NBER WORKING PAPER SERIES

SUEZ

David S. Jacks
Christopher M. Meissner
Nikolaus Wolf

Working Paper 33250
http://www.nber.org/papers/w33250

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2024

This paper was written while Jacks was the Milne Visiting Professor of Economics at the University of Western Australia, and he thanks the UWA Business School for its hospitality. We appreciate feedback from Tim Hatton, Noel Maurer, and Thierry Mayer as well as conference and seminar participants at UBC, UC Irvine, the 2023 EHES Conference, the 2024 Australian Cliometrics Workshop, the 2024 EHA annual meeting, and the 2024 NBER Summer Institute. Finally, Jacks gratefully acknowledges research support from the National University of Singapore. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed additional relationships of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w33250

Suez
David S. Jacks, Christopher M. Meissner, and Nikolaus Wolf
NBER Working Paper No. 33250
December 2024
JEL No. F1, N7

ABSTRACT

For all its importance, there still is no comprehensive quantitative assessment of the Suez Canal's opening in 1869. We find that it led to a 72% relative increase in bilateral exports for affected country pairs and a likely permanent increase in world trade. With respect to the composition of trade, Suez was associated with large changes in export shares but only for a handful of goods categories. With respect to mechanisms, the relative cost of using steamships on Suez-affected routes fell dramatically and immediately after 1869, suggesting a vital role for the canal in the global diffusion of steam technology.

David S. Jacks
Department of Economics
National University of Singapore
1 Arts Link, #06-02 AS2
Singapore 117570
dsjacks@gmail.com

Christopher M. Meissner
Department of Economics
University of California, Davis
One Shields Avenue
Davis, CA 95616
and NBER
cmmeissner@ucdavis.edu

Nikolaus Wolf
Humboldt University
Department of Economics
Spandauer Strasse 1
10178 Berlin
Germany
nikolaus.wolf@wiwi.hu-berlin.de

Introduction

From its opening in 1869, the Suez Canal has been hailed as an engineering marvel, a major contributor to the process of globalization in the 19th century, and one of the primary means for consolidating European imperial reach worldwide (Huber, 2015). The reason is straightforward: this single 195 kilometre cut from Port Said in northern Egypt to Suez in the south tremendously reduced the maritime distances separating critical ports like Bombay and London which saw the gap between them shrink from 19,755 to 11,619 kilometres (Fletcher, 1958). Thus, Suez served to pull Asia and Europe closer together with presumably profound implications for international mobility, relations, and trade. What is more, it remains one of the critical chokepoints of international commerce with 80% of maritime trade between Asia and Europe transiting the canal in the present day, representing roughly 15% of all world trade (Øiestad, 2019).

But for all this, over 150 years later, we still do not have a comprehensive assessment of the quantitative effects of the canal's opening and subsequent operation. To be sure, there are measures of the uptake of the canal's services which indicate prodigious rates of growth until the outbreak of World War I: thus, Adams (1971) reports a forty-fold increase in tonnage passing through the canal between 1870 and 1910. However, metrics like these give us no indication as to whether the canal: (1) increased the volume of trade for all country pairs through its implicit increase in shipping capacity or only those most immediately affected through its explicit reduction in bilateral trade costs; (2) affected the volume of trade of all goods or had an outsized impact on narrower categories of goods; and (3) influenced the diffusion of new transport technology and, thus, altered the global pace of the sail-to-steam transition. Advances in data collection, econometric modelling, and economic theory now allow us to answer these questions.

Using multiple sources of data on bilateral trade, we find that country pairs that were affected by the Suez Canal (e.g., British India and the United Kingdom) experienced lower shipping costs/times and significantly faster growth in trade from 1865 to 1900 relative to pairs that were unaffected by the opening of the canal (e.g., the United Kingdom and the United States). We do so by running an event study on the canal's opening in the context of a structural gravity equation, ruling out the role of pre-trends and finding that the rise in trade for affected country pairs was persistent over time but took roughly five years to fully come into play. More specifically, we find that its opening led to a 72% relative increase in bilateral exports for affected country pairs. This effect was also highly consistent, suggesting a likely permanent increase in world trade. Across different sub-samples, time horizons, and sources of data, we find quantitatively similar results. We additionally document how the Suez Canal differentially affected trade on the basis of the proportional changes maritime distances it induced and how the Suez Canal was effectively a global public good. In contextualizing these findings, we also contend with the possibility that trade diversion might be influencing our results, concluding instead that the canal was associated with pure trade creation.

We also discuss and use new sources of data on product-level bilateral trade data for British India, the United Kingdom, and the United States to explore changes in the composition of trade due to the canal. We do so by running a set of difference-in-difference regressions on country-level shares of SITC one-digit sections/two-digit divisions in total exports. Our results suggest that the Suez Canal was not associated with broad-based changes in the composition of exports. Rather, the number of affected sections/divisions was small on both a country-by-country and collective basis, suggesting large, concentrated (relative) changes in the composition of trade.

To better understand the mechanisms behind these results, we revisit the theory-informed shipping cost calculations underlying Harley (1971, 1972). In so doing, we move beyond the truism that reductions in distance mechanically lead to reductions in trade costs by highlighting the more subtle role of distance in the process of technological change in the maritime shipping industry. As distance was the key mediating variable governing the diffusion of steam technology, we evaluate the shock of Suez by first calculating shipping costs across multiple cost components, routes, and years. We then consider relative costs across destinations and means of propulsion to assess Suez's potential role in the transition from sail to steam. The results of this exercise are clear in their implications: immediately after 1869, the relative cost of shipping by steam fell in general, but did so even more dramatically on Suez-affected routes. Thus, not only was the mode-of-shipping choice of merchants affected, but also the fleet deployment choice of shipowners now favoured the use of steamships on Suez-affected over non-Suez-affected routes for the first time.

This paper first relates to a burgeoning literature on the role of trade costs in the creation of a global economy from the mid-19th century (Jacks, Meissner, and Novy, 2010). Many of the papers in this literature seek to re-evaluate the sources of the so-called first wave of globalization in light of state-of-the-art techniques in causal inference. Thus, Jacks and Pendakur (2010) along with Pascali (2017) consider the role of the maritime transport revolution in driving global trade flows while also accounting for the endogeneity of bilateral trade and freight rates. Likewise, Juhasz and Steinwender (2018) and Steinwender (2018) examine the role of improvements in communication technology in respectively fostering the fragmentation of production and commodity market integration.

This paper also speaks to a smaller set of papers which consider the effects of Suez on other aspects of international trade. In the paper closest to ours, Pascali (2017) estimates the effects of changes in shipping times in the late 19th century on bilateral trade flows and, from there, the effects of country-level openness (i.e., export-to-GDP ratios) on economic growth. Critically for our purposes, his estimates never separately distinguish between changes in shipping times arising from the opening of the Suez Canal and from the transition from sail to steam. However, as we later argue, the mass adoption of steam technology east of Suez itself was dependent upon the opening of the canal in 1869, given the critical role of distance in influencing the choice of sail versus steam by merchants and shipowners alike.

Following this work, Xu (2022) examines a 1866 banking crisis originating in London but with worldwide effects as sources of trade credit dried up and trade patterns were permanently altered. As part of this exercise, two variables for sail and steam capturing the difference in maritime distances before and after Suez are used as controls in a robustness exercise. However, no separate estimate of the effect of Suez's opening on bilateral trade is reported. Hugot and Umana Dajud (2016) also use the opening of the Suez Canal – along with that of the Panama Canal – to estimate a time-varying elasticity of bilateral trade with respect to distance. On this basis, they argue that while the distance elasticity may have well increased since the 1950s, it remains a relatively modest determinant of bilateral trade flows.

