CYCLICAL FACTORS IN CARTEL STABILITY: EMPIRICAL EVIDENCE FROM LATE NINETEENTH CENTURY RAILROAD CARTELS

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Summary

The possibility of achieving cartel success with internal enforcement devices is explored by examining the behavior of railroad cartels in the years just before the creation of the Interstate Commerce Commission and the passage of the Sherman Act. The collusion is found to have been relatively stable, periods of breakdown being determined by reduction in the demand for rail freight service. Econometric work confirms that the probability of cartel adherence varied directly with the volume of flour and grain shipped and with other important structural variables.
Although there have been extensive studies of the history of certain cartels, almost all of which seem to exhibit a pattern of intermittent success and failure at maintaining joint-profit-maximizing prices and output,¹ there has not yet been an empirical test of hypotheses regarding the causes for this pattern. The research reported here seeks to offer such a test for the case of railroad cartels operating between the Midwest and the Atlantic coast in the late nineteenth century in the years just before the establishment of the Interstate Commerce Commission. This subject is particularly well-suited for the sorts of studies cartel theory has long urged: neither regulatory nor statute constraint interfered with the operations of the railroad cartels. That is, the colluders had neither the protection often associated with a regulatory agency nor the fear of discovery by private or public enforcers of the antitrust laws. Under these circumstances, it will be seen, the principle determinant of whether the collusion worked or not was the pattern of fluctuation in the demand for the cartel's output.

Section I offers a brief description of the method of internal enforcement of cartel rules which the railroads developed. Section II presents tabular evidence relating cartel fortunes to the business cycle. Section III describes the data which have been collected, the theoretical model which will be tested, and the results of the empirical tests. Section IV summarizes the findings of the research and offers conclusions.

I.

Collusive agreements figured in nearly all inter-city and passenger traffic at one time or another.² Among the most significant of these cartels were the Iowa Pool, a combination among the roads running between
Council bluffs and Chicago;\(^3\) the Southern Railway and Steamship Association, which included all major lines south of the Ohio and east of the Mississippi Rivers, as well as the competing river and coastwise steamers;\(^4\) and the Joint Executive Committee, a rate-setting and market-share enforcing group of trunk line and connecting roads between the Midwest and the eastern seaboard ports north of Baltimore.

Following the successful example, after 1875, of the Southern Railway and Steamship Association, the trunk line roads leading west from the Atlantic seaboard agreed in 1876 to quote the same rates and to divide all westbound dead freight from the coast in fixed proportions calculated from average market shares over the past four years. After several breakdowns, the trunk lines and their western connections formalized an agreement in April, 1879, to divide eastbound tonnage from the common point of Chicago. The new organization was called the Joint Executive Committee, and Colonel Albert Fink became its commissioner.\(^5\)

Meanwhile, roads leading east from Peoria, St. Louis, Decatur, Indianapolis, Louisville, Cincinnati, et al., undertook pooling arrangements of their own. Each of these pools was represented on the Joint Executive Committee and attempted to set its rules and rates consistently with those in other parts of the cartel. For example, the tariff of rates quoted by each of the pools was calculated on the basis of the Chicago-New York rate for grain in one hundred pound lots.\(^6\)

Three classes of commodities were pooled in the commercial centers whence a cartel operated. Each class had its own administrative body and allotted market shares to members. Dead freight included all tons
shipped of flour, grain (wheat, corn, oats, rye, and barley), and provisions (beef, pork, cured meats, lard, and canned meats). There was a pool on livestock from June, 1879, and from June, 1880, pooling of both east- and west-bound passenger traffic. In addition, from October, 1880, the New York Central, Erie, and Pennsylvania attempted a separate immigrant pool.7

This proliferation of merchandise covered by collusive agreements created another source of possible instability in any one of the arrangements. The roads which ran from Chicago to the seaboard may be taken as a case in point. Suppose that conditions were such that those roads were, ceteris paribus, inclined to adhere to the same supra-competitive rates and to their assigned market shares. If we now relax the cet. par. assumption, it is clear that the interdependence of the eastbound transport network and of the various separate pooling arrangements on different commodities might cause troubles in the otherwise stable Chicago pool. The effect of some exogenous dislocation in a competing center, say, St. Louis, would, because of the method of setting rates in St. Louis on the basis of the Chicago-New York rate, cause disequilibrium between the Chicago and St. Louis markets. Worse still, within the Chicago pool a dispute regarding the livestock pool might cause a spillover disruption in the dead freight pool. And again, a fight in the westbound market among the trunk lines might occasion instructions to the western connections to take up the battle on the eastbound business as well, through refusing to transfer tonnage in settlement of accounts with the rivalrous western connections of the warring trunk lines.
This is a formidable list of things that might go wrong. If it were also true that there were no effective internal policing devices in each of the separate cartels nor any effective policing mechanism by the Joint Executive Committee to stop local disruptions from spreading, we should be comfortable with a prediction for the quick demise of the cartel.

The colluders were not, however, blind to the temptation to violate the agreement. The JEC had five means of reducing the incentive to cheat on the cartel contract. The first was the compilation and publication of statistics on tonnage movements by members. These figures had been verified by the station agents, who were not employees either of the roads or of the cartel. Those figures were then verified by minions of the powerful Chicago Board of Trade. Subsequently the Board instituted a Weighing Association, which further verified the correct billing by weight of packaged shipments from each road's terminal. Once the statistics began being gathered at the point of origin, they quickly found their way into print. The Chicago Tribune and Railway Review, listed the weekly shipments as well as a summary of the pool's activities in the preceding seven days. The wide availability of these presumably accurate tables—only once did a member question their accuracy—must have greatly reduced the incentive to cheat since discovery was so very certain.

