The Cost of Railroad Regulation: The Disintegration of American Agricultural Markets in the Interwar Period

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Discussion Papers on Business and Economics
No. 20/2012

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ISBN 978-87-91657-73-3

The Cost of Railroad Regulation: The Disintegration of American Agricultural Markets in the Interwar Period[1]

By Giovanni Federico and Paul Sharp *

Abstract: We investigate the costs of transportation regulation using the example of agricultural markets in the United States. Using a large database of prices by state of agricultural commodities, we find that dispersion fell for many commodities until the First World War. We demonstrate that this reflected changes in transportation costs which in turn in the long run depended on productivity growth in railroads. 1920 marked a change in this relationship, however, and between the First and Second World Wars we find considerable disintegration of agricultural markets, ultimately as a consequence of the 1920 Transportation Act. We argue that this benefited railroad companies in the 1920s and workers in the 1930s, and we put forward an estimate of the welfare losses for the consumers of railroad services (i.e. agricultural producers and final consumers).

Keywords: Market integration, price convergence, United States, agriculture, transportation regulation

JEL Codes: K23, L51, N5, N7

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[1] We are grateful for research assistance by Hege Susanne Haugland, Andreea-Alexandra Maerean, and Mekdim Regassa. Some of this article was written during Paul Sharp's time as an academic assistant at the Robert Schuman Centre for Advanced Studies at the European University Institute as part of the ERC funded research programme 'Market integration and the welfare of Europeans'. We would like to thank Stephen J. DeCanio, Price Fishback, Karl Gunnar Persson and participants at the 'Fifth Summer School "Economic Integration and Spatial Dynamics in Historical Analysis"', Universidad Carlos III Madrid, the BETA Workshop 2011 in Strasbourg, and at seminars at Copenhagen, the EUI, Humboldt and the LSE for help and suggestions.

I

Nominal rigidities can have a substantial impact on the economy, as macroeconomists have long been aware. There is for example a substantial literature about wage stickiness and other rigidities as a cause of the Great Depression[2]. This paper deals with the rigidity in the price of transportation brought on by the policy of the ICC (Interstate Commerce Commission), the regulatory body for railroads, following the guidelines of the Transportation Act of 1920. We also provide tentative calculations suggesting that, by causing real transportation costs to increase with the deflation of the interwar years, the resultant market disintegration led to losses corresponding to a not insubstantial share of American GDP. This claim is not entirely new: economists raised the issue in the 1930s and O'Brien[3] has investigated the effect of this regulation on industrial employment. The present paper complements his work by considering agricultural goods, arguably more sensitive to transportation costs than manufactures, and improves it by analyzing more carefully the relationships between transportation costs, rail productivity and regulation.

The paper speaks also to the still expanding literature on market integration[4]. This shows that European domestic markets integrated in the 'long 19th century', mostly, but not exclusively, as a result of the construction of railroads. Further developments have attracted very little if any attention. This seems to be because all the literature considers domestic integration to be a state of nature – once achieved, it is achieved for good, unless the country breaks apart, as in the case of Austria-Hungary[5]. This view also applies to the United States. Slaughter[6], following the earlier lead by Fishlow[7], has argued that the 'antebellum transportation revolution' caused widespread convergence in prices before the Civil War. The trend continued after 1870[8] and there is also evidence of a parallel increase in efficiency in the market for wheat[9] and for perishables after the introduction of mechanical refrigeration in railroads[10]. As far as we know, no work covers the

[2] Cf. e.g. Cole and Ohanian, 'The Great Depression'; Bernanke, *Essays;* Bordo et al, 'Sticky wages'; Ohanian, 'What – or who'.
[3] O'Brien, 'Freight rates'.
[4] Federico, 'Market integration'.
[5] Schulze and Wolf, 'Border effects'.
[6] Slaughter, 'Antebellum'.
[7] Fishlow, *American railroads.*
[8] Williamson, *Late Nineteenth-century.*
[9] Solakoglu and Goodwin, 'Railroad development'.
[10] Goodwin et al, 'Mechanical refrigeration'; Craig and Holt, 'Temporal price dynamics'.

period after 1910. By neglecting this period, we claim, scholars have missed a very interesting story, which this paper aims at presenting. Prices for agricultural products did converge in the long-run from the Civil War to the late 1960s, but the process slowed down to the point of stagnation in the 1920s and reversed at the beginning of the Great Depression. We interpret this latter as a consequence of regulation.

The next section traces the long-run price convergence and shows the extent of the reversal, while section 3 relates these changes to the variations in (real) costs of transportation by rail and also by water. Section 4 shows that the real costs of rail transportation followed productivity growth before the First World War, and that that relationship broke down after 1920. Section 5 sketches out the history of regulatory policies, focusing on the 1920 Transportation Act, which changed the very principle of regulation of railroads. Section 6 deals with the welfare effects: the policy benefited railroad companies in the 1920s and workers in the 1930s at the expense of farmers and consumers. Section 7 concludes.

II

Market integration is a twofold process, featuring both an increase in the speed of return to equilibrium price gaps after a shock and a decline in these gaps – i.e. σ-convergence[11]. The return to equilibrium is the outcome of arbitrage by profit-seeking traders and thus the increase of speed reflects growing market efficiency à la Fama[12] – most notably a better circulation of information about prices and fundamentals. In an efficient market, equilibrium price differentials must be equal to the transaction costs for trade. These two conditions ought to be tested separately, with different techniques. Testing efficiency needs time-series cointegration methods with high-frequency data[13], while in levels it can be measured by pairwise trends in relative prices or, for a large number of markets, by trends in the coefficient of variation. In this paper, we focus on this latter concept for two reasons. First, levels of prices are more important than the adjustment to equilibrium, as they determine decisions by consumers and producers. Second, high-frequency price data are available only for a few locations and commodities. In contrast, prices of agricultural

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[11] Federico, 'Market integration'.
[12] Fama, 'Efficient capital'.
[13] See Brunt and Cannon, 'Integration', for a discussion on the dangers of using infrequent data for these types of analyses.

commodities on an annual basis are quite abundant: the ATICS dataset, collected and described in detail by Cooley et al[14], which was kindly made available to us by Stephen J. DeCanio, provides them for all states between 1866 at the earliest and 1970 at the latest.

The data refer to farm gate prices and thus they measure directly the effect of price convergence on the welfare of farmers, which affected heavily politics in agricultural communities. Farm gate prices are bound to differ from (city) market prices by the transportation costs to cities and they might be noisier than comparable market prices, to the extent that farmers had less information than city traders. On top of this, until 1909 the ATICS data refer to December 1st prices, and thereafter to 'season average prices'. The two sets of prices are not strictly comparable, and the former may be less representative of levels, as they may reflect a temporary disequilibrium position, not yet absorbed by arbitrage. Yet, there is no clear evidence of breaks in the series after the switch to season prices in 1909. Besides, our analysis focuses on the period after this date. 'Season average prices' may not be comparable to yearly averages, as the season, especially for perishables, lasted for only a few months. On the other hand, results of a pair-wise comparison between wheat prices in major cities[15] and our farm-gate prices from the same states are reassuring. The series follow each other very well and the difference is fairly constant. Thus, the differences in data are not big enough to jeopardize the conclusions of our analysis. After 1933, prices include the product-specific proceeds from the Agricultural Adjustment Act and other government support programmes.

The ATICS database covers 22 products (barley, buckwheat, cotton, corn, flaxseed, 'all hay', hops, oats, peanuts, potatoes, rice, rye, soybeans, sweet potatoes, sugar-beets, tame hay, tobacco, wheat, 'all cattle', hogs, milk cattle and 'stock sheep and lambs'). Some series are too short or refer to minor commodities: we thus omit them, focusing on eight main crops (barley, cotton, corn, oats, potatoes, rye, tobacco, and wheat) and three livestock (hogs, milk cattle, and 'stock sheep and lambs')[16]. The three columns on the left of Table 1 report the averages of the coefficient of variation for these products at the beginning and the end of the period and in the worst years of the Great Depression. As expected, prices converged in the long-run, but the

[14] Cooley et al, *ATICS.*
[15] Jacks, 'International commodity'.
[16] In 1929, the eight products accounted for 73% of the total gross output of crops, and the omitted ones for 6% (Strauss and Bean, *Gross farm income*).

process is much less impressive than one would expect. The dispersion of the mid-1960s was still fairly high for many commodities. Just for comparison, the coefficient of variation for wheat prices in European markets declined from a peak of slightly below 0.4 during the Napoleonic wars to about 0.10-0.15 in the heyday of free-trade in the 1870s[17]. Furthermore, there are some notable exceptions to the overall pattern. Dispersion in prices of cotton was very low from the beginning, as the plant was cultivated only in a few Southern states, and thus there was not much room for further convergence, while the high dispersion of tobacco prices reflects the atypical prices in marginal states[18]. Last but not least, milk cattle were a production good, with huge qualitative differences, which increased price dispersion and made arbitrage difficult.

