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CARTEL STABILITY AND THE JOINT EXECUTIVE COMMITTEE (1880-1886)

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Abstract

In this paper we analyse a railroad cartel run by the Joint Executive Committee (JEC) in the United States in the nineteenth century. The JEC was a cartel whose members anticipated a periodic fall in demand due to competition from the Great Lakes. In a simplified situation we model the optimal price setting behaviour of a cartel that fully anticipates a large and prolonged (infinite) switch to a lower level of demand. We show that joint profit maximisation is not sustainable as a perfect equilibrium before the switch (in the lakes closed regimes). We also show that an optimal cartel may have had to revise its official rate downwards in the periods leading up to the infinite switch in demand. Empirically we show that the number of weeks leading up to the opening of the lakes is a significant factor in explaining downward price revisions by the JEC in lakes closed regimes. Unanticipated demand shocks and entry of new firms are also found to be significant factors. The factors that determine price revisions in the lakes open regimes cannot be analysed due to insufficient data points and control variables.

Acknowledgements

This paper was initially prepared as an exercise for John Sutton’s Ph.D. students in the London School of Economics. We thank John Sutton for setting up the project and for his help and comments. We thank Robert Porter for the use of his data set. We also thank Mike Harrison, Francis O’Toole and Paddy Waldron for useful suggestions. This paper was given at the European Association for Research in Industrial Economics ‘93 in Tel Aviv and to the Belfast Economic Workshop in Queen’s Belfast. We thank all participants for their comments.
Introduction

Several theoretical papers have discussed the problem of Cartel Stability in both traditional and game theoretic frameworks. Their main concern has been to develop a general theory of the intermittent success and failure of maintaining cartel stability over the business cycle. The apparent causes of price wars over the business cycle are quite different between the traditional and game theoretical schools of thought and even within the game theoretical models themselves.

Ulen (1983) outlines the traditional view in a simple model of "capacity constraints" and "internal enforcement" which leads a cartel to be stable during a business upturn but unstable during a downturn. The game-theoretic literature on cartel stability suggests that the factors underlying stability are more subtle and complex than the traditional view implies.

Roemerberg and Saloner (1986), discuss the problem of cartel stability in a game-theoretic framework and put forward the theory that a price war can be triggered by an unanticipated boom in demand. This goes against traditional thinking where the outbreak of instability should be in the bust period and not in the boom period. Yet, it is better to think of this model as a theory about downward price revisions during unexpected booms in demand rather than as a model of a price war. Roemerberg and Saloner (1986), motivate Joint Profit Maximisation with an application of a Folk Theorem. They use this framework to introduce us to a theory of price revisions during unexpected booms in demand. Demand in each period is stochastic. The demand shocks are identically and independently distributed over time. In each period, firm, observes the current state of demand before setting its price.

A deviant firm, will always calculate the one period marginal gain relative to the longer term marginal loss of cheating (the forgone present discounted value of a share in collusive profits over an infinite series). An unexpected positive demand shock can be large enough to ensure that, for the duration of the shock, the price corresponding to Joint Maximisation cannot be supported as a perfect equilibrium. The cartel has the choice of either reducing the industry price (and hence industry profits) below the Joint Maximisation level or allow the cartel to break down and firms to produce at competitive levels. The optimal choice is to reduce the industry price to a level that equates the marginal gain and marginal loss of deviation to firm. The industry price and profits that result will be somewhere in between monopoly and competitive levels for the duration of the shock. The industry price set by the cartel still
moves cyclically over the business cycle even though in the boom period it is below the level that corresponds to joint profit maximisation.

The Green and Porter (1984) model explains why price wars can be finite and intermittent over the business cycle. In their model, cheating by a firm is hard to detect. The price war in this framework is triggered by a fall in demand for firm’s product. Firm, is uncertain as to whether this is a result of a demand shock or a result of another firm cheating. To maintain the cartel, firm, puts the cartel through a non-collusive period.

