more radical changes to railroad safety.

By 1968, at least one commentator has indicated, such legislation was desper-

second constitutional challenge in *Second Employers' Liability Cases*, 223 U.S. 1 (1912).

¹⁴ August 11, 1939, 53 Stat. 1404, codified at 45 U.S.C. §54 (1982).

¹⁵ May 20, 1926, 44 Stat. 572, codified at 45 U.S.C. §§151-164 (1982). For an examination of organized labor in railroads for an earlier period, see Chandler [1965].

¹⁶ April 11, 1958, 49 C.F.R. Part 132.

¹⁷ June 2, 1959, 49 C.F.R. Part 91.

ately needed, implying the inspection acts of 1958 and 1959 were only of minor importance.

The tragedy that becomes obvious from mentioning these standards, is that the Safety Appliance standard is essentially the same in 1968, the time of the publication of this Book, as *it was in 1910 when they were first formulated*. This means, of course, that Railroad workers, with all the advances made in Science and Technology and Safety Information, are still working with basically the same equipment as far as getting on and off and coupling and uncoupling cars, as *they were in 1910*.¹⁸

Hence, prior to 1970, the most important legislative changes occurred by the earlier twentieth century, thereby providing us with an ideal experiment to test the importance of the major legal interventions. Given our history of railroad legislation, it is apparent that five independent events from above were potentially of great importance to workers' safety in the period spanning 1890 to 1970: The Safety Appliance Act of 1893, the Hours of Service Amendment in 1916, the Federal Employers' Liability Act of 1908, the assumption of risk amendment to the FELA in 1939, and the Railroad Labor Act of 1926.

In this statistical study, the effects of some legal events in the history of railroad safety law are overlooked. The amendments to the SAA had little substantive affect on safety requirements, essentially only clarifying and strengthening the IC-C's authority. The original Hours of Service legislation made minor limitations on workers (e.g., maximum of 14 hour workdays, etc.), unlike the 8 hour work day amendment in 1916. Additionally, this act occurred only a year before the new FELA, and so it will be difficult in any event to disentangle the effects of the two pieces of legislation. The Power Brake Law and the Locomotive Inspection Law are ignored as they were essentially enforcement mechanisms which had little substantive effect on required safety practices. Finally, the original FELA is ignored in the statistical investigations below since it was ruled unconstitutional shortly after its inception.

3. AN ECONOMIC ANALYSIS OF THE SAFETY LAWS

This paper is primarily interested in the question of what the effect of changes in common law defenses was upon work-related accidents during the period 1890-1970. Two theories regarding the effect of liability law offer competing predictions: the efficient market hypothesis and the transaction costs hypothesis.

¹⁸Robb and Lustig [1968, p.328], emphasis in the original.

3.1 EFFICIENT MARKETS IN RISK AND SAFETY

If workers and railroad employers can freely contract over wages and safety and each is fully informed about the likelihoods of accidents and the costs and benefits of safety improvements, then any change in legal regime can only introduce inefficiencies. Indeed, some legal scholars have argued that the fellow servant rule and the assumption of risk defense were optimal for the time period under study. Posner [1972], in his classic treatment of common law in the late 19th century, suggested that

[t]he 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 damages 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.¹⁹

In addition Posner suggests that the assumption of risk rule provided risk-taking workers an ability to contract for reduced safety. As a consequence, under Posner's assumptions, the introduction of the Federal Employers' Liability Act, together with the 1939 amendment entirely removing the assumption of risk defense, should have increased employee deaths if anything.

FELA forced contractual terms upon the railroads, around which they were not allowed to contract. A weaker variant of the efficient markets hypothesis takes worker behavior as given (the assumption being that workers will always attempt to prevent accidents to avoid injury) and concludes that the level of safety will remain unchanged by an elimination in employers' defenses. In fact, if employers were made strictly liable, there would still be no effect if common law compensation is roughly equal to the harms imposed on workers. Efficient markets imply that employers are already producing the correct level of workplace safety. Shifting the costs to the employer will only produce a corresponding reduction in the workers' real wages.

