A re-examination of four decades' deregulation effect on competition and productivity of the US freight rail transportation industry

Received 2 July 2023
Revised 27 December 2023
Accepted 20 January 2024

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Abstract

Purpose – The purpose of this study is to compare the competition and productivity of the US freight rail transportation industry for the past 41 years (1980 ~ 2020), which consists of the two periods, before and after the abolishment of the Interstate Commerce Commission (ICC) in 1995.

Design/methodology/approach – This study investigates any relationships between the market concentration index values and labor productivity values in the separate two periods, and how the existence of a regulatory body in the freight transportation market impacted the productivity of the freight rail transportation industry by using a Cobb–Douglas production function on annual financial statement data from the US stock exchange market.

Findings – This study found that, after the abolishment of the ICC: (1) the rail industry became less competitive, (2) even if the rail industry had an increasing labor productivity trend, there was a strong negative correlation between the market concentration index and labor productivity and (3) the rail industry's total factor productivity was decreased.

Originality/value – This study is to find empirical evidence of the effect of the ICC abolishment on the competition and productivity levels in the US freight rail transportation industry using a continuous data set of 41-year financial statements, which is unique compared to previous studies.

Keywords Rail industry, Deregulation, ICC, Competition, Productivity

Paper type Research paper

1. Introduction

The US freight rail system is known as a crucial component of the US transportation system. The rail transportation mode is reliable; it provides a predictable means of transportation, which allows for the smooth flow of goods throughout the US supply chains (Buck, 2022). Among the freight transportation modes, such as truck, air freight, and maritime shipping, rail transport is most cost-effective for bulk shipments of agriculture, energy, and manufacturing products (Coyle *et al.*, 2015) According to the report ("Moving Goods in the United States") of the Department of Transportation (DOT)'s Bureau of Transportation Statistics (BTS), while the average shipment by trucks was 63 miles, that of rail transport was 640 miles. Therefore, the rail transportation mode is the preferred choice of mode for long-haul shipments.

The Interstate Commerce Commission (ICC) was established in 1887 as a regulatory agency of the US freight transport industry. The starting point of economic deregulation of

JEL Classification — L92, R48

Journal of International Logistics and Trade
Vol. 22 No. 1, 2024
pp. 22-38
Emerald Publishing Limited
e-ISSN: 2508-7592
p-ISSN: 1738-2122
DOI 10.1108/JILT-07-2023-0046

the US transportation industry was considered to be the Airline Deregulation Act of 1978; the year 2018 was the 40th anniversary of the deregulation of the US transportation industry (Fischer, 2018). In 1980, the US freight rail transportation industry had been deregulated by the Stagger Rail Act of 1980. This law significantly deregulated the US freight rail transportation industry. The purpose of the economic deregulation in the transportation industry was to increase the transport market competition, which could lead to improvements in the industry's productivity by lowering costs and serving more consumers with lower rates. The culmination of economic deregulation in the US freight transportation industry was the ICC Termination Act of 1995. At the end of 1995, the ICC was abolished and the rail freight industry was still controlled by the Surface Transportation Board (2009) even after the abolishment of the ICC. The reason for the creation of the STB was to continue regulatory oversight of the freight rail market because historically the rail industry was considered a natural monopoly due to the high building cost of rail networks (Layton, 2019). While the ICC used to take comprehensive control of economics and services in the rail industry, the STB, a successor of the ICC, had reduced power to regulate the economic aspect of the freight rail industry (Spychalski, 1997). Spychalski (1997) mentioned that the abolishment of ICC in 1995 was a historical event in US freight transportation; the creation of the STB in 1996 as an independent regulatory agency by the DOT led to a new era of the rail freight transportation industry.

TR News, Transportation Research Board's magazine, had a special issue (May–June 2018), "40 Years of Transportation Deregulation". Several articles within the special edition presented a historical view of deregulation and its effect on the US rail industry. Fischer (2018) mentioned that the purpose of deregulation was to modify and modernize regulation, not to eliminate it; the economic freedom from the regulatory agency was to provide forces of innovation and efficiency to the US transportation industries. Gallamore (2019) compared the dynamic changes in traffic volume, revenue, price, and productivity in the US rail transportation industry before and after the Stagger Rail Act of 1980. He described how the deregulation permitted increased traffic volume and decreased average rail rates, which led to increased rail transportation productivity. He highlighted the advantage of deregulation in the technology improvements and operation innovation aspects of the rail transportation industry. Gallamore (2019) considered an intermodal freight service as a symbol of the freight industry's technological and operational innovation. He mentioned that long-term contracts between carrier-shipper partnerships allowed for intermodal container services of double-stack trains, which led to improved cash flow and re-investment towards technology improvement.

This study aims to find empirical evidence of the effect of deregulation on the competition and productivity levels in the US freight rail transportation industry from 1980 to more recent years in the 21st century. As previously noted, the Staggers Rail Act of 1980 and the ICC Termination Act of 1995 represented crucial milestones in the deregulation of the US rail industry. While earlier studies focused extensively on the deregulatory impact of the Staggers Act, limited attention was given to the analysis of the ICC Termination Act. The previous studies about the rail freight deregulation effect either compared the outputs of productivity in intervals of every 5th/10th year or focused on the short time intervals, comparing pre-deregulation and post-deregulation. Gordon (1992) mentioned that examining the rail freight industry over long-term sample periods, as opposed to shorter intervals, offered benefits and sampling timing was important for productivity studies. Since long-term sample periods allow researchers to analyze trends over extended periods, long-term productivity studies can provide a more comprehensive view of the industry's performance by encompassing macroeconomic conditions such as economic growth or recession, financial crisis, or oil shocks. In this paper, the examination of the continuous 41 years involves categorizing the years into two segments, based on the presence or absence of the ICC.

