Discussion Paper Series

IZA DP No. 18692

May 2026

Explaining Divergence in Ocean Freight Rates and Passenger Fares, 1863–1913

Timothy J. Hatton
Australian National University,
University of Essex
and IZA@LISER

IZA@LISER NETWORK
ISSN: 2365-9793

IZA DP No. 18692 May 2026

Explaining Divergence in Ocean Freight Rates and Passenger Fares, 1863–1913*

Abstract

Late nineteenth-century globalisation was fostered by falling transport costs in ocean shipping as average freight rates fell by about half. The literature has emphasised the importance of progress in steamship technology in explaining this trend. Passenger fares did not share this long-run decline even though passenger ships incorporated the same technological advances as those carrying goods. For passenger shipping, increasing space per passenger and improving quality of service absorbed much of the gains from technological progress. From the late 1880s cartels set minimum fares and established market sharing pools, which encouraged the shipping lines to compete on quality.

JEL classification

F22, F55, N73, O33

Keywords

steamships, passenger fares, freight rates

Corresponding author

Timothy J. Hatton
tim.hatton@anu.edu.au

* *Acknowledgements*: I am grateful for comments on an early draft from participants at the Asia-Pacific Economic and Business History Conference, Monash University, February 2025, and for comments on a later draft from Knick Harley and Rich Sicotte. I am especially grateful to Drew Keeling, on whose work I have drawn heavily, for help with data and extensive comments and advice.

Explaining Divergence in Ocean Freight Rates and Passenger Fares, 1863-1913

Introduction

In the first era of globalisation financial and goods markets became more integrated between countries and continents; that for people, in the form of international migrants, less so. One reason for the expansion of trade is the transition in ocean shipping from sail to steam followed by continued improvement in steamship efficiency. The latter is reflected by the decline in ocean freight rates. Nominal freight rates for tramp shipping fell by about half from the early 1870s to the early 1910s. However, historians have observed that passenger fares did not follow the same long-run decline. Dupont et al. (2017, p. 21) note from their data that "By 1914 steerage fares had climbed back to about where they had been in the 1830s. Freight rates, over the same time period, dropped by roughly half, but with many ups and downs in between." Feys (2013, p. 317) notes that "[w]hile freight rates plummeted, passenger fares peaked as the market boomed at the turn of the century." And Keeling (2008b, p. 227-8) comments that "[t]ransatlantic freight rates fell by more than a quarter between 1881 and 1913, but fares for steerage passengers rose between these two peak migration years. This means that the doubling of annual European migration to the United States over these three decades cannot be ascribed to falling steamship fares, since the fares did not fall."

While markets for the transport of goods and for passengers were increasingly distinct, the development of the underlying shipping technology was common to both. From mid-century the age of steam saw a dramatic increase in the size and carrying capacity of ships, as measured by their tonnage. Underlying technological improvements included the shift from wooden to iron and subsequently to steel hulls, from paddle wheels to screw propellers and, above all, gains in engine efficiency as low pressure engines gave way to compound engines, triple expansion engines and eventually steam turbines. The important point to stress is that these improvements in steamship technology were common to both freight and passenger shipping. This raises the question of why passenger fares did not fall broadly in line with freight rates. While the trends have been widely noted, no previous attempt has been made to quantify the factors underlying this divergence. A possible reason is that, while tramp shipping was common for freight, passengers were almost universally carried by liners running to regular schedules and dominated by few large companies. This suggests that some account must be taken of the differences in organisation.

In this paper I investigate and compare the factors underlying the differing price trends for freight and passenger transport on the North Atlantic from the 1860s to the eve of World War I. From the 1870s passenger fares fell similarly to freights until the 1890s and then diverged strongly as fares increased up to 1913. For freight rates, influential studies find that the key element underlying the decline in freights was total factor productivity (TFP) growth of 1 to 1.5 percent per annum, some of which is accounted for by growth in the size of ships and higher load factors. Similar calculations for North Atlantic passenger shipping from 1863-7 to 1909-13 produce negative TFP growth, which is due largely to the period from the late 1880s onwards. It suggests that something is missing.

One feature of the long-run trend was an overall decline of 40-50 percent in passenger capacity per ship-ton but there were also numerous other enhancements to passenger comfort, which are not measured in the TFP calculation. Thus, while improvement in steamship technology led to lower freight rates, in the passenger trade, gains in efficiency were absorbed by the costs of higher quality in the form of more space per passenger, enhanced on-board facilities and better passenger service. Once those costs are taken into account measured TFP growth becomes positive but it is smaller from the late 1880s than before, as prices increased almost as fast as costs.

A contributing factor was the emergence and growing strength of shipping cartels (conferences), which set minimum fares. In an oligopolistic setting with barriers to entry, when a minimum price is set, firms compete on quality of service. The evidence suggests that from the late 1880s the minimum fares set by shipping conferences accelerated the pace of improvement in the quality of service, which raised costs and absorbed much of the increased revenue from higher fares. This view is supported by the finding that strong conference organisation was associated with higher fares for emigrants. And it also helps to account for the apparent slowing in the measure of quality-adjusted TFP growth.

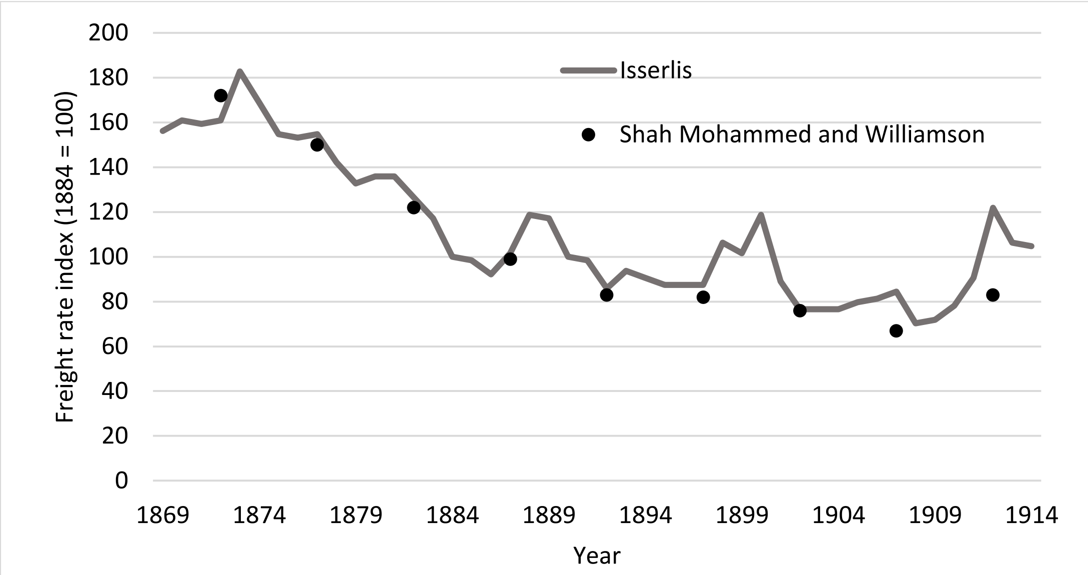
This paper contributes to the literature on productivity in ocean shipping pioneered by Harley (1970; 1988) and Shah Mohammed and Williamson (2004) and to assessing the contribution of steam technology by Crafts (2004) among others. But it emphasises that industrial development in the late nineteenth century was not only about lowering cost but also about increasing quality. As such it also contributes to the emerging literature on trends in the comfort and safety of travel by sea (Kelly et al. 2021), by rail (Leunig 2006; Pring 2019) and by road (Bogart et al. 2026) as well as the rise in travel for pleasure (Weiss and Dupont 2024). It also contributes to the literature on the business development of passenger shipping and the changing structure of the industry (Hyde, 1975; Keeling 2012; Feys 2013). Finally, the focus on shipping conferences contributes to linking the qualitative findings of historians with econometric evidence on the effects of cartels on migrant flows by Deltas et al. (2008) and Deltas and Sicotte (2017).

The paper proceeds as follows. I first compare trends in freight rates and passenger fares over the decades up to 1913. I then provide an overview of studies that decompose trends in freight rates into their underlying components. This is followed by an examination of trends in passenger capacity per ton of ship for the major passenger lines as well as developments in other dimensions of service quality. I then present a conventional decomposition of trends in passenger fares, highlighting that this produces negative estimated TFP growth, particularly from the late 1880s. But the estimate turns positive when the costs of improvements in quality are taken into account. An overview of the activities shipping conferences is followed by a an outline of the possible effects of setting minimum prices on competition over quality. Consideration of the evidence on the effect of shipping conferences on passenger fares and its implications for the estimation of TFP growth is followed by a short conclusion.

Comparing freight rates and passenger fares

There has been considerable interest in examining trends in ocean freight rates as a key element of globalisation. Figure 1 (the continuous line) shows the well-known Isserlis (1938) index of ocean freight rates for outward and homeward voyages of British merchant ships. Alternative estimates (as five year averages) by Shah Mohammed and Williamson (2004) show a similar trend (the dots in Figure 1). From 1870-4 to 1910-14 freight rates declined in nominal terms by about 50 percent. Jacks and Pendakur (2010) produced another global index and find a similar downward trend in freight rates. These indices are principally for transporting goods on tramp steamers, which carried the bulk of long-distance merchandise trade. Important for what follows, as Figure A3 in Appendix 1 shows, the trends in freights (often carried on liners) on the North Atlantic alone do not deviate substantially from the global average.

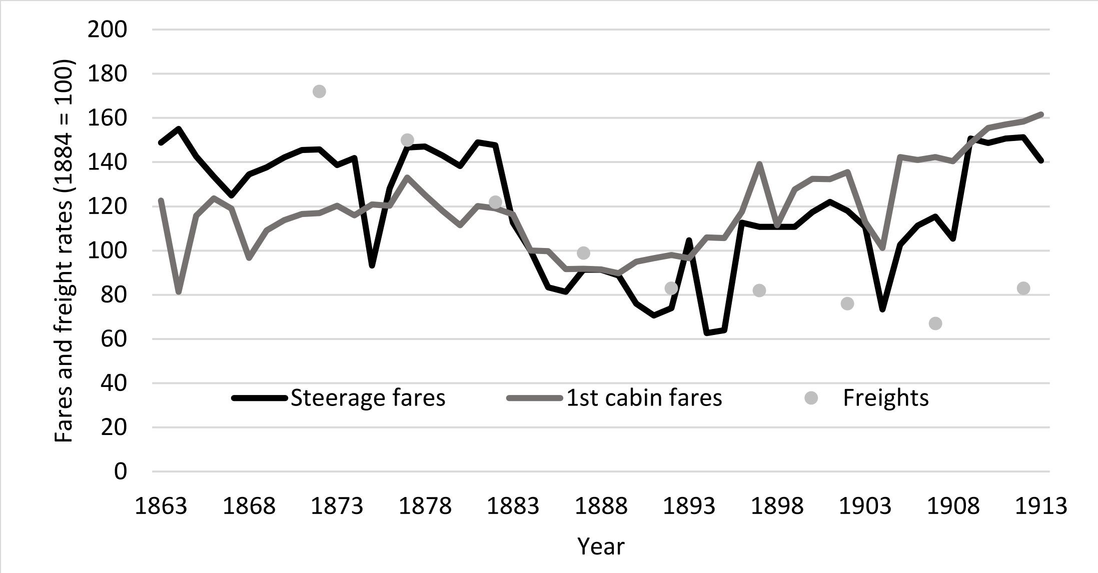
Figure 1: Global nominal freight rates, 1869-1914 (1884 = 100)



Source: Isserlis (1938), p. 122; Shah Mohammed and Williamson (2004), p. 188.

Passenger fares are available for only a few routes, notably for the North Atlantic, but these cover a large share of ocean travel. Figure 2 shows indices for westward steerage (third class) and eastward first class cabin fares on the route between the UK and the US. These are based on series reported by Keeling (2008a) and Dupont et al. (2017); see Appendix 1 for further details. While there is considerable volatility from year to year in the steerage fare index, nominal fares in 1913 were similar to those of the early 1870s. It is important to note for what follows that there is a strong decline of about 50 percent from the 1860s to around 1890, followed by an equally steep increase up to 1913. This can be compared with freight rates from Figure 1 (the dots), which indicates that much of the divergence between freights and fares is due to the second half of the period when the trend in freights was relatively flat while that of fares was upward. Although the steerage index from 1883 is based on one UK-based shipping line (Cunard), as reported in Figure A2 of Appendix 1, the upward trend from the early 1890s is very similar to those for shipping lines based in continental European ports. Figure 2 also shows that first-class cabin fares were a little less volatile and increased over the whole period by around one third. While there was some decline during the decade from the late 1870s it was somewhat less than that of steerage fares. But from 1890 onwards the overall upward trend is similar to that of steerage fares.

Figure 2: Westward steerage and eastward cabin fares between the UK and the USA, 1863 to 1913 (1884 = 100)



Sources: Steerage fares from 1866 to 1882 are from Dupont et al. (2017, p. 62), with additional fare quotes for 1863-5, and dollar values are adjusted to pounds using exchange rates from Officer (2022). From 1883 to 1913 the series is the average of quarterly westward steerage fares from Keeling (2008a, Appendix 1), based on Cunard's steerage revenue per adult equivalent. Eastward first cabin fares from 1863 to 1913 are from Dupont et al. (2017, p. 55-56), and are similarly adjusted to pounds. Freight rates from Shah Mohammed and Williamson (2004) as depicted in Figure 1.

It is worth repeating that the shipping of passengers and of freight on ocean voyages share the same underlying technology. The decks and infrastructure of new steamships could be fitted out for either passengers or goods. Although the internal structures of ships gradually became more specialised to one or the other trade, notably due to the elaboration of cabins in passenger ships, the basic hull construction and engine technology was the same for both. But the improving productivity of steamships evidently did not have the same effect on prices in passenger as in merchandise shipping, especially after about 1890.

Freight rates and productivity growth in merchant shipping

Several studies have examined the determinants of trends in freight rates from the cost side. Harley (1988) and Mohammed and Williamson (2004) decompose the decline in freight rates by converting the Cobb Douglas total cost function for steamships to annual rates of growth and assuming that price equals cost. These are for return voyages and so they include both outward and return legs. Their calculations are reproduced in Table 1 where the average annual growth rates of nominal freight rates are decomposed into the growth rates of factor prices weighted by their shares in total cost and the residual which represents total factor productivity (TFP) growth.

Table 1: Annual rates of growth of freights, costs and productivity in ocean shipping

	Harley (1988)	Shah Mohammed and Williamson (2004)			
Route	All UK voyages	Eastern N. America	Alexandria	Riga	Bombay
Years	1852/58 to 1908/23	1871/73 to 1909/11	1871/73 to 1909/11	1871/73 to 1909/11	1871/73 to 1909/11
Nominal freight rates	-1.51	-2.05	-1.66	-2.18	-2.50
Contribution of:					
Ship price	-0.46	-0.57	-0.57	-0.57	-0.57
Coal price	0.11	-0.27	-0.15	-0.21	-0.37
Wages	0.06	0.02	0.02	0.02	0.02
Miscellaneous prices	0.04				
Residual: TFP growth					
TFP growth	1.26	1.23	0.96	1.42	1.59
TFP contribution (%)	83.18	60.16	57.67	65.34	63.47
Ship price contribution (%)	30.20	27.68	34.22	26.10	22.68
Explaining TFP growth					
Ship size		0.36	0.52	1.07	0.61
Load capacity		0.39	0.37	0.37	0.39
Coal consumed		0.01	-0.04	0.38	-0.02
No of seamen		0.15	0.08	-0.10	0.07
Time at sea		-0.13	-0.08	0.16	0.18
Time at port		0.35	0.27	-0.03	0.17
Total		1.13	1.12	1.85	1.40
Explained % of TFP growth		91.48	116.60	129.77	88.24

Sources: Harley (1988), p. 861; Shah Mohammed and Williamson (2004), pp. 192, 198. *Notes*: Shah Mohammed and Williamson provided separate calculations for two sub-periods 1871/3 and 1887/9 and 1887/9 to 1909/11; here these have been combined by taking the average of growth rates weighted by length of period.

Harley's calculation covers a longer period and is for all British shipping, with freights based from 1870 on the Isserlis index. Shah Mohammed and Williamson provide the decomposition for four return routes from the UK over a shorter period. The calculations in Table 1 present a consistent story. They indicate that that much of the overall decline in nominal freight rates is accounted for by total factor productivity growth (as measured by the residual) of about 1 to 1.5 percent per annum. This accounts for around 60 percent of the decline in freights;

Harley's calculation suggests even more if starting from the 1850s.[1] It is worth noting also the importance of declining ship prices, measured as the nominal price per ton of ship, which accounts for around a quarter to a third of the price decline and which, in turn, emphasises the importance of technical progress in shipbuilding.

