

The Influence of the Suez Canal on Steam Navigation

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Economic Honors

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Abstract

The Suez Canal provided steamships, but not sail ships, a shortcut to Asia after it opened in 1869. Although the Canal has long been recognized as an impetus for the use of steamships, little previous research investigates how the Suez Canal affected the diffusion of steamships. This thesis uses data on the tonnage of British sail and steamships which entered ports in the United Kingdom from worldwide locations to examine the effect that the Suez Canal had on steamship use. Difference-in-difference-in-difference modeling separates the increase in steam tonnage caused by the opening of Suez from increases caused by changing cargo and improving steamship technology. Suez made steamships competitive on Asian routes, but these routes constituted a small share of worldwide shipping. The Suez Canal caused roughly a 178 percent increase in steamship use on Asian routes from 1869 until 1874.

Introduction:

Steamships began to replace sail ships in the 19th century, and become widely used for ocean commerce in the second half of the 19th century. This diffusion of steamships depended on cargo, technology, currents and infrastructure. For worldwide cargo, steamships replaced sail ships as steamships became faster and more regular than sail ships. However, steamships were burdened by a dependence on coal. As the distance a steamship traveled increased, so did the amount of cargo space devoted to coal (Harley 1971). The further a steamship traveled, all else equal, the more it cost. Therefore, sail ships were displaced first on short-distance routes, then, as steamship technology improved, on progressively longer distance routes. Long distances were the final frontier for steamships.

When the Suez Canal opened in 1869, it cut the shipping distance to Asia by connecting the Mediterranean and Red Seas. However, rounding the Cape of Good Hope remained the cheapest route for sail ships. The effect of the Suez Canal was to cut the distance to Asia for steamships but not for sail ships. Thereby, the Suez Canal counteracted the cost using steamships on this long-distance route and made steamships a possible substitute for sail ships on Asian routes. The goal of this thesis is to explain to what extent the Suez Canal changed worldwide and Asian steamship use.

The primary data are from the Shipping and Merchant Shipping House of Commons Parliamentary Papers. These Papers record the tonnage of sail and steamships which entered United

Kingdom ports from international locations each year from 1865 to 1874.¹ Tonnage of steamships entered from international locations surpassed that of sail in the late 1860's. Steam dominance was based on short distances where shipping was concentrated. Steamship use for long distances lagged behind. In 1868, the year before Suez opened, 60 percent of the 7.5 million tons that entered from Europe, North America, and the Mediterranean, all of which can be classified as short-distance locations, were steamships. But only 12 percent of the 2 million tons from long-distance locations - Asia, the Caribbean, Central America and South America - were steamships. From Asian locations just 2 percent of the 1.1 million tons entered were steamships. In the four years after Suez opened there was a rapid increase in steam tonnage from Asia.

Due to the fact that ships were durable goods, it took a number of years for the market to adjust to Suez. At the same time as steam tonnage from Asia was responding to Suez, Asian cargo and improving steam technology also influenced the amount of steam tonnage from Asia. Suez affected only steam tonnage from Asia. Asian cargo affected both sail and steam tonnage from Asia. And improving steam technology affected steam tonnage from worldwide locations. Because of the differential impact of Suez, cargo, and technology, difference-in-difference-in-difference (DDD) modeling can isolate the effect Suez had on steam tonnage from Asia. By subtracting the change in Asian sail tonnage from the change in Asian steam tonnage after 1869, the change caused by Suez is separated from changes caused by Asian cargo. By subtracting the change in Non-Asian steam tonnage from the change in Asian-steam tonnage after 1869, the change caused by Suez is separated from changes caused by steamship technology. Suez increased steam tonnage from Asia by about 178 percent in the four years after opening, holding constant cargo and technology.

¹ Tonnage of Ships Entered = Volume Per Ship x Number of Entries

Background:

After rounding the Cape of Good Hope, Europeans began direct sea trade with Asia in the 16th century. At the beginning of the 17th century, the British East India Company was chartered by Elizabeth I to trade in Asia. With the Moghul Empire in decline, the East India Company established direct holding of Bengal, in Northeast India, during the Seven Years War (1756-63). The British greatly expanded their holdings in India, drove imperial rivals out of Asia, and became the supreme worldwide naval power during the Napoleonic Wars (1793-1815) (Darwin 2008). By 1869 the British shipped extensively to India, China and Australia.

The Suez Canal which opened in 1869 was not the first canal to connect the Mediterranean and Red Seas. From the 7th century BC until the 8th century AD, canals, using the Nile River, at times connected the Seas. During the Crusades - the 11th through the 13th century - the French became interested in reviving a canal. Much later, in 1798, Napoleon Bonaparte invaded Egypt, seeking possession of Egypt and the possibility of a canal as a way to undermine British dominance in Asia. With no definite plan for the construction of a canal, the French were driven out of Egypt by the British in 1801. Rather than a canal to facilitate Asian trade, the British favored and, in 1854, completed a railway from Alexandria to Cairo (Hallberg 1974).

Under heavy British political opposition, the French and Egyptian owned Suez Canal Company began construction in 1859. Planning and construction were headed by the Frenchman Ferdinand de Lesseps. Lesseps' proposal to the Viceroy of Egypt notes the "immense impulse" the Canal would give to steamship use. The modern Canal is different from ancient canals in that it runs straight across the Isthmus of Suez rather than using the Nile River. The Red and Mediterranean Sea levels are the same, so there are no locks on the Suez Canal. Water and fish move freely between the Seas, while ships pay to pass through.

Some early observers recognized the Suez “canal would be useless except for steamers” (Bedford 1859, 191). Conversely, others recognized that Suez alone did not make steamships a viable alternative to sail ships for Asian routes (Sumada 1870). Given coal-capacity constraints, steamships were inefficient for long distances. Because coal was cheapest in Britain throughout the 19th century and “coal used in ocean navigation came almost entirely from British coal fields” (Harley 1988, 863), the option of re-coaling did not greatly alleviate the relationship between the distance traveled and cost of using coal. Nevertheless, as steamship technology developed faster than sail ship technology, ship owners replaced sail ships on increasingly long-distance routes (Harley 1971).