The second device used by the Joint Executive Committee was a hired Board of Arbitrators to settle disputes among members. Typically the complaint raised was about the size of allotment. In a few instances the complainant disrupted the cartel through rate-slashing so as to make
the strength of its dissatisfaction known. More frequently, the member was content to leave the decision to the arbitrators. Never in the history of the JEC were share revisions the cause of a rate war. In large part this is probably attributable to the presence of distinguished names on the board, men hired from outside the immediate area and community but with a national reputation for expertise in railroad affairs.

A third device was used from March 11, 1881: the assignment to the commissioner of the power to match any price cut discovered on the floor of the Board of Trade in Chicago. Although Orr and MacAvoy have correctly shown that this device should not necessarily compel the cheater to abandon his disruption, the practice did have its periods of effectiveness, though by and large it must be admitted to have been a weak tool.

Fourthly, various economic sanctions were imposed on cheaters. From March, 1882, there is mention in the Railway Review of the handing-in of good faith deposits by the members to the commissioner, a device used from its beginning by the Southern Railway and Steamship Association. Clearly the deposit of a substantial sum of money which would be forfeited in whole or in part upon a proven accusation of cheating would be a strong incentive to calculate very carefully before disrupting the cartel. A second form of economic sanction was the refusal to transfer freight with a road known to be cheating. This usually applied not to the western connections of the trunk lines themselves but to the smaller local roads which had no direct access to seaboard markets.

Between June, 1879, and January, 1887, the positive inducement to remain loyal to the Chicago pool lay in the repeated attempts to equalize
equal and allotted shipments of the dead freight carried east. Before 1882 the joint agent of the JEC used the weekly statistics of the cartel to issue instructions to freight forwarders as to where to direct freight. The freight agents of a road "over" were asked to send custom to either the joint agent's office or the freight agent of a road "under." This was much to ask of an assiduous employee interested in his own commission. Therefore, independent agents of the cartel stationed at members' terminals saw to the redirection of traffic themselves from an early date in the collusion's history. As court rulings began to find illegal this taking from the shipper the right to name his route without the shipper's prior consent, the joint agent began to offer discounts to large shippers assigning the joint agent the right to get the goods to their destination by whatever route he saw fit. The shipper was advised of the route selected and was asked to pay that particular road.

II.

The pattern of cartel stability and instability between 1880 and 1886 was not random, but rather cartel success and failure seem to follow the business cycle. Evidence that this is an accurate summary of events in the Chicago cartel for the period 1873 to 1893 is presented in the following tables and figures. Table 1 presents the annual figures on the shipments of flour and grain from the city and on the revenues realized from the transport of all freight by thirteen roads which served Chicago. Seven of the roads were in the east and members of the Joint Executive Committee; the remaining six were tributary to Chicago and members of the Iowa Pool. In the last two columns of the table the annual rates of change for the two series are compared. Revenues are,
for the purposes at hand, to be taken as a proxy for the earnings of the roads in question. In that the tonnage series and the revenue series cover slightly different markets, the correlation between the two will be imperfect. Nonetheless, it can be seen that there is enough of a relationship to warrant the inferences developed below. Lastly, the Chicago cartel colluded on all dead freight, not just on flour and grain. However, those two commodities made up, on average, more than 80% of all cartelized output so that flour and grain shipments may be taken as a reasonable proxy for the market demand for eastbound transportation services. 14

The table seems to indicate, first, that there was a cyclical pattern to the volume of flour and grain shipments leaving Chicago between 1873 and 1896. In the early 1870's that volume fell for several years, and then revived in 1876 for a stretch of five years, through to the end of 1880. The period 1881 through 1886 was one of nearly continuous decline in the volume of shipments, 1883 standing out by comparison. Then began a long period of continuous, strong improvement in the transport of grain and flour, an improvement which continued for six years. There was a drop in 1893 and 1894, and then a renewal of the increase. It can be seen by reference to Figure 1 that this pattern of grain shipment from Chicago corresponds roughly to the cyclical pattern of national income growth through this period, as determined by the National Bureau reference cycle chronology given along the horizontal axis on the figure and more explicitly in the notes accompanying the figure.

In Table 2 the annual change series from the first table is reproduced and compared to the total number of miles of railroad built in
each year from 1873 to 1896 and, for the 1880's, with an index of adherence to the Chicago East-Bound Dead Freight Pool's tariff of rates and an index of the average rate on grain transport from Chicago to New York. The adherence index is the percentage of the weeks in the calendar year during which there was no discounting from the official rate reported in any of the following four sources: Railway Review, Chicago Tribune, Bradstreet's, and Railroad Gazette. The more complete the adherence to the collusion, the closer the index is to 1.

The index on grain rates for the 1880's was developed from the same sources and has been weighted by the number of weeks in the calendar year during which each particular observation was reported. A comparison with the official rates reported in the Annual Report of the Chicago Board of Trade for each year in the period reveals that the actual and the official rates frequently were not equal. Since the same sources which were used for the rate index for 1880-1886 were not available for either 1873-1879 or for 1887-1896, that index series could not be developed for the entire period.

To complement the material contained in Table 2, the number of miles of rail built each year and the amount of grain and flour shipped from Chicago each year are graphed for the years 1873-1896 in Figure 1. Again the cautionary note must be appended that the miles-constructed series is not strictly for the same market as covered by the shipment series. The construction series from Poor's Manuals covers the entire United States, not just the area in which the Joint Executive Committee operated. We may assume that construction of railroad miles in the
cartel territory between Chicago and the Atlantic coast and tributary to Chicago from the west moved with the national figures.

