Shipwrecks on the Great Lakes and the Lake Carriers Association

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Abstract

In this paper we investigate the relationship between accidental shipping losses on the Great Lakes between 1900 and 1939 and the role the Lake Carriers Association played in preventing or limiting such losses. Moreover, we address the relative benefits of private effort, through the Lake Carriers Association, and public sector effort to reduce shipwrecks and capital losses through weather information transmission from the National Weather Service. Overall, our results confirm existing research that weather information supplied through National Weather Services stations generally resulted in smaller accidental shipping losses. However, we also find that increases in Lake Carriers Association membership also reduces such losses, and to a greater degree. This result is consistent across different measures and types of shipping losses.

JEL Codes: L13, L61, N62, N82

I. Introduction

This paper addresses the role the Lake Carriers Association (LCA) may have played in reducing accidental shipping losses on the Great Lakes between 1900 and 1939. In doing so, this study sheds light on the potential social benefits that industry trade associations may generate, as well as offering a comparison of private sector successes in achieving desirable outcomes, through such associations, with public sector successes.

While these institutions have existed in some form or another for centuries, industry trade associations became increasingly widespread in the early part of the twentieth century (Laurent, 1992). Membership usually required the payment of dues and regular meetings were established, largely for the purposes of information exchange and market coordination activities. Much of the existing scholarship on trade associations has highlighted the market coordination efforts of these organizations. Roberts (1926), for instance, articulated that the major benefit of any trade association is to create an environment whereby members profit by the affiliation, perhaps through coordinated supply constraints and price-fixing agreements. Indeed, in a study of price-fixing cases in the United States, Hay and Kelley (1974) reported that 7 out of 8 cases involving 15 firms, trade associations were involved. Frass and Greer (1977) found that trade associations were involved in some 36 percent of all price fixing cases and Posner (1970) found in his study of all anti-trust cases in the United States, 44 percent involved trade associations. As for Great Lakes shipping, the Lake Carriers Association, the largest such association in that region of the United States, was the most important institutional device for communication and market coordination among shippers

(Laurent, 2002).[1] As a result, it is generally accepted that trade associations can and do result in higher prices and supply restrictions that generate welfare losses in the markets in which they operate.

However, several authors have indicated that the activities of trade associations go beyond price and production coordination and that these other activities may be welfare enhancing. Bradley (1965) describes nine different activities engaged in by trade associations. Among the most salient include standardization of products and services and establishing criteria for product quality, sponsoring research designed to improve product or service quality, and educational efforts such as the sponsoring of workshops, short courses, and clinics, for such things as employee training and safety. Schaede (2000,176) documents successful efforts by a Japanese trade association representing door shutter manufacturers, to introduce safety and minimum quality standards that became adopted industry-wide. Evidence is mixed however, as to the efficacy of trade association efforts to bring about socially desirable outcomes. King and Lenox (2000) investigated the Chemical Manufacturers Association's (CMA) Responsible Care program and found little evidence that firms that participated in Responsible Care improved their environmental performance more than nonmembers, suggesting that sanctions levied by the CMA on its participating members for failing to achieve program goals were not efficacious enough.

The King and Lenox (2000) study hints that a combination of public and private efforts to impact firm behavior may be necessary. This, however, prompts the question:

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[1] The association was founded in 1892 and its main stated objectives were to facilitate shippers' abilities to secure quality labor, improve and support labor-management relations, and aid shippers in information sharing to improve lake navigation. The association, primarily comprised of shippers engaged in large bulk freighting on the Great Lakes, was the most important institution for disseminating information between shippers and was the primary mechanism for the promotion of shipping interests on the lakes Laurent (1992) offers a concise and complete review of the Lake Carriers Association and its relative importance to shipping on the Great Lakes.

Which element, public or private, offers the greatest opportunity for success? The literature of public versus private enterprise is substantial. Yet there is still much debate over the relative merits of each. In an investigation of nineteenth century arctic explorations, Karpoff (2001) found evidence that while publicly funded expeditions were better funded, they tended to meet with less success and greater disaster than privately-funded exploration efforts. In an investigation of Great Lakes shipping in the 1870s and 1880s, Craft (1998), found publicly-funded construction and management of weather stations, and, one can infer, the weather information collected and disseminated by these stations, on the Great Lakes substantially reduced shipping losses, thus generating socially welfare enhancing results. While Craft (1998) did not consider private-sector efforts to reduce losses, the results clearly indicate that government investments in promoting economic growth can be quite effective.

Herein lies the critical element to this study. A theme running through much of the previous discussion is information dissemination. It is quite clear that publicly funded and managed weather stations provide information on weather patterns, etc., valuable to shippers. Yet, as alluded to above, trade associations also provide an efficient means of information sharing that would be quite valuable to shippers as well. The association, in effect, can be thought of as a means of making valuable information more readily available, and easily implemented. Indeed, each shipper's experiences could be unique as would the solutions to the problems they encounter. Thus knowledge would be distributed among different firms within the association. Examples of this knowledge might be solutions involving new techniques, the use of new products, and information of unique weather or topography (i.e., weather anomalies, shifting sandbars, currents, handling certain cargos, etc.).Much of this would be unknown if not shared. That is, there are large externalities (spillovers) from the sharing of such information.