Wind and currents also played a role in whether sail or steamships were used on a route. Before the Suez Canal opened, while very few steamships went directly to Asia, primarily steamships were used on both sides of the Alexandria-Cairo railroad line (Houghton 1869). After Suez opened, poor sailing conditions on the Suez route and towing cost through the Canal for sail ships maintained the Cape of Good Hope as the cheapest sailing route to and from Asia for sail ships (Richards et al. 1869). Just two hundred of the five thousand ships which passed through Suez in the five year after its opening were sail ships (Fletcher 1958). Table (1) shows the difference in distances between rounding the Cape of Good Hope (the sailing route) and using the Suez Canal (the steam route) to reach Asian locations from London.

Table (1):

Suez and Cape Shipping Route Lengths

Ports	Distance by Cape	Distance by Canal	Miles Saved by Canal	Percent of Voyage Saved by Canal
Bombay	10,667	6,274	4,393	41.2
Madras	11,280	7,313	3,967	35.2
Calcutta	11,900	8,083	3,817	32.1
Singapore	11,740	8,362	3,378	28.8
Hong Kong	13,180	9,799	3,381	25.6
Shanghai	14,050	10,669	3,381	24.1
Adelaide	11,780	11,100	680	5.8
Melbourne	12,140	11,585	555	4.6
Sydney	12,690	12,145	545	4.3
Wellington	13,610	13,055	555	4.1

Data From: Rabino (1887) pg. 526

*In nautical miles

By the mid-19th century the British had developed the most advanced steam-shipbuilding industry and steamship fleet (Pollard 1957). British-Asian trade and steam-shipping supremacy made using the Suez Canal mainly a British activity. British-owned tonnage accounted for 66 percent of the tonnage passing through Suez in 1870 and 74 percent by 1874 (Rabino 1887).

Literature Review:

Half a year after Suez opened, Samuda (1870) discussed to what extent steamships were expected to replace sail ships on Asian routes. He argues that Suez was important in the diffusion of steamships because by 1869 steamship technology had reached a level sufficient to make steamships, using Suez, a substitute for sail ships on Asian routes. Ten years earlier, steam engines were too inefficient at burning coal and there were too few steamships for the Canal to have been used effectively. However, based on engine efficiency and the fleet size in 1869 steamships were expected to gain most cargo shipped to Bombay. Furthermore, he expected Bombay on the northwest coast of India to become the main port in India based on its proximity to Suez. Steamships were not expected to make significant progress into trade with China or Australia as the distance advantage steamships gained traveling to these locations was smaller.²

Graham (1956) discusses how cargo, technology and the Suez Canal affected steamship use. The opening of the Suez Canal and the introduction of the compound engine in 1860's gave steamships an advantage over sail ships for most ocean commerce in the early 1870's. "For two or three years after 1869 the building of the larger [wooden] ships almost stopped" (Graham 1956, 83). Yet, expanding commerce in cheap bulk-cargoes, specifically coal, kept sail ships afloat for more than another decade. For Asian shipping Suez reduced the longest gap between coaling stations from five thousand miles to two thousand miles (Graham 1956). Furthermore, the Suez route gave steamship access to depots with cheaper coal (Fletcher 1958). These two factors further decreased the cost of steamships on the Suez route.

² Sumada (1870) unclearly estimates that a steamship in 1869 of around 2,500 tons traveling at a speed of nine knots used about four hundred tons of coal on the one way trip to India and about eight hundred tons on the trip to China.

Fletcher (1956) makes the most direct statement about the effect Suez had on the diffusion of steamships. Using data on new-sail and new-steamship tonnage per year, Fletcher argues that “Suez made the transition from sail to steam sharp and decisive” (Fletcher 1956, 563). Before Suez opened new-sail tonnage per year had always been greater than new-steam tonnage per year. Conversely, in 1869 there was more than twice as much new-steam tonnage. New-sail tonnage was greater than new-steam tonnage in merely two years subsequent to the opening of Suez (Fletcher 1956). The demand for new-steamships was increased, by the recently developed compound engine and the opening of Suez. The spike in demand for new steamships caused by Suez was especially high because steamships equipped with compound engines alone could effectively use the Suez route (Fletcher 1958). Moreover, it was high because Suez was too narrow for the largest pre-Suez steamships (Hallberg 1974). Fletcher argues that the increase in steam production associated with the opening of Suez was large enough to make steamships the principal carrier of British commerce (Fletcher 1958). In 1874 registered-steam tonnage was half the size of registered-sail tonnage, but Fletcher speculates that steamships’ speed and regularity allowed them to carry about three times as much cargo per year.

Harley (1971) argues that steam gradually displaced sail from European and Atlantic routes based on currents, cargo, and technology. On routes to Asia, the displacement of sail was accelerated by the opening of the Suez Canal. With intermittent data of the tonnage of sail and steamships entering the UK, Harley (1971) argues that steamships gained cargo from Bombay quickly, but the most dramatic steam gains were in shipping from China because of the high proportion of luxury goods shipped. For luxury and other time-dependent cargo, such as mail, passenger, and perishables the speed and regularity of steamships was highly demanded (Harley 1971).

Graham (1956) and Fletcher (1958) use data on new ships to argue that Suez was a major factor in increasing the demand for new steamships. With data on the tonnage of sail and steamships entering the UK from some Asian locations at various times after 1869, Harley (1971) argues that Suez was a factor in the increase of steamship use on Asian routes. The literature identifies cargo, technology and

Suez as the main factors of steamship diffusion from 1860 to 1880. At the same time, none of these authors separate the increase in steam production or steam use caused by Suez from increases caused by changing cargo and improving steam technology. I use data on the tonnage of ships entering the UK from worldwide locations, to isolate how Suez increased steamship use. My data allow for testing of the theory that steamships first displaced sail from short distance routes. It allows for the revision of previous conclusions, such as when steam surpassed sail as to dominant vehicle for ocean commerce, how much more cargo steam could carry than sail ships per year, and which Asian locations saw the fastest increases in steam use after Suez opened. Most importantly, this thesis places the impact of Suez in perspective of increasing worldwide steamship use and clearly answers how the Suez Canal affected steamship use to Asia.