Holmes and Schmitz (2010) reviewed the literature regarding the relationship between competition and productivity; they reviewed several industry cases, including rail transportation. They found that the increase in competition led to increased industry productivity in the 20th century. This study also analyzed the relationship between competition level and labor productivity in the US rail transportation industry and tried to find evidence of a positive relationship in the 21st century. This study has the following research questions:

RQ1. Is there any significant difference in industry competition level in the US freight rail transportation industry after the ICC was abolished in 1995?

RQ2. What relationship exists between the competition level and the industry's labor productivity? Is there any difference between the two periods, one with the ICC and the other without the ICC?

RQ3. Did the ICC have an impact on the productivity in the US freight rail transportation industry since 1980, the year of starting economic deregulation, and after 1995, the year of ICC abolishment?

This paper is structured as follows. First, it presents a brief literature review and then presents the dataset used in this paper. In the following section, it presents the trends of market competition. The next section analyzes the ICC's effect on the productivity of the freight rail transportation industry using a regression model. Discussion and conclusion sections follow in the end.

2. Literature review

Productivity is a crucial indicator of the overall health and efficiency of an industry. Comparing productivity levels among industries is a common practice to assess their relative performance and efficiency (US Bureau of Labor Statistics, 2021). The US DOT'S BTS (2016) published a report, "Transportation Economic Trends", where productivity was defined as "a ratio of total output to the inputs used in the production process". The BTS calculated two measures of transportation productivity: labor productivity and multifactor productivity. Labor productivity was defined as "industry output divided by paid labor hours" and multifactor productivity, which was also called total factor productivity (TFP), was defined as "output per unit of a weighted average of multiple factors, such as fuel, equipment, and materials".

Shi *et al.* (2011) chronologically summarized previous studies about productivity of the US rail transportation. They reviewed seven papers published in the 1990s (Duke *et al.*, 1992; Vellturo *et al.*, 1992; Friedlaender *et al.*, 1993; Berndt *et al.*, 1993; Bereskin, 1996; Martland, 1997; Wilson, 1997) and 2 papers published in the 2000s (Martland, 2006; Lim and Lovell, 2008). All 9 papers agreed that during the post-deregulation periods, there was remarkable productivity growth in the US rail transportation industry. Before the passage of the Staggers Rail Act of 1980, the US rail transportation industry was heavily regulated by the ICC and suffered financial troubles. The railroad companies were not allowed to abandon unprofitable routes. Without the permission of the ICC, they were unable to change their regulated transportation rates and were not allowed to merge with and acquire other companies. After the passage of the Staggers Rail Act of 1980, railroad companies had partial independence regarding their economic decisions about the optimization of their rail networks, which led to cost savings and productivity increases. The productivity increases also led to a lower rate for shippers. All the mentioned papers agreed that deregulation was the main driver for cost saving and productivity increases.

Wilson (1997) agreed that in the short term, productivity increase by deregulation was significant but he mentioned that there would be no guarantee that the impact of deregulation would last in the long term. Winston (1998) generalized the deregulation in US industries, including the rail transportation industry, and their adjustments for 20 years since the mid-1970s. He observed that after the deregulation, competition in the transportation industry had grown highly, operating costs of the rail industry sectors had fallen significantly, and their profits had increased greatly. In addition, consumer welfare had increased. He concluded that an economic adjustment to deregulation would be shaped by increasing competition and long-term efficiency.

Martland (1999, 2012) analyzed two 30-year periods of rail transportation productivity: 1965 ~ 1995 and 1980 ~ 2010. He summarized that there were five drivers of US Rail Transportation productivity growth: Network rationalization, technological improvements, regulatory changes, advanced information technology, and labor agreement. He accepted deregulation as one of the drivers of productivity growth, but he argued that the Northeast Rail Crisis in 1970 ignited the US rail system's transformation. He calculated the productivity by freight revenues and freight expenses for every 5th year, adjusted by a rail price index and a railroad cost recovery index, respectively. He found that productivity improvement was greater after 1980; it began accelerating in 1990, increased up to 9%, and declined to 4% in 2008.

Most papers mentioned above analyzed the Class I railroads because their revenue took up 90% of the rail transportation industry (Shi *et al.*, 2011). However, the degree of competition has changed as time went by. The number of Class I railroad companies in 1978 was 36 but it was 7 in 2004 (McCullough, 2005). McCullough (2005) mentioned the Herfindahl-Hirshman Index (HHI) of US rail transportation. The HHI is a market concentration index that the US Department of Justice (DOJ) uses to measure market concentration. When the HHI value is over 1,000, the DOJ usually begins to investigate issues from mergers and acquisitions in an industry. The Class I railroad HHI had increased from 578 in 1978–2263 in 2004, which meant that the Class I rail industry was no longer a competitive market in 2004 (McCullough, 2005).