Indeed, the type of detailed information flow facilitated by a trade association is likely to improve the long-term efficiency of day to day operations, including safety promotion, which is unlikely to be supplied by government. In fact, as we detail below, the Lake Carriers Association periodically published several information booklets specifically addressing guidelines to promote on-board safety operation to prevent loss of like and cargo. Many of these guidelines are far too detailed to have been instituted (legislated) through standard governmental regulation, and unlikely to be communicated via weather station information.

In what follows, we reconsider Craft's (1998) model to address the role the Lake Carriers Association played in reducing accidental shipping losses on the Great Lakes between 1900 and 1939. Overall, our results confirm existing research that weather information supplied through National Weather Services stations (a public-sector effort) generally resulted in smaller accidental shipping losses. However, we also find that increases in Lake Carriers Association membership reduce losses as well, and to a greater degree. This result is consistent across different measures and types of shipping losses.

This paper is organized as follows. In section II we briefly review the link between trade associations and self-regulatory safety efforts with specific attention paid to such efforts by the Lake Carriers Association. In section III we present our basic model and data. In section IV we discuss some salient econometric issues and in section V we present our basic results. Section VI concludes.

II. Trade Associations and Safety Promotion

While much attention is given to trade associations and their impact on prices, production and a few other market-oriented attributes such as product standardization and quality control, little attention has been addressed that specifically links trade associations with safety promotion, whether it be worker or consumer-related. Clearly there is liability attached to negligence toward both consumers and workers, not to mention the loss of productive inputs and capital in the event of accidents, and therefore it would seem natural that industry trade associations would devote energy to limiting such losses.

Aldrich (1997) documents several actions undertaken by trade associations to limit work-place accidents. The National Association of Manufacturers created the "Committee on Accident Prevention" in 1910. The National Metal Trades Association created an office of accident prevention, publishing its *Accident Prevention Bulletin* annually since 1914. Moreover, the Portland Cement Association and the National Electric Light Association both formed bureaus and committees to address work-place safety and accident prevention in the early twentieth century as well.[2]

Evidence suggests that the Lake Carriers Association was also quite concerned with limiting shipping accidents on the Great Lakes. This may not be too surprising given the composition of vessel types during the latter part of the nineteenth and early twentieth century. In an extensive study of Great Lakes shipping, Williamson (1977) describes the development of the Great Lakes as a shipping hub from 1870 to 1911 in substantial detail. His work describes the significant changes in Great Lakes shipping over the 40 years of his study including products shipped, origination of shipping, and the

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[2] Many of these efforts started around the same time, perhaps in response to worker compensation laws that were being adopted by many states at the turn of the twentieth century. One might ask, then, whether or not these associations would have been as inclined to establish offices and bureaus for safety prevention had these worker compensation laws not been passed. To be sure, a useful research effort would be to test whether or not the proliferation of such safety efforts were indeed prompted by such legislation. From our perspective, however, this issue is of lesser importance. We are interested in whether or not trade association activity limited accidental losses and to what degree, not if trade associations were pressured to promote safety in response to worker compensation legislation.

changes in the type of ship. This last item mentioned bears directly on our analysis. The five years from 1885 to 1890 witnessed a 50% increase in the steam ship size due, at least in part, to the construction of all-steel vessels (Williamson, 183). The additional weight and other stability characteristics of such vessels tend to make them less prone to accidents caused by extreme weather conditions relative to their wind-powered counterparts. Yet, despite the advantages of steel steam ships, wind-powered sailing vessels remained in use. This was due to the fact that many were towed by steam ships for all or part of the trip, extending their useful life as commodity carriers (Williamson, 183). Hence, heightened safety concerns remained.[3]

Indeed, the Lake Carriers Association's concern with accident prevention at the turn of the twentieth century was is evident from a number of examples. In conjunction with the Fleet Engineers Association, the Lake Carriers Association periodically published and distributed booklets to members outlining recommendations for accident prevention on board ship. These recommendations could be quite detailed, involving appropriate lighting on board ship, the location of ladders and handlebars, face guards on machinery, location of fire extinguishers, and signage on board ship.[4] While many of the recommendations appear to be aimed specifically at limiting crew injuries, and the number are specifically designed to ensure fewer losses to cargo and vessels. For

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[3] Indeed, safety and accident prevention continue to be of interest even today. For instance, Fowler and Sogard (2000) recently attempted to quantify the risks in shipping. While their analysis does not include any variables for information sharing between shipping companies, clearly quantifying the dangers of navigating these waters continue to be an area of interest.