The first conclusion to be derived from Table 2 is that for the early 1880's the grain rate moved in the same direction as did the index of cartel adherence. The stronger the collusion the higher was the charge for hauling grain from Chicago to New York. It also appears to be the case that railroad construction followed changes in flour and grain shipments fairly closely but with glaring exceptions: in the years just after 1880 and in the early 1890's. In the 1870's the relationship between flour and grain shipments and miles of rail laid was direct and very close.

From Column 4 in Table 2 and from the summary of cartel affairs at the end of section I, we know that in two of those periods the cartel operating in trunk line territory had difficulty. In the early 1880's it appears to have been the case that the number of miles of rail constructed was increasing extremely rapidly at the same time that shipments from Chicago were declining precipitously. When those shipments rose again in 1882 and 1883, the cartel's fortunes improved. But the downturn in freight in the following year caused two consecutive years of difficulty in the collusion as the dwindling amount of business had to be passed out among the greatly increased number of roads in the market for transportation to the east.

III.

A continuous 328-week series of binary data on adherence and non-adherence in the Chicago Eastbound Dead Freight Pool has been compiled from the Railway Review, the Chicago Tribune, the Railway Age, and
Bradstreet's. The period covered is January 1, 1880, through April 18, 1886. Over the 328 weeks examined these four sources gave contradictory evidence on the state of the cartel fewer than ten times. In each of those instances, any report of non-adherence was accepted. Are there any systematic biases in the data? That is, is there any reason to believe there is either a systematic undercount or overcount of the number of weeks of non-adherence?

It would seem to be reasonable to guess that too much adherence has been counted. The argument would be that cheating is by its very nature a secret affair. It is only nonrandomly discovered when it reaches epidemic proportions. Therefore, all the secret deals struck week by week with individual shippers by the various cartel members have not been captured in the dichotomous dependent variable.

As against this one might maintain that the incidents of non-adherence may be overreported because each shipper had an incentive to whisper the untruth that he was the beneficiary of a discount from road X, in hope that this false report would spark a rate war. Thus, many weeks reported as containing nonadherence on the strength of rumors of cheating were in fact weeks of complete adherence. Bringing these two arguments together, one might claim that these two biases offset each other so that the expected value of the error term is truly zero. There are other reasons for trusting the data or at least for believing there are no serious biases affecting the results.

Given the manner in which the floor of the Chicago Board of Trade operated and the incentives on all sides to discover what was really afoot, the great hustle and bustle of the commodity exchange when flour
and grain shipments were booming could not help but increase the probability of detecting a discount. Conversely, when business was poor, there were fewer traders on the floor, and less incentive on the part of a shipper to disclose a discount, despite the increased incentive to discount on the part of any member of the cartel. Thus, a rate cut was more likely to have been unearthed in good times and less likely, in bad times. The four sources from which the dichotomous adherence series was derived would have been more likely, therefore, to report non-adherence when through shipments of dead freight from Chicago were booming and less likely to report non-adherence when shipments were very slow. If this is true, then by recording the dependent variable on the basis of those reports the case has been prejudiced against finding a direct relationship between variations in the demand for transport services and in cartel stability.

This last point can be put more formally. Assume that the weekly data on adherence or non-adherence has been generated by a process involving many separate decisions as to what price to charge. For example, rates could have been set with a certain amount of discretion by individual roads' freight agents. For each of these contracts written by the agents there is a probability of adherence to the official rate. Define these probabilities over j contracts as \( \theta_j \); and assume them confined to the interval [0, 1]. Assume that they follow a beta distribution with parameters \( a \) and \( b \) such that

\[
\theta_j = \frac{\Gamma(a + b)}{\Gamma(a) \Gamma(b)} \theta_j^{a-1}(1 - \theta_j)^{b-1} \quad a, b > 0
\]

where \( \Gamma(a) = \int_0^\infty \theta_j^{a-1} e^{-\theta_j} d\theta_j \).
The mean probability of adherence over all the freight contracts written is then

\[ E(\theta_j) = \frac{a}{a + b}. \]

One may now argue that the binary observations which have been gathered for 1880-1886 have come from observations on the "representative" or "mean" contract. A 0 will have been assigned to the period if the mean contract was made at the cartel rate and 1 otherwise. The journalists who reported adherence or non-adherence may have in fact had bellwether contracts of a mean size which they attempted to monitor so as to be aware of the state of the cartel. In view of these considerations the binary variables on reported adherence may be used to estimate \( E(\theta_j) \).

Further assume that the parameters of the beta distribution, \( a \) and \( b \), are functions of independent variables which indicate conditions in the eastbound market from Chicago, the state of the cartel in the last time interval, the difference between allotted and actual shares for deficit roads, and so on. Define \( x' \) as the vector of these variables for a given period and assume that the parameters of the beta distribution follow the functional forms

\[ a = \exp(ax') \]
\[ b = \exp(bx'). \]

We may then write the mean probability of adherence as

\[ E(\theta) = \frac{\exp(ax')}{\exp(ax') + \exp(bx')} \]
Manipulation then gives the logistic function,

\[
E(\hat{\theta}) = \frac{\exp[-(\beta - \alpha)x']}{1 + \exp[-(\beta - \alpha)x']}
\]

\[
E(\hat{\theta}) = \{1 + \exp[-(\beta - \alpha)x']\}^{-1}
\]

Non-linear estimation techniques can then be used to identify \((\beta - \alpha)\). In this formulation it will prove impossible to estimate \(\alpha\) and \(\beta\) separately, and so \(a\) and \(b\) cannot be predicted. The strength of this formulation is that it demonstrates explicitly how the probability of adhering to the representative contract is related to the binary observations, and that the probability of adherence changes as cartel conditions change.\(^{16}\)

Within the time period dictated by the tonnage figures, it was possible to gather data on other variables bearing on the eastbound cartel. One of these variables was each road's allotment under the various cartel contracts. Whenever the contract was revised or altered by an arbitrator's ruling, the new allotments were published in the Railway Review, the Railway Age, and the Tribune. Specific starting dates for reckoning shares were also announced with each new assignment. Between January 1, 1880, and April 18, 1886, there were six revisions in the percentages for dead freight. Using these and the previously described tonnage figures, it was possible to calculate deviations between actual and allotted tons for each week in the sample period. These form the basis for variables \(X_1\) through \(X_6\) and \(X_9\) in Table 3.

