

The Telegraph, Co-ordination of Tramp
Shipping, and Growth in World Trade,
1870-1910

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Abstract

The growth of trade after 1860 has been attributed to declining tariffs, to falling transport costs, and, recently, to monetary arrangements. However coincident with the rise of trade, the second half of the nineteenth century saw the development of the first electric communication network: the telegraph. The first successful trans-oceanic cable was operating in 1865. The telegraph remained the only direct trans-oceanic communication link until into the twentieth century. Little research has been conducted explicitly linking the impact of telegraphs on international shipping and international trade. A panel is used to show that there is a correlation between the diffusion of the telegraph, coordination of shipping, and the growth of world trade even with the impact of the other well-studied effects. The telegraph reduced the time ships spent in port and allowed ships to travel farther among ports to collect more valuable cargo.

Introduction

Before the introduction of the telegraph, information behaved as any other traded commodity. It moved along with the cargo, and though not usually bulky, its speed was limited to that of the fastest mode of travel of the day (Clark and Feenstra 2003, p. 295). The telegraph was the first mode of communication to virtually

eliminate the effect of distance, allowing for near instantaneous communication. While bandwidth still acted to constrain the volume, that information could arrive at its destination essentially instantly was truly revolutionary.¹

The telegraph brought many benefits, including some specifically economic like increased market integration. Over the nineteenth century, distance began shrinking. While intercontinental trade has always been possible, it was not until the recent past that the decline in transport costs meant markets separated by oceans became truly integrated. Though the effects of transportation improvement have been well-analyzed, the contribution of the telegraph has yet to be quantified. The telegraph has been shown to have impacted both rail and ocean transport, and to have brought about price convergence in some markets. The focus of this study is the impact of the telegraph on shipping and hence on trade flows, even after controlling for the impact of other well-studied effects.

The next section will detail how the telegraph brought about greater market integration through a lowering of the cost of trade by increasing the capacity utilization of shipping. The sections following will provide empirical evidence of the link between the telegraph and trade, and the impact of the telegraph on shipping respectively.

The Impact of the Telegraph

The telegraph was first used commercially in 1837. By the late 1840s, it was rapidly diffusing across Europe and the United States. While overland routing

dominated initially, technology was soon developed to allowing wires to travel underwater. The English Channel was crossed in 1851, and North America and Europe were connected across the Atlantic in 1865. The first line ran from Ireland to Newfoundland. However, many transoceanic cables were built to bridge much shorter distances, so that by the mid-1870s most of the important trading centers of the world were linked by cable.² Though there continued to be substantial expansion of telegraph cable installed up until World War I, much of this was to directly link locations that had formerly been linked only via more circuitous routes. While some of the motivation was for faster, more direct links, the principal reason was for nations to establish their own national links (Headrick, 1991; Ahvenainen, 1981). It is the telegraphic links connecting regions separated by water that made significant contributions. By the late nineteenth century, information could travel by rail reasonably quickly. Shipping, however, was no close substitute.³ And while the telephone was rapidly diffused within urban regions in the late nineteenth century, there was no practical competition for transoceanic communication until at least 1956, with the laying of the first trans-Atlantic telephone cable.⁴

Because of its revolutionary potential, the telegraph must have increased market integration. Kenwood and Lougheed (1999, p. 15) simply state that the telegraph had ‘immense significance for the growth of world trade.’ It is an unsupported statement perhaps because it is so apparently obvious. According to Harley

The improved organization of trade in the late nineteenth century itself depended on advances in transportation and communication. It is

hard to imagine that progress in a world without steam transport on land and water, or without the telegraph and the marine cable (Harley 1988, p. 867).

Harley's focus is on transportation, but he certainly makes clear the assumed role for the telegraph. More generally, Ahvenainen (1986, p. 514) characterizes the intercontinental telegraph as having shifted the global economy "onto real time", thereby expanding international commerce.

O'Rourke and Williamson (2002a, 2002b) show that true market integration began only in the nineteenth century. Their evidence on commodity market integration is drawn from the second half of the nineteenth century, utilizing data on staples traded from North America to Europe. It is in this period that transportation advanced rapidly (Harley 1988). It is also the period in which transoceanic communication was transformed.

DuBoff (1980, 1983) was the first to provide direct evidence that the telegraph, distinct from the spread of railroads, directly spurred market integration. This was particularly evident on cotton markets in the antebellum U.S. (DuBoff 1983, p. 257). DuBoff (1983, p. 255) also observed that railroads and telegraphs were complementary. Telegraphs were strung along railroad right-of-ways. Railroads in turn, by providing for greater market penetration, increased telegraph demand. The railroad benefited from the telegraph in its use for coordinating traffic. Field (1992) extends this by observing that the telegraph allowed railroads to economize on their use of capital. With telegraphs for communicating, railroads were better able to utilize their track and avoid double-tracking. Other means by which the

telegraph enhanced capital saving was in allowing merchants in remote locations to increase their inventory turnover rates. Davies (2002) discusses an example of merchants in Lagos utilizing the telegraph to forward advances received from local banks on cargo being shipped to Europe. These advances could then be used to acquire European goods for sale in Africa before their goods being exported had arrived at their destination in Europe. Field (1998), as well as DuBoff (1983), also analyze the impact of the telegraph on securities markets.

The telegraph had a significant effect on shipping, and shipping companies were among its early users. Most importantly, it allowed shipping companies to redirect ships in response to changing opportunities (Scholl 1998, p. 200; Ville 1990, p. 94). This made possible the expansion of tramp shipping, which by World War I accounted for more than half of British shipping (Thornton 1939, p. 85). To be effective, tramp ships needed to respond to changing market conditions and source cargoes as they came available. Without communication, tramps would have to set out a route in advance; whereas with the telegraph, tramps could remain informed of changing opportunities while in foreign ports, thereby better utilizing shipping capacity.⁵

Blainey (1966) provides some direct evidence of the impact of the telegraph on shipping and trade with examples from Australia. Australia is perhaps the best example of a country for which the telegraph was particularly valuable due to its remoteness from principal trading partners, as well as the remoteness of locations within Australia from each other. Shipowners relied on the use of the telegraph in particular to source cargo to maximize capacity utilization for the return voyage

to Europe from Australia. As well, exporters in Europe and elsewhere could use information from the telegraph to better match supply with demand. Prior to the telegraph, it was not unusual for shippers to provide excess of some goods while failing to supply enough of other goods, thereby leading to frequent scarcity. Copper mines in particular relied upon timely price information to determine levels of output. Telegraphs were also used to transmit information on water conditions of inland waterways which were not navigable year round, in order to maximize their useful season.⁶

The ability of ships to remain in touch with the ship owner in turn influenced the management and division of power within shipping companies. A significant share of the decision-making had been the ship captain's prerogative, because once the ship left port, no further information could be obtained from head office. With the extension of the intercontinental telegraph network, ships could stay in contact with head office when in any port. Therefore, the organization and management of shipping increasingly became concentrated with the managing directors and the independence associated with the ship captain began to wane (Harley 1985, p. 178). Centralization of command further increased with the introduction of wireless technology in the twentieth century (Scholl 1998, p. 212).

