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The Effects of the Interstate Commerce Act on Transport Costs: Evidence from Wheat Prices

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Abstract There is significant debate over the effect of the Interstate Commerce Act (ICA) on the cost of rail transport to shippers. Taking price differences across locations as proxy for transport costs, we use data on wheat prices before and after the implementation of the ICA to see if the Act led to smaller differences in wheat prices across American cities relative to a control group of European cities. We find that the ICA had no effect on US transport costs; however, it reduced their volatility substantially. This evidence supports the view that the ICA helped stabilize cartel prices after a period of significant price wars.

Keywords Cartel · Price wars · Railroad · Regulation · Threshold regression

1 Introduction

The Interstate Commerce Act (ICA) was adopted in the United States over 125 years ago to address pricing practices by the railroad industry that were perceived as yielding prices that were too high and also discriminatory across markets. As part of the legislation, the Interstate Commerce Commission (ICC) was formed to monitor prices and policies of the railroad industry. The main charge of the ICC was to ensure fair and just prices that were publicly posted, and to prohibit (except in special circumstances)

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price discrimination—particularly in cases where rates were higher for shorter routes than for longer routes.

Given the explicit cartel activities by railroads prior to the legislation and the fact that so many short-haul routes faced service from only a single (monopoly) railroad provider, the effect of such legislation on competition and prices in the industry might be expected to be quite substantial and non-controversial. In other words, the traditional view was that the ICA should have led to generally lower freight rates and had pro-competitive effects on the market.

However, a number of important reasons have been given for why such effects are far from certain. First, as hypothesized by Kolko (1965), state regulations on railroads were abundant beginning in the mid 1800s and may have already imposed regulations that were as strenuous as the federal regulations that came into effect with the ICA.

Second, the ICA legislation was far from specific in the charge that it gave to the ICC to regulate the industry. Thus, it is not clear that the ICA would lead to any tangible changes in industry behavior. Perhaps more intriguing is what Gilligan et al. (1990) terms the revisionist interpretation that the ICA provided stable cartel prices after an extended period of volatile price wars.[1] Stabilization of the cartel would mean greater profits for the railroads at the expense of consumers. Relatedly, one of the more specific parts of the regulation was the requirement that railroads make their rates public. While this created transparency, it could also have had the unintended effect of helping to support collusion amongst railroad firms.

Finally, Aitchison (1937), MacAvoy (1965) and others document how a string of court rulings within the first decade of the Act led to potentially significant mitigation of the ICA's scope and the ICC's power to enforce the ICA.

Despite the theoretical ambiguity of ICA effects, there has been little analysis to assess quantitatively its economic effects due in large part to data availability issues. Spann and Erickson (1970) use industry level data on railroad costs and quantities, rate changes across short- and long-haul routes, and assumptions on demand to estimate the consumer surplus effects of the ICA. Key to their analysis is evidence from a survey of rates that indicate the extent to which long-haul rates increased and short-haul rates fell due to the non-discrimination statutes of the ICA. They estimate that the losses to consumers from rate increases on the long-haul routes were twice as large as the gains on the short routes from lower rates. In a follow-up study, however, Zerbe (1980) shows a number of errors in the Spann and Erickson (1970) calculations that lead to a quite opposite conclusion: Gains in the short-haul routes outweigh the losses in the long-haul routes. A related concern for both studies is that they use "a small sample of 1886 and 1890 prices for various distances" as their key data (Spann and Erickson 1970, p. 239).

Another set of papers has used event study analysis to examine the impact of ICA-related events on the stock prices of railroads during the period. According to the well-known capital-asset pricing model (CAPM), changes in a firm's stock price should directly reflect changes in a firm's expected future discounted profits. Binder (1985) studies over 20 different US regulatory events, and finds no statistically significant

[1] See Porter (1983) for an interesting theoretical and empirical analysis that confirms switches in industry behavior from cartel pricing to non-cooperative oligopoly pricing in the years immediately preceding the ICA.

abnormal returns to the related firms' stock price returns when most of these regulatory acts were publicly announced, including in the case of the ICA. This leaves open the question of whether the regulatory events had no effect on firms' profits or whether the event study approach is not adequate for identifying such effects.

Prager (1989) focuses explicitly on the events surrounding the ICA and subsequent court rulings in the 1890s that may have significantly affected the interpretation of the ICA or the abilities of the ICC to enforce it. Her analysis finds some evidence of a modest positive abnormal return for the railroads from the passage of the ICA, but stronger evidence that subsequent court rulings that limited the powers of the ICC had significant negative effects on railroad's profitability. This provides evidence in favor of the revisionist view that the ICA was (initially) more beneficial to the railroads than the farmers and other users of rail transport.

Gilligan et al. (1990) also conduct an event study analysis of railroad firms' returns from ICA events and finds widely heterogeneous responses across both railroads *and shippers* (i.e., users of rail transport) to the introduction of the ICA, depending on such factors as whether they were mainly associated with short- or long-haul routes, and whether they mainly served agricultural regions. They find some modest evidence that shippers on short-haul routes and railroads on long-haul routes benefitted from the passage of ICA. But like Prager (1989) they also find that these effects were largely reversed by subsequent court decisions.

Beyond Spann and Erickson (1970) small survey of post-ICA changes in rail rates, a few other studies have collected data on railroad transport rates from this time period, but don't really focus on evaluating the effects of the ICA. MacAvoy (1965) looks at movements in shipments, rail rates, and price differences between Chicago and New York for wheat and lard, both before and after the ICA. However, he does not use the data to look for any systematic change due to the ICA. Binder (1985) uses similar data to examine the impact of a 1897 court ruling that the railroad industry violated the 1890 Sherman Antitrust Act (not the ICA) on rail industry performance, and finds no effect of the ruling on rates charged to transport lard between Chicago and New York.

A real issue for these studies is data availability, as they only rely on available rates for a few commodities for one route (Chicago to New York). Also, they use posted rates; but there is the real concern that railroads provided special deals to enough customers even after the ICA that the effective rates could be quite different from posted rates (MacAvoy 1965). As a way around the difficulty of finding available and appropriate data on transport costs, recent literature has refined techniques to infer (or estimate) transport costs across locations using more available data on differences in market prices of commodities at each location. Such studies include O'Rourke et al. (1996), Ejrnaes and Persson (2000), Persson (2004), Jacks (2005, 2006), Shiue and Keller (2007), and Donaldson (forthcoming).

In this paper, we use a rich dataset on estimated transport costs for wheat constructed by Jacks (2005, 2006) for a large set of US and European cities in the 1800s and early 1900s to evaluate the effect of the ICA. Grains have been a major commodity class for railroads throughout history, with wheat comprising a large share of grain transport. Jacks estimates implied transport costs using wheat price differences for over 10,000 city pairs from 1805 to 1910. While an ideal data set would have such observations for freight rates, rather than estimated transport/arbitrage costs, Jacks database is the best that is available. We employ a difference-in-differences strategy to examine whether US cities saw significant changes to these transport costs in the wake of the ICA in 1887. The many European city pairs in the data provide a useful control group to allow us to identify the ICA effects on transport costs from common technological, demand, and supply shocks.