Besides the weak or possibly positive effect of FELA on employee deaths, other testable implications from the efficient markets hypothesis exist. First, regulatory improvements in safety such as the Safety Appliance Act and the Hours of Service Act should have the effect of reducing the death rate among employees, although

¹⁹Posner [1972], p.44.

this effect may be weakened by increased risk taking by employees.²⁰ Second, changes which improve negotiations between labor and the railroads such as the Railroad Labor Act should have no effect on safety as efficient markets have already achieved the desirable levels of risk and real wages. Third, when decreases in the death rate occur, employees' real wages should decline accordingly, as workers will bear less risk of tragedy. Thus, altogether four predictions of the efficient market hypothesis exist: FELA should have a weak or positive effect on deaths, safety regulations should have a weak or negative effect, the RLA should have no effect, and real wages should respond positively to the death rate.

3.2 TRANSACTION COSTS

The transaction costs hypothesis maintains that various trading frictions exist which prevent an efficient market in risk and safety. Such transactions costs, broadly defined, include bargaining problems (e.g., asymmetric information, free-rider problems, etc.) and the costly acquisition of information regarding the costs and benefits of safety. As a consequence of these frictions, altogether different predictions exist regarding the effects of the legal changes affecting the railroads. Three important types of transaction costs are isolated below.

3.2.1 WORKER UNDERESTIMATION OF RISK

If it is costly for workers to estimate the risks of their employment, and if workers perceive the risks facing them to be lower than they are in reality (perhaps through cognitive dissonance), they are unlikely to accept a lower wage for a reduction in the death rate, and hence employers have insufficient incentives to increase safety. Inefficiencies result because of asymmetric information. Furthermore, no individual worker has an incentive to gather information regarding the dangers involved, as his singular demand for increased safety will be ignored by the railroad.

The implications of this hypothesis are four fold. First, the real wage should be only weakly responsive (if at all) to changes in the employee death rate. Second, the advent of the RLA might eliminate some of the worker misperceptions since a national union would presumably pursue safety issues; concomitantly, a decrease in employee death rates might be observed. Third, as with the efficient markets hypothesis, statutory regulations for safety should reduce the death rate. Fourth,

²⁰Peltzman [1975], for example, makes a persuasive argument that automobile safety legislation has been disappointing for precisely this risk-substitution effect. But to the extent that the actions of one worker more frequently cause harm to another worker rather than himself, increased levels of safety are less likely to cause a great substitution into riskier behavior since the worker is possibly ignoring safety considerations.

however, the FELA should increase safety, making the employer now more fully bear the costs of an unsafe environment.

3.2.2 MANAGERIAL MISCALCULATIONS

It is possible that the railroad industry, during its genesis and growth in the 19th and early 20th centuries, made managerial miscalculations due to the costliness of gathering information about accident prevention. One possible miscalculation is that workers would not accept a lower wage for an increase in safety. A myopic manager might plausibly reason that safety choices are a zero sum game played with workers, and that profit maximization requires skimping on the workplace concerns of employees. Of course, ex post, managers may realize that such a policy was misguided. In this sense, FELA and the statutory regulations would have had the effect of forcing managers to adopt procedures which they later discover are profit maximizing. We would expect both FELA and the statutory changes to decrease the death rate, and subsequently, decrease the real wage demanded by labor. This hypothesis predicts nothing about the RLA. Of course, we recognize the implausibility of a theory which requires a large and sophisticated industrial enterprise such as the railroads at the turn of the century to have miscalculated the cost and benefits of worker safety. Nonetheless, the possibility of such an empirical finding cannot be ruled out.

