The Regulatory Determinants of Railroad Safety

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Abstract: The dramatic improvement in railroad safety since the 1970s has been accompanied by a substantial increase in safety regulation and a substantial reduction in economic regulation after 1980. We assess the effects of both regulatory changes on railroad safety with the use of RegData: a new data set that was developed by one of the authors that measures the amount of regulation that is imposed by specific regulatory agencies on specific industries. We find that partial economic deregulation is associated with improved safety. Safety regulation was most closely associated with improved railroad safety during the period when economic regulation curtailed railroads' incentives to operate safely.

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1 Introduction

Railroad safety in the United States has improved dramatically since the 1970s. The total number of accidents on the seven current Class I U.S. railroads and their predecessors fell from more than 11,000 in 1978 to 1,867 in 2013 -- despite the fact that revenue ton-miles doubled. The number of injuries declined even more sharply: from 1,486 in 1978 to 166 in 2013.[1] These improvements have coincided with two significant regulatory changes. First, the quantity of safety regulation imposed by the Federal Railroad Administration (FRA) quadrupled.[2] Second, the government removed most economic regulation of railroads in the Staggers Rail Act of 1980.

These policy changes created a significant debate over whether the improvement in safety was caused by safety regulation, partial economic deregulation, or both. The Staggers Act deregulated most rail rates, made it easier for railroads to abandon unprofitable lines, and established time limits for regulators to decide whether to approve mergers. It also retained some rate regulation for shippers who lacked competitive alternatives to a single railroad. Railroads argue that improved financial health caused by partial deregulation allowed them to invest in maintenance, which improved safety (Hamberger, 2015, p. 15). Regulators argue that railroads' improved financial health gave them the resources to comply with regulations (Savage, 1998, pp. 151-52). "Since these changes occurred at roughly the same time, it is difficult to determine whether increased safety regulation or the improved financial health of railroads was primarily responsible for the improvements in safety observed after the Staggers Act" (Bier et al., 2001).

Track maintenance illustrates the conundrum of disentangling the effects of contemporaneous policy changes. Savage (1998, p. 152) contends, "Since the early 1980s, track

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[1] Figures calculated by the authors based on the dataset used in this paper.

[2] See Figure 1 below and accompanying text for derivation of this figure.

capital expenditures and government inspections have tracked each other closely, making any econometric untangling of their relative contribution to the decline in accident rates difficult." Perhaps responding to this challenge, Dennis (2002) estimated a production function for railroad safety that included both investment and regulatory activity. He found that the track-related accident rate is correlated with investment but not with federal inspection activity or railroad compliance with federal track standards. Safety regulation, however, could have motivated some of the track-related maintenance investment.

We shed new light on the "safety regulation vs. economic deregulation" debate by utilizing a new database that measures separately the amounts of safety regulation and economic regulation that applied to railroads each year from 1975 to 2013. The database, RegData, counts the number of restrictions (words such as "must," "shall," etc.) in each chapter of the Code of Federal Regulations (CFR) and produces an index that measures the amount of regulation that applies to each 3-digit industry in the North American Industrial Classification System (NAICS) (Al-Ubaydli and McLaughlin 2015). Thus, RegData allows us to assess whether a discrete change in the amount of safety or economic regulation applied to railroads is correlated with the level of railroad safety.

We can also determine whether the size, significance, or direction of this correlation changed following partial economic deregulation after 1980. Partial economic deregulation provides a unique opportunity to observe whether normal market incentives motivate railroads to operate safely, or if society must rely on direct regulation of safety as the primary method to ensure safety. The answer to this question should be of interest in the broader debate over the efficacy and efficiency of safety regulation in many industries -- not just railroads.

We find that increases in RegData's measure of FRA regulation are associated with improved safety prior to partial economic deregulation, but not after. Increases in RegData's measure of economic regulation, meanwhile, are associated with higher accident rates before the passage of the Staggers Act, but not after. The Staggers Act itself is associated with a large reduction in accident rates, accounting for as much as 89 percent of the decline in the accident rate between 1978 and 2013. These results suggest that FRA safety regulation had its biggest effect on railroad safety during the period when economic regulation curtailed railroads' incentives to operate safely and make investments that would improve safety. The removal of much economic regulation substantially improved safety by altering railroads' investment and operating behavior. One consequence is that changes in safety regulation post-Staggers appear to have little marginal effect on safety.

2 Measuring Railroad Regulation

To measure railroad-related regulations from specific regulatory agencies, we used a new database called RegData.[3] RegData quantifies regulatory restrictions relevant to specific industries in the CFR: the set of documents that are published annually that contain all regulations that are in effect each year. Restrictions are those words used in legal language to either obligate or prohibit an action. RegData specifically searches for a subset of all restrictions that consist of the strings "shall", "must", "may not", "prohibited", and "required". While this subset is obviously not comprehensive of all of the ways in which a restriction can be created

[3] RegData is a database that quantifies regulation by industry over time using text analysis software. It was created by Omar Al-Ubaydli and Patrick A. McLaughlin, and is broadly described in their recent journal article (Al-Ubaydli and McLaughlin 2015). It is also described and freely distributed on the website www.regdata.org.

with legal language, it likely is representative of the restrictiveness of a given example of regulatory text.

RegData version 2.1 relies upon machine-learning algorithms to classify chunks of text in the CFR according to their relevance to specific industries, as defined by the NAICS. NAICS classifies businesses and other economic agents by their method of production. The system identifies a set of codes at increasingly specific levels of differentiation that are intended to be mutually exclusive and collectively exhaustive. For our purposes, the only industry that was important was the NAICS-defined industry coded 482: "Rail Transportation".

The program was trained to identify the relevance of regulatory text to specific industries with the use of selected documents from the *Federal Register*: a daily publication of the federal government that includes rules, proposed rules, presidential documents, and a variety of notices of current or planned government activity. Some of these documents are specifically labeled with relevant NAICS codes, and the language that they employ is similar to that of the CFR. Training documents for each 3-digit NAICS industry were obtained by searching *Federal Register* documents that are available on the *Federal Register* website for an exact match for the word "NAICS" and the code for the 3-digit code and each 4, 5, and 6-digit code that it contains.[4] Additionally, the exact names of the 3-digit industries and their subsidiary industries were used to identify documents. These searches yielded approximately 24,500 documents which were associated with at least one NAICS 3-digit industry. Industries with fewer than 20 positive training documents were excluded from the analysis.

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[4] Some exclusion rules were also applied, in order to avoid false positives. See McLaughlin and Sherouse (forthcoming).

For the analysis, documents were analyzed using a vocabulary of 10,000 words that were learned from the training documents. Word counts were weighted with the use of the Term Frequency-Inverse Document Frequency method that was introduced by Robertson and Jones (1976). We employed several well-established methods of classification: Support Vector Machines (SVM) with a linear kernel (Cortes and Vapnik, 1995); Logistic Regression (Logit); Random Forests (Breiman, 2001); and K-Nearest Neighbors. Of these, all but SVM produce a probability score as well as a boolean classification (and the latter is, in fact, derived from the former, given some threshold). All classification was carried out using the scikit-learn toolkit (Pedregosa et al., 2011). Cross-validation tests and other evaluation scores indicated that the Logit model outperformed all other models, although only by a narrow margin (McLaughlin and Sherouse, forthcoming). We have therefore used the Logit-based classifications that are available in RegData 2.1.

This classification methodology yields a set of probability scores ranging from 0 to 1 for each CFR part – a legal division of text that typically houses a regulatory program. We have considered only the CFR parts published by the Federal Railroad Administration (FRA), the Interstate Commerce Commission (ICC), and the ICC's successor: the Surface Transportation Board (STB). We focus on these agencies because we want to measure the effect on railroad safety of the changes to economic regulations of the ICC that the Staggers Act precipitated, while controlling for the simultaneous growth of safety regulations from the FRA.