These calculations are perforce crude and both Harley and Shah Mohammed and Williamson explore a range of developments in shipping technology that underlie the estimated residuals reflecting TFP growth. These are based on physical quantities, not prices. The lower panel of Table 1 shows the latter's decomposition for the four different routes. Clearly, the most important contributions are ship size and load capacity. Relevant to what follows, on the route across the North Atlantic, these account for three quarters of estimated TFP growth. The contribution of ship size (tonnage) reflects economies of scale in the operation of larger ships. Load capacity reflects the increased carrying capacity for a given tonnage largely due to the shift from iron to steel in shipbuilding.[2] Other factors were less important. Consumption per day of coal and the number of seamen changed only slowly. But overall costs of capital, coal and labour also depended on average time at sea and in port, the trend of which varied across routes.

Tonnage and passenger capacity of ships on North Atlantic routes

Increases in average tonnage and load factors were important components of TFP growth that contributed to the decline in ocean freight rates. In order to calculate average carrying capacity of passenger ships I draw on the comprehensive account of ships by Noel Bonsor under the title *North Atlantic Seaway* (Bonsor 1975; 1978; 1979a; 1979b). Bonsor records details of all the shipping lines that carried passengers from Europe to North America by steam. He provides details of the specification of each of the individual steamships that comprised their fleets and the years during which each ship was active in the North Atlantic. Most important for my purposes are the gross tonnage of the ship and, where available, its passenger capacity. I use information on ships of 15 major passenger lines over the years that they were active in the North Atlantic. Table 2 reports average tonnage and passenger

[1] Citing the same sources Crafts (2004, p. 347) puts TFP growth at 1.6 percent in both 1850-70 and 1870-1910.
[2] More efficient engines meant that for a given length of voyage, engines and coal occupied less space, releasing more space for cargo (Harley 1970). In the calculations of Shah Mohammed and Williamson this factor seems to have been absorbed in the effects of ship size and possibly also load capacity.

capacity for decadal benchmarks from 1863 to 1913 for steamships that were active in those years. In order to represent emigrant or 'bulk passenger services', these are ships for which a figure for steerage or third class is reported. Further details are provided in Appendix 2.

Table 2: Average tonnage and capacity of passenger steamships on the North Atlantic

Year	1863	1873	1883	1893	1903	1913
Ships	32	105	129	161	160	165
Gross tonnage	2030.5	2768.5	3458.8	4393.8	7995.4	11388.4
Passenger capacity	572.0	777.5	945.1	1081.9	1433.5	1785.6
Capacity per 100 tons	29.0	28.2	27.5	26.5	20.4	17.3
Cabin passenger capacity (%)	25.1	19.4	17.2	17.4	19.2	21.1
Weighted passenger capacity	967.8	1201.7	1454.5	1679.1	2156.9	2687.5
Weighted capacity per 100 tons	48.4	43.5	41.8	38.6	28.8	24.4

Source: data derived from Bonsor (1975; 1978; 1979a; 1979b). *Note:* a ship is counted as active during the years from its first voyage to its last voyage on the North Atlantic. For further details, see Appendix 2.

Table 2 shows that the average tonnage of passenger ships increased more than five-fold over the six decades while average passenger capacity increased by a factor of three. As a result, passengers per 100 ship-tons fell by almost 40 percent—in sharp contrast to the increase in load factors for freight. However, this takes no account of trends in cabin versus third class capacity. The share of cabin passengers fell in the decade from 1863 to 1873, reflecting the shift away from the original focus of steamships on mail and cabin passengers, as mail was challenged by the telegraph while steam replaced sail in carrying steerage passengers. Thereafter there was a gradual shift towards cabin capacity especially, second class (see Keeling, 1999, p. 50; 2012, p. 229). As shown in Appendix 2 Table A2, this was more marked for the UK/US/Canada (mainly UK) lines than for the continental lines—the latter reflecting the growth in emigrant demand from southern and eastern Europe.

In order to better account for changes in the composition of accommodation, passenger capacity can be weighted by class of travel: first (cabin), second (cabin) and third or steerage. The weights are based on space allocated per passenger by class of passenger: first class is given a weight of five times third class and second class is two times third class.[3] Cabin berths

[3] This is based on Keeling (2008b, p. 241) who estimates that the ratio of relative floor space for first to third class passengers was 1.4 times the ratio of fares, and the assumption of a ratio of relative floor space to relative fares of 1.2 for second to third class. Appendix 2 provides further details.

(first and second) fell from a quarter of ship capacity in 1863 to 17 percent in 1883 before rising to 21 percent in 1913. Over the six decades, passenger capacity weighted by class of accommodation fell by a factor of 2.7 and this implies that weighted capacity per ton fell by almost half.

Table 3: Weighted passenger capacity regressed on ship tonnage 1853-1913

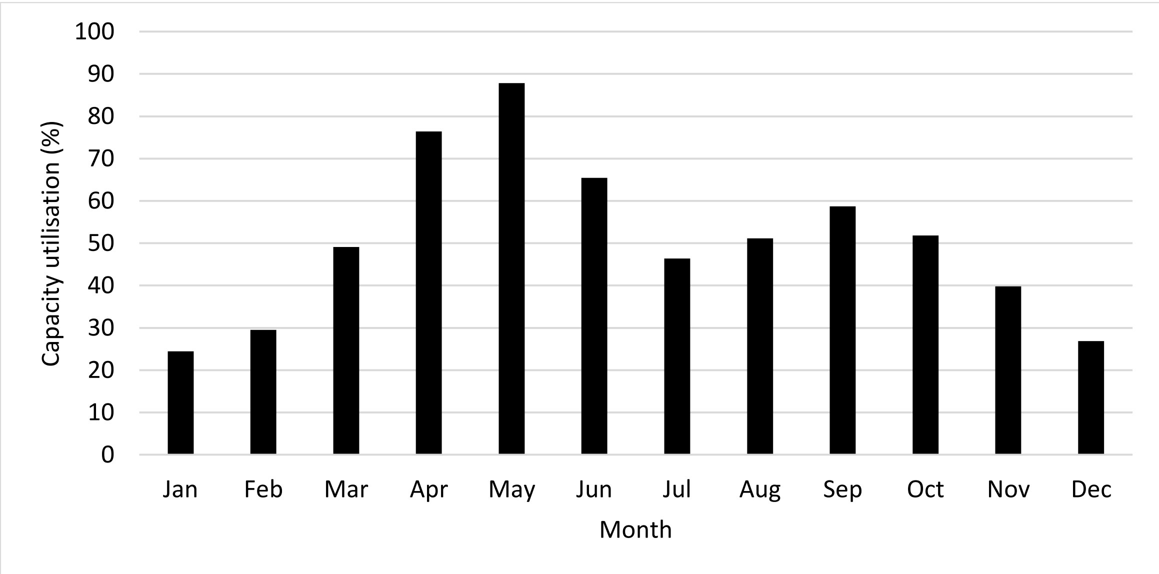
	(1)	(2)
Log gross tons	1.035***	0.997***
	(0.05)	(0.07)
Launch year	-0.017***	
	(0.00)	
Launch 1864-73 (= 1)		-0.049
		(0.05)
Launch 1874-83 (= 1)		-0.172**
		(0.08)
Launch 1884-93 (= 1)		-0.313***
		(0.10)
Launch 1894-1903 (= 1)		-0.596***
		(0.12)
Launch 1904-13 (= 1)		-0.622***
		(0.13)
Observations	609	609
R-squared	0.775	0.772

Note: Fixed effects for 15 shipping lines. The excluded group in column (2) is ships launched before 1864. Wild bootstrapped standard errors in parentheses; significance, *** 1%, **5%, * 10%.

As noted above, some of the productivity growth in freight transport has been attributed to economies of scale in ship size. But for passenger services, passenger capacity per ton declined over time as average ship tonnage increased. This could be because larger ships had less capacity per ton or, alternatively, because later vintage ships had less capacity per ton. In order to assess these possibilities Table 3 presents regressions of the log of weighted passenger capacity on gross tonnage of the ship and its launch year using the database underlying Table 2 and with shipping line fixed effects. In column (1) the coefficient on tonnage is close to one and passenger capacity by year of launch declines at about 1.7 percent per annum. In column (2), where year of launch is replaced by decade dummies, tonnage is again insignificantly different from one and the vintage effects decrease steeply from 1874-83 to 1894-1904. Thus the decline in weighted passenger capacity per 100 tons evident in Table 2 is due to the changing vintage of ships rather than to passenger capacity increasing less than in proportion to tonnage.[4] Alternative specifications presented in Appendix 2, Table A3 show that the vintage effects decline strongly even when using different weights for the three passenger classes.

Passenger capacity is not the same as passengers actually carried. Passenger ships were typically not filled to capacity, not least because shipping lines often ran to regular schedules throughout the year but demand for passages varied widely over the seasons. This is illustrated in Figure 3, which shows monthly capacity utilisation rates for 580 westward voyages by major shipping lines that arrived in New York in 1888. I calculate capacity utilisation by voyage as the ratio of the number of passengers to total (unweighted) passenger capacity. The number of passengers is calculated from the passenger lists for ships arriving in New York—see Appendix 2 for details. Unfortunately, it is not possible to do this by class of berth so this is just for the total number.

Figure 3: Passenger capacity utilisation of ships arriving in New York in 1888



Sources: Passenger number from passenger lists from Ancestry.co.uk; capacity derived from Bonsor (1975; 1978; 1979a; 1979b, as described above.

Figure 3 shows that monthly capacity utilisation ranged from just under a quarter in January to 88 percent in May. The seasonal peak of passengers in the late spring was followed by a lesser peak in the early autumn. Overall capacity utilisation on these voyages is 52 percent and so, on this measure, ships were only half full. This is consistent with Keeling (2008b, p.

[4] It is worth stressing that an equi-proportional relationship between tonnage and passenger capacity is a technical relationship that does not necessarily imply constant returns to scale in total costs.

234) who finds that, taking into account the time that ships spent idle or under repair, shipping capacity utilisation in 1900-13 was just 40 percent.[5] While utilisation rates varied with the ups and downs of migration, rates of around a half represent a long run equilibrium rather than chronic overcapacity due to persistently deficient demand or oversupply.

The Rise in Quality of Service

While the US Passenger Acts of 1855 and 1860 and the UK Acts of 1855 and 1863 were aimed at improving conditions for steerage passengers on sailing ships, such standards were quickly exceeded with the advent of steam "leaving no improvement to be desired" according to one contemporary account (US Senate 1874, p. 24). Further regulations introduced in the 1880s and after the turn of the century focused chiefly on improving passenger space and ventilation and partitioning single males, single females and families.[6] The US Immigration Commission of 1911 noted that "the great improvements during the past twenty-five years in steerage conditions on the ships of some lines has been due, perhaps, more to competition and the will of such steamship companies than to the requirements of any steerage law" (Vol. 37, p. 379).

While in the late nineteenth century shipping lines competed initially on speed (for the Blue Riband), luxury became more important, as epitomised by the White Star line (Butler 1998, p. 7; Coleman 1977, p. 45). By the twentieth century the accommodation and service on liners had been transformed from the quality of the boarding house to that of the five-star hotel, especially for first class passengers (Fletcher 1913; Maxtone-Graham 1972).[7] But even for second and third class passengers the quality of service improved in a variety of dimensions. Bastin (1971, p. 57) found that in the early 1880s fast ships did not attract more passengers than slower ships and he concluded that "For the average passenger general shipboard conditions were more important than half a day clipped off the crossing." Indeed, from the early 1890s to 1913 there was essentially no reduction in average westward voyage durations,

---

[5] The 60 percent under-utilisation percentage includes time ships spent idle or under repair. As this is about 20 percent of total time, the utilisation rate while active would be about half. Keeling also notes that on around 2 percent of voyages the utilisation rates exceeded 100 percent, something that was managed by shifting passengers between classes or by temporary expedients, such as additional temporary beds or cots.

[6] Complaints about steerage conditions were found to be largely unfounded by a UK enquiry of 1881; the main valid concern was the means of maintaining the separation between single males, single females and families with young children and controlling unruly behaviour, particularly by crew members (GB Board of Trade 1881).

[7] Indeed, the interiors of some HAPAG ships were designed by designers of luxury hotels and for cabin class passengers the ships employed hotel-trained restaurant staff (Maxtone-Graham 1972, pp. 87-97).

which averaged around eight days (Hatton 2024). By this time passenger shipping lines were competing more on quality of service and less on speed or on price, a point to which I return below. [8]

Important for improved comfort was the introduction of closed berths for steerage/third class passengers. To quote Keeling (1999, p. 49): "there was a marked trend, beginning in the 1890s and accelerating after about 1905, in the provision of private 'closed' berths in steerage. By 1914, 1/3 to 1/2 of the steerage accommodations on ships from Northern European ports were of this so-called 'new steerage' variety, rather than the older, more crowded, noisy, odorous, and immodest open bunkrooms characteristic of 'old steerage'." But more space per passenger was just one dimension of improvement in the quality of the passenger experience. Associated with this development were substantial improvements in amenities such as better furnishings, plumbing, electric light and elevators, well-appointed dining rooms, smoking rooms and lounges, promenade decks and leisure facilities for games and entertainment, as well as statements of opulence such as grand halls and staircases.

Improved service is reflected in the composition of ships' crews, which are divided into three main sections, the deck crew, the engine room crew and the passenger service crew, often called the steward's crew or the victualling crew. This includes stewards, stewardesses, cooks, waiters, general servants, butchers, bakers, barbers, cabin boys etc. Unfortunately, the UK statistics on crews do not separate passenger liners from all other foreign-going ships.[9] Instead I have used the surviving records of crew agreements for passenger ships originating in Liverpool and sailing to US ports to count crew members in each section. For consistency, the shipping lines included are restricted to Cunard, Inman/American and White Star. As described in Appendix 3 these records are for varying numbers of voyages in any one year and the sample is restricted to ships for which there are crew lists for at least four voyages.

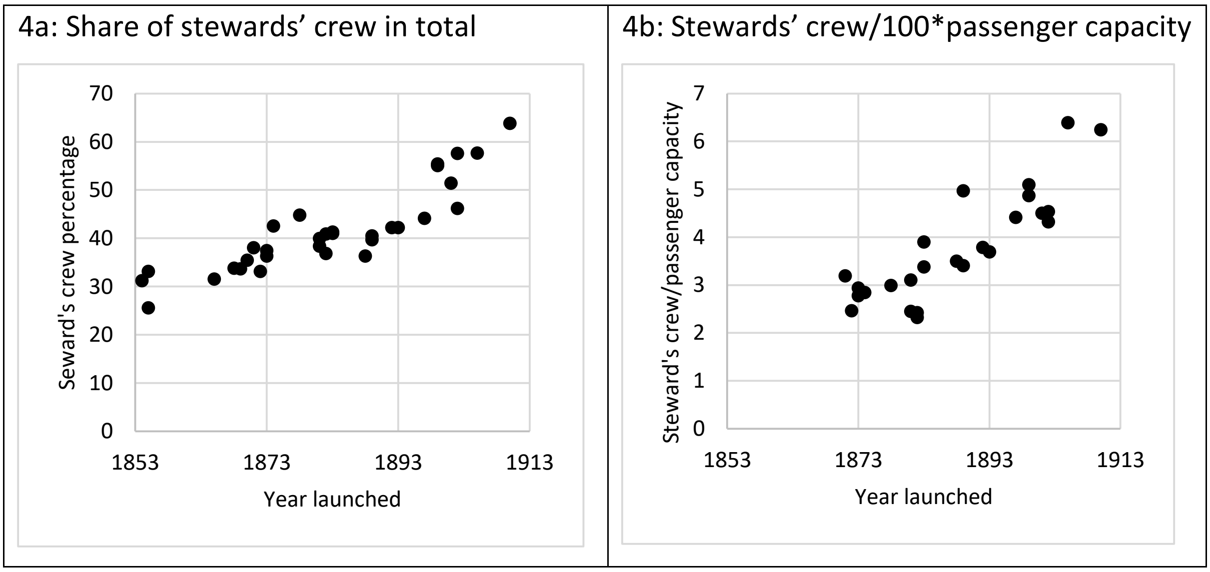
For any given ship the numbers in deck and engine room crews were fairly stable across the year but the number in stewards' crews typically reflected seasonal variations in passenger numbers, as illustrated in Figure 3. So, for each ship, the ratio of steward's crew to total crew

[8] Cecil (1967, p. 22) noted that NDL first introduced luxury ships in 1881; other shipping lines were at first reluctant to follow but HAPAG did so in 1889. The Cunard ships that entered service in 1900 were slower but consumed less coal and provided more space for passengers (Hyde 1975, p. 72).