The three columns on the right report results of a formal test of price convergence. Following Razzaque et al[19], we run the regression:

$$\Delta\, lnCV_t = \alpha + \beta TIME + \psi lnCV_{t-1} + \phi ln\,\Delta\, CV_{t-1} + u_t \qquad (1)$$

If $\beta \neq 0$ and $-1 < \psi < 0$, the coefficient of variation *lnCV* has a non-zero deterministic trend, to which it reverts after any short-term shock (e.g. a war, the opening of a new railroad). In this specification, the long-run trend rate can be computed as $t = -(\beta/\psi)$. A negative value implies long-run convergence. The coefficient ψ measures the speed of return to this long-run path, while the lagged shock term is added to address possible serial correlation.

[Table 1 about here]

All the ECM terms are negative and significant, and they imply half-lives of shocks ranging from a minimum of six months for potatoes to a maximum of five years and one month for milk cattle. Prices converged in seven cases out of eleven (eight if rye is included), albeit at different rates. Not surprisingly, convergence was faster for goods consumed nationwide than for those traded mostly

[17] Federico, 'European markets'.

[18] Prices were very high in Massachusetts, Connecticut and (from the 1920s) Louisiana, which jointly accounted for less than 2% of American tobacco acreage. Omitting these three marginal states, the coefficient of variation drops sharply (to 0.3 in the 1860s and to 0.25 one century later)

[19] Razzaque et al, 'Secular decline'.

locally, such as potatoes. The latter products were also more sensitive to local weather conditions[20].

Finding convergence in prices in the railroad era is not really a surprise. What is surprising is the time pattern of the process, as exemplified in Figure 1 by the case of wheat[21]. Prices converged fairly steadily until 1920 and after 1940, but dispersion remained roughly constant in the 1920s and 1930s, with a very high peak in the early 1930s. Convergence was extremely fast during the Second World War and the early 1950s, when dispersion attained its lowest level for the whole century.

[Figure 1 about here]

Figure 2 looks at the significant breaks in the trend, from 1-step Chow test statistics for recursive estimation of regressing the CVs for wheat on a trend.

[Figure 2 about here]

The largest Chow statistics (F-statistics of over 11) are for the years 1920 and 1930. Other large breaks fall in 1916, and in the period immediately following the Second World War.

One might argue that wheat was not representative since its fast convergence process (Table 1) magnified a small fluctuation in dispersion as a major reversal. Wheat was indeed an extreme case from this point of view (Table 2), but dispersion was substantially above trend throughout the whole interwar period for about half the products and it was exceptionally high in the early 1930s for all products except cotton, hogs and sheep. Furthermore, the majority of significant break points are concentrated in the early 1920s and in the 1930s. There is therefore something to explain.

[Table 2 about here]

[20] Libecap and Steckel, *Climate change.*

[21] Hickey and Jacks, *Nominal rigidities,* look at market integration within Canada during the twentieth century and find somewhat similar patterns for the interwar period for some goods, although there is no discussion of this in their paper.

III

The American constitution forbids barriers to trade and thus one could infer that changes in equilibrium price gaps reflected exclusively movements of transportation costs. This statement has to be qualified, because from 1933 the equilibrium level of prices was also affected by New Deal legislation[22]. The Agricultural Adjustment Act (May 1933) subsidized farmers who agreed to set aside part of their land[23]. The scheme was designed not to interfere with the normal working of the market and indeed the impact on market prices for wheat were small and very short-lived[24]. However, it does affect our estimates because the farm gate prices from the ATICS database include the set-aside payments, which were equal all across the United States. The effect is clearly higher in states with lower prices (typically those that produced more) and our estimate of dispersion is correspondingly biased downward relative to the 'true' one (computed with market prices). However, this bias only affects the results in 1934-1935, because the program was suspended in January 1936 when the Supreme Court ruled the Agricultural Adjustment Act unconstitutional.

Market prices were also affected by the activities of the Commodity Credit Corporation (or CCC), which was established in November 1933. It lent money to farmers upon the promise of crops, which were valued at a pre-determined loan rate. A rational farmer would forfeit the crops if the market price fell below the loan rate, and this thus acted as a minimum price, equal across the whole country. If the loan rate exceeded the (unobservable) price which would have prevailed without the CCC, the lending facilities of the CCC fostered integration. This seems to have been the case for corn and above all for cotton. In fact, the loan rate was quite close to the observed market prices (on average in the decade 85% for corn and about 90-95% for cotton) and loans

[22] Benedict, *Farm policies.*

[23] The Act listed specifically wheat, cotton, corn, hogs, rice, tobacco, and milk, and amendments in 1934-35 added cattle, rye, flax, barley and potatoes. Thus, the Act covered all the products we consider except sheep and oats. For wheat, producers received a subsidy equivalent of a fixed proportion of past production, provided they agreed to cut their acreage by 15%. The AAA opened the possibility of marketing agreements between the Department of Agriculture and associations of producers or processing firms to control the interstate commerce of commodities not covered by the basic program. Few such agreements were stipulated and none of them concerned the commodities we are interested in.

[24] Davis, *Wheat*, pp. 147, 361, and pp. 364 the processing tax on milling to pay for the program increased price of bread.

were substantial especially for cotton[25]. In contrast, loans from the CCC to wheat producers remained negligible until 1939.

Summing up, the New Deal farm policies fostered the integration of the corn and cotton markets after 1934, but they only affected the wheat market very marginally before the late 1930s. However, our source is likely to understate the actual dispersion of wheat prices in 1934-1935. and it would thus be imprudent to interpret our results after 1934 solely as a consequence of changes in transportation costs. In contrast, we are convinced that transportation costs must have been the main cause of integration (or lack thereof) until 1933.

Transportation costs are usually measured by the ratio of unit costs to the price at origin – or freight factor[26]. We proxy unit costs with a series of average railroad revenues per ton/mile, and, given our interest in agricultural markets, we divide it by an index of agricultural prices[27]. Figure 3 compares this freight factor with the coefficient of variation for wheat.

[Figure 3 about here]

From visual inspection, the trends appear fairly similar, and this first impression is confirmed by statistical testing (Table 3). The first column reports the p-values of the Johansen test for (no) cointegration, while the two others give the coefficients of real revenues per ton-mile (RATES) in the OLS regression

$$ln(CV) = a + bln(RATES) \qquad (3)$$

[Table 3 about here]

Given the regulation of rail transportation (Section 5), one can safely assume rates to have been exogenous. The long-run elasticity for wheat (0.74) implies that a 1% increase in transportation costs by rail increased the coefficient of variation of wheat prices by about 0.1 points at the mean.

[25] Loan rates Carter et al, *Historical Statistics,* series Da 1368, Da 1373, Da 1382. On average outstanding loans accounted for 20% of the value of cotton crop (up to 45% in 1939) but for less than 5% of that of corn and wheat. Ibid, series Da 1368, Da 1373, Da 1382.

[26] Hummels, *Transportation costs.*

[27] The series of nominal rail revenues is obtained by splicing together the data from O'Brien, 'Freight rates', Appendix B for the years 1867-1881 with series Df908 and Df979 from Carter et al, *Historical Statistics,* for the period 1882-1939 (rescaling the former to take into account the difference in level when overlapping). The index of farm prices is the Warren-Pearson index (ibid, Cc 114) to 1890 and later the BLS index (ibid, Cc67).

The elasticity for the period 1867-1933 is somewhat lower (0.47), but the difference is not statistically significant.

The results for other commodities by and large confirm the causal relation between costs of transport by rail and the integration of the market. However, the elasticities differ widely for all the products and, even when the relationship holds in the long run, there are noticeable divergences in the medium and short run, such as in the 1950s and 1960s for wheat (Figure 3). These differences might reflect, at least in part, two shortcomings of revenues per ton/mile as a measure of overall transport costs.