Since the CFR is published annually, RegData offers probability scores for each CFR part in each year from 1975 to 2013. A probability score reflects the probability that a given part is relevant to a given industry. In our case, the only industry considered is rail transportation. The probability score is still relevant, however, because the ICC also regulated the trucking industry for many of the years in our sample, and the ICC and STB have regulated certain water carriers and pipelines as well (STB 2016). Simply counting the ICC and STB regulatory restrictions would over-state the amount of railroad regulation.

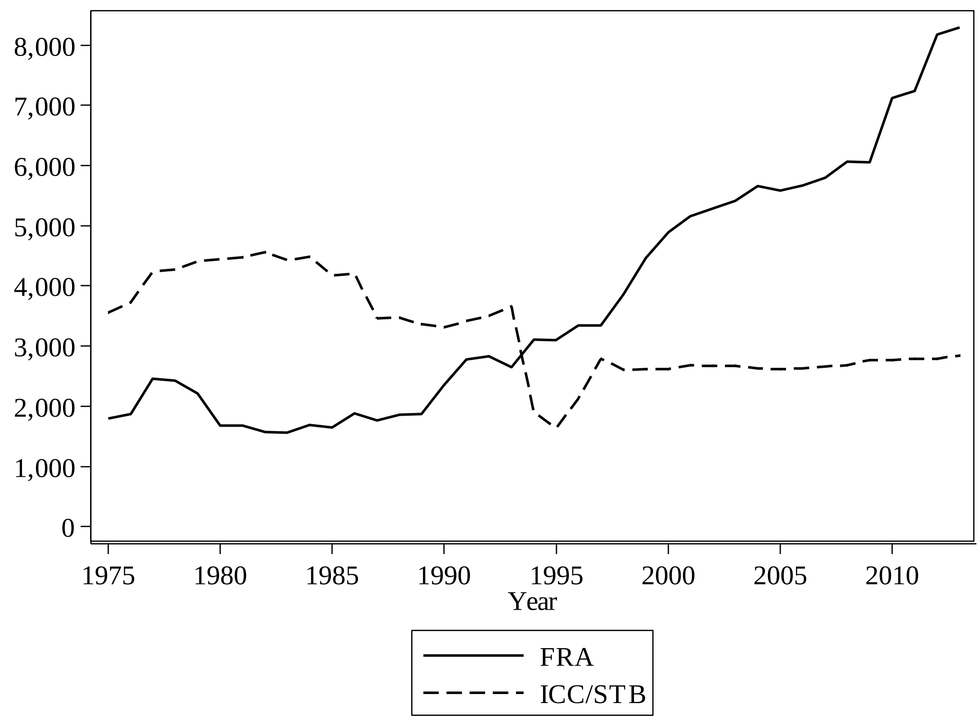
Following the regulation index methodology established in Al-Ubaydli and McLaughlin (2015), we multiply each part's probability score by the number of restrictions contained in the same part, and then sum across all parts for each agency. Thus, for each agency, the regulation index for the rail transportation industry is calculated as:

$$R_{a,t} = \sum_{j=1}^{J}(P_{j,t} * r_{j,t}) \quad (1),$$

where $R_{a,t}$ is the regulation index for the rail transportation industry for agency *a* in year *t*; $P_{j,t}$ is the probability that part *j* is relevant to the industry in year *t*; and $r_{j,t}$ is the number of restrictions in part *j* in year *t*, and there are *J* parts in the regulatory text published by agency *a* in year *t*.

Figure 1 shows the time paths of the regulation index for FRA and for ICC combined with its successor, the STB.

Figure 1: Regulation Index for FRA and ICC/STB



A few remarkable trends are evident. First, while there is a brief, temporary drop in the FRA regulation index in the late 1970s, the overall trend for the FRA is one of growth. Between 1975 and 2013, the regulation index for the FRA more than quadrupled, and the surge in the index after 2008 likely reflects the promulgation of rules required by the Rail Safety Improvement Act of 2008. Second, the ICC/STB regulation index reflects "deregulation" only for a few years after the signing of the Staggers Act in 1980. This measure of regulation gradually increased during the late 1970s, but drifted downward for the half-decade after 1980. The regulation index fell substantially in 1986 and 1987, then further declined in 1994-95 during debate and passage of the ICC Termination Act, which transferred the ICC's remaining regulatory responsibilities to the newly created STB. The jump after 1995 reflects some new rulemakings that were mandated in the ICC Termination Act, such as the creation of simplified standards for determining rate reasonableness. (See TRB, 2015, p. 132) Since then, economic regulation has remained essentially flat for a decade, perhaps resuming a very gradual upward climb in 2009.

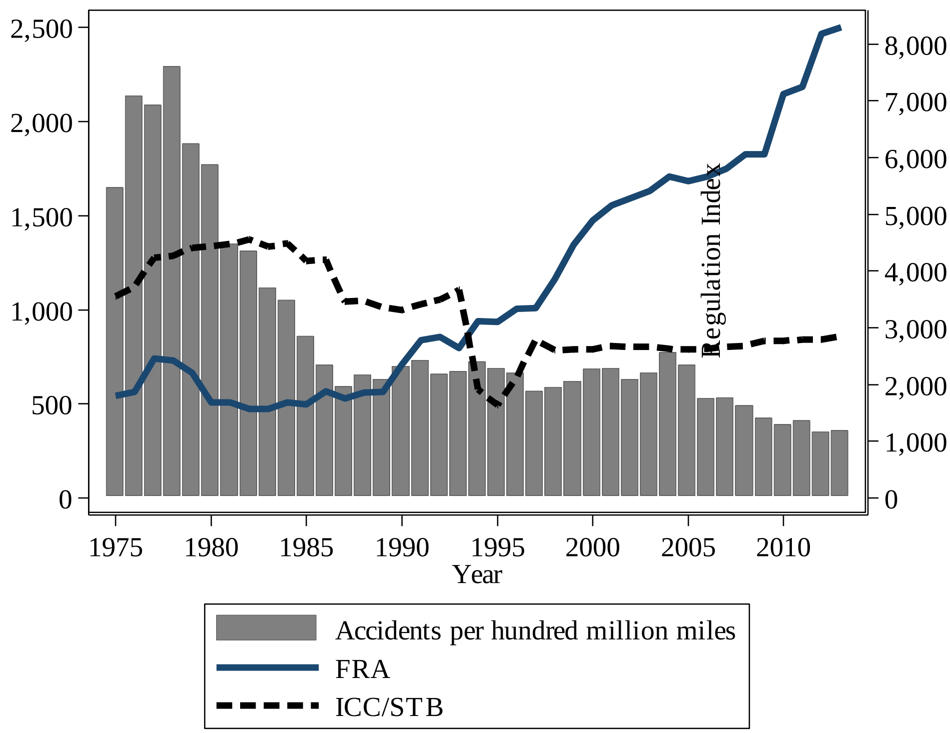
In addition to the change in the quantity of economic regulation, economic regulation changed qualitatively after passage of the Staggers Act. The Staggers Act eliminated regulation of most railroad rates and made it easier for railroads to cease serving unprofitable lines. It also eliminated the practice of "open routing," which had allowed a shipper to force a railroad to transfer that shipper's traffic to another railroad even if the first railroad could handle the entire movement on its system. Much of the economic regulatory activity after 1980 involved implementation of the Staggers Act's deregulatory provisions. Thus, the apparent growth in economic regulation after 1986 (such as the slight increase in the early 1990s) was growth in a different kind of regulation than the ICC administered before 1980.

The reader will have observed that our data cover only five years before the Staggers Act, and multiple decades afterwards. Unfortunately, that is the limit of our dataset—our key data source, RegData, only dated back to 1975 at the time of this writing.