[9] These statistics are presented in Appendix 3.

is adjusted for departure month, standardising on the month of June (see Appendix 3). Improvements in the quality of service went along with more space and improved infrastructure and so in Figure 4a the average share of stewards' crews (in June) is plotted against the year the ship was launched. Although the sample is small, the share of stewards' crews in total increases strongly with the vintage of ship, especially after the mid-1890s. While there are few observations for the later years, this trend is reflected in the composition of the crew of one of the most famous ships, White Star's *Titanic*. On its ill-fated maiden voyage of April 1912, the *Titanic* carried a crew of 885 of whom 494 (55.3%) were in victualling.[10]

Figure 4: Stewards' crews on passenger liners from Liverpool to New York by launch year



Sources: see text and Appendix 3. *Notes*: There are 32 ships in Figure 4a but only 25 in 4b as passenger capacity is missing for some of the earlier cases.

As steamers decreased their reliance on sail, either as auxiliary power or as insurance against mechanical breakdown or shortage of coal, the shares of deck crew declined while engine room crew increased. In part, the rise in the share of stewards' crew may simply reflect the decline in the share of deck crews. An alternative measure is the size of the steward's crew relative to the number of passengers, which also provides a more direct indicator of the trend in passenger service. However, this must take into account the passenger composition as a larger number of stewards would be required to service first and second class passengers than third class passengers. So Figure 4b shows the ratio of steward's crew to the total

[10] Another famous ill-fated ship, Cunard's *Lusitania* (launched in 1906), sank in 1915 with a crew of 702 of which 311 (44.3%) were classified as victualling. But it was torpedoed on a return voyage from the United States during wartime, so it may not have carried as large a steward's crew as in peacetime.

passenger capacity in third class equivalents, weighted as in Table 2. As stewards' crews varied across the seasons this ratio is also adjusted to the month of June. Figure 4b illustrates a clear upward trend in steward's crew per 100 third class equivalent passenger capacity by year of launch of the ship. This represents a substantial increase in comfort and convenience for the average passenger, which seems to have accelerated after the 1880s.

Joint Production

There are important elements of joint production in shipping, a point stressed by Harley (1988, 1990, 2008). One element of jointness is that for every outward voyage there is a return voyage and profitability would depend on both legs. If there was growing excess capacity eastward, then this would drive down eastward fares and freights, which would restrict the decline in westward fares. It might be supposed that strong growth in emigration from Europe from the 1880s would have generated more eastbound capacity as the number of voyages and the size of ships increased. It has been noted, however, that the share of eastbound passengers increased as rising incomes, particularly in North America, generated more return voyages and as business travel increased (Dupont et al. 2012; Dupont et al. 2017). Over the years 1900-14 average annual eastbound passenger flows between Europe and the United States were 42 percent of westbound, double the rate in 1870-82 (Keeling 2010, p. 169).[11] Even though there remained a considerable imbalance in the numbers travelling, the eastbound and westbound ticket prices were approximately equal.

A second element of jointness is that passenger ships also carried goods, which was an important additional source of revenue. Keeling (1999, p. 49) records that freight accounted for 23 percent revenues on Cunard's US routes in 1890-99 and 15 percent in 1900-14. By the turn of the century the internal space of passenger ships had become more specialised (as noted above) and hence less easily convertible to carrying bulk goods. Nevertheless, growth in total passenger liner capacity, which kept pace with the surge in emigration, also generated more available space for cargo. It seems likely that the latter effect dominated, especially eastbound.

[11] These are gross flows that include short-term back and forth transits rather than measuring the return rates of migrants who had initially intended to stay.

Harley (2008) points out that the weight to space ratio for passengers is relatively low and so heavy cargo or ballast was required in order to compensate for excess buoyancy (another element of jointness). On eastward voyages, this could be achieved with heavier cargoes such as grain and timber. From the early 1880s passenger liners increasingly carried meat carcases, particularly beef, which was shipped in refrigerated holds. But this still left excess capacity for heavy cargo, especially as there was competition from shippers of live animals, for which the weight to space ratio is also relatively low (Harley 2008). As a result of the growth in competition the eastward berth rates for grain tended to fall more steeply than general freight rates although this was partly offset by a growing diversity of cargoes for which freights fell by less. On westward voyages iron goods and coal were important in the earlier years (Inwood and Keay 2015), and this was followed in later years by an increasingly wide variety of manufactured goods.

Fares and TFP calculations for passenger shipping on the North Atlantic

What are the likely implications for TFP calculations for passenger shipping and thus for the difference in trends between freight rates and passenger fares? For passenger shipping from the UK to the US and return Table 4 presents a calculation in the spirit of the estimates of productivity in ocean freights reported in Table 1. The table compares annual growth rates of nominal prices and costs from 1863-67 to 1909-13 divided into to two equal sub-periods to capture the U shape in fares evident in Figure 2. In principle these calculations represent average costs and revenues for round trips over a fixed period, say a year. The average growth in output price is represented by a weighted average of growth rates for steerage fares, cabin fares and freight rates. The fares are the westward steerage and eastward cabin fares presented in Figure 2 above. This is based on the assumption that the growth rates of westward and eastward fares were roughly equal, so that they represent complete voyages. Freight rates for cargo relevant to passenger liners, taken from Harley (2008), are based on Cunard's average rate for freight carried back in time using berth rates for grain (details in Appendix 1). The user cost of ships is represented by their construction cost, wage rates by a new index for UK seafarers, coal by the South Wales price, and miscellaneous costs, such as food, chandlery and other non-voyage costs by the wholesale price index. Details of these series and the weights applied are provided in Appendix 4.

The first column of Table 4 shows that over the whole period from 1863-67 to 1909-13 the weighted average of fares and freight rates fell slightly—by 0.17 percent per annum. This decline is largely driven by the freight component. Between 1863-67 and 1909-1913 the contributions of factor prices, weighted by cost shares were also modest, except for ship prices which fell strongly. Over the whole period the residual is negative at -0.16 percent per year. Thus technical progress, as conventionally measured, was negative. However, this takes no account of the increased costs incurred by the radical improvements in the quality of service noted above. Two adjustments are included at the bottom of the table. One is the increase in costs due to declining passenger capacity per ton of ship (as in Table 2) weighted by the share of ship capital in total cost. The other is the cost of improved passenger service measured by the growth in steward's crew per passenger, based on the data in Figure 4b and weighted by the share of crew and miscellaneous in total cost. Accounting for these costs of increased quality yields a more respectable TFP growth rate of 1.04 percent per year.

Table 4: Fares, costs and TFP in passenger shipping (growth rates % p. a.)

	1863-67 to 1909-13	1863-67 to 1886-90	1886-90 to 1909-13
1. 1st class fares (weight = 0.2)	0.14	-0.18	0.46
2. 2nd and 3rd class fares (weight = 0.55)	0.06	-1.19	1.31
3. Freight rates (weight = 0.25)	-0.37	-0.23	-0.51
4. Overall price index	-0.17	-1.60	1.26
Contribution of :			
5. Ship prices per gross ton (weight = 0.4)	-0.44	-0.62	-0.26
6. Crew wages (weight = 0.2)	0.06	0.03	0.10
7. Coal (weight = 0.2)	0.13	-0.03	0.29
8. Miscellaneous (weight = 0.2)	-0.08	-0.29	0.13
9. Residual: TFP growth: (5)+(6)+(7)+(8)-(4)	-0.16	0.69	-1.01
Quality adjustments:			
10. Passenger capacity per ton (weight = 0.4)	-0.54	-0.26	-0.81
11. Passenger service (weight = 0.4)	-0.66	-0.44	-0.88
12. Quality adjusted TFP growth (9)-(10)-(11)	1.04	1.40	0.68

Notes: Passenger fares from Figure 2 above; eastward freight rates constructed from Harley (2008) p. 1055-6 and converted from dollars to pounds, see Appendix 1 for details. Ship prices (construction costs) from Maywald (1956) p. 50; crew wages, new index constructed as a weighted average of four occupation groups; coal price (South Wales, export value) from Mitchell (1984) p. 274-5; miscellaneous (Sauerbeck wholesale price index) from Mitchell (1988) p. 725 (full details in Appendix 4) . The weights for price and cost series are also discussed in Appendix 4. Passengers per ton is from the calculations underlying Table 2 above weighted by ships share (0.4). Passenger service is crew/passenger capacity from data underlying Figure 4b above (see Appendix 3 Table A7 for details) weighted by the share of crew and miscellaneous (0.4).

As noted above, a key feature is the difference between the two sub-periods. In 1863-67 to 1886-90 the price index fell by 1.60 percent per annum, in line with the trend in freight rates in Table 1. Unadjusted TFP growth is 0.69 percent per annum, and when adjusted for the increasing cost of declining capacity per ship ton and increasing service quality, this increases to 1.40 percent, a figure which matches the estimates of TFP growth in freight in Table 1. Over the years from 1886-90 to 1909-1913, when the price index increased by 1.26 percent per annum, estimated unadjusted TFP growth is negative overall at -1.01 percent per annum. When adjusted for the faster growth of quality, the remainder becomes positive at 0.68 percent per annum. Clearly, accounting for accelerating quality improvement makes a dramatic difference to estimated TFP growth from 1886-90 to 1909-13 but it is still only half of that in 1863-67 to 1886-90. Alternative calculations in Appendix 4 Table A10 show that the results overall are robust to plausible variations in the weights used.

It is possible that technical progress slowed after 1890, but Shah Mohammed and Williamson (2004, p. 192) find little evidence that TFP growth in freight shipping slowed after the late 1880s. One contribution to technical progress on passenger shipping is declining voyage times, which increased the productivity of ships by allowing more voyages per year. The duration of voyages of passenger steamers from Liverpool to New York fell from 15.2 days in 1863-67 to 8.0 days in 1909-13 and it fell somewhat faster in the earlier years (Hatton 2024). This could account for perhaps 20 percent of the difference in adjusted TFP growth over the two periods.[12] Although steam engines became more efficient in their use of coal, this was largely offset by faster speeds which increased coal consumption. It also required larger engine room crews, which as noted, grew in size relative to deck crew. The evidence suggests that the operating crew (deck plus engine room) per ton of ship fell at about 2.7 percent per annum overall. But some of this could be accounted by the substitution of capital for labour rather than by technical progress, as the cost of capital fell relative to the cost of labour.

[12] Assuming that (1) voyage durations westward and eastward fell by the same proportions, (2) that time in port was one week after each voyage and (3) that ships were laid up for two months each year, the potential number of voyages per year increased from 6.9 in 1863-7 to 8.7 in 1886-90 and 10.1 in 1909-13. Converting these to growth rates and weighting by the share of ship capital gives a contribution to TFP growth 0.41 percent per annum in 1863-67 to 1886-90, 0.26 percent in 1886-90 to 1909-13 and 0.34 percent overall. The difference between the two sub-periods is 0.26 - 0.41 = - 0.15 which could account for 20.8 percent of the 0.68 – 1.40 = - 0.72 percentage point difference in TFP growth.

TFP calculations are based on the assumption that prices depend on factor costs and productivity, as under perfect competition, or at least that markups over cost are not changing. But a prominent feature of the literature is the rise of shipping cartels, known as conferences, particularly in the second half of the period under study. From 1886-90 the price index increased faster than basic costs. As will be suggested below, in the absence of cartelisation, fares might have risen by less and the estimate of technical progress would therefore become more positive. Faster increase in price relative to cost as a result of cartelisation may have resulted in higher profits. But accelerated increase in the provision of quality from 1886-90 ensured that quality adjusted TFP growth was positive, although it was modest. Indeed, it has been suggested that one effect of the shipping conferences was that much of the increased revenue was absorbed by the costs of allocating ever more space per passenger and of providing better quality of service. In the following sections I explore the possible effects of shipping conferences on quality and on price.

Collusion and Shipping Conferences

With the transition from sail to steam passenger voyages became shorter and less variable and so steamship lines increasingly ran to regular schedules throughout the year. Initially the competition was with sail but by 1870 the main competition was between steamship lines. They faced competition from tramp steamers only insofar as they carried freight. High fixed costs and increasing market concentration meant that periodic excess supply could lead to cutthroat competition and this provided the incentive for cooperation aimed at fixing minimum fares.[13] Deltas et al (1999) found that effective conferences were more likely to emerge where organisational and enforcement costs were lower, specifically on routes that were dominated by few large firms and where they overlapped across different routes. Boyce (1995; pp. 160-7) emphasised importance of shared risks and the building of trust through establishing reputations for cooperation.

Shifting alliances among major passenger lines coalesced around three main routes based on origin ports: UK-Scandinavian, Continental and Mediterranean. In the late 1860s agreement was reached between British lines under the North Atlantic Steam Conference but they soon

[13] Conferences were also established among freight shipping lines from the 1870s, although not on the North Atlantic.

faced competition from rapidly expanding German lines carrying passengers from Central and Southern Europe through Northern European ports (Hyde 1975, Ch. 4; Feys 2008). Competition within and between conferences and with outside lines, intensified by emigration agents and brokers, limited the control over fares and the duration of agreements. Fares slumped in the early 1880s as supply outran demand for passages.

A more durable conference was agreed in 1885 by the four leading continental lines, which subsequently reached agreement with the British lines. A Mediterranean conference was also organised reflecting the growing importance of migration from southern and eastern Europe (Feys 2013, p. 129). Even so it was difficult to control fares until a stronger agreement, the Nortlandische Dampfer Linien Verband (NDLV) was established in 1892 with a pool that allocated market shares of steerage passengers.[14] But the mid-1990s slump in demand exacerbated existing tensions and precipitated a fare war between British and German lines culminating in a new agreement in 1895 (Feys 2013, pp. 144-6).[15] Another fare war that broke out in 1904 was initiated by the German lines' response to Cunard's withdrawal from the agreement in 1903 and its foray into the Mediterranean route (Keeling 2012, Ch.4).[16] Cooperation was partially restored in 1905 and substantially strengthened with the establishment of the Atlantic Conference which pooled the British/Scandinavian and Continental steerage markets (including eastbound) in early 1908 (Hyde 1975, pp. 114-5; Keeling 2012, pp. 210-14). The 1908 agreement (renewed in 1911) included a combined UK-NDLV pool; by this time there were 12 linked agreements covering 30 shipping lines including the Mediterranean routes.

The conferences included restrictions on the ports to and from which each line could sail, and sometimes also the number of sailings. High capital costs and exclusive access to docking facilities at origin ports formed major barriers to entry. Non-member shipping lines, expanding outwards from their home ports and countries, were sometimes contested and

---

[14] The four continental lines and their principal passenger terminals were North German Lloyd (NDL, Bremen), Hamburg America (HAPAG, Hamburg), Holland America (Rotterdam) and Red Star (Antwerp); the leading British rivals were Cunard and White Star (both Liverpool until the latter moved to Southampton in 1907).

[15] The fall in passenger demand manifested by the economic slump in the US was exacerbated by a cholera outbreak in Hamburg in 1892, which prompted US government quarantine restrictions and sanctions against lines carrying diseased passengers.

[16] Another background factor was the 1902 creation by J. P. Morgan of a combine of six major passenger lines, which included White Star, and which formed an alliance with the two major German lines (Hyde 1975, p. 110; Vale 1984; Keeling 2012, pp. 70-105).

sometimes encouraged to join the conferences or merged with existing members.[17] The conferences reached agreements for a fixed period of several years, increasingly with cross-conference agreements. For first and second class travel, they fixed minimum fares that varied between lines, often according to the route and the speed, quality and aged of individual ships. For third class, minimum fares were difficult to enforce but independent tallies at destination ports were more easily monitored than ticket prices. Market share quotas (or pools) that reflected shares of passengers over a preceding period, were agreed as a key means of supporting the agreed minimum fares. Lines that exceeded their shares were required to pay compensation (about 60 percent of the minimum) to those that undershot their quota and to make adjustments, typically by raising their fares above the minimum. These provisions were accompanied by comprehensive monitoring and enforcement mechanisms (Stevens 1914).

Governments sometimes regulated access to origin ports, provided subventions for the carriage of mail and preferential loans for the building of ships that could be used as auxiliary cruisers in the event of war. But subsidies that were both ubiquitous and small in relation to revenues, had very little effect on the competitiveness between different lines (Aldcroft 1968, pp. 331-42).[18] Shipping conferences were not illegal but were not enforceable by law and rising anti-trust concerns at the turn of the century led to government enquiries about the pros and cons of conference operation, although focusing mainly on freight.[19] Representatives of the passenger shipping lines argued that maintaining stable prices reduced uncertainty and encouraged the lines to keep down costs and to invest in more regular and better quality services. They argued that the arrangements were not anti-competitive because there was still keen within-conference competition for passengers. And

[17] Scott Morton (1997) found that, in freight conferences involving British merchant shipping lines around the turn of the 20th century, predatory pricing was used mainly against smaller entrants with limited experience and financial resources.
[18] United States regulations on the screening of passengers increased over time but, of course, this applied to immigrants on all carriers as did the immigrant head tax.
[19] Specifically, the UK Royal Commission on Shipping Rings (1909) and the US Congress House Committee on Merchant Marine and Fisheries, Investigation of Shipping Combinations under House Resolution 587 (1913-14). See Also Huebner (1914), Marx (1953) pp. 45-67 and Hyde (1975) pp. 104-5. However, regulation was eventually introduced by the United States under the Merchant Marine Act of 1916, which assessed pooling agreements in light of the Sherman Act.

unlike the freight lines, which used systems of deferred rebates, they claimed to have limited control over emigration agents.[20]

Shipping Conferences and Service Quality

Some contemporaries stressed the effect of conferences on quality of service. Thus Johnson and Huebner (1920, p. 301) noted that "[n]owhere in the world has such progress in ship construction and service improvement been made as in the North Atlantic passenger business, and yet the great lines that compete so keenly as regards the kind of service rendered are parties to rate agreements and pooling arrangements. Conference control over rate competition so enhances the security of capital invested in these ocean lines as to render it easier for them constantly to improve their facilities and yield to the demands of the travelling public." A vice-director of the of the Hamburg America line (HAPAG) put it thus: "No line can obtain a premium without offering improved facilities, and it has been competition not monopoly that has resulted in the fast and palatial type of steamer now operated between the United States and Europe" (Sickel 1914, p. 154). Another contemporary noted that "the firm owning the most luxurious vessels can depend on securing the most passengers" (Fletcher 1913, p. 83-4).