But yet again, no separate estimate of the effect of Suez's opening on bilateral trade is reported.

Finally, our paper speaks to and suggests new directions for a well-established literature linking changes in economic geography to improvements in transportation technology. Donaldson (2018) explores the introduction and articulation of British India's railroad network from 1870 to 1930, finding that rail technology reduced external and internal trade costs, increased external and internal trade flows, and raised real income levels. Fajgelbaum and Redding (2022) consider the combined effects of improvements in steam technology for maritime and overland transportation in the case of Argentina from 1869 to 1914. They also demonstrate that these improvements affected location's disposition towards trade and, from there, their long-run structural transformation. A set of other papers document similar effects occurring in Canada (Galiani, Jaramillo, and Uribe-Castro, 2022), Colombia (Belmar, 2023), and the United States (Maurer and Rauch, 2023) in the wake of the opening of the Panama Canal. Notably, all of these papers emphasize the degree to which the location of economic activity responds to exogenous changes in transport technology. In slight contrast, this paper considers the degree to which the diffusion of a particular technology – the application of steam to maritime transport – itself responded to the singular change in economic geography arising from the opening of the Suez Canal.

The rest of the paper proceeds as follows. Section 2 lays out the historical context related to the opening of the Suez Canal and its subsequent operation. Section 3 introduces our data. Section 4 presents our results while Section 5 considers potential mechanisms which arose from the opening of the Suez Canal and its interaction with the diffusion of technological change in the maritime shipping industry. Section 6 concludes.

2. Historical background

Conceptually, there was nothing new about the Suez Canal. The advantages of connecting the Mediterranean and Red Seas had been clear to various Pharaonic, Persian, Roman, and Arab leaders and observers. However, these long-standing aspirations never quite materialized into tangible results. And they were only actively revived during the brief period around 1800 when Napoleon occupied Egypt in an attempt to transform the Mediterranean into a "French lake" and thereby undermine British interests in India and the Middle East (Dzanic, 2016). Critically, this episode also took place when the formidable, but not insurmountable technological barriers to carving a ditch in the desert were dissipating thanks to the industrial revolution. Here, we briefly discuss the features of the Suez Canal and its opening in November 1869 that are important for purposes of establishing our working hypotheses as well as our identifying assumptions and variation.[1]

As was noted earlier and many times before by others, the power of the Suez Canal came in its ability to dramatically decrease the maritime distances separating the main population centers of the Eurasian landmass. What is also very important for our purposes is the degree to which certain locations – or more precisely, certain country pairs – were affected by the opening of the Suez Canal whereas others remained entirely removed from the process. In what follows, we make comparisons between country pairs which saw increased connectivity with other parts of the world due to the Suez Canal versus country pairs which saw no change in their connectivity at this time. Thus, we implicitly contrast the varying experiences of Australia versus New Zealand, East versus West Africa, and North versus South America as the latter countries/regions belong to the set of locations which the Suez Canal effectively by-passed.[2]

---

[1] Naturally, there is a very large literature charting the development of the Suez Canal from the middle of the century which we need to side-line for the moment. At the heart of the entire endeavour was Ferdinand de Lessep who leveraged personal ambition, contacts, and entrepreneurial skills to see the project through to completion. In Baer's words (1954, p. 361), "de Lesseps was not a politician, a financier, an engineer, a promoter, or a businessman, [yet] he succeeded brilliantly in a venture requiring consummate mastery of all these professional fields."

[2] Future work could also exploit the significant variation within countries. Thus, while Suez reduced the maritime distance from Bombay to Liverpool by 4,393 nautical miles, it "only" reduced that of Calcutta to Liverpool by 3,817 nautical miles (Rabino, 1887). In the context of the gravity model, it is not only declines in the level of trade costs like these across country pairs which matter but also the relative changes across potential export destinations. Thus, prior to 1869, Calcutta suffered from a +12% "distance penalty" with respect to Bombay. After 1869, this penalty increased to +29%. A similar dynamic can be observed on a west-to-east gradient for Australia: Fremantle/Perth experienced the largest decline in maritime distance to European markets while Sydney experienced the smallest.

Another critical element to consider is that successful year-round navigation of the Suez Canal – and especially the Red Sea – was predicated on adoption of steam technology. Inauspiciously, the first sailing ship to transit the canal in December 1869 promptly wrecked just south of Suez (Fletcher, 1958). This foreshadowed a very minimal uptake by sailing ships as they represented less than 0.2% of canal clearances in the years from 1876 to 1886 (Rabino, 1887). However, the historical literature is clear that the mass adoption of steam technology east of Suez was heavily constrained by the ready availability of both British coal and fresh water (Fletcher, 1975, Barak, 2022) and potentially accelerated by the opening of the Suez Canal (Fletcher, 1958; Sargent, 1918). This literature also emphasizes distance as the key mediating variable governing the diffusion of steam technology at any given point of time. This is a theme which we pursue in more detail in Section 5. Critically for purposes of estimation, we note that this implies an absence of anticipation. Mercantile firms were unlikely to establish strategic footholds in affected markets prior to November 1869 given the very significant expense involved in either taking the overland route from Cairo to Suez or traversing the Cape of Good Hope (Nourse, 1884, pp. 57-58). Thus, in a standard event study framework, we would not expect the presence of any significant pre-trends.

On a related note, we emphasize that we evaluate the effects of the Suez Canal from its inauguration in 1869. However, final work on the canal was not completed until 1871. It also took time to learn how to successively navigate known hazards in the canal which were only eased once its channel was widened, obstructions were removed, and its sidings enlarged. Nourse (1884, p. 78) reports that "the greatest draught of a vessel passing through the canal in 1870 was just 22 feet, and this with care," limiting the size of vessels which could initially transit. Nourse also reports that the other greatest impediment to the canal's early use was a disagreement between the British government and the Suez Canal Company on the measurement of tonnage, the basis by which the company levied its fees.[3] Eventually, the

[3] In its founding documents, the Company specified a maximum fee of 10 francs per ton of capacity without specifying what measure of capacity was to be used. At the time, Britain possessed the world's largest mercantile fleet, and most countries of the world followed its use of net tonnage as a measure of ships' cargo capacity. In this manner, net tonnage was simply calculated as gross tonnage minus 50% for sailing ships and minus 25% for steamships. In contrast, "the French method, as might be

company's tolls were reduced from January 1, 1875 (Yousri, 1968, p. 296). Thus, such incremental improvements to navigation and the reduction in canal tolls from 1875 suggests that a period of transition in the canal's early days might be expected.

A final consideration which we explore below is the degree to which the Suez Canal acted as a global public good. In the 1850s and 1860s, the British Foreign Office was resolutely opposed to any potential canal, seeing a worrying parallel to Napoleon's attempt to establish twin ports on the two ends of the Isthmus of Suez. The Foreign Office had come to fear that a canal would jeopardize its grip on British India, lead to the demise of the Cape Colony as it would be relegated to also-ran status in global commerce, and open up the dangerous possibility of French imperial expansion in East Africa. This British concern and that of other nations led to the Canal's Second Concession of 1856 to repeatedly emphasize that the canal would always be a neutral passage for all merchant ships (Piquet, 2004).

On the other hand, a widely held opinion at the time was that the Suez Canal "had been cut by French energy and Egyptian money for British advantage" (*The Economist*, 1869, p. 1367). This suspicion was only heightened when in 1875 Disraeli engaged in a secret purchase of the Khedive of Egypt's 44% stake in the company. Seemingly overnight, this move effectively reversed the Foreign Office's long-standing opposition, further giving the impression that the Suez Canal was fundamentally a British affair. And while British ships – if not necessarily British goods – later dominated the traffic of the Suez Canal (Issawi, 1982), the degree to which the canal differentially affected trade between the United Kingdom and its Empire to the east of Suez remains an open question.