The Chicago Board of Trade's Annual Reports for the period 1880-1886 also gave the dates on which the navigation season opened and closed. These were gathered in order to test, through the use of
dummy variables, whether the presence of competition on the lakes influenced the probability of cartel success. Whether competition really prevailed between the steamers and the railroads is a moot point, as we shall see. The data on the navigation season's being open or closed will be used to distinguish between these two hypotheses.

Finally, there are potentially important data which have proved impossible to locate. Three continuous series of dummy variables on trouble in contiguous eastbound pools, in the westbound pool, and in the other two commodity pools from Chicago would have been useful in attempting to explain the variation in the dependent variable. Only a partial series for any of these was available, so the impact of these forces could not be tested.

The model which was specified for estimation was a logistic function, as in equation (6) above,

\[
PA = L(X'\gamma) = \left[1 + \exp(-X'\gamma)\right]^{-1}
\]

where PA is equal to 1 if there were no reports of cheating in any of the four contemporary journals and to 0 otherwise. The vector of independent variables is described in the notes to Table 3.

For purposes of interpreting the results the partials of PA with respect to the independent variables must be specified.

\[
\frac{\partial PA}{\partial X_i} = \gamma_i \cdot \frac{\exp(X'\gamma)}{[1 + \exp(X'\gamma)]^2}.
\]

Therefore,

\[
\frac{\partial PA}{\partial X_i} > 0 \text{ as } \gamma_i > 0.
\]
The sign on the estimated parameters of the logistic function will therefore indicate whether changes in variable \( X_1 \), \textit{ceteris paribus}, increase or decrease the probability of adherence to the representative contract in the Chicago Eastbound Dead Freight Pool.

The first five independent variables are included to test the influence on cartel stability of overruns and shortfalls in each member's allotment. It should be noted, a point previous investigators have overlooked, that it is not a foregone conclusion that deviations were a sign of malfunction in the cartel. Indeed they could have been caused by the transfer of freight from roads over to roads under in settlement of accounts.\(^{18}\)

\( X_6 \)--the total tonnage of dead freight shipped east by the cartel in the period (t1) is meant to capture the effect of fluctuations in the demand for transport services on cartel adherence. I have argued that a cartel was more likely to remain stable when business was good and more likely to break up when business was declining. This suggests that the estimated coefficient for this variable, \( \gamma_6 \), should have a positive sign. It should further be noted that the correlation between flour and grain tonnage and total dead freight tonnage was very high. That is, flour and grain shipments made up the bulk of the total market demand for the cartel's services. The percentage of total dead freight tonnage accounted for by this subset was less than 75% of all tons shipped east for only a few weeks in the sample period and averaged 84% of dead freight tonnage shipped east for the 328-week period.\(^{19}\)

The interaction term, \( X_7 \), isolates the specific effect on cartel stability of large shortfalls in market shares. If non-adherence in the
cartel was reported during the previous week, the interaction term dis-
appears. However, if the cartel was working well in the preceding week, 
then this variable appears as simply the total tons under allotments. 
This does not necessarily imply that roads short are thought to have 
always started rate wars. The hypothesis would simply be that the 
larger the shortfall, ceteris paribus, the less likely would be adherence. 
Thus, it should be the case that \( \gamma_7 < 0 \). The reader should note that 
\[
X_7 = \sum_{i=1}^{5} X_i 
\]

Given this, the variable is really measuring the effect on cartel adher-
ence for large deviations from all allotments, not just deficits, when 
reports of cheating have already been received. There will therefore, 
be a strong correlation between \( X_7 \) and the first five independent var-
iables.

Variable \( X_8 \) tests the hypothesis that the presence and absence 
of competition from Great Lakes' vessels had an effect on the probability 
of adherence to the cartel by the railroad members. The contention in 
earlier work was that the cartel became less stable when the lakes 
closed. There are reasons for doubting this influence. First, there 
were reports of joint-ownership of rail and steamer lines; and second, 
some cartel members benefitted whether dead freight was received at 
Chicago or at Buffalo and thus would not be much disturbed by the ac-
tivities of the lake vessels. Which of these hypotheses regarding 
inter-modal competition is believable can be resolved by observing the 
sign and significance of \( X_8 \). The variable has been valued such that it
is equal to 1 when the lakes are open and to 0 otherwise. Thus, if the beginning of the navigation system adversely effected the probability of cartel adherence, then the coefficient on \( X_q \) should be less than zero. A large and significant positive value for the estimated coefficient would be difficult to explain. The smaller the value of the parameter, if it is positive, the more comfortable one would feel about accepting the hypothesis that the presence of lake competition had no effect on cartel stability. The historical evidence would then support the contention that the only effect which the lake vessels had with regard to the rail collusion was on the level of rates. Typically when the lakes closed in December or November the cartel, in concert, raised the tariff of rates 5¢/100 lbs. of grain. When the ice broke up around the Straits of Mackinac in the spring, the cartel commissioner would announce that all the roads would lower their tariff 5¢.