The telegraph was an expensive communication medium and was therefore used sparingly. It was used to communicate specific information but not to hold open-ended conversations. A comparison between email and telephone calls today is indicative of this difference. While email is cheap, it is asynchronous so complex planning, let alone negotiation, becomes costly in terms of time con-

sumed. The telegraph allowed brokers to communicate either their demand for shipping space or their availability of capacity from any port with cable access to an office in London (Kaukiainen, 2001b, pp. 137-8). The actual negotiations over freight took place at the Baltic Exchange in London where traders could negotiate face-to-face on the trading floor. The instructions resulting from these negotiations would then be cabled back to the port (Boyce, 1995, p. 34-5; Fayle, 1933, p. 266-7; Thornton, 1939, p. 139-40). The growth of a complex web of ship-broking and freight forwarding thus developed out of this communications revolution (Fischer and Nordvik, 1992, p. 140, 144). The relative importance of the cable to shipping was, therefore, not necessarily proportional to the share of international messages sent.

Sanford Fleming, a leading figure in transportation and communication in the late nineteenth century, made the following presentation to the Canadian Parliament in 1898 in support of the construction of a telegraph cable from Canada to Australia.

Steam and electricity go hand in hand. Trade and telegraphy are intimately blended, the latter being the most valuable ally of the former in building up and expediting all business. As the means of collecting cargoes for shipment, the telegraph is indispensable – without electric cables across the Atlantic the successful operation of fleets of ocean steamships would be impossible [Canada 1899, p. 9].

If the telegraph benefited shipping, then it must have benefited trade. This hypoth-

esis will be given support in the following sections.

Telegraph and Trade: Model and Estimates

To test for the impact of the telegraph, the spread of the telegraph could be correlated to the decline in price dispersion as in DuBoff (1983). That approach awaits the collection of the necessary data. Given available data, another method is to correlate the expansion of trade with the spread of the telegraph. This can be done using a gravity model specification.

The gravity model is a well-utilized tool of international trade to explain bilateral trade controlling for the two economies' distance from each other and their size. It is an empirical regularity that trade falls off with distance. Distance itself captures effects that impede trade. The gravity model has been used to measure the importance of national borders (McCallum 1995, Helliwell 1998), as a tool for assessing the causal link from trade to economic growth (Frankel and Romer 1999), and for evaluating the impact of geographical remoteness and infrastructure investment (Limão and Venables 2001). Recently, an evaluation of the impact of membership in the WTO on trade has been explored (Rose 2004). He finds no connection.

The gravity model has also been utilized in tests of the impact of shared monetary arrangements on trade (Glick and Rose 2002, Rose 2000). This has been particularly appropriate to economic history as greater variability among monetary regimes is available when utilizing historical data (Flandreau 2000, Estevadeordal

et al. 2003, Lopez-Cordova and Meissner 2003). Estevadeordal *et al.* (2003) use the gravity model as a tool to predict bilateral trade flows given estimates of elasticities of trade to GDP and other variables in a way similar to Frankel and Romer (1999).

The gravity model is estimated as

$$\begin{aligned}
 \ln(x_{ijt}) = & \beta_0 + \beta_1 \ln(y_{it} \cdot y_{jt}) + \beta_2 dist_{ij} \\
 & + \beta_3 \ln(tele_{it} \cdot tele_{jt}) + \beta_4 \ln(rail_{it} \cdot rail_{jt}) \\
 & + \beta_5 \ln(pop_{it} \cdot pop_{jt}) + \beta_6 \ln(area_i \cdot area_j) \\
 & + \beta_7 \ln(cust_{it} \cdot cust_{jt}) + \Theta Z_{ijt} + u_{ijt}
 \end{aligned}$$

where x_{ijt} is trade between countries i and j , y_{it} is GDP of country i , pop_{it} is population of country i , $dist_{ij}$ is the distance between the economic centers of gravity of countries i and j , $tele_{it}$ is number of telegraph messages sent from country i , $rail_{it}$ is rail mileage of country i , $cust_{it}$ is customs revenue as a share of imports for country i , $area_i$ is the square-mileage of country i , Z_{ijt} is a vector of other possible influences, and t indexes the time period. GDP captures the size of the economy – that is, a country’s capacity to trade. Trade will increase with the size and wealth of the economies trading. The error term is assumed $u_{ijt} = \nu_t + \epsilon_{ijt}$ where ϵ_{ijt} are assumed to be independently and identically distributed and the ν_t capture any time-specific disturbances. Country-pair and country specific effects are also included in some of the specifications. ⁷

Bilateral trade flows are to be explained as a function of the density of the telegraph network within a country as a proxy for the cost of transporting goods to consumers. Transport costs increase the difference between the price received by the producer and the price paid by the consumer. Lower distributional costs imply lower prices paid by consumers and higher prices received by producers; hence an expansion of trade. Variables capturing rail and communications density have been used by others as proxies for measures of these transport and distributional costs. Limão and Venables (2001), and Bandyopadhyay (1999) use kilometers of rails and road; and both include a variable to capture communications density: Limão and Venables (2001) uses telephone main lines per person, while Bandyopadhyay (1999) uses telephones per thousand persons.

This form of infrastructure variable is appropriate for telegraphs. Direct connections between countries were not required for international communications. The telegraphic network was a serially-connected system. International connectivity simply required each node of the network to be connected. For example, the link from Britain to India utilized lines through several countries. Even Australia was already linked to Britain in the 1870s albeit via a choice of circuitous routes through Indonesia-Singapore-India or through China-Japan-Canada. Therefore telegraphs were international communication links and all countries with domestic telegraph networks could be linked into the international network through connections with their neighbours. The measure of telegraphic activity is meant to capture the equilibrium quantity used. On the supply side, international bandwidth was a function of the number of international links, including submarine

cables. There were some significant new routes introduced through the period studied, particularly the cable from the North American West Coast directly to Australia in 1903. More direct connections between countries would principally increase the effective bandwidth lowering cost and would be reflected in greater volumes of telegraphic messages.⁸

The telegraph was the fastest communication technology of the nineteenth century. Its expansion would have the effect of lowering distribution costs within the exporting and importing countries. A rail network would have the same effect. The number of telegraph messages sent and the number of kilometers of rails are used as measures of infrastructure depth. As well, both country population and country area are included to adjust for per capita and per mile densities of the telegraph and rail networks respectively.

Telegraph construction was very closely linked to railway construction (DuBoff 1982, Field 1992). Railroad network density will increase trade. The more dense the rail network, the greater the capacity to move goods regardless of destination within and across borders. The inclusion of railroad network density controls for the likely close correlation between rail and telegraph expansion. This is to ensure that any evidence on the impact of the telegraph is not simply a spurious measure of the impact of railroads on trade.

In addition to this basic set, gravity models can include a host of other shift variables to account for certain specific attributes that may explain trade flows between two countries including: common border, common language, island, water-access, shared monetary arrangement, membership in a preferential trad-

ing arrangement, colonial links, etc. Shared borders and common language will be included, as well as others to be discussed below.