[4] An example of one of these booklets published in 1915 by the Lake Carriers Association is *Codification of the Recommendations of the Industrial Committee, the Committee on Aids to Navigation, and Fleet Engineers Association for the prevention of accidents, years 1913, 1914, 1915*. The Industrial Committee and the Committee on Aids to Navigation were committees formed and operated by the Lake Carriers Association. According to William Livingstone, President of the Lake Carriers Association between 1909 and 1925, the publication "is expected to be helpful in carrying out the recommendations of the various committees working under the direction of the Welfare Plan tending to minimize accidents." (p. 8). Copies of these booklets are limited and the authors are grateful to Mr. William C. Barrow, Special Collections Librarian at the Cleveland State University Library for supplying us with copies of a few of these booklets.

instance, there are several recommendations for the safe handling of steam valves, boilers, and pipelines to limit the start and spread of shipboard fires.

The detail as to safety recommendations is noteworthy. There are recommendation as to the location of likes, color of paint, the use and location of cables instead of link chains as well. To give a specific example, to prevent injury or loss of life, when crews are painting over the side of a ship on a staging that an additional attendant remain above the staging on deck at all times and that all stagings should use manila rope of at least 2.5 inches. This type of detail is likely only to be understood by experienced shippers and is only likely to be effectively implemented through within industry information mechanisms. It is highly unlikely that such suggestions (or regulations) would be articulated through governmental authority. Clearly, then, the Lake Carriers Association was actively involved in efforts to limit shipboard accidents in a highly detailed way. Given this background, in what follows, we test whether or not, and to what degree, these efforts were successful.

III. Model and Data

To address the hypotheses discussed above, we developed a model similar to that of Craft (1998) in terms of the type of variables used and general model estimation. The general model statement is:

$$\mathrm{LOSS} = f(\mathrm{LCA/TONS}, \mathrm{STATIONS}, \mathrm{CYC}, \mathrm{STEAM\,\&\,DIESEL}, \mathrm{PROD})\,. \tag{1}$$

In the analysis to follow, LOSS is measured three different ways. Using data collected from various issues of the US Department of Commerce's *Statistical Abstract of the United States*, we collected data on 1) the physical tonnage of Great Lakes vessels lost or damaged, 2) the inflation-adjusted dollar value of vessel losses, and 3) the inflation-adjusted dollar value of lost cargo between 1897 and 1939.[5]

STATIONS measures the number National Weather Service Weather Bureau stations operating in Michigan, Minnesota and Wisconsin, in a given year. This data was compiled from the *Index of Original Surface Weather Records* for stations in these three states as published by the National Climatic Data Center, US Department of Commerce. As in Craft (1998), these stations, constructed and operated by the federal government, proxied for public weather information services. We expect this variable to be negatively related to shipping losses as more weather-related information should result in navigational and other accident-avoidance activities by shippers on the Great Lakes.

To capture the impact of extreme adverse weather events, we collected data published in Angel and Isard (1998) on the number of major cyclones, CYC, that were recorded between 1900 and 1939.[6] One would expect larger losses in those years registering higher major cyclone activity.

Using data published in Barnet (1992), STEAM&DIESEL is the proportion of total ships sailing on the Great Lakes that are not powered by sail but rather by either steam or diesel engines in a given year. Following Craft's (1998) results, ships powered by steam or diesel are more likely to be larger, more stable, embody superior navigation

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[5] Issues of these statistical abstracts from 1878 to the current publication can be found at the following web page: http://www.census.gov/compendia/statab/past_years.html. The dollar value of shipping losses were deflated using the US GNP implicit Price deflator in Gordon (2000, A1).

[6] Craft (1998) used average wind speed data as recorded at the Aplena weather station in Michigan as his measure of prevailing weather conditions. Such data proved allusive to obtain for our period of study, 1900-1939 where we had LCA and Great Lakes losses data. Moreover, during the period of time investigated by Craft (1998), the 1873-1887 period, the proportion of sail-driven ships was much larger than the later period investigated here where larger steam and diesel powered ships tended to be employed in greater proportion. Hence, average wind speed may not be as effective a regressor during this later period as it is for earlier periods. Also, information on wind speeds and direction would likely be communicated to vessels form area weather stations, a variable included in our model. Hence, instead of wind speed, we chose to employ Angel and Isard's (1998) cyclone data where such extreme events may be much more difficult to observe at weather stations and which would likely put at greater risk not only sail-driven but also steam and diesel powered vessels..

technology, and have hulls made of steel, characteristics that would likely result in fewer wrecks and losses.[7]

Finally, again following Craft's (1998) specification, PROD measures the total tonnage of grains, coal and iron shipped on the Great Lakes in a given year. Again taken from Barnet (1992), this variable proxies for commercial shipping activity on the Great Lakes. A higher degree of shipping activity, larger payloads and more vessels in use, might put more vessels at risk, thus one would expect higher losses associated with higher shipping volumes.[8]

To this basic model we add Lake Carriers Association membership data published by Laurent (1992, 2002). The variable LCA/TONS measures the total registered vessel tonnage of association members (LCA) to total gross vessel tonnage (TONS) on the northern Great Lakes.[9] To be consistent with our shipping losses data, we took from these sources data for the period 1897 to 1939. [10] If, as suggested above, LCA membership does have benefits in terms of communication and information

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[7] While contrary to Craft's (1998) findings, one might hypothesize that a greater proportion of such ships might result in greater losses in that 1) these ships are larger and therefore constitute a greater capital loss in the event of a wreck and 2) they tend to carry larger cargos, likely of higher aggregate value than sail ships.