First, even if rates for each product on every route remain constant, revenues can change because of changes in the distribution of total rail traffic. It is possible to control, at least partially, for this composition effect by using the data on revenues and quantity shipped by product from the official freight statistics (ICC ad annum[28]). From 1928 onwards, we can compute indexes of gross revenue per ton for all products we are covering except potatoes. We also build an index by weighting the product-specific series with the average shares by quantity or by value of shipments [29]. Over the period 1928-1938 the series of nominal revenues per ton/mile is highly correlated to these indexes (0.89 and 0.9 in the two versions) and also to product-specific indexes. In seven cases out of nine the coefficients of correlation exceed 0.50, with a maximum of 0.96 for tobacco, while they are negative for cattle and sheep.

Second, the cost of transportation by rail might not measure accurately total costs to the extent that shippers could substitute rail with water or road transport. The available data (Figure 4) do show a decline in the share of railways in the interwar years, which was however reversed during the Second World War[30].

[Figure 4 about here]

[28] ICC, *Freight commodity,* ad annum.
[29] The series cannot be adjusted for changes in the length of the trip. In 1932, it varied from 291 miles for corn to 542 for sheep (Barger, 'Transportation', tab. C.1).
[30] The missing figures for coastal traffic in 1941-1945 are estimated by assuming that it moved as much as inland waterways traffic. The data for trucking include both commercial ('for hire') and private transport. Without these, the shares would be roughly half.

The figure documents the beginning of the trucking revolution in transportation, which however is unlikely to have contributed much to interstate integration (or lack thereof) for the agricultural products we are covering, with the possible exception of livestock. In fact, trucking was particularly competitive for 'the short-haul, perishable, and relatively high priced commodities, the majority of which had previously been shipped by rail at less-than-carload or express rates'[31]. In 1938 trucks ferried 40% of shipments of fruits, vegetable and butter and over 50% of shipments of livestock into (a sample of) main markets. The use of road transport for long-range shipment of bulky commodities was hampered by the technical shortcomings of the early trucks and, above all, by the dearth of suitable roads, before the construction of the interstate highway system in the 1950s.

Before World War Two, the real competitor to rail for long-range commerce was still water transport. Indeed, rail companies recognized this fact by setting higher rates to customers without access to water transport[32]. The share of water transport increased from 32% in 1922 to 45% in 1939 and this must have reduced the total cost of transportation. If, for instance, water transport cost a third less than rail transport (a reasonable conjecture), the rise of its share would cut total costs by almost 4%. The lack of data also prevents us from estimating the extent of substitution for agricultural goods (and the subset we are focusing on). However, one can quote two pieces of indirect evidence, which seem to imply that substitution affected less agricultural products than other goods. First, the marketed share of agricultural production, and thus the demand for transportation services, which had been growing since the beginning of the 20th century, declined by a few percentage points during the Great Depression[33]. Second, the shipments of agricultural products by rail decreased less than total shipments both throughout the whole interwar period and during the Great Depression[34]. Summing up, real revenues per ton/mile seem to be a fairly accurate measure of the cost of rail transportation and possibly also of aggregate costs, at least in

[31] Barger, 'Transportation', pp. 206.
[32] Sharfman, *Interstate.*
[33] The share of 'cash marketing receipts' in the sum of this latter and 'farm goods consumed on farm' (Carter et al, *Historical Statistics*, Da1288 and Da1290) decreased from 82% in 1910 to 86.9% in 1929 and then decreased to a minimum of 82.7% in 1932.
[34] Total rail shipments fluctuated in the 1920s, peaking in 1929, halved until 1932, and then they recovered, but in 1938 they were still about 60% of their 1920 level. The shipments of agricultural and animal products declined by 27% during the Great Depression (33% for the nine products) and in 1938 were only 20% lower than in 1920 (ibid, Df965, Df967, and Df968, not adjusted for the length of haul).

the long run. On the other hand, they are likely to overestimate the fluctuations in total costs, to the extent that substitution between alternative means of transportation caused the share of each of them to be inversely related to the relative cost.

It is possible to probe deeper by focusing on some specific product/routes. This, in practice, means the Chicago-New York grain trade, which is exceptionally well documented[35]. This case is interesting for a number of reasons. First and foremost, it was one of the great commodity flows of the 19th and 20th century American economy. The Chicago market collected grain from a wide area of the Midwest and the Great Plains, to be shipped to the East Coast for local consumption or export. Second, competition on this route was intense, both between water and rail and between rail companies. Water transport via the Great Lakes to Buffalo and from there to New York had been possible since the opening of the Erie Canal in 1825, while the first all-rail link was opened in the late 1850s[36]. Towards the end of the century, shippers could choose between four rail companies. It was also possible to use a mixed solution, meaning water to Buffalo and then rail to New York[37]. However, water transport was impossible during the winter, since the Great Lakes (usually) froze from December to March. On average between 1875 and 1970 56% of all grains shipped from Chicago went by rail, but their share varied a lot. It rose from about 25% in the 1870s to over 80% in the 1940s and 1950s, to decline again in the 1960s and 1970s. However, short term fluctuations swamped these long-term trends: for instance, the share collapsed from 72% in 1928 to 26% in 1932 and then rebounded to 81% three years later.

It is possible to show that the share shipped by rail was inversely related to the relative costs of transportation costs by regressing it on the ratio of rail to water costs. These latter can be measured by all-water freights for the period 1875-1920 and by mixed rail-water freights for 1875-1933. In both cases, the coefficients are significant at 1% and the elasticities, respectively -0.6 and – 0.4, are not statistically different from each other. The competition by water can explain how the

[35] All data are Chicago Board of Trade, *Annual report,* (ad annum), with the exception of all water freights 1908-1920 from the US Statistical Abstract. The series of freights after 1907 refer to transportation for domestic consumptioon. There are almost no other suitably long series of freights for a product/route for the period of interest. The main exception seems to be a series of rates for transportation of grain from St. Louis to New York, 1889 to 1920 (US Statistical Abstract, *Department of Commerce,* 1911 and 1920). The series is, unsurprisingly, correlated at 0.98 with the similar series for Chicago-New York.

[36] MacAvoy, *Regulation.*

[37] For further details see Coleman, 'Storage'.

average yearly price gap between Chicago and New York could be lower than the all-rail rates for several years (Figure 5)[38].

[Figure 5 about here]

On the other hand, a visual inspection shows a clear coincidence of trends, and indeed the two series are cointegrated at 1%. A regression with the market price gap (as in Figure 5) as dependent variable and the all-rail nominal rate as the measure of transportation cost yields an elasticity of 1.04 (significant at 1%) for the period 1867-1939[39]. Using the Illinois-New York gap in farmgate prices increases the elasticity for the same period to 1.34, still significant at 1%, while for the whole period 1867-1967 the elasticity is much lower (0.28) and not significant. This result might reflect the distortions from the fixed-rate loans of the CCC. Indeed, adding a dummy for the period 1939-1967 the elasticity rises to 0.96 (significant at 1%), while the dummy itself is negative and significant at 1%. These results are robust to the addition of the share of rail shipments on total grain shipments, as a measure of the competition between rail and water and/or of a time trend as more generic measure of changes in market organization and efficiency.

To sum up, the available evidence, from both nationwide and route-specific data, confirms that changes in railroad rates caused similar, although not identical, movements in price differentials and thus in the level of integration.

IV

Given the conclusion of the previous section, the next question is obvious: what drove real rail rates? What caused their long term decline and why do they display wide deviations from this trend, such as the collapse during World War One, the sudden recovery in 1919-20, and the peak of the early 1930s (Figure 3)?

According to basic economic theory, in a competitive market, real prices depend on productivity and thus they are bound to decline if productivity grows. If, in contrast, competition is limited by

[38] Market prices in New York from Jacks, 'International commodity', for 1868-1913 and from Statistisches Jahrbuch, *Deutsche,* for 1924-1937, in Chicago from http://www.nber.org/databases/macrohistory/rectdata/04/m04001a.dat (accessed 30 June 2008). When overlapping, this series is co-integrated with the price gap between Illinois and New York from the ATICS data-base at 1% and the coefficient of correlation between the two is 0.87.