Our analysis uncovers a number of new and interesting results: First, there is no statistical evidence that US wheat transport costs experienced any systematic change from the introduction of the ICA relative to world trends. This contrasts with the traditional view that railroad rates would fall substantially in the wake of the ICA, but is consistent with revisionists' arguments that the ICC interpretation of the ICA and initial court rulings strongly mitigated any need for the railroads to adjust their rate structures. In contrast, we find that volatility in transport cost changes appears to decline significantly with the introduction of the ICA. This contrasts with the years immediately prior to the ICA, which were characterized by sharp declines in transport costs relative to trends. This evidence is consistent with the revisionist view that the ICA helped stabilize cartel prices after a period of significant price wars.

2 The Debate on the ICA and Its Causes and Consequences

There are two types of views that are typically offered for why the ICA was ultimately introduced in the US Congress and passed into law. The traditional view is that high transport rates by railroads, particularly monopoly prices charged by railroads on shorter routes in agricultural regions, were the primary motive for the ICA. And this view makes much sense. The well-known Granger Movement was a coalition of farmers in agricultural regions of the United States that organized in the 1860s and 1870s expressly to combat what were seen as monopoly prices by railroads to ship their products. They were able to push many states to adopt significant regulation on railroads prior to the passage of the ICA (see Buck 1921; Miller 1971). Relatedly, Benson (1955) argues that merchants on the eastern seaboard of the US were another group of downstream consumers of railroad transport that were also upset at high rates and that were an important lobbying group for the ICA.

Examination of many of the main sections of the ICA regulation supports the traditional view as well. After an initial section defines terms, Sects. 2, 3, and 4 specifically address prices and make "unjust discrimination" illegal. Section 4 explicitly makes it illegal for a railroad to charge

> greater compensation in the aggregate for the transportation of passengers or of like kind of property, under substantially similar circumstances and conditions, for a shorter than for a longer distance over the same line, in the same direction, the shorter being included within the longer distance …

Section 5 makes pooling of freight rates illegal, and Sect. 6 establishes the ICC to enforce the ICA, with broad powers to "inquire into the management of the business of all common carriers subject to the provisions of this act." Thus, taken at face value, the ICA seemed quite intent to make certain that railroads charged "just" and "non-discriminatory" prices, with an oversight body given substantial powers to enforce this mandate.[2] And this would presumably remedy the key complaints by farmers and merchants, and lead to lower rates, particularly on those routes that had little or no competition.

Kolko (1965) and MacAvoy (1965) are typically credited with introducing a revisionist view of the ICA, which has been supported by writings and analysis of subsequent studies, including Spann and Erickson (1970) and Ulen (1980). The revisionist view begins by noting that the railroads had not been able to sustain cartels in the decades prior to the ICA, with clear evidence of major oscillations from periods of cartel pricing to substantial price wars. (see, e.g., Porter 1983). From this point the revisionist view splits a bit. Kolko (1965, p. 52) argues that because of their inability to maintain their cartels, railroads were big supporters of the ICA because the newly-formed ICC could coordinate cartel prices, concluding that "using the new law as authority the railroads revamped their freight classification, raised rates, eliminated passes and fare reductions, and revised less-than-carload rates on all types of goods, including groceries."[3,4] In contrast, Ulen (1980) suggests that the railroads had developed much more stable methods of maintaining their cartels (at least in normal market periods) in the early 1880s, and the ICA was basically ineffectual and did not prevent the railroads from maintaining their cartels. In this view, the railroads were not big supporters of passing the ICA, but were also not very concerned about its passage.

Regardless of one's view about the intent of the ICA, it is clear that a number of subsequent events likely weakened its effects. First, MacAvoy (1965, p. 113) suggests that the ICC's first report setting practical standards in implementing the ICA "left the strong impression at once that rate discrimination, within prescribed limits, was legal." In other words, interpretation of the law under the ICC would be broad, not strict, thus mitigating the potential policy impact of the ICA. Perhaps more important were a number of subsequent court rulings in the following decade that questioned the ICC's role in setting rates in the industry (the "Maximum Freight" case of 1897) and that struck down existing ICC standards and broadened interpretations of the ICA short-haul/long-haul sections (the "Osborne decision" of 1892, the "Social Circle case" of 1893, and the "Troy case" of 1897). Echoing the sentiment of much of the literature, Aitchison (1937) concludes that by 1897 court decisions had rendered the existing ICA "futile."

3 Hypotheses

Given our data, we wish to examine how the ICA affected US transport costs, where railroads were a significant portion of transport for the commodity that we examine:

[2] See Aitchison (1937) for a detailed description of the ICA.

[3] He also notes a memo from an ICC Commissioner, Aldace F. Walker, who resigned after his first 2 years to take another position, indicating the Commissioner's opinion that the ICC was more effective at maintaining cartel prices than the railroads' own "pool" prior to the ICA.

[4] Relatedly, the "Wabash decision" in 1886 was a court ruling that prohibited states from regulating railroads on interstate transport, setting the stage for the passage of the ICA to establish federal regulation of interstate transport. This is viewed by many as a substantial gain for railroad interests as well, because it eliminated many state regulations that had become quite severe in some circumstances.

wheat. However, from the discussion above, it is difficult to get a definitive hypothesis from the literature about what effects the ICA would have on railroad rates. This may be especially true of long-haul rates, which we believe our analysis will primarily identify from using the major city-pairs in our data. Given this, our null hypothesis is that the ICA did not have any statistically significant effect on the long-haul transport costs that we examine.

The most obvious alternative hypothesis is that transport costs on long-haul routes rose after the ICA due to two reasons. First, the anti-discrimination provisions of the ICA would put pressure on the railroads to raise more competitive long-haul rates, while decreasing rates on monopolized short-haul routes.[5] Second, the transparent posting of prices and the involvement of the ICC to mediate rate wars could help support more stable and higher cartel prices on the competitive long-haul routes. A second alternative hypothesis is that transport costs *fall* in our sample after the ICA. This would be the case if many of our routes were actually monopolized at the time (despite being fairly long-haul distances) and therefore saw pressure for them to fall in order to satisfy anti-discrimination requirements.

We can also examine the extent to which the ICA affected the *volatility* in transport costs due to the ICA, which is a novel question for the literature on the effects of the ICA.[6] In fact, an examination of this issue can help us assess which of the two revisionist's viewpoints is correct: Did the ICA help create a stable cartel for the railroads? Or was it largely ineffectual in altering market behavior? Our null hypothesis is that there is no effect of the ICA on the volatility of transport costs. This would be supportive of the revisionist point of view that argues that the ICA was ineffectual and did not alter market behavior. The alternative hypothesis is that the ICA reduced volatility due to the creation of a more stable cartel environment, as suggested by others from the revisionist viewpoint. There do not appear to be any implications for the effect of the ICA on transport cost volatility that stem from the traditional viewpoint.