\[ X_q = \text{the sum of all deviations, over and under allotments for period (t1), weighted by the mean tonnage of flour and grain shipped by the cartel over the past month--attempts to get at the effect on cartel adherence of deviations, given changes in the transferable subset of dead freight passing through Chicago. Not all of the dead freight tonnage eastbound for the coast from the Midwest could be diverted among the pool roads so as to equalize actual and allotted market shares. In fact the only freight which could satisfy this requirement was flour and grain for export to Europe. It did not much matter through which port between Baltimore and Boston the grain and flour passed; the differentials from Chicago to the various cities had been established such that--among other reasons--the export rate (the combined domestic rail/}
trans-Atlantic ocean shipping rate from Chicago to Liverpool) would be equal no matter the route. The figures available from the *Railway Review* and the Chicago *Tribune* do not distinguish between through shipments of cereal grain and flour for export and for domestic destinations. Weekly grain export statistics did appear in the *Commercial and Financial Chronicle*, but they were sporadic rather than continuous, and, worse, they gave exports by port but not by point of origin of the shipment. In view of these difficulties, it seemed reasonable to use total flour and grain shipments of the Chicago cartel as the simple proxy for the transferrable subset of all dead freight. The implicit assumption is that flour and grain tons marked for export were proportional to all through tonnage of those commodities.  

21 A road short may be assumed to have gauged the likelihood of receiving transfers from roads over from the size of the transferrable subset of dead freight. Conversely, for roads over, the ease of discharging their transfers to deficit roads would be easier, the larger the volume of flour and grain shipments eastbound to the coast. These considerations suggest that the probability of adherence should vary inversely with respect to \( X_q \). That is, the larger the tonnage of the transferrable subset relative to the inter-road tonnage obligations, the smaller will be \( X_q \), and the smaller would be the probability of the offering of a discount on the representative contract. \( \hat{\gamma}_q \) should be \(< 0\).  

The results of two regressions are given in Table 3 as equations 1 and 2. The second regression is simply the first equation with the statistically insignificant variables omitted. The last four estimators in the first regression are significant, and all save the navigation
season dummy have the anticipated sign for the estimated parameter. For the lakes dummy variable the indication is that the opening of the navigation season on the Great Lakes reduced the probability of adherence to the cartel but that the effect was very weak. None of the first five variables is statistically significant, even given the large number of degrees of freedom. The signs of the coefficients on those terms are also ambiguous. The Durbin-Watson statistic reveals no significant autocorrelation in the error term. Taken together these nine variables explained over 90% of the variance in adherence to the rates of the Chicago eastbound dead freight pool between January 1, 1880, and April 18, 1886.

The results of the second regression are stronger. The estimated values of the coefficients were remarkably stable when the other variables were dropped. Again there is non-significant autocorrelation, and these two variables alone account for 89.3% of the variance in the adherence measure, a trivially lower $R^2$ from the previous regression. The signs on the estimators are once more compatible with a priori expectations.

These regressions suggest very strongly that periods of railroad cartel stability and instability before the passage of the Act to Regulate Commerce can be adequately explained. The crucial factors in causing the probability of adherence to fall were a drop in the total tonnage presented to the cartel for shipment east and an increase in deviations from allotments relative to the volume of flour and grain shipments. When this freight available for diversion in settlement of inter-firm accounts fell at the same time as, for whatever reason, the deviations
between actual tons carried and tons allotted under the cartel contract grew larger, the chances of the collusion's holding together fell especially dramatically. Lastly, if the cartel rates were already being shaded, then a large volume of tons under allotments caused conditions to worsen, as indicated by the coefficient on $X_7$.

IV.

The research reported here indicates that internal policing mechanisms adopted by a cartel are capable of leading to intermittent cartel success. That is, it is not necessarily true that enforcement of the cartel contract must be external to the collusion to be effective. But it is further evident from the behavior of the late nineteenth century railroad cartels that internally-achieved collusive success fluctuates with the demand for cartel output. It would be a step forward if this hypothesis could be tested for cartels which have operated with external enforcement (e.g., the government enforced the collusive contract) and under the added pressure of avoiding detection by the antitrust authorities. Behavior under those circumstances should not be significantly different from that reported here.

Additionally, the research here reported implicitly questions the widely-held belief that the first federal regulatory agency, the Interstate Commerce Commission (1887), was necessary for the railroads to achieve joint-maximum profits. Further research must now establish whether the record of the railroad cartels was significantly different after 1887 and if so, whether that difference was due to the regulatory agency's acting as a cartel manager or to a coincidental boom in the demand for rail freight service.
Footnotes


4 The only sources on this remarkable cartel are William H. Joubert, Southern Freight Rates in Transition, (Gainesville: University of Florida Press, 1949), and Henry Hudson, "The Southern

5 For further sources and a more detailed history of the collusion see Ulen, supra note 1.

6 It should be noted here that observations on the state of these contiguous pools was only intermittently available and thus could not be included in the regression model reported later.

7 Railway Review, October 30, 1880, p. 566.

8 Railway Review, September 28, 1880, p. 446: the Fort Wayne claimed that it had carried 500 more tons than were reported.


10 The Chicago and Grand Trunk, a Canadian road, was the prime culprit here. The source of dissatisfaction was that the Grand Trunk believed that its allotment in the livestock cartel was too low. Arbitrators agreed and the trouble ended.


12 Railway Review, September 8, 1883, and Fink's letter to the New York Tribune reproduced on page 531 of that same issue of the Railway Review.
13. See the discussion in section III.

14. Further institutional reasons for concentrating on flour and grain volume as indicators of relevant business for studying this cartel's health is given in section III.

15. See the discussion in section III on these reports.


17. MacAvoy, op. cit., supra n. 1, had suggested that the lake steamer lines and the railroads were competitors, and that the rail cartel often suffered breakdowns during the spring, summer, and fall—the lake navigation season.