Each school of thought has a prediction on the effect of demand on the intermittent success and failure of a cartel. With this agenda in mind the following three papers have cited the Joint Executive Committee (JEC) as providing empirical support for their opposing views - Ulen (1983), Porter (1983) and Rosenberg and Saloner (1986). Obviously the above theories and predictions were derived in the spirit that each theory is robust and will hold generally across many different cartels. As we will outline the data collected and the situation faced by the JEC seemed to be an ideal opportunity to test and discriminate between the various theories of cartel stability over the business cycle. Using the same data set all schools of thought find empirical evidence for their respective theory. Our approach is not to try and discriminate between the different theories of cartel stability but to engage in data description and model the exact situation faced by the JEC.

The JEC controlled eastbound freight shipments from Chicago to the Atlantic Coast in the years before the formation of the Interstate Commerce Commission (1887) and the passing of the Sherman Act (1890). Regulatory and common law restraints on collusion were minimal. The JEC handled shipments of flour, grain and provisions and set the official rates and market share allotments for traffic out of Chicago. Through-shipping of grain accounted for 75 per cent of all dead freight tonnage handled by the JEC. The official rates set for flour and provisions were linked to the grain rate. For these reasons we focus our analysis on the shipments of grain. The JEC looked after clearing arrangements for those above and below their allocated tonnage and the cartel passively accepted new entrants who faced a "no-exit" constraint. The JEC did not try to control structure with the official rates it set. The JEC made official rates, tonnage of traffic by each company and deviations between allocated and actual tonnage public knowledge through weekly reports in the Railway Review and the Chicago Tribune. We have a 328 week series of data between January 1, 1880 and April 18, 1886. The list of variables we use in this paper are summarised in Table 1. The main role we give to the JEC is to call out an official rate such that a deviant firm’s one period marginal gain relative to the longer term marginal loss of cheating (the forgone present discounted value of a share in collusive profits over an infinite series) would be equal. The JEC’s price revisions were to stabilise the cartel in the face of demand shocks, entry of new firms and price undercutting by some of its members. We have no data on the prices actually charged by the individual firms, hence our analysis relates only to the official rate setting by the JEC. This is not a data set about price wars but about the price revisions made by the JEC that prevent cartel breakdown in the face of the above internal and external shocks. The theory developed by the traditional school and Green and Porter (1984) explained why price wars can happen over the business cycle. As long as the official rate setting was in operation we had a cartel and no price wars. This is not a story about the intermittent success and failure of the JEC. The JEC was a success over the period analysed.

The Lake Steamers and Sailships were the principal source of competition for the railroads. However, these only operated during the Spring, Summer and Fall. Table 2 is taken from Porter (1983) and shows the annual eastbound shipments of grain from Chicago by lake and rail over the period analysed. On average, 70% of the annual eastbound shipments of grain were made by the Lake Steamers and Sailships. The opening and closing of the Great Lakes lead to a very well defined business cycle and two very different competition regimes. The central focus of our analysis is on the setting of the official grain rate by the JEC and how it tried to call out prices that stabilised the cartel in the face of demand shocks and the entry of new firms. An usually feature of the business cycle faced by the members of the JEC cartel is the large and prolonged switch in demand that was fully anticipated by all firms in the railroad industry due to the opening and closing of the great lakes. This is clearly not a story of just unanticipated demand shocks on cartel stability. To analyse the price revisions made by the JEC we felt it was natural to split our analysis and data into lakes closed and lakes open regimes with forward expectations of the future regime.

In the lakes closed regimes the large and prolonged switch in demand that would follow the opening of the Great Lakes was fully anticipated by all firms in the railroad

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1 For a complete history we refer to MacAvoy (1965) and Ulen (1978).
industry. Our analysis shows the importance of this fact for the setting of the official grain rate by the JEC in the lake closed regimes. In addition, we demonstrate the importance of unanticipated demand shocks and entry of new firms in the setting of the official rate in the lakes closed regimes.