[39] In this case we use the nominal rate because the dependent variable is the absolute price gap.

collusive agreements or by regulation, part of the productivity gains could be transformed into rents, to be appropriated by sector-specific factors (capital or labour). Productivity gains were indeed huge: from the 1870s to the early 1950s, the total factor productivity of railroads increased nine times[40]. Railroads easily outperformed the rest of the economy, as in the same years the total factor productivity of the American economy increased by 'only' 3.5.

In the long run, as expected, productivity growth caused the real rail revenues per ton mile to fall[41]. Indeed the elasticity of real rates to TFP for the period 1889-1953 is close to unity (-0.94)[42]. However, movements of rail revenues and TFP (reported in Figure 6 on an inverted scale for the sake of comparison) differ quite markedly during the First World War and the 1920s[43].

[Figure 6 about here]

In the 1920s, total factor productivity increased by about 15%, while real revenues increased by 40%. On the other hand, the increase in rates in the early years of the Great Depression did coincide with a sharp, but short-lived fall in productivity (an 18% decline from 1929 to 1932). A Quandt-Andrews test shows that the year 1921 marked a break in the relationship, and indeed separate regressions for the periods 1889-1920 and 1921-1953 yield widely different coefficients. The elasticity of rail revenues to TFP drops from -1.19 (t-stat 10.88) in 1889-1920 to -0.48 (t-stat 5.99) in 1921-1953 and the difference is highly significant[44]. In 1920-1940, the elasticity of revenues to TFP is practically nil (-0.07 and not significant). The model is admittedly an over-simplified one, and thus the results are to be regarded as evidence of a discontinuity rather than a precise estimate of its magnitude[45], but the message is clear. Before 1920, railroads transferred

[40] Kendrick, *Productivity trends,* table G III.
[41] In this case, revenues are deflated with wholesale prices (Carter et al, *Historical Statistics*, Cc. 84), rather than with prices of agricultural products only, as we are considering the whole transportation. Anyway, the results of a deflation with farm prices are qualitatively very similar.
[42] The coefficient is significant at 1% (t-stat 4.10) and residuals are stationary.
[43] The null hypothesis of a break in trends of Total Factor Productivity in 1914 or 1920 cannot be rejected even at 10%.
[44] Re-running the regression with Illinois freight factor (computed with the farm-gate prices), the estimated elasticities are higher (-1.54 over the whole period, -1.69 and -1.10 in 1889-1919 and 1920-1953), but they still differ significantly between the two periods.
[45] A more comprehensive model should also take into account trends in productivity in other sectors (if not already accounted for in a perfect price index) and any difference in the rate of growth in demand across sectors. The necessary data for building such a model, however, are not easily found, and the task would steer us too far away from the main issue of the present paper.

almost all their productivity gains to their clients, while they retained most of the gains in the next two decades.

V

The federal government started to regulate interstate rail transportation in February 1887, after the failure of state-level regulation[46]. It met the request by farmers, who had been accusing railroad companies of colluding in order to extract monopoly profit since the 1860s[47]. The Interstate Commerce Act forbade companies to share traffic (pooling), but allowed them to set common rates, provided that rates did not discriminate between customers (notably between short and long-range hauls) and were 'reasonable and just', with no further specification. Monitoring was entrusted to a new agency, the ICC (Interstate Commerce Commission). Three years later, the pro-competitive orientation of legislation was confirmed by the approval of the Sherman Anti-Trust Act (1890), which severely limited mergers among railroad companies. During the 'progressive' era, under the presidencies of Roosevelt and Taft, Congress approved four main pieces of railroad legislation: the Elkins Act (1903), the Hepburn Act (1906), the Mann-Elkins Act (1910) and the Panama Act (1912). The first of these four acts may have affected competition negatively, as it prohibited discrimination among shippers – i.e. rebates for large-scale clients - and allowed a sort of (disguised) pooling. The three others enhanced competition. The Panama Act forbade railroad companies to own water companies which directly competed with them. The Hepburn Act authorized the ICC to impose a maximum rate, at its discretion and upon shippers' complaints, without waiting for a court order. The Mann-Elkins Act subjected all changes in rates to a preventive authorization from the ICC. Thus, on the eve of World War One, the ICC could prevent companies from raising rates if it deemed the increase unjustified, but it could not prevent them from cutting rates, provided that the cuts did not discriminate between their clients. As Stone[48] puts it, 'generally, the commission's task [was] of keeping rates down and competition up'.

In December 1917 the federal government took charge of the management of railroad companies to cope with the war-time increase in traffic. It returned the companies to private ownership in

[46] This account is based on Locklin, *Economics of transportation* (1st and 3rd edition); Martin, *Enterprise;* Martin, *Railroads;* Kolko, *Railroads and regulation*; Stone, *The Interstate Commerce Commission;* and above all Sharfman, *Interstate.*
[47] Higgs, 'Railroad Rates'; Ulen, 'Market for regulation'.
[48] Stone, *The Interstate Commerce Commission*, pp.22.

March 1920. The move was prepared for by the approval of a new comprehensive piece of legislation, the Transportation Act (February 1920), introduced by Esch-Cummings. It dealt with many issues, from the capitalization of companies to labour relations, but the key provisions from our point of view are those related to regulation. They were clearly meant to reduce competition in order to make investment in railroads attractive again. In fact, the Act allowed pooling among companies, subjected the building of new lines (a major source of competition) to preventive authorization by the ICC and gave the agency a broad and vaguely defined power to re-organize the rail networks and to exempt if necessary the companies from the anti-trust legislation. Above all, the Act gave the ICC the task of setting minimum rates and, unlike previous laws, specified a clear guiding principle for its decisions. The ICC had to guarantee a 'fair return', around 5.5%, to the total capital invested in railways, although not to each company. Five years later, Congress tried to soften this rigid principle, by approving the Hoch-Smith resolution which asked the ICC to take into account, while setting the fares, also the needs of distressed productive sectors (a code-word for agriculture). A resolution was not as binding as an Act, and thus the action of the ICC was ruled by the 1920 Act until June 1933. The new Emergency Railroad Transportation Act substituted the principle of fair return with a more generic appeal to the needs of traffic, the overall interests of the economy and, only as the third item on the list, the condition of the companies. It also created a (temporary) position of Federal Coordinator of Transportation[49]. The appointee, Eastman, did very little to co-ordinate railways but he lobbied hard and successfully for an extension of the powers of the ICC. The ICC was given regulatory powers on pipelines in 1934, on road transportation in 1935 (the Motor Carrier Act) and on water transportation in 1940 (the Transportation Act)[50]. Thus, from 1940 onwards the ICC could regulate all modes of transportation, with few exceptions, including the road transportation of agricultural goods. The 1940 Act instructed it to 'recognize and preserve the inherent advantage of each [means of transportation]'[51]. The ICC interpreted this provision by keeping ratios between rates by road, rail and water roughly constant – the so-called 'umbrella rate' policy[52]. Thus, the Act tightly regulated

[49] Latham, *The politics.*
[50] Water transportation had previously been regulated only indirectly by the ICC for joint transportation with rail or partially by the Shipping Board for the regular services on coastal trade.
[51] Harbeson, 'Transportation Act', pp.293.
[52] Stone, *The Interstate Commerce Commission.*

the transmission of benefits of technological progress to consumers[53]. The limits to competition among means of transportation were relaxed by the Transportation Act of 1958, as interpreted by court decisions in the early 1960s[54]. However, the ICC was only to lose its powers in 1980, with the Staggers Rail Act and the Motor Carrier Act[55]. To sum up, this very brief sketch of legislative history suggests dividing the period from the Civil War to World War Two into four periods – the unfettered and unregulated market until 1887, the mild but increasingly assertive pro-competition policy under the Interstate Commerce Act 1887-1920 and the progressive era legislation, the protection of railroad companies under the 1920 Transportation Act, and lastly the heavy intervention under the New Deal legislation, which lasted under the final liberalization.