4 Data

Our aim is to evaluate the economic effects of ICA on the US rail transportation sector, by comparing them to the outcomes in a control group that is formed by markets that were not targeted by the policy change. For this effort, one needs consistent data on transport costs across both US and non-US locations for a sufficient time period, both before and after the implementation of the ICA. This is a seemingly impossible data task for a period such a long time ago. However, there have been a number of recent

[5] Spann and Erickson (1970) estimate from their limited survey that rates fell 15–30 % on short-haul routes and went up only slightly on long-haul routes. MacAvoy (1965) provides a more detailed, and complicated, picture about how rates changed. Posting of public rates subsequent to the passage of the ICA appears to have led to the elimination of "special", discriminatory rates for certain customers, tending to keep rates higher. Yet, even within the first year, there were examples of competitive rate decreases on the longer haul routes.

[6] Dennis (1999) is an example of the estimation of the impact of railroad deregulation on volatility of transport costs in another (more modern) setting: steam coal rates after the 1980 deregulation.

efforts in the trade and economic history literatures to infer trade and transportation cost information from the commodity price margin between two locations (Shiue and Keller 2007; Jacks 2005, 2006; Ejrnaes and Persson 2000; Canjels et al. 2004; Goodwin and Grennes 1998).

For this project we use the dataset from Jacks (2005, 2006), which includes an impressive set of variables that characterize the wheat markets across cities in the US and Europe during the nineteenth century. The unbalanced sample covers a total of 102 cities from 10 countries (see Appendix Table 5 for a complete list of country and city coverage), which are observed at 5-years intervals over the period 1805–1910. The thirteen US cities covered in our sample are Alexandria, Chicago, Cincinnati, Indianapolis, Ithaca, Kansas City, Minneapolis, New Orleans, New York City, Philadelphia, Richmond, St. Louis, and San Francisco. Importantly, grain was the primary product transported by rail during this period. Ripley (1906) reports that 73 % of all rail tonnage was grain as of 1882.[7]

A unit of observation in our dataset is a city pair. For each city-pair, we have information on geography (distance, waterways, border), current transportation technology (railroads, water), indicators of social and economic integration (common language, gold standard adherence, monetary union, ad valorem wheat tariffs, trade prohibition), and conflict variables (effects of war and war alliances). Critical for our analysis, the dataset from Jacks (2005, 2006) includes estimates of trade costs at the city-pair level, covering the entire sample period. In this paper, we will use the estimated trade costs as a proxy for the transportation cost between two locations. Even though Jack's estimated trade costs may capture other trade frictions than transportation costs, the ability to directly control for these alternative impediments to trade mitigates this problem. Table 1 reports the summary statistics for the variables in our sample.[8] Given the methodology below, the transportation costs are measured as a percent (in decimal form) of the average wheat price across the two cities in the bilateral-city pair.

The methodology to uncover transportation costs between locations using only price data is founded on the simple idea of arbitrage. Whenever the wheat price difference between two locations becomes larger than the cost of transporting the good, arbitrage will occur so that the price difference is no larger than the transport cost. Following the notation of Jacks (2005, 2006), suppose transport costs in a given time period t from city 1 to city 2 are denoted as C_t^{12}, and transport costs in the reverse direction in time period t are denoted as C_t^{21}. Then the difference in the two prices in cities 1 and 2, P_t^1 and P_t^2 respectively, will satisfy the following conditions due to arbitrage:

$$-C_t^{12} \leq (P_t^1 - P_t^2) \leq C_t^{21} \tag{1}$$

$$-C_t^{21} \leq (P_t^2 - P_t^1) \leq C_t^{12} \tag{2}$$

[7] We are unable to find data for only wheat shipments for this general period, even from Interstate Commerce Commission reports, but others (e.g., Fogel 1964) note that wheat and corn were the two main grain shipments at the time.

[8] See Table 2 in Jacks (2006) and related online data appendices at http://www.sfu.ca/~djacks/data/publications/publications.html for further details on data sources and measurement.

Table 1 Summary statistics

Variable	Obs	Mean	SD	Min	Max
Transportation cost	11,578	0.384	0.267	0	1.954
Distance (thousands of miles)	11,578	2.531	3.232	0.030	27.270
Distance squared (millions of miles)	11,578	16.846	48.548	0.001	743.649
Exchange rate volatility	11,540	0.005	0.019	0	0.156
Border	11,578	0.466	0.499	0	1
Railroad	11,578	0.440	0.485	0	1
Railroad × distance	11,578	571	1,342	0	8,079
Canal	11,578	0.050	0.218	0	1
River	11,578	0.028	0.166	0	1
Port	11,578	0.099	0.299	0	1
Gold standard	11,578	0.111	0.302	0	1
Monetary union	11,578	0.021	0.142	0	1
Common language	11,578	0.065	0.247	0	1
Ad valorem (tariff)	11,578	0.070	0.158	0	0.983
Prohibition	11,578	0.073	0.197	0	1
Neutral	11,578	0.026	0.093	0	1
Allies	11,578	0.008	0.077	0	1
At war (external)	11,578	0.014	0.102	0	1
At war (internal)	11,578	0.051	0.167	0	1
Civil war (external)	11,578	0.021	0.086	0	0.621
Civil war (internal)	11,578	0.019	0.081	0	0.621

The sample covers the time period 1805–1910 in 5-years intervals. Transportation costs are measured as a percent (in decimal form) of the average wheat price across the two cities in the bilateral-city pair. See Table 2 in Jacks (2006) and related online data appendices at http://www.sfu.ca/~djacks/data/publications/publications.html for further details on data sources and measurement

This setting allows Jacks to estimate transport costs and speed of arbitrage (or "adjustment") through a regression technique called an asymmetric-threshold error-correction-mechanism (ATECM) model.[9] The intuition is that the change in prices for a given city each period follows a random walk (due to exogenous shocks in the local environment) unless that city's price differential with another city is greater than the transport costs between the two cities; that is, one of the conditions in Eqs. (1) or (2) is violated. When a condition is violated, there will be arbitrage of the prices from period $t-1$ to period t. The degree of arbitrage that can occur in one period is captured by an adjustment parameter, $-1 \leq \rho \leq 0$, where a value of -1 indicates complete arbitrage in just one period. Denoting, a city i's change in prices from period $t-1$ to period t as ΔP_t^i, we can write down the following ATCEM model for the adjustment in prices over time for the city pair:

[9] Further details on the econometrics of threshold regression techniques can be found in Balke and Fomby (1997), Hansen (1997), and Hansen and Seo (2002)

$$\Delta P_t^1 = \begin{cases} \rho_1 \left(P_{t-1}^1 - P_{t-1}^2 - C_{t-1}^{21}\right) + \eta_t^1 & \text{if} \quad P_{t-1}^1 - P_{t-1}^2 > C_{t-1}^{21} \\ \eta_t^1 & \text{if} \quad -C_{t-1}^{12} \leq \left(P_{t-1}^1 - P_{t-1}^2\right) \leq C_{t-1}^{21} \\ \rho_1 \left(P_{t-1}^1 - P_{t-1}^2 + C_{t-1}^{12}\right) + \eta_t^1 & \text{if} \quad P_{t-1}^1 - P_{t-1}^2 < -C_{t-1}^{12} \end{cases} \quad (3)$$

$$\Delta P_t^2 = \begin{cases} \rho_2 \left(P_{t-1}^2 - P_{t-1}^1 - C_{t-1}^{12}\right) + \eta_t^2 & \text{if} \quad P_{t-1}^2 - P_{t-1}^1 > C_{t-1}^{12} \\ \eta_t^2 & \text{if} \quad -C_{t-1}^{21} \leq \left(P_{t-1}^2 - P_{t-1}^1\right) \leq C_{t-1}^{12} \\ \rho_2 \left(P_{t-1}^2 - P_{t-1}^1 + C_{t-1}^{21}\right) + \eta_t^2 & \text{if} \quad P_{t-1}^2 - P_{t-1}^1 < -C_{t-1}^{21} \end{cases}, \quad (4)$$

where we assume $(\eta_t^1, \eta_t^2) \sim Nid(0, \Omega)$. The system of equations can then be estimated via seemingly unrelated regression (SUR), where the log-likelihood function is

$$\log L = -\frac{TM}{2} \log(2\pi) - \frac{T}{2} \log|\Omega| - \frac{1}{2} \sum_{t=1}^{T} \eta_t' \Omega^{-1} \eta_t, \quad (5)$$

where T is the number of observations, and M is the number of equations.

While it is straightforward to see how the adjustment speed parameters, ρ_1 and ρ_2, are estimated in this model, the major complication is unavailable data on transport costs—the key variables of interest to our study. Jacks (2005, 2006) is able to estimate these transport costs within the estimation system by calculating the log-likelihood for all possible transport cost values for any given pair of city in a given time period, and choosing the combination of transport costs, $C_{t-1}^{12}$and C_{t-1}^{21}, that maximize the log-likelihood function for the observed set of prices. Through this computationally intensive procedure, he can then provide estimates of C_{t-1}^{12} and C_{t-1}^{21} and their standard errors. It is these estimates that we can then use for our estimation of the effects of the ICA on US transport costs.

5 Empirical Strategy

Our empirical strategy is to employ a difference-in-difference estimator to test whether the ICA reduced transport costs across US cities after it was introduced in 1887, vis-à-vis a control group of non-affected (i.e., non-US) cities.[10]

In line with Jacks (2006), we specify a model for the determinants of the bilateral transport costs that characterize any two cities in our sample. Conditioning on other trade frictions that inhibit arbitrage (i.e., wheat trade) and price convergence over space, we evaluate the marginal contribution of the ICA to changes in transportation

[10] A difference-in-differences specification simply estimates the relative effect of a "treatment" on a treated group vis-à-vis a non-treated (or control) group with respect to a particular outcome (here, wheat transport costs). This relative difference-in-difference effect is typically estimated by an interaction of a variable that indicates a "treated" observation and a variable indicating the period of treatment. This is exactly how our ICA_{ijt} variable is defined in Eq. (6), where the "treatment" is the ICA and our treatment group is the US city-pairs in our sample. See Meyer (1995) and Angrist and Pischke (2008) for general discussion of the methodology.

costs. The baseline regression model that we take to the data is given by the following equation:

$$\begin{aligned} TransportCost_{ijt} = {} & \beta_0 ICA_{ijt} + \beta_1 Dist_{ij} + \beta_2 DistSq_{ij} + \beta_3 ExRateVol_{ijt} \\ & + \beta_4 Border_{ij} + \beta_5 Rail_{ijt} \\ & + \beta_6 (Rail \times Dist)_{ijt} + \beta_7 Canal_{ijt} + \beta_8 River_{ij} + \beta_9 Port_{ij} \\ & + \beta_{10} GoldSt_{ijt} + \beta_{11} MU_{ijt} \\ & + \beta_{12} CommonLang_{ij} + \beta_{13} AdValorem_{ijt} \\ & + \beta_{14} Prohibition_{ijt} + \sum_k \omega_k Conflict_{kijt} + u_t + \varepsilon_{ijt} \end{aligned} \tag{6}$$

where i, j and t index the origin city, destination city and year, respectively; and u_t denotes year fixed effects. The variable of interest is *ICA*, which is an indicator variable that takes the value of 1 for all US city pairs and all years following 1887, and zero otherwise. The coefficient β_0 is identified from any systematic time variation in bilateral transport costs after 1887 across city-pairs within the US relative to the global transportation costs trend.

Many of the transport costs determinants included in the regression model are not only standard in the trade literature, but also very intuitive. There is no doubt that bilateral distance ($Dist_{ij}$) affects the cost of shipping wheat between two cities, and the squared distance term ($DistSq_{ij}$) adds flexibility to the estimation, allowing for possible non-linearities in the relation between distance and transport costs. Similarly, crossing a country border ($Border_{ij}$) or sharing a common language ($CommonLang_{ij}$), both represent trade costs that directly influence the profitability of a cross-border transaction.

The exchange rate volatility ($ExRateVol_{ijt}$) affects the cost of trading internationally by adding more risk to the transactions. Thus we expect β_3 to be positive. Unlike the unexpected exchange rate shocks, participation in a monetary union (MU_{ijt}) or adherence to the gold standard ($GoldSt_{ijt}$) provides a deeper level of economic integration, which brings more certainty and stability in trade transactions. This implies that $\beta_{10}$and β_{11} should be positive.

The transportation technology that is available between two cities at a point in time is another crucial determinant of the bilateral transport cost. The availability of railroads connecting two locations, their differential benefit for long- versus short-haul transport ($(Rail \times Dist)_{ijt}$),the availability of canals ($Canal_{ijt}$) and rivers ($River_{ij}$) connecting two cities, as well as the development of city ports ($Port_{ij}$), all contribute towards facilitating the movement of wheat between markets in search for arbitrage opportunities, thus contributing to an increased level of market integration.

The existence of ad valorem import tariffs for wheat ($AdValorem_{ijt}$) or, even worse, prohibitions on wheat imports ($Prohibition_{ijt}$) directly affect the profitability of engaging in price arbitrage, and thus on the extent of price convergence and wheat market integration across cities.