3 Regulation and Rail Safety

Dissatisfaction with railroad safety problems in the 1960s led to creation of the FRA in 1967, which took over regulation of safety from the ICC. The Federal Railroad Safety Act of 1970 expanded the FRA's regulatory authority to encompass all aspects of railroad safety (Bier et al., 2001, 4-6). The FRA's first major new initiative was the establishment of track standards, accompanied by federal inspections and fines for noncompliance (Savage, 1998, p. 24). As Figure 2 shows, the steady increase in FRA regulation since 1978 has coincided with a significant reduction in the accident rate per hundred million train-miles.[5] The reduction in the accident rate, however, also appears to be loosely correlated with economic regulation. Below, we outline theories that may explain the relationship between both types of regulation and railroad safety.

Figure 2: Accident rate and regulation



3.1 Economic Regulation

In theory, partial economic deregulation could diminish safety by prompting cost-conscious railroads to reduce safety-related expenditures. Prior studies, however, have found that economic deregulation is either positively correlated or uncorrelated with safety, in both the US

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[5] Railroads are required to report accidents to the FRA if an incident (which could be a collision, derailment, or other event that causes equipment damage) causes damages to equipment in excess of the reporting threshold, or if an incident causes an injury or death. The threshold is updated from year to year. In 2002, it was $6,700, while by 2010, it had been raised to $9,200 (FRA 2013)

and other countries (OECD, 2010; Elvik, 2006; Evans, 2007; Clark and Loeb, 2005). Studies of other transportation industries deregulated about the same time, such as trucking and airlines, also generally find that deregulation either improved safety or had no effect on safety. (See studies that are reviewed in Crandall and Ellig 1997.) Many scholars and observers agree that economic regulation prior to the Staggers Act impaired railroad safety, and deregulation improved safety. A simple regression of accidents per hundred million train-miles on a time trend, a Staggers Act dummy variable, a variable equal to 1/(Years since Staggers) and railroad-specific fixed effects reveals that both the time trend and the Staggers Act have negative, statistically significant coefficients.[6] Similar results occur if we restrict the data to the three years before and after Staggers; economic deregulation clearly has a significant positive correlation with safety separate from the time trend.[7]

Under normal market circumstances, railroads have relatively strong financial incentives to operate safely. Railroad accidents harm railroads' own property, employees, shippers' goods, shipper-owned railcars, and third parties. Firms have a direct incentive to prevent accidents that harm their own property. Railroad employees and labor unions are well-informed about safety hazards and have strong incentives to negotiate contracts that force railroads to internalize the costs that accidents impose on employees (Savage, 1998, pp. 77-90). The Federal Employers Liability Act (FELA) makes railroads financially responsible for injuries to workers and increases workers' ability to recover damages by removing many defenses that railroads had under common law (Squires, 2000, pp. 106-07). Railroads are liable for damage to the goods that

[6] *Accident rate* = 2487 [0.00] – 1167**Staggers* [0.000] + 666*1/Years since Staggers [0.007] -12.9**Time trend* [0.034] + (Railroad dummies omitted to conserve space) (p-values in brackets).
[7] *Accident rate* = 3700 [0.00] + 328*Staggers [0.192] – 435*1/Years since Staggers [0.028] + (Railroad dummies omitted to conserve space) (p-values in brackets).

they ship. Legal liability and insurance should also help internalize the costs that accidents impose on third parties.

Economic regulation diminished these incentives in several ways. It depressed investment in maintenance by reducing railroads' profitability, bankrupting some railroads, and limiting others' ability to attract capital (Keeler, 1983; Savage, 1998, p. 23). Firms that are closer to bankruptcy are more likely to engage in risky behavior, such as deferred maintenance, since the shareholders can avoid full responsibility for a major accident by declaring bankruptcy (Bier et al., 2001, pp. 4-6; Golbe, 1983; Savage, 1998, p. 111). Even for railroads that were profitable, regulation made it difficult to abandon unprofitable lines, so one rational option was to defer maintenance on lines that did not generate enough revenue to support themselves. Poorly-maintained track and equipment are less safe. Railroad investment in track is negatively correlated with the rate of track-related accidents (Dennis, 2002). Barriers to investment also slowed the adoption of new technologies that improve safety, such as car retarders, automated switching, and diesel engines (Aldrich, 2005, pp. 320-21). Partial economic deregulation dramatically improved railroads' financial performance, largely by reducing costs and increasing productivity (Ellig, 2002; Wilson, 1997; GAO, 1990; Gallamore, 1999). Improved finances can lead to greater investment, which can improve safety.

Aside from the effects on investment, economic regulation reduced safety by forcing railroads to operate in ways that increased the risk of accidents. Switching increases the risk of accidents (Savage, 1998, p. 187); consequently, regulation that promoted more switching could increase accidents. Regulation hampered the introduction of unit trains, which reduce the amount of yard switching (Aldrich, 2005, p. 321; Bier et al., 2001, pp. 4-9; Savage, 1998, p. 17). Regulation required "open routing," which allowed shippers to force the originating railroad to switch cars containing their shipments to another railroad even if the originating railroad could handle the entire movement as a through shipment on its own network. The common carrier obligation prevents railroads from refusing to transport hazardous materials, but regulation can prevent railroads from charging rates that fully compensate them for shouldering the associated risks or from requiring shippers to assume responsibility for risks that are not the railroad's fault. Thus, shippers who supply their own railcars may not have adequate incentives to control risks.[8] Partial economic deregulation also prompted railroads to pursue end-to-end mergers, which likely enhanced safety compared to the regulated era by reducing the amount of switching.

For these reasons, the amount of economic regulation should be negatively associated with safety prior to the Staggers Act. After the Staggers Act, the predicted effect of the remaining economic regulation is more ambiguous. Post-Staggers economic regulation could reduce incentives for safety, for the same reasons economic regulation reduced safety prior to Staggers. Alternatively, post-Staggers economic regulation could increase incentives for safety, because the regulatory actions implemented the largely deregulatory provisions of the Staggers Act.

3.2 Safety Regulation

Intuition suggests that additional safety regulation should be associated with improved safety, but theory suggests that safety regulation could also have no effect or even a negative effect on the margin.

3.2.1 Why safety regulation could improve safety

The incentives for safety that are created by the marketplace and our broader legal system may not always work perfectly. A railroad with market power may either over- or under-produce

[8] This is still an issue under the current regulatory system. See TRB (2015, p. 147).

safety. Infrequent users of railroads may lack accurate information about the railroad's level of safety, which prompts railroads to under-provide safety.

Not all types of damages to bystanders are legally recoverable (Savage, 1998, pp. 96-127). Burton and Egan (2011, pp. 547-50) cite a series of cases in which federal courts decided that the Federal Railway Safety Act of 1970 shields railroads from liability for injury to third parties that are affected by railway accidents. Many accidents involve two parties, such as the railroad and an employee or the railroad and a motorist at a grade crossing. If the court system does not require the appropriate level of care from each party, or if both parties are not adequately informed about the risks and measures to mitigate them, safety may be under-provided (Savage, 1998, pp. 45-54). Squires (2000) and Savage (1998, pp. 196-97) argue that FELA's adversarial process, in which railroads and workers try to prove an accident resulted from the other side's negligence, may impede safety by undercutting open communication about safety between rail labor and management.

Most notably, economic regulation of railroads undercut many of the normal market incentives for maintenance and safe operation:

> It seems clear that poor financial health of railroads in the 1960s and 1970s resulted in reductions in expenditures on track maintenance and possibly other safety-related maintenance. This eventually resulted in higher rates of accidents. The governmental response to these problems was twofold. First, the establishment of the FRA increased regulatory pressure on the railroads through the imposition of track standards, which were enforced by FRA inspections and backed by fines for violations. Second, concern about the financial health of the

railroads led to substantial (but not complete) economic deregulation of the railroad industry. (Bier et al., 2001, pp. 4-7)

Given the potential for market failures, failures of the liability system, and the policy failure created by economic regulation, there is room for rail safety regulation to improve safety.