3.2.3 EXTERNALITIES AND OTHER BARGAINING PROBLEMS

If one believes that workers were cognizant of the risks facing them and that the railroad industry was not myopic, a set of more realistic explanations for the nonexistence of various safety practices would include bargaining problems and externalities. One story which has an intuitive appeal focuses on the problems of free-riding and is analogous to the provision of a public good. If workers are only informed about the national or regional average death rate associated with working in a railroad, any individual railroad has insufficient incentives for increasing safety. Safety at a particular railroad is a public good which benefits all railroads by lowering the average death rate. Unfortunately, an individual firm cannot capture all of the gains from a reduction in death rates on its own railroad, and so inefficiently invests in safety practices. Such a story predicts that FELA, SAA, the Hours of Service Act, etc., should all reduce the death rate to more efficient levels as it coordinates the activities of all the railroads. Additionally, the RLA might reduce the death rate by introducing the national labor union which could more effectively press for efficient safety reductions by ascertaining the levels of

safety at various railroads.

3.3 A COMPARISON OF THEORIES

The analysis above suggests a clear procedure to discriminate between efficient market theories and transaction costs hypotheses. If transaction costs are serious, the introduction of the FELA and its amendment, the SAA, the Hours of Service Act, and the RLA should all produce a reduction in the death rates. Additionally, if worker misperceptions are the fundamental transaction problem, we should not expect the wages to respond strongly to a decrease in the death rate. The efficient markets hypothesis, on the other hand, predicts that FELA should have no effect on the death rate. Additionally, workers' wage demands should be fully responsive to the death rate. Finally, as with transaction cost theories, the SAA and Hours of Service Act should have a negative effect on death rates. Hence, the effect of FELA and the responsiveness of the real wage to the death rate are at the heart of our tests to disentangle the competing theories.

4. DATA AND METHODOLOGY

We study two different dependent variables: the proportion of railroad employees killed each year and the real wage of railroad workers. We consider the following two relationships which are empirically tested below.

$$\begin{aligned} \text{DeathRate} = & \alpha_0 + \alpha_1 SAA + \alpha_2 FELA1908 + \alpha_3 Hours + \alpha_4 RLA \\ (1) \quad & + \alpha_5 FELA1939 + \alpha_6 Year + \alpha_7 DeathRate_{-1} + \epsilon_1, \end{aligned}$$

$$\begin{aligned} RR-Wages = & \beta_0 + \beta_1 DeathRate + \beta_2 Hours + \beta_3 RLA + \beta_4 WWI \\ (2) \quad & + \beta_5 WWII + \beta_6 Year + \beta_7 Unemp + \beta_8 Mfg-Wages + \epsilon_2, \end{aligned}$$

where ϵ_i has a mean of zero and is identically and independently distributed over time for each i . The variables used in (1) and (2) are constructed from yearly data which are compiled in the *Historical Statistics of the United States*.²¹

²¹The relevant series used are Series D-740 (average annual earnings for manufacturing employee), Series D-747 (average annual earnings for railroad employee), Series D-773 (average weekly earnings by railroad employees), Series D-781 (average weekly earnings by manufacturing employees), Series D-86 (percent of civilian labor force unemployed), Series E-135 (consumer price index for all items, 1967 dollars), Series Q-307 (passenger miles traveled), Series Q-398 (thousands of employees in railroad industry), Series Q-402 (passengers killed per year), and Series Q-404 (employees killed per year).