In the six lakes open periods, we had a highly competitive regime. The factors that determined the price called out by the JEC in this regime cannot be analysed. There are three lakes open periods with many price revisions of the official rate and three with none. At the end of a longer than usual lakes closed period we had price revisions that spilled over into a lake open period with many price revisions. The closing of the lakes should have been the important factor helping the JEC to stabilise the cartel. The external competition from the Great Lakes should have been the important destabilising factor in the lakes open regimes. There is not enough data points or control variables to test how significant these factors were.

Other studies of this data set out to test and discriminate between theories on the intermittent success and failure of maintaining cartel stability over the uncertain business cycle. We feel that the JEC data set is an inappropriate case study to test the predictions of these very precise models. As long as the official rate setting was in operation we had a successful cartel. There is no story of intermittent success and failure. Secondly, the cartel faced an unusually business cycle in that large and prolonged switches in demand were fully anticipated by all firms in the railroad industry. This is not just a story of unanticipated demand shocks on cartel stability.

I. The Theoretical Analysis

Rotenberg and Saloner (1986) use the above framework to introduce us to a theory of price revisions during unexpected booms in demand. An unexpected positive demand shock can be large enough to ensure that, for the duration of the shock, the price corresponding to Joint Maximisation cannot be supported as a perfect equilibrium. The optimal choice is to reduce the industry price to a level that equates the marginal gain and marginal loss of deviation to firm. The industry price and profits that result will be somewhere in between monopoly and competitive levels for the duration of the shock.

We wish to introduce a theory of price revisions that result from the cartel's anticipation of a large and prolonged switch to a lower level of demand. We set up a simplified situation that reflect the effect the opening of the great lakes may have had on the prices set by the JEC in lakes closed regimes. A cartel, in setting its optimal price rates, is faced with the demand conditions in fig. 1. The demand conditions are identical for $t < t'$. For $t \geq t'$ we have an infinite switch to a lower level of demand. Let $D_t = D_t(P_t)$ for $t < t'$ and $D_t = D_t(P_t)$ for $t \geq t'$. Let $N$ identical firms produce a homogenous product at an unit variable cost $c$. Let $\pi_t = (P_t - c)D_t(P_t)$ if $t < t'$ and $\pi_t = (P_t - c)D_t(P_t)$ if $t \geq t'$. Let the constituent game played in each period be the Bertrand game. The strategy for firm $i$ in the repeated game is a function that maps the prices set by firms in the periods $t, t+1$ into $P_t$ for firm $i$ in period $t$. Firm $i$ sets the official cartel price in period $t$ if and only if no price in any earlier period was below the official rate called out by the cartel. Otherwise firm $i$ produces at the Bertrand price level. The optimisation problem faced by cartel is the following:

$$\max_{P_t} \quad V = \sum_{i=0}^{t'-1} \sum_{t'=i}^{t'-1} \pi_t \quad \text{(1)}$$

Subject to:

$$\delta \pi_t(N-1) \geq \sum_{i=0}^{t'-1} \pi_t + \sum_{t'=i}^{t'-1} \pi_t$$

The cartel must choose a vector of prices $P_t = (P_0, P_1, \ldots, P_t, \ldots)$ that maximise the present discounted profit of firm $i$, subject to an infinite set of restrictions. In setting an official rate, in period $t$, the cartel is constrained by the fact that firm $i$ must have no incentive to deviate from the official rate set. The present discounted value of the short term gain at period $t$ must be less than or equal to the present discounted value of the longer term marginal loss due to the firms reverting back to competitive levels from the next period onwards. There are two points of interest here. As we approach $t'$ the present discounted value in the share of industry profits for firm $i$ is shrinking over the infinite horizon. Hence the punishment for a deviant firm $i$ at some date before $t'$, discounted at that date, is also shrinking. As we increase $N$, in any given period, the discounted short term gain increases and the discounted longer term loss decreases. The optimal pricing sequence will take these factors into account.
What is the optimal price vector \( P' \) that solves from (1)? The following condition ensures that the monopoly profit (price) \( \pi'(P') = \pi(P') \) can be sustained in each period after \( t' - 1 \). This condition is obtained, without loss of generality, by looking at a representative period \( t = t' \). Condition 1 ensures that \( P' \) and Joint Maximisation can be sustained from \( t' \) onwards. Condition 1 is a strong assumption, but the following theorems hold once the presented discounted value of a share in profits from \( t' \) onwards is not zero.