---

expected was more scientific and based on a regular calculation, the dimensions being multiplied and divided after a formula" while "the English mode, however rough, [had] the advantage of simplicity" (Nourse, 1884, p. 79). Critically, the "French method" always yielded a higher number. Resolution of this seemingly innocuous detail only occurred after the Khedive of Egypt had sent troops and a frigate to the canal to ensure its free passage in response to de Lesseps' threat to temporarily shut it down over the issue. Finally, we note that the canal's capacity was also initially limited by the fact that it was in effect a "one-way street" and that it was incapable of accommodating nighttime transits until 1887 due to its lack of electrification (Nourse, 1884; Sargent, 1918).

3. Data

For our results in Section 4, the data are drawn from three main sources: existing datasets on annual bilateral (directed) trade volumes for large numbers of country pairs in the latter half of the 19th century; a new dataset on product-level bilateral exports from British India, the United Kingdom, and the United States for select years from 1866 to 1899; and a new indicator regarding the technologically feasible use of the Suez Canal for shipping between country pairs drawn from an early 20th century source. These are discussed along with details of data construction in sections 3.1, 3.2, and 3.3, respectively.

3.1 Dependent variable: aggregate bilateral exports

There now exists a wide number of datasets on historical bilateral trade which can be used to determine the degree to which the opening of the Suez Canal increased the volume of trade for affected country pairs relative to those that remained outside of its reach. Our primary focus and baseline results will be drawn from the data underlying Jacks, Meissner, and Novy (2011). The sample comprises bilateral trade from 27 countries and 148 unique country pairs across the Americas, Asia, Australasia, and Europe, representing over 70% of world exports and GDP in the late 19th century (Jacks and Tang, 2021). The original sample was fully balanced, but its extension back to 1850 entails a loss of data for some country pairs. As a consequence, the final observation count is 9,439 for our preferred sample from 1865 to 1900, relative to a hypothetically possible, balanced observation count of 10,656 (i.e., 89% coverage).

Critically, all the data is drawn from contemporary official sources documenting exports and imports at the individual country level (e.g., the various statistical abstracts of the United Kingdom) or works directly derived from the same (e.g., the retrospective historical data released by the Japan Statistical Association). That is, at no time does this dataset rely upon third-party accounts of bilateral trade occurring between other states (e.g., French consular reports on the state of trade between Brazil and Paraguay) or other sources of unclear provenance. This partially ensures that our baseline data and results are of the highest quality. In Section 4.1 below, we trace out larger trends in the export data by non-Suez- and Suez-affected routes from 1860 to 1900.

Alternative datasets are available which allow for higher observation counts. However, data quality issues come to the fore as many of these additional observations are drawn from third-party accounts and other sources. Moreover, it is unclear precisely what additional information is conveyed via the introduction of – oftentimes very small – countries and country pairs constituting the remainder of world exports and GDP. Consequently, these datasets are reserved for purposes of assessing the robustness of our main results. Chief among these alternative datasets is Pascali (2017) which is comprised of exports from 95 countries and 413 country pairs. The final observation count in this dataset is 21,258 from 1865 to 1900, relative to a theoretically possible, balanced observation count of 29,736 (i.e., 71% coverage).

Likewise, the datasets of Fouquin and Hugot (2016) and Dedinger and Girard (2017) are respectively comprised of exports from 208 regions[4] and 2,337 region pairs and exports from 173 countries and 1,453 country pairs. For the former, the final observation count is 41,865 from 1865 to 1900, relative to a theoretically possible, balanced observation count of 168,264 (i.e., 25% coverage). For the latter, the final observation count is 45,556 from 1865 to 1900, relative to a theoretically possible, balanced observation count of 104,616 (i.e., 44% coverage). Finally, all these datasets express bilateral export values in nominal Great British Pounds throughout the sample period.

3.2 Dependent variable: product-level bilateral exports

To determine the degree to which the opening of the Suez Canal increased the volume of trade of all goods or had outsized effects on narrower categories of goods, we move beyond existing and easily accessible datasets on historical bilateral trade flows. To this end, we have collected new data on bilateral, product-level exports from British India, the United Kingdom, and the United States in 1866, 1869, 1875, 1880, 1885, 1890, 1895, and

[4] We distinguish regions from countries here as the Fouquin and Hugot dataset includes sub-national entities like the provinces of Canada or states of Australia whereas all the other datasets aggregate such units to the country level.

1899. These years were chosen to provide us with at least two pre-period years (1866 and 1869) and a viable match across countries over the longest span of years possible as the British records abruptly end in 1899 after 200 years of continuous publication.[5]

As this is a data-intensive task, we are limited in the number of origin countries we can consider, but we note that these three countries alone represented roughly 30% of world exports and 40% of world GDP in the late 19th century (Jacks and Tang, 2021). They are also distinguished by their varying levels of economic development and export composition as well as their differential exposure to the opening of the Suez Canal. For example, the whole of British Indian exports to the rest of Asia remained unaffected – at least directly – by Suez.[6]

We identify 70 mutually consistent destinations across the three national datasets on product-level exports. Next, all observations at the one-digit SITC section (two-digit SITC division) level are collapsed by origin-country, creating 10 (66) observations for each destination country and year combination.[7] In total, this process generates a fully balanced sample of 16,800 observations at the section level (= 3 origin countries * 8 years * 10 SITC one-digit sections * 70 destination countries) and 110,880 observations at the division level (= 3 origin countries * 8 years * 66 SITC two-digit sections * 70 destination countries). Of these, 16,080 and 106,128 observations can be assigned unambiguous "treatment" status vis a vis the opening of the Suez Canal.[8] In Section 4.2 below, we trace out larger trends in the export data by country and section.

3.3 Independent variable

Throughout, we rely on the sharpest difference in exposure to the Suez Canal possible: an indicator variable, S_{ij}, for whether *i* and *j*'s main ports were ever connected via

---

[5] Appendix A details the underlying sources and dimensions of this data.
[6] Appendix B provides country lists and maps for our samples and individual countries' exposure to the Suez Canal for both the bilateral (directed) trade flows discussed in Section 3.1 and the product-level bilateral exports discussed here in Section 3.2.
[7] Appendix C provides a numbered lists of the 10 sections and 66 divisions used in the paper.
[8] That is, three composite destinations ("British Africa", "German Oceania and Africa", and "Portuguese Possessions in Africa") are too coarse for purposes of assigning Suez "treatment".

Suez after 1869. Our source for this information comes from *Philips' Centenary Mercantile Marine Atlas* (1935) which reports maritime distances separating ports and indicates which canals and passages ships actually used in bilateral trade. Importantly, this source represents the state of affairs prevailing circa 1920, providing us with the full set of routes which were eventually affected by Suez, but only once it became technologically feasible. As such, we argue that using this definition of the Suez "treatment" attenuates our estimates as the set of countries using the canal in 1920 was certainly larger than that using it in 1870. Given improvements in maritime shipping technology and transiting the canal over the subsequent 50 years, this suggests that our results may in fact be lower-bound estimates.[9]

In our preferred sample of bilateral trade flows drawn from Jacks, Meissner, and Novy (2011), there are 148 unique country pairs. Of these, 34 (or 23%) were affected by the opening of the Suez Canal. In 1869, trade among affected country pairs accounted for 21% of the value of exports in the sample. In our new sample of bilateral, product-level exports from British India, the United Kingdom, and the United States, there are 210 unique country pairs. Of these, 62 (of 31%) were affected by the opening of the Suez Canal. In 1869, trade among affected country pairs accounted for 27% of the value of exports in the sample.