[8] Craft (1998) actually included two "market activity" variables: total vessel tonnage on the Great Lakes – as a proxy for industry capacity, and a "commerce" variable constructed based on various product shipments data. These two variables were correlated at 74 percent in his dataset, suggesting a possible collinear relationship (and perhaps one of the reasons for the general finding that these variables were not significant determinants of shipping losses). In our dataset, we too find a relatively high degree of correlation between total vessel tonnage on the Great Lakes, TONS, and tons of product shipped, PROD, of about 60 percent. Therefore, we chose to drop total Great Lakes tonnage as an independent regressor from our model since the inclusion of it did generate an upward bias in regression coefficient standard errors.

[9] We chose to look at registered tonnage rather than, say, number of association members, because the tonnage data likely better reflects relative importance and industry influence. .

[10] The LCA tonnage data was consistently available from Laurent (1992, 2002) over the period 1897 to 1939. However, the total vessel tonnage (TONS) data was not available between the years 1915 to 1918. To fill in these missing observations, we used the growth rate patterns from the total vessel tonnage data found in Barnett (1992) which is available over the period 1915 to 1918. It should be noted that while we could have used Barnett's total vessel tons data in our analysis, to maintain consistency, we did focus on the Laurent data for the LCA and TONS data in our model. These two different sets of total vessel tonnage data, however, while not identical, are correlated at 95 percent. Indeed, the results presented here are not substantively different from those estimated using Barnett's series.

dissemination, one would expect fewer accidents and smaller losses overall with membership increases.[11] Summary statistics of the variables are presented in Table 1.

IV. Econometric Specification

In our first specification, we model physical vessel tonnage lost as a proportion of total vessel tonnage. When implementing our empirical model, we could have used standard OLS, modeling the natural log of LOSS/TONS as a function of the variables discussed above. However, doing so does not take into account that the accident rate is essentially bounded between zero and one. Hence, the unbiasedness and consistency of the resulting estimators cannot be assured.[12] We therefore adopt a modeling procedure which explicitly takes this characteristic into account. Specifically, we assume LOSS/TONS is a conditional probability that follows a logistical distribution. Using the independent variables discussed above, we estimate the following equation:

$$\begin{aligned}\ln\left(\frac{\mathrm{LOSS_t / TONS_t}}{1-\mathrm{LOSS_t / TONS_t}}\right) &= \beta_0 + \beta_1 \ln(\mathrm{LCA_{t-1} / TONS_{t-1}}) + \beta_2 \ln(\mathrm{STATIONS_t}) \\ &\quad + \beta_3 \ln(\mathrm{CYC_t}) + \beta_4 \ln(\mathrm{STEAM\ \&\ DIESEL_t}) \\ &\quad + \beta_5 \ln(\mathrm{PROD_t}) + \varepsilon_t \end{aligned} \tag{2}$$

where we use the log-form of our continuous dependent variables so that the resulting coefficients can, with some modification, be conveniently interpreted as elasticities. This is of importance to this study given the quantitative nature of the hypotheses discussed

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[11] To be sure, a more precise test of the association's impact would be to test losses by members only and compare those with losses of non-members. Unfortunately, no such accident or loss data appears to exist. Hence, we are left testing the impact membership has on aggregate shipping losses. That said, it is nonetheless a valuable test of an association's impact. Not only might we expect that increases in membership reduces losses among members, thus reducing aggregate losses, it is also reasonable to presume that increased membership may result in information spillover into nonmembers. Hence, reductions in losses by non-members may occur as well. Again, while there is currently no way to determine whether or not non-members benefit in this way given available data, clearly an overall reduction in losses is possible.

[12] Kmenta (1986, p. 549) offers a complete discussion of the problems encountered when the bounded nature of a dependent variable are not accounted for in the econometric model. Greene (1993) provides general background on logitistic regression analysis as well.

above testing the relative benefit of public versus private effort to limit accidental shipping losses.

Since the error term in (2) is heteroscedastic, we first estimate our model via OLS to obtain consistent estimates of the model parameters. The fitted equation is then used to construct weights that correct the heteroscedasticity problem.[13] Equation (2) is then re-estimated via weighted least squares.