**Condition 1**

\[
\delta' \pi'(N-1) \leq \sum_{t=t'1}^{t'N} \frac{\delta t}{N} \quad \Rightarrow \quad \delta' \equiv (N-1)
\]

Let \( A \) be the presented discounted value of a share in monopoly profits from \( t' \) onwards. The *optimal* price set in \( t' - 1 \) ensures that the present discounted marginal gain to firm \( i \) of deviating in period \( t' - 1 \), just equals the present discounted loss from \( t' \) onwards \((A)\).

\[
\delta' \pi_i(N-1) = A = \sum_{t=t'}^{tN} \frac{\delta t}{N} \tag{2}
\]

Using condition 1, the above expression implies that \( \pi_i, t' > \pi_i \). The *optimal* price set in \( t' - 2 \) satisfies the following:

\[
\delta' \pi_i(N-1) = \delta' \pi_i + A \tag{3}
\]

(2) and condition 1, imply that \( \pi_i, t' > \pi_i, t' \). With backwards induction we get a non-increasing sequence of optimal profits and corresponding prices. The optimal price vector is a non-increasing series before \( t' - 1 \) (\( P' \leq P' \leq \cdots \)).

*Theorem 1* The optimal prices set by the cartel before \( t' \) is a non-increasing sequence.

If condition 1 is a strict inequality, there are two points worth noting. First, the further away you are from \( t' \), the higher the price cost mark-up that can be sustained as a perfect equilibrium. Secondly as the number of firms in the industry increase, the mark-up in the non-increasing series get smaller. In the case where condition 1 is a strict equality, the second property ensures that the unique price cost margin that can be sustained before \( t' \) at a lower level.

Given the above, can the monopoly profit (price) \( \pi_i'(P') = \pi_i(P') \) be sustained in any period before \( t' \)? Without any loss of generality, we can look at the representative period \( t = 0 \) and we set \( \pi = \pi \), for all \( t \geq t' \). In period \( t = 0 \) firm, will deviate from the monopoly price if the following condition holds:

**Condition 2**

\[
\pi_0(N-1) > \sum_{t=t'1}^{t'N} \frac{\delta t}{N} \pi = \pi_0(N-1) - 1 + \delta' \pi > 0
\]

Condition 1 ensures that the first term on the L.H.S. is \( \geq 0 \). By definition \( \pi > \pi \). Hence the second term on the L.H.S. is strictly positive. Condition 2 is strictly positive and hence \( P' \) cannot be sustained in \( t = 0 \) or any period before \( t' \).

*Theorem 2* The monopoly price \( P' \) cannot be sustained as a perfect equilibrium in any period before \( t' \).