How much did these policies affect actual price setting and thus can explain the changes in the rate of pass-through of productivity gains to lower prices? Both Martin[56] and Kolko[57], who disagree on almost everything else, deem that the market for rail transportation before 1887 was highly competitive, as shippers had many options and new lines were being built. The whole argument of Kolko's book is that, contrary to conventional wisdom, companies welcomed, if not actively sought, regulation to avoid this cutthroat competition[58]. However, both authors rely on anecdotal evidence, such as statements by railroad managers in official enquiries, which is highly suspicious for examining these issues. Economic historians have tried to assess the effectiveness of collusive agreements (pools) on the Chicago-New York route, without reaching an agreement[59]. Whatever the situation on that route, anyway, competition was likely to be higher than on routes not subject to competition from water transport and on local traffic.

Historians do not agree in their assessment of rail regulation before 1920. Most of them are quite sceptical about the effectiveness of the action of the ICC under the 1887 Act: Sharfman calls it 'restricted in scope and feeble in effects'[60] and Stone 'ineffective'[61]. The agency could act only upon complaints from shippers and it had to rely on courts to enforce its decisions. Pending the

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[53] Dewey, 'Transportation Act'.
[54] Healy, *US railroads.*
[55] Winston, *Last exit.*
[56] Martin, *Railroads.*
[57] Kolko, *Railroads and regulation.*
[58] The argument is very controversial (cf. e.g. Martin, *Railroads,* pp.353) and not very convincing. It is unclear which provision of the 1887 Act, if any, could reduce cutthroat competition.
[59] MacAvoy, *Regulation;* Ulen, 'Market for regulation' and 'Railroad cartels'; Porter, 'Cartel stability' and 'Price wars'.
[60] Sharfman, *Interstate*, vol I, pp. 23.
[61] Stone, *The Interstate Commerce Commission,* pp.8.

decision, the companies could easily avoid a negative ruling by changing the rates. MacAvoy[62] has a less negative view, but only for the first decade. In fact, the powers of the ICC were drastically reduced by the Supreme Court, which in 1897 allowed exceptions to the short-long range clause at the companies' discretion. The effect of the legislation of the 'progressive era' changed the situation is likewise controversial. Sharfman[63] stresses the relevance of the Hepburn Act, while Martin[64] argues that the role of the ICC changed only after the approval of the Mann-Elkins Act. Before 1910, the ICC had paid very little attention to the level of rates, focusing on avoiding discrimination among shippers. Indeed, companies applied for a generalized increase in rates already in summer 1910. However, the ICC adopted a very conservative approach. It rejected the request altogether, and rejected similar requests in 1913, 1915 and 1917, with limited exceptions for some routes. It is thus not surprising that there is no statistical discontinuity either in the cost of rail transport (the series of nominal revenues per ton/mile, or of all rail freights on the Chicago-New York route) or in the rate of pass through of productivity gains to rail rates. On the eve of the First World War, transportation by rail cost less in the United States than in Britain, Germany and France[65]. The war-time increase in prices, with no matching adjustment in rates, caused the real cost of transportation to plummet. In 1917 the real rates were 40% lower than in 1913 and in May the all-rail rate on the New York-Chicago route amounted to only 4.3% of the Chicago prices. In 1918, the ICC approved a small increase which did not change the situation. The companies prospered only thanks to the federal subsidies, which were motivated by the war-time emergency.

According to the Transportation Act, the federal guarantee to railroad companies (i.e. the subsidies) was to disappear in September 1920. The ICC prepared this movement by approving massive increases in rates (i.e. 33.5% for interstate traffic). The motivation for this decision was impeccable, but the timing was unfortunate. In fact, prices had started to fall in summer 1920 and the combined effect of the fall and the rise in rates caused a sudden upward jump in the real cost of transportation. Real rate revenues doubled from 1920 to 1921 and the freight factor on the Chicago-New York route tripled from 6.7% in June 1920 to 22.5% in November 1921. Predictably, shippers flooded the ICC with protests and eventually the Commission complied, cutting the rates

[62] MacAvoy, *Regulation.*
[63] Sharfman, *Interstate.*
[64] Martin, *Enterprise.*
[65] Comparison, *Railroad freights.*

in October 1921, although only by a modest 10%. From 1922, the ICC kept rates stable, rejecting both the companies' requests for increases (as in Spring 1925) and the repeated pleas of shippers for cuts (e.g. in 1924, 1924 and 1925), ignoring the Hoch-Smith resolution. The real cost of railway transport fluctuated according to changes in prices, but before 1929 the movements were fairly small.

The collapse in prices during the Great Depression caused the cost of transportation to rise steeply, while traffic was falling[66]. In 1931, real revenues per ton/mile were 20% higher than in 1929 and railway shipment a third lower. The companies asked for a 15% increase in rates, but the ICC turned down their request. It argued that this would have pushed the cost of rail transportation to unbearable levels and warned companies that the increase would have shifted to road and water transportation. Company executives must have been aware of the danger and indeed Sharfman[67] suggests that their request was a preventive move to stave off the petitions for a massive cut. If this was the aim, the companies were successful. The ICC left rates unchanged throughout 1932, even as traffic was plummeting and costs were increasing. In the second quarter of 1932, rail traffic was about 40% its 1929 level and nominal revenues per ton mile were 11% higher[68]. In November 1932, the freight factor on the Chicago-New York route reached a stunning 51.3%. After countless petitions by shippers for a cut, the ICC opened an enquiry in March 1933. In spite of the approval of the new Transportation Act, four month later, the agency rejected the request for a generalized reduction, although with a strong dissenting minority. The majority argued that a reduction in rates would have jeopardized further the already parlous financial conditions of the companies. The ICC imposed a modest cut of 10% in May 1934, and in the next 12 years it changed rates only six times and by very small steps. In May 1946, both specific rates and nominal revenues were still 10% lower than in 1929, while agricultural prices were 20% higher and Chicago wheat prices 60% higher. Given the 'umbrella rate' policy, one could surmise that all transportation costs remained low during the war, and, together with the effect of the loan policy

[66] Cf. for a similar effect in Poland in the same years Wolf, 'Border effects', pp. 427.
[67] Sharfman, *Interstate,* pp. 191.
[68] ICC, *Freight commodity,* ad annum.

by the CCC (Section 3), this can explain the integration. After 1946, the ICC started to increase rates, and the freight factor returned to its long-term trend levels[69].

To sum up, changes in the regulatory framework and in policy decisions by the ICC can explain the movements in nominal and real costs of transportation, especially during the Great Depression and the two world wars. These changes tally well with trends in integration.

VI

The evidence so far points to a clear-cut hypothesis about winners and losers from railroad regulation. Until 1920, the ICC at the very least did not restrict competition and probably fostered it as much it could, given its powers. Therefore, 'consumers of rail services benefited at the expense of owners of railroad inputs'[70]. Under the 1920 Transportation Act, railroad companies earned rents at the expense of consumers and the whole American economy paid a price in terms of foregone trade and income. How big were these gains and losses?

As a starting point, Figure 7 reports two indexes of profitability of railways companies, the ratio of net returns to stock market capitalization and to gross revenues[71]. The two series are poorly correlated for the whole period 1890-1970 (0.41), but they coincide almost perfectly in the years 1920-1940 (0.98).

[Figure 7 about here]

Here we will focus on the ratio to market capitalization, as this latter is the best available proxy for the value of companies, to which the ICC had to guarantee a fair return[72]. Profits were quite low in the 1890s but they rose in the 1900s to about 3-3.5%. During the war, profits increased further, thanks to subsidies, to fall in the late 1910s slightly below their pre-war levels. Thus, a 5.5% 'fair' return was quite high in historical perspective, although consistent with the returns to safe

[69] Healy, *US railroads.*
[70] Fishlow, 'Internal transportation', pp. 598.
[71] The data of capital (Carter et al, *Historical Statistics*, Df982) are net of shares of other companies. The net returns are computed by deducting expenditures, including payment of interests from total revenues (ibid, Df998).
[72] Actually, the accuracy of market capitalization as a measure of the capital invested in railways was very controversial. Companies allegedly over issued stock and thus reduced the return. The Congress approved a Valuation Act (1913) in order to have an independent assessment of the capital of the companies. After fifteen years of work, the committee arrived to a figure very close to the market capitalization (Martin, *Enterprise*, pp.358).

investments during those years (US Treasury yielded 4.90% in 1920-1922)[73]. In the 1920s, the policy of the ICC did steadily increase the returns, without ever achieving its target. The ratio of net return to capital peaked in 1929, at 5.23%, a level well above the yields on state bonds in the same year (around 3.7%). Railroad employees also gained, although the increase in their average compensation (about 10% in real terms) did not match the 30% growth in output per worker[74]. The Great Depression worsened dramatically the situation of railroad companies as of any other business in the country. Their net revenues fluctuated between 0.14% and 1.20% of market capitalization, but companies lost money only in 1932 and 1938. The gainers in those years were the workers – or to be precise those among them who were lucky enough to keep their jobs. In the four years from 1929 to 1933, the companies shed about 40% of their workforce (785,000 out of 1.8 million), while total traffic halved. Output per worker decreased by 6%, and the average compensation per employee, the only proxy for wages, fell by 17% in nominal terms but in real terms it increased by 9%. It continued to grow for the whole of the 1930s, so that in 1940, on the eve of the war, it was a third higher than in 1929.