18. See Ulen, op. cit., supra n. 1, especially the appendix to chapter 2.

19. In an earlier regression \( X_6 \) covered only flour and grain and the resulting coefficient was not much different from that reported below. Flour and grain tons transported by the cartel now enters into variable \( X_9 \) in the current regression in a far more defensible manner.

20. MacAvoy, passim; especially p. 195, n. 3.

21. Ibid., p. 195, n. 3. "Demand for the transport of grain for export was an important part of total demand. The statistical Appendix to Chapter 6, p. 265, indicates that exports were smaller, and the declared value of exports smaller, in 1881-1882 than in the previous
year—so that demand for export-grain transport had fallen in this year of cartel breakdown. This is true of 1883-1884 as well, but not of 1884-1885; and grain exports in 1886-1887, another disastrous year for the cartel, were the largest of the decade. Demand for the transport of export-grain appears to have greatly declined in 1887-1888, but there was no disloyalty to the agreement this first year of regulation. In the 1890's, demand declined in the 1893 to 1895 period, as did the success of the cartel; demand increased from 1896 to 1898, while the cartel continued to be ineffective." Actually the correlation is somewhat better than this excerpt indicates. 1886-1887 was not a "disastrous year for the cartel." Two new roads were invited in: an older member, the Chicago and Atlantic came back in; and the grain rate was raised to 30c/100 lbs. of grain, the highest level in nearly 18 months. Moreover, 1884 and 1885 were years not much different from 1881 (see Table 2, col. (5)), which MacAvoy identified as one of breakdown. Finally, the contention that 1886-1887 was a year of the largest grain shipments of the decade is not quite correct. The following table gives total exports of flour, wheat, corn, and rye from the United States to Europe for the period 1880-1896.

Additionally, taking export grain as the relevant measure of the demand for cartel output is incorrect. Variable $X_6$ accomplishes that. Variable $X_9$ incorporates export grain shipments (through a proportional proxy, total tons of flour and grain shipped east) as the transferrable subset for equalizing actual and allotted tons.
Table 1

Annual Shipments and Freight Revenues, 1873-1896

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Flour and Grain Shipments from Chicago bu.</th>
<th>Freight Revenue, 13 U.S. Roads $1000</th>
<th>Annual % Change in Flour &amp; Grain Shipments</th>
<th>Annual % Change in Freight Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1873</td>
<td>91,597,092</td>
<td>389,036</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1874</td>
<td>84,020,691</td>
<td>379,467</td>
<td>- 8.27</td>
<td>- 2.46</td>
</tr>
<tr>
<td>1875</td>
<td>72,369,174</td>
<td>363,960</td>
<td>- 13.87</td>
<td>- 4.09</td>
</tr>
<tr>
<td>1876</td>
<td>87,241,306</td>
<td>361,137</td>
<td>+ 20.55</td>
<td>- 0.78*</td>
</tr>
<tr>
<td>1877</td>
<td>90,706,076</td>
<td>347,705</td>
<td>+ 3.97</td>
<td>- 0.37*</td>
</tr>
<tr>
<td>1878</td>
<td>118,675,469</td>
<td>365,466</td>
<td>+ 30.84</td>
<td>+ 5.11</td>
</tr>
<tr>
<td>1879</td>
<td>125,528,379</td>
<td>386,676</td>
<td>+ 5.77</td>
<td>+ 5.80</td>
</tr>
<tr>
<td>1880</td>
<td>154,377,115</td>
<td>467,749</td>
<td>+ 22.98</td>
<td>+ 20.97</td>
</tr>
<tr>
<td>1881</td>
<td>140,307,597</td>
<td>551,968</td>
<td>- 9.11</td>
<td>+ 18.01*</td>
</tr>
<tr>
<td>1883</td>
<td>141,720,259</td>
<td>539,510</td>
<td>+ 23.38</td>
<td>+ 11.06</td>
</tr>
<tr>
<td>1884</td>
<td>138,652,155</td>
<td>502,870</td>
<td>- 2.16</td>
<td>- 6.79</td>
</tr>
<tr>
<td>1885</td>
<td>135,587,921</td>
<td>509,691</td>
<td>- 2.21</td>
<td>+ 1.36*</td>
</tr>
<tr>
<td>1886</td>
<td>129,636,678</td>
<td>550,359</td>
<td>- 4.39</td>
<td>+ 7.98*</td>
</tr>
<tr>
<td>1887</td>
<td>151,658,224</td>
<td>636,666</td>
<td>+ 16.99</td>
<td>+ 15.68</td>
</tr>
<tr>
<td>1888</td>
<td>156,659,986</td>
<td>639,201</td>
<td>+ 3.30</td>
<td>+ 0.40</td>
</tr>
<tr>
<td>1889</td>
<td>179,035,997</td>
<td>665,962</td>
<td>+ 14.28</td>
<td>+ 4.19</td>
</tr>
<tr>
<td>1890</td>
<td>204,674,918</td>
<td>734,822</td>
<td>+ 14.32</td>
<td>+ 10.34</td>
</tr>
<tr>
<td>1891</td>
<td>207,987,762</td>
<td>---</td>
<td>+ 1.62</td>
<td>---</td>
</tr>
<tr>
<td>1892</td>
<td>216,182,008</td>
<td>---</td>
<td>+ 3.94</td>
<td>---</td>
</tr>
<tr>
<td>1893</td>
<td>198,791,216</td>
<td>---</td>
<td>- 8.04</td>
<td>---</td>
</tr>
<tr>
<td>1894</td>
<td>148,638,822</td>
<td>---</td>
<td>- 25.23</td>
<td>---</td>
</tr>
<tr>
<td>1895</td>
<td>171,464,137</td>
<td>---</td>
<td>+ 15.36</td>
<td>---</td>
</tr>
<tr>
<td>1896</td>
<td>219,710,781</td>
<td>---</td>
<td>+ 28.14</td>
<td>---</td>
</tr>
</tbody>
</table>