**II. The Empirical Evidence**

We restrict ourselves to looking at the data when the lakes were closed. There were seven lakes closed regimes. There were many price revisions in the years 1882, 1885 and 1886. In the years 1880, 1881, 1883 and 1884 the JEC's official rate, coming into in and in the early stages of the lakes closed regime, was constant. In three out of four cases, the JEC, as shown in fig.2, revised its official rate downwards before the opening of the lakes. We wish to determine what were the internal pressures within the cartel that led to revisions in the official rate in all lake closed regimes. From the above theoretical section we know that the 1883 was a special year in that the total shipments by both rail and lakes demand, as shown in table 2, was low relative to other years. The lakes were also closed for a shorter period of time.
JEC, in anticipation of a large prolonged switch to a lower level of demand, should not attempt to set the monopoly price in lake closed regimes. If it did, this would lead to instability and internal pressures leading to downward price revisions by the JEC to stabilise the cartel. As the theory and some periods suggest, the anticipated prolonged switch in demand (due to the opening of the Great Lakes) may also lead to increasing internal pressure to revise the official rate downwards as we get closer to the opening of the Great Lakes. Unanticipated observable demand shocks and entry of new firms would also cause an optimal cartel to revise its official rate in lake closed regimes.

To capture information on the unexpected demand shocks and secret price cutting by individual members of the cartel, we first decompose the total quantity of grain shipments into that which can be explained by movements in the official rate set by the JEC and that which cannot. The results are given in table 3. In table 4 we decompose the residuals into that which can be explained by history and its random component. We found that an AR(1) process is present, \( U_t = \rho U_{t-1} + \epsilon_t \). Previous week demand shocks could reflect the Rotenberg and Saloner effect. The official rates were published each week. The official rate set by the JEC could not take into account an unexpected demand shock occurring ex-post during the week. The JEC adjusted for the shock in the following week in its next publication. There could also be a realisation, during the week, that the official rate was set too high. This would lead firms to secretly cut their price and expand output. The JEC in the following week could stabilise the cartel by lowering its official rate. To reflect the entry of the Grand Trunk Railway and the Chicago and Atlantic Railway into the industry we use the dummies DM1 and DM2 in table 1. TREND1 in table 1 is an empirical proxy for the number of weeks to the opening of the Great Lakes.

In table 5 we outline the results of a probit estimation. The dependent variable is 0 when we have no price revisions for 10 periods or more and 1 otherwise. The probability of having a reversionary period when the lakes are closed is positively and significantly related to the entry of new firms, previous period demand shocks and the number of weeks to the opening of the lakes (the fully anticipated switch in demand for a prolonged period). This is consistent with the predictions of the theory in section II.

III. Previous Commentators

Why did the econometric studies of Ulen (1983) and Porter (1983) not find the opening and closing of lakes, entry of new firms, and unanticipated demand shocks to be significant factors explaining movements in the official rates set by the JEC?

Ulen (1983) using the full 328 week data set did not find the opening and closing of the lakes to be statistically significant in explaining the probability of cartel adherence. Yet, the probability of cartel adherence was positively and significantly related to the volume of trade presented to the railroad cartel. Thus, collusion was likely to be more unstable in the business downturn. We feel that this story is consistent with the data on this cartel. Revisions in the official rate occurred, for the most part, during three lakes open regimes. The volume of freight shipments handled by the JEC naturally increased as these regimes were more competitive due to the competition from the Great Lakes. As outlined in the introduction, disruption in the weeks leading up to the opening of the lakes, in these three periods, spilled over into competitive regimes. The JEC had to set a rate that stabilised a cartel thrown into an industry with increased competition. There are not enough data points to determine the important factors that helped the JEC to stabilise the cartel in these lake open regimes. However, the volume of trade was certainly higher. This is consistent with our analysis.

Rotenberg and Saloner (1986), as outlined in section I, discuss the problem of cartel stability and cite the JEC as evidence for their theory. A price revision is likely to result for the duration of an unanticipated boom in demand. If the cartel does not revise its price downwards this can lead to cartel instability. Rotenberg and Saloner (1986) point to the JEC and note that the three key periods of price revisions over the 328 weeks started at the end of a lakes closed or boom period. This view is consistent with our evidence where we show that both an unanticipated positive demand shock and the anticipated prolonged negative demand shock can cause the JEC to revise its rate downward in boom or lakes closed periods.