How much did producers and consumers lose? Federico[75] puts forward a simple formula to estimate deadweight losses as a variant of the well-known Harberger triangles which allows a positive wedge (i.e. transaction costs) to remain. Given a exogenous price change ΔP, losses for a producing (or consuming) area can be computed as

$$\frac{DWL}{GDP} = \Delta P|\alpha - \beta| + 1/2\, \Delta P^2(\eta\alpha + \varepsilon\beta), \qquad (2)$$

where η and ε are the price elasticicities (in absolute terms) and the parameters α and β are the shares of production and consumption of GDP in each area for the relevant goods. Thus, $\alpha > \beta$ in a producing area (e.g. 'Chicago') and vice-versa in a consuming one ('New York'). The difference $|\alpha - \beta|$ is a simple index of specialization, ranging from 0 (all areas are self-sufficient for all goods) to 1 (all areas are fully specialized in one product).

[73] Carter et al, *Historical Statistics*, series Cj1192.

[74] Average compensation computed as total wages/number of employees (ibid, Df1003 and Df1002). Deflated with BLS consumer price index (ibid, series Cc1). Output per worker from Kendrick, *Productivity trends*, tab G-III.

[75] Federico, *Grain invasion.*

In the case at hand, ΔP is the difference between the actual change in transportation costs and the counterfactual costs had the Transportation Act not been approved. We obtain an index of these costs by extrapolating the 1920 real revenues over the whole period to 1940 according to the growth in TFP given the coefficient from the revenue-TFP ratio equation (Section 4) for the period 1889-1919. Then we convert this index into an estimate of the freight factor by assuming that the nationwide freight factor was 10% in 1920[76]. If it had changed as much as productivity, it would have fallen to 7% in 1939 rather than increasing to 18%. The difference between this counterfactual freight factor and the actual one is a crude measure of losses from regulation (or ΔP). Since we have no information on elasticities, we will simply assume that the price elasticity of demand ranged from -0.5 to -1 and the price elasticity of supply from 0.5 to 1.5.[77]

In theory, one should estimate the total losses according to equation 2 for all trading areas for each product. This task needs some evidence on the shares of production and consumption of GDP and on how the change in the price wedge is distributed between (each pair of) producing and consuming areas. These data are not available and collecting them is plainly beyond the reach of this paper. Just to give a hint of the possible outcomes, we provide here a highly simplified back-of-the envelope estimate, considering a 'composite' good transported from a producing area (P) to a consuming one (C). The losses are thus respectively

$$\frac{DWL}{GDP_P} = \Delta P_P|\alpha_P - \beta_P| + 1/2\,\Delta {P_P}^2(\eta_P\alpha_P + \varepsilon_P\beta_P) \qquad (2.1)$$

and

$$\frac{DWL}{GDP_C} = \Delta P_C|\alpha_C - \beta_C| + 1/2\,\Delta {P_C}^2(\eta_C\alpha_C + \varepsilon_C\beta_C) \qquad (2.2)$$

The total losses for the country are the sum

$$\frac{DWL}{GDP_{TOTAL}} = \frac{DWL}{GDP_P} + \frac{DWL}{GDP_C} \qquad (3)$$

It is possible to simplify further the expression by assuming that the total increase in the price wedge (10%) was evenly distributed between the two areas – so that $\Delta P_C = \Delta P_P = \Delta P = 0.05\%$

[76] In that year the Chicago and Illinois freight factors were respectively 7% and 10.5%, and the Missouri one (the ratio of transportation costs from St. Louis to New York to the farm gate prices) 13%.

[77] Cf. for a comprehensive list of (old) estimates of agricultural supply Askari and Cummings, *Agricultural supply.*

and that demand and supply elasticities were equal ($\eta_C = \eta_P = \eta$ and $\varepsilon_C = \varepsilon_P = \varepsilon$). Thus the expression becomes

$$\frac{DWL}{GDP_{TOTAL}} = \Delta P(|\alpha_C - \beta_C| + |\alpha_P - \beta_P|) + 1/2\, \Delta P^2[\eta(\alpha_C + \alpha_P) + \varepsilon(\beta_P + \beta_C)] \quad (3)$$

To get an upper bound of losses we hypothesize that all tradable goods were transported by rail and that all areas were fully specialized – i.e. that nothing was consumed in the producing area ($\beta = 0$) and nothing was produced in the consuming area ($\alpha = 0$). In this extreme case, we assume the differences $|\alpha - \beta|$ to be 30%, which is the share of tradable goods, defined as the sum of agriculture, mining and manufacturing, in American GDP[78]. As a lower bound we assume that the difference $|\alpha - \beta|$ was only 5% (e.g. as a result of $\alpha = 17.5\%$ and $\beta = 12.5\%$ in producing areas). These parameters yield four estimates, with a range between 0.55% of GDP (minimal specialization, low elasticities) and 3.10% (full specialization, high elasticities). These estimates are very robust to changes in elasticity parameters. In fact, they determine only the extent of change in trade (second term in equation 2), which accounts for only a small part of total welfare losses. Most of these latter (the first term in equation 2) accrued to railroad companies in terms of higher gains on the remaining transportation.

These estimates are very crude, but they at least give some idea as to the magnitude of the losses due to the disintegration of markets between the wars. With a different method, O'Brien[79] estimates that ICC policy cut industrial employment by about 8%. Value Added in manufacturing accounted for about 20% of GDP and thus losses might have been around 1.5-2%. Neither O'Brien[80], nor ourselves claim that the Transportation Act caused the Great Depression, but these are not trivial sums. Furthermore, these estimates refer to static losses, omitting the dynamic effects: Williamson[81] estimates that a 50% (estimated) reduction in transportation costs from 1870 to 1890 augmented American GDP by up to 20%. On the other hand, there is no evidence that without regulation (and thus with much worse profit prospects) technical progress would not have slowed down or that railroads would have continued to invest enough to maintain stock and track, or that competition would not have caused bankruptcy and perhaps the merger of companies into

[78] Carter et al, *Historical Statistics*, ca. pp. 35-53.
[79] O'Brien, 'Freight rates'.
[80] Ibid.
[81] Williamson, *Late Nineteenth-century.*

a single large monopolist. Martin[82] argues that the rejection of an application for a rate increase in 1906 reduced investments below the minimum necessary and the missing investments were to haunt railroads for a long period, being also a motivation for the 1920 Transportation Act[83]. This argument may have held true also in the counterfactual world without this act, in the 1920s and above all for the Great Depression, when companies were hardly profitable and their prospects even bleaker.

VII

This paper has demonstrated that important insights can be gained through an investigation of domestic market integration, even for the twentieth century. In the United States, the well known decline of price dispersion for agricultural goods from the late nineteenth to the late twentieth century was interrupted by a period of considerable market disintegration during the interwar period.

We demonstrate that changes in price dispersion were caused by changes in the cost of transportation by rail, only partially offset by substitution to cheaper means of transportation. Until the First World War, the cost of transportation closely followed changes in railroad productivity, but the 1920s mark a major discontinuity, at which point railroads were able to retain a larger part of the productivity gains instead of passing them to their consumers. This break is associated with the 1920 Transportation Act, from which point changes in the regulatory framework and in policy decisions by the ICC explain the movements in the cost of transportation, and thus by implication market integration. Finally, we demonstrate that losses from the resultant disintegration made up a substantial share of GDP at a very delicate moment. From 1933, however, the situation changed for institutional decisions – the Agricultural Adjustment Act had a small effect, but more importantly the change in remit of the ICC caused it to revise its policies. Integration could thus resume.

[82] Martin, *Enterprise.*
[83] Harbeson, 'Transportation Act'.