Historians have recognised that the conferences enhanced the quality of service, even though other demand factors were present, and have suggested that this was associated with increased fares. Vale (1984, p. 75) suggested that that "Possibly pooling shifted the competitive emphasis away from fares and towards services." With reference to the Continental agreement of 1895 Feys (2013, p. 161) comments that "the increased cost for the passenger was partly compensated by improved service." And Keeling (2008b, p. 229; 2012, pp. 9, 14, 58) notes that, rather than cutting fares, companies such as Cunard and White Star reinvested savings from technical development and passed the benefits on to customers in the form of more space and better amenities.[21] Conference-induced higher ticket prices could have led to sustained super-normal profits but if these were largely absorbed by higher costs of enhanced quality then the effects on profitability could have been modest.

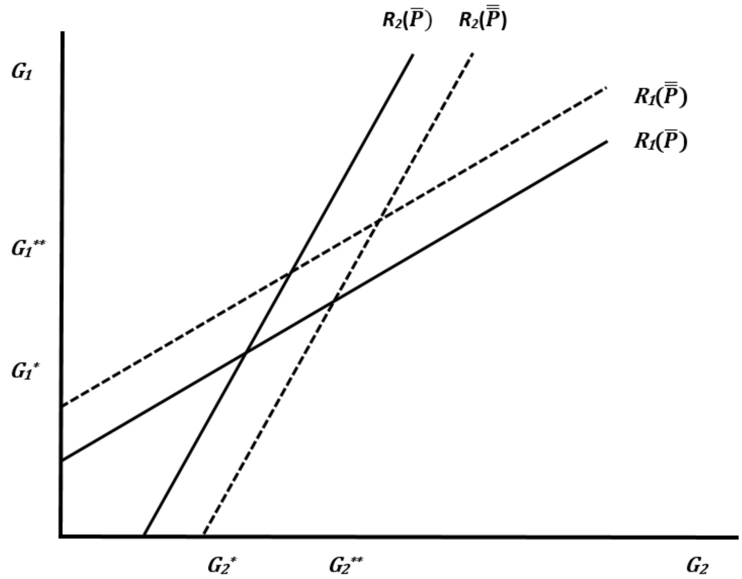
---

[20] Deferred rebates are where a proportion of the freight charged to shippers is retuned after six months provided that they exclusively use the ships of a line or conference.

[21] Earlier and weaker agreements may also have encouraged competition over quality of service (Hyde, 1975, pp. 90-6), although to a lesser extent.

The insights of historians may be illustrated with a textbook-style linear model of quality of service in a duopoly. Appendix 5 sets out a model where two identical firms face a binding minimum price. Each firm's demand depends positively on its own quality, negatively on the other firm's quality and negatively on the fixed price. Long-run cost has two components, the cost of the most basic service and the cost of quality enhancements. Solving the reaction functions of the two profit-maximising firms facing the price $\bar{P}$ gives the Nash equilibrium in quality provision depicted in Figure 5. Firm 1's reaction function is $R_1(\bar{P})$ and that of firm 2 is $R_2(\bar{P})$, giving equilibrium quality G_1^* and G_2^* respectively.

Figure 5: Equilibrium in quality of service



An increase in the minimum price to $\bar{\bar{P}}$ shifts firm 1's reaction function to the left and firm 2's to the right leading to new and higher equilibrium qualities G_1^{**} and G_2^{**} respectively. Thus a higher price unambiguously leads to higher equilibrium quality. An increase in basic cost would have the reverse effect, leading to lower equilibrium quality. The outcome for firm profits is more complicated but as shown in Appendix 5, the effect of an increase in the cartel price on equilibrium profit could be positive or negative; and the effect of an increase in basic cost is also ambiguous.[22] This model is highly stylised and abstracts from many details. But it accords with the historical literature on shipping conferences, which suggests that their effect

[22] It is worth stressing that any deviation by a firm from its equilibrium quality would reduce its profits.

was to increase price and quality but not necessarily to deliver super-normal profits. This is not to suggest, however, that all of the long term increase in quality is accounted for by the price effects of the conferences, only that they accelerated an underlying trend.

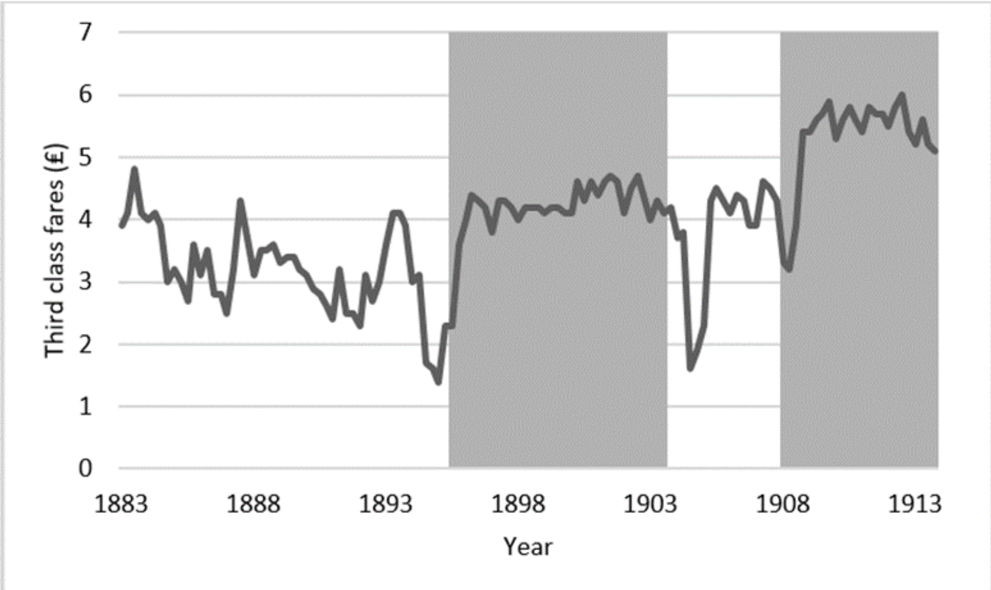
Evidence on conferences and ticket prices

If shipping conferences led to intensified competition on quality, and investment in quality, then they must have raised fares. Econometric evidence of the effect of the North Atlantic shipping conferences is provided in studies by Deltas et al. (2008) and Deltas and Sicotte (2017). Deltas et al. (2008) estimate the relationship between an index of conference strength and the number of emigrants travelling along ten different routes between Europe and North America from 1899 to 1911. They distinguish times when a conference was strong, as essentially when a pooling arrangement was in effect, weak when a conference existed without a pooling arrangement, and absent when no agreement existed. Using quarterly data, they find that a strong conference has a significant negative effect on the on the volume of westward migration flows (as compared with no agreement), but a weak conference has an insignificant effect. While they do not estimate the effect on ticket price directly, they suggest that a strong conference raised ticket prices by almost one third, suggesting a demand elasticity for passages of around -0.7.[23]

In a further study Deltas and Sicotte (2017) estimate the effects of strong conferences on data for different fare types, finding an effect on steerage prices of 20-30 percent. Using a calibrated analytical model, the effects are even greater; they predict increases of 93 percent eastbound and 60 percent westbound. While the latter may seem unduly large, Feys (2013, p. 318), commenting on the 1890s, notes that "[t]he impact of the conference on the HAL's gross prices shows that these doubled after the pool agreement [of 1895] and tended to stabilize thereafter," although this partly reflects the rebound from the ruinous fare war. And Keeling (2011, p. 371) finds that the 1904 fare war reduced steerage fares by around 50 percent. As a result, the number of migrants increased by 25 percent and 'circular' repeat crossings by even more.

[23] If, as suggested here, passengers valued the quality of service, and if in the long run conference-induced price increase went along with higher quality then the estimated elasticity of demand would capture both the negative effect of the price increase and the positive effect of the increase in quality. So the (long-run) demand elasticity, holding quality constant, would be even larger.

Figure 6: Westward steerage fares and cartel strength, quarterly 1883 to 1913.



Sources: See text and Appendix 6.

The link between conference strength and fares is illustrated in Figure 6. This shows Cunard's westward steerage fares quarterly from 1883 to 1913 (from Keeling 2008a). The shaded areas represent periods when the UK/Scandinavia conference was in full operation, taken from Deltas and Sicotte (2017) and extended back to 1883. The graph clearly shows that fares increased in the wake of conference agreement and decreased when it broke down or was suspended. Table 5 presents regressions where the dependent variable is the log of the westward steerage fare. It is likely that fares were also influenced by other factors and so the controls include the quarterly number of immigrants admitted to the United States as an indicator of demand for passages. Alternatively, an indirect measure of passenger demand is a quarterly index of US real GDP, which since Jerome (1926), has been recognised as a major driver of fluctuations in immigration. The quarterly index of UK wholesale prices is also included to adjust for general price movements. Data sources are detailed in Appendix 6.

In Table 5 the conference effectiveness dummy is lagged one quarter, as is the log of US immigration or the log of GDP and the log price index. The lagged dependent variable is included to allow for partial adjustment; also included (but not reported) is a linear time trend and three seasonal dummies. In column (1) the conference dummy gives a significant positive coefficient and US immigration is significant at 10 percent while the price index is positive but not significant. If immigration was responsive to fares, as has been suggested, then immigration would be endogenous, even though it is lagged one quarter. In column (2) immigration is replaced by the log of US real GDP, which as expected, takes a positive coefficient. But the coefficient on the cartel dummy is little affected.

Table 5: Regression analysis of westward steerage fares, quarterly from 1884 to 1913

	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
Conference effective (=1), t-1	0.189***	0.168***	0.165**	0.151***
	(0.05)	(0.04)	(0.07)	(0.06)
Log steerage fare, t-1	0.621***	0.615***	0.641***	0.632***
	(0.07)	(0.07)	(0.08)	(0.08)
Log US immigration, t-1	0.078*		0.067	
	(0.05)		(0.05)	
Log US real GDP, t- 1		0.781**		0.761**
		(0.32)		(0.32)
Log UK wholesale price index, t-1	0.239	0.222	0.216	0.185
	(0.25)	(0.23)	(0.25)	(0.24)
Under-identification, χ^2 (1)			24.7	24.7
Weak identification, F (119,1)			64.4	73.4
R-squared	0.795	0.802	0.795	0.802
Observations	120	120	120	120

Sources: Cunard fares from Keeling (2008a, pp. 24-28); the dummy for conference effectiveness based on Deltas an Sicotte (2017, p. 677), extended back to 1883. Further details, and sources for US immigration, US GDP and the Sauerbeck/Statist wholesale price index are provided in Appendix 5. *Notes*: All regressions include three seasonal dummies and a linear time trend. The standard errors in parentheses are adjusted for serial correlation of up to four quarters; significance levels, *** 1%, **5%, * 10%. The under-identification (Kleinbergen Paap) statistic is a test for the irrelevance of the excluded instrument (null: under-identification; critical 5% value 7.9). The weak identification (Cragg-Donald) test reflects the correlation of the excluded instrument with the endogenous regressor (null: weak identification; critical 10% value 16.38). The first-stage IV regressions are reported in Appendix 6, Table A10.

It is worth stressing that times when conferences were not operating at full strength include varying degrees of cooperation, including fare wars, and this will be reflected in the estimated coefficients. If sagging fares undermined conference stability, then conference strength could be endogenous. In columns (3) and (4) the conference dummy (t-1) is instrumented with its own value lagged two further periods on the assumption that the three-period lag affects fares only though its correlation with the one period lag. This produces similar results overall. An alternative is to use as an instrument a variable representing the average effectiveness of three other North American conferences. This is only possible for the shorter period from 1899 to 1913. As shown in Appendix 6 Table A11, this produces slightly weaker but still significant coefficients despite the fact that over that period there are only two switches in the conference dummy (as Figure 6 shows).

In column (4) the short run conference coefficient is 0.15 and the long run effect (taking into account the lagged dependent variable) is 0.41, which implies a 50.7 percent increase in fares.[24] If the conference effect on fares is taken as zero in 1886-90, between then and 1909-13 it would account for an increase of 1.78 percent per annum in second and third class fares. Thus, in its absence, the growth rate of the overall price index in Table 4 would be reduced from 1.26 percent to 0.28 and the estimate of unadjusted TFP growth would increase from -1.01 to -0.03 percent per annum. However, if conferences induced greater expenditure on upgrading quality of service then, absent the conference effect, costs would also have grown more slowly but we have no estimate of exactly how much more slowly. If the conference effect accounted for half of the acceleration in quality between 1863-7 to 1886-90 and 1886-90 and 1909-13 then its removal would result in an estimate of quality-adjusted TFP growth in the latter period of 1.17 percent per annum (as compared with 0.68 percent in Table 4). But this can only be speculative.

The evidence from regressions on a single time series is tentative but it is consistent with a range of other evidence on fares. And economic theory suggests that this could have provided the both incentive and the resources for passenger lines to upgrade the quality of service that they provided in order to stay competitive. In the short and medium term conference cohesion should also have been reflected in higher returns on capital. Thus Feys (2013, p. 161) notes that "[i]n the five years following the agreement, HAPAG averaged a dividend of 7.6 percent, while the NGL earned an average of 6.8 percent." Hyde (1975, p. 153-4) provides an annual series of the return on capital for Cunard. For the years of conference effectiveness in Figure 6 above, the annual returns averaged 4.86 percent as compared with 3.05 percent for the other years.[25] While conference effectiveness is associated with higher profitability these

[24] The long run effect is calculated as: 0.151/(1 - 0.632) = 0.410; converted to a percentage change this amounts to: 100*(EXP(0.410)-1) = 50.7%. It is worth noting that three-quarters of the long run effect takes place within the first year.

[25] For comparison, over the same periods, the return on accumulated capital on British railways was 4.70 percent (conference effective) and 4.88 percent (other years) (Mitchell et al. 2011, p. 806). The dividend yield on UK equities (weighted by paid up capital) was 2.74 and 2.56 percent respectively and the average total return was 3.00 and 4.08 percent respectively (Grossman 2002, pp. 136, 138).

are not spectacular returns, consistent with the idea that much of the increased revenue was absorbed by the costs of improvement in the quality of service.

Conclusion

The story of the first wave of globalisation in the late nineteenth century is largely one of radical technical change reducing the costs of travel and communication. This includes applications of the steam engine to travel by land and by sea and of the electric telegraph to the transmission of information. These developments stimulated the globalisation of trade and finance and one might have expected the same to apply to migration and ocean travel more widely. Such a supposition would be based on the fact that the transportation of goods and of passengers shared the same underlying developments in steamship technology. Yet, over the long run from the 1860s to the 1910s, fares did not fall as might have been expected from technical change. While this fact has long been recognised by historians, the contrast with the steep decline in ocean freight rates has yet to be fully investigated. This paper represents one step in that direction.

The standard decomposition of the decline in freight rates into the contribution of factor prices and the residual emphasises the primary contribution of rapid growth in total factor productivity. Yet when the same methodology is applied to passenger shipping it indicates that TFP growth, as conventionally measured is negative over the whole period. This in turn suggests that something is missing from the calculation. In this paper I emphasise the dramatic improvement in the quality of the passenger experience which is represented not only by more space per passenger but by a host of other improvements that that transformed the shipboard environment from that of the boarding house to the that of the five-star hotel. Thus while, for commodity trade, technical progress resulted in a decline freight rates, for passenger shipping, it was manifested in vastly improved quality of service rather than a decline in fares.

One feature emphasised here is that, while passenger fares did decline in concert with freight rates up to the late 1880s, from then until 1913 that trend was reversed. The evidence suggests that improvements in the quality of travel advanced even more rapidly than before and that shipping lines increasingly competed on the basis of the quality of service that they offered. One reason is that from the 1880s shipping conferences, which set minimum fares, widened and strengthened. In a setting where prices are set at above basic cost, firms compete on quality, investment in which in turn absorbs some of the gains from increased prices. The evidence presented here is consistent with that idea and it provides an important part of the rationale for the divergent trends in freight rates and passenger fares. But at the same time there is scope for further research in order to construct a more comprehensive database and provide a more rigorous empirical analysis.