Data:

I utilize multiple sources of data to analyze how the Suez Canal influenced steamship use. The primary data were obtained from House of Commons Parliamentary Papers. Shipping Papers (1865-1867) list the tonnage of ships which entered into UK ports, including repeated voyages, with cargo and in ballast distinguishing by British and foreign, steam and sail ships, and international location, from 1865 until 1867. Merchant Shipping Papers (1870-1876) list the tonnage of ships with cargo distinguishing by British and foreign, steam and sail ships, and international location, from 1868 until 1874. The data document Tonnage of Ships, which is the carrying capacity of ships. Both the Shipping and the Merchant Shipping Papers were returns of compiled information by the Board of Trade in response to orders made by Parliament. The purpose of the Board of Trade was to track and analyses UK trade statistics and thereby promote economic activity (National Archives 2010). *Lloyd's Register of British and Foreign Shipping*, Annual Statement of Navigation House of Commons Papers, *British Historical Statistics* by Mitchell (1988), *Tonnage Statistics of the Decade: 1870-80* by Glover (1882), *The Statistical Story of the Suez Canal* by Rabino (1887) and additional information from Shipping and Merchant Shipping Papers are supplementary data.

Lloyd's Register has continuously recorded characteristics and classed ships based on seaworthiness to provide the shipping community with information on the character of ships since 1760. I compiled a 5 percent random sample of all ships in the 1871 Lloyd's Register.³ Mitchell (1988) consolidates information from Parliamentary Papers, Lloyd's Register, and a variety of other sources about shipping and trade in order to track and provide data on economic growth. Glover (1882) compares assorted statistics about shipping from 1860, 1870, and 1880 to analysis the effects of repealing the Navigation Act in 1849. Rabino (1887) records information on the use and revenue of the Suez Canal in order to affirm the importance of the Canal.

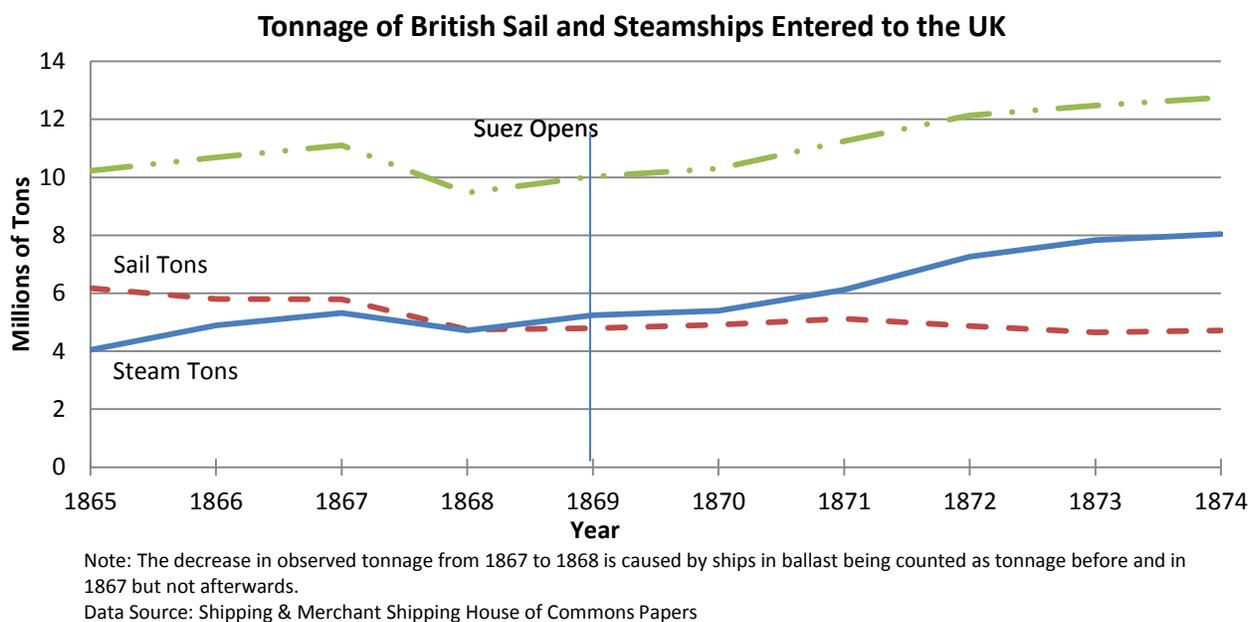
Descriptive Statistics:

In 1870, the total tonnage of ships entered inwards and cleared outwards from UK ports was 72 million tons. Thirty-six million tons were the coastal shipping of England, Scotland and Ireland. Steamships are expected to have gained coastal shipping first because steamships were least hampered by the cost of using coal on these short-distance routes. Tonnage entered from and cleared to foreign countries and British possessions accounted for the remaining 36 million tons shipped in 1870. This study looks at the shipping from these international locations to determine how Suez affected steamship use. Tonnage cleared is not observed for all years, so the data are restricted to tonnage entered for most of the analysis. Additionally, because of British supremacy in steam-shipping, Asian trade and therefore using Suez, the data are further restricted to British ships.

Figure (1), graphs tonnage entered to UK ports from international locations distinguishing by sail and steam from 1865 until 1874.

³ Furthermore, 10 percent random sample of newly and re-registered ships in Lloyd's Register for every other year from 1865 until 1874 were taken but are not used in this thesis.