Some effects act as barriers to trade; in particular protectionism and transport costs. Customs revenue is a proxy for tariff barriers to trade and is taken as customs revenue as a share of imports. Both customs revenue and import values are from Mitchell (2003). As a measure of the change in freight rates over time, the Isserlis index is commonly used. Recently Mohammed and Williamson (2004) propose a modified index. In its construction, they gather several route-specific, commodity-specific indices.⁹ Wherever possible, these route-specific freight rate indices have been used. On routes for which there is no reported rate, like Japan to Indonesia for example, their aggregated index is used.¹⁰ Because markets separated by water required goods to be transshipped from rail to ship to rail, handling costs would be higher. We capture this effect with an intercontinental dummy variable with a value of one for markets separated by ocean and zero for markets potentially linked by rail.

All data are the dyad products logarithmically transformed, except for distances between the country pairs taken from Rose (2000). The data set is an unbalanced panel of over 1300 bilateral trade pairs for 50 countries from 1870-1910 at five-year intervals.¹¹ This sample was chosen to maximize the number of usable observations. European trade is over-represented compared to trade among other continents. As well, intra-European trade is particularly over-represented compared to all other intra-continental trade.¹²

Lopez-Cordova and Meissner (2003) deflate nominal trade figures into 1990

U.S. dollars using a U.S. consumer price index, thereby allowing for use of Maddison's (1995) real GDP data. Telegram message counts and railroad mileage were taken from Mitchell (2003). Population is from Maddison (1995) and country area is from Banks (1976). Descriptive statistics of variables used are in Table 1.

The growth rates of trade and telegram messages by 5-year periods is illustrated in Figure 1. Because the dataset is an unbalanced panel, Figure 1 illustrates a subsample, the maximum number of country pairs for which there were observations in every five-year period. Telegraph usage grows particularly rapidly in the early period and displays strong growth throughout, typical of diffusing technology. Trade growth is particularly vigorous in the early period, followed by a slowing and then a resurgence in the latter period.

Basic Results

There are a few available options for handling panel data. For this data set, n is large relative to t so pooling is a good solution. For comparison, several methods are tested and results reported in Table 2.¹³ Time dummy variables – eight used for the nine periods available – are included to control for any time-specific effects, but are not reported. The results from the basic pooled regression, Regression 1, are consistent with other gravity model studies. The elasticity on income is significant and close to one. The elasticity on distance is negative and significant. Common language and a common border are both positive and significant. Both infrastructure variables, rail and telegraph, are positively related to trade expansion.

sion and are strongly significant, comparable to results from studies like Bandyopadhyay (1999). Further, the elasticity of the response of trade to telegraph is of the same magnitude as the elasticity of trade to rail mileage, a direct influence on trade volume.

The significance of both the coefficients on rail and the telegraph suggests that not only do both rail and the telegraph act jointly to increase trade, they also contribute independently.¹⁴ Better rail connections mean cheaper freight rates regardless of telegraphic density. A denser telegraphic network would increase trade through better use of the rail network, but it could contribute to expanded trade through other channels as well. In particular, as will be supported below, it contributed through increased shipping efficiency. The coefficient on the intercontinental dummy is negative and significant, indicative of the trade-reducing effect of markets being linked by shipping alone in an era of expanding rail networks. While distance has been included, the results reinforce a standard result from the gravity model literature that distance alone is essentially a proxy for a variety of trade-reducing impediments not explicitly modeled. That appears to be what the intercontinental dummy is capturing; and it is this gap that the telegraph helped overcome.

Customs revenue is negative as expected but insignificant. While indicative of protectionism, customs revenue is also a source of government revenue. Furthermore, customs revenue is a more important tax revenue base for the wealthy land-abundant New World countries, countries with substantial trade (Irwin 2002).¹⁵ Therefore the correlation between trade and customs revenues may be weak in a

panel of dissimilar countries.

It is likely that the effect of the telegraph on trade depends on the distance between trading countries. Regression 2 includes a term to capture the interaction between the telegraph and distance.¹⁶ The inclusion of these variables does not materially affect the other coefficients, though the coefficient on GDP increases and is insignificantly different than 1, its theoretical value. The coefficient on the telegraph variable itself becomes negative, but the effect of the telegraph is determined now by both this coefficient and the coefficient on the interaction term. The coefficient on the interaction term between telegraph and distance is positive and statistically significant which means that the telegraph has a greater impact on trade the farther apart are the two trading countries. That the impact of the telegraph on trade is greater for countries at greater distance from each other is consistent with the anecdotal reports, and is consistent with results to be presented below on the impact of the telegraph on shipping.

There is an important specification issue regarding the exogeneity of the telegraph to trade expansion. In many of the histories of the telegraph, expansion of networks is linked to competition (Ahvenainen, 1981) or to nationalistic interests (Headrick, 1991). As well, an attribution of demand for the telegraph to commercial interests is rarely mentioned. It is possible, though, that countries with greater infrastructure to support trade, such as port infrastructure, will also be countries with greater investment in communications networks. If port infrastructure in general is correlated with GDP and since greater GDP implies more trade, it is possible that trade and GDP are simultaneously determined. To address

this potential simultaneity, a lagged value of GDP is used as an instrument for GDP, reported in Table 2 as a two-stage least squares regression 3. Though there are modest changes in magnitude of some of the coefficients, and a reduction in significance of the coefficients on common borders and population, the basic conclusions remain unchanged from the pooled basic OLS regression (1). The coefficient on the telegraph is positive and statistically significant. Though not shown, the changes in an instrumental variables regression version of regression (2) - pooled with interaction term *telegraph*distance* - are similar with the signs and significance of the telegraph coefficients virtually unchanged.

Several more regression forms are presented to show that results on the telegraph are robust to the specification of the model.¹⁷ To account for possible unobserved or unspecified country-specific effects, country dummy variables are included in the regression 4. Each dummy variable takes on the value one if that country is included in the country pair and zero otherwise. The dummy variables capture any effects specific to a country not captured by the explanatory variables; in particular, a country's multilateral openness to trade (Anderson and van Wincoop, 2003). The country dummy variable coefficients are not reported but are jointly significant.¹⁸ In general, there are no large changes with the inclusion of country-specific effects compared to regression 2. All three coefficients (*telegraph*, *distance* and *telegraph*distance*) are larger, but their combined marginal effect on the dependent variable is virtually unchanged. The coefficient on the interaction term between telegraph and distance remains positive and statistically significant.¹⁹ The change of note is that the coefficient on rail is no longer sig-

nificant. This is also why the sign on the tariff variable switches, even though tariffs are not statistically significant. The only variable to change materially is the coefficient on area becoming negative and modestly significant. So once country-specific effects are included, larger countries will trade modestly less.

The inclusion of country-specific effects is a step toward inclusion of possible country pair-specific effects. While a particular country may be relatively open to trade, it may have special trade relationships with only a subset of countries. A fixed effects model is used to capture such country-pair specific effects. The fixed effect is defined at the level of the country trade pair. The data contain 256 country-pair observations with each ranging from one to nine years of observations. The problem with the fixed effects model is that time-invariant effects that are theoretically or empirically important – like distance, common language and common borders – are removed.