Finally, given the turbulent periods of the nineteenth century, the regression model accounts for a vector of military-conflict-related variables ($Conflict_{kijt}$) that Jacks

(2005, 2006) includes: We control for the fraction of time in a decade that the countries of each city in the pair are in a war with each other ($Atwar(external)_{ijt}$), that the two countries are allied in war against a common enemy ($Allies_{ijt}$), or one of the two trading partners is neutral when the other trading partner is at war ($Neutral_{ijt}$). We also control for the fraction of time that two trading partners (from the same country) see their country at war with another country ($Atwar(internal)_{ijt}$). In addition, we include two war variables that are analogous to ($Atwar(external)_{ijt}$) and ($Atwar(internal)_{ijt}$), except for the case of a civil war rather than a war between two different countries—($Civilwar(external)_{ijt}$) and ($Civilwar(internal)_{ijt}$). The war-time measures are expected to have a negative effect on commercial relations, and thus increase transport costs, while being "neutral" or "allies" may have positive effects on commercial relations, as they mitigate the negative effects of war.

Since the dependent variable is an estimated variable, we estimate Eq. (6) using the generalized least squares (GLS) method, and rely on the number of observations used for generating the dependent variable as analytical weights.[11] Furthermore, because the transport cost variable is generated for each sample year based on monthly price data that span 10-years overlapping periods, we also impose a first-order autoregressive covariance structure.

While the model specification given by Eq. (6) controls for many transport cost determinants, there may be other city-pair variables that are omitted from the regression and possibly correlated with the ICA variable of interest. To account for this concern, we modify the baseline regression model by taking first differences. The resulting specification can be written as follows:

$$\begin{aligned}\Delta \ln TransportCost_{ijt} = {} & \delta_0 \Delta ICA_{ijt} + \delta_1 \Delta ExRateVol_{ijt} + \delta_2 \Delta GoldSt_{ijt} \\ & + \delta_3 \Delta MU_{ijt} + \delta_4 \Delta Rail_{ijt} + \delta_5 \Delta RailDist_{ijt} \\ & + \delta_6 \Delta Canal_{ijt} + \delta_7 \Delta AdValorem_{ijt} \\ & + \delta_8 \Delta Prohibition_{ijt} + \sum_k \lambda_k \Delta Conflict_{kijt} + u_t + \varepsilon_{ijt}\end{aligned} \tag{7}$$

Note that by first differencing the regression model given by Eq. (6), the time-invariant controls drop out from the estimation. At the same time, first differencing the data also mitigates concerns regarding the autocorrelation process that may be embedded by construction in our dependent variable. As before, we continue to use the number of observations underlying the data-generating process for the dependent variable as analytical weights, though necessarily taking the average over the two periods of the first difference.

The coefficient of interest is again δ_0, and measures the effect of ICA on the transport cost of wheat between two cities, holding constant other determinants of transport costs such as measures of economic integration (gold standard status, monetary union

[11] Jacks reports that results are robust to weighting by other related measures, such as the standard error or p value of the estimated transport costs. Saxonhouse (1976) provides the econometric theory for the application of such weights when using a generated dependent variable.

membership) or conflict/political instability. Note that by first differencing the ICA variable, the non-zero observations used in identifying the coefficient of interest δ_0 corresponds to year 1890. Thus, the initial assumption that we are making is that the effect of the ICA on transportation cost gets realized immediately (i.e., within a 5 years time interval), though we will later explore possible longer-run effects.

6 Empirical Results

6.1 Baseline Estimates

Table 2 reports the results from estimating the baseline regression model given by Eq. (6). For comparison purposes, column 1 reproduces the specification in Jacks (2006). Our estimates come very close to the ones that are reported in the original paper. They emphasize the main determinants of bilateral transport costs: distance and transportation infrastructure (ports, canals), trade frictions such as exchange rate volatility, ad valorem tariffs or trade prohibition, factors of economic integration such as gold standard adherence, monetary union participation, and, finally, conflict variables such as internal and external wars and civil wars.

In column 2 we add the ICA variable of interest, in addition to allowing for a separate intercept for US-only city pairs (i.e., $Domestic_{ij}$ control variable). The negative and significant coefficient for ICA suggests that transport costs between two US cities fell on average by 0.10 relative to the control group of non-US cities. When evaluated at the sample mean, this is equivalent to a fall in transport costs of 26 %.

In the next two columns of Table 1 we re-estimate the baseline model in Eq. (6) in log-log form.[12] The benefits of expressing the continuous variables in log form are two-fold. First, it attenuates the significant skewness observed in the distribution of some of the key variables. Second, it removes any scale differences among the regression variables, and mitigates any distortionary effects of outlier observations.

Comparing column 3 to column 1, one can notice the consistency in sign and significance level across the two specifications. The same observations apply for the results reported in column 4, relative to the corresponding estimates in column 2. Focusing on the variable of interest, we again find a negative and significant effect of ICA on the bilateral transport cost between US cities. The estimate suggests that, all else equal, the rail regulation instituted by the ICA has led to a 24.9 % drop in transport costs relative to the worldwide average trend. The magnitude of this effect is close to the corresponding estimate from column 2, and it is consistent with the range of price changes documented in the existing literature (e.g., see Spann and Erickson 1970).

Nevertheless, as discussed in the previous section, one concern with the current model specification is that it does not control for city-pair fixed effects. This may be problematic because of the incidence of omitted variable bias. For example, regional specialization and the agricultural output of a location are clear determinants of local wheat prices, directly influencing our estimated

[12] The continuous variables that we express in log form are the transport cost, distance, distance squared, rail × distance, exchange rate volatility, and ad valorem tariff.

Table 2 Baseline estimation

Dependent variable	Trade cost		Log trade cost	
	(1)	(2)	(3)	(4)
ICA		−0.099		−0.287
		[0.018]***		[0.042]***
Distance	0.024	0.022		
	[0.002]***	[0.002]***		
Distance squared	−0.001	−0.001		
	[0.000]***	[0.000]***		
Exchange rate volatility	1.164	1.155		
	[0.072]***	[0.071]***		
Border	0.177	0.195	0.328	0.347
	[0.011]***	[0.012]***	[0.029]***	[0.029]***
Railroad	−0.016	−0.014	−0.076	−0.079
	[0.010]	[0.010]	[0.018]***	[0.018]***
Railroad × distance	0.004	0.002		
	[0.003]	[0.003]		
Canal	−0.109	−0.110	−0.341	−0.346
	[0.013]***	[0.013]***	[0.035]***	[0.034]***
River	−0.028	−0.035	0.049	0.052
	[0.017]*	[0.017]**	[0.043]	[0.043]
Port	−0.019	−0.018	−0.056	−0.056
	[0.010]**	[0.010]*	[0.024]**	[0.024]**
Gold standard	−0.115	−0.120	−0.180	−0.190
	[0.010]***	[0.010]***	[0.024]***	[0.024]***
Monetary union	−0.011	−0.012	−0.019	−0.019
	[0.016]	[0.016]	[0.037]	[0.037]
Common language	−0.070	−0.069	−0.149	−0.148
	[0.013]***	[0.013]***	[0.031]***	[0.031]***
Ad valorem (tariff)	−0.002	−0.001		
	[0.014]	[0.014]		
Prohibition	0.163	0.161	0.126	0.134
	[0.016]***	[0.016]***	[0.039]***	[0.039]***
Neutral	0.023	0.025	0.022	0.027
	[0.022]	[0.022]	[0.050]	[0.050]
Allies	−0.027	−0.030	−0.146	−0.147
	[0.029]	[0.029]	[0.067]**	[0.067]**
At war (external)	0.090	0.085	0.088	0.086
	[0.028]***	[0.028]***	[0.064]	[0.063]
At war (internal)	−0.007	−0.008	0.050	0.048
	[0.021]	[0.021]	[0.047]	[0.047]
Civil war (external)	0.185	0.184	0.240	0.246