References

Aldcroft, D. H. (1968), "The Merchant Marine," Ch. 11 in D. H Aldcroft (Ed.), *The Development of British Industry and Foreign Competition 1875–1914*, London: Allen and Unwin.

Bastin, R. (1971), "Cunard and the Liverpool Emigrant Traffic 1860 to 1900" MA thesis, University of Liverpool.

Bogart, D., Rosevear, A. and Shaw-Taylor, L. (2026), "A Better Ride: New Evidence on Travel and the Quality of Roads in England and Wales, 1660-1820," *Explorations in Economic History*, 100, paper 101748.

Bonsor, N.R.P. (1975; 1978; 1979a 1979b), *North Atlantic Seaway,* Vols 1-4, London: David and Charles.

Boyce, G. (1995), *Information, Mediation and Institutional Development: The Rise of Large-scale Enterprise in British Shipping, 1870-1919*, New York: Manchester University Press.

Butler, D. A. (1998), *The Unsinkable: The Full Story of the RMS Titanic*, Mechanicsburg PA: Stackpole Books.

Cecil, L. (1967), *Albert Ballin: Business and Politics in Imperial Germany, 1888-1918,* Princeton NJ: Princeton University Press.

Coleman, T. (1977), *The Liners*, London: Penguin

Crafts, N. F. R. (2004), "Steam as a General Purpose Technology: A Growth Accounting Perspective," *Economic Journal*, 114 (495), pp. 338-351.

Deltas, G., Serfes, K. and Sicotte, R. (1999), "American Shipping Cartels in the Pre-World War I Era," *Research in Economic History*, 16, pp. 1-38.

Deltas, G., Sicotte, R. and Tomczak, P. (2008), "Passenger Shipping Cartels and their Effect on Trans-Atlantic Migration," *Review of Economics and Statistics*, 90 (1), pp. 119-133.

Deltas, G. and Sicotte, R. (2017), "Cartel Organization, Price Discrimination, and Selection of Transatlantic Migrants: 1899-1911," *Southern Economic Journal*, 83 (3), pp. 668-704.

Dupont, D., Gandhi, A. and Weiss, T. (2012), "The Long-term Rise in Overseas Travel by Americans, 1820-2000," *Economic History Review*, 65 (1), pp. 144-167

Dupont, D., Keeling, D. and Weiss, T. (2017), "First Cabin Fares from New York to the British Isles, 1826–1914," *Research in Economic History*, 33, pp. 19-63.

Feys, T. (2008), "Prepaid Tickets to the New World: The New York Continental Conference and Transatlantic Steerage Fares 1885-1895," *Revista de Historia Económica*, 26 (2), pp. 173-204.

Feys, T. (2013), *The Battle for the Migrants: The Introduction of Steamships on the North-Atlantic and its Impact on the European Exodus,* Liverpool: International Maritime Economic History Association.

Fletcher, R. A. (1913), *Travelling Palaces: Luxury in Passenger Steamships,* London: Pitman & Sons.

Great Britain, Board of Trade (1881), *Report on Emigrant Accommodation on board Atlantic Steamships*, House of Commons, C. 2995, London: HMSO.

Great Britain, Royal Commission on Shipping Rings (1909), *Report and Minutes of Evidence*, Cd. 4685, London: HMSO.

Grossman, R. S. (2002), "New Indices of British Equity Prices, 1870-1913," *Journal of Economic History,* 62 (1), pp. 121-146.

Harley, C. K. (1970), "British Shipbuilding and Merchant Shipping: 1850-1890," *Journal of Economic History*, 30 (1), pp. 262-266.

Harley, C. K. (1988), "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed," *Journal of Economic History,* 48, pp. 851–76.

Harley, C. K. (1990), "North Atlantic Shipping in the Late Nineteenth Century: Freight Rates and the Interrelationship of Cargoes," in R. Fischer and H. W. Nordvik (eds.) *Shipping and Trade, 1750–1950: Essays in International Maritime Economic History,* Pontefract: Lofthouse Publications.

Harley, C. K. (2008), "Steers Afloat: The North Atlantic Meat Trade, Liner Predominance, and Freight Rates, 1870–1913," *Journal of Economic History*, 68 (4), pp. 1028-1058.

Hatton, T. J. (2024), "Time on the Crossing: Emigrant Voyages across the Atlantic, 1853–1913," *European Review of Economic History*, 28 (1), pp. 120–133.

Huebner, S. S. (2014), "Steamship Line Agreements and Affiliations in the American Foreign and Domestic Trade," *Annals of the American Academy of Political and Social Science*, 55, pp. 75-111.

Hyde, F. E. (1975), *Cunard and the North Atlantic, 1840-1973: A History of Shipping and Financial Management*, London: Macmillan.

Inwood, K. and Keay, I. (2015), "Transport Costs and Trade Volumes: Evidence from the Trans-Atlantic Iron Trade, 1870–1913," *Journal of Economic History*, 75 (1), pp. 95-124.

Isserlis, L. (1938), "Tramp Shipping Cargoes and Freights," *Journal of the Royal Statistical Society*, 101 (1), pp. 53-134.

Jacks, D. S. and Pendakur, K. (2010) "Global Trade and the Maritime Transport Revolution," *Review of Economics and Statistics*, 92 (4), pp. 745-755.

Jerome, H. (1926), *Migration and Business Cycles,* New York: National Bureau of Economic Research.

Johnson, E. R. and Huebner, G. G. (1920), *Principles of Ocean Transportation*, New York: Appleton & Co.

Keeling, D. (1999), "The Transportation Revolution and Transatlantic Migration, 1850-1914," *Research in Economic History*, 19, pp. 39-74.

Keeling, D. (2008a), "The Voyage Abstracts of the Cunard Line as a Source of Transatlantic Passenger Fares, 1883-1914," *Business Archives Sources and History*, 96, pp. 15-36.

Keeling, D. (2008b), "Transport Capacity Management and Transatlantic Migration, 1900–1914," *Research in Economic History*, 25, pp. 225–283.

Keeling, D. (2010), "Repeat Migration between Europe and the United States, 1870–1914," in L. Cruz and J. Mokyr (eds), *The Birth of Modern Europe: Culture and Economy, 1400-1800. Essays in Honor of Jan de Vries,* Boston: Brill, pp. 157-186.

Keeling, D. (2011), "North Atlantic Shipping Cartels and the Effects of the 1904 Fare War upon Migration between Europe and the United States," In M. Müller, H. R. Schmidt and L. Tissot (eds.), *Regulierte Märkte: Zünfte und Kartelle,* Zurich: Kronos.

Keeling, D. (2012). *The Business of Transatlantic Migration Between Europe and the United States, 1900–1914*, Zurich: Chronos Verlag.

Kelly, M., Ó Gráda, C. and Solar, P. M. (2021), "Safety at Sea during the Industrial Revolution," *Journal of Economic History*, 81 (1), pp. 239-275.

Leunig, T. (2006), "Time is Money: A Re-Assessment of the Passenger Social Savings from Victorian British Railways," *Journal of Economic History*, 66 (3), pp. 635 – 673.

Marx, D. (1953), *International Shipping Cartels*, New York: Greenwood Press.

Maywald, K. (1956), "The Construction Costs and Value of the British Merchant Fleet, 1850-1938," *Scottish Journal of Political Economy*, 3, pp. 44-66.

Maxtone-Graham, J. (1972), *The Only Way to Cross,* New York: Macmillan

Mitchell, B. R. (1984), *Economic Development of the British Coal Industry, 1800-1914*, Cambridge: Cambridge University Press.

Mitchell, B. R. (1988). *Abstract of British Historical Statistics*, Cambridge: Cambridge University Press.

Mitchell, B., Chambers, D. and Crafts, N. (2011), "How Good was the Profitability of British Railways, 1870-1912?" *Economic History Review*, 64 (3), pp. 798-831.

Officer, L. H. (2022), "Exchange Rates Between the United States Dollar and Forty-one Currencies," at: https://www.measuringworth.com.

Pring, M. (2019), *Luxury Railway Travel: A Social and Business History,* Barnsley: Pen and Sword Books.

Scott Morton, F. M. (1997), "Entry and Predation: British Shipping Cartels 1879–1929," *Journal of Economics & Management Strategy*, 6 (4), pp. 679-913.

Shah Mohammed, S. I. and Williamson, J. G. (2004), "Freight Rates and Productivity Gains in British Tramp Shipping 1869–1950," *Explorations in Economic History*, 41, pp. 172–203.

Sickel, W. G. (1914), "Pooling Agreements," *Annals of the American Academy of Political and Social Science*, (55), pp. 144-154.

Stevens, W. H. S. (1914), "The Administration and Enforcement of Steamship Conferences and Agreements," *Annals of the American Academy of Political and Social Science*, 55, pp. 112-143.

United States Senate (1874), *Report of an Investigation into the Treatment and Condition of Steerage Passengers,* Senate Exc. Doc. 23, 43rd Congress 1st Session.

United States Congress (1913-14), *House Committee on Merchant Marine and Fisheries, Investigation of Shipping Combinations under House Resolution 587*, 62nd Congress, Washington: GPO.

United States Immigration Commission (1911), *Vol. 39, Steerage Legislation, 1819-1908,* Senate Doc. 758, 61st Congress, 3rd Session, Washington: GPO.

Vale, V. (1984), *The American Peril: Challenge to Britain on the North Atlantic, 1901-04,* Manchester: Manchester University Press.

Weiss, T. and Dupont, B. (2024), "Travel and Tourism," in C. Diebolt and M. Haupert (eds.), *Handbook of Cliometrics*, Switzerland: Springer Nature.

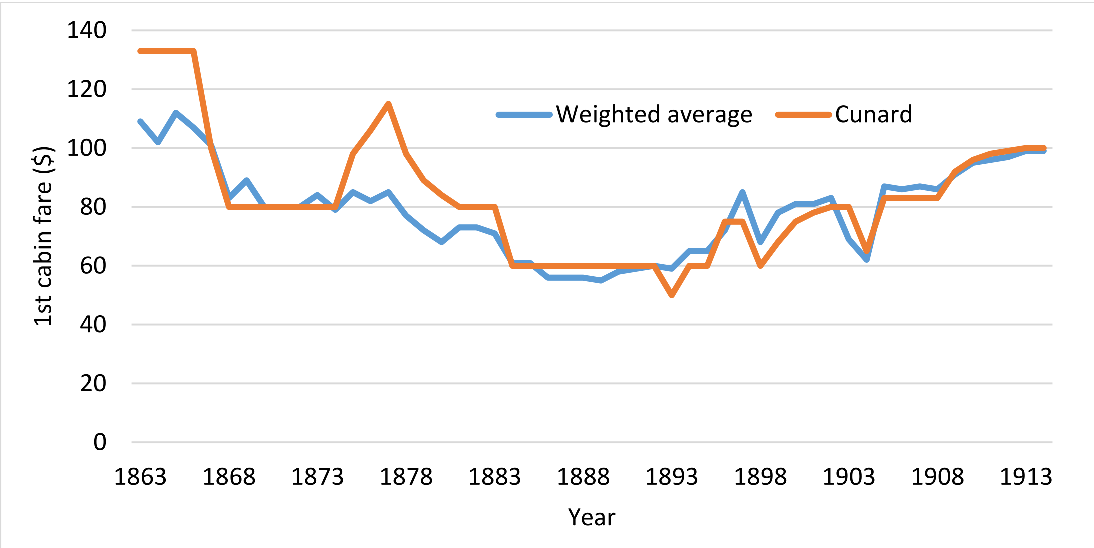
Appendices for: "Explaining Divergence in Ocean Freight Rates and Passenger Fares, 1863-1913,"

Appendix 1: Annual data on fares and freight rates

Other North Atlantic steamship fares

As noted in the main paper, time series on passenger fares are available only for a few routes. The most consistent series over the long run is that for steerage/third class fares reported in Figure 2 in the main paper and this is derived by linking data on fares from Dupont et al. (2017) with those based on Cunard, from 1883 onwards, from Keeling (2008a). These estimates do not include the immigrant head tax that the US first introduced in 1882 and increased in subsequent years. The eastward first cabin fares also come from Dupont et al. (2017). Figure A1 plots their series of advertised first cabin fares from New York to ports in the UK (from 1896 these are conference minimum prices), which is a volume-weighted index of eight major shipping lines, and this is compared with the series for Cunard alone. This provides a check on whether Cunard fares evolved differently from other lines. From the graph it appears that, apart from 1863-6 and 1875-9, Cunard first class fares closely track the average for all major shipping lines, which probably reflects the influence of the conferences. With this and other data, Dupont et al. (2017) confirm that advertised fares follow a similar profile to series for revenue per passenger, which provides some assurance for linking the two steerage series for Figure 2. They also find that eastward fares were generally similar to westward fares, which supports the use of westward steerage and eastward 1st cabin fares to represent fares in both directions in Table 4.

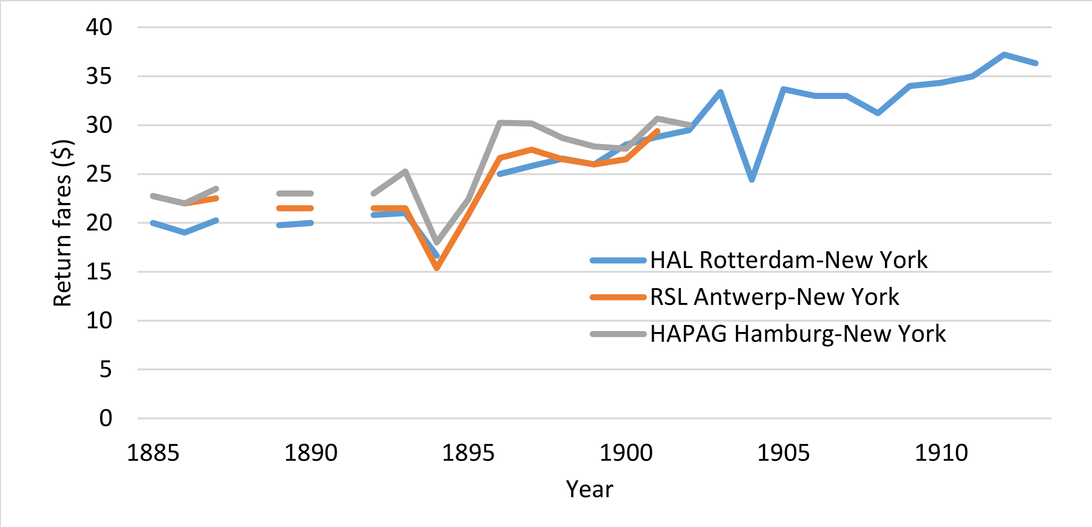
Figure A1: Advertised first class fares New York to UK, 1863-1913 (1884 = 100)



Source: Dupont et al. (2017), p. 55-8. *Notes*: The eight shipping lines forming the average are: Cunard, White Star, Anchor Britain, Inman/American, National Guion, HAPAG and NGL.

The steerage fares used in Figure 2 of the main paper rely heavily on Cunard from the 1880s but the subsequent upswing in fares is common to all major passenger lines. Figure A2 taken from Feys (2013) shows the rising trend in the prepaid steerage return fares from 1885 to 1913 of HAL (Holland Amerika Line), RSL (Red Star Line) and HAPAG (Hamburg-Amerikanische Paketfahrt Aktien Gesellschaft). For HAL, which covers the whole period, the average annual rate of growth is 2.6 percent per annum, which is a little more than the growth rate of steerage fares used in Table 4. See also Keeling (2008b), pp. 271-4 for the years 1901-13.