In our second and third specifications, we model the inflation-adjusted dollar value of vessel losses and the inflation-adjusted dollar value of lost cargo via OLS:

$$\begin{aligned}\ln(\mathrm{LOSS_t}) = \beta_0 + \beta_1 \ln(\mathrm{LCA_{t-1}} / \mathrm{TONS_{t-1}}) + \beta_2 \ln(\mathrm{STATIONS_t}) \\ +\beta_3 \ln(\mathrm{CYC_t}) + \beta_4 \ln(\mathrm{STEAM\,\&\,DIESEL_t}) \\ +\beta_5 \ln(\mathrm{PROD_t}) + \varepsilon_\mathrm{t}\end{aligned} \tag{3}$$

Again, the double-log specification is useful in that the resulting coefficients can be interpreted as elasticities and their relative magnitudes assessed.[14]

Before continuing, a couple of points need to be made, first note that we lagged LCA/TONS. If membership in the LCA is advantageous as it facilitates information flow between members on means of limiting losses, one might hypothesize that increased membership may be prompted by increased vessel and cargo losses by non-members. That is, the causal link between losses and LCA membership may run counter to what it

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[13] For the Logistic model, the error term ε_t is heteroscedastic with a variance equal to $Var(\varepsilon_t) = \frac{1}{n_t \Lambda_t (1-\Lambda_t)}$ where Λ_t is the LOSS/TONS and n_t is the number of "trials" in period t. Hence, the weights used to estimate (2) are $w_t = \sqrt{n_t \Lambda_t \left(1-\Lambda_t\right)}$. Since Λ_t is not known, we adopt the following two step procedure where we first estimate (2) via OLS and then calculate the fitted values of the injury rate: $\overline{\Lambda_t}$, which are used to construct w_t and then used to re-estimate (2). The number of "trials", n_t, is total vessel tonnage, i.e the total tonnage "at risk" of being lost in period t.

[14] These equations were estimated using the standard Newey and West's heteroskedasticity consistent variance-covariance matrix to account for any heteroskedasticity of known form. We chose to use this estimator over White's common covariance matrix largely because it tends to be a more general estimator. White's estimator assumes a-priori that the residuals of the estimated equation are serially uncorrelated. Newey and West (1987) constructed this covariance estimator so as to be consistent in the presence of both heteroscedasticity and autocorrelation of unknown form. That said, there is little substantive difference between the results presented here with those using White's estimator.

hypothesized. To limit this concern, we lagged LCA membership by one year in equations (2) and (3).[15]

Second, there is a potential endogenous relationship between LCA membership and the number of weather stations. One might reason that the LCA has an incentive to apply political pressure to increase weather station construction on the Great Lakes. To address this issue, we conducted a pair-wise Granger Causality test between $LCA_{t-1}/TONS_{t-1}$ and $STATIONS_t$. Presumably, if increased LCA membership prompts subsequent weather station construction, then $LCA_{t-1}/TONS_{t-1}$ should Granger-cause $STATIONS_t$. The results of this test are reported in Table 2. In each instance, we fail to reject the null indicating there is no statistical evidence to support a link between these two variables.[16]

Third, given the time-series nature of our data, if the LOSS data are non-stationary (i.e. they contain a stochastic trend), these data may follow a random walk, may therefore not be predictable based on any econometric specification, and might require estimating our model in first differences. Moreover, concerns over spurious regression results arise. Table 3 presents estimation results for a standard Augmented Dickey-Fuller (ADF) test conducted on our dependent variables from equations (1) and (2).[17] The results suggest that we can reject the presence of a unit root in these series.

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[15] Moreover, statistical tests, not reported here but available from the authors upon request, suggested a Granger-causal direction favoring the direction hypothesized above, i.e. that LCA membership impacts losses, and not the reverse. Since this statistical test involves lagged values of LCA membership, we retained that structure here.

[16] We only included two lags in our Granger causality models due to the relatively small size of our dataset. That said, we did try alternative lag lengths ranging from 1 lag to 5 lags. In each instance, no statistical causality could be detected.

[17] The ADF formulation estimated here was $\Delta y_t = \alpha + \beta \mathrm{trend} + (\rho - 1) y_{t-1} + \sum_{i=1}^{n} \Delta y_{t-i} + \varepsilon_t$, where y_t represents our dependent variables and our LCA variable. For the results presented in Table 2, n was selected to generate the best fit of the data based on the Schwarz Information Criteria. Note that the deterministic time trend is significant in these ADF regressions, suggesting a time trend should appear in equations (2) and (3). However, since STEAM&DEISEL and STATIONS appear to modestly trend over

Therefore, the three LOSS series do not follow a random walk process. We thus proceed with our estimation in levels.