- Death Rate. The number of railroad employees killed in work-related accidents per thousand employed in a given year. The -1 subscript denotes a yearly lag.
- SAA. A dummy variable set equal to one beginning in 1893, the year the Safety Appliance Act became law.
- FELA1908. A dummy variable set equal to one beginning in 1908, the year in which the revised Federal Employers' Liability Act became law.
- Hours. A dummy variable set equal to one beginning in 1917, 4 months after the 8-hour workday amendment to the Hours of Service Act of 1907.
- RLA. A dummy variable set equal to one beginning in 1926, the year in which the Railroad Labor Act became law.
- FELA1939. A dummy variable set equal to one beginning in 1939, the year in which the "No Assumption of Risk" amendment to the revised Federal Employers' Liability Act was passed.
- Year. The year of the current set of observations.
- RR-Wages and Mfg-Wages. Average yearly real wages for railroad and manufacturing workers, respectively. The nominal rates for railroad workers (manufacturing workers) were found by combining Series D-740 (D-747) with Series D-781 (D-773). The real wage variables were calculated by dividing by the consumer price index (in 1967 dollars).²²
- WWI. A dummy variable set equal to one for the period of 1917-1919 so as to capture the effects of World War I on the sample. Additionally, this variable also captures some of the effects of President Wilson's wartime nationalization of the railroads. Mullin [1990], for example, finds a significant increase in railroad profits attributable to nationalization during World War I.
- WWII. A dummy variable set equal to one for the period of 1939-1945 so as to capture the effects of World War II in the sample.

²²Of the two series to be combined, one covers the period 1900-1970 while the other covers 1890-1926. The first series was regressed on the second series and a constant term for the years during overlapping periods and the resulting coefficients were used to extend the first series back to cover 1890-1899. The resulting R^2 statistics for the simple railroad and manufacturing regressions were .9986 and .9956, respectively.

- Unemp. The percent of the civilian labor force unemployed.

Additionally, we use the following data in the construction of other variables and as instruments.

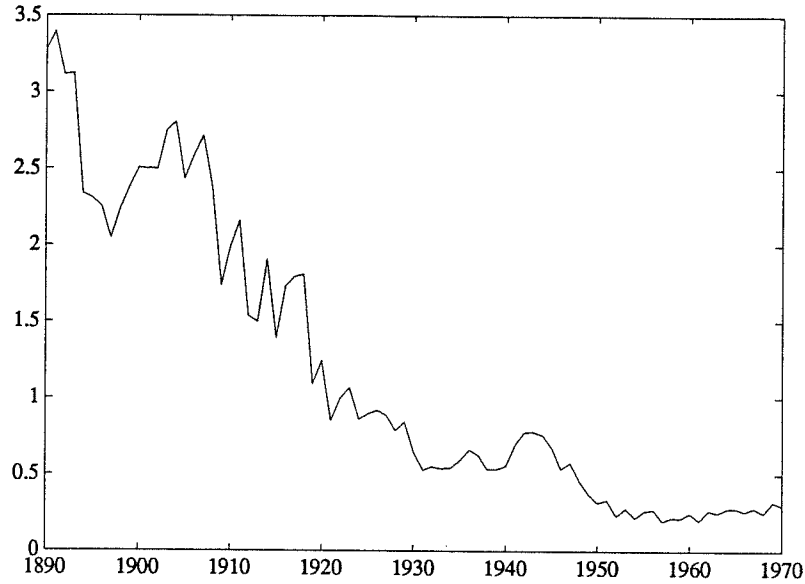
- Consumer Price Index. The consumer price index (BLS) for all items expressed in 1967 dollars. This variable is used to construct the real wage series above.
- Passenger Death Rate. The ratio of passenger deaths per year to total passenger miles traveled. This variable is used as an instrument in the estimation of equation (2).

As a measure of the effect of safety legislation on railroad accidents, we focus exclusively on worker mortality rather than worker injuries for several reasons. First, definitions and recording practices for injuries from accidents have varied over the period of study, 1890-1970. Most importantly, following the Accidents Report Act of 1910, railroads had greater incentives to accurately report accidents to the ICC. Previously, it is likely that under reporting occurred. With mortality data, this is far less likely. Second, to an extent, an increase in safety may transform deaths into injuries, thereby clouding the affects of the safety legislation. Railroad worker mortality levels are normalized by dividing by the number employed in the railroad industry and multiplying by one thousand. The series is shown in Figure 1.

The system of equations in (1) and (2) are estimated as a test of the competing economic theories regarding work-safety legislation.