Table 2 continued

Dependent variable	Trade cost		Log trade cost	
	(1)	(2)	(3)	(4)
	[0.018]***	[0.018]***	[0.041]***	[0.041]***
Civil war (internal)	0.137	0.133	0.365	0.367
	[0.021]***	[0.020]***	[0.047]***	[0.047]***
Domestic		0.146		0.196
		[0.015]***		[0.038]***
Log distance			0.200	0.195
			[0.010]***	[0.010]***
Log distance squared			−0.042	−0.041
			[0.005]***	[0.005]***
Log (1 + exchange rate volatility)			2.952	2.905
			[0.171]***	[0.171]***
Railroad × log distance			0.042	0.044
			[0.011]***	[0.011]***
Log (1 + ad valorem tariff)			0.118	0.117
			[0.043]***	[0.043]***
Year fixed effects	Yes	Yes	Yes	Yes
Observations	11,539	11,539	11,537	11,537

The reported coefficients are obtained from text. The estimation method used is generalized least squares (GLS), with analytical weights given by the number of wheat price observations employed in the construction of the transport cost dependent variable

transport cost measure. Similarly, geography, climate, and the existence and availability of other modes of transport not directly controlled for in the model, represent additional examples of factors that may influence the estimated transport cost.

6.2 First Difference Estimates

Without directly controlling for unobservable city-pair fixed effects in the model, any systematic differences in transport costs that are specific to US cities are going to be picked up by the ICA indicator. To avoid such omitted variable bias, in what follows we estimate the regression model in first differences, as described by Eq. (7).

Table 3 reports the results. Column 1 includes only the transport cost determinants from the original Jacks (2006) paper, while column 2 adds our variable of interest, ICA. Unlike our initial estimates in Table 2, the effect of ICA on bilateral transport costs is not distinguishable from zero after controlling for the city-pair fixed effects.[13]

[13] Our first difference model imposes the constraint that the slope coefficients are common across US and non-US city pairs. In unreported results, we have experimented with a more flexible model specification that also includes interaction terms between the regression variables and the indicator for US domestic city-pairs. However, the ICA estimate remains insignificant.

Table 3 First difference estimation

Dependent variable	Δ Log trade costs			
	(1)	(2)	(3)	(4)
Δ ICA		−0.006	−0.006	−0.021
		[0.048]	[0.048]	[0.039]
ICA × year 1895			−0.016	
			[0.043]	
ICA × year 1900			0.040	
			[0.061]	
Δ ICA × ln distance				−0.094
				[0.053]*
Δ Exchange rate volatility	3.108	3.107	3.102	3.107
	[0.191]***	[0.191]***	[0.191]***	[0.191]***
Δ Railroad	−0.009	−0.009	−0.009	−0.009
	[0.027]	[0.027]	[0.027]	[0.027]
Δ Railroad × ln distance	−0.026	−0.026	−0.026	−0.026
	[0.013]**	[0.013]**	[0.013]**	[0.013]**
Δ Canal	0.191	0.191	0.190	0.191
	[0.069]***	[0.069]***	[0.069]***	[0.069]***
Δ Gold standard	−0.140	−0.140	−0.139	−0.140
	[0.037]***	[0.037]***	[0.037]***	[0.037]***
Δ Monetary union	−0.013	−0.013	−0.013	−0.013
	[0.036]	[0.036]	[0.036]	[0.036]
Δ Log ad valorem	0.090	0.090	0.090	0.090
	[0.051]*	[0.051]*	[0.051]*	[0.051]*
Δ Prohibition	0.113	0.113	0.112	0.113
	[0.044]**	[0.044]**	[0.044]**	[0.044]**
Δ Neutral	0.018	0.018	0.018	0.018
	[0.049]	[0.049]	[0.049]	[0.049]
Δ Allies	−0.201	−0.201	−0.200	−0.201
	[0.073]***	[0.073]***	[0.073]***	[0.073]***
Δ At war (external)	0.055	0.055	0.056	0.055
	[0.066]	[0.066]	[0.066]	[0.066]
Δ At war (internal)	0.037	0.037	0.039	0.037
	[0.044]	[0.044]	[0.044]	[0.044]
Δ Civil war (external)	0.107	0.107	0.107	0.107
	[0.047]**	[0.047]**	[0.047]**	[0.047]**
Δ Civil war (internal)	0.088	0.088	0.088	0.088
	[0.045]**	[0.045]**	[0.045]**	[0.045]**
Year fixed effects	Yes	Yes	Yes	Yes

Table 3 continued

Dependent variable	Δ Log trade costs			
	(1)	(2)	(3)	(4)
R^2	0.080	0.080	0.080	0.080
N	10,581	10,581	10,581	10,581

The reported coefficients are obtained from OLS estimations of the first differences regression model given by the Eq. (7) in the main text. For more estimation precision, the number of wheat price observations used in generating the transport cost dependent variable is used as weights in the model estimation
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; Robust standard errors in brackets

Recall however that by estimating the model in first differences, ΔICA takes the value of one only for the time interval 1885–1890 during which the policy was enacted; thus, the data variation for this time period represents the only source of identification for our coefficient of interest. This implies that the effect of ICA on transport costs must be realized within a short span of time. To investigate if there are any phase-in effects associated with ICA, in column 3 we allow for two additional ICA variables, corresponding to each 5-years interval period following year 1890. The results remain unchanged: ICA has neither an immediate nor a longer run effect on US bilateral transport costs.[14]

6.3 Short- Versus Long-Haul Estimates

The literature makes a distinction between the expected effects of the ICA on short- and long-haul rail rates. In the last column of Table 3 we explore this with our data by allowing the ICA effect to vary with distance. Focusing on the regulatory variables of interest, the estimates suggest that while the ICA has no significant effect on transport costs between proximate markets, it has a negative and significant effect on long haul routes. For a city-pair that is located 1,700 miles apart, such as New York to Minneapolis, the transport cost falls by a statistically significant 6.5 %, on average, as a result of the introduction of the ICA. This result is inconsistent with prior literature and may be due to the fact that we do not have routes that had low enough traffic to be monopolized, which seems to be a necessary criterion to be termed "short-haul" by the literature.[15]

[14] In unreported results, we also investigate the effect of ICA on the rate of wheat price adjustment (i.e., ρ parameters in the system of Eqs. 3) and (4). Data on the speed of adjustment is available from the same source: Jacks (2005, 2006). A high degree of market integration is associated with a rapid convergence in wheat prices within a city-pair. While we are agnostic about the potential impact of ICA on the speed of price adjustment, our estimation results suggest that the new regulatory regime introduced by the ICA had no direct effect on the rate of price convergence.