Figure (1):

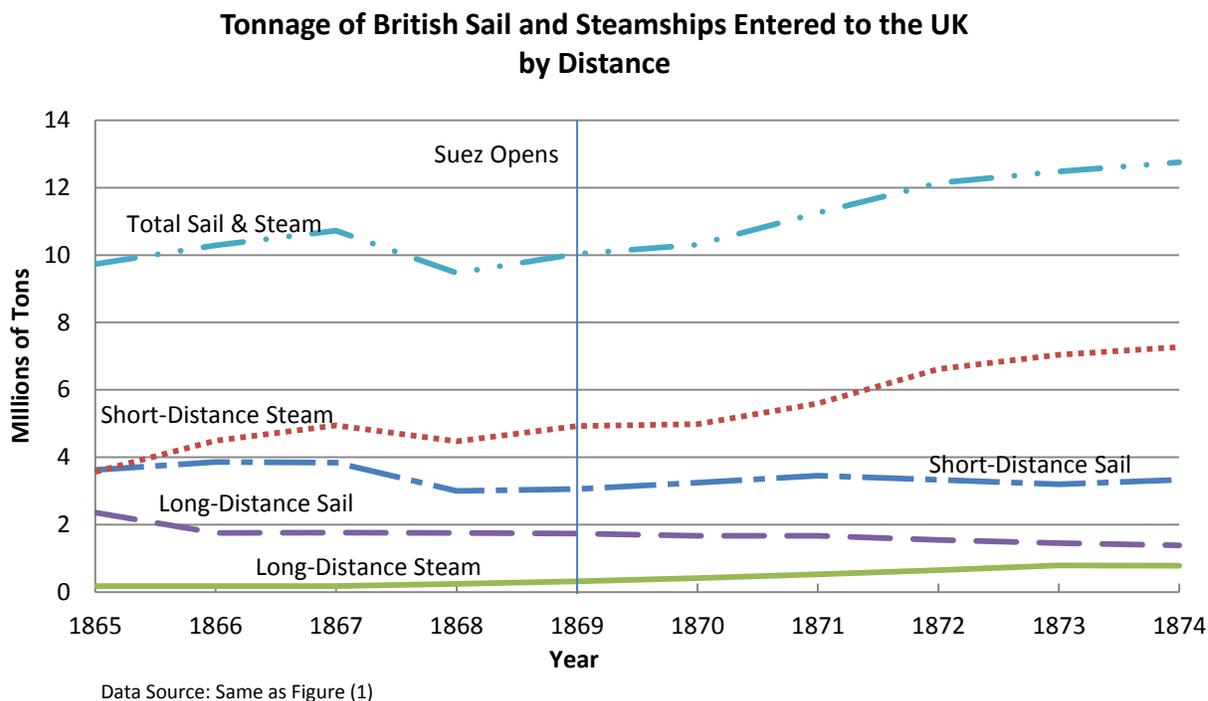


While total shipping expanded through the period, sail steadily decreased and steam fairly steadily increased. Steam surpassed sail as the dominant British mode of international shipping in the late 1860's or early 1870's. In spite of registered-steam tonnage totaling one million tons and registered-sail tonnage totaling five million tons (Mitchell 1988), more steam tonnage entered in 1869 because steamships were faster, more regular and, as will be shown, steamships were mostly used on short routes. Steam surpassed sail before Suez could have had an impact.

In order to begin isolating the effect of Suez, tonnage from long-distance and short-distance locations were separated. Short-distance locations are all of Europe, the Mediterranean, the United States, the Baltic and anywhere closer than 35 hundred miles from the English Channel.⁴ Long-distance locations are South America, Central America, the Caribbean, and all of Asia. Figure (2) graphs the tonnage entered distinguishing by sail and steam and distance to the locations the ships entered from.

⁴ Grouping the United States as short distance is somewhat problematic because Southern ports and Western Ports are further than thirty-five hundred miles from England. Annual Navigation papers show that 1.5 million tons entered from U.S. ports on the Atlantic while 56 thousand tons entered from ports on the Pacific.

Figure (2):



Shipping was concentrated on short-distance routes. Steam surpassed sail tonnage from short-distance locations in 1865. But steam did not surpass sail from long-distance locations during the time period. This supports the notion that steamships were limited on long-distance routes by the increasing amount of coal needed. Steamships gained long-distance routes last, and on some of these long-distance routes Suez had an effect. There was an increase in steam tonnage entered from long-distance locations that coincided with the opening of Suez. This increase was small compared to the gains steamships made at short distances.⁵

The decrease in observed tonnage caused by ships in ballast not being counting after 1867 took place on short-distance routes.⁶ More precisely, the decrease was mostly in sail tonnage from short-distance locations. This shows that some sail ships were employed carrying cargo one way, or employed

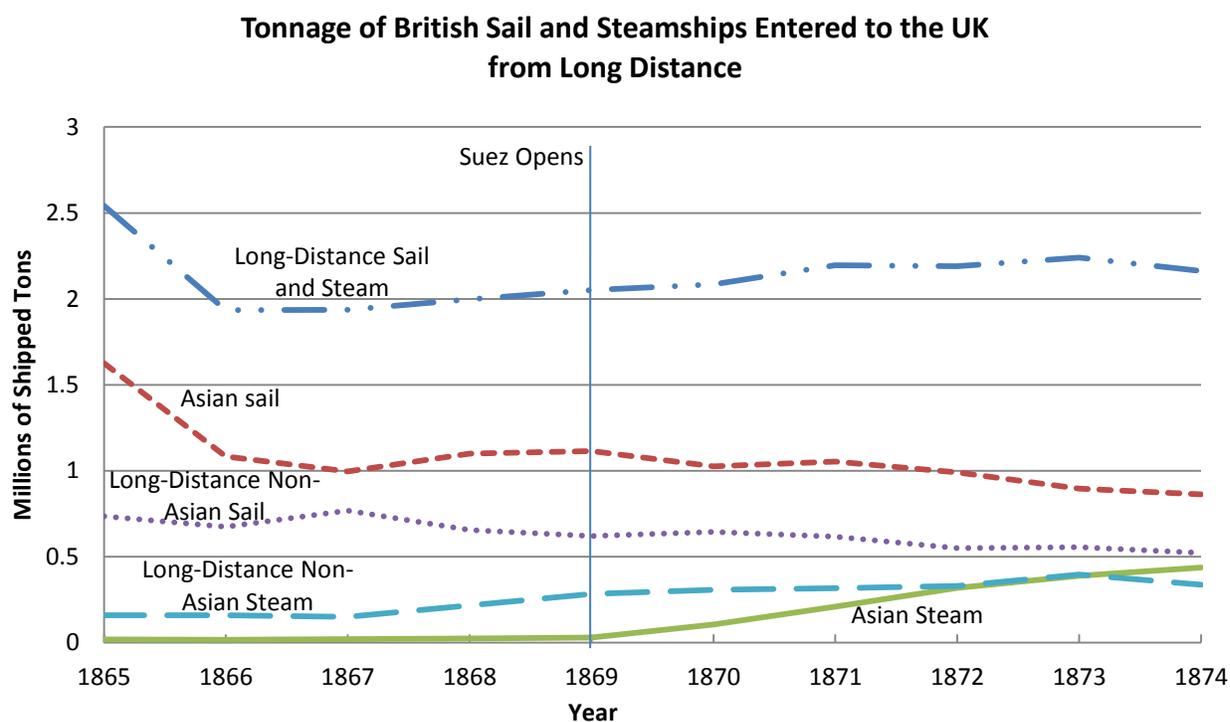
⁵ The effect Suez had on the tonnage of new steamships built, which is what Graham (1956) and Fletcher (1958) examine, was magnified because narrow steamships with compound engines were needed to use to Suez and because of the time it took to ship to Asia.