Equation (1) estimates the determination of the employee death rate during the period 1890-1970. The dummy variables for SAA, FELA of 1908, the 1916 amendment to the Hours of Service Act, the Railroad Labor Act, and the 1939 amendment to the FELA are used to capture the effects that these laws had on the proportion of employee deaths per year. We expect that the coefficients of both the Safety Appliance Act and the Hours of Service Amendment should be negative, indicating an increase in safety. Additionally, if transaction costs are significant so that an inefficient level of safety existed prior to these changes, then our hypothesis is that both FELA and the FELA Amendment dummies should have negative coefficients. If, however, markets for risk operated efficiently prior to the legal changes in employer liability, and if the common law damages paid to employees did not exceed the actual cost borne by the workers (in terms of risk), then we should expect insignificant coefficients on the FELA variables. To the extent that the Railroad Labor Act explicitly promoted discussions over work

FIGURE 1: EMPLOYEES PER THOUSAND KILLED EACH YEAR



conditions, we might also expect that the RLA variable would have a negative coefficient if prior to the enactment of the law an inefficient level of safety was being provided. Finally, the *Year* and *DeathRate₋₁* variables are included in (1) to allow for a dynamic transition process. With *DeathRate₋₁* included, a change in the law has an immediate effect, α_i , which gradually grows to a long-run effect equal to $\frac{\alpha_i}{1-\alpha_i}$. The *Year* variable is added to account for any exogenous changes in the declining rate of deaths over time.

Equation (2) estimates the determination of the workers' real wage during the period 1890-1970. The dummy variables for the Railroad Labor Act and the Amendment to the Hours of Service Act are included to capture the effects of these variables on the workers' wages. We are agnostic as to what effect the RLA had on real wages. On the one hand, it reduced the ability of workers to strike, thereby decreasing their bargaining power and their real wage. On the other hand, the RLA promoted efficient arbitration between labor and management and recognized the right of workers to organize. The Amendment to the Hours of Service Act most likely had a negative effect on yearly real wages since each employee presumably

worked less per week as a result.

The *DeathRate* variable is included in (2) to capture the workers' risk premium attached to employment in a hazardous job. If workers are cognizant of the risks attached to their employment, it is likely that an increase in the death rate per employee would command a premium and a higher real wage. The manufacturing real wage is included as an independent variable to capture common movements in real wages; since it will measure common movements with some error, instrumental variables are used to correct for the measurement error. The dummy variables for World Wars I and II are included to take into account the effects of price and wage controls instituted during war time, as well as surges in production. Additionally, WWI also captures the effect of President Wilsons' nationalization of the Railroads which took place between December 1917 and March 1920. Unemployment is included in the equation to capture the economy wide difference between labor supplied and labor demanded; to an extent, the variable proxies for high real wages elsewhere in the economy (beyond railroads and manufacturing) as well as other aggregate variables which would likely influence railroad worker's wages positively. Finally, as in equation (1), we include *Year* to capture any residual dynamic affects inherent in a model of wage formation.

The equations in (1) and (2) are estimated using standard regression techniques. Equation (1) is estimated using ordinary least squares, with White's robust correction for standard errors. Equation (2) is estimated using instrumental variables due to the endogeneity of the worker death rate and the measurement error involved in using manufacturing wages as a proxy for economy-wide movements in real wages. Passenger deaths per mile as an instrument in addition to the other exogenous variables used in equation 1. White's robust correction for standard errors is applied to the second regression as well.

From the results of these regressions, we test our hypotheses from Section 2.