Schmalensee and Wilson (2016) compared various productivity ratios in 10-year increments, such as average railroad ton-miles, average network size, average length of haul, and ton-miles per train-hour. They presented that all productivity ratios had an increasing trend. In summary, the previous studies listed above have all mentioned that there had been a positive effect of deregulation on the productivity in the US rail industry for 30 years since the Stagger Rail Act of 1980.

3. Data

This study uses the *Compustat* databases to obtain 41 years' worth of annual financial statements for US publicly traded companies between 1980 and 2020. According to the North American Industry Classification System (NAICS), which consists of 6 digits, the transportation industry starts with 48 and the first three digits represent a sector (482 for the rail sector). The dataset contains only companies listed in US stock exchanges, such as the NYSE, AMEX, NASDAQ, and PHLX.

The numeric data items used in this study are Assets Total (AT), Number of Full-Time Workers (EMP), and Revenue Total (RT). The categorical data items are Fiscal Year (FY), NAICS, Security Exchange Code (SEC), and Ticker Symbol (TS). The TS represents the stock market symbol of an individual transportation company. In addition to the annual financial statement data items, the historic retail gas prices are added to the dataset. The average retail gas price of each year was obtained from the US Bureau of Labor Statistics (BLS). Table 1 represents a list of data items in this study.

The total number of downloaded data records is 763. Among them, records with missing AT and RT were removed and zero values were also removed because of log transformations in later analysis. The remaining data set is 635 data records. The dataset in this study

Data item	Name	Type	Source
AT	Assets Total	US $ (millions)	Compustat
EMP	Number of Full-Time Employee	Number (thousands)	
FY	Fiscal Year	Number (yyyy)	
NAICS	North America Industry Classification System	Number (6 digits)	
RT	Revenue Total	US $ (millions)	
SEC	Security Exchange Code*	Number (2 digits)	
TS	Ticker Symbol	Text	
GAS	Average Retail Gas Price (All Types per Gallon)	US $	US Bureau of Labor Statistics

Note(s): *NYSE (11), AMX (12), NASDAQ (14), PHLX(18)
Source(s): The author's own work

Table 1.
Sample variables

consists of two subsets by two time periods (see Table 2); Period 1, 16 years with the ICC (1980 ∼ 1995) and Period 2, 25 years without the ICC (1996 ∼ 2020).

There are 39 companies in the rail industry in the 41 years. If it is a completely balanced dataset, the number of records should be 1,599 (=39 companies x 41 years), but the total record is only 635. Thus, the dataset used in this study is unbalanced panel data. There are only three companies listed for all 41 years in the US stock market (Burlington Northern Santa Fe, CSX Corp., and Kansas City Southern). Table 3 presents descriptive statistics of the three main variables, AT, EMP, and RT, and their log-transformed variables, ln(AT), ln(EMP), and ln(RT). The distribution of the three original variables is extremely right-skewed. The reason for using log-transformed data is to make the data close to a normal distribution, which is appropriate for later statistical analysis and for applying Cobb–Douglas production theory. Figure 1 shows histograms of those variables.

4. Market competition and labor productivity

4.1 Market concentration index

The HHI is a well-known measure of the market concentration index and it is the sum of the squares of each company's percentage of industry sales (Shin and Eksioglu, 2015). Because the HHI gives greater weight to the larger market percentage, an industry with a large

Period 1: 1980–1995 (ICC = 1)	Period 2: 1996–2019 (ICC = 0)	Total
381	254	635

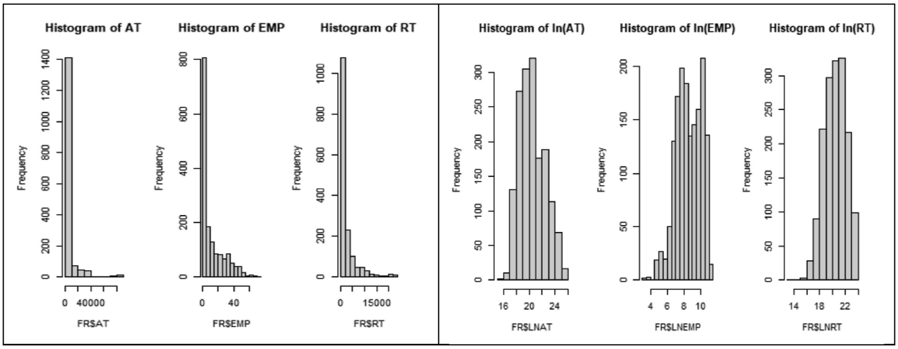
Source(s): The author's own work

Table 2.
Two subsets of data

	At (millions)	EMP (thousands)	RT (millions)	ln(AT)	ln(EMP)	ln(RT)
n	635	635	635	635	635	635
Mean	11113.98	20.51	4284.11	21.85	9.05	21.03
Median	4570.37	19.10	2238.60	22.24	9.86	21.53
S.D.	17236.45	18.15	5423.16	1.93	1.76	1.93
Min	6.64	0.03	3.51	15.71	3.22	15.07
Max	88660.00	75.00	23988.00	25.21	11.23	23.90