⁶ Ballast: heavy material, such as gravel, sand, iron, or lead, placed low in a vessel to improve its stability (Stevenson 2010).

carrying purely ballast. More importantly it shows that steamships and ships from long distances imported cargo. The fact that ships in ballast stopped being counted is not a significant problem for this study because it has little effect on the tonnage observed from long-distance locations.⁷

Suez promoted steamship use only from Asia out of the long-distance routes. To further isolate the effect Suez had on tonnage of steamships entered, Asian and long-distance Non-Asian locations were separated. Long-distance Non-Asian locations are Central American, South America, and the Caribbean. Asian locations are Arabia, India, China, Australia, and anywhere that steamships could cut the distance to by using Suez. Figure (3) graphs the tonnage entered from long-distance locations distinguishing by sail and steam, and Asian and Non-Asian.

Figure (3):

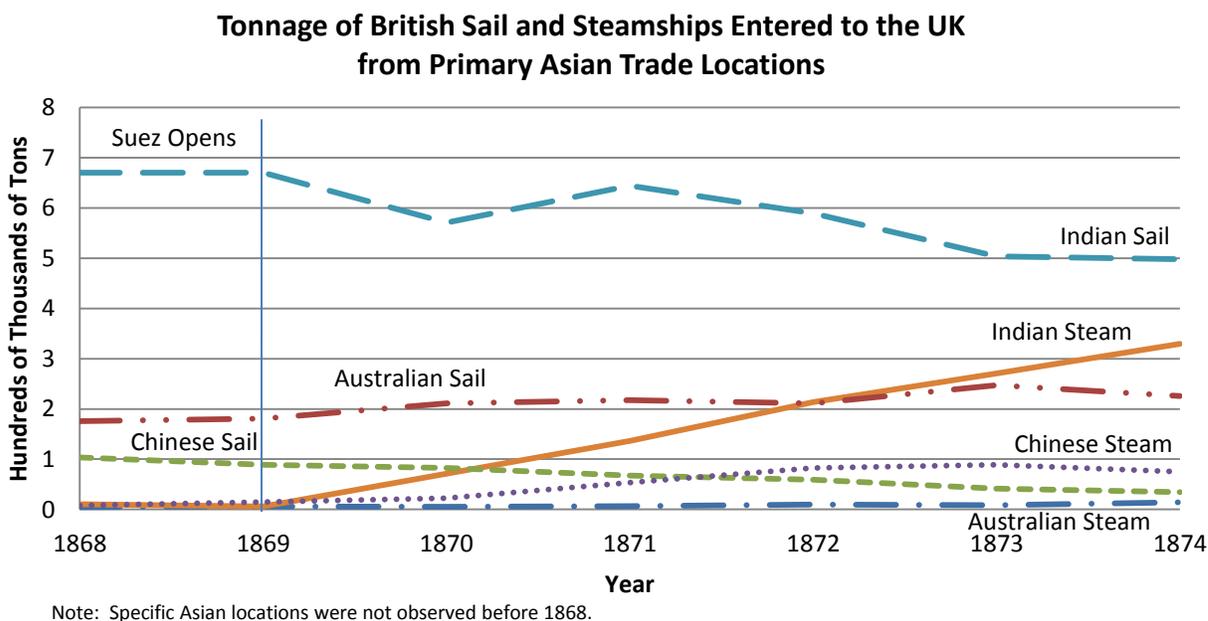


Note: The scale of this graph is much smaller than that of earlier graphs.
Data Source: Same as Figure (1)

⁷ There is a fifty thousand ton decrease in sail tons imported from Central and South America attributed to ballast tons ceasing to be recorded.

In the four years after the Suez Canal brought Asia within the reach of steamships, steam tonnage from Asia increased by about five hundred thousand tons. At the same time, steam tonnage from long-distance Non-Asian locations increased slightly, likely as a result of improving steam technology, and Asian Sail tonnage gradually decreased, likely as a result of being displaced by steamships. The large decrease in sail tonnage from Asia from 1865 until 1866 was mostly a result of British cotton trade returning the United States after the Civil War.⁸ Variations in tonnage entered from locations and of sail ships, which Suez had no effect on, signify that the Canal was not the only factor influencing tonnage entered. Suez cannot be fully credited with the increase in steam tonnage from Asia after 1869. In the Methodology and Results sections I develop and use a DDD model to identify the increase in steam tonnage from Asia caused by the Suez Canal.

To see which locations were affected the most by Suez, Asia was separated into specific locations. Figure (4) tracks sail and steam tonnage entering from India, China, and Australia, Britain's three main Asian trading partners from 1868 to 1874.