5. RESULTS

The regression results from the estimation of equations (1) and (2) are as follows. The absolute value of the ratio of each coefficient to its standard error is given in parentheses.

$$\begin{aligned} \text{Death Rate} = & 13.20 - .2850 \text{ SAA} - .2998 \text{ FELA1908} - .2435 \text{ Hours} \\ & (2.80) \quad (1.70) \quad (2.56) \quad (1.55) \\ & -.1462 \text{ RLA} + .0120 \text{ FELA1939} - .0062 \text{ Year} + .5161 \text{ DeathRate}_{-1} \\ & (1.80) \quad (.237) \quad (2.61) \quad (4.39) \end{aligned}$$

$$\bar{R}^2 = .961$$

$$\begin{aligned} \text{RR-Wages} = & -143079 + 903.41 \text{ DeathRate} + 412.67 \text{ Hours} - 404.19 \text{ RLA} \\ & (2.43) \quad (2.32) \quad (2.60) \quad (2.72) \\ & -242.98 \text{ WWI} + 464.89 \text{ WWII} + 74.42 \text{ Year} + 39.62 \text{ Unemp} + 0.613 \text{ Mfg-Wages} \\ & (0.94) \quad (1.57) \quad (2.42) \quad (2.88) \quad (2.44) \end{aligned}$$

$$\bar{R}^2 = .974$$

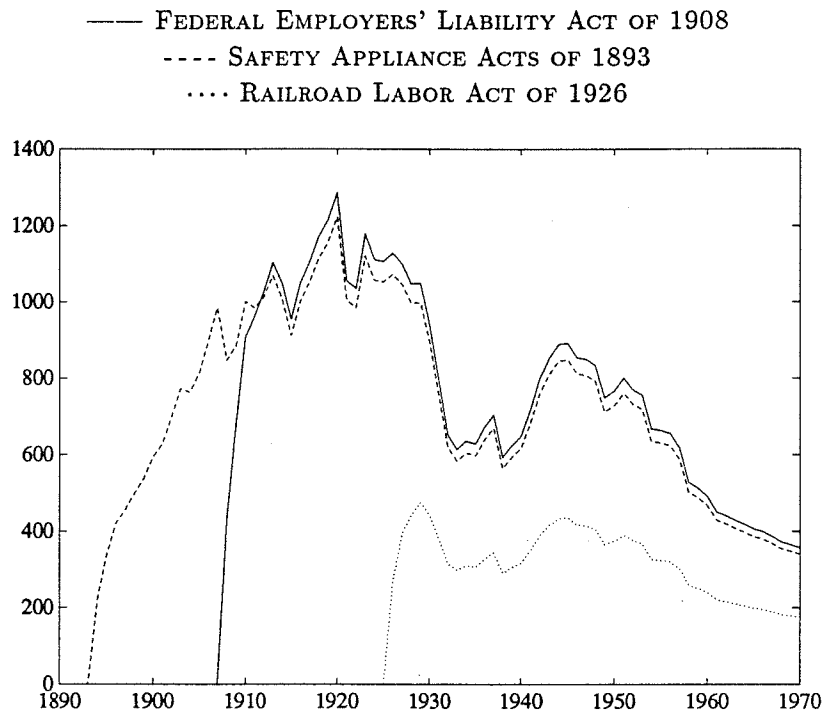
It is immediately apparent from the first equation that the Federal Employers' Liability Act of 1908 had a statistically significant negative effect on employee death rates. In addition, both the Railroad Labor Act and the Safety Appliance Act had statistically significant and negative effects on death rates if one chooses a significance level of 10 percent. Neither the Assumption of Risk amendment to the FELA nor the Hours of Service amendment has a statistically significant relationship to employee death rates, although the lack of statistical significance of the latter is marginal. We thus have strong discrediting evidence for the efficient markets hypothesis.

Given the dynamic nature of the equation, to understand fully the effects of the FELA, SAA, and RLA on employee death rates we can calculate the death reduction associated with each of the legal changes using the size of the labor force to place our numbers in real life savings. This is illustrated in Figure 2.

The total per year life savings attributable to each legal change from date of adoption until 1970 can be calculated by taking the integral of each of the curves in Figure 2. We find that the FELA saved 48,945 lives over a 62 year period, the SAA saved 56,113 lives over a 77 year period, and the RLA saved 14,320 lives over a 44 year period. Note however, that these results not only rely crucially upon the numbers generated in the above regression, but assume that in absence of legal change, voluntary change within the industry would not have occurred. This is unlikely. Nonetheless, the numbers are suggestive. The long-term per year reductions in the death rate per thousand employees is .62 for FELA, .59 for SAA, and .30 for RLA.