Figure A2: Prepaid westward steerage fares for HAL, RSL and HAPAG, 1885-1913

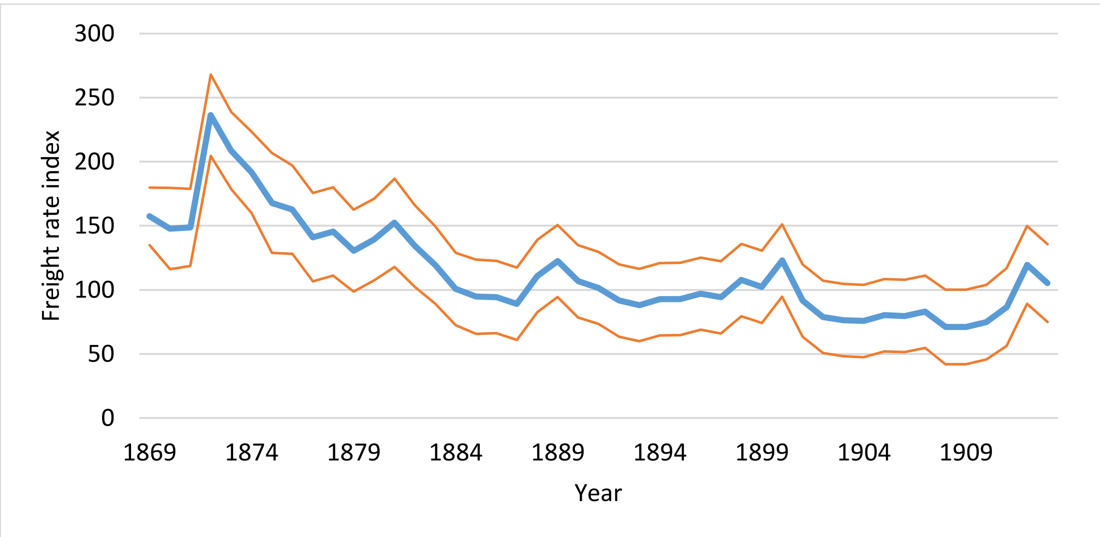


Source: Prepaid return steerage fares for HAL (Holland Amerika Line), RSL (Red Star Line) and HAPAG (Hamburg-Amerikanische Paketfahrt Aktien Gesellschaft) from Feys (2013), pp. 323-7. *Notes*: The underlying series often include several observations for any one year and these are simply averaged.

North Atlantic freight rates

The series reported in Figure 1 from Isserlis (1938) and Shah Mohammed and Williamson (2004) are for British tramp shipping worldwide and not just on the North Atlantic. These could have evolved differently, although the average annual decline of 2.05 percent per annum for the Eastern US in Table 1 is broadly in line with other major routes. Shah Mohammed and Williamson (2004, p. 182-3) also report time series index numbers (1884=100) for individual routes/commodities (eastward or westward). A panel comprising seven series for North Atlantic trade was regressed on year dummies with fixed effects by route. The predicted values (with 95 percent confidence intervals in red) are plotted in Figure A3. The profile over time is very similar to that of Isserlis and to the five year averages in Figure 1. So, average North Atlantic freights do not deviate substantially from the global average. However, it must be remembered that these are for tramp shipping and not liner shipping.

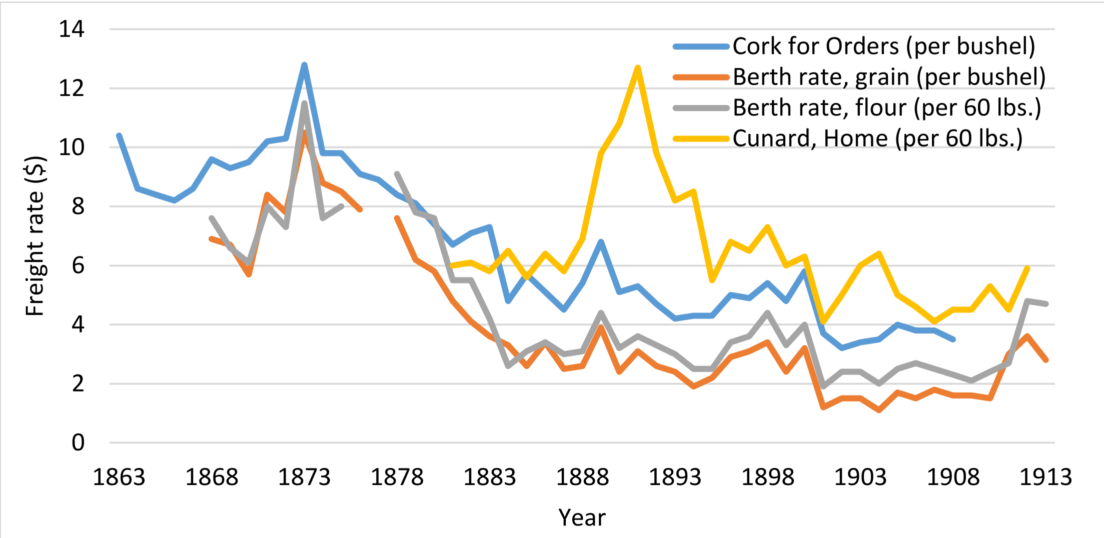
Figure A3: Average freight rates on the North Atlantic



Source: Data from Shah Mohammed and Williamson (2004, p. 182-3). Predicted values from year dummies in a regression with fixed effects for 7 routes.

More relevant to the productivity calculation in Table 4 are rates for freight carried on passenger liners, as distinct from tramps. Harley (2008, p. 1055-6) provides series for eastward (New York to Liverpool) berth rates for wheat and flour as well as wheat on 'Cork for orders' contracts (shipments to Cork for onward destinations). Such heavy bulk goods eastbound to the UK were not subject to conference agreements (Huebner 1914, p. 77). These are plotted in Figure A4 and they illustrate a steep downward trend, which Harley attributes to the intensity of competition as liner capacity expanded. Also shown is the average homeward revenue per ton for goods carried by Cunard. The latter is used to represent the trend in freight rates on passenger ships used in Table 4 and is carried back to 1863 by splicing to the berth rate for grain (the most important berth cargo) at 1881 and then to Cork for orders at 1868.

Figure A4: Eastward freight rates, 1863-1913



Source: Harley (2008, p. 1055-6)

Appendix 2: Tonnage and Passenger Capacity of Ships on the North Atlantic

As mentioned in the text, I measure passenger capacity for passenger shipping lines on the North Atlantic using the data for individual ships compiled by Bonsor (1975; 1978; 1979a; 1979b). The data extracted from these volumes is confined to 15 major shipping lines. These are lines that owned at least 15 passenger ships that plied the North Atlantic between 1853 and 1913. The passenger lines, the total number of ships, and the period active are listed in Table A1. These exclude the many lines that were active for short periods with just a few ships, some of which are well known (such as the Collins and Guion lines). Lines that operated passenger ships but were mainly engaged in freight were also excluded in order not to conflate passenger and freight services. Notable among these are the Donaldson Line, the Furness Line, Elder Dempster, the Wilson Line, the Beaver Line and the Atlantic Transport Line.

The ships included for each line are only those that were owned by that line, so this excludes those that were chartered from other lines, which avoids double counting. Ships that were cargo or mainly cargo carriers are also excluded. Bonsor provides the year of first voyage and last voyage on the North Atlantic for each ship while owned by a line, even if chartered to another line. So for the purposes of Table 2, a ship is counted as active in a given year if it falls within that window. However, it should be noted that, during that time, ships were sometimes deployed on other routes, notably to South American or Mediterranean ports, so a ship may not have sailed the North Atlantic in a given year within the window but would still be counted as active in that year. Bonsor also provides information on when ships were lengthened or refitted, which affected the tonnage and passenger capacity. In such cases the ship appears twice in the database with different specifications for non-overlapping years.

Table A1: Passenger lines and ships included in the database for 1853 up to 1913

Passenger ship line (country)	Years in business from 1853 to 1913	Number of ships (including refits)	No. with passenger capacity listed	Average years on N. Atlantic
Cunard (UK)	1953-1913	76	60	10.8
Inman (UK)	1853-1893	34	14	8.9
Allan (UK)	1854-1913	91	57	12.6
HAPAG (Hamburg-Amerikanische Paketfahrt Aktien Gesellschaft) (Germany)	1856-1913	127	119	8.5
Anchor (UK)	1856-1913	77	45	13.7
NDL (Norddeutscher Lloyd) (Germany)	1858-1913	116	113	10.9
CGT (Compagnie Générale Transatlantique) (France)	1864-1913	54	37	7.1
White Star (UK)	1871-1913	33	24	12.3
Dominion (UK)	1872-1913	33	23	9.0
Red Star (Belgium, US, UK)	1873-1913	25	25	13.0
Holland Amerika (Netherlands)	1873-1913	27	25	10.5
American (US)	1873-1913	17	12	19.0
NGI (Navigazione Generale Italiana) (Italy)	1881-1913	35	22	8.7
Canadian Pacific (UK, Canada)	1903-1913	18	13	6.8
Unione Austriaca (Austria)	1904-1913	20	20	3.4

Source: Derived from Bonsor (1975; 1978; 1979a; 1979b). *Notes*: Number of ships and passenger capacity as described above. Years of service on the North Atlantic is for ships (and refits) for which third class passenger capacity is listed.

Gross tonnage is provided for all of the ships. Passenger capacity is provided for three classes but this is absent in some cases and partial for other cases (for example where a figure is given only for first class but not for second or third—even though it is noted that such classes were present). These cases were excluded as were a few with no third class accommodation. The passenger capacity is often reported as round numbers—tens for cabin classes and hundreds for third/steerage. While the underlying figures for passenger capacity are often rounded, the averages are probably more reliable. The year the ship was launched is also recorded and this is used in Table 2. When the ship is recorded as having been lengthened or refitted so that capacity is changed, this is treated as a fresh launch and, for this reason, some ships appear twice in the regression analysis of Table 3. They are also counted as separate ships in Table A1 above.

As noted in the main paper the weights allocated to 1st, 2nd and 3rd class are 5, 2 and 1 respectively, and these are justified as follows. Based in the floor plans of 14 ships (13 of which are in the database used here) Keeling (2008b, ftn. 65, p. 257) finds that the floor space allocated to first class passengers was 4.6 times that allocated to third class (as compared to a ratio of 3.3 for fares). Given that all but one of these ships were launched after 1890 I have raised this ratio to 5 to allow for the fact that closed berths were uncommon in third class in the earlier years. Keeling notes that the ratio of relative space to relative fares of first to third is 1.4. He does not provide a space ratio for second to third class but elsewhere provides fares for second and third class for Cunard and Holland America in 1903-1913 (Keeling 2007, p. 165). The average ratio of second to third class fares is 1.7 and assuming that the ratio of space to fares was somewhat less than for first/third, say 1.2, this suggests a space ratio for second/third of 1.7×1.2, which is about 2.

Table A2: Average tonnage and capacity of passenger ships of the North Atlantic

	1863	1873	1883	1893	1903	1913
UK/US/Canada lines (8)						
Ships	22	63	67	67	65	66
Gross tons	1810.1	2760.9	3738.7	4898.4	8507.1	11853.4
Passengers	567.0	860.2	1066.5	1176.4	1285.3	1651.2
Passengers per 100 tons	31.5	31.3	29.4	26.6	17.6	15.6
Percent cabin passengers	21.8	15.2	17.7	20.6	22.5	25.4
Weighted passengers	973.9	1318.0	1685.5	1963.4	2084.8	2628.8
Weighted passengers per 100 tons	52.9	47.9	45.6	41.8	27.5	23.5
Continental lines (7)						
Ships	10	43	62	94	95	99
Gross tons	2515.4	2779.5	3156.3	4034.1	7645.3	11078.4
Passengers	583.0	658.3	813.8	1014.5	1534.9	1875.2
Passengers per 100 tons	23.5	23.8	25.5	26.5	22.4	18.5
Percent cabin passengers	32.4	25.5	16.6	15.2	17.0	18.2
Weighted passengers	954.2	1033.9	1204.9	1476.5	2206.2	2726.6
Weighted passengers per 100 tons	38.5	37.1	37.7	36.3	29.6	25.0

Source: data derived from Bonsor (1975; 1978; 1979a; 1979b). *Note*: a ship is counted as active during the years from its first voyage to its last voyage on the North Atlantic.

Table 2 in the main paper presents averages of tonnage and passenger capacity for 15 lines. In Table A2 the data are divided into 8 UK/US/Canadian based lines (Cunard, Inman, Allan, Anchor, White Star, Dominion, American and Canadian Pacific) and 7 continental lines (HAPAG, NDL, CGT, Red Star, Holland Amerika, NGI and Unione Austriaca). As noted in the main text both groups share a downward trend in passengers per ton, although it is somewhat less steep for the continental lines.

Table 3 in the main paper reports regressions of weighted passenger capacity on gross tonnage and the year or decade that the ship was launched. Table A3 provides regressions with different weights applied to passenger capacity. Column (1) replicates column (2) in Table 3. Reducing the weight of first class (Column 2) or increasing the weight of second class (Column 3) produces slightly different coefficients as might be expected, but the coefficients on tonnage remain close to one and the coefficients on decade of launch still become progressively more negative. The final column shows the (unrealistic) case where the dependent variable is just the unweighted total. As the share of 1st and 2nd class capacity increased from the 1870s the unweighted series grows more slowly giving the misleading impression that passenger capacity increased less than proportionately with gross tonnage, while providing little evidence of vintage effects.

Table A3: Passenger capacity, with different weights, regressed on ship tonnage 1853-1913

	(1)	(2)	(3)	(4)
Passenger capacity (weights: 1st, 2nd, 3rd)	Weights: 5, 2, 1	Weights: 4, 2, 1	Weights: 5, 3, 1	Weights: 1, 1, 1
Log gross tons	0.997***	0.942***	1.029***	0.625***
	(0.07)	(0.07)	(0.07)	(0.08)
Launch 1864-73 (= 1)	-0.049	-0.016	-0.078*	0.202***
	(0.05)	(0.05)	(0.04)	(0.06)
Launch 1874-83 (= 1)	-0.172**	-0.113	-0.214***	0.250**
	(0.08)	(0.07)	(0.07)	(0.10)
Launch 1884-93 (= 1)	-0.313***	-0.237**	-0.365***	0.193
	(0.10)	(0.10)	(0.11)	(0.12)
Launch 1894-1903 (= 1)	-0.596***	-0.476***	-0.643***	0.160
	(0.12)	(0.12)	(0.13)	(0.13)
Launch 1904-13 (= 1)	-0.622***	-0.483***	-0.644***	0.224
	(0.13)	(0.13)	(0.15)	(0.17)
Observations	609	609	609	609
R-squared	0.772	0.774	0.786	0.660

Note: Fixed effects for 15 shipping lines. The excluded group is ships launched before 1864. Wild bootstrapped standard errors in parentheses; significance, *** 1%, **5%, * 10%.

Actual westward passenger loads on ships to New York in 1888

As noted in the main paper, for most voyages, ships were not full to capacity, not least because most lines kept to regular sailings throughout the year while demand for passages fluctuated widely across the seasons. The data underlying Figure 3 were calculated using the database for ships active during 1888 from Bonsor, as explained above. The number of passengers was calculated from Ancestry.co.uk: "All New York, U.S., Arriving Passenger and Crew Lists (including Castle Garden and Ellis Island)". For a given ship, the data was first searched to find all its arrivals in New York during the year. Then the number of passengers was taken from the summary for each voyage. The ratio of passengers to capacity was then calculated for each voyage. Unfortunately, it is not possible to do this by class of travel as this would require counting through the entire passenger lists (which are often hundreds of pages for each voyage), and even then it is sometimes difficult to distinguish the different classes.

Table A4 shows details by shipping line of the 580 voyages to New York for which capacity utilisation could be measured. As noted in the text, the average utilisation rate is 52.2 percent. As the table shows, utilisation rates are relatively similar across shipping lines, with one exception where the ratio could be computed for only two voyages.

Table A4: Tonnage, passengers and capacity utilisation in 1888

Shipping line	No. of voyages	Average tonnage	Average passengers	Capacity utilisation
American Line	8	3104	967	49.9
Anchor	71	4515	1109	54.0
CGT	52	7046	1103	53.5
Cunard	66	6875	1384	50.8
HAPAG	93	3161	1030	54.0
Holland America	33	3191	724	49.7
Inman	44	5490	1491	44.1
NDL	100	4843	1224	56.4
NGI	2	2244	520	35.2
Red Star	52	4502	1123	49.4
White Star	59	4280	1379	51.4

Source: data derived from Bonsor (1975; 1978; 1979a; 1979b) and from Ancestry.co.uk, as described above.

Reference not in listed the main paper

Keeling, D. (2007), "Costs, Risks and Migrant Networks between Europe and the United States, 1900-1914, in T Feys, L. R. Fischer, S Hoste and S. Vanfraecham (eds), *Maritime Transport and Migration: The Connections between Maritime and Migration Networks*, St John's: International Maritime Association

Appendix 3: Composition of crews

Data on the composition of crews on British foreign-going ships was reported in UK reports on *Returns of Seamen*. Table A5 reports series from this source at five year intervals from 1891. These show that the share of passenger service crews in total increased from 13 percent in 1891 to 17.4 percent in 1911. However, this includes all British foreign-going merchant ships. (Some of these were based in ports outside the UK, which accounts for the large share of lascars). Of this total, passenger liners would account for only a small part. So the growth of service crews would loom much larger for the major passenger lines alone (Burton 1985, p. 314). In order to measure these more directly I turn to an alternative source.