Source(s): The author's own work

Table 3.
Descriptive statistics



Source(s): The author's own work

Figure 1. Histograms

number of small companies, i.e. a competitive market, has a low HHI, while an industry with a small number of large companies, i.e. a concentrated market, has a high HHI. According to Horizontal Merger Guidelines (1997, US DOJ and FTC), the US DOJ uses the HHI when it evaluates a potential merger and acquisition issue. It divides the spectrum of market concentration into three categories of market competition: (1) competitive (HHI $\leq$ 1,500), (2) moderately concentrated (1,500 $<$ HHI $\leq$ 2,500), and (3) highly concentrated (HHI $>$2,500) (Marshall *et al.*, 2021). This study uses the HHI index as a proxy of the market competition level. For example, there are six rail companies in the rail sector in 2020. The market share of each company is calculated as a percent of the revenue out of the sum of all the companies' revenue, i.e. Market $\text{Share}_i = (RT_i/\sum RT_i)$ x 100. The HHI is calculated by summing the squares of the market share percentage of each company, i.e. HHI $= \sum$ (Market Share_i)^2, and the HHI value of the year 2020 is 2,059.69 (see Table 4).

Figure 2 presents a trend of the number of companies and HHI. While the number of companies had an upward trend between 1980 and 1995, it had a downward trend between 1996 and 2020. By mergers and acquisitions in 1995–1998, the number of rail companies listed in the US stock market was less than 15 in 1999.

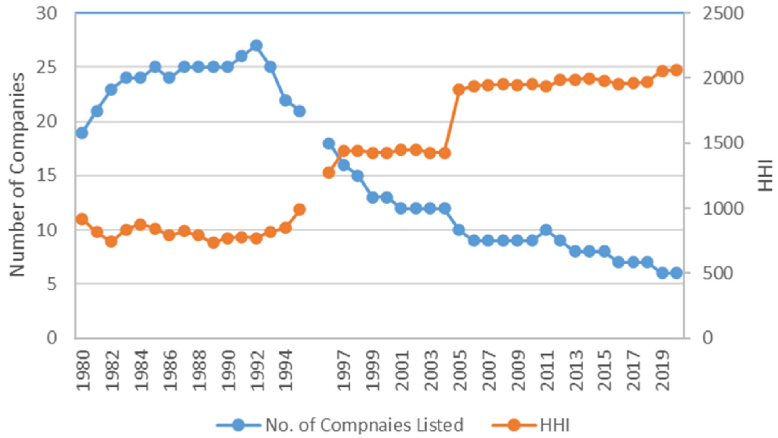
For the HHI trends, the rail industry experienced a stepwise increase in its HHI level. The rail industry had stayed at a competitive market in Period 1. For 9 years after 1995, it had been on the borderline between a competitive market and a moderately concentrated market. Since 2005, the HHI of the rail industry has stayed at around 2,000 in a moderately concentrated market.

As mentioned earlier, the HHI data items are grouped into two periods: Period 1 (1980 ~ 1995) and Period 2 (1996 ~ 2020). Table 5 presents descriptive statistics of HHI in the two

Year	Company name	RT	Market share	(Market share)^2
2020	Burlington Northern Santa Fe	20869.0	24.97%	623.35
2020	BNSF Railway Co	20180.0	24.14%	582.87
2020	Union Pacific Corp	19533.0	23.37%	546.09
2020	CSX Corp	10583.0	12.66%	160.30
2020	Norfolk Southern Corp	9789.0	11.71%	137.16
2020	Kansas City Southern	2632.6	3.15%	9.92
Total		*83586.6*	*100.00%*	*2059.69*

Source(s): The author's own work

Table 4. HHI calculation example



Source(s): The author's own work

Figure 2.
Trends of number of companies and HHI

Table 5.
Descriptive statistics of HHI

	Period 1 (1980 ~ 1995)	Period 2 (1996 ~ 2020)
n	16	25
Mean	821.40	1772.05
Median	816.09	1946.8
S.D.	66.23	275.03
Min	734.48	1274.72
Max	990.44	2059.68

Source(s): The author's own work

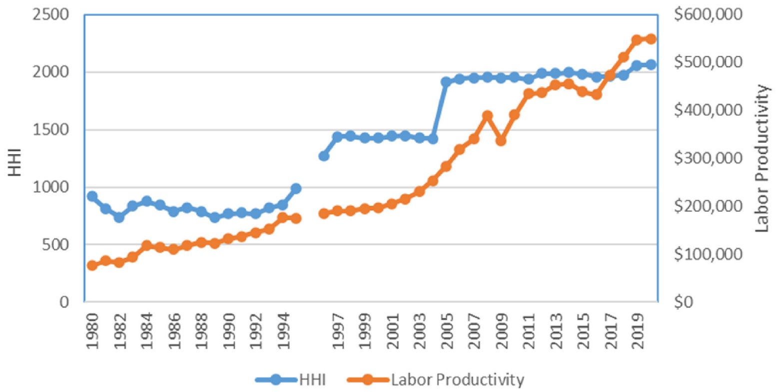
periods. The mean value of period 2 (1,772.05) is much greater than that of period 1 (821.40) and the maximum value of period 1 (990.44) is less than the minimum value of period 2 (1,274,72). Therefore, the level of competition in Period 2 was weaker than in Period 1.