The results of regression 5 remain very similar to those of the pooled regression.²⁰ The coefficient on the interaction between telegraph and distance is positive and significant, though the point estimate of the elasticity is smaller than for the pooled regressions or the regressions with country-specific effects. The coefficient on income is positive and significant, and similar in value to the estimate obtained in a pooled regression. The coefficient on rail mileage is also positive and significant, while shipping is negative but insignificant. As in the country-effects specification, the coefficient on area is negative, large and statistically significant. This specification still identifies the telegraph as significant to trade.

Another approach to eliminating the fixed country-pair specific unobserved

effects is to take differences. As in a fixed effects regression, time-invariant effects are also lost, but unlike the fixed effects regression, the first observation in each time series is lost. Observations not spaced at 5-year intervals are also eliminated. The results of the differenced regression is reported in regression 6. Results are again similar. The coefficient on telegraph is positive and significant even while the coefficient on rail is insignificant. The differenced data also confirm that the telegraph had an impact on trade.

The dataset is an unbalanced panel. An additional test was performed on the basic regressions (1 and 2) with a balanced panel. There are only 324 observations common across all years, yet even with this small sample size, the general results of the signs and statistical significance on the telegraph coefficient and the telegraph-distance interaction term are consistent with the results for the full sample. In the balanced-panel version of regression 1, the coefficient on telegraph is positive and statistically significant; and in regression 2, the interaction term of telegraph and distance is positive and statistically significant.

Estevadeordal *et al.* (2003), Lopez-Cordova and Meissner (2003), and Rose (2000) show that monetary arrangements enhance trade. To determine if the telegraph still increases trade after accounting for shared monetary arrangements, the Lopez-Cordova and Meissner (2003) monetary variables are added to the pooled regression models 1 and 2. These include three dummies for country pairs sharing a common monetary standard: gold, silver, or a bimetallic standard. There is a dummy for country pairs in a formal monetary union and a dummy for country pairs sharing some form of political union. They also include a variable to ac-

count for the volatility of the exchange rate. With the inclusion of the monetary arrangement dummies, the coefficients on telegraph remain statistically significant in either specification with and without the telegraph-distance interaction term.²¹

The quantitative impact of the telegraph on trade from the simple pooled OLS model (regression 1) is demonstrated using a simple counterfactual analysis. The model is run on the average of the independent variables in the sample, but the telegraph variable is held constant at its 1870 average to predict counterfactual trade. As well, the prediction is run with the telegraph variable held at constant at its 1910 average.²² The prediction thus generated is shown in Table 3. Results with the telegraph held at its 1870 level are in column 1 and results at the 1910 level are in column 2. At the 1870 level, trade drops to about 50% of its actual level by 1890. After 1890, there is modest variation, but the impact of the telegraph is much less significant. The second counterfactual shows virtually the same pattern. Trade would have been doubled in 1870 with the telegraphic output of 1910; while by 1890 trade would have been about 10% greater. The counterfactuals indicate that the telegraph did contribute substantially to trade expansion, particularly in the early years of network growth after 1870.

In summary, the results of a simple pooled OLS regression support the hypothesis that the telegraph did have a stimulative effect on trade. Adjustment for unobserved country-specific or country-pair specific effects does not alter this result. The link between the use of the telegraph and increases in trade can be attributed generally to the ability of markets to be better integrated. One potentially large source of that market integration is attributable to transportation innovation.

Evidence to be presented in the next section will support the hypothesis that the telegraph increased the efficiency of shipping, which was partly responsible for growing international trade.

The Telegraph and Shipping Voyages

An important link between the diffusion of the telegraph and the growth of world trade in addition to any specifically domestic effects on exporters and importers, was its use to increase the efficiency of shipping by allowing ship owners to better allocate their shipping capacity. A ship represents a fixed cost. The more revenue generated per period, the higher the return. The telegraph allowed shippers to improve their returns in two ways. The telegraph allowed ship owners to coordinate supply and demand of cargo to update routes in response to changes during the ship's voyage therefore increasing the value of each leg of the journey. As well, the telegraph allowed ships to potentially reduce time spent in port. The ideal test for the impact of the telegraph on shipping would be to track the capacity utilization of a ship's voyage and correlate that utilization with the availability of the telegraph at the ports of call. Lacking comprehensive data on cargoes carried and individual port connectivity makes calculating capacity utilization and linking it to the telegraph difficult.²³ Indirect tests of the impact of the telegraph on the geography of ships' voyages are presented, followed by tests of the impact of the telegraph on port time.

Without any communication between the owners and the ship, the owner must

make the routing decision using data available prior to sailing. The problem is deterministic; an optimal path can be determined prior to sailing. Specifically, the shipper's problem is to choose a path of ports to visit that will maximize profit.²⁴ Profit depends directly on the rate charged for the cargo available at any port. As well, time in transit between ports is costly. For steam, fuel costs increase with distance and with speed. Also the larger the ratio of transit time to port visits, the lower the return to the capital invested in the ship. As steam represented a larger investment than sail on average, steam would be more sensitive to transit times among ports.

At any particular port, the voyage profit can be broken down into the profitability of the next leg plus the expected profit of all following legs starting from a new voyage beginning at the next port. Updated information obtained in a port of call can be used to re-evaluate the profitability of the next leg against alternate route choices. The optimization problem for the rest of the voyage is solved recursively, given the current choice for the next leg of the voyage.

While the tramp would sell space on the outward voyage, the choice of destination would be based on expectations of cargo available for the next leg of the voyage.²⁵ Once unloaded, the ship would be directed to the nearest location to reload, if not at the current port, and would then again proceed to the nearest port where cargo could be expected to be valuable. While cargo values can change while the voyage is underway, because the ship owners cannot communicate with the ship, these changes are irrelevant. However, if the ship can remain in contact with the shipowner en route, updating of the route becomes a possibility.

This class of problem can be categorized generally as a stochastic vehicle routing problem (Psaraftis, 1988). When information arrives stochastically, route choice can change after the ship leaves its home port. Larson, Madson and Solomon (2002) show in a particular subset of the vehicle routing problem that voyages will be lengthier with stochastic demand compared to the deterministic case where information does not change after departure. Therefore, it is hypothesized that voyage length will increase with the availability of the telegraph to provide the updated information. Without the telegraph, the routing problem devolves to the deterministic class. A positive relationship between the telegraph and voyage length would be evidence supporting the broader test of the favourable influence of the telegraph on shipping efficiency.

The other potential impact of the telegraph was to reduce the time spent in port. As shipowners could communicate with ports, arrangements could be made in advance of the ship's arrival. Therefore a test of the hypothesis of reduced port time requires data on port arrivals and departures.

Data on shipping voyages are available through the Atlantic Canada Shipping Project (ACSP). It provides a 1% random sample of *British Agreements and Accounts of Crews*, the official documents filled by all British ships, for almost 19,000 voyages for the years 1858-1913. For each voyage there is information on ship size and horsepower if steam-powered, as well as information on home port, ports visited and intended duration of voyage. However, there is no information on cargo, so these data cannot be used for direct tests of voyage profitability.