Porter (1983) in a simultaneous equation switching regressions model set out to explain that the switching from a regime of price revisions by the JEC to a regime of price setting stability was due to the internal disruption of its cartel members. The switching from stability to reversionary periods in the JEC official rate was seen to be consistent with the Green and Porter (1984) model where the punishment periods are finite and intermittent. We
are not willing to accept that the reversionary periods in the official rate can be interpreted as resulting from price war but were there to prevent a price war. Porter’s main result was that the intermittent switching from price stability to reversionary periods was indeed endogenous to cartel members. This result is not disputed by us and is consistent with our analysis. The JEC rates always adjusted to control the deviate firm. Porter (1983) found that the entry of new companies, the opening and closing of the lakes and demand shocks did not have any significant explanatory power in explaining the switch from stability to reversionary periods. He felt the switch must be explained by the Green and Porter (1984) mechanism. This point is disputed by us. Once the JEC was calling out official rates this cartel was always in operation. This is not a data set about price wars. However, this does not rule out the possibility that a type of Green and Porter mechanism was also present. The data does not seem good enough to provide a direct test for this proposition. However, there are two points worth noting. First, cheating is not perfectly detectable in the JEC data and this study. This is not a case study about cartel breakdown or the effect of the business cycle on cartel breakdown. It is a case study of how the JEC stabilised and prevented cartel breakdown in the presence of fully anticipated and prolonged switches in demand, unanticipated demand shocks and entry of new firms.

Our approach was to analyse the determinants of price revisions by the JEC under the two different regimes. We found that this was only possible in the lakes closed regimes. The opening and closing of湖泊, entry of new firms, and unanticipated demand shocks were the significant factors that explained movements in the official rates set by the JEC in the lakes closed periods. There is not enough data to control variables to determine the important factors that explain price revisions in the three key lakes open periods. Lakes open regimes dominate the data set. One would not expect the factors that effect the lakes closed regime to come through on the full data set. This was the case in Ulen (1983) and Porter (1983).

IV Conclusions

We first analysed theoretically the situation faced by the cartel in lakes closed regimes, when approaching an anticipated fall in demand in a period $t'$. In no period before $t'$ would a cartel, acting in an optimal way, attempt to set the monopoly price. As $t'$ approaches, an optimal cartel is likely to revise its price downwards. We confirmed, in our empirical analysis, that the number of weeks to lakes opening was a significant factor explaining price revisions by the JEC in lakes closed periods. Secondly, we analysed the theoretical predictions concerning unanticipated demand shocks and entry of new firms. We found empirically that these factors also contributed to the downward price revisions in the lakes closed periods.

In contrast to other studies of this data which set out to test and discriminate between theories on the intermittent success and failure of maintaining cartel stability over an uncertain business cycle. We feel that the JEC data set is an inappropriate case study to test the predictions of these very precise models. As long as the official rate setting was operating, we had a successful cartel. There is no story of intermittent success and failure. Secondly, the cartel faced an unstable business cycle in that large and prolonged switches in demand were fully anticipated by all firms in the railroad industry. This is not a story of unanticipated demand shocks on cartel stability.

The focus of our analysis is on the determinants of price revisions by the JEC. We found that it was only possible to analyse the determinants of price revisions in lakes closed regimes. The opening and closing of lakes, entry of new firms, and unanticipated demand shocks proved to be significant factors. The econometric studies of Ulen (1983) and Porter (1983) (admittedly with a different agenda to ours) did not find these factors to be important in their studies. As we outlined in section III, one would not expect the factors that effect price revisions in the lakes closed regimes to come through on a data set that was dominated by lakes open regimes with indeterminable price revisions.
Table 1

List of Variables: Week 1 in 1880 to Week 16 in 1886

GR The official grain rate, in dollars per 100 lbs

TQG Total quantity of grain shipped, in tons.

LAKES Dummy Variable; = 1 if the great lakes were open to navigation; = 0 otherwise.