4.2 Labor productivity

Labor productivity is a ratio between output total, which is the amount of goods and services produced, and the amount of labor used for producing those goods and services. The US BLS publishes labor productivity with the number of hours worked as an input factor. In this paper, RT and EMP, as proxy values for output total and labor factor, are used to calculate labor productivity per full-time employee. Figure 3 presents a trend of labor productivity and HHI. Since 1980, the labor productivity has continuously been increasing.

4.3 Correlation analysis

Backus (2019) researched industry-level correlations between productivity and competition. He found that the competitive markets induced companies with efficient production ways, which led to enhanced productivity, i.e. there is a positive correlation between competition and productivity. In this study, a correlation analysis with HHI and labor productivity was made. A positive correlation between HHI and labor productivity means that there is a negative correlation between labor productivity and the market competition level. There is a strong positive correlation (0.9015) in Period 2 and a weak positive correlation (0.2114) in



Source(s): The author's own work

Figure 3. Comparison between HHI and labor productivity

Period 1. Therefore, in Period 2, the rail industry shows that the less competitive it is, the higher the labor productivity becomes, indicating a different result from Backus's study.

5. Regression analysis

5.1 Cobb–Douglas production function

The Cobb–Douglas production function is used to represent the relationship between output and two inputs, capital (K) and labor (L) (Shin and Eksioglu, 2015). It was developed for statistical evidence with US manufacturing industry data by Cobb and Douglas in 1928 (Bao Hong, 2008). The assumptions in the Cobb–Douglas production function are: that capital and labor are the two inputs for determining a level of production, and that the marginal productivity of capital/labor is proportional to the amount of production per unit of capital/labor. Equation (1) is the production function used by Cobb and Douglas:

$$P(L,K) = AK^{\alpha}L^{\beta} \tag{1}$$

where P = total production, L = labor input, K = capital input, A = total factor productivity, α = output elasticity of labor, and β = output elasticity of capital.

Total production refers to "the monetary value of all goods and services produced in a year" (Bao Hong, 2008). The number of full-time employees and fixed assets are typically used for capital and labor inputs (Shin and Eksioglu, 2014). TFP is "the portion of output not explained by the amount of inputs used in production" (Comin, 2006). TFP is assumed to be a constant that is independent of both labor and capital but TFP could vary due to technology innovations or changes in industry policy (US BTS, 2016). Intermodal freight transportation is a good example of TFP change due to technology innovations, while deregulation is an example of TFP change due to industry policy. In the transportation industry, the two largest operating expenses are fuel and employee salary (Coyle *et al.*, 2015). In addition to capital and labor, fuel (F) is another important input in the transportation operation.

equation (2) is a modified Cobb–Douglas production function used in this study:

$$P(L,K,F) = AK^{\alpha}L^{\beta}F^{\gamma} \tag{2}$$

where F = Fuel and γ = output elasticity of fuel.

Applying the log transformation to equation (2), a linear model is generated:

$$lnP(L,K,F) = ln(A) + \alpha\, ln(K) + \beta\, ln(L) + \gamma\, ln(F) + \varepsilon_{ij}) \quad (3)$$

In equation (3), the output elasticity of each input (α, β, γ) becomes a coefficient of the log-transformed variables. The outputs of the transportation industry are services with movement of people and products and the outputs should be measured in dollar units (Ingene and Lusch, 1999). According to King and Park (2004), while the US Census Bureau uses gross income as a measure of output, the US BLS uses sales/revenue as an output. Sales/revenue is frequently used for the total output in service industry analysis (Shin and Eksioglu, 2015). In this study, sales/revenue, i.e. RT, is used for the output in the modified Cobb–Douglas production function. Because of the absence of gas consumption information, we used an average retail gas price assuming to influence the same effect on the transportation market. In addition, a binary dummy variable, ICC, is added to find the effect of ICC on the productivity of rail industry. The following equation will be used for basic linear regression analysis:

$$ln(RT_{ij}) = ln(A) + \alpha\, ln(AT_{ij}) + \beta\, ln(EMP_{ij}) + \gamma\, ln(GAS_i) + \delta\, ICC + \varepsilon_{ij} \quad (4)$$

where i = fiscal year 1980 ~ 2020, j = Ticker Symbol, RT = Revenue Total, AT = Asset Total, EMP = Number of Full-Time Employee, GAS = Average Retail Gas Price, ICC = 1 if ICC exists, otherwise 0.

5.2 Pooled regression model

This study uses both cross-sectional and time-series panel data, which has 39 companies and 41 years. The pooled regression model ignores the time series dimension and it considers the dataset as cross-sectional data. Table 6 presents the output of the pooled regression model with equation (4). The p-values of all coefficients are 0.000. The pooled regression models need to be tested for multicollinearity, residual analysis, and homeoskedasticity. Table 7 presents the results of the Breusch–Pagan (BP) test and values of VIF (Variance Inflation Factor). In the BP test, the null hypothesis of constant variance was rejected, indicating that the

Table 6. Results from the pooled regression model

Intercept (p-value)	A (p-value)	β (p-value)	γ (p-value)	δ (p-value)	R^2
2.230 (0.000)	0.725 (0.000)	0.312 (0.000)	0.155 (0.000)	0.122 (0.000)	0.988