Table A5: Passenger service crews on British registered steamers engaged in foreign commerce

	1891	1896	1901	1906	1911
Officers and deck crew	32.8	30.7	29.1	28.8	28.1
Engineers, firemen etc.	28.1	26.8	26.6	27.5	27.2
Stewards, stewardesses, cooks etc.	13.0	12.6	13.8	15.9	17.4
Surgeons, pursers etc.	1.9	2.6	3.1	2.4	2.1
Lascars and other	24.2	27.4	27.4	25.5	25.1
Total crew	101,166	113,861	130,053	150,516	170,416
Ships		3,153	3,131	3,435	3,689
Net tonnage		4,799,845	5,916,124	7,409,545	8,661,794
Crew per ship		36.1	41.5	43.8	46.2
Crew per 1,000 tons		23.7	22.0	20.3	19.7

Sources: Crew numbers from UK House of Commons, *Return of Seamen,* 1912-13; number and net tonnage of ships from *Return of Seamen* 1896, 1901, 1906, 1911. *Notes*: Officers and deck crew includes masters, mates, petty officers, sailors, apprentices and boys. Engineers, firemen etc. includes engineers, firemen and trimmers and others in the engineer's department. Stewards, stewardesses, cooks etc. includes stewards, stewardesses, waiters, butchers, bakers, barbers, and general servants, including cabin and mess-room boys etc. Surgeons and pursers includes surgeons, pursers, clerks etc. Lascars and other includes lascars and others not classified.

The composition of crews can be found in crew agreements. Captains of ships registered in UK ports were required to fill in forms that listed the name of each crew member, the individual's occupation or role, the wage to be paid and the date of embarkation; the entry line was then signed by each crew member. Those that that subsequently failed to join the ship, were transferred or deserted were noted in the documents as were substitutes who were recruited to replace them. Some of these can be found in the surviving records of crew agreements for ships whose home port was Liverpool. The records on Ancestry.co.uk cover 913 ships that departed in the years 1861 to 1919. Unfortunately, few of these are passenger ships that were included in the Bonsor database noted above. The records sometimes have pages missing or out of order and often cover less than the full set of voyages in any given year. Some ships appear in multiple years.

The procedure used here is to start with years ending in '3', from 1873 to 1913 and then work back through the previous decade. I focus on voyages by ships of the Cunard, Inman/American and White Star lines heading from Liverpool to the United States in order to ensure that the ships were consistently at the upper end of the quality spectrum throughout the years. A set of voyages is only included in the database if there were at least four voyages by that ship in that year. Working back from each decade benchmark I add ships not listed in the year(s) previously examined or where there were less than four voyages. This results in 195 voyages of 32 ships and their details are listed in Table A6 below. Crew members in each department are those on board for the westward voyage across the

Atlantic. Those who failed to join the ship, deserted or were transferred prior to sailing are excluded and those added as substitutes in Liverpool or Queenstown are included. Those who deserted in the US or were recruited in the US port for the return voyage are not counted, neither are stowaways discovered at sea and enlisted into the crew.

Table A6: Liverpool crew lists

Ship	Line	Year obsvd	Launch year	Deck crew	Engine crew	Stewd crew	Wgted capcty	No of voyags
City of Limerick	Inman	1863	1855	25.3	18.8	13.8		4
City of Paris	Inman	1868	1865	42.9	41.1	36.1		8
City of Baltimore	Inman	1870	1855	38.4	26.4	29.6		7
City of Washington	Inman	1870	1869	42.1	27.8	32.7		9
Etna	Inman	1870	1854	38.6	27.0	27.5		8
City of Brooklyn	Inman	1873	1868	42.9	36.2	36.4		9
City of Brussels	Inman	1873	1872	44.7	47.5	39.7	2000	6
City of Chester	Inman	1873	1873	52.5	52.8	54.3	2095	4
City of Limerick	Inman	1873	1870	33.0	27.0	33.5		4
City of Berlin	Inman	1881	1874	40.3	52.9	65.1	2550	9
Gallia	Cunard	1882	1878	48.4	47.0	73.0	2700	9
Pavonia	Cunard	1882	1882	49.3	42.0	47.8	2500	4
Servia	Cunard	1882	1881	60.8	83.5	92.0	3150	6
City of Montreal	Inman	1882	1871	38.4	42.4	45.9	1620	10
City of Richmond	Inman	1882	1873	38.8	54.1	53.1	2095	8
Catalonia	Cunard	1883	1881	47.8	34.2	42.4	2500	5
Cephalonia	Cunard	1883	1882	45.4	39.8	56.2	2500	5
City of Chicago	Inman	1883	1883	40.0	54.8	58.5	1700	4
Majestic	White Star	1889	1889	47.6	165.0	133.3	2880	11
Aurania	Cunard	1890	1883	54.8	92.4	93.9	3100	10
City of New York	Inman	1890	1888	57.8	192.5	138.5	4100	6
Servia	Cunard	1891	1889	53.7	92.2	88.3	2900	10
Lucania	Cunard	1901	1893	50.4	188.8	163.4	4800	11
Cymric	White Star	1902	1897	47.1	59.0	80.2	1910	9
Ivernia	Cunard	1902	1899	44.8	64.6	127.0	2820	12
Campania	Cunard	1903	1892	55.2	191.0	168.8	4800	9
Saxonia	Cunard	1903	1899	50.3	66.8	133.6	2820	10
Cretic	White Star	1904	1902	39.4	59.0	78.0	2070	5
Cedric	White Star	1904	1902	52.8	97.4	190.4	4497	12
Haverford	American	1911	1901	42.2	41.6	79.6	2000	5
Carmania	Cunard	1912	1905	62.8	140.3	252.9	4200	8
Franconia	Cunard	1913	1910	61.4	94.1	269.1	4400	7

Sources: Crew numbers calculated from "Liverpool, England, Crew Lists 1861-1919" in Ancestry.co.uk. The original source is: Crew lists. 387 CRE. Liverpool Record Office, Liverpool, England. Weighted passengers (third class equivalents) is from the database described in Appendix 2 above. The ships City of Limerick and Servia appear twice as they were refitted in 1870 and 1889 respectively, the former also lengthened.

Deck, engine and steward's crews are listed here as averages over the voyages in the year of observation. As the last column shows, the number of voyages covered in a ship/year is between four and twelve, and where there are fewer voyages, these are often concentrated in part of the year. As noted in the main paper, for any given ship the number listed in deck and engine-room crews varies very little between voyages but stewards' crews are related more closely to the number of passengers which varies across the seasons. For that reason, some adjustment is necessary for the different months of sailing and so the following regression was used to standardise by month of departure:

$$y_{s,m} = \alpha + \beta_s s + \gamma_m m + \varepsilon_{s,m}$$

Where $y_{s,m}$ is either the share of steward's in total crew or the ratio of steward's crew to weighted passenger capacity, and *s* denotes the ship and *m* the month of departure. This is regressed on dummy variables for the ship and the month. The variables displayed in Figure 4 in the main paper are the predicted values for each ship holding the month constant at June.

Annual rates of growth of stewards' crew to passenger capacity used Table 4 is estimated using the following equation:

$$\ln(crew/passcapacity)_m = \alpha + \beta launchyear + \gamma_m m + \varepsilon_m$$

To account for the difference in trends across the two sub-periods the equation is estimated separately for launch years up to 1888 and from 1889 onwards. The results in Table A7 show that the estimated average annual rate of growth is 1.1 percent in the earlier period and 2.2 percent in the later period. These are the growth rates used in Table 4 with an average over the whole period of 1.6 percent per year. Also shown are equations where the dependent variable is the log of the share of stewards in total crew members, which shows a similar acceleration in the growth rate.

Table A7: Trends in steward's crew to passenger capacity and share of steward's crew in total

	Dependent var: Log (steward's crew/passenger capacity)		Dependent var: Log (steward's crew/total crew)	
	Launch < 1889	Launch > 1888	Launch < 1889	Launch > 1888
Launch year	0.011***	0.022***	0.011***	0.025***
	(0.00)	(0.00)	(0.00)	(0.00)
Observations	86	109	135	109
R-squared	0.539	0.533	0.566	0.796

Sources: As listed above. *Notes*: All regressions include a full set of monthly dummies. Significance levels, *** 1%, **5%, * 10%. Fewer observations for steward's crew/passenger capacity for the years before 1889 is due to missing observations on passenger capacity

References

House of Commons (various years), *Return of the Number, Ages, Ratings and Nationalities of Seamen Employed,* London HMSO.

Burton, V. C. (1985), "Counting Seafarers: The Published Records of the Registry of Merchant Seamen 1849–1913," *Mariner's Mirror,* 71 (3), pp. 305-320.

Appendix 4: Costs, weights and alternative TFP calculations

Fares and Freights: The passenger fares used in the TFP calculations in Table 4 are those in Figure 2 of the main paper: the construction of which are described in Appendix 1 above. Eastward freight rates are constructed as described in Appendix 1 from data in Harley (2008) displayed in Figure A4.

Cost of ships: The source is Maywald (1956). This is an index of construction costs of steamers per gross registered ton. This includes both hulls (based on the costs of plates and labour) and machinery. This is regarded as a good measure of the trend in basic construction costs although it would not take account of the additional fittings for passenger ships and their enhancement, which are accounted for separately in the Table 4 calculations.

Coal price: The series for the export price of South Wales coal is taken from Mitchell (1984, p. 274-5). South Wales was the main source of steam coal.

Miscellaneous goods: The series is the Sauerbeck index for wholesale prices, mainly food and raw materials from Mitchell (1988, p. 725-6). This is aimed to represent consumables and chandlery and some non-ship fixed costs. Wholesale prices are preferred to a consumer price index or GDP deflator as representing the price of inputs.

A new wage index for steamship crew.

For use in Table 4 I have generated new index of the wages of steamship crews from UK government reports, mostly in Parliamentary Papers. This covers a wider range of roles than just able seamen and is specifically for steamships on the North Atlantic. Sources for the four component series for monthly wages (some values of which are midpoints of a given range) are as follows:

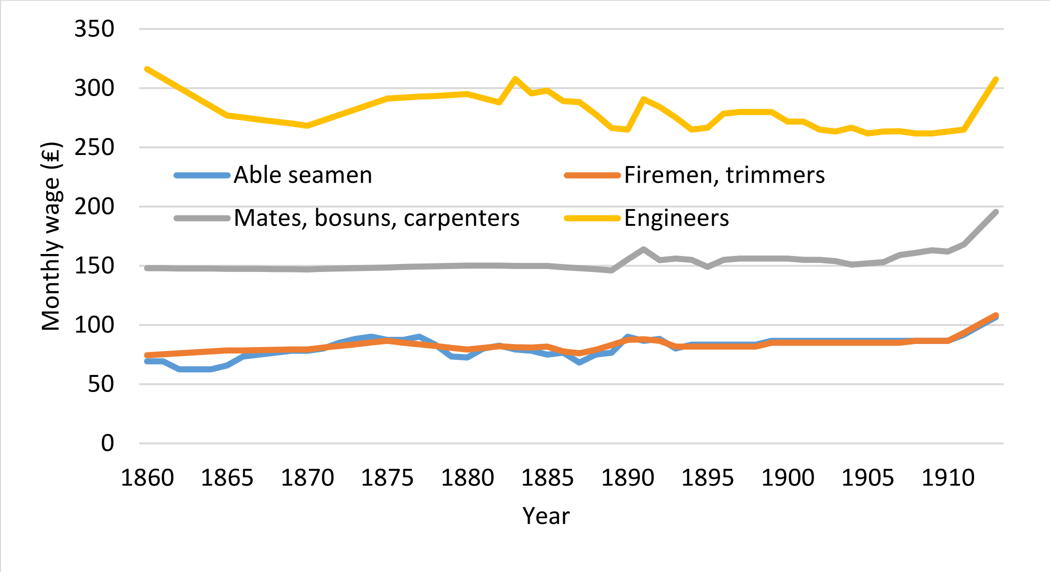
Able seamen: This is a series for able seamen on steamships to the east coast of North America from three ports: London, Liverpool and Glasgow (equally weighted). 1869-1905 from *Rates of Wages and Hours of Labour* (1908). 1906-1911 from *Progress of Merchant Shipping* (1913). 1913 from *Rates of Wages and Hours of Labour* (1914); wage rates for 1912 are interpolated. 1860-66 from *Seamen's Wages* (1867); 1867 and 1868 interpolated.

Firemen and Trimmers: This series covers firemen and trimmers on steamships to the east coast from the same three ports. Average of six rates (three ports, two occupations) 1895-1911 from *Rates of Wages and Hours of Labour* (1908). 1913 from *Rates of Wages and Hours of Labour* (1914); wage rates for 1912 are interpolated. This series is carried back with the average of leading firemen and firemen on steam ships of 2,000 tons and over engaged in foreign trade (not port specific and spliced at 1894-5); for the years 1860, 1865, 1870, 1875, 1880, 1885 and 1882-94, from *Progress of Merchant Shipping* (1889, 1895, 1900, 1907 and 1913), missing values linearly interpolated.

Officers and deck crew: This series covers five occupations: 1stmates, 2nd mates and 3rd mates, boatswains and carpenters (equally weighted) on foreign-going steamships of 2,000 tons and over. 1860, 1870, 1880, 1885 and 1889-1911 from *Progress of Merchant Shipping* (1889, 1895, 1900, 1907 and 1913), missing values linearly interpolated, 1912 and 1913 based on movement of able seamen.

Engineers: Average of 1st, 2nd and 3rd engineers on foreign-going steamships of 2,000 tons and over. 1860, 1865, 1870, 1875, 1880 and 1882-1911 from *Progress of Merchant Shipping* (1889, 1895, 1900, 1907 and 1913), missing values linearly interpolated, 1912 and 1913 based on movement of firemen and trimmers.

Figure A5: Annual series of seafarers' nominal monthly wages



Source: see text above.

The four series are shown in Figure A5. Not surprisingly engineers were the most highly paid followed by mates etc. Firemen and trimmers and able seamen are very close with little trend until the last few years of the period. Unfortunately, there is no data for service crew although stewards were paid about the same as able seamen and others somewhat less (Mäenpää 2000). Similarly, there is nothing for lascars although most of these were on ships based in ports beyond the UK and the North Atlantic (Burton, 1985, p. 312).

It is worth stressing that the series for mates etc. and for engineers are heavily interpolated before 1885 but the stability of the other series suggests that this may not be too misleading. Table A8 reports the values for years ending in 0 or 5, of which only two (in italic) are interpolated. The four series are combined into an overall index with weights reflecting broad groups in 1891. Not surprisingly there is very little long term trend.

Table A8: Monthly wages for benchmark years and overall index

	Able seamen	Firemen and trimmers	Mates, boatswains, carpenters	Engineers	Weighted average
1860	69.2	74.5	148.0	316.0	122.4
1865	65.8	78.4	*147.5*	276.9	115.8
1870	78.3	79.4	147.0	268.3	119.2
1875	87.5	86.6	*148.6*	291.3	129.2
1880	72.5	79.2	150.2	295.0	121.9
1885	75.0	81.7	149.8	298.0	124.2
1890	90.0	87.4	155.2	265.0	126.7
1895	83.3	81.7	149.0	266.7	121.8
1900	86.7	85.0	156.0	271.7	125.9
1905	86.7	85.0	152.0	261.7	123.7
1910	86.7	86.7	162.0	263.3	125.7

Source: see text above. Notes: the weights used in the overall index are: able seamen 0.37, firemen and trimmers 0.34, mates, boatswains, carpenters 0.12, engineers 0.17.

Growth rates of fares and prices

Table A9: Growth rates (% p. a.) of and fares and prices used in TFP calculations

	1863-7 to 1909-13	1863-7 to 1886-90	1886-90 to 1909-13
1st class fares	0.71	-0.88	2.31
2nd and 3rd class fares	0.11	-2.16	2.39
Freight rates	-1.49	-0.93	-2.05
Ship prices per gross ton	-1.10	-1.54	-0.66
Crew wages	0.31	0.15	0.48
Coal	0.65	-0.15	1.44
Miscellaneous	-0.38	-1.43	0.66
Passenger capacity per ton	-1.34	-0.65	-2.03
Passenger service	-1.65	-1.10	-2.20

Weights used in TFP calculations

Prices: The shares of revenue accounted for by freight differ widely but, based on Hyde (1975, pp. 84-87, 108) and Keeling (1999, p. 49; 2007, p. 122-3) for Cunard, its share is about 0.25. The calculation of revenue from fares is based on the ratio of first to third class fares which is 3.3 based on the series presented in Figure 2 of the main paper (see also Keeling, 2008b, ftn. 65, p. 257). The ratio of second to third class fares is 1.7 based on the average for Cunard and Holland America in 1903-13, as noted in Appendix 2 above. Keeling (2012, p. 285) reports total passenger traffic between the US and Europe (westward and eastward) by class for 1900-1914. This indicates that 11 percent were first, 15 percent second and 74 percent third class. Multiplying these shares by relative fares to get revenue and then scaling to 75 percent gives revenue weights of 0.20 for first class and 0.55 for second and third (of which second class is 0.14).