In the first test, voyage distance among ports of call is regressed on the tele-

graph variable from the previous section for the country of the port of call visited. Generally, the greater the domestic telegraph usage the greater the international usage. Table 4 reports international and domestic traffic for a sample of countries in 1879. Domestic and international messages have a correlation coefficient of 0.97. Certainly only a small share of telegraph usage would be generated by the demand for the telegraph by shipping. As discussed, shipping companies used the telegraph sparingly as it was very expensive. It is a maintained assumption that greater telegraphic utilization is correlated with greater usage by all users. However it is impossible to determine how much the telegraph was used by a particular user. Regardless, greater overall usage of the technology by all users implies increased availability. Lacking direct evidence of telegraph usage and connectivity by individual ports, statistical evidence linking the telegraph and its predicted effect on the response of shipping will be presented.

The dependent variable, distance among ports of call, is the sum of distances between each pair of ports of call, not including either the distance from the home port to the first port of call, or the distance from the last port of call to the final destination. Characteristics of both the ship and the voyage might influence distance traveled between ports of call. Larger ships would have fewer port options available and might have to travel farther to visit more ports to utilize capacity. Steamships with more power could travel faster. Also, voyages with longer intended durations would likely be longer voyages.

The geography of each voyage would influence route choice as a voyage to a remote location would increase distances among ports of call. A voyage to a

remote location would be more risky since options to deliver cargo and find cargo to reload are reduced. In particular, evidence suggests that the use of the telegraph to coordinate shipping is more valuable for remote locations.

Remoteness of a port is calculated as the average weighted distance of a port from all other ports in the dataset. Ports distance is weighted by its frequency in the data set to capture its economic importance. In other words, ports visited more often – presumably because they are more important – would be less economically remote. There are 1371 different ports of call in the dataset over the entire period so an individual port’s remoteness is its average weighted distance from all 1370 other ports.²⁶ This measure would suffer from changes in the number of ports due to settlement.²⁷ Remoteness of Valparaiso, Chile, for example, would tend to decline over time as the number of ports increased along the west coast of South and North America. This bias works against the hypothesis that ship voyages between ports of call increased due to the telegraph because with port expansion over time, distance traveled among ports of call would fall. The remoteness per voyage is taken as the average of the remoteness of each port visited in a voyage.

The proxy used for telegraphic utilization is the number of telegraph messages per country of port location in the year of the port visit is used (Mitchell, 2003a, 2003b, 2003c; supplemented by Banks, 1976). Since the dependent variable is distance traveled per voyage, the average of telegraph messages for the country of each port of call is used. If the telegraph did increase profitability, then a country with better telegraphic infrastructure would be more attractive to shippers.

While the benefits of the hypothesized increased efficiency to shippers of us-

ing the telegraph might have been fully absorbed by ship owners rather than reflected in greater world, the industry structure of the time and the technology suggest competition would have worked to reduce windfall profits over the long run. While liners become cartelized late in this period, tramp shipping remained competitive (Fayle, 1933, p. 277-8; Kirkaldy 1914, p. 192; Palmer, 1984, p. 109). In fact observers would often characterize competition in this period as ruinous. Tramps were flexible, hence entry was relatively easy. And this is the characteristic of tramp shipping that is hypothesized to have benefited from the use of the telegraph. Further shipping was a high fixed cost but low marginal cost industry so that owners could easily cover variable costs while incurring losses in the long run.

There are almost 11,000 voyages with complete data over the years 1861-1913. A time trend is used to capture time-dependent effects like technological change, availability of ports, etc.²⁸ Results are reported in Table 5. Two sets of regressions are reported and each regression is run separately for sail and steam voyages. The first set of results reports the basic regression. For steam, distance from home port is positive and statistically significant while the time trend is negative and statistically significant. Ships visiting ports farther from the home port tend to travel farther among ports of call, while distance traveled among ports of call declines over time. Neither ship size nor engine size appear to be significant. Intended duration is strongly significant, not surprisingly since it reflects a shipowner's initial intentions. Remoteness is also strongly significant. And importantly, telegraphic capacity of the country of the port of call is strongly significant.

It is quantitatively significant as well, on the same order of magnitude as the effect of distance from home port and intended duration. The results for sail are generally similar, though distance from home for sailing voyages has a higher elasticity than the telegraph; whereas for steam the elasticities were approximately equal. This suggests that while the telegraph influenced sail as well as steam, the effect is relatively weaker for sail.

The effect of remoteness, however, differs markedly between sail and steam. The coefficient is negative and insignificant for sail while it was positive and significant for steam. The more remote a port of call the longer the voyage among ports of call for steamship voyages. While this relationship is not surprising, that it holds only for steam suggests a difference between the voyages of steam and sail. Despite there being no direct influence of port remoteness on sail voyage length among ports of call as hypothesized, the impact of the telegraph still appears to be significant, even if the effect is not as strong relative to the effect of distance from home port.

As the impact of the telegraph may be stronger on voyages to ports of call more distant from the home port, and more remote from each other, an interaction term between the telegraph and distance from home port and an interaction term between the telegraph and port remoteness are included in regression sets 2 and 3 in Table 5 respectively. For steam, the coefficient on the telegraph is positive and statistically significant, but the coefficient on the interaction term between telegraph and distance is insignificant. For sail, the coefficient on the interaction term is negative and statistically significant while the coefficient on the telegraph

remains positive. Unlike steam, the impact of the telegraph on sail declines as distance from home port increases. For steam, the distance from home does not seem to significantly alter the impact of the telegraph. The declining impact of the telegraph on sail at greater distances from home may reflect the effects of weather and season restricting the elasticity of sail to respond and switch course. It must be noted, though, that sailing routes for sail and steam did differ. The average distance among ports of call for sail is almost twice that of steam in the regression sample.

For interactions with remoteness rather than distance, reported as regression 3 in Table 5, the coefficients on the interaction terms is only modestly statistically significant for sail, and not significant for steam, though in both cases the coefficient on telegraph and its interaction with remoteness are jointly significant. Sail may have benefited from telegraph usage when visiting remote ports.

The sample was then divided into sub-periods of approximately one decade and the regressions in Table 5 were then rerun on each decade. The results were essentially unchanged with the coefficient on telegraph remaining positive and significant for each decade, though the coefficient did decline slightly in size over time. This held both for steam and sail.

The second test is of the link between the telegraph and time spent in port. It is hypothesized that the coefficient on the telegraph should be negative if telegraphs helped reduce port time. Variables capturing the characteristics of the ship and its voyage are included in the regression. Variables capturing the differences among ports are also included: port remoteness and per capita income of the country.

It is possible that the results are completely spurious if telegraphs usage was determined by port development. Without detailed data on port infrastructure, it is impossible to distinguish between the effect of the telegraph and the effect of port development more generally so per capita income of the port country is included as an indicator of development.