Source(s): The author's own work

Table 7. Test statistics and results

Test	Results
VIF for multicollinearity	ln(AT) 14.15 ln(EMP) 12.37 ln(GAS) 2.47 ICC 2.72 Result: Multicollinearity
Breusch–Pagan test for Homoscedasticity (Ho: Homoscedasticity)	χ^2 = 61.46 p-value = 0.0000 Result: Heteroskedasticity

Source(s): The author's own work

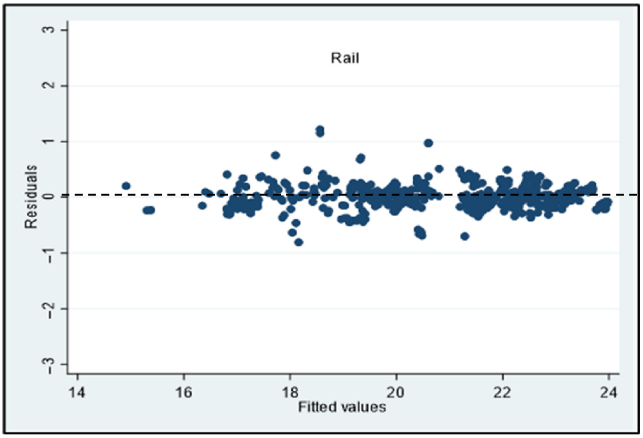
dataset has a heteroscedasticity issue. The VIF values of ln(AT) and ln(EMP) are greater than 10, indicating multicollinearity. Even if the Cobb–Douglas production function is the best production function used in production analysis, one of the issues is multicollinearity (Enaami *et al.*, 2011). Thus, one of the variables with a high correlation should be dropped. However, because the main focus in the analysis is to compare the TFP of the two periods, a period with ICC and a period without ICC, equation (4) will be used in further analysis.

The residual plots in Figure 4 are scatter plots of fitted values and residuals. The residual plot shows data randomly dispersed around a horizontal zero line. Thus, there are no specific patterns in the residual plots and the linear model is a good fit.

Table 8 presents the summary statistics of residuals. The mean value of residuals is close to zero. Table 9 presents the covariance values between the residuals and the independent variables. All covariance values are also close to zero, indicating that there is no endogenous issue.

5.3 Panel data regression model

Because the rail industry data have a heteroscedasticity issue and a multicollinearity issue, a panel data regression is introduced. The panel data in this model consists of a panel ID variable, a variable that identifies each transportation company, and a time variable. Because



Source(s): The author's own work

Figure 4. Residual plots

n	Mean	S.D.	Min	Max
635	1.83e−13	0.2126	−0.8057	1.2185

Source(s): The author's own work

Table 8. Summary of residuals

n	LNAT	LNEMP	LNGAS	ICC
635	5.3e−11	3.6e−10	1.5e−10	−6.3e−11

Source(s): The author's own work

Table 9. Covariance with residuals

the panel ID variable is a variable measured at multiple points in time, the panel data is also called cross-sectional time series data (Bartels, 2009).

The most frequently used panel data regression models are fixed effect models and random effect models (Shin and Eksioglu, 2014). Equation (4) is used for the panel data regression with TS as a panel ID variable and FY as a time variable.

Table 10 presents the outputs of both panel regression models. P-values of all coefficients and model p-values are 0.000, indicating that the models are well-fitted and all coefficients are acceptable at a significance level of 1%. The Hausman test can be used to differentiate between the fixed effect model and the random effect model. The result of the Hausman test is that the fixed effect model is more appropriate at a significant level of 1%. Additional tests to do before we accept the fixed effect model is the Woodridge test for autocorrelation in panel data. Table 11 presents that the dataset has an issue of autocorrelation with a significance level of 1%. A likelihood ratio (LR) test is used for panel data homoscedasticity. The LR test is a Chi-square test between a model of homoscedastic assumption and a model of heteroscedastic assumption. The result of the LR test is homoscedastic. However, the panel data have still multicollinearity issues because their values of VIF for ln(AT) and ln(EMP), are greater than 10.

5.4 Panel data generalized least square regression

Hoechle (2007) suggested a model for use in overcoming heteroskedastic, cross-sectional correlated, and/or autocorrelated panel data: the Feasible Generalized Least Square (FGLS)

		Fixed effect			Random effect	
Variable	Coefficient	S.E.	P-value	Coefficient	S.E.	P-value
Intercept	3.761	0.308	0.000	3.036	0.260	0.000
ln(AT)	0.712	0.016	0.000	0.727	0.016	0.000
ln(EMP)	0.178	0.017	0.000	0.220	0.017	0.000
ln(GAS)	0.110	0.030	0.000	0.108	0.030	0.000
ICC	0.089	0.024	0.000	0.107	0.024	0.000
R^2	0.986			0.987		
Model fit	F = 1,810.94		0.000	F = 9,880.02		0.000

Source(s): The author's own work

Table 10. Panel regression results

Test	Results
Hausman test (with sigmamore option) (Ho: Random Effect Model)	$\chi^2 = 52.10$ $p = 0.000$ Result: Fixed Effect
Wooldridge test for autocorrelation (Ho: No autocorrelation)	$F = 26.30$ p-value = 0.000 Result: Autocorrelation
Likelihood ratio test for homoscedasticity (Ho: Heteroscedasticity)	LR $\chi^2 = 313.44$ P-value = 0.000 Result: Homoscedasticity
VIF for multicollinearity (with uncentered option)	ln(AT) 92.36 ln(EMP) 77.07 ln(GAS) 4.86 ICC 4.45 Result: Multicollinearity

Source(s): The author's own work

Table 11. Test statistics and results for panel regression models

when N < , T = time dimension and N = cross-sectional dimension. The panel dataset in this study has $T = 41$ years and $N = 39$ companies. The FGLS model is good when the covariance structure is unknown. Table 12 is the output from the FGLS regression model with a common first-order autocorrelation option. However, the FGLS regression models cannot also resolve the multicollinearity problem.