[15] In a related specification, we replace the continuous distance measure with an indicator variable for short- versus long-haul routes. City–pairs that are located within a 500-mile radius are classified as short-distance routes; the remaining city-pairs are in the category of long-haul routes. In unreported estimations, we find similar results: The ICA has no significant effect on transport costs between proximate cities, but leads to a fall in transport costs of 17 % (relative to short-haul routes) on long-distance routes.

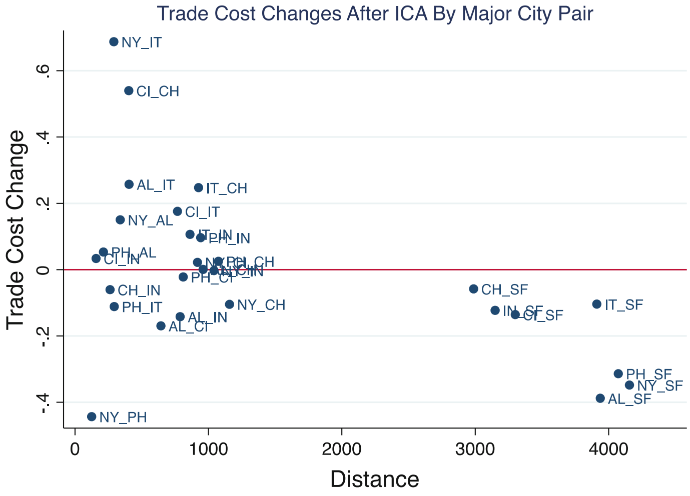

Fig. 1 Transport cost changes after ICA by major city-pair. *Notes* (1) Each *point* in the *scatterplot* represents the coefficient on the corresponding city-pair dummy variable that is obtained from estimating an augmented version of the regression model given by Eq. (7) in the main text. (2) Major cities are Alexandria (AL), Chicago (CH), Cincinnati (CI), Indianapolis (IN),Ithaca (IT), New York (NY), Philadelphia (PH), and San Francisco (SF)

To explore further the heterogeneity in ICA effects over distance, in unreported model estimation, we allow the ICA coefficient to be city-pair specific (US cities only). Figure 1 plots the estimated slope coefficients against the city-pair bilateral distance. Interestingly, the ICA coefficients involving San Francisco—the single West Coast city in our sample—are systematically below the zero line. This sheds more light on the underlying data variation that leads to the negative and significant effect of the ICA on long haul transport costs.[16]

6.4 Further Robustness Checks

To ensure the robustness of our findings regarding the effect of the ICA on the level of transport costs, we perform several additional estimations. In the interests of space, we only describe the aim and outcome of these data exercises. These estimates are available upon request.

A possible concern with the current data sample and the resulting estimated coefficients is the presence of US cross-border city pairs (i.e., international city pairs where one city is in the US) as part of the model's control group. These US international city-pairs are composed of a US city that has seen some of its connections (its internal US ones) "treated" by the ICA policy and a non-US city that has not seen any of its

[16] We have also experimented with city-specific (rather than city-pair) ICA effects in order to see whether the insignificant effect of the ICA is due to opposing effects in monopolized versus competitive markets. The city-specific ICA coefficients turn out to be insignificant in most cases, except for a positive effect for Ithaca and negative effect for San Francisco.

routes subject to this "treatment." If the ICA effect on US shipments affects US cities' wheat shipment decisions to non-US cities, this interdependence could contaminate the cross-ocean routes from the US, invalidating them as appropriate control group observations.

To investigate whether the insignificant effect of ICA on transportation costs is related to the inclusion of US international city-pairs in the control group, we re-estimate the model specification in first differences without these "ambiguous" city-pairs. The estimation results are very similar to the ones reported in Table 3, reinforcing the conclusion of no significant impact of ICA on the level of bilateral transport costs.

The second robustness check that we perform investigates the sensitivity of our results to the elimination of all Chicago-based city pairs. The direct access of the city of Chicago to the Great Lakes has made shipping via waterways an attractive and efficient transportation mode. In fact, as of 1870 over 90 % of wheat from Chicago transported eastbound was going via the Great Lakes—not railroad. Because of the competition created by these alternative modes of transport, railway transportation prices involving the city of Chicago may look and respond differently to the ICA than the rest of the sample. Therefore, in unreported data exercises, we eliminate the city-pairs between Chicago and our east coast cities. Yet again, the main findings of the paper continue to hold: The effect of ICA on transport costs remains insignificant.[17]

6.5 Examining the Impacts of the ICA on Transport Cost Volatility

As discussed in our hypothesis section, the prior literature suggests a null hypothesis that the ICA had no effect on US transport cost volatility because of its inability to affect market behavior, and, as an alternative hypothesis, that it reduced volatility due to its ability to coordinate a more stable railroad cartel. We examine the impact of the ICA on transport cost volatility in two ways:

First, in a separate, unreported estimation (available upon request), we allow the year fixed effects to take US specific values so as to capture the period-on-period deviations in transport costs relative to world trends. The resulting US-specific time effects are depicted in Fig. 2. Two things become transparent from the transport cost trend line: First, the post-ICA period is characterized by significant price stability compared to the prior decades. This finding is very much in line with the anecdotal evidence and the existing literature on the regulatory effects of ICA in helping to maintain stable cartel rates. Consistent with this, US transport costs experienced unusually large decreases relative to the global trend during the two decades prior to 1887—which is evidence of the price wars that dominated the railroad industry prior to the formation of the ICC. Overall, the trend line that is depicted in Fig. 2 provides confidence in our estimated transport cost measure (as it reproduces data patterns that are consistent with prior expectations), and is strong evidence that the average ICA effect (measured by the coefficient δ_0 in Eq. 7) is not masking heterogeneous responses to the regulatory change.

[17] We have also examined the change in estimates when we exclude all of the city–pairs that involve Ithaca, which is a considerably smaller market compared to the rest of the sample cities. We found no qualitative difference between those estimates and the main results that are reported in this paper.