The estimates from the Real Wage equation reveal that workers *did* require a wage premium for the risks they faced. We find that a worker required an ad-

FIGURE 2: YEARLY DEATH REDUCTIONS ASSOCIATED WITH LEGAL CHANGES



ditional \$ 903 (in 1967 dollars) for an increase in risk of 1/1000 chance of death per year. This meant that an employer could save over \$ 3.5 million in 1990 dollars for each life saved in the workplace! Far from finding that workers had miscalculated the risk of life in their employment, it appears that workers had a reasonable valuation. Apparently, employers either miscalculated the benefits of safety improvements or a public good problem existed which reduced the employers' marginal gains from such improvements. This discredits the worker-misperception variant of the transaction costs hypothesis. Workers were cognizant of the risks they faced.

It is possible that employers did not think that a reduction in workplace mortality would lead to a great reduction in their wage bill or that the marginal costs of reducing employee deaths was greater than \$ 3.5 million (1990 dollars), although we find the latter explanation highly unlikely. According to Lardner's

[1850] detailed examination of the British railroads in the mid-nineteenth century, over 88 percent of employee railway accidents could be prevented by simple safety measures and workplace rules. Alternatively, it may have been that workers only had an assessment of the risks for the average railroad, not any particular employer. As such, an individual employer might invest a suboptimal amount in workplace safety since the benefits of such investment would not be captured entirely by the employer; individual investment would only partially reduce the average mortality rate on which workers based their wage demands. The evidence is consistent with the managerial miscalculation and externality variations of the transaction costs story.

Also significant from the estimation of the second equation are the effects of Hours of Service Act and the RLA. The Hours of Service Act has a strong positive effect on increasing annual real wages while the RLA has a strong negative effect. One possible economic explanation for the former effect is that railroads had fairly inelastic demands for labor hours while workers had relatively low marginal disutility for additional hours of work. When the Act reduced the total allowable hours per worker, current workers were unwilling to take much of a pay cut for the small increase in utility while railroads were forced to hire many more workers, driving up the market clearing real wage. A plausible economic explanation for the negative effect of the Railroad Labor Act is that by preventing strikes and requiring arbitration, the RLA reduced the bargaining position of labor, thereby lowering the real wage.

It is interesting to compare this work with that of Chelius [1974,1975]. Chelius [1974] examines the effect of safety on wages across several industries and finds a negative premium for workplace injuries. Such a result, however, may have resulted from his use of workplace injury data and the possibility that the introduction of workmen's compensation led to an increase in reporting injuries and an increase in the wage. In Chelius [1975], Chelius examines workmen's compensation and employment liability laws on the state level with mortality data and arrives at conclusions similar to our own. He finds that both workmen's compensation (a form of strict liability) and employers' liability statutes (similar to FELA) decrease accident rates with workmen's compensation having a stronger effect, and concludes that a transaction cost theory is supported. Chelius, however, did not estimate a wage equation to determine the extent that transaction costs were involved.

6. CONCLUSIONS

Of the two competing theories, efficient markets and transaction costs hypotheses, the transaction costs hypothesis seems more in accord with the data from the period. Furthermore, the particular transaction cost involved does not appear to be worker misperceptions, but rather a problem on the railroad's side of the bargaining table – the most plausible theory being that a public goods problem existed with respect to safety improvements.

Our analysis suggest that employer liability laws which restrict common law defenses had a positive impact on safety due to the transaction costs produced by incomplete information regarding railroad safety at the turn of the century. In addition, safety legislation of the period also contributed significantly to reductions in employee death rates, as did the Railroad Labor Act. Given the magnitude of the savings in life (without considering the corresponding reduction in injuries) it is reasonable to conclude that the legislative changes of at the turn of the century were beneficial from a societal viewpoint.

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