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Tables

Table 1: A statistical analysis of price convergence

	Average CV			Rate of change, $t = -(\beta/\psi)$		
	1866-70	1930-32	1963-67	Yearly	Cumulated	ECM (ψ)
Wheat	0.239	0.280	0.055	-1.749***	-82.9	-0.275***
Rye	0.290	0.412	0.249	-0.244	-21.8	-0.510***
Corn	0.391	0.271	0.143a	-1.330***	-71.4	-0.670***
Oats	0.394	0.314	0.130	-1.030***	-64.7	-0.477***
Barley	0.237	0.320	0.113	-0.905***	-59.9	-0.329***
Cotton	0.076b	0.086	0.239	0.880	111.3	-0.418***
Potatoes	0.375	0.330	0.270	-0.491***	-39.1	-0.769***
Tobacco	0.430	0.543	0.601c	0.234	26.1	-0.311***
Milk cattle	0.331	0.362	0.223	0.182	20.2	-0.128***
Sheep	0.322	0.227	0.168	-0.780***	-54.5	-0.240***
Hogs	0.511	0.216	0.130	-1.302***	-73.2	-0.269***

*** Significant at 1%

a: 1956-60; b: 1876-80; c: 1961-65

Source: See text

Table 2: Trends in coefficients of variation and significant breaks

	Ratio to trend		Significant breaks
	1920-1940	1930-1932	
Wheat	1.435	2.351	1916,1920, 1930, 1948, 1950, 1951, 1952
Rye	1.155	1.667	1930, 1948
Corn	1.151	1.579	1920,1935, 1936
Oats	1.198	1.499	1920
Barley	1.342	1.778	-
Cotton	0.885	0.720	-
Potatoes	1.026	1.212	1956
Tobacco	1.049	1.255	-
Milk cattle	1.248	1.370	1924,1926,1932
Sheep	1.034	1.038	1926,1956,1960
Hogs	0.924	0.936	1908,1924,1934,1944

Table 3: The cost of rail transportation and the integration of commodity market

	Cointegrated?	Elasticity	
	(1867-1967)	1867-1933	1867-1967
Wheat	2 %	0.47***	0.74***
Rye	1%	0.37 ***	0.34***
Corn	5%	0.54**	0.72***
Oats	1%	0.48***	0.68***
Barley	1%	0.21 *	0.57***
Cotton	no	-1.01**	-0.53 ns
Potatoes	5%	0.22**	0.31***
Tobacco	5%	-0.15ns	-0.12ns
Milk cattle	5%	0.19*	0.18***
Sheep	1%	0.19**	0.12 ns
Hogs	1%	0.75***	0.85***