5.5 Industry level analysis

The main focus of the regression analysis in this study is to find any differences in productivity between Period 1 (ICC = 1) and Period 2 (ICC = 0). The dataset structure used in the previous sections is based on annual values of RT, AT, and EMP of individual freight rail transportation companies. Because of the limitation of analysis with unbalanced datasets, the authors made a new dataset structure based on the annual values of RT, AT, and EMP at an industry level. In each of the 41 fiscal years, the data items such as RT, AT, and EMP are averaged and converted into log-transformed data. The dimension of the dataset is a single dimension of 41 years of observations. Table 13 presents the descriptive statistics of log-transformed averaged RT, AT, and EMP items.

Equation (5) is the same as equation (4) except for no j index because the dataset is summarized by the time variable (FY). equation (5) is used for the industry-level regression analysis.

$$ln(RT_i) = ln(A) + \alpha\, ln(AT_i) + \beta\, ln(EMP_i) + \gamma\, ln(GAS_i) + \delta\, ICC + \varepsilon_i \qquad (5)$$

where i = fiscal year 1980 ~ 2020, RT = Revenue Total, AT = Asset Total, EMP = Number of Full-Time Employee, GAS = Average Retail Gas Price, ICC (1 if ICC exists, otherwise 0).

Tables 14 and 15 present the results from the pooled regression model using the industry dataset and its test statistics. The p-values of coefficients in the rail industry are zero except for the coefficient of ICC (0.012). There is no violation of OLS assumptions.

	Coefficient	p-value
Intercept	1.809	0.000
ln(AT)	0.772	0.000
ln(EMP)	0.239	0.000
ln(GAS)	0.222	0.000
ICC	0.171	0.000
Model fit	Wald $\chi^2 = 13{,}076.90$, $p = 0.000$	

Source(s): The author's own work

Table 12. Feasible general least square panel regression model

	ln(AT)	ln (EMP)	ln (RT)
n	41	41	41
Mean	23.14	9.97	22.27
Median	23.17	9.99	22.24
S.D.	0.94	0.18	0.70
Min	21.73	9.64	21.29
Max	24.72	10.26	23.48

Source(s): The author's own work

Table 13. Descriptive Statistics of industry/sector level dataset

5.6 TFP comparison

This study is interested in the values of TFP for each period, which is the sum of the intercept and a coefficient of dummy variable, ICC. Table 16 presents the intercepts and coefficients of ICC from Table 14, and the sum of both values. Because equation (5) is transformed with log functions, the "*ln(A) + Coefficient of ICC*" values are reversed with exponential functions to get the TFP values. Comparing the TFP values between Period 1 (ICC = 1) and Period 2 (ICC = 0), shows that the TFP value of Period 2 is lower than that of Period 1. Thus, the TFP value of the rail industry decreased by 8.24% from Period 1 to Period 2. Therefore, when comparing the TFC values between the two periods, there is a decreasing TFC value in the rail industry.

6. Discussion

As we mentioned earlier, technology innovations and industry policy can explain the improvement of TFP values. In the US freight transportation industry, intermodal transportation and deregulation are good examples of technology innovations and industry policy (Gallamore, 2019). Moore (2007) mentioned that as a result of the Staggers

Table 14. Results from the pooled regression model

Intercept (p-value)	A (p-value)	B (p-value)	γ (p-value)	δ (p-value)	R^2
4.907 (0.000)	0.651 (0.000)	0.214 (0.001)	0.251 (0.000)	0.086 (0.012)*	0.995

Note(s): * > 0.01
Source(s): The author's own work

Table 15. Test statistics and results

Test	Results
VIF for Multicollinearity	ln(AT) 7.67 ln(EMP) 3.98 ln(GAS) 3.87 ICC 1.66 Result: No Multicollinearity
Breusch–Pagan test for Heteroskedasticity (Ho: Homoskedasticity)	$\chi^2 = 0.63$ p-value = 0.4282 Result: Homoskedasticity
Durbin–Watson test for autocorrelation (Ho: No autocorrelation)	DW d (5, 41) = 1.431 d_l(5,40, 0.01) = 1.047 d_u(5,40, 0.01) = 1.583 Result: No autocorrelation

Source(s): The author's own work

Table 16. Total factor productivity

Period	Period 1 (ICC = 1)		Period 2 (ICC = 0)
(a) ln(A)	4.907		4.907
(b) Values from ICC variable	0.086		0.000
(c) (a) + (b)	4.993		4.907
(d) TFP = exp^(c)	147.4		135.2
(e) TFP change (%)		−8.24%	

Source(s): The author's own work

Rail Act of 1980, the rail industry developed trailer-on-flatcars and container-on-flatcars, which enabled intermodal transport services. According to the report ("Freight Rail and Intermodal") from the Association of American Railroads (AAR), the US rail intermodal volume has increased since the 1990s; in 2022, the intermodal service accounted for 27% of revenue for Class I US railroads.