Of course, another threat to identification arises here if any time-varying determinant of bilateral trade costs is correlated with the opening of the Suez Canal temporally and its treatment of country pairs geographically. Potential confounders along these lines comes from the global extension of the telegraph network (Juhasz and Steinwender, 2018), declines in the duration of voyages under sail and steam (Pascali, 2017), and the 1866 London banking crisis (Xu, 2022). A priori, we have no reason to suspect a systematic geographic component to these forces wherein Suez-affected country pairs were differentially exposed,

[9] As an ex-post observation, this distinction matters less than we supposed in practice. There are two alternative definitions of a Suez indicator available: one coming from Hugot and Umana Dajud (2016) which is based on use of the canal circa 2015 and another coming from Pascali (2017) which is based on imputations of minimum voyage duration. Given the very high correlations among these definitions (>0.95), the results reported here are highly consistent with those when using either of these two alternative definitions.

but we need to econometrically eliminate this as a possibility. To this end, Appendix D reports the results of a number of robustness exercises along these lines.

4. Results

Our results are presented in two main parts, corresponding to the two forms of trade data at our disposal, namely aggregate bilateral exports for a large number of countries and product-level bilateral exports for British India, the United Kingdom, and the United States. First, we consider our main event study on the effects of the Suez Canal on aggregate bilateral exports. This is followed by a battery of difference-in-differences estimates which aid the interpretation of magnitudes as well as demonstrate that our results are robust to different definitions of our sample and alternative datasets. Finally, we explore potential heterogeneity in our main results along the lines of the British Empire and the size of the Suez shock with respect to its proportional reduction in maritime distances.

Second, we consider the effects of the Suez Canal on the composition of trade by using our new product-level bilateral export data for British India, the United States, and the United Kingdom. There, we first lay out some broad trends in the flows emanating from these three countries. We then present difference-in-differences estimates which differentiate the effects of the Suez Canal on the export shares of SITC one-digit sections and two-digit divisions on a country-by-country basis.

4.1 Suez and the volume of trade

We begin with a presentation of underlying trends in bilateral trade flows. We do so by plotting the sum of annual trade for those country pairs in the Jacks, Meissner, and Novy (2011) dataset which were connected by the Suez Canal post-1869 versus those which were not. In this instance, we only consider those country pairs for which there are uninterrupted export data from 1860 to 1900. The resulting series are presented below in Figure 1 with non-Suez-affected country pairs (n = 120) depicted in grey and Suez-affected country pairs (n = 28) depicted in black.

Here, the two series are normalized to a value of 100 in 1860 and their subsequent growth to 1900 is tracked.[10] For the period prior to 1870, there are a few interesting features: for one, Suez-affected country pairs seem to have experienced a trade boom and bust between 1863 and 1867 which is likely related to the American Civil War. More importantly, the difference in the two series is essentially trendless, suggesting that the parallel trends assumption might be satisfied. From 1870, trade between non-Suez-affected country pairs grew tremendously in the early 1870s but eventually flatlined over the next 20 years. In contrast, trade between Suez-affected country pairs initially flatlined in the 1870s but then commenced on a strong trajectory of growth over the next 20 years.

Of course, this type of visual analysis is purely impressionistic as it does not condition on changes in the size and structure of national economies or changes in their unilateral commercial policy and multilateral resistance. And of course, such changes may have been occurring for many reasons not related to the opening of the Suez Canal. The empirical framework outlined below allows us to more rigorously assess the potential effects of Suez through a panel model with a large battery of fixed effects which are intended to control for a wide range of unobservables.

4.1.1 Event study

In this section, we conduct an event-study analysis in the context of a difference-in-differences research design that exploits the differential exposure to the opening of the Suez Canal in November 1869. Our regression specification is given below where we estimate a standard structural gravity equation.[11] That is, the value of bilateral exports depends on

[10] In the 1860s, the nominal value of exports for country pairs not affected by the opening of the Suez Canal was roughly five times higher than for those affected by Suez, reflecting the dominance of both intra-European and trans-Atlantic trade at this time.

[11] The structure referenced here comes from the general equilibrium properties of international trade: what one observes with respect to exports between two countries actually depends on changes in the trade costs between all potential trading partners worldwide. For example, the value of exports from British India to the United Kingdom depends on what is happening not only in and between these two countries but also what is happening in and between the United Kingdom and the United States.

factors common to all countries, factors within particular countries, and factors which are specific to country pairs (that is, the costs of conducting trade between two countries):

$$ln(X_{ijt}) = \sum_{l=-10,l\neq-1}^{30} \alpha_l S_{ij1870+l} + \beta_{ij} + \gamma_{it} + \delta_{jt} + \zeta_t + \varepsilon_{ijt}$$

Thus, the log of bilateral exports from origin country *i* to destination country *j* in year *t*, X_{ijt}, is a function of treatment effects associated with the opening of the Suez Canal in late 1869, α_l, with 10 lags and 30 leads along with fixed effects for time-invariant productivity/trade cost factors: (a) at the country-pair level, β_{ij}; (b) at the origin-country level, γ_{it}; (c) at the destination-country level, δ_{jt},; and (d) which affect all country pairs, ζ_t. Importantly for our purposes, this specification captures all unobserved, general-equilibrium effects arising from Suez, potentially including any trade diversion which the canal may have induced.

Following best practice in the literature, our empirical model is estimated in levels of the dependent variable via PPML. Doing so fully utilizes the information contained in zero observations while PPML also yields unbiased estimates even in the presence of heteroskedasticity unlike OLS (Santos Silva and Tenreyro, 2006). Furthermore, PPML automatically eases the "adding-up constraints" presented by reduced form approaches like ours (Fally, 2015). Finally, we cluster standard errors at the country-pair level, ensuring that residuals are appropriately adjusted for arbitrary within country-pair/year serial correlation.

Figure 2 presents our event-study using the 120 never-affected country pairs (out of 148) in the sample as the control group. Naturally, in the case of the Suez Canal's opening, we expect to see non-zero effects emerge after 1869 but not before, provided that the canal is not confounded with pre-trends. We summarize our results in three parts:

(1) Nearly all of the point estimates for $t < -1$ (before 1869) are statistically insignificant, and collectively, they are inconsistently signed. Reassuringly, there is a lack of any discernible pre-trend. This also suggests that there were no anticipation effects. That is, there is no evidence of firms to establishing strategic footholds in affected markets prior to Suez's opening, given the significant expense involved in either taking the overland route from Cairo to Suez or

traversing the Cape of Good Hope as well as potential uncertainty over when the canal would become fully operational.

(2) Nearly all of the point estimates for $-1 < t < +6$ (from 1870 to 1875) are also statistically insignificant, and collectively, they are inconsistently signed albeit trending upwards. This suggests that there was a transition period of roughly five years as final work on the canal was only completed in 1871, the hazards of traversing the canal were progressively diminished, its tolls declined from 1875, and the commercial advantages of the route became more readily apparent.

(3) All of the point estimates for $t > 5$ (after 1875) are positive and statistically significant, showing no sign of decline even as late as 1900. This suggests that the Suez Canal was responsible for a permanent increase in bilateral trade for affected country pairs after an initial period of transition as the problems above related to information and navigation were ironed out and trade costs fell.

But is there any other evidence which might corroborate this last claim with respect to trade costs? Here, we can consider the trajectory of bilateral trade costs using the same dataset. Conveniently, the approach used by Jacks, Meissner, and Novy (2011) explicitly takes into account the general equilibrium forces underlying structural gravity models. Somewhat inconveniently, this approach also requires annual information on not only aggregate and bilateral exports but also country-level GDP. The last element is not consistently available prior to 1870. However, we can document the trajectory of this measure of bilateral trade costs from 1870, using the same sample of non-Suez- and Suez-affected country pairs as in Figure 1.