Costs. Harley (1989, p. 861) used weights of 0.4 for capital (ships), 0.1 for wages, 0.2 for coal and 0.3 for miscellaneous, based on "a large number of voyage manuscript accounts." Shah Mohammed and Williamson (2004, p. 194) used Harley's weights for ships, wages and coal scaled up to exclude miscellaneous. Capital costs represent the user cost of capital, which is the cost of interest, depreciation, repairs and insurance, the rates of which are assumed to be constant so that the rate of change is represented by the price of ships. Roberts (1947, p. 297) estimated these costs at around 40 percent of total for the early 1920s. Passenger ships were much more expensive than freighters mainly because of the superior construction and additional fittings for passengers, but these elements of quality are proxied by the trend in tons per passenger in Table 4 and given the same weight, so the weight is kept at 0.4. Keeling (1999, p. 66-7) reports, for Cunard ships in 1885-1914, shares of operating costs of: coal 39 percent; wages and provisions 35 percent; port loading 19 percent; other 7 percent. Scaled by 50 percent (to allow for fixed costs other than ships), coal would be about 20 percent of total, consistent with Roberts (1947, p. 297) thus an overall weight of 0.2. Assuming that wages would account for 20 of the 35 percent (of operating costs) for wages and provisions (see also Roberts 1947, p. 297) and about the same for loading etc., this would give an overall weight of 0.2. Miscellaneous goods, accounting for provisions, chandlery and some non-ship fixed costs would make up the remainder: about 20 percent of operating costs, scaled to 10 percent plus an additional 10 percent of other fixed costs for an overall weight of 0.2.

Alternative TFP estimates

Given that the calculations of total factor productivity depend on the particular weights used it is worth assessing the effects of alternative weights. Some comparisons of the resulting estimates of unadjusted and quality adjusted TFP growth are reported in Table A10. For the output prices the most important issue is the weight given to freight rates as its trend differs sharply from those of fares (Table A9 above). Case 1 at the top of the table is the result from Table 4 of the main paper. In case 2 the weight given to freight is reduced to 0.2 and in case 3 it is increased to 0.3. Giving more weight to freight increases TFP growth somewhat over the whole period (col. 1) but narrows the gap in TFP growth between the two sub-periods in cols. (2) and (3).

Case 4 again repeats the results in Table 4. This time the comparison is between the weight allocated to ships versus operating costs (specifically miscellaneous). In this case the alternative weights also apply to the quality components adding a further modification to quality adjusted TFP growth. Overall and between periods the differences produced by reducing the weight allocated to ships is rather modest. In all these comparisons unadjusted TFP growth is always negative in the second sub-period (Col. 3) and overall (col. 1). Quality adjusted TFP growth is always positive with slight variations between the two sub-periods.

Table A10: TFP calculations with alternative weights

	(1)	(2)	(3)
	1863-7 to 1909-13	1863-7 to 1886-90	1886-90 to 1909-13
Cost weights, Ships=0.4, wages=0.2, coal=0.2, misc=0.2			
1	Price weights 1st=0.2, 2nd & 3rd=0.55, freight=0.25		
TFP growth unadjusted	-0.16	0.69	-1.01
TFP quality adjusted	1.04	1.40	0.68
2	Price weights 1st=0.2, 2nd & 3rd=0.6, freight=0.2		
TFP growth unadjusted	-0.24	0.75	-1.23
TFP quality adjusted	0.96	1.46	0.46
3	Price weights 1st=0.2, 2nd & 3rd=0.5, freight=0.3		
TFP growth unadjusted	-0.08	0.63	-0.79
TFP quality adjusted	1.12	1.33	0.90
Price weights 1st=0.2, 2nd & 3rd=0.55, freight=0.25			
4	Cost weights, Ships=0.4, wages=0.2, coal=0.2, misc=0..2		
TFP growth unadjusted	-0.16	0.69	-1.01
TFP quality adjusted	1.04	1.40	0.68
5	Cost weights, Ships=0.45, wages=0.2, coal=0.2, misc=0.15		
TFP growth unadjusted	-0.19	0.69	-1.07
TFP quality adjusted	0.99	1.37	0.61
6	Cost weights, Ships=0.35, wages=0.2, coal=0.2, misc=0.25		
TFP growth unadjusted	-0.12	0.70	-0.94
TFP quality adjusted	1.09	1.42	0.76

References not listed in the main paper

Burton, V. C. (1985), "Counting Seafarers: The Published Records of the Registry of Merchant Seamen 1849–1913," *Mariner's Mirror,* 71 (3), pp. 305-320.

GB Board of Trade, Labour Department: (1908), *Rates of Wages and Hours of Labour in Various Industries in the United Kingdom for a Series of Years*, London: Board of Trade [not in Parliamentary Papers].

GB Board of Trade, Labour Department: (1914), *Report on Changes in Wages and Hours of Labour in the United Kingdom in 1913 with Comparative Statistics*, London: HMSO. [PP 1914-16, 61 LXI.769; Cd 7635].

GB House of Commons (1867), *Return of the Average Rate of Wages of Able Seamen . . .,* [1867, 64, LXIV.173; Paper no. 158].

GB House of Commons (various years), *Tables Showing the Progress of Merchant Shipping in the United Kingdom and Principal Maritime Countries*, London HMSO.

Keeling, D. (2007), "Costs, Risks and Migrant Networks between Europe and the United States, 1900-1914, in T Feys, L. R. Fischer, S Hoste and S. Vanfraecham (eds), *Maritime Transport and Migration: The Connections between Maritime and Migration Networks*, St John's: International Maritime Association.

Mäenpää, S. (2000), "Galley News: Catering Personnel on British Passenger Liners, 1860-1938," *International Journal of Maritime History*, 12 (1), pp. 243-260.

Roberts, R. O. (1947), "Comparative Shipping and Shipbuilding Costs," *Economica*, 14 (56), pp. 296-309.

Appendix 5: A linear duopoly model of quality with a fixed price

The main paper provides a diagram based on a text-book model of a duopoly where the price is exogenously fixed and the firms compete on quality. This appendix provides a formal derivation of the model underlying the diagram.

There are two identical firms, 1 and 2. For firm 1 demand (for its voyages in the case of shipping) is:

$$Q_1 = -\alpha_1\bar{P} + \alpha_2 G_1 - \alpha_3 G_2 \quad (1)$$

Where Q_1 is the number (of passages) sold and $\bar{P}$ is the cartel price, which is assumed to be binding and common to both firms. Demand is positively related to the index of quality effort, G_1, of firm 1 and negatively to the index of quality effort of firm 2, G_2. Firm 2 faces the same demand conditions and so the total market demand is:

$$Q = Q_1 + Q_2 = -2\alpha_1\bar{P} + (\alpha_2 - \alpha_3)(G_1 + G_2) \quad (2)$$

It is worth noting that increases in the supply of quality increase total demand only if $\alpha_2 > \alpha_3$; the positive own quality effect is greater than the negative effect of firm 2's quality on firm 1's demand, which seems a reasonable assumption .

Firm 1's profit is total revenue minus long run cost (so all costs are variable):

$$\pi = \bar{P}Q_1 - cQ_1 - G_1 Q_1 \quad (3)$$

Where c is the per unit voyage cost including capital (as this is the long run) for the most basic product and G_1 represents cost of enhancing the quality above the basic level.

The firm maximises its profit over the choice variables $Q_1$and G_1 subject to the demand curve (as $\bar{P}$ is fixed by the cartel it is not a choice variable). From the first order conditions for profit maximisation the optimum quality for firm 1 is:

$$G_1 = \frac{(\alpha_1 + \alpha_2)\bar{P} - \alpha_2 c}{2a_2} + \frac{\alpha_3 G_2}{2\alpha_2} \quad (4)$$

The first term indicates that a higher cartel price induces the firm to invest in greater quality effort, while an increase in basic cost has a negative effect on the choice of quality. The second term shows that an increase in firm 2's quality would induce an increase in quality effort by firm 1. This is the reaction function and its positive slope implies that the quality choices are strategic complements. Note also that if firm 1's demand depended only on the difference in quality between the two firms so that $\alpha_2 = \alpha_3$, then the slope of the reaction function would be one half.

Firm 2 is assumed to be identical to firm 1 so that its reaction function is:

$$G_2 = \frac{(\alpha_1 + \alpha_2)\bar{P} - \alpha_2 c}{2a_2} + \frac{\alpha_3 G_1}{2\alpha_2} \quad (5)$$

Solving reaction functions (4) and (5) for the Nash equilibrium gives the quality for firm 1 as:

$$G_1^* = \frac{(2\alpha_2 + \alpha_3)[(\alpha_1 + \alpha_2)\bar{P} - \alpha_2 c]}{(2\alpha_2)^2 - (\alpha_3)^2} \tag{6}$$

Where G_1^* is equilibrium quality effort and similarly for G_2^*, so that $G_1^* = G_2^*$. In this expression the denominator is positive (as $2\alpha_2 > \alpha_3$). An increase in the cartel price induces an equilibrium increase in quality and an increase in basic cost reduces quality.

As in (3) above, firm 1's profit is price minus cost times quantity:

$$\pi_1 = Q_1(\bar{P} - c - G_1^*) \tag{7}$$

From (1) above, firm 1's demand curve (and as $G_1^* = G_2^*$) is:

$$Q_1 = -\alpha_1\bar{P} + (\alpha_2 - \alpha_3)G_1^* \tag{8}$$

Substituting for Q_1, equilibrium profit can be written as:

$$\pi_1^* = -\alpha_1\bar{P}^2 + (\alpha_2 - \alpha_3)\bar{P}G_1^* + \alpha_1 c\bar{P} - (\alpha_2 - \alpha_3)cG_1^* + \alpha_1\bar{P}G_1^* - (\alpha_2 - \alpha_3){G_1^*}^2 \tag{9}$$

While this expression is somewhat messy the derivative with respect to $\bar{P}$ is:

$$\frac{d\pi_1^*}{d\bar{P}} = \alpha_1(c - 2\bar{P}) + (\alpha_1 + \alpha_2 - \alpha_3)\left(G_1^* + \bar{P}\frac{dG_1^*}{d\bar{P}}\right) - (\alpha_2 - \alpha_3)(c + 2G_1^*)\frac{dG_1^*}{d\bar{P}} \tag{10}$$

The first term and third terms are negative and the second term is positive (given that from (6) above $\frac{dG_1^*}{d\bar{P}} > 0$). The overall sign is ambiguous and so profit could increase or decrease as the cartel price increases (the choice of which is not considered here).

The derivative with respect to basic cost, c, is:

$$\frac{d\pi_1^*}{dc} = \alpha_1\bar{P} + (\alpha_1 + \alpha_2 - \alpha_3)\left(\bar{P}\frac{dG_1^*}{dc}\right) - (\alpha_2 - \alpha_3)G_1^* - (\alpha_2 - \alpha_3)(c + 2G_1^*)\frac{dG_1^*}{dc} \tag{11}$$

Here the first and fourth terms are positive and the second and third are negative (given that from (6) above $\frac{dG_1^*}{dc} < 0$) and so the effect of an increase in basic cost is also ambiguous.

It worth stressing that these effects arise from profit maximising responses in the Nash equilibrium and so any deviation by one firm would reduce its profits.

These results are not uniquely dependent on this particular specification as they accord with those obtained in more general theoretical frameworks as applied to health care (see Gaynor 2006, also Montifiori 2003). For an assessment of alternative models of shipping conferences, see Sjostrom (2010).

References

Gaynor, M. (2006), "What Do We Know About Competition and Quality in Health Care Markets?" University of Bristol: CMPO Working Paper 06/151.

Montefiori, M. (2003), "Hotelling Competition on Quality in the Health Care Market," POLIS Working Papers 33, Institute of Public Policy and Public Choice, Università del Piemonte Orientale.

Sjostrom, W. (2010), "Competition and Cooperation in Liner Shipping," in C. T. Grammenos (ed.) *Handbook of Maritime Economics and Business* (2nd edn.), London: Routledge.

Appendix 6: Quarterly data and supplementary regressions

Quarterly data

Sources for the quarterly data used in the regression analysis in Table 5 and in Tables A10 and A11 below are as follows:

Fares. Quarterly steerage/third class fares are taken from Keeling (2008a, pp. 24-28). These are based on Cunard's revenue per adult equivalent passenger so they represent actual receipts rather than advertised fares and they do not include agent's fees.

Conference strength. This is taken from Deltas and Sicotte (2017, p. 677) for the UK-Scandinavia conference (Agreement A A). It takes the value 1 when a conference was in full operation, otherwise 0. This is carried back to 1883 on the basis of descriptive accounts by Aldcroft (1968) and Hyde (1975, Ch. 4).

Immigrant flows. Total quarterly arrival of alien immigrants into the United States, 1883 I to 1903 II is taken from US Bureau of Commerce, *Monthly Summary of Commerce and Finance*, June 1903. 1903 III to 1905 II monthly from the same publication. February 1904 and April 1905; 1905 II to 1913 IV monthly from US Commissioner of Immigration, *Annual Reports*, 1906 to 1914.

US real GNP. Originally from Balke and Gordon (1986), accessed at: https://www.nber.org/research/data/american-business-cycle-continuity-and-change-historic-data-tables, (series RGNP72).

Wholesale price index. This is a quarterly version of the Sauerbeck/Statist index compiled by the NBER at: https://data.nber.org/databases/macrohistory/rectdata/04/m04053.dat.

Supplementary regressions

In columns (3) and (4) of Table 5 of the main paper, conference effectiveness was instrumented with the same variable lagged two further periods. The first stage regressions are presented in Table A11 These illustrate the strong correlation between the conference variable lagged one and three periods. The only other significant variable is the potentially endogenous variable for US immigration.

An alternative is to instrument using the effectiveness of conferences on other routes from Deltas and Sicotte (2017). Unfortunately, these go back only to 1899 and I lack the information to extend them back to the 1880s as for the UK-Scandinavian route. The results are presented in Table A12 below. For this period, I use as the instrument the average of three routes by origin: Mediterranean, France and Rhineland and this is lagged one quarter to match the endogenous variable. The IV coefficients on the conference dummy in columns (3) and (4) can be compared with the OLS coefficients of columns (1) and (2), which cover the same period. The coefficients on the conference dummy are slightly weaker than in Table 5, which perhaps is not surprising as the dummy switches only twice over this period. In both OLS and IV regressions, they are of the same order of magnitude as in Table 5. But the main difference in the results is that the variables for US immigration or US GDP now lose significance.

Table A11: First stage for IV regressions in columns (3) and (4) of Table 5; dependent variable: Conference effective (=1), t-1

	(1)	(2)	(3)	(4)
			IV	IV
Conference effective (=1), t-3			0.704***	0.777***
			(0.08)	(0.09)
Log steerage fare, t-1			0.120	0.107
			(0.13)	(0.14)
Log US immigration, t-1			-0.259***	
			(0.07)	
Log US real GDP, t- 1				-0.637
				(0.61)
Log UK wholesale price index,			0.119	-0.445
t-1			(0.43)	(0.45)
Under-identification, χ^2 (1)			24.7	24.7
Weak identification, F (119,1)			64.4	73.4
Observations			120	120

Sources: As listed above. *Notes*: All regressions include three seasonal dummies and a linear time trend. The standard errors in parentheses are adjusted for serial correlation of up to four quarters; significance levels, *** 1%, **5%, * 10%. The under-identification (Kleinbergen Paap) statistic is a test for the irrelevance of the excluded instrument (critical 5% value 7.9). The weak identification (Cragg-Donald) test reflects the correlation of the excluded instrument with the endogenous regressor (critical 10% value 16.38).

Table A12: Regressions of westward steerage fares, quarterly from 1899 to 1913

	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
Conference effective (=1), t-1	0.147**	0.174***	0.139*	0.183**
	(0.07)	(0.06)	(0.08)	(0.07)
Log steerage fare, t -1	0.590***	0.518***	0.597***	0.507***
	(0.11)	(0.12)	(0.12)	(0.13)
Log US immigration, t-1	0.043		0.037	
	(0.07)		(0.08)	
Log US real GDP, t-1		0.928		0.979
		(0.64)		(0.68)
Log UK wholesale price index,	0.325	0.228	0.320	0.232
t-1	(0.49)	(0.49)	(0.49)	(0.49)
Under-identification, χ^2 (1)			25.2	29.1
Weak identification, F (58,1)			142.2	150.1
R-squared	0.703	0.714	0.703	0.714
Observations	59	59	59	59

Sources: As listed above. *Notes*: All regressions include three seasonal dummies and a linear time trend. The standard errors in parentheses are adjusted for serial correlation of up to four quarters; significance levels, *** 1%, **5%, * 10%. The under-identification (Kleinbergen Paap) statistic is a test for the irrelevance of the excluded instrument (critical 5% value 7.9). The weak identification (Cragg-Donald) test reflects the correlation of the excluded instrument with the endogenous regressor (critical 10% value 16.38).

References not listed in the main paper

Balke, N. S and Gordon, R. J. (1986) "Appendix B: Historical Data," in R. J. Gordon (Ed.), *The American Business Cycle: Continuity and Change,* Chicago IL: University of Chicago Press.