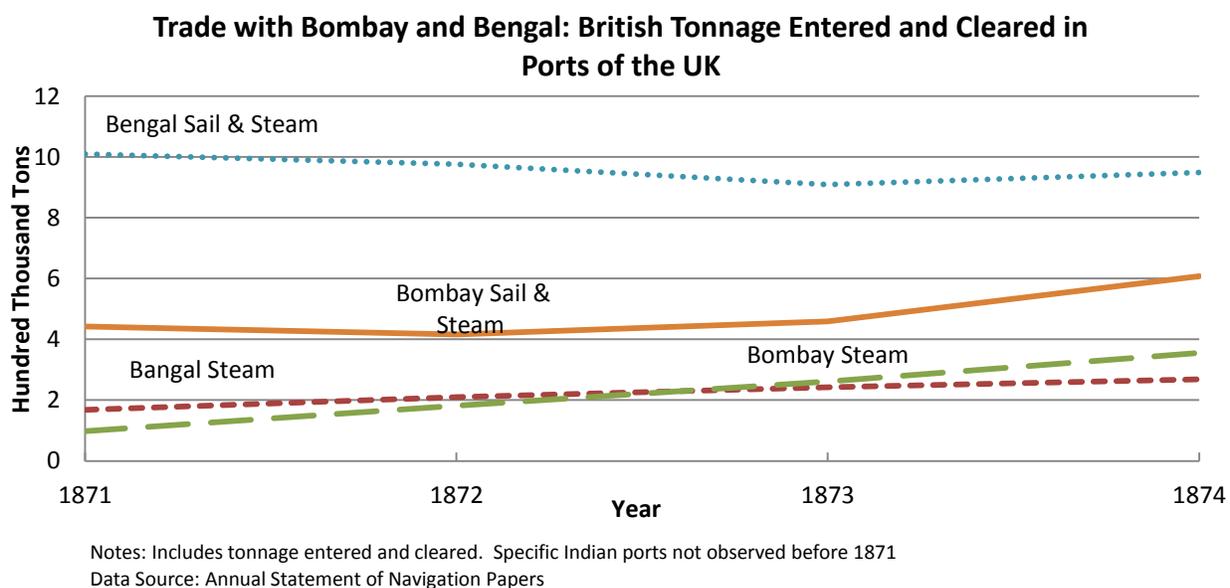


⁸ Tonnage of both British sail and steamships entered from the U.S. increased by two hundred thousand tons from 1865-1866. Raw cotton imports from the U.S. increased by 192,000 tons from 1865-1866 (Mitchel 1988, 334).

Aden, Ceylon (Sri Lanka), Japan, Siam (Thailand), and Singapore were excluded from the graph because there was little cargo shipped from these places, mostly much less than seventy thousand tons per year. The main increase in steamship use to Asia after 1869 was to India, Britain's main Asian trading partner. But proportionately, China had the most dramatic gains. Steam surpassed sail tonnage from China 1872, while steam did not surpass sail tonnage from India during the period. Although, steamships gain less of a distance advantage on Chinese routes, the high share of luxury goods exported from China promoted steam use (Harley 1971).

Figure (5) separates the prominent ports in Indian to see where in India Suez had the largest effect.

Figure (5):



While Bengal on the northeast coast of India was the largest trading port in 1869, by 1874 more steam-tonnage entered the UK from Bombay, on the northwest coast of India. This accelerated growth for shipping from Bombay is explained by Bombay being twenty percent closer to the UK using the Suez

route but only ten percent closer using the Cape route.⁹ This made trade with Bombay more convenient after Suez opened. Total tonnage entered from Bombay was approaching tonnage from Bengal by 1874. It appears that Suez was a factor in the growth of trade with Bombay, which is currently India's largest city.

Again, more steam tonnage than sail tonnage entered the UK by the early 1870's. Steamships first gained short distance routes where most shipping occurred. For long distances steamships were limited by the cost of using coal, so sail ships remained as the primary vehicle for these routes through 1874. When the Suez Canal opened in 1869 it gave steamships an advantage for the long-distance routes to Asia. Steam tonnage entered from Asia increased rapidly directly after Suez opened. This increase was from expanding steam tonnage from India and China.

Methodology:

The opening of the Suez Canal was an infrastructural development that promoted steamship use on Asian routes. But ships lasted years, even decades, and took months to build.¹⁰ Furthermore, only narrow-enough steamships with compound engines could efficiently ship on the Suez route. Preceding figures illustrate that it took time for steamship use on Asian routes to increase in response to Suez. Changes in steam tonnage entered from locations not affected by Suez and changes in sail tonnage entered indicate that other factors were shifting tonnage entered per year. Previous research identifies cargo, technology and Suez as the main factors which determined steamship use. While Suez promoted steamship use on Asian routes after 1869, changing cargo and improving technology also shifted the equilibrium steam tonnage from Asia. To determine the effect Suez had on steamship use from 1869 to 1874, I use a difference-in-difference-in-difference (DDD) model. This separates the increase in steam

⁹Percent differences were calculated using data from Table (1). The distance to Calcutta, the main port in Bengal, was used as the distance to Bengal.

¹⁰In 1871, the average sail ship was eleven years old and the average steamship was six years old (Lloyd's Register 1871). Steamships were younger because they were a new product, not because they were less durable.

tonnage from Asia caused by Suez from increases in steam tonnage from Asia caused by changing cargo and improving technology.

The data for this model are the same as used in Figure (3). An observation is tonnage entered from location i at time t using mode s . The locations are Asian and long-distance Non-Asian. The time frame is from 1866 until 1874. This is enough time to estimate the change in steamship use before and after the opening of Suez but a short enough time that changing cargo, technology, and unobserved variables are minimized. The modes are sail and steamships. The dependent variable is the tonnage of ships entered. The independent variables are whether the observation is from Asia, the year, whether the observation is after 1869, and whether the observed mode is steam.