According to AAR's other report ("Freight Rail and the Staggers Act of 1980"), the productivity of US freight railroads has increased continuously since 1981 (100%); it reached more than 250% in 1995. After the abolishment of the ICC, the productivity level has fluctuated around 240%. The ARR's productivity trends demonstrated that the dramatic phenomenon of rapidly increasing productivity had lasted 15 years between two notable events: the Staggers Act and the Termination of the ICC. There were no more dramatic productivity increases after the ICC abolishment.

According to the report from US DOT BTS (2021), labor productivity and TFP of the rail industry for 30 years from 1990 (100%). Labor productivity had increased continuously from 1990 to 2020, except for the financial crisis of 2009, which was in line with the labor productivity trend analysis in this study; While TFP had increased up to 140% in 2003, TFP had a stable pattern between 140 and 145% from 2004 to 2020. In this paper's analysis, TFP in Period 2 was lower than in Period 1, which confirmed the findings of Martland (2006, 2012) that the productivity growth came to an end in the early 21st century.

The STB (2009) published a report about the competition in the US rail industry, which was initiated by the recommendation from the US Government Accountability Office to check the possible market power abuse by the US railroad carriers. The STB report used the ratio of price over marginal cost as a measure of exercising market power. The STB found that in the years from 1987 to 2006, there was no evidence for the Class I rail industry to earn above normal profit, and in 2007 and 2008, the railroad rate increase was a result of declining productivity growth and increased cost. This result is similar to the HHI trends in the rail industry in Figure 2; in 2005, the HHI values of the rail industry jumped up from a competitive market to a moderately concentrated market, which confirmed the findings of McCullough (2005) that the rail industry market was no more competitive in the early 21st century.

Many studies in the existing literature evaluated deregulation's effect on productivity of US freight transportation in the 20th century and a few studies extended their study into the first decade of the 21st century. While the studies regarding the productivity of the 1980s and 1990s concluded that the deregulation of the rail industry had a positive effect on the industry's productivity growth, the studies regarding the productivity of the early 21st century pointed out that the growth rate of productivity was slowed down after 2 decades of deregulation. This paper extended their analyses for 10 more years with a publicized dataset of the freight transportation companies; the author concluded that, despite a continuous increase of labor productivity for 41 years, the rail industry had become less competitive and that there had been lower TFP in the last 25 years since the abolishment of the ICC. In summary, after the Staggers Rail Act of 1980, the US rail industry experienced regulatory changes and technological improvements to boost industry productivity, which led to the industry becoming competitive. After the ICC abolishment, the US rail industry had a decline in productivity, the number of rail companies shrank, and the rail industry became less competitive.

The findings of this study have several managerial and policy implications for deregulation and productivity in the US freight rail industry. Rail industry managers should understand the impact of deregulation on productivity over the long term and adapt to the changing environments of the industry after deregulation occurs. This study underscores the importance of technological improvements along with the deregulation of the rail industry. The rail industry managers need to consider investing in modernized infrastructure and leveraging new technologies to improve operational efficiency. Policymakers should consider both short-term and long-term effects when they make regulatory frameworks for the freight rail industry and they need to continuously monitor the industry's competitiveness. When policymakers make new regulatory frameworks, they also need to consider encouraging investments in infrastructure modernization and helping the adoption of new technology for the rail industry's improvement in productivity.

7. Conclusion and limitation

This study analyzes 41 years of data from the US rail industry to find out if there were changes in competition level and productivity. This study also checks how the level of competition and productivity are after the milestone year of 1995 and in the 21st century. Eliminating the ICC was expected to give the freight transportation industry more economic freedoms to boost the competition in the market, to increase the efficiency of operations, and to increase the productivity of the transportation industry. However, after the ICC abolishment, even if labor productivity has risen continuously during the 41 years, the rail industry experienced less competition and lower total factor productivity compared to the first 16 years of the deregulated period by the ICC.

This study has also limitations regarding the output measure and labor input measure. For the output measure, most previous studies used ton-miles as an output of the freight transportation industry. According to the US Bureau of Transportation Statistics (2016), a ton-mile is the most frequently used measure of freight transportation output. It is defined as "one ton of freight shipped one mile". Revenue-ton-mile is defined as "the revenue earned for transporting one ton of freight across one mile". Therefore, total revenue-ton-miles is the appropriate measure of freight transportation output in terms of dollar value. However, since total revenue-ton-miles is not available in the annual financial statements of freight transportation companies, RT was used as an output measure in this study. For the labor input measure, when calculating labor productivity and TFP, the number of full-time employees was used as a proxy of labor input, which includes neither contracted workers nor part-time workers. The total number of hours worked, including both full-time and part-time employees, is a more appropriate measure of labor input. Since labor statistics such as the number of hours worked are not available in the annual financial statements, the number of full-time employees was used as an input factor in this study.

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