3.2.2 Why safety regulation could be ineffective

Capture theory suggests that safety regulation could be ineffective, at least on the margin. Railroad regulation is the paradigmatic example of capture (Kolko, 1965; Stigler, 1971). The industry is relatively concentrated and well-organized. Burton and Egan (2011, p. 550) essentially argue that federal rail safety regulation is ineffective because the FRA is too deferential to the industry. Capture may involve rail labor as well as management. Labor unions "attempted to prevent certain long-overdue reforms of working practices by trying to write these practices into law under the guise of safety regulation." (Savage, 1998, p. 205) The FRA has engaged in negotiated rulemaking that involves both industry and labor representatives since at least the mid-1990s, which helps ensure that regulations reflect industry expertise but also increases the likelihood of capture.[9]

It would be an extreme form of capture, however, that would render all safety regulation ineffective. Peltzman's (1976) model posits that the political influence of regulated industries leads to a compromise in which regulation is binding but sub-optimal. Even in the "Bootlegger and Baptist" theory, which posits that social regulation arises due to an alliance of firms seeking protection from competition and ideological advocates who provide a public interest rationale for the regulation, the public interest advocates receive some of what they want (Yandle 1983).

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[9] Cothen et al. (2005) document the history of negotiated rulemaking at the FRA.

These models imply that safety regulation can improve safety, but some safety regulations may be ineffective; thus, safety regulation may be ineffective on the margin.

3.2.3 Why safety regulation could reduce safety

Safety regulation can have perverse effects. When safety regulation takes the form of detailed, mandated actions, it encourages firms to focus on complying with the mandates or negotiating exceptions rather than creatively using their own expertise to manage and reduce risks (Hale et al., 2011). Many railroad safety regulations fit this description; they are design standards rather than performance standards. The principal exceptions are rules that are related to signaling and window glazing, which are more performance-oriented (Savage, 1998, p. 140).

The most significant recent legislative and regulatory mandate -- Positive Train Control -- might appear to be a performance standard. It requires railroads to implement systems that automatically control trains on certain routes to override human errors. The implementing regulations require that Positive Train Control systems have specified functionalities and meet specified standards, without explicitly mandating a technology railroads must adopt. However, the legislation mandates a particular type of solution to the problem of human error -- Positive Train Control – rather than simply setting a performance standard for accident reduction and allowing railroads to find the most effective and least-cost means to meet the standard. Thus, Positive Train Control is closer to a design standard than a performance standard.

Design standards can impede progress in developing or implementing new technologies or operating practices that could improve safety (Squires, 2000, p. 105; Gallamore, 1999, p. 519; Savage, 1998, pp. 153-54). Savage (1998, p. 149) provides an illustration in regard to track standards: “A possible side effect is that today’s younger engineers may decide on proper construction and maintenance by deference to the federal regulations rather than by using their own professional judgment." In short, by diverting attention from safety outcomes to compliance, design standards can make railroads less safe than they would otherwise be. In the extreme case, this might mean that safety regulation reduces safety. A more likely scenario is that marginal additions to safety regulation reduce safety even if the net effect of all safety regulation is still positive.

4 Econometric Analysis

4.1 Variables

We employ the accident rate per hundred million train-miles as a measure of rail safety.[10] We model railroad safety as a function of the Staggers Act, the ICC/STB railroad regulation index, the FRA railroad regulation index, interaction terms for the Staggers Act and the regulation indices, a time trend, several operational and macroeconomic control variables, railroad mergers, and railroad-specific fixed effects.

Formally, the regression equation is

$$Acc.Rate_{i,t} = \alpha + \beta_0 Staggers_t + \beta_1 \left(\frac{1}{Years\ since\ Staggers_t}\right) + \beta_2 FRA\ Reg\ Index_{t-2} + \beta_3 (FRA\ Reg\ Index_{t-2} * Staggers_t) + \beta_4 ICC/STB\ Reg\ Index_{t-2} + \beta_5 (ICC/STB\ Reg\ Index_{t-2} * Staggers_t) + \boldsymbol{\gamma National_t} + \boldsymbol{\rho Railroad_{i,t}} + \delta timetrend + \varepsilon,$$

where $Acc.Rate_{i,t}$ is accidents per hundred million miles; $Staggers_t$ is a dummy variable that indicates the passage of the Staggers Act; $\left(\frac{1}{Years\ since\ Staggers_t}\right)$ is a variable that captures any short-run effects of Staggers that differ from its long-run effects; $FRA\ Reg\ Index_t$ is the FRA railroad regulation index; $ICC/STB\ Reg\ Index_t$ is the ICC/STB railroad regulation index; $\boldsymbol{National_t}$ is a vector of national-level control variables, including the real GDP growth rate and

[10] The accident rate is conventionally presented as accidents per million miles; accidents per hundred million miles is just a scaling factor that allows us to avoid superfluous decimal places in the regression coefficients.

recession indicators; ***Railroad*** $_{i,t}$ is a vector of railroad-specific control variables, including merger dummy variables and railroad-specific dummy variables; and *timetrend* is a year counter that begins with 1978=1. Table 1 lists the variables and summary statistics.

[Insert Table 1 about here.]

The RegData regulation indices provide an opportunity to disentangle the effects of safety regulation and partial economic deregulation. The regulatory indices are lagged two years; thus, for example, accidents in 1980 are a function of FRA and ICC regulation in 1978. There are two reasons for the lag: First, it takes time to make investments and alter railroad operating procedures in response to regulations. Second, the effective date of new regulations may lag the publication of the rule by one, or sometimes, multiple years.

We measure the extent of economic regulation both with the ICC/STB regulation index and with a dummy variable for the Staggers Act that equals 1 for every year after 1980. President Carter signed the Staggers Act in October 1980, so 1981 is the first full year it was in effect.[11] Both variables are included because a great deal of partial economic deregulation occurred as a direct result of legislation, rather than regulations written to implement the legislation. The Staggers Act itself made significant changes in the amount of administrative decision-making that did not require rulemakings that would otherwise result in substantial CFR entries. It deregulated rates for traffic for which the shipper has other competitive options. It also removed rate regulation for any shipment for which the railroad and shipper signed a contract. Proceedings on abandonment of service had to be completed within 255 days, and railroads were

[11] As robustness checks, we employed several phase-in variables described below; the results for our regulatory variables of interest remained unchanged.

allowed to include capital costs, not just out-of-pocket costs, when they attempted to demonstrate that the service that they wanted to abandon was unprofitable (Ellig, 2002, pp. 145-47).

When regulators made decisions on specific railroad rates or abandonments, they devoted substantial time to regulatory proceedings and decisions, but they were not writing regulations. RegData would not capture this activity by counting regulatory restrictions.

Our sample includes eight freight railroads: the current seven Class I railroads plus Conrail (which was divided between CSX and Norfolk Southern in 1999). Class I railroads are currently defined by the Surface Transportation Board as "having annual carrier operating revenues of $250 million or more" after adjusting for inflation.[12] We only examine freight railroads, so Amtrak is excluded. The regulatory variables are lagged two years, and some of our other data series begin in 1978. Therefore, the regressions include 40 data points with pre-Staggers regulatory index values and 234 with post-Staggers regulatory index values. This leaves us with five years of pre-Staggers data across eight different railroads—an adequate number of data points to establish a baseline.

Many of the current Class I railroads acquired other railroads through mergers. For the pre-merger years, each variable in each Class I's dataset is an aggregate figure that includes the data from major merger partners. This approach was necessitated by the source of some of our operating data, which aggregated data for the premerger years.[13] In one model, we control for the effect of mergers on the dependent variable through the use of a dummy variable that is equal to 1 for the years after the merger. Thus, the merger dummy variable should indicate whether the consolidation after the merger is associated with any change in accidents per million train-miles,

[12] 49 CFR 1201 Subpart A §1-1.