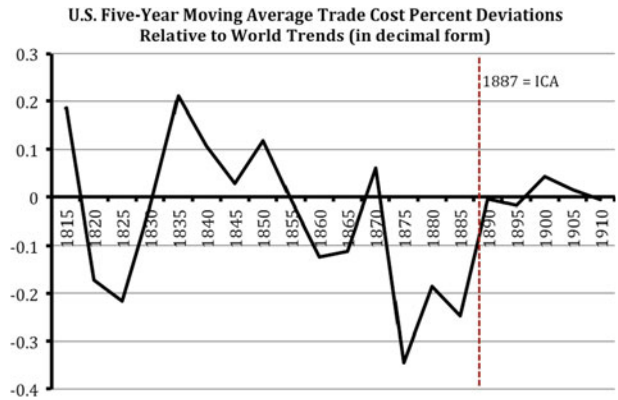

Fig. 2 US transport costs before/after ICA (deviations from world trend). *Note* The trend line is constructed based on US specific-year fixed effects, obtained by estimating the regression model given by Eq. (7) in the main text, augmented with interaction terms between year dummy variables and a US indicator for domestic city-pairs

We also conduct a more formal statistical analysis of the volatility hypothesis. We define volatility as the standard error over a series of transport cost values, and we construct two transport-cost volatility measures for each city-pair in our sample: one over five consecutive time periods preceding the ICA (i.e., 1865–1885), and another over five consecutive time periods following the ICA (i.e., 1890–1910). To examine the hypothesis that the ICA brings price stability to the railroad sector, we estimate a simple linear regression model:

$$Volatility_{ij,T} = \gamma_0 + \gamma_1 Domestic_{ij} + \gamma_2 PostICA_T + \gamma_3 (Domestic_{ij} \times PostICA_T) + \varepsilon_{ijt} \quad (8)$$

where T stands for the two time periods: pre- and post-ICA, respectively; $Domestic_{ij}$ is an indicator variable that is equal to one for US-only city-pairs, and zero otherwise; and $PostICA_T$ is also an indicator variable that is equal to one for the period of time following the ICA. We are interested in the coefficient γ_3 since it measures the average change in the volatility of transport costs in the US relative to the rest of the world, over the interval of time following the ICA. If the data pattern that is observed in Fig. 2 is statistically significant, then we should expect γ_3 to be negative and significant.

Table 4 reports the estimation results. In Columns 1 and 2, volatility is calculated using the initial transport cost values, while in columns 3 and 4 volatility is calculated using log values of transport costs. Furthermore, the estimations that are reported in columns 2 and 4 also include city-pair fixed effects. Across all four specifications, the coefficient on the interaction term between the post-ICA indicator and US city pair indicator is negative and highly significant. This result gives further support to the claim that one of the main impacts of the ICA on the activity of the railroad sector was to stabilize freight rates.

Table 4 Transport cost volatility

Dependent variable	SD (transport cost)		SD (ln transport cost)	
	(1)	(2)	(3)	(4)
Post-ICA	−0.057	−0.046	−0.104	−0.076
	[0.005]***	[0.004]***	[0.008]***	[0.009]***
Domestic (USA == 1)	0.053		0.185	
	[0.018]***		[0.025]***	
Post-ICA × domestic	−0.071	−0.085	−0.178	−0.216
	[0.018]***	[0.017]***	[0.029]***	[0.035]***
City pair fixed effect	No	Yes	No	Yes
Observations	1,515	1,515	1,515	1,515
R^2	0.13	0.28	0.14	0.19

The reported results are obtained from estimating the regression model given by Eq. (8) in the main text. The dependent variable measures the volatility of transport costs at the city-pair level over two distinct intervals of time: pre-ICA period (1865–1885) and post-ICA period (1890–1910). The Post-ICA dummy variable acts as a time fixed effect. The Domestic dummy variable identifies the city-pairs where both locations are within the US

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; Robust standard errors in brackets

7 Conclusions

In 1887, the United States passed the ICA, a piece of legislation put into place in order to oversee and regulate the activity of the railroad industry. Prior to the ICA, railroad transport was characterized by monopoly rates on short-haul routes and cartel prices on longer haul routes (that escalated into non-cooperative oligopoly pricing). Thus, the main aim of the ICA was to prohibit price discrimination by trip length, and ensure transparent and fair shipping rates. However, achieving such objectives was far from certain. Partly this is because of the railroad regulations at state level that were already in place at the time of ICA. Adding to it, there have been claims that the ICA efforts towards price transparency and stability only helped stabilize cartel prices following a period of significant price wars.

The aim of this paper is to shed more light on the ambiguous impact of ICA on the railroad activity in the US. Using a rich dataset on estimated transport costs for wheat covering a century long time period spanning pre- and post-ICA implementation, we provide an empirical analysis of the effects of ICA on the level and volatility of estimated transport costs for wheat. Having access to information on city-pair price differences for wheat across markets within the US and several European countries, we are able to employ a difference-in-differences estimation strategy. We compare the change in transport costs following the ICA that is observed among city pairs in the US relative to the change in transport costs observed in the control group of European cities during the same period of time. The panel nature of the dataset allows us to identify the ICA effect independent of time and city-pair specific effects, thus reducing the incidence of omitted variable bias.

Our empirical analysis generates several interesting results. First, we find no statistical evidence that the US transport costs experience any systematic change after the introduction of the ICA, on average. However, we do find that the volatility of the estimated shipping rates declines significantly following the ICA. This evidence is consistent with the revisionist view that the ICA helped stabilize cartel prices after a period of significant price wars.

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8 Appendix

See Table 5.

Table 5 Country coverage

Country	Number of cities	Cities
Austria-Hungary	10	Prague, Lwow, Vienna, Innsbruck, Budapest, Krakow, Ljubljana, Linz, Czernowitz, Trieste
Belgium	4	Ghent, Brussels, Antwerp, Bruges
France	12	Arras, Marseilles, Paris, Lyon, Mende, Bar-le-Duc, St. Briec, Chateauroux, Bordeaux, Toulouse, Pau, Bayeux
Germany	12	Stettin, Konigsberg, Magdeburg, Koln, Leipzig, Frankfurt, Danzig, Breslau, Lindau, Berlin, Munich, Posen
Italy	12	Avellino, Bergamo, Parma, Carmagnola, Naples, Modena, Padua, Genoa, Rome, Maddaloni, Brescia, Verona
Norway	3	Christiania, Bergen, Stavanger
Russia	12	Riga, Saratof, Samara, Nicolaief, Odessa, Rostov, Moscow, St. Petersburg, Libau, Warsaw, Ieletz, Novorossiysk
Spain	12	Gerona, Leon, Cordoba, Oviedo, Granada, Santander, Burgos, Segovia, Lerida, Toledo, Zaragoza, Coruna
UK	12	Exeter, Manchester, Liverpool, Carmarthen, Leeds, Gloucester, Cambridge, London, Norwich, Newcastle, Dover, Worcester
USA	13	Alexandria, Chicago, Cincinnati, Indianapolis, Ithaca, Kansas City, Minneapolis, New Orleans, New York City, Philadelphia, Richmond, Saint Louis, San Francisco

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