The Suez Canal only directly affected steam tonnage from Asia. The other main factors - cargo and technology – affected sail and steam tonnage, and Asian and Non-Asian tonnage. This model assumes that the changing amount of Asian cargo increased sail and steamship tonnage proportionately because neither mode gained an advantage. Accordingly, the increase in steam tonnage from Asia caused by Suez is separated from increases caused by changes in Asian cargo by subtracting the change in Asian sail tonnage from the change in Asian steam tonnage after 1869. Because Asian sail tonnage was overstated in 1865, due to a temporary shock, this year is eliminated from the data.¹¹ Since sail and steamships were better suited for different types of cargo, changes in the type of cargo shipped may have altered sail and steamship tonnage. Because the time period is short it is not unreasonable to consider the type of cargo shipped as constant.¹²

This model assumes that diffusion of technology increased steam tonnage on routes which steamships were already efficient on and improving technology increased steam tonnage on progressively longer routes. Technology increased Asian and long-distance Non-Asian steam tonnage proportionately

¹¹ If 1865 was not eliminated, sail tonnage from Asia before 1869 would be overestimated, making the increase caused by Suez likewise overestimated.

¹² In opposition to this assumption, Graham (1956) argues that expansion of Asian bulk cargo played an important role in sustaining sail ship use on Asian routes. If Asian bulk cargo was expanding, not holding type of cargo constant would cause the effect of Suez to be underestimated, because bulk cargo promoted sail use more than steam use.

because they were about the same distances from the UK for steamships after 1869.¹³ Accordingly, the increase in Asian steam tonnage caused by Suez is separated from increases in Asian steam tonnage caused by diffusing and improving steam technology by subtracting the increase in long-distance Non-Asian steam tonnage from the increase in Asian steam tonnage after 1869. Lastly, currents are considered as constant through the period.

Equation (1) is the model used to isolate the increase in Asian steam tonnage caused by Suez.

$$\log(T_{i,s,t}) = \beta_1(A_i M_s P_t) + \beta_2(A_i P_t) + \beta_3(M_s P_t) + \beta_4(A_i M_s) + \beta_5(A_i) + \beta_6(M_s) + \eta_t + \varepsilon_{i,s,t} \quad (1)$$

In which $T_{i,t,s}$ is the tonnage of ships entered from location i at time t using mode s . The variable A_i is a dummy in which observations from Asia have a value of one and zero otherwise; P_t is a dummy in which observations from after 1869 have a value of one and zero otherwise; M_s is a dummy in which observations of steam tonnage have a value of one and zero otherwise, η_t are year fixed effects, and $\varepsilon_{i,t,s}$ is the error term. A log-level specification is used because it is reasonable to assume that shifts in cargo increased sail and steam tonnage to Asia proportionately and improving technology increased long-distance Non-Asian and Asian steam tonnage proportionately.

The coefficient β_1 on the third-level interaction is the parameter of importance. β_1 captures the increase in tonnage unique to steamships (relative to sail), from Asia (relative to long-distance Non-Asian locations) and after Suez opened (relative to before).¹⁴ The second-level interactions control for the shifts in Asian tonnage due to cargo (β_2), the increases in worldwide long-distance steamship use due to technology (β_3), and the difference between steam tonnage from Asia and Non-Asian locations before

¹³ On average Asian locations were about nine thousand miles from the UK while long-distance Non-Asian locations were about six thousand miles from the UK. Likely, steam tonnage increased faster to long-distance Non-Asian locations because they were closer to the UK. Meaning that the increase in steam tonnage caused by technology is overestimated and the increase caused by Suez is underestimated. Using only tonnage from South America would make a better control group, but South and Central America are observed together until 1868.

¹⁴ This is the increase in tonnage caused by Suez. The estimated increase in tonnage caused by Suez = $[(T_{A=1,M=1,P=1} - T_{A=1,M=1,P=0}) - (T_{A=0,M=1,P=1} - T_{A=0,M=1,P=0})] - [(T_{A=1,M=0,P=1} - T_{A=1,M=0,P=0}) - (T_{A=0,M=0,P=1} - T_{A=0,M=0,P=0})]$

Suez opened (β_4).¹⁵ The dummies account for the baseline difference between Asian and long-distance Non-Asian tonnage (β_5) and between sail and steam tonnage (β_6). Yearly fixed effects (η_t) are included to allow for variation of tonnage by year.¹⁶

Results:

The Suez Canal gave steamships a large distance and time advantage for Asian shipping. Because of the durability of ships it took years for the market to adjust to Suez. As the market adjusted, changing Asian cargo and improving steam technology also increase the equilibrium quantity of steam-shiping from Asia. Equation (1) estimates the increase in steamship use to Asia caused by Suez holding constant the amount of cargo and technology. This model estimates that Suez increased steam tonnage from Asia by 178 percent in the four years following its opening. Table (2) presents the results.

Table (2):

Estimated Log Tonnage

	(1) DDD
β_1 (Asian x Steam x After)	1.777*** (0.325)
β_2 (Asian x After)	0.0961 (0.182)
β_3 (Steam x After)	0.854*** (0.168)
β_4 (Asian x Steam)	-2.545*** (0.148)
β_5 (Asian)	0.417*** (0.101)
β_6 (Steam)	-1.392*** (0.119)
Observations	32
R-squared	0.967

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

¹⁵ By controlling for steam tonnage to Asia before Suez opened, the possibility of some steam tonnage not going through the Suez Canal after 1869 is controlled for.

¹⁶ The explanation of Equation (1) follows Zaiceva's (2010) structure.

Sail tonnage to Asia was not statistically significantly different from zero, meaning that there was not a cargo boom in Asia which accounted for some of the increase in steam tonnage from Asia. Holding constant the amount of Non-Asian cargo there was a large, 85 percent, increase in steam tonnage from long-distance Non-Asian locations. This indicates that technology increased long-distance steam use by about 85 percent in the four years after 1869. As technology increased steam use based on distance, this suggests that a significant amount of the increase in Asian steam tonnage from 1869 to 1874 was from diffusing and improving steam technology. Asian steam tonnage increased by 178 percent on top of the 85 percent increase caused by technological advancement. To review, expanding Asian cargo did not increase steam tonnage from Asia significantly, improving and diffusing steam technology did increase steam tonnage from Asia, but the major increase in steam tonnage from Asia after 1869 was caused by the opening of the Suez Canal.