* significant at 1%; ** significant at 5%; *** significant at 1%

Figures

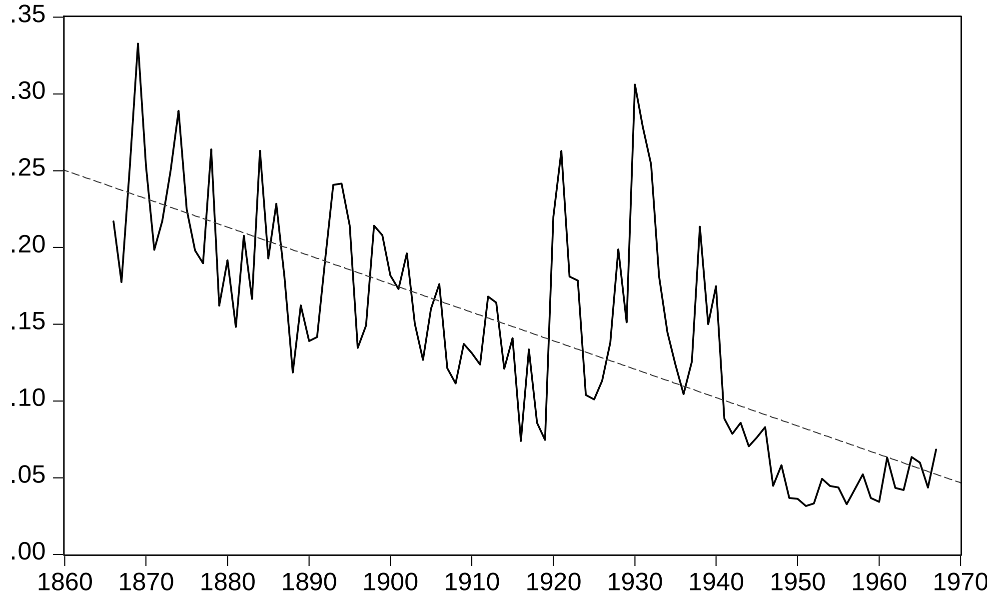

Figure 1: Coefficient of variation, wheat 1867-1967

Source: Cooley et al, *ATICS.*

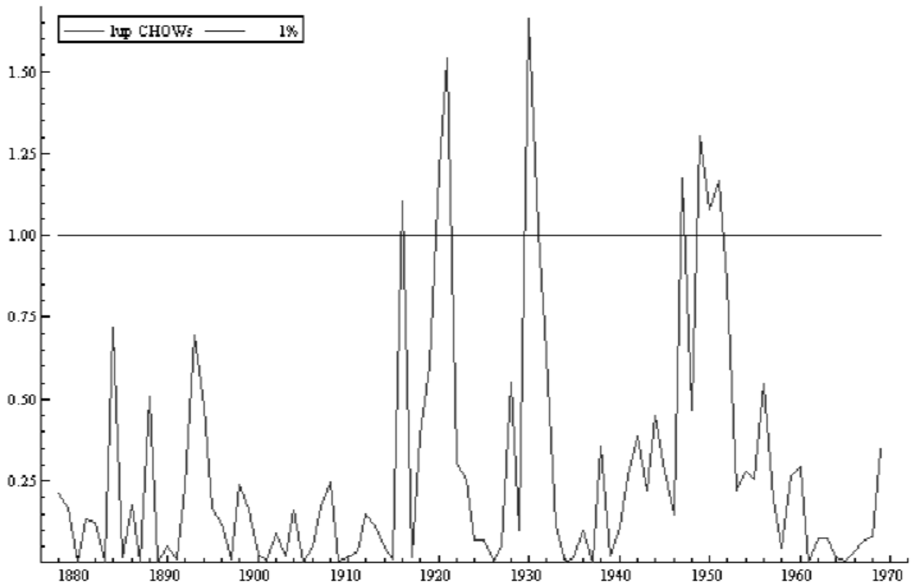

Figure 2: 1-step Chow tests for recursive estimation of CVs for wheat on a trend

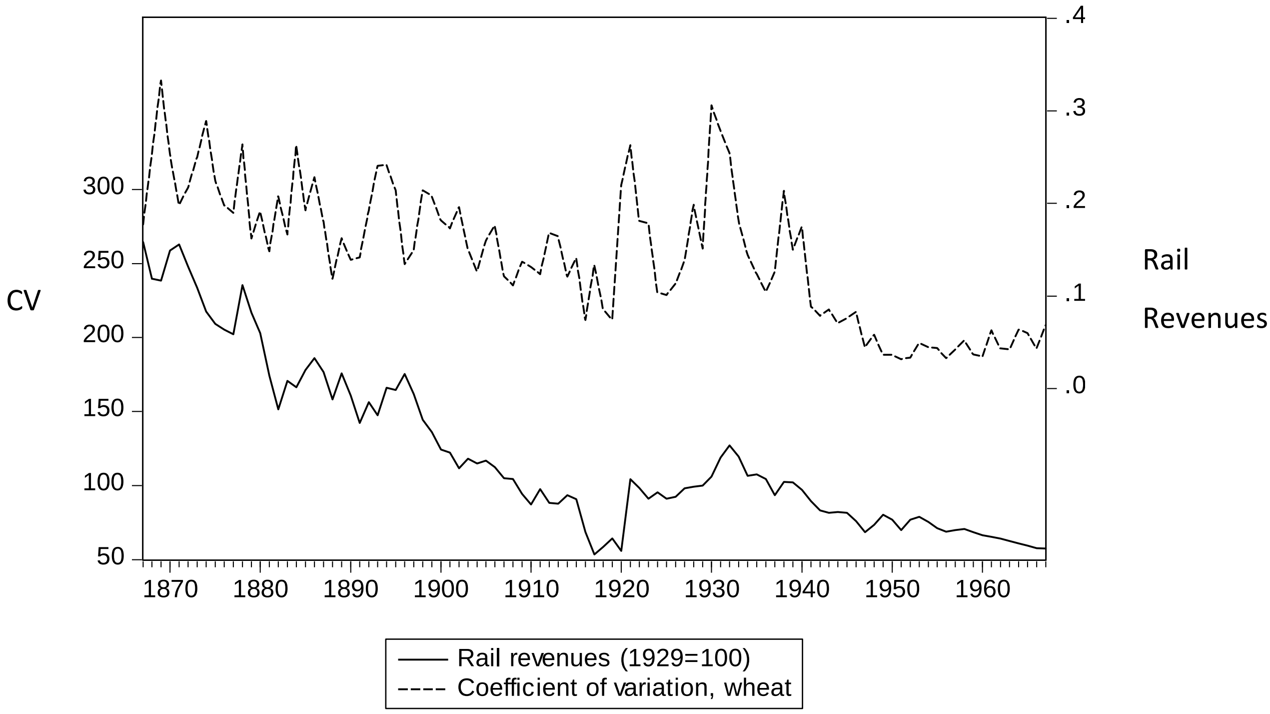

Figure 3: The cost of rail transportation and the integration of the wheat market

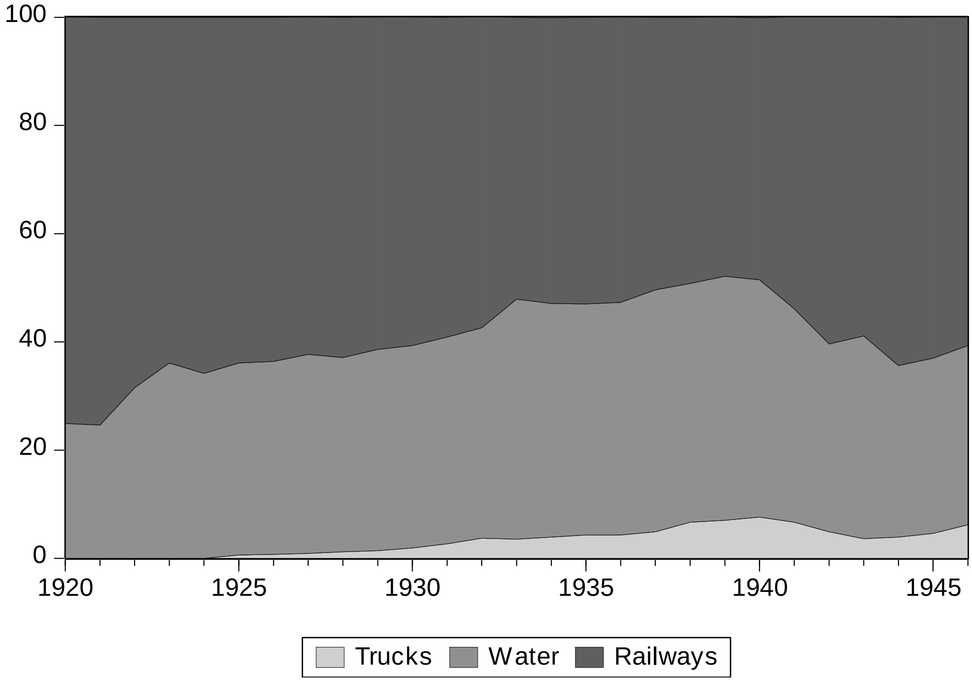

Figure 4: Distribution of total freight traffic

Source: Barger, 'Transportation'.

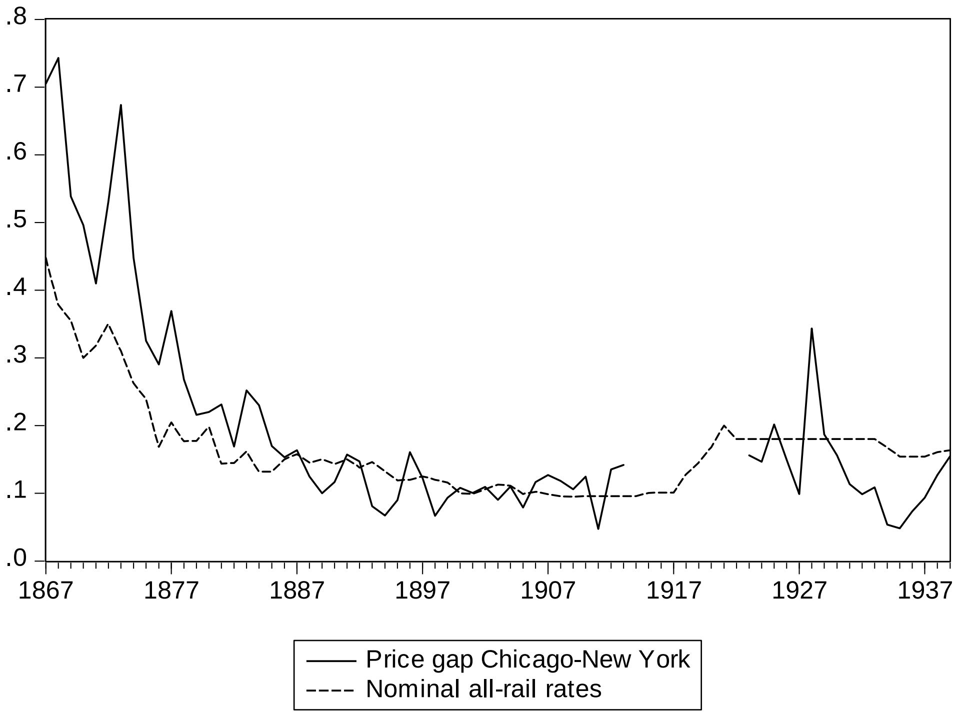

Figure 5: comparison all rail rate and price gap ($/bushel)

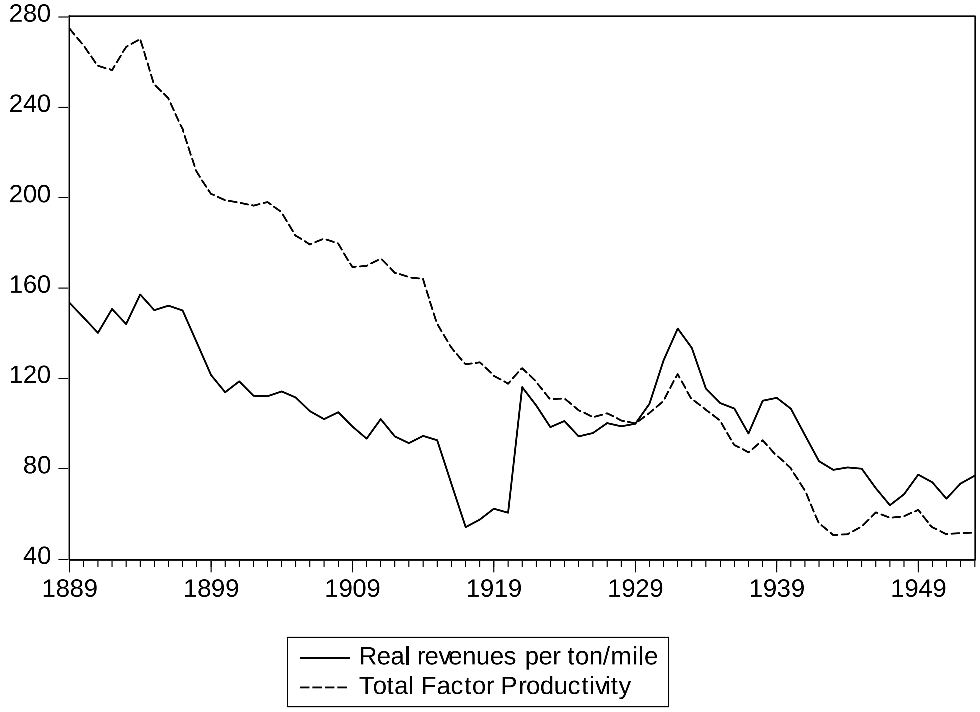

Figure 6: Rail revenues and total factor productivity for rail, 1889-1953

Figure 7: The profitability of railroad companies, 1890-1970