V. Results

The results from our logit model are presented in Table 4. The first set of results, labeled specification 1, indicate that the model explains about 45 percent of the total variation in the proportion physical vessel losses and the F-statistic of 7.46 indicates that the model has statistical validity. Neither the proportion of non-sail power vessels nor the frequency of major cyclones on the Great Lakes seems to impact tonnage losses. However, the coefficient on the PROD variable is statistically significant at the 5 percent level as is the STATIONS variable, consistent with Craft (1998). The coefficient on the LCA/TONS variable is statistically significant as well. However, the Durbin-Watson and Q-statistic indicate the presence of serial correlation, suggesting the standard errors on the coefficients might be biased downwards.[18]

To correct for this, in the second set of results, labeled specification 2, we include two lags of the natural log of the LOSS/TONS variable. The resulting reported Q-statistic, as well as visual inspection of the resulting residual correlogram, indicates no serial correlation.[19]

Again, with this correction for serial correlation, we find that the PROD and STATIONS variables continue to be statistically significant. Increases in PROD and

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time, as one might expect given innovation in shipping and weather station construction, we have not included a separate time trend variable. Note that we also checked for stationarity of our primary variable of interest, LCA/TONS. It too proved not to contain a unit root, further limiting the concern over spurious results.

[18] The Q-statistic reported here is calculated using five lags of the estimated residuals' correlations. We also calculated Q-statistics using between 2 and 10 lags. In each case, the Q-statistics were consistent with those reported here.

[19] Based on visual inspection of the residual correlogram, one lag on the LOSS/TONS variable did not completely remove serial correlation from the regression. Two lags on LOSS/TONS proved sufficient to reduce the residuals to white noise errors. These correlograms are not reported here but are available upon request from the authors. Alternative means of eliminating serial correlation from the results, such as the Cochran-Orcutt procedure, proved ineffective as well, perhaps due to the relatively small sample size of our dataset.

STATIONS tend to reduce proportional vessel losses, as hypothesized. Moreover, increased membership in the Lake Carriers Association also proved to be effective at reducing proportional vessel losses.

In terms of magnitude of effect, after some modification to the estimated coefficients, we find that, while increasing both association membership and the number of government constructed and run weather stations does reduce proportional vessel losses, increases in association membership appears to have a greater impact. For instance, using results reported in column 2 of Table 4, a one percent increase in LCA/TONS reduces proportional vessel losses by 1.77 percent. By way of comparison, a one percent increase in STATIONS results in a 0.45 percent reduction in proportional vessel losses.[20]

Table 5 reports estimation results for the dollar value of total loss (vessel plus cargo), cargo loss, and vessel loss equations. Inspection of the adjusted R^2 indicates that between 38 and 55 percent of the total variation in losses is explained by these models and the F-statistics indicate that each equation is statistically meaningful. Moreover, the Durbin-Watson and Q-statistics indicate no serial correlation as well.

While the proportion of non-sail power vessels and the frequency of major cyclones on the great lakes still appear to have no impact on vessel and/or cargo losses, consistent with both Craft (1998) and results presented in Table 4, PROD, STATIONS, and LCA/TONS are consistently statistically significant determinants of total, cargo, and vessel losses. In each instance, increased shipping of iron, grains, and coal increase

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[20] While it may appear that the estimated coefficient is the elasticity itself, strictly speaking, this is not true. For the logistic model: $\ln\left(\frac{x}{1-x}\right) = \beta \ln z$, the resulting elasticity is $\beta(1-x)$. We follow convention and evaluate this elasticity at the mean of *x*. In the case of our LOSS/TONS mean is about 19.66 percent. Hence, the elasticity between LCA/TONS and LOSS/TONS is $-2.198 * (1-0.1966) \approx -1.766$.

losses, while increases in the number of government run weather stations, and an increase in Lake Carriers Association membership, reduce losses.

Moreover, the estimated elasticity on LCA/TONS consistently shows that Lake Carriers Association membership levels have a significantly larger impact on reducing shipping losses than does the number of National Weather Service stations. For total losses, a one percent increase in LCA/TONS reduces losses by 2.19 percent, where as a one percent increase in STATIONS reduces accidents by 0.61 percent. For cargo losses, a one percent increase in LCA/TONS reduces such losses by 4.68 percent. By contrast, a one percent increase in STATIONS reduces cargo losses by 1.54 percent. For vessel losses only, a one percent increase in LCA/STATIONS reduces such losses by 2.00 percent, while the number of weather stations appears not to impact the dollar value of vessel losses. In general both increased weather stations and increased membership reduce losses, though increases in association membership appear to generate greater loss-saving benefits.

VI. Conclusion

In this paper we have investigated the relationship between accidental shipping losses on the Great Lakes between 1900 and 1939 and the role the Lake Carriers Association played in preventing or limiting such losses. Moreover, we address the relative benefits of private effort to promote safety information, through the Lake Carriers Association, and public sector effort to reduce shipwrecks and capital losses through weather information transmission from the National Weather Service. Overall, our results confirm Craft's (1998) findings that weather information supplied through National Weather Services stations generally resulted in smaller accidental shipping losses. However, we also find that increases in Lake Carriers Association membership also reduces such losses, and to a greater degree. This result is consistent across different measures and types of shipping losses as well. It seems reasonable, then, to conclude that as the association's reach increases, there is increased informal information flows that ultimately benefit shipping activities in the form of reduced accidental losses of capital and cargo. To be sure, from our results we cannot conclude that increased Lake Carrier's Association membership could serve as a substitute for weather station construction and maintenance by the National Weather Service. Clearly, public-sector funding that facilitates the dissemination of weather information is effective at reducing accidental losses. However, information flows through private efforts also to reduce losses, and such information may indeed be more effective at reducing such losses than other efforts.