The unweighted averages of bilateral trade costs are presented in Figure 3 with non-Suez-affected country pairs (n = 120) depicted in grey and Suez-affected country pairs (n = 28) depicted in black. These series indicate that the former declined by 20% from 1870 to 1900 while the latter declined by 35% in the same period.[12] They also indicate that after a

[12] This result is bascially unaffected whether we consider the series on a GDP-weighted, trade-weighted, or unweighted basis as depicted here.

period of potential teething pains in the 1870s, Suez-affected country pairs saw greater rates of decline in their trade costs relative to their non-affected peers.

4.1.2 Difference-in-differences estimates and robustness

Having shown that there were no discernible pre-trends in Figure 2, we turn to a consideration of the equivalent difference-in-differences estimates to aid the interpretation of magnitudes as well as demonstrate that our results are robust to other definitions of our sample and alternative datasets. In Table 1, the specification for Column 1 fully corresponds to the event study in Figure 2, where bilateral exports from 1860 to 1900 are a function of country-pair, time-varying exporter, time-varying importer, and year fixed effects. We find a statistically significant (relative) increase in bilateral exports of 0.56 log points for those country pairs which were directly affected by the opening of the Suez Canal in 1869 relative to non-Suez-affected country pairs.

The remainder of Table 1 establishes the robustness of our results to various other specifications. Column 2 considers a longer time horizon, extending the sample from 1850 to 1900. While it does so by making the sample more unbalanced, the results are not statistically significantly different from those in Column 1. Likewise, Column 3 only uses data from 1865 to 1900, thereby excluding the years of the American Civil War, with essentially the same results as in Columns 1 and 2. Finally, Column 4 is our preferred specification. It retains the sample from 1865 to 1900 but focusses our attention on a smaller "high quality" sample which excludes country pairs for which there are fewer than 10 observations and/or the minimum (positive) value of exports is less than 1,000 GBP. In any case, this exercise yields results which are highly consistent with those Columns 1 through 3.

Thus, we conclude that the opening of the Suez Canal led to a 0.54 log point – or 72% – relative increase in bilateral exports for affected country pairs. We also know from Figure 2 above that this effect persisted decades later. But what of the possibility that trade diversion might be influencing our results? Following Head and Mayer (2014), we assess such a potential role in the context of the general equilibrium and welfare impacts of the opening of the Suez Canal in Appendix E. The results there strongly suggest the primacy of trade creation with a very limited role for trade diversion: the median predicted change in bilateral flows for non-Suez-affected country pairs in a counterfactual world with no Suez Canal is less than 0.1%.

We can also consider what happens to our results when we use the three alternative datasets described in Section 3.1. In what follows, we take the period from 1865 to 1900 as our preferred sample for two reasons. First, it excludes the volatile years of the American Civil War in the early 1860s. Second, and more importantly, it most closely corresponds to the sample period we employ in Section 4.2. With this in mind, we reproduce our baseline results in Column 4 of Table 1 in Column 1 of Table 2 below. Columns 2, 3, and 4 then report the results of using bilateral trade data from Pascali (2017), Fouquin and Hugot (2016), and Dedinger and Girard (2017), respectively. For purposes of comparability, we exclude country pairs in all datasets for which there are fewer than 10 observations and/or the minimum (positive) value of exports is less than 1,000 GBP. In sum, while the coefficients differ due to different sample country pairs, we note that all of them are positive and significantly different from zero while none of them are statistically significantly different from our baseline results in Column 1 or from one another.

4.1.3 Heterogeneity analysis

We can also consider the possibility that the Suez Canal differentially affected trade: on the basis: (a) of countries belonging to the British Empire and (b) of the proportional changes in maritime distance the canal induced. Table 3 below addresses the suspicion that the Suez Canal had been cut "for British advantage" and the possibility that this spilled over to the trade between the United Kingdom (as metropole) and its colonial possessions east of Suez. Columns 1 through 4 use the same "high quality" samples as in Table 2. They also include an interaction term for Suez-affected routes which involved the United Kingdom as an origin or destination. They suggest that while British metropole trade was enhanced by the introduction of the Suez Canal, non-metropole trade saw an even greater proportional increase. Thus, while the British Empire may have gained geopolitical or other strategic advantage from the Suez Canal, this did not necessarily register in its pattern of bilateral trade relations. In this particular sense, it may then be argued that the Suez Canal was a global public good — or at least, one for the dominant powers of the day.

Of course, our baseline results through their use of a simple indicator for maritime trade via Suez only captures something like the average treatment effect of the canal. Another form of heterogeneity that might be informative comes from variation in the proportional decline in maritime distances induced by the opening of the canal. Here, we use the maritime distances separating country pairs – both before and after 1869 – reported in Hugot and Umana Dajud (2016) to construct the variable, "Suez factor". This is simply the proportional decline in maritime distances following in the wake of Suez at the country-pair level. From there, we construct four indicator variables for the interaction between Suez's opening and the first (-0.10, 0.00), second (-0.23, -0.10), third (-0.38, -0.23), and fourth quartiles (-0.56, -0.38) of the "Suez factor".[13] That is, Table 4 considers the differential effect of Suez on the basis of the smallest (first quartile) to largest (fourth quartile) proportional declines in maritime distances.

All of the results suggest positive and significant treatment effects for the Suez Canal. Moreover, the effects of Suez are increasing in the size of the proportional decline in maritime distances, but only through the third quartile. Indeed, for those country pairs which experienced the largest proportional declines, the estimated coefficient is roughly one-tenth the size of that for the third quartile. The country pairs in the fourth quartile primarily feature British India as either their origin or destination in our sample. But the consistent presence of countries with ports in the Mediterranean Sea is perhaps more telling: there is a historical literature which highlights that the high hopes for places like Greece, Italy, and the Ottoman Empire due to Suez's opening never quite materialized (Barak, 2022; Huber, 2015). In the third quartile, British India appears again as does the Dutch East Indies. However, the majority of country pairs in this quartile feature Japan as either the origin or destination. Thus, concurrent with its dramatic re-engagement with the world and nascent industrialization

[13] Appendix F fully enumerates these proportional declines in maritime distance by country pair in our sample.

(Meissner and Tang, 2018), Japan was able to seize the opportunity of Suez's opening to establish itself as one of the world's premier trading nations by the end of the 19th century. This result, thus, serves to amplify the message of Table 3 in which the United Kingdom was not the primary beneficiary of the Suez Canal, at least with respect to bilateral trade flows.

4.2 Suez and the composition of trade

In this section, we address the possibility that the Suez Canal not only had an effect on the volume of trade but also its composition. We do so in the context of the product-level export data discussed in Section 3.2. Before proceeding to the analysis, we first lay out some broad trends in the export flows emanating from British India, the United Kingdom, and the United States in this period. Panels A through C of Figure 4 respectively chart British India's: (1) total exports; (2) share of manufacturing goods in its total value of exports; and (3) share of non-zero observations on the basis of destination-country/one-digit SITC section cells. These series are also delineated across trades routes for British India which were and were not affected by the opening of the Suez Canal. Panels D through F and Panels G through I respectively do the same for the United Kingdom and the United States.