[13] Operating and financial data were supplied by the Association of American Railroads.

compared to the sum of the individual railroads' accidents divided by the sum of their train-miles before the merger. The one exception is Conrail, which was divided between CSX and Norfolk Southern in 1999. Since no separate pre-merger data series exist for the separate collections of Conrail assets that CSX and Norfolk Southern acquired, we include Conrail in the data set as a separate railroad.[14]

Partial economic deregulation provided the impetus for many railroad mergers, and the Staggers Act's goal of restoring railroads' financial health prompted regulators to take a permissive approach to mergers for two decades. Nevertheless, controlling for mergers is a useful robustness check; we would have less confidence in the results for the regulatory variables if they disappeared when adding the merger variables.

Table 2 lists the railroad mergers that are coded with 0-1 dummy variables in our regressions. In several cases, railroads undertook multiple mergers in closely adjacent years. Due to collinearity, it was not possible to add a dummy variable for each of these mergers. For this reason, several of the dummy variables may pick up some effects of another merger that occurred a year or two previously. These are the mergers that are listed as "collinear" in the table; they do not have their own dummy variables. Because it takes time to integrate railroad operations following a merger, the merger variables are lagged two years.

[Insert Table 2 about here.]

We also investigate whether regulation is correlated with railroad investment or the percentage of train-miles that are switching miles. This tests two plausible ways that regulation could affect safety.

[14] The regression results reported below are similar when we omit Conrail.

4.2 Estimation method

Previous researchers have noted that measurements of regulatory processes, especially those that track regulatory accumulation, can follow unit root processes (Coffey, McLaughlin, and Tollison, 2012). Similarly, accident rates over time might be non-stationary, and the estimation of a relationship between two potentially non-stationary variables may reveal only spurious correlations. Indeed, Figure 1 above suggests that the FRA's regulation index may indeed follow a unit root process, although it is not obvious whether the ICC/STB regulation index has a unit root. We formally tested our regulation indices and the accident rate variable for unit root processes.

Because the regulation indices are singular to each agency—that is, even though we consider a panel of railroads, the regulation indices have only one value for each agency in each year—we can test them using the augmented Dickey-Fuller test for unit root processes. The Dickey-Fuller tests shown in Table 3 suggest that the FRA regulation index follows a unit root process, and the ICC/STB regulation index probably does as well. However, the first-differenced indices are both stationary ($p<0.01$).

[Insert Table 3 about here.]

We also tested our dependent variable: accidents per hundred million miles. While we could test accidents per hundred million miles for each railroad individually using augmented Dickey-Fuller tests, we have instead opted to test them jointly using a Levin-Lin-Chu test (Levin et al., 2002). The Levin-Lin-Chu test is designed for panel data and has the advantages that it can impose a common autoregressive parameter across all panels and include panel-specific means—conditions that more closely resemble a typical fixed effects approach that is often used in panel data analysis. The Levin-Lin-Chu test of *accidents per hundred million miles* is reported in Table 4.

[Insert Table 4 about here]

Table 4 shows that the Levin-Lin-Chu soundly rejects the null hypothesis that the panels contain unit roots. The Levin-Lin-Chu test requires a strongly balanced panel, and one of the railroads in our study (Conrail) does not have observations for the entire period. For this reason, we excluded Conrail from the Levin-Lin-Chu test reported above, which is why there are only seven panels instead of eight. However, we can repeat the test above while restricting the other panels to runs that match the observations for Conrail—that is, observing only the years 1975 to 1999, for which we have data on all eight railroads. The Levin-Lin-Chu test for that restricted panel also rejects the null hypothesis that the panels contain unit roots ($p<0.01$; these results are not reported here, but are available upon request from the authors). Table 4 also reports Levin-Lin-Chu tests for unit roots in all of the other variables that are included in our regressions.[15]

Because the dependent variable does not contain a unit root, spurious correlation should not be a problem. Therefore, we did not first-difference any variables. Non-stationarity of the regulatory variables, however, could affect the variance estimates by creating heteroscedasticity and serial correlation. To correct for this potential problem, all of the regressions implement heteroscedasticity-and-autocorrelation robust estimators using the ivreg2 command in Stata (Baum et al., 2007). This command implements the Newey-West (Bartlett kernel function) estimator to correct the effects of correlation in the error terms caused by either autocorrelation or heteroscedasticity in panel data (Newey and West, 1987). The bandwidth on the kernel function was chosen optimally using the selection criterion of Newey and West (1994).

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15 We also performed Fisher-type unit root tests on *accidents per hundred million miles*, including from one to five lags, and soundly rejected the null hypothesis that all panels contain unit roots in each test. Fisher-type unit root tests combine p-values from augmented Dickey-Fuller tests performed separately on each individual panel.

4.3 Econometric results

4.3.1 Principal results

Table 5 shows regression results that use accidents per hundred million train-miles as the dependent variable. Column 1 regresses the accident rate on a time trend, a Staggers Act dummy variable, a variable equal to 1/(Years since Staggers), the RegData regulation indices for FRA and ICC/STB regulation of railroads, both regulatory indices interacted with the Staggers Act dummy, and railroad-specific fixed effects. The inclusion of the linear time trend follows a widely employed approach to modeling technical change that was originally specified by Binswanger (1974). Column 2 adds adds *Real GDP Growth Rate* and a *Recession* dummy variable. Column 3 adds a dummy variable for each merger, plus a variable equal to 1/(Years since merger) to account for the possibility that mergers have different short-run and long-run effects Column 4 interacts each railroad with a Staggers dummy and a variable equal to 1/(Time since Staggers) to control for the possibility that Staggers had different short-run and long-run effects for different railroads. The model in Column 4 also interacts each railroad with the time trend dummy, to control for the possibility that time trends differ across railroads.[16]

[Insert table 5 about here]

In every specification, the regulatory variables of interest have the expected signs and are highly statistically significant. Based on the coefficients in the first three columns of table 5, the Staggers Act is associated with a reduction of approximately 1,582-1,873 accidents per hundred million train-miles in 2013.[17] The accident rate for the railroads in our sample peaked at about 2,292 accidents per hundred million train-miles in 1978 and fell to about 358 per hundred million

[16] We could not include the merger variables and the railroad-specific Staggers and time trend variables in the same regression, because many variables were dropped due to collinearity.
[17] The value of 1/(Years since Staggers) is 0.03 in 2013. Thus, using figures from the regression in column 1, the calculated reduction in accidents associated with Staggers would be 1873 – 1139*0.03 = 1839.

train-miles in 2013. How much of that is attributable to Staggers, based on the estimates presented in Column 4 of table 5? While the marginal contribution of the Staggers Act differs from one railroad to the next, the average across the seven class I's in our data as of 2013 is about 89 percent. In other words, our model predicts that approximately 89 percent of the reduction in the accident rate from 1978 to 2013 was because of the Staggers Act.

But the accident rate also varies with regulatory activity. An increase in our measure of FRA safety regulation is associated with a lower accident rate. An increase in our measure of ICC/STB regulation is associated with a higher accident rate. When both regulatory index variables are interacted with S*taggers*, the coefficients are roughly the same size but have the opposite sign for their coefficients for the entire time period. The last two lines of the table test the null hypothesis that the pre- and post-Staggers coefficients sum to zero in the post-Staggers period—that is, whether $\beta_1 FRA\ Reg\ Index_{t-2} + \beta_2 (FRA\ Reg\ Index_{t-2} * Staggers_t) = 0$ or $\beta_3 ICC/STB\ Reg\ Index_{t-2} + \beta_4 (ICC/STB\ Reg\ Index_{t-2} * Staggers_t) = 0.$ For FRA regulation, the high p-values indicate that we cannot reject the null hypothesis. For ICC/STB regulation, we can reject the null hypothesis based on the regressions in columns 2 and 4, but not for the regressions in columns 1 and 3. Thus, it appears that the post-Staggers accident rate does not vary with our measure of FRA safety regulation, but the accident rate might be negatively correlated with our measure of ICC/STB economic regulation.