References

Aldrich, Mark. 1997. *Safety First.* Baltimore: The Johns Hopkins University Press.

Angel, James R., and Isard, Scott A. 1998. "The Frequency and Intensity of Great Lake Cyclones," *Journal of Climate*, 11: 61-71.

Barnett, Le Roy. 1992. *Shipping Literature of the Great Lakes: A Catalog of Company Publications, 1852-1990.* East Lancing: Michigan University Press.

Bradley, Joseph F. 1965. *The Role of Trade Associations and Professional Business Societies in America.* University Park: The Pennsylvania State University Press.

Craft, Erik D. 1998. "The Value of Weather Information Services for Nineteenth-Century Great Lakes Shipping." *American Economic Review*, 88(5): 1059-1076.

Fowler, Timothy G. and Sorgard, Erik. 2000. "Modeling Ship Transportation Risk." *Risk Analyst,* 20(2) 225-244.

Frass, Arthur G., and Greer, Douglas F. 1977. "Market Structure and Price Collusion: An Empirical Analysis." *Journal of Industrial Economics*, 21:21-44.

Gordon. Robert J. 2000. Macroeconomics, 8th ed. Reading: Addison-Wesley Longman, Inc.

Greene, William H. 1993. *Econometric Analysis, 2nd ed.* Englewood Cliffs: Prentice-Hall, Inc.

Hay, George A., and Kelley, Daniel. 1974. "An Empirical Survey of Price-Fixing Conspiracies." *Journal of Law and Economics*, 17:13-38.

Karpoff, Jonathan M. 2001. "Public versus Private Initiative in Arctic Exploration: The Effects of Incentives and Organizational Structure." *Journal of Political Economy*, 109(1): 38-78.

King, Andrew A., and Kenox, Michael J. 2000. "Industry Self-Regulation Without Sanctions: The Chemical Industry's Responsible Care Program." *Academy of Management Journal*, 43(4): 689-716.

Kmenta, Jan. 1986. *Elements of Econometrics, 2nd ed.* New York: Macmillan.

Laurent, Jerome K. 1992. "Trade Associations and Competition in Great Lakes Shipping: The Pre-World War I Years." *International Journal of Maritime History*, 4(2): 117-153.

__________. 2002. "And Cut Throat Competition Prevented: Concentration and Control in Great Lakes Transportation, 1915-1940." *International Journal of Maritime History*, 14(2): 43-84.

Newey, W. and West, K. 1987. "A Simple Positive Demi-Definite, Heteroscedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica*, 55: 703-708.

Posner, Richard A. 1970. "A Statistical Study of Antitrust Enforcement." *Journal of Law and Economics*, 13: 365-419.

Roberts, George. 1926. "The Present Legal Status of Trade Associations and Their Problems." *Proceedings of the Academy of Political Science in the City of New York*, 11(4): 5-18.

Schaede, Ulrike. 2000. *Cooperative Capitalism: Self-Regulation, Trade Associations, and the Antimonopoly Law in Japan*. New York: Oxford University Press.

United States Bureau of the Census. 1975. *Historical Statistics of the United States, Colonial Times to 1970, Bicentennial Edition, Part 1*. Washington, D.C.

United States Bureau of the Census. Various years. *Statistical Abstract of the United States*. Washington, D.C.

Williamson, Samuel. 1977. "The growth of the Great Lakes as a major transportation resource, 1870-1911." *Research in Economic History*. ed. Paul Uselding. Vol. 2, 173-248.

Table 1. Summary Statistics

Variable	Definition	units	mean	std. dev.
LOSS - for different measures (1)	total and partial vessel losses due to Great Lakes shipping accidents	Tons	491,233.1	277,433.1
	total cargo and vessel losses due to Great Lakes shipping accidents	$ (real 1992 dollars)	$30,580,809.0	$26,130,390.0
	total cargo losses due to Great Lakes shipping accidents	$ (real 1992 dollars)	$3,743,323.0	$3,961,929.0
	total vessel losses due to Great Lakes shipping accidents	$ (real 1992 dollars)	$26,837,485.0	$23,599,342.0
TONS (2)	Registered Vessel Tonnage on Northern Great Lakes	Tons	2,485,198.0	338,478.5
LCA (2)	Registered Vessel Tonnage for Lake Carriers' Association members	Tons	1,967,669.0	335,883.2
STATIONS (3)	Number of National Weather Service weather stations in operation	Tons	24.8	9.6
STEAM&DIESEL (4)	Proportion of steam and diesel (non-sail) powered vessels on Great Lakes	Proportion	0.9	0.1
PROD (4)	Tons shipped of grains, iron and coal	Tons	76,113,598.0	23,356,157.0
CYC (5)	number of "major" cyclones recorded on Great Lakes	Count	9.6	3.8

[1] Statistical Abstract of the United States, various years.