For British India, total exports grew considerably rising 62% from 1866 to 1899. Its Suez-affected routes also notably dominated its exports throughout the period with a 71% share while export growth rates for its non-Suez- and Suez-affected routes were similar at 65% and 61%, respectively. Its share of SITC manufacturing sections (5 through 9) increased in aggregate from 10% in 1866 to 20% in 1899. Primarily, this reflects a large increase of 10 percentage points for non-Suez-affected routes as the share of manufacturing goods on Suez-affected routes remained roughly the same. Over time, its exports also grew on the extensive margin as the fraction of non-zero observations for destination-country/one-digit SITC section cells grew. Notably, this growth was somewhat faster for Suez-affected routes than non-Suez-affected routes.

For the United Kingdom, total exports grew more modestly in the period rising 40% from 1866 to 1899, albeit from a higher base (roughly 4x that of British India). Here, Suez-affected routes were in the minority with a 30% share of exports. However, they were gaining ground: the growth rate for exports for Suez-affected routes (62%) outstripped that for non-Suez-affected routes (32%), reflecting the burgeoning potential of Asia in world trade. Curiously, its share of SITC manufacturing sections actually declined in aggregate from 91% in 1866 to 82% in 1899. But there is also a clear asymmetry here: whereas as manufacturing goods on non-Suez-affected routes saw their share decline by 15 percentage points those on Suez-affected routes saw their share increase by 5 percentage points. Finally, in 1866, the fraction of non-zero observations for destination-country/one-digit SITC section cells was considerably higher for non-Suez-affected routes than Suez-affected routes, but this gap entirely disappeared – indeed, it was even reversed – by 1899.

Somewhat anomalously, the United States experienced explosive export growth in this period of 154%.[14] And while its Suez-affected routes massively outperformed its non-Suez-affected routes in terms of export growth (at 541% and 145%, respectively), the United States is also exceptional here in that the former only commanded a 3.5% export share. The greater economic activity and lower internal trade costs of the eastern United States along with the sheer economic mass of Europe worked to keep exports to Suez-affected destinations marginal at this time. Furthermore, its share of manufacturing sections in aggregate increased from 8% in 1866 to 23% in 1899 with nearly all of this increase coming from a 13 percentage point increase in the share of manufacturing goods on non-Suez-affected routes. We do, however, see a narrowing of the gap in the fraction of non-zero observations across non-Suez- and Suez-affected routes at the end of the period.

4.2.1 DiD on export shares before and after the opening of the Suez Canal

The data used in this section are two fully balanced samples of 16,080 observations of bilateral exports at the SITC one-digit section level and 106,128 observations of bilateral exports at the SITC two-digit division level. From these, we form the respective shares of total

[14] Base year effects might matter here as the US was only emerging from the Civil War in 1866. However, using 1869 as the base, its export growth was even more pronounced at 208%. Even using 1875, its export growth was 110%, underlining the growing stature of the American economy on the world stage. Thus, its cumulative export growth lead the United States to catch up with the United Kingdom by 1899 when the value of the former's exports was 94% of that of the latter.

exports by goods category, origin country, Suez/non-Suez routes, and year. In total, this process generates a fully balanced sample of 480 observations at the section level (= 2 routes * 3 origin countries * 8 years * 10 SITC one-digit sections) and 3,168 observations at the division level (= 2 routes * 3 origin countries * 8 years * 66 SITC two-digit divisions).

Against this backdrop, we assess the degree to which the opening of the canal changed the distribution of export shares for particular goods by origin country across non-Suez- and Suez-affected routes. That is, we would like to learn whether the opening of the Suez Canal affected the volume of trade of all goods or had an outsized impact on narrower categories of goods and, thereby, changed the composition of trade. To do so, we estimate a battery of difference-in-differences regressions for each origin country, successively drilling down from the level of the manufacturing/non-manufacturing sectors to one-digit sections and then two-digit divisions. The intent of this progression from broadest to narrowest good categories is that it allows us to easily see the largest movers in the underlying data by making use of the additive properties of these shares. That is, because shares must sum to one for any origin country/year, the changes in shares within appropriately defined sectors, sections, and divisions will nest one another.

In particular, we estimate the following two-way fixed effects model by origin country:

$$Share_{iskt} = \alpha_{ik} S_{ist>1869} + \gamma_{ik} S_{is} + \delta_{ikt} + \varepsilon_{iskt}$$

where $Share_{iskt}$ is the share of total exports for a single origin country (*i*) to destinations which are/are not affected by the Suez Canal (*s*) in a particular sector, section, or division (*k*) and year (*t*). Thus, the indicator variable, S_{is}, delineates the set of destinations which were ever affected by the Suez Canal. As an example, our first regression uses the data underlying Panel B of Figure 4 for British India. That is, we evaluate whether the gap in the share of manufacturing goods in total exports between non-Suez- and Suez-affected routes increased, narrowed, or remained the same after the opening of the Suez Canal in 1869.[15] We then do the same for the share of non-manufacturing goods in total exports from British India.

[15] Ideally, we would do so in the context of an event study as in Figure 2 to evaluate the validity of the parallel trends assumption. However, this would require collection of annual export data for the three

Panel A of Figure 5 depicts the estimated coefficient and related confidence interval for this regression. There, we see that the opening of the Suez Canal is associated with a (significant) 11.71 percentage point increase in the share of total exports which were non-manufacturing goods shipped to destinations affected by Suez in 1869 and a (significant) 5.54 percentage point decrease in the share of the same coming from manufacturing goods. Here, it is important to emphasize that these estimates only speak to differences in relative baseline mean outcomes and are not necessarily statements about changes in levels of these shares. Thus, the latter captures the fact that while British India's share of manufacturing goods increased in aggregate, its share of total exports in the form of manufacturing goods on Suez-affected routes remained roughly constant throughout.

Panel B of Figure 5 helps us pin down the sources of this result by considering the underlying shares of the 10 SITC one-digit sections. There, we see economically and statistically significant results (of greater than three percentage points magnitude) associated with the opening of the Suez Canal in the following:

+8.17 percentage points for 0 ("Food and live animals"); and

-4.72 percentage points for 6 ("Manufactured goods classified chiefly by materials").

Interestingly, six of the sections register coefficient values very near zero (with a mean of 0.05 percentage points), suggesting that for a large range of goods there were no changes in the differences in export shares across routes after 1869. Instead, the effects of the Suez Canal on the composition of trade seem to be limited to a relative handful of sections.

This impression is further affirmed in Panel C of Figure 5 which turns to SITC two-digit divisions as there is a similar pattern of a large number of near zero coefficients (29 of the 44 divisions estimated with non-zero observations for British India). More strikingly, there are only a few economically and statistically significant coefficients for the following:

+5.39 percentage points for 07 ("Coffee, tea, cocoa, spices, and manufactures thereof");

+4.75 percentage points for 21 ("Hides, skins and furskins, raw");

---

origin countries which is a far from trivial task given the dimensions of the raw data. Therefore, some degree of caution is warranted in ascribing a truly causal role for Suez in our discussion below.

-21.25 percentage points for 26 (“Textile fibres and their wastes”);
+19.21 percentage points for 29 (“Crude animal and vegetable materials”); and
-4.85 percentage points for 65 (“Textile yarn, fabrics, and made-up articles”).
Again, this suggests that the effects of the Suez Canal on the composition of trade was large but concentrated in just a small number of divisions.[16]

Turning to Panels A through C of Figure 6 for the United Kingdom, we repeat the exercise above moving in succession from sectors to sections and then divisions. In this case, the opening of the Suez Canal is associated with a (significant) 5.89 percentage point decrease in the share of total exports which were non-manufacturing goods shipped to destinations affected by Suez in 1869 and a (significant) 18.57 percentage point increase in the share of the same coming from manufacturing goods. This last result is noteworthy for the fact that the United Kingdom’s share of manufacturing goods in aggregate was in decline as seen in Panel E of Figure 4.