Results are reported in Table 6. The coefficient on the telegraph variable is negative and significant for steam and for sail. The telegraph appears to have reduced time spent in port for all ships. The response of steam and sail do differ modestly. The elasticity on the telegraph coefficient is larger for steam. As well, time spent in port for steam is not affected by the remoteness of the ports, while remoteness increases time in port for sailing ships. The coefficient on per capita income is negative but is insignificant. Results are very similar if the per capita income variable is not included.

A couple of tests were done to insure that changes in telegraphic usage are not capturing other time-dependent technological change. The coefficient on the time trend is statistically insignificant. With the basic regressions run without the telegraph variable, the time trend remains insignificant. As well, a regression using time dummy variables rather than a linear time trend is reported as regression 2. There is almost no change in the point estimates of the coefficients, though the significance of the telegraph coefficient falls below 5% (5.8%, but reported as 10%). The evidence supports the hypothesis that the use of the telegraph contributed to increased port efficiency.

The regressions 1 in Table 6 were rerun by decade. The results, not reported,

indicate that the telegraph was significant in reducing port times for the 1880s and the 1890s for both steam and sail; but after 1900 its effect on port times becomes insignificant. This could indicate that port infrastructure development had become more important, but such a conclusion would require additional data for support. However, the telegraph was still influencing the routing of ship voyages for the entire period until the first world war regardless of its influence on time spent in port.

Availability of the telegraph appears to have influenced the geography of shipping voyages. Ships visiting ports in countries with greater telegraphic capacity tended to travel farther among ports and tended to visit more ports. For sail there is some evidence that the influence of the telegraph fell off with distance though there is still strong evidence in support of the link between shipping and the telegraph for both steam and sail. There is also evidence supporting the link between the telegraph and a reduction in time spent in port. Taken together, these two pieces of evidence add additional support for the link between the finding that world trade itself responded elastically to telegraphic expansion and the impact of the telegraph on the efficient utilization of shipping capacity.

Conclusion

The telegraph does appear to have enhanced trade in the late nineteenth century. The growth of the telegraph is strongly correlated with trade expansion before World War I. The impact of industrialization on transportation has been rightly

stressed. Industrialization brought about steam ships, but it also resulted in benefits such as lighter and stronger materials which allowed for larger ships, both steam and sail. Port facilities as well were greatly enhanced. But industrialization also transformed communications, and communications contributed to expanded commerce. The evidence presented above supports the link between an expanding telegraph network and increased trade.

The telegraph was a boon for shipping much the same way it had been virtually a necessity for the rapid expansion of railroad networks. Railroads used the telegraph initially to increase utilization of track. It also allowed ship owners to increase the utilization of the ship itself. It allowed ships to remain in communication while in foreign ports and thereby enabled them to be redirected to sources of cargo, and to respond to changing market conditions. Both steam and sail benefited, though the impact on each transport technology did differ modestly. As steamships represented a substantial investment, utilization was important. Visits to remote port was associated with longer voyages, increased uncertainty for obtaining cargo and therefore reduced utilization. Availability of the telegraph compensated for this risk. For sail the effect of the telegraph declined with distance from home port. Because weather and season had a larger impact on sail, the telegraph did have a significant impact. But for sailing ships plying the longer trade routes, seasonal patterns probably dominated in terms of route choice. The value of updated information in altering route choice for the long-distance sailing ship was therefore reduced.

In response to the telegraph, the shipping industry would subtly reorganize its

operation. Trade in cargo would become more centralized in the London Shipping Exchange and the Baltic Exchange. Shipping companies could discover availability of cargoes and destinations with demand for cargoes. They could communicate this information to their ships upon arrival in their port of call. The more distant and remote the port of call, the more valuable was this communication link since those ships would take longer to return to home port or even to a familiar port.

More specific tests should be carried out utilizing data from port infrastructure development and from shipping capacity utilization. This analysis is of measures indicative of the efficiency gains from communication links. The literature is dotted with quips and comments to this effect, but as yet there has been little systematic gleaning of this information.

It is impossible to avoid comparing the telegraph expansion in the nineteenth century with the rapid expansion of personal communication in the recent past due to the Internet and wireless technology. One contrast must be stressed. Prior to the diffusion of the Internet and the adoption of wireless devices, communication networks were deeply enmeshed in commercial activities, certainly since World War II. Transoceanic telephone cables already connected the world by the 1950s. When the telegraph was introduced, there was no substitute, close or distant, for transoceanic communication. Its impact must have been all the more transforming.

Notes

¹Messages had to be retransmitted at every node so that delivery times could be days or longer depending on the status of the network.

²There were two principal links from Europe to Eastern Asia in the 1870s: one via the Persian Gulf to India and beyond, the other via Siberia to northern China. North America and South America were linked via cables bridging the West Indies, later in the century to be supplemented by direct links.

³At least that is the view expressed by Ahvenainen (1986). Kaukiainen (2001a) argues that the rate of increase in the speed of communication was just as rapid, if not even more so, in the two decades prior to the introduction of the telegraph. While not arguing the telegraph was unimportant, he stresses the rapid increase in the rate of information transfer due to the use of steamships and rails, and due to the growth in the demand for information.

⁴Transatlantic radio telephone links were available by the late 1920s, but were very expensive and impractical for frequent usage.

⁵This elasticity of steam to the telegraph cable is mentioned, though never in great detail, in a variety of sources on shipping from the early 20th Century. See for example, Kirkaldy (1914, p. 334) and Fyale (1933, p. 263-4). Liners were not flexible in that they adhered to fixed schedules. They adapted themselves to the cargo demand at their ports and relied on extensive networks at each port to keep

freight capacity utilized. Freight came to the liners whereas the tramps went to the freight.

⁶An early use was for a watch along the coast to communicate the imminent arrival of a ship to prepare for its unloading (Prescott, 1890, p. 255-6), a task adopted from the use of the optical telegraph (Field, 1994, p. 345; Scholl, 1998, p. 199).

⁷Often per capita GDP is included directly. But because both GDP and population are already included in the model, and because the model is specified in log-linear form, per capita GDP is implicit. As $\delta \ln(gdp/pop) = \delta (\ln(gdp) - \ln(pop))$, the addition of per capita GDP as an independent regressor merely alters the coefficient on population. The terms $\alpha \ln(gdp) + \beta \ln(pop)$ and $\gamma \ln(gdp) + \delta \ln(gdp/pop)$ are related as $\beta = -\delta$ and $\alpha = \gamma + \delta$.

⁸There were strategic political reasons to choose to control direct linkages (Headrick, 1991).

⁹These data are reported in the appendix to Mohammed and Williamson (2004) downloaded from http://econweb.fas.harvard.edu/faculty/jwilliam/papers/Tramp_Shipping_Appendices.pdf

¹⁰An aggregate index only was used in an earlier draft. Results are generally similar. But inferences drawn regarding the impact of the telegraph are unchanged.

¹¹The trade data were graciously provided by Chris Meissner, from Lopez-Cordova and Meissner (2003).

¹²The availability of customs data is most limiting, followed next by availability of trade data.

¹³Standard errors are robust to heteroskedasticity of a non-specific form and to clustering on country pairs.