[2] Laurent (1992, 2002)

[3] *Index of Original Surface Weather Records: Michigan* , *Index of Original Surface Weather Records: Minnesota, Index of Original Surface Weather Records: Wisconsin* , National Climatic Data Center, US Department of Commerce.

[4] Barnett (1992)

[5] Angel and Isard (1998)

Table 2. Pairwise Granger Causality Tests

Note: two lags employed

Null Hypothesis:	*F-stat*	*p-value*
$\ln(\text{STATIONS}_t)$ does not Granger Cause $\ln(\text{LCA}_{t-1}/\text{TONS}_{t-1})$	1.81	0.18
$\ln(\text{LCA}_{t-1}/\text{TONS}_{t-1})$ does not Granger Cause $\ln(\text{STATIONS}_t)$	0.84	0.44

Table 3. Augmented Dickey Fuller Test Results

LOSS variables: first differenced dependent variable with trend, lag length determined by Schwarz Information Criterion

	coeff	t-statistic
Vessel tons lost/total tonnage	-0.401	-3.237
Dickey Fuller critical values: 5% level		-3.521
10% level		-3.191
Trend	-0.002	-2.142 **
Value of cargo and vessel losses	-1.003	-6.350
Dickey Fuller critical values: 5% level		-3.521
10% level		-3.191
Trend	-947,906	-2.889 ***
Value of cargo losses	-1.467	-6.385
Dickey Fuller critical values: 5% level		-3.521
10% level		-3.191
Trend	-254,282	-4.289 ***
Value of vessel losses	-0.966	-6.110
Dickey Fuller critical values: 5% level		-3.521
10% level		-3.191
Trend	-754,228	-2.550 **

Dickey Fuller critical values from Davidson and MacKinnon (1993, Table 20.2).
* - Significant at the 10 percent level.
** - Significant at the 5 percent level.

Table 4. Estimation Output: Proportional Vessel Losses in Tons (weighted least squares)

	Specification 1		Specification 2	
	Coef.	Elasticity	Coef.	Elasticity
Constant	-21.765 **	-17.486	-14.464 *	-11.621
	(0.028)		(0.053)	
$\ln(LCA_{t-1}/TONS_{t-1})$	-3.760 **	-3.021	-2.198 *	-1.766
	(0.020)		(0.093)	
$\ln(CYC_t)$	0.188	0.151	0.008	0.007
	(0.352)		(0.966)	
$\ln(STATIONS_t)$	-0.821 **	-0.660	-0.446 *	-0.358
	(0.031)		(0.081)	
$\ln(STEAM\&DIESEL_t)$	-2.323	-1.866	-1.713	-1.377
	(0.368)		(0.416)	
$\ln(PROD_t)$	1.176 **	0.945	0.808 **	0.649
	(0.026)		(0.044)	
$\ln(LOSS_{t-1}/TONS_{t-1})$			0.783 ***	0.629
			(0.000)	
$\ln(LOSS_{t-2}/TONS_{t-2})$			-0.210	-0.169
			(0.186)	
Durbin-Watson Statistic	1.193		2.095	
Q-statistic (5 lags)	10.790 *		1.616	
F-Statistic	7.457 ***		8.803 ***	
Adjusted R^2	0.453		0.583	

p-values reported in parentheses.
* - Significant at the 10 percent level.
** - Significant at the 5 percent level.
*** - Significant at the 1 percent level.

Table 5. Estimation Output: Value of Shipping Losses (OLS)

	Total Losses	Cargo Losses	Vessel Losses
Constant	3.059	-2.722	3.416
	(0.633)	(0.796)	(0.586)
$\ln(LCA_{t-1}/TONS_{t-1})$	-2.192 *	-5.328 ***	-2.000 *
	(0.054)	(0.000)	(0.074)
$\ln(CYC_t)$	-0.257	-0.369	-0.195
	(0.218)	(0.176)	(0.327)
$\ln(STATIONS_t)$	-0.605 *	-2.027 ***	-0.524
	(0.088)	(0.000)	(0.146)
$\ln(STEAM\&DIESEL_t)$	-2.543	-1.878	-2.605
	(0.211)	(0.487)	(0.210)
$\ln(PROD_t)$	0.866 ***	1.269 **	0.821 **
	(0.010)	(0.027)	(0.013)
Durbin-Watson Statistic	2.095	1.891	2.045
Q-statistic (5 lags)	1.202	0.960	1.213
F-Statistic	7.052 ***	10.787 ***	5.832 ***
Adjusted R^2	0.437	0.649	0.383

Estimate using Newey-West Variance Covarience Matrix.
p-values reported in parentheses.
* - Significant at the 10 percent level.
** - Significant at the 5 percent level.
*** - Significant at the 1 percent level.