Sources:


Col. (2): U.S. Bureau of the Census, Historical Statistics of the United States, Colonial Times to 1957, Series Q-27, p. 428. The data are originally from the various annual issues of Poor's Manual of the Railroads of the U.S. and cover the freight revenues of the following 13 roads: the Pennsylvania; the Pittsburgh, Ft. Wayne & Chicago; the New York Central; the Lake Shore; the Michigan Central; the Boston & Albany; the New York, Lake Erie & Western; the Illinois Central; the Chicago & Alton; the Chicago & Rock Island; the Chicago, Burlington & Quincy; the Chicago & Northwestern; and the Chicago, Milwaukee & St. Paul.

Col. (3): Calculated from column 1.

Col. (4): Calculated from column 2.
### Table 2
Determinants of Revenue Changes for Chicago Roads, 1873-1896

<table>
<thead>
<tr>
<th>Year</th>
<th>(1) Annual % Change in Flour &amp; Grain Shipments</th>
<th>(2) Annual % Change in Freight Revenues</th>
<th>(3) Total miles of railroad construction in US</th>
<th>(4) Index of Cartel rate, Chicago to New York, Adherence</th>
<th>(5) Avg. Grain c per 100 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1873</td>
<td>---</td>
<td>---</td>
<td>4,097</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1874</td>
<td>- 8.27</td>
<td>- 2.46</td>
<td>2,117</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1875</td>
<td>- 13.87</td>
<td>- 4.09</td>
<td>1,711</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1876</td>
<td>+ 20.55</td>
<td>- 0.78*</td>
<td>2,712</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1877</td>
<td>+ 3.97</td>
<td>- 0.37*</td>
<td>2,280</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1878</td>
<td>+ 30.84</td>
<td>+ 5.11</td>
<td>2,679</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1879</td>
<td>+ 5.77</td>
<td>+ 5.80</td>
<td>4,817</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1880</td>
<td>+ 22.98</td>
<td>+ 20.97</td>
<td>6,712</td>
<td>1</td>
<td>32.71</td>
</tr>
<tr>
<td>1881</td>
<td>- 9.11</td>
<td>+ 18.01*</td>
<td>9,847</td>
<td>.33</td>
<td>24.20</td>
</tr>
<tr>
<td>1883</td>
<td>+ 23.38</td>
<td>+ 11.06</td>
<td>6,743</td>
<td>.90</td>
<td>26.88</td>
</tr>
<tr>
<td>1884</td>
<td>- 2.16</td>
<td>+ 6.79*</td>
<td>3,924</td>
<td>.42</td>
<td>22.60</td>
</tr>
<tr>
<td>1885</td>
<td>- 2.21</td>
<td>+ 1.36*</td>
<td>2,982</td>
<td>.23</td>
<td>21.35</td>
</tr>
<tr>
<td>1886</td>
<td>- 4.39</td>
<td>+ 7.98*</td>
<td>8,012</td>
<td>.50(^a)</td>
<td>25.42</td>
</tr>
<tr>
<td>1887</td>
<td>+ 16.99</td>
<td>+ 15.68</td>
<td>12,878</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1888</td>
<td>+ 3.30</td>
<td>+ 0.40</td>
<td>6,912</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1889</td>
<td>+ 14.28</td>
<td>+ 4.19</td>
<td>5,184</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1890</td>
<td>+ 14.32</td>
<td>+ 10.34</td>
<td>5,337</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1891</td>
<td>+ 1.62</td>
<td>---</td>
<td>4,072</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1892</td>
<td>+ 3.94</td>
<td>---</td>
<td>4,426</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1893</td>
<td>- 8.04</td>
<td>---</td>
<td>2,277</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1894</td>
<td>- 25.23</td>
<td>---</td>
<td>1,927</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1895</td>
<td>+ 15.36</td>
<td>---</td>
<td>1,520</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1896</td>
<td>+ 28.14</td>
<td>---</td>
<td>1,688</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Sources and Notes:

a. The entry covers only January 1 - April 18, 1886, after which time continuous records were not available.

Cols. (1) and (2): See Table 14, Sources.


Col. (4): Reports of adherence to the cartel rate were derived from Railway Review, the Chicago Tribune, Bradstreet's, and Railroad Gazette. If any of the four sources reported cheating in a given weekly edition, it was assumed that cheating occurred during that week. The number of weeks during which no reports of non-adherence were recorded was divided into the number of weeks in the calendar year to derive the given index.
Col. (5): Chicago Board of Trade, *Annual Reports*, v. 23-29 (1880 - 1886) and *Railway Review*, 1880 - 1886; Chicago Tribune, 1880 - 1886. The averages shown are derived from actual rather than officially quoted rates. The average was derived as a weighted average, the weights being the percentage of total weeks of the calendar year during which each rate held.
Figure 1

- Total miles of railroad constructed in the U.S.
- Flour and grain shipments from Chicago to the east
Sources and Notes to Figure 1:

(1) Total miles constructed in the United States, 1873-1896: Chicago Board of Trade, *Annual Report*, v. 39 (1896) as taken from the annual issues of Poor's *Manuals* and annually revised.