¹⁴As a test of possible collinearity, the basic pooled regression was rerun with only the telegraph variable and again with only the rail variable. The coefficients on both variables were positive and significant when each was included alone. Other coefficient changes were very slight, though the coefficient on income increases to over unity in either of the cases.

¹⁵There are several other reasons why customs revenue may not be an accurate measure of protection. Low tariff rates on goods with a high elasticity of import demand will appear more protectionist. Estevadeordal (1997) estimates measures of protection adjusted for resource endowment differences, but for one year only, and for a more limited set of countries.

¹⁶In addition to distance, the remoteness of a particular country could possibly affect the impact of the telegraph. Remoteness of country i from all other countries j , defined as $remoteness_i = \frac{1}{\sum_j \frac{gdp_j}{distance_j}}$, was included but proved insignificant in all specifications.

¹⁷In models which include an interaction term between telegraph and distance, the coefficient on the telegraph alone is consistently negative while the coefficient on the interaction term is positive. Without the interaction term, the coefficient on the telegraph remains positive and significant in all specifications.

¹⁸The time dummy variables are still included. The standard errors are robust to heteroskedasticity and to clustering on country pairs.

¹⁹If the interaction term is excluded, the coefficient on telegraph remains almost unchanged from its value in regression 1 and it remains significant at the 5% level.

²⁰Dummy variables for the time periods are also included. The reported standard errors are robust to heteroskedasticity, serial correlation, and country-pair clustering.

²¹Results not reported but available from the authors. The sample size is reduced to 1226 observations.

²²Because the panel is unbalanced, the sample used in the counterfactual analysis is balanced.

²³For example, Alexander (1979) does calculate shipping productivity, but does so under assumptions that capacity is utilized at a constant rate. Such a technique would not allow for differentiation by voyage leg.

²⁴The vessel positioning problem is formalized in Magirou et al. (1997).

²⁵This problem of utilizing shipping capacity is more complicated. Because some cargoes are dense and take up buoyancy while others are bulky and take up volume, shippers will optimize over several variables. See Harley (1988). The complexity of cargo loading due to the interdependency of different cargoes would only increase the value of communication at a port of call.

²⁶Distances are measured as the great circle distance between any two points, but adjusted to take account of major geographic obstacles. Distances between the east and west coasts of North America are assumed to be via Cape Horn. Europe is linked to Asia via the Suez canal.

²⁷The impact of the opening of the Suez canal is not included in the remoteness variable, distances are calculated assuming the Suez canal was available throughout. The calculated remoteness will therefore tend to understate the remoteness of ports influenced by the canal. To the extent shipping was influenced by the telegraph to better utilize these ports, the bias works against the hypothesis that remote ports were more influenced by the availability of the telegraph. There is only one voyage in the sample by a steamship to southern or eastern Asia before the opening of the Suez canal, London to Bombay in 1867-1869, so the effect on the sample is small. While sail did not utilize the canal, shippers had the option of sending cargo by steam via the canal.

²⁸Regressions were run with year dummy variables as well, but the time effect is well-captured by a linear trend.

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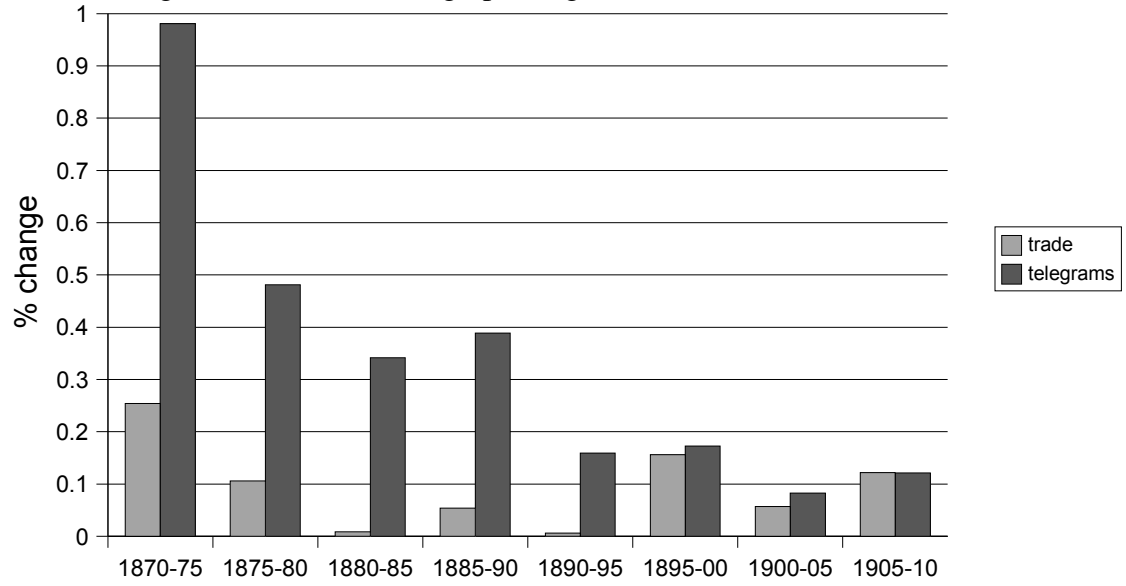
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Figure 1: Growth of telegraph usage and trade, 1870-1910



Notes: See text.

Table 1: Descriptive Statistics

	mean	standard deviation	min	max	
trade	4.60	2.35	-6.72	9.45	Total trade (millions 1990 \$US) between countries i and j (Lopez-Cordova and Meissner, 2003)
telegrams	31.55	1.78	25.66	36.41	Telegrams sent (Mitchell, 2003)
gdp	48.20	1.73	43.17	52.93	Real GDP in 1990 International Geary-Khamis dollars (Maddison, 1995)
rail mileage	17.60	1.98	11.52	22.90	(Mitchell, 2003)
customs share	-4.81	1.46	-10.56	-0.34	Ratio of customs revenue to imports (Mitchell, 2003)
population	32.70	1.86	26.97	38.11	(Maddison, 1995)
area	24.30	2.60	18.78	31.13	Country square mileage (Banks, 1976)
freight index	-0.15	0.28	-0.77	0.59	See text

n=1243

All variables logarithmically transformed.

Variables other than trade are products of values for countries i and j .