TREND1 = 0 when the great lakes are open; 1, 2, 3, 4,... from the first day of lakes closed to the first day of lakes opening.

PR = 0 when there is no revision in the official grain rate for ten periods or more; = 1 otherwise.

DM1 = 1 from week 28 in 1880 to week 10 in 1883; = 0 otherwise; reflecting entry by the Grand Trunk Railway.

DM2 = 1 from week 26 in 1883 to week 11 in 1886; = 0 otherwise; reflecting entry by the Chicago and Atlantic Railway.

Table 2

Annual Eastbound Shipments of Wheat from Chicago by Lake and Rail in Millions of Bushels.

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<thead>
<tr>
<th>Year</th>
<th>Lake</th>
<th>Rail</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Percentage</td>
<td>Total</td>
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<tr>
<td>1880</td>
<td>16.7</td>
<td>77.9</td>
<td>4.7</td>
</tr>
<tr>
<td>1881</td>
<td>7.7</td>
<td>50.0</td>
<td>7.7</td>
</tr>
<tr>
<td>1882</td>
<td>14.9</td>
<td>86.2</td>
<td>2.4</td>
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<tr>
<td>1883</td>
<td>7.0</td>
<td>73.2</td>
<td>2.6</td>
</tr>
<tr>
<td>1884</td>
<td>11.5</td>
<td>66.0</td>
<td>5.9</td>
</tr>
<tr>
<td>1885</td>
<td>5.4</td>
<td>51.5</td>
<td>5.1</td>
</tr>
<tr>
<td>1886</td>
<td>10.5</td>
<td>82.6</td>
<td>2.2</td>
</tr>
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### Table 3

Week 1 in 1880 to week 16 in 1886, Method of Estimation: OLS, Dependent Variable: LOG(TOG).

\[ R^2 = .25 \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>T-Statistic</th>
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<tr>
<td>C</td>
<td>9.59</td>
<td>0.16789</td>
<td>57.112</td>
</tr>
<tr>
<td>LAKES</td>
<td>-0.8499</td>
<td>0.23780</td>
<td>-3.5744</td>
</tr>
<tr>
<td>LOG(GR)</td>
<td>-0.46194</td>
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<td>LOG(GR)(LAKES)</td>
<td>-0.31038</td>
<td>0.16431</td>
<td>-1.8890</td>
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### Table 4

Week 1 in 1880 to Week 16 in 1886, Method of Estimation: OLS, Dependent Variable: Residuals.

\[ R^2 = .59 \]

<table>
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<tr>
<td>Residuals(-1)</td>
<td>.77488</td>
<td>0.036182</td>
<td>21.416</td>
</tr>
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</table>

### Table 5

Weeks 1-14, 49-72, 101-119, 153-171, 205-226, 258-280 and 310-328. Probit Estimation; Number of observations=139; Number of positive observations=59. Dependent Variable: PR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>T-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-1.7</td>
<td>0.41</td>
<td>-4.15</td>
</tr>
<tr>
<td>( pU_{-1} )</td>
<td>0.83</td>
<td>0.42</td>
<td>2.0</td>
</tr>
<tr>
<td>( \xi )</td>
<td>0.40</td>
<td>0.44</td>
<td>0.92</td>
</tr>
<tr>
<td>TREND1</td>
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<td>0.02</td>
<td>2.97</td>
</tr>
<tr>
<td>DM1</td>
<td>0.93</td>
<td>0.38</td>
<td>2.45</td>
</tr>
<tr>
<td>DM2</td>
<td>0.95</td>
<td>0.37</td>
<td>2.56</td>
</tr>
</tbody>
</table>

Percentage of Positive Observations = .424460

Percentage of Correct Predictions = .676259
Fig. 1

An infinite switch in demand at \( t' \)

Fig. 2

The official grain rate (price), in dollars per 100 lbs and the total quantity of grain shipped, in tons, during lake closed regimes.
References