With respect to the section shares for the United Kingdom, we can see how the effect of Suez on manufacturing exports was also concentrated in the following:
-3.89 percentage points for 3 (“Mineral fuels and lubricants”); and
+20.62 percentage points for 6 (“Manufactured goods classified chiefly by materials”).
These results are also fully mirrored and likewise narrowly defined at the division level:
-4.65 percentage points for 32 (“Coal, coke and briquettes”); and
+11.24 percentage points for 65 (“'Textile yarn, fabrics, and made-up articles”).

Finally, we arrive at the equivalent results for the United States in Panels A through C of Figure 7. Here, the effects of Suez seem more muted with respect to both non-manufacturing and manufacturing goods. However, within the non-manufacturing sector, there were large, countervailing, and narrowly concentrated changes as seen in Figure 7c:
-5.51 percentage points for 01 (“Meat and meat preparations”);

[16] Appendix G considers the potentially outsized role played by three key commodities in the global economy of the late 19th century: coal (SITC 32), cotton (SITC 26), and opium (SITC 29). Excluding these commodities naturally changes the values of the point estimates discussed here, but does not materially affect the conclusions of this section with respect to the small number of affected divisions.

-11.49 percentage points for 04 ("Cereals and cereal preparations");
+3.02 percentage points for 12 ("Tobacco and tobacco manufactures"); and
+25.34 percentage points for 26 ("Textile fibres and their wastes").

In sum, these results underline the message that the Suez Canal was not associated with broad-based changes in the composition of exports for our three sample countries. Not only were the number of affected sections/divisions small in number on a country-by-country basis, they were also collectively small in number with only nine divisions significantly at play. This figure contrasts with the 66 possible divisions for which we observe positive trade values in this period. This suggests that there might have been more systematic forces at play such as the interaction of capacity constraints in the maritime shipping industry and value-to-weight ratios for goods in determining the canal's effect on the composition of trade. In the interest of space, we leave the exploration of these margins of adjustment for future work.[17]

5. Suez and the transition from sail to steam

In this section, we consider a potential mechanism underlying the effects previously identified in the wake of the Suez Canal's opening. In particular, we move beyond the truism that reductions in maritime distances are mechanically associated with reductions in trade costs. On the one hand, it is obvious that distance is a key determinant of a wide range of variable cost components like capital, fuel, and labor. On the other hand, the role of distance in the process of technological choice and change in the maritime industry is more subtle.

Purely in terms of timing, we know that the opening of the Suez Canal was closely linked to the wholesale transition to steam propulsion in maritime transport, coming at a time when roughly 80% of world shipping was still under sail.[18] For one, its opening contributed to a pronounced boom in steamship construction (Girard, 1966). What is more, this boom itself

[17] Also, in the interest of space, we only present results on the extensive margins of trade in Appendix H. There, the strongest effects identified relate to British India which saw an increase in its probability of export activity which, in turn, likely came from an increase in its number of exported products but not necessarily in its number of export destinations.
[18] Appendix I lays out the underlying trends in global gross tonnage and relative shares for sail and steam during this period of transition.

reflected not only expectations about the commercial potential of the canal but also the fact that sailing ships were unsuitable for using it. At the same time, the historical literature has long pointed to a potential role of the Suez Canal in shaping the diffusion and development of steam technology in the maritime shipping industry, but quantitative evidence to this effect has been very thin on the ground.

Harley (1971, 1972) and others have made clear that distance was the key mediating variable governing the diffusion of steam technology at any given point of time. That is, the prodigious fuel requirements of steam engines necessarily reduced the size of potential cargoes and, thus, defined a distance threshold which determined a route's profitability for shippers. This fact along with technological change in the industry helps us understand why at the beginning of this period steam was limited to carrying high value-to-weight cargoes over short distances but it was eventually carrying low value-to-weight cargoes over long distances by the end of this period.

Thus, to assess the role of the Suez Canal in the transition from sail to steam, we need to understand the factors that shaped the relative costs of shipping in the late 19th century and, in particular, how the opening of the canal and technological change interacted with one another. Our starting point is the set of calculations underlying Harley (1972) which estimate the costs of shipping via sail and steam over the period from 1850 to 1890 for a large number of maritime routes. We revise these calculations to allow for additional known costs to the production of shipping services. Thus, they measure supply-side conditions for shipping services, are not directly tied to demand for the same, and thereby remove much of the inter-annual volatility in observed freight rates (Jacks and Stuermer, 2021). Nonetheless, we validate our calculations against the latter for nine trade routes to demonstrate their representativeness. Appendix J details the assumptions and data going into these calculations along with the full results of our validation exercise.

Given the very high correlation between calculated shipping costs and observed freight rates (>0.95), our next step is then to extend this approach to 210 routes, corresponding to the origin-destination combinations found in our bilateral, product-level data for British India, the United Kingdom, and the United States. These cost calculations allow us to decompose total shipping costs on a per ton basis into the contribution of capital and labour (for both sail and steam) as well as the price of coal and Suez passage (for steam). Critically, at any given point of time, variation in shipping costs across routes for both sailing and steamships primarily arises from variation in distance, conditional on ship size. And of course, the opening of the Suez Canal in late 1869 represented a large, discrete shock to the distances travelled by merchant ships. Thus, the canal should have had very large effects on the relative costs of shipping via sail versus steam and especially for the smaller number of origin-destination combinations directly affected by its opening.

Figure 8 below depicts the evolution of average calculated shipping costs for these 210 routes across two dimensions: sail versus steam propulsion and non-Suez- versus Suez-affected routes. A few general observations are in order. First, shipping costs were decreasing across the board, ranging from a decline of 23% for sail on non-Suez-affected routes to a decline of 69% for steam on Suez-affected routes. Second, for our sample of origins and destinations, shipping costs for Suez-affected routes were always higher than non-Suez-affected routes, regardless of the means of propulsion or year. This premium paid on Suez- versus non-Suez-affected routes, in large part, reflects the greater distances associated with the former (even after 1869). However, this premium was clearly falling: for sail, it slowly declined from 92% in 1860 to 88% in 1890 while for steam, it collapsed from 118% in 1860 to 47% in 1890. Importantly, the two series for shipping costs under steam also converged on the respective series for shipping costs under sail. Indeed by 1890, shipping costs via steam were lower than those via sail across both the non-Suez- and Suez-affected routes in our sample.[19]

Apart from these broad trajectories, is it possible to more clearly see the potential role of the Suez Canal in driving the diffusion of steam technology? We begin with the observation that the demand for the services of sailing versus steamships will depend on

[19] Appendix K considers the examples of British India/United Kingdom and the United Kingdom/United States to illustrate that similar forces were working at the country-pair level as these global averages, albeit at differential rates. It also contains a comparison of our shipping cost calculations to the voyage duration calculations of Pascali (2017), underlining that our series demonstrate a larger amount of variation, particularly over time.

their relative cost from the perspective of an individual merchant. That is, while merchants may be willing to pay a premium for the greater speed and reliability of steamships, too great of a divergence in relative shipping costs will limit the appeal of employing steam. Likewise, from the perspective of a shipowner, they are unlikely to deploy steamships to locations where the market will not bear the price of their services on both the outward and homeward journeys and will rely on sail to get the job done instead. Of course, this constraint is particularly binding for more far-flung destinations.