The finding for our measure of ICC/STB regulation is perhaps not a surprise, since the Staggers Act eased many of the constraints on investment and operations that undermined safety. More surprising is the finding that changes in our measure of FRA regulation since 1980 are not correlated with the accident rate. Partial economic deregulation improved railroads' incentives to operate safely, which reduced the marginal impact of safety regulation.

The merger variables indicate that four of the mergers had no statistically significant correlation with the accident rate in either the short run or the long run (p> 0.050). When merger variables are statistically significant, there is no clear pattern than would allow us to generalize about effects of mergers on safety. F-tests strongly reject the hypotheses that the merger variables are either equal or collectively insignificant.

Column 4 allows the coefficients on the Staggers variables and the time trend to vary with the identity of each railroad. The coefficients on the Staggers variables suggest a great deal of heterogeneity in railroads' response to the Staggers Act. F-tests strongly reject the hypotheses that the coefficients on each group of railroad-specific variables are equal or collectively insignificant for all railroads. For each railroad, however, the size of the negative coefficient on *Staggers* exceeds the size of the positive coefficient on *1/(Years since Staggers* Thus, for each railroad, Staggers is associated with a reduction in accidents per hundred million miles. *)* Since *1/(Years since Staggers)* declines over time, the net improvement in safety associated with the Staggers Act increases over time.

4.3.2 Robustness checks

We subjected the regressions in columns 2 - 4 to a battery of robustness checks.[18] In almost every case, the regulatory index variables and the Staggers Act dummy had the same signs and statistical significance as in table 5. Robustness tests for column 2 include:

- Removing the time trend. The statistical significance of the regulatory index variables and the Staggers Act variables increased.

[18] Regression results are omitted here to conserve space but are available from the authors.

- Adding variables that phased in the effects of Staggers over three years or five years. In each case, the coefficient on the plain Staggers dummy variable remained negative and statistically significant, but the phase-in variables were not statistically significant.
- Lagging the Staggers variable by one or two years. Staggers remained statistically significant, but the regulatory index variables became statistically insignificant or switched signs, with a worse fit (as measured by the R-squareds). We interpret these results to mean that the Staggers Act's effect on safety really did start in 1981.
- Adding the square and cube of the time trend variable to allow for a more flexible time trend. Neither variable was statistically significant.

Robustness checks for the model with merger variables in column 3 included the use of several different lags of merger dummy variables to estimate only the long-run effects of mergers. The lag models produced similar results for many, though not all, mergers. For example, a two-year lagged merger dummy produced the same result as the model in column 3 for 10 out of the 16 mergers. In all of the regressions using lagged merger dummies, the Staggers Act and regulatory variables had the same signs and significance as in Table 5. We believe this indicates that our main results in this paper are robust regardless of how mergers are included in the regressions, but we urge caution in using the model in column 3 to assess the effect of any individual merger on safety.

Since column 4 appears to be the most extensive model with the best fit, we subjected this model to three more extensive robustness checks:

- Using two different data sets to create alternative variables that measure the amount of regulation: the FRA's and ICC/STB's annual word count in the Code of Federal Regulations, and each agency's annual number of regulatory restrictions in the Code of

Federal Regulations. Both of these approaches produce results that are similar to table 5 with a slightly worse fit, as measured by the r-squareds.

- First-differencing the accident rate and the explanatory variables. In this case, the Staggers Act dummy variable was not significant, but the *1/(Years since Staggers)* variable was negative and significant; this suggests that Staggers is negatively correlated with the change in the accident rate, but the effect declines over time.
- Employing alternative measures of safety as the dependent variable. Table 6 shows the results using damages per train-mile, fatalities per hundred million train-miles, and employee injuries per hundred million train-miles as the dependent variable. The explanatory variables are the same as in column 4 of table 5, but the railroad-specific fixed effects and time trends are omitted from the table to conserve space. The r-squareds for these regressions are lower than in table 5, which suggests that these measures of safety are noisier than the accident rate. Nevertheless, the signs of the regulatory variables in the regressions are similar to those in table 5, although some of the coefficient estimates no longer achieve statistical significance. This difference is most pronounced in the first equation for damages. The Staggers dummies, however, become highly significant when the "Years since Staggers" variables are removed.

[Insert table 6 about here.]

4.3.3 Regulation, investment, and switching miles

We hypothesized that regulation affects safety by affecting both investment and operations. Table 7 sheds some light on these hypotheses by examining the correlation of regulation with capital expenditures on road as a percent of assets and the percentage of train-miles that are switching miles. The table uses the regression model from column 4 of table 5. Expressing capital expenditures as a percent of assets allows us to control for the size of the railroad and obviates the need to select a price index to calculate "real" capital expenditures. [Insert table 7 about here]

Column 1 seems to indicate that neither the regulatory variables nor the Staggers Act are correlated with capital expenditures. The r-squared and F-statistic, however, are quite high. In column 2, removing the regulatory variables reveals that capital expenditures as a percent of assets are highly correlated with the Staggers Act for every railroad. Combining the railroad-specific Staggers coefficients with the coefficients on the *1/(Years since Staggers)* phase-in variables indicates that investment on road as a percent of assets increased more rapidly for some railroads than for others. For CSX, KCS, and UP, this measure began increasing the year after Staggers. For Conrail, it did not increase until 6.7 years after Staggers.

Results for the regulatory variables in the switching-miles regression are similar to the results in table 5 for accidents. Staggers is associated with a reduction in the percentage of switching miles and is again statistically significant. Even in the first year after Staggers, the size of the negative coefficient on the railroad-specific Staggers dummy exceeds the size of the *1/(Years since Staggers)* phase-in for every railroad. Increases in the FRA regulation index are also associated with a lower percentage of switching miles prior to Staggers, but not after. Increases in ICC/STB regulation index are associated with an increase in switching miles both before and after Staggers, but the net size of the coefficient is smaller after Staggers.

5 Conclusion

The results in this paper suggest that extensive economic regulation of railroads prior to 1981 significantly diminished rail safety by discouraging investment and encouraging switching. Passage of the Staggers Act is associated with a substantial reduction in the rate of accidents. In addition, increases in regulatory restrictions from the ICC are correlated with higher accident rates in the years prior to Staggers. Staggers may be responsible for most of the reduction in the accident rate from its 1978 high of 1800 accidents per hundred million train-miles.

Increases in FRA regulation are associated with improved railroad safety prior to partial economic deregulation. This is precisely the period when railroads faced weakened market incentives to operate safely. Safety regulation thus substituted for weak market discipline. Increases in our measure of FRA regulatory restrictions that have been adopted since the Staggers Act, however, are not associated with improved safety. This suggests that partial economic deregulation's restoration of normal market incentives has accomplished much of the job that safety regulators sought to accomplish.

Table 1: Variables and summary statistics

	N	Mean	S.D.	Min.	Max.
Accidents per hundred million miles	274	803	608	216	4144
Capital expenditures on road/assets	273	0.044	0.018	0.005	0.122
Switching miles/total train-miles	274	0.184	0.068	0.068	0.408
Staggers	274	0.912	0.283	0	1
FRA railroad regulation index	274	3775	2008	1565	8292
ICC/STB railroad regulation index	274	3224	811	1637	4556
Total track miles	274	29,569	21,243	0	76,371
Revenue ton-miles	274	1.68e+08	1.74e+08	8,980,739	6.75e+08
Real GDP growth rate	274	0.028	0.020	-0.028	0.073
Recession	274	0.248	0.433	0	1
Real return on equity	274	0.056	0.129	-0.087	1.75
Railroad-specific fixed effects					
Burlington Northern Santa Fe					
Canadian National (US operations)					
Canadian Pacific (US operations)					
Conrail					
CSX					
Kansas City Southern (omitted category in regressions)					
Norfolk Southern					
Union Pacific					

Sources: Federal Railroad Administration Office of Safety Analysis (safetydata.fra.dot.gov); Association of American Railroads; RegData.org; Bureau of Economic Analysis; NBER via FRED Economic Data.