Table 2: Gravity Model Regression Results

	Pooled – Basic (1)	Pooled – interactions (2)	2sls (3)	Country Effects (4)	Fixed Effects (5)	Differenced (6)
GDP	0.846 *** (0.241)	0.921 *** (0.250)	0.621 ** (0.274)	1.024 *** (0.354)	0.930 *** (0.278)	1.280 *** (0.306)
Distance	-0.528 ** (0.220)	-3.483 *** (1.096)	-0.752 *** (0.264)	-6.606 *** (1.291)		
Common Language	0.806 ** (0.335)	0.823 ** (0.325)	0.772 ** (0.342)	0.830 *** (0.238)		
Border	0.514 * (0.292)	0.535 ** (0.270)	0.295 (0.311)	0.981 *** (0.249)		
Rail Mileage	0.302 *** (0.099)	0.265 *** (0.098)	0.378 *** (0.117)	0.093 (0.114)	0.257 *** (0.095)	0.031 (0.057)
Telegrams	0.241 ** (0.104)	-0.497 * (0.291)	0.301 *** (0.116)	-1.385 *** (0.347)	-0.435 (0.272)	0.140 ** (0.063)
Telegrams x Distance		0.095 *** (0.033)		0.194 *** (0.041)	0.070 ** (0.031)	
Tariffs	-0.094 (0.081)	-0.093 (0.079)	-0.091 (0.084)	0.039 (0.062)	-0.016 (0.047)	-0.074 ** (0.037)
Population	-0.412 ** (0.168)	-0.436 ** (0.172)	-0.285 (0.179)	-2.114 *** (0.631)	-0.786 (0.630)	-0.754 (0.469)
Area	0.011 (0.071)	0.019 (0.071)	0.007 (0.078)	-4.852 ** (2.004)	-2.531 ** (1.012)	0.377 (1.474)
Intercontinental Dummy	-1.045 *** (0.349)	-1.091 *** (0.329)	-0.639 (0.470)	-0.599 (0.406)		
Shipping Index	-1.912 *** (0.434)	-1.646 *** (0.467)	-1.544 *** (0.438)	-0.191 (0.433)	-0.316 (0.219)	-0.389 (0.284)
Observations	1243	1243	1091	1243	1243	914
R ²	0.63	0.63	0.66	0.77	0.33	0.05
Root MSE	1.44	1.43	1.39	1.13	0.62	0.71

*** significant at 1% level

** significant at 5% level

* significant at 10% level

Notes: Standard errors in brackets. Standard errors robust to heteroskedasticity, serial correlation, and country-pair clustering. Time period dummies and constant included in all regressions but not reported in Table. Country effect dummies in regression 4 not reported.

Table 3: Ratio of Counterfactual to Actual Trade Given Telegraphic Activity of 1870 and 1910

	telegraph 1870	telegraph 1910
1870	1.00	2.07
1875	0.80	1.66
1880	0.73	1.52
1885	0.64	1.32
1890	0.54	1.11
1895	0.53	1.10
1900	0.54	1.11
1905	0.52	1.07
1910	0.48	1.00

Table 4: Telegraph Messages: Domestic and International, 1879

	Messages (millions)		International Share
	Domestic	International	
Germany	10.3	1.7	14.2%
Austria	3.2	0.69	17.7%
Hungary	1.7	0.5	22.7%
Belgium	2.1	0.4	16.0%
Bulgaria	0.0	0.01	28.6%
Denmark	0.4	0.1	20.0%
Egypt	0.2	0.01	3.6%
Spain	1.3	0.2	13.3%
France	13.1	1.2	8.4%
Greece	0.3	0.03	7.7%
Italy	4.5	0.4	8.2%
Norway	0.5	0.1	16.7%
Netherlands	1.8	0.4	18.2%
Romania	0.4	0.1	20.0%
Sweden	0.6	0.1	14.3%
Switzerland	1.7	0.3	15.0%
UK	23.6	3.1	11.6%
British India	1.3	0.2	13.3%
Dutch Indies	0.3	0.05	14.3%
Japan	1.2	0.08	6.3%
Russia	5.0	1.0	16.7%
Victoria	1.0	0.01	0.7%
New Zealand	1.3	0.02	1.7%

Source: *The Journal of the Telegraph*, Jan 16, 1881, p. 18 and May 16, 1881, p. 147.

Table 5: Ship Voyage Regression - Voyage Distance

	1		2		3	
	steam	sail	steam	sail	steam	sail
Distance from home	0.320 *** (0.078)	0.693 *** (0.154)	2.716 *** (0.590)	2.222 *** (0.368)	0.343 *** (0.078)	0.734 *** (0.142)
Time	-0.034 *** (0.005)	-0.032 *** (0.005)	-0.033 *** (0.005)	-0.030 *** (0.005)	-0.034 *** (0.005)	-0.032 *** (0.005)
Gross tonnage	-0.045 (0.143)	-0.217 ** (0.093)	-0.440 (0.786)	1.316 * (0.750)	-0.056 (0.146)	-0.194 ** (0.089)
Horsepower	0.139 (0.172)		4.581 *** (1.220)		0.144 (0.173)	
Telegrams	0.418 *** (0.035)	0.524 *** (0.034)	0.396 * (0.210)	1.097 *** (0.284)	2.169 (2.074)	2.827 ** (1.375)
Remoteness	1.625 *** (0.269)	-0.631 (0.472)	2.457 *** (0.260)	-0.355 (0.596)	2.688 ** (1.261)	0.575 (0.961)
Intended duration	0.497 *** (0.082)	0.854 *** (0.106)	0.470 *** (0.075)	0.795 *** (0.099)	0.493 *** (0.083)	0.822 *** (0.102)
Telegrams x distance from home			0.005 (0.028)	-0.064 ** (0.031)		
Telegrams x remoteness					-0.124 (0.141)	-0.160 * (0.095)
Constant	41.618 *** (9.572)	65.912 *** (11.282)	24.892 *** (10.064)	44.526 *** (16.377)	-45.701 (32.255)	47.931 *** (17.347)
Observations	8294	2567	8294	2567	8294	2567
R ²	0.40	0.42	0.41	0.43	0.41	0.44
F	75	108	82	112	74	99

*** significant at 1%

** significant at 5%

* significant at 10%

Dependent variable is distance traveled among ports of call. Standard errors in brackets. Standard errors robust to heteroskedasticity and clustering by individual ship.

Table 6: Ship Voyage Regressions - Time Spent in Port

	1		2	
	steam	sail	steam	sail
Distance from home	0.086 (0.056)	-0.077 * (0.042)	0.087 (0.055)	-0.083 ** (0.042)
Average distance among ports	0.171 *** (0.026)	0.085 *** (0.021)	0.168 *** (0.026)	0.086 *** (0.021)
Time	0.000 (0.004)	0.001 (0.002)		
Gross tonnage	0.469 *** (0.078)	0.202 *** (0.040)	0.501 *** (0.080)	0.197 *** (0.041)
Horsepower	-0.458 *** (0.130)		-0.492 *** (0.130)	
Telegrams	-0.057 ** (0.028)	-0.040 ** (0.017)	-0.049 * (0.026)	-0.042 ** (0.017)
Remoteness	-0.293 (0.193)	0.312 *** (0.121)	-0.293 (0.194)	0.323 *** (0.122)
Income	-(0.012) (0.066)	-(0.028) (0.043)	-(0.011) (0.068)	-(0.031) (0.045)
Intended duration	0.286 *** (0.058)	0.295 *** (0.054)	0.297 *** (0.056)	0.295 *** (0.055)
Constant	2.425 (7.030)	-5.548 (3.744)		
Observations	7698	2206	7698	2206
R ²	0.20	0.31	0.21	0.32
F	38.70	118.82	35.69	27.65

*** significant at 1%

** significant at 5%

* significant at 10%

Dependent variable: average time spent in ports. Time dummies in regression 2 not reported. Standard errors in brackets. Standard errors are robust to heteroskedasticity and clustering by individual ship.