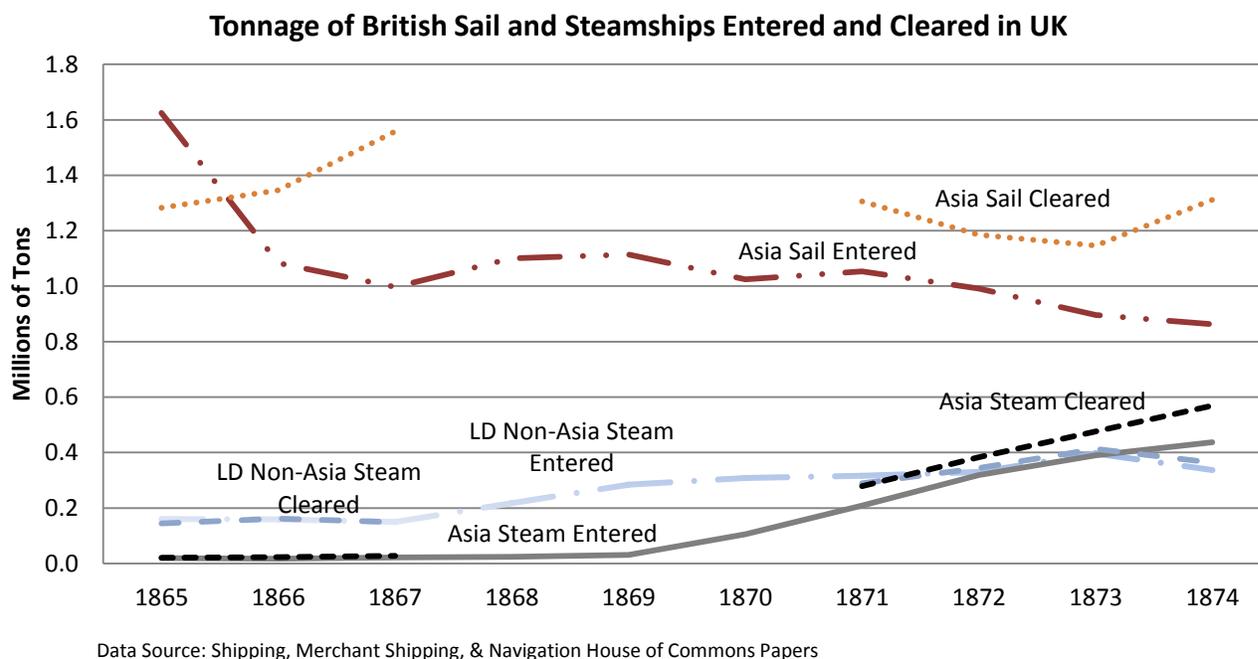
Conclusion:

Tonnage of steamships entering the UK from worldwide locations more than doubled from 1865 to 1874. The main increases came from expansion of steam tonnage on short-distance routes where shipping was concentrated. Steamships gained long-distance routes more slowly. When the Suez Canal opened, it gave steamships a distance advantage on the long-distance routes to Asia. After 1869, tonnage of steamships from Asia increased quickly. In the four years after opening, Suez caused a 178 percent increase in the tonnage of steamships entering the UK from Asia. To conclude this thesis, I discuss how representative the increase in tonnage of ships entered is of aggregate UK shipping. Then, I discuss potential ways to expand the study, such as including foreign ships, tonnage cleared and extending the time frame.

Previous graphs display that there was a large increase in tonnage of steamships entered from Asia after 1869. The DDD model indicates that the opening of the Suez Canal was mostly responsible for

this increase. Until now, except figure (5), the data were restricted to tonnage which entered the UK. It is possible that tonnage entered developed differently than tonnage cleared outwards and the results are biased by excluding tonnage cleared. Figure (6) graphs the tonnage of ships entered and cleared distinguishing, sail and steam, and Asian and long-distance Non-Asian locations.

Figure (6):



Mostly, tonnage entered and cleared were consistent with each other. Steam tonnage entered and cleared for both Asia and Non-Asia long-distance locations followed each other closely. There was slightly higher steam tonnage cleared to Asia after 1871. With all else equal, this would mean that the effect of Suez was slightly underestimated. The long-distance Non-Asian sail tonnage entered and cleared trends followed each other fairly closely (omitted from figure). Asia sail tonnage entered and cleared trends were different. This was probably the result of triangular trade on sail ships' return route. Ships exported cargo to Asia, but before returning stopped somewhere to drop off cargo or pick up cargo. The problem is that tonnage of sail ships cleared to Asia did seem to change independent of tonnage entered. The divergent Asian sail trend could cause the estimated effect of Suez to be too large or too small.

Nonetheless, there is no clear increase in sail tonnage cleared to Asia in the years after 1869, and therefore no evidence of an Asian cargo boom. The conclusion that Suez was the main factor which increased steamship use on Asian routes, after 1869, stands.

This thesis has focused on British ships entering UK ports. House of Commons Papers also record the total (British and foreign owned) tonnage of ships entered and cleared at UK ports. The main advantage of including foreign ships is that the aggregate tonnage of British and foreign ships entered and cleared was recorded for every year of the time frame.¹⁷ Including foreign ships is expected to cause the effect of Suez be smaller, in terms of both worldwide and Asian steamship use. Foreign countries with undeveloped steamship industries could not replace sail ships on Asian routes as quickly as the British. Finally, the time frame for this thesis is short. The unimpeded increase of Asian steam use through 1874 suggests that the market had not fully adjusted to Suez. Extending the time frame would allow for a more complete understanding of the effect of the Suez Canal on steamship use in the late 19th century.¹⁸

¹⁷ This requires combining data from the Shipping, Merchant Shipping, and Annual Statements of Navigation Papers.

¹⁸ Using Annual Navigation and Merchant shipping Papers the time frame could be extended into the 1880's and beyond.

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