Table 2: Class I merger dummy variables

1980	Grand Trunk Western – Detroit, Toledo & Ironton (GTW-DTI)
1982	Norfolk & Western – Southern (NW-SR)
	Burlington Northern – Colorado Southern (BN-CS)
	Collinear with Burlington Northern-Frisco (1980)
	CSX – Louisville & Nashville – Clinchfield (CSX-LN)
1983	Union Pacific – Western Pacific (UP-WP)
	Collinear with Union Pacific - Missouri Pacific (1982)
1985	Soo-Milwaukee Road (SOO-MILW)
1987	Consolidation of Seaboard, Baltimore & Ohio, and Chesapeake & Ohio within CSX (CSX-BO-CO)
1989	Union Pacific – Missouri, Kansas, & Texas (UP-MKT)
1990	Canadian Pacific – Soo (CP acquired full ownership of Soo and consolidated it with CP) (CP-SOO)
1993	Canadian National – Grand Trunk Western (CN-GTW)
	Union Pacific – Denver & Rio Grande Western (UP-DRGW)
	Collinear with Southern Pacific – St. Louis Southwestern (1992)
1996	Burlington Northern – Santa Fe (BN-SF)
	Union Pacific – Southern Pacific
	Collinear with Union Pacific -- Chicago & Northwestern (1995)
1998	Canadian National – Illinois Central (CN-IL)
1999	CSX – Conrail (CSX-CR)
	Norfolk Southern – Conrail (NS-CR)

Merger years were obtained from http://www.railroadsignals.us/mergers/index.htm and cross-checked with web searches of sites that contain historical information about various railroads.

Table 3: Augmented Dickey-Fuller tests for unit root processes in regulation variables

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
VARIABLE: *FRA regulation index*			Obs = 38	
Interpolated Dickey-Fuller				
Z(t)	1.986	-3.662	-2.964	-2.614
MacKinnon approximate p-value for Z(t) = 0.9987				
VARIABLE: *Δ FRA regulation index*			Obs = 37	
Interpolated Dickey-Fuller				
Z(t)	-5.503	-3.668	-2.966	-2.616
MacKinnon approximate p-value for Z(t) = 0.0000				
VARIABLE: *ICC/STB regulation index*			Obs = 37	
Interpolated Dickey-Fuller				
Z(t)	-2.709	-3.662	-2.964	-2.614
MacKinnon approximate p-value for Z(t) = 0.0726				
VARIABLE: *Δ ICC/STB regulation index*			Obs = 37	
Interpolated Dickey-Fuller				
Z(t)	-5.704	-3.668	-2.966	-2.616
MacKinnon approximate p-value for Z(t) = 0.0000				

H0: Variable contains a unit root.

HA: Variable generated by stationary process.

Table 4: Levin-Lin-Chu tests for unit root processes in panel data

Number of panels = 7

Number of periods = 36

AR parameter: Common across panels   Asymptotics: N/T -> 0

Panel means: Included

Time trend: Not included

Augmented Dickey-Fuller regressions: 1 lag

Long run variance: Bartlett kernel, 10.00 lags average (chosen by LLC)

Ho: Panels contain unit roots

Ha: Panels are stationary

VARIABLE: *Accidents per hundred million miles*		
	Test Statistic	p-value
Unadjusted t	-9.88801	
Adjusted t*	-6.2656	0.0000
	Test Statistic	p-value
VARIABLE: *revenue ton-miles*		
Unadjusted t	-1.1634	
Adjusted t*	0.6754	0.7503
VARIABLE: *d1.revenue ton-miles*		
Unadjusted t	-11.7826	
Adjusted t*	-8.0792	0.0000
VARIABLE: *Real GDP growth rate*		
Unadjusted t	-9.5737	
Adjusted t*	-6.2789	0.0000
VARIABLE: *Total track miles*		
Unadjusted t	-4.3022	
Adjusted t*	-2.3766	0.0087
VARIABLE: *Real return on equity*		
Unadjusted t	-5.5203	
Adjusted t*	-1.3586	0.0871

Table 5: Regulation is correlated with accident rate

	Dependent variable: Accidents per hundred million train-miles			
	(1) Regulatory variables and time trend	(2) State of economy	(3) Merger dummies	(4) RR-specific time and Staggers effects
Staggers	-1873 (0.000)	-1582 (0.007)	-1823 (0.006)	
1/(Years since Staggers)	1139 (0.018)	774 (0.110)	971 (0.090)	
FRA Regulation Index lag2	-1.05 (0.009)	-0.97 (0.014)	-0.99 (0.017)	-0.99 (0.009)
FRA Regulation Index x Staggers lag2	1.13 (0.004)	1.05 (0.007)	1.06 (0.011)	1.08 (0.003)
ICC/STB Regulation Index lag2	0.35 (0.014)	0.40 (0.006)	0.44 (0.007)	0.42 (0.002)
ICC/STB Regulation Index x Staggers lag2	-0.43 (0.003)	-0.45 (0.002)	-0.51 (0.003)	-0.46 (0.001)
Time trend	-29.7 (0.058)	-28.4 (0.065)	-26.1 (0.079)	
Real GDP Growth Rate		3341 (0.11)	3489 (0.014)	3280 (0.012)
Recession		104 (0.013)	87 (0.022)	107 (0.009)
BNSF x Staggers				-1250 (0.003)
CN x Staggers				-1401 (0.001)
CP x Staggers				-1377 (0.001)
CR x Staggers				-1867 (0.000)
CSX x Staggers				-1783 (0.000)
KCS x Staggers				-3128 (0.000)
NS x Staggers				-947 (0.027)
UP x Staggers				-1210 (0.005)
BNSF x 1/(Years since Staggers)				542 (0.120)
CN x 1/(Years since Staggers)				133 (0.731)
CP x 1/(Years since Staggers)				707 (0.056)
CR x 1/(Years since Staggers)				1009 (0.010)
CSX x 1/(Years since Staggers)				694 (0.054)
KCS x 1/(Years since Staggers)				2263 (0.002)
NS x 1/(Years since Staggers)				371 (0.300)
UP x 1/(Years since Staggers)				718 (0.050)
BN-CS			536 (0.240)	
BC-CS x 1/(Years since merger)			-568 (0.034)	
BN-SF			467 (0.105)	
BN-SF x 1/(Years since merger)			-318 (0.362)	
GTW-DTI			424 (0.289)	
GTW-DTI x 1/(Years since merger)			-869 (0.060)	
CN-GTW			76 (0.527)	
CN-GTW x 1/(Years since merger)			408 (0.000)	
CN-IC			-170 (0.132)	
CN-IC x 1/(Years since merger)			-60 (0.634)	
SOO-MILW			-403 (0.119)	

SOO-MILW x 1/(Years since merger)			736 (0.000)	
CP-SOO			-365 (0.012)	
CP-SOO x 1/(Years since merger)			1027 (0.000)	
CSX-LN-CCO			428 (0.254)	
CSX-LN-CCO x 1/(Years since merger)			-501 (0.070)	
CSX-BO-CO			-162 (0.009)	
CSX-BO-CO x 1/(Years since merger)			378 (0.000)	
CSX-CR			250 (0.055)	
CSX-CR x 1/(Years since merger)			-117 (0.337)	
NW-SR			1041 (0.004)	
NW-SR x 1/(Years since merger)			-553 (0.032)	
NS-CR			117 (0.413)	
NS-CR x 1/(Years since merger)			-82 (0.498)	
UP-WP			590 (0.078)	
UP-WP x 1/(Years since merger)			205 (0.097)	
UP-MKT			18 (0.667)	
UP-MKT x 1/(Years since merger)			44 (0.262)	
UP-DRGW			-94 (0.042)	
UP-DRGW x 1/(Years since merger)			14 (0.820)	
UP-SP			147 (0.193)	
UP-SP x 1/(Years since merger)			-371 (0.004)	
Constant	3433 (0.000)	2913 (0.000)	3162 (0.000)	3780 (0.000)
R^2 (Centered, Uncentered)	(.75, .91)	(.75, .91)	(.86, .95)	(.89, .96)
F-statistic	20.56 (0.000)	19.44 (0.000)	1500 (0.000)	1959 (0.000)
N	274	274	274	274
Post-Staggers net effects				
FRA Regulation Index post-Staggers net	0.08 (0.233)	0.09 (0.211)	0.08 (0.99)	0.100 (0.117)
ICC/STB Regulation Index post-Staggers net	-0.08 (0.092)	-0.05 (0.199)	-0.07 (0.04)	-0.040 (0.185)

Railroad-specific fixed effects and railroad-specific time trend effects are omitted to conserve space. Absolute p-values in parentheses, based on Newey-West robust standard errors.