(2) The NBER reference cycle chronology: Milton Friedman and Anna J. Schwartz, *A Monetary History of the United States*, Princeton: Princeton University Press for the National Bureau of Economic Research, . The actual phases are as follows:

- Expansion: 2nd qtr., 1879 - 1st qtr., 1882.
- Contraction: 2nd qtr., 1882 - 2nd qtr., 1884.
- Expansion: 3rd qtr., 1884 - 1st qtr., 1887.
- Contraction: 2nd qtr., 1887 - 1st qtr., 1888.
- Expansion: 2nd qtr., 1888 - 2nd qtr., 1890.
- Contraction: 3rd qtr., 1890 - 2nd qtr., 1891.
- Expansion: 3rd qtr., 1891 - 4th qtr., 1892.
- Contraction: 1st qtr., 1893 - 2nd qtr., 1894.
- Expansion: 3rd qtr., 1894 - 4th qtr., 1895.

Table 3

Short-Run Cartel Adherence, 1880 - 1886: Chicago Eastbound Dead Freight Pool

<table>
<thead>
<tr>
<th>Equation 1</th>
<th>Estimator</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>6.185</td>
<td>5.776</td>
</tr>
<tr>
<td>$X_1$ (NYC)</td>
<td>3.472</td>
<td>1.267</td>
</tr>
<tr>
<td>$X_2$ (PRR)</td>
<td>0.898</td>
<td>0.444</td>
</tr>
<tr>
<td>$X_3$ (GT)</td>
<td>-4.744</td>
<td>-1.005</td>
</tr>
<tr>
<td>$X_4$ (C&amp;A)</td>
<td>-1.884</td>
<td>-0.789</td>
</tr>
<tr>
<td>$X_5$ (B&amp;O)</td>
<td>1.043</td>
<td>0.621</td>
</tr>
<tr>
<td>$X_6$ (Tons)</td>
<td>7.207</td>
<td>2.903</td>
</tr>
<tr>
<td>$X_7$ (PA$_{t-1}$ - Deviations)</td>
<td>-0.067</td>
<td>-2.055</td>
</tr>
<tr>
<td>$X_8$ (Lakes)</td>
<td>-0.019</td>
<td>-1.539</td>
</tr>
<tr>
<td>$X_9$ (Deviations: Flour and Grain Tons)</td>
<td>15.248</td>
<td>-3.363</td>
</tr>
</tbody>
</table>

$R^2 = 0.906$

d.o.f. = 321

D - W = 1.761

<table>
<thead>
<tr>
<th>Equation 2</th>
<th>Estimator</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.534</td>
<td>6.111</td>
</tr>
<tr>
<td>$X_6$ (Tons)</td>
<td>7.030</td>
<td>4.104</td>
</tr>
<tr>
<td>$X_7$ (PA$_{t-1}$ - Deviations)</td>
<td>-0.033</td>
<td>3.141</td>
</tr>
<tr>
<td>$X_8$ (Lakes)</td>
<td>0.055</td>
<td>-1.775</td>
</tr>
<tr>
<td>$X_9$ (Deviations: Flour and Grain Tons)</td>
<td>-14.044</td>
<td>4.556</td>
</tr>
</tbody>
</table>

$R^2 = 0.886$

d.o.f. = 321

D - W = 1.813

Sources: The Railway Review, Chicago Tribune, The Railway Age, Bradstreet's, Annual Reports of the Chicago Board of Trade. See the text for details.
Notes to Table 3:

a. The independent variables are as follows:

\[ X_1 = \text{the proportional deviation between allotted and actual tonnage in the preceding week for the New York Central affiliates (the Lake Shore, the Michigan Central, and the Nickel Plate),} \]

\[ = \frac{\text{ABS}(NYCAL_{t-1} \cdot \text{CARTELT}_{t-1} - NYCTT_{t-1})}{NYCAL_{t-1} \cdot \text{CARTELT}_{t-1}} \]

where

\[ \text{NYCAL} = \text{the percentage of dead freight allotted to the New York Central affiliates in the most recent cartel contract.} \]

\[ \text{CARTELT}_t = \text{the total tons of dead freight shipped by all members of the cartel in week } t. \]

\[ \text{NYCTT}_t = \text{the actual number of tons carried by the New York Central affiliates in week } t. \]

\[ X_2 = \text{similarly for the Pennsylvania Railroad's affiliates (the Ft. Wayne and the Pan Handle),} \]

\[ X_3 = \text{similarly for the Chicago and Grand Trunk,} \]

\[ X_4 = \text{Similarly for the Chicago and Atlantic,} \]

\[ X_5 = \text{similarly for the Baltimore and Ohio,} \]

\[ X_6 = \text{the total tonnage shipped east by the cartel in the previous period } (t-1), \]

\[ X_7 = \text{an interaction term: the state of the cartel in the preceding week times the total number of tons below allotments in the entire cartel in the previous period,} \]

\[ X_8 = \text{a dummy variable equal to 1 if the lakes were open and to 0 if they were closed,} \]

\[ X_9 = \text{the sum of all deviations in tonnage in period } (t-1) \text{ divided by the mean tonnage of flour and grain shipped by the cartel over the past month.} \]

For the regressions the specification was that the dependent variable was binary, equal to 1 if adherence was reported to the cartel rates and to 0 if non-adherence was reported. The independent variables were expressed in the logistic function, viz.,

\[ L(X'y) = \frac{1}{1 + \exp(-X'y)} \]
As noted in the text, 

$$\frac{\partial PA}{\partial X_i} = \gamma_i \frac{\exp(-X'\gamma)}{[1 + \exp(-X'\delta)]^2}.$$ 

Thus, \( \frac{\partial PA}{\partial X_i} \stackrel{>}{=} 0 \) as \( \gamma_i \stackrel{>}{=} 0 \).

Since for non-linear estimation of the logistic function with a binary dependent variable, \( \sigma_u^2 \) may not be homoskedastic, \( \sigma_u^2 \) was graphed against each of the independent variables. In no instance was a systematic relationship discovered; thus, the assumption was that there was no heteroskedasticity.