Table 6: Alternative safety measures

	Dependent variable (all per hundred million train-miles except damages)			
	Damages/ Train-mile	Damages/ Train-mile	Fatalities	Employee Injuries
FRA Regulation Index lag2	-0.0006 (0.092)	-0.0004 (0.007)	-0.026 (.001)	-0.050 (0.017)
FRA Regulation Index x Staggers lag2	0.0008 (0.075)	0.0006 (0.010)	0.024 (0.001)	0.049 (0.008)
ICC/STB Regulation Index lag2	0.0002 (0.037)	0.0002 (0.028)	0.009 (0.000)	0.025 (0.001)
ICC/STB Regulation Index x Staggers lag2	-0.0003 (0.010)	-0.0002 (0.002)	-0.009 (0.000)	-0.020 (0.002)
Real GDP Growth Rate	0.74 (0.681)	1.71 (0.035)	68.77 (0.088)	12.16 (0.937)
Recession	0.010 0.866)	0.039 (0.272)	1.82 (0.163)	-2.63 (0.602)
BNSF x Staggers	-0.61 (0.232)	-0.23 (0.007)	-29.86 (0.012)	-41.23 (0.211)
CN x Staggers	-0.86 (0.091)	-0.54 (0.000)	-37.26 (3.22)	-76.35 (0.021)
CP x Staggers	-0.64 (0.203)	-0.35 (0.001)	-29.48 (0.013)	-88.01 (0.008)
CR x Staggers	-0.98 (0.099)	-0.45 (0.000)	-35.36 (0.004)	-112.97 (0.002)
CSX x Staggers	-0.72 (0.156)	-0.35 (0.000	-34.29 (0.004)	-77.61 (0.020)
KCS x Staggers	-1.36 (0.014)	-0.69 (0.001)	-29.27 (0.039)	-205.87 (0.000)
NS x Staggers	-0.65 (0.203)	-0.24 (0.007)	-38.12 (0.002)	-57.92 (0.079)
UP x Staggers	-0.53 (0.298)	-0.19 (0.034)	-31.78 (0.008)	-82.57 (0.014)
BNSF x 1/(Years since Staggers)	0.33 (0.507)		15.35 (0.162)	8.04 (0.790)
CN x 1/(Years since Staggers)	0.18 (0.724)		17.81 (0.088)	15.53 (0.607)
CP x 1/(Years since Staggers)	0.09 (0.861)		25.44 (0.019)	21.85 (0.474)
CR x 1/(Years since Staggers)	0.65 (0.274)		19.85 (0.079)	79.78 (0.017)
CSX x 1/(Years since Staggers)	0.32 (0.526)		17.56 (0.106)	42.56 (0.168)
KCS x 1/(Years since Staggers)	1.19 (0.075)		16.63 (0.256)	429.79 (0.000)
NS x 1/(Years since Staggers)	0.44 (0.379)		18.68 (0.094)	32.57 (0.279)
UP x 1/(Years since Staggers)	0.23 (0.646)		19.77 (0.073)	43.97 (0.157)
Constant	2.48 (0.000)	2.13 (0.000)	24.63 (0.024)	147.08 (0.000)
R^2 (Centered, Uncentered)	(0.58, 0.85)	(0.57, 0.84)	(0.35, 0.57)	(0.76, 0.88)
F-statistic	590 (0.000)	757 (0.000)	138 (0.000)	662 (0.000)
N	274	274	274	274
Post-Staggers net effects				
FRA Regulation Index post-Staggers	0.0001 (0.131)	0.0002 (0.180)	-0.0008 (0.640)	0.001 (0.810)
ICC/STB Regulation Index post-Staggers	-0.0001 (0.061)	-0.0001 (0.050)	0.0005 (0.472)	0.005 (0.115)

Railroad-specific fixed effects and railroad-specific time trend effects are omitted to conserve space. Absolute p-values in parentheses, based on Newey-West robust standard errors.

Table 7: Regulation, investment, and switching miles

	Dependent variable		
	Capex_ road/ assets	Capex_road/ assets	Switching miles/ train-miles
FRA Regulation Index lag2	-3.05e-06 (0.756)		-0.0001 (0.000)
FRA Regulation Index x Staggers lag2	-3.79e-06 (0.608)		0.0001 (0.000)
ICC/STB Regulation Index lag2	-4.50e-06 (0.311)		0.00005 (0.000)
ICC/STB Regulation Index x Staggers lag2	5.46e-06 (0.031)		-0.00004 (0.000)
Real GDP Growth Rate	-0.035 (0.753)	0.070 (0.334)	0.119 (0.278)
Recession	0.001 (0.686)	0.005 (0.085)	0.014 (0.008)
Real return on equity	0.017 (0.001)	0.018 (0.000)	
BNSF x Staggers	-0.001 (0.979)	0.034 (0.000)	-0.154 (0.000)
CN x Staggers	-0.027 (0.212)	0.007 (0.032)	-0.141 (0.000)
CP x Staggers	-0.011 (0.634)	0.046 (0.000)	-0.163 (0.000)
CR x Staggers	-0.030 (0.239)	0.063 (0.000)	-0.116 (0.006)
CSX x Staggers	-0.009 (0.676)	0.026 (0.000)	-0.167 (0.001)
KCS x Staggers	-0.008 (0.736)	0.027 (0.011)	-0.341 (0.000)
NS x Staggers	-0.007 (0.733)	0.028 (0.000)	-0.097 (0.030)
UP x Staggers	-0.003 (0.891)	0.032 (0.000)	-0.204 (0.000)
BNSF x 1(Years since Staggers)	0.004 (0.845)	-0.035 (0.000)	0.100 (0.006)
CN x 1/(Years since Staggers)	0.018 (0.383)	-0.020 (0.000)	0.084 (0.031)
CP x 1/(Years since Staggers)	-0.016 (0.518)	-0.054 (0.000)	0.112 (0.004)
CR x 1/(Years since Staggers)	-0.006 (0.801)	-0.424 (0.000)	0.036 (0.387)
CSX x 1/(Years since Staggers)	-0.013 (0.507)	-0.025 (0.000)	0.149 (0.005)
KCS x 1/(Years since Staggers)	0.005 (0.388)	-0.019 (0.178)	0.292 (0.000)
NS x 1/(Years since Staggers)	0.013 (0.791)	-0.033 (0.000)	0.092 (0.056)
UP x 1/(Years since Staggers)	0.0.013 (0.566)	-0.026 (0.002)	0.177 (0.000)
Constant	0.046 (0.019)	0.020 (0.000)	0.402 (0.000)
R^2 (Centered, Uncentered)	(.50, .93)	(.48, .93)	(0.89, 0.99)
F-statistic	550 (0.000)	770 (0.000)	653 (0.000)
N	273	273	274
FRA Regulation Index post-Staggers net	-6.83e-06 (0.057)		9.94 e-06 (0.235)
ICC/STB Regulation Index post-Staggers net	-9.58e-07 (0.700)		0.00001 (0.003)

Railroad-specific fixed effects and railroad-specific time trend effects are omitted to conserve space. Absolute p-values in parentheses, based on Newey-West robust standard errors.

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