Along these lines, Figure 9 uses the same raw data as that underlying Figure 8, but instead considers the ratio of steam-to-sail shipping costs across routes. Thus, in 1860 steam shipping was 45% and 65% higher than sail for non-Suez- and Suez-affected routes, respectively. Not surprisingly, these ratios also decline over time with steam shipping being consistently cheaper than sail for non-Suez-affected routes from 1877 and for Suez-affected routes from 1870. However, this bird's eye view misses a very important reversal in the rank ordering of the two series. Up to 1869, the relative cost of steam was always lower for non-Suez-affected routes than Suez-affected routes. Immediately after the opening of the Suez Canal in 1869, the relative cost of shipping by steam fell in general due to changes in the underlying technology parameters and heavy investment in steamship construction. But it did so even more dramatically on Suez-affected routes as the absolute cost of using steam declined by 33% from 1869 to 1870 alone and the relative cost of using steam was subsequently always lower for Suez-affected routes than non-Suez-affected routes.[20] Thus, not only was the mode-of-shipping choice of merchants altered, but also the fleet deployment choice of shipowners now favoured the use of steamships on Suez-affected routes for the first time.

[20] This discussion of the relative costs of shipping neglects the fact that steam was also the quicker means of transportation and that it significantly improved over time. Our shipping cost calculations also embed estimates of shipping times. In 1860, steam is estimated to have been 24% and 27% quicker than sail on non-Suez- and Suez-affected routes, respectively. In 1890, it is estimated to have been 35% and 60% quicker than sail on non-Suez- and Suez-affected routes, respectively.

6. Conclusion

This primary purpose of this paper has been to provide the first comprehensive quantitative assessment of the Suez Canal's opening and subsequent operation in the late 19th century. As such, it finds that the canal increased the volume of trade for affected country pairs, had an outsized impact on a fairly narrow range of goods, and vitally influenced the diffusion of new transport technology and, thus, altered the global pace of the sail-to-steam transition. One open question – naturally, outside the scope of the present paper – is whether the opening of the Suez Canal also influenced the direction of technical change in maritime shipping itself. Many historians have alluded to this possibility, citing key innovations in engine and hull design which occurred after 1869 and which arose to address specific issues related to the operation of steamships to the east of Suez (cf. Fletcher, 1958; Girard, 1966; Harley, 1971). In this way, endogenizing the process of technological change in the sail-to-steam transition could further amplify this paper's message that the opening of Suez was a key catalyst for the first wave of globalization.

APPENDIX A: PRODUCT-LEVEL EXPORT DATA SOURCES

The product-level export data for British India was extracted from various years of the *Annual Statement of the Trade and Navigation of British India with Foreign Countries and of the Coasting Trade of the Several Presidencies and Provinces* (*ASTNBI*) listed below. Altogether, these yield 11,153 lines of raw data. From these, we assign consistent country identifiers and one-digit SITC codes to 7,578 observations (with further assignment to 6,907 observations at the two-digit and 6,187 observations at the three-digit SITC levels).

1866 – *ASTNBI*. Calcutta: Superintendent of Government Printing, 1869.
1869 – *ASTNBI*. Calcutta: Superintendent of Government Printing, 1871.
1875 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1877.
1880 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1881.
1885 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1890.
1890 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1895.
1895 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1899.
1899 - *ASTNBI*. Calcutta: Superintendent of Government Printing, 1901.

The product-level export data for the United Kingdom was extracted from ledgers of exports for the United Kingdom held in the National Archives in the folders of CUST 8 listed below. This is the same data underlying Jacks, O'Rourke, and Taylor (2020). Altogether, these yield 216,761 lines of raw data. From these, we assign consistent country identifiers and one-digit SITC codes to 206,932 observations (with further assignment to 202,063 observations at the two-digit and 188,561 observations at the three-digit SITC levels).

1866 - *Ledgers of Exports of British Merchandise under Countries*, 103
1869 - *Ledgers of Exports of British Merchandise under Countries*, 109-110
1875 - *Ledgers of Exports of British Merchandise under Countries*, 116
1880 - *Ledgers of Exports of British Merchandise under Countries*, 121
1885 - *Ledgers of Exports of British Merchandise under Countries*, 126
1890 - *Ledgers of Exports of British Merchandise under Countries*, 131
1895 - *Ledgers of Exports of British Merchandise under Countries*, 136
1899 - *Ledgers of Exports of British Merchandise under Countries*, 140

The product-level export data for the United States was extracted from various years of the *Annual Report of the Secretary of the Treasury on the Commerce and Navigation of the United States* (*ARSTCNUS*) listed below. This is the same data underlying Meissner and Xu (2022). Altogether, these yield 106,243 lines of raw data. From these, we assign consistent country identifiers and one-digit SITC codes to 97,967 observations (with further assignment to 97,310 observations at the two-digit and 97,171 observations at the three-digit SITC levels).

1866 – *ARSTCNUS*. Washington: Government Printing Office, 1868.
1869 – *ARSTCNUS*. Washington: Government Printing Office, 1871.

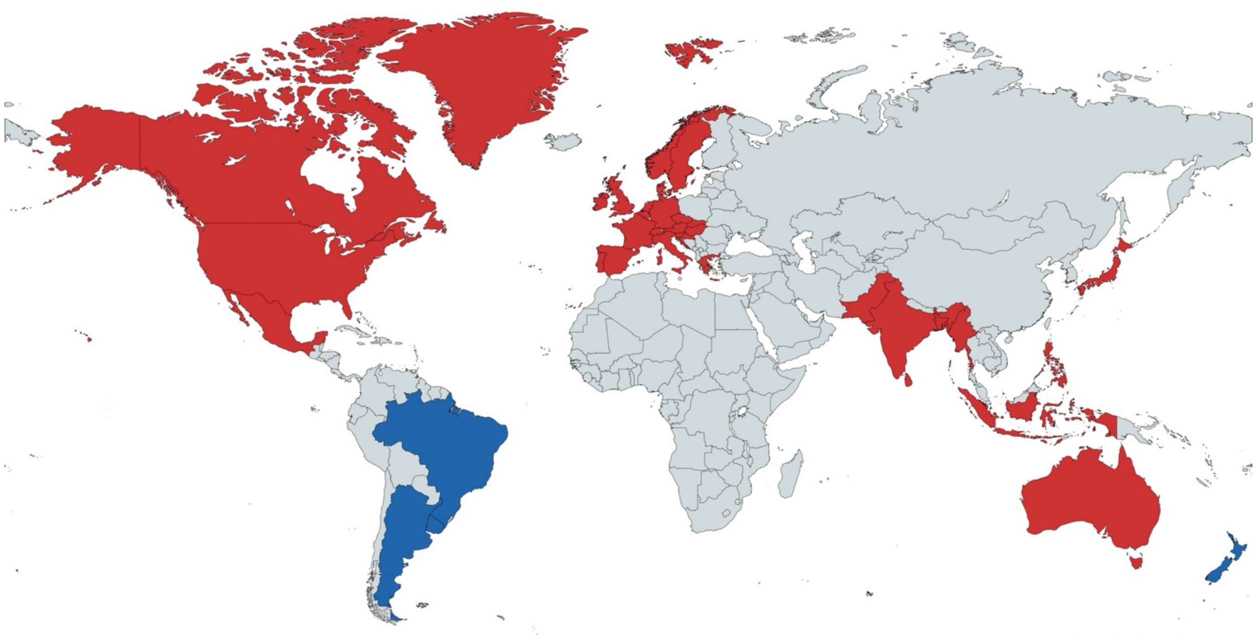
1875 – *ARSTCNUS*. Washington: Government Printing Office, 1877.
1880 – *ARSTCNUS*. Washington: Government Printing Office, 1882.
1885 – *ARSTCNUS*. Washington: Government Printing Office, 1887.
1890 – *ARSTCNUS*. Washington: Government Printing Office, 1892.
1895 – *ARSTCNUS*. Washington: Government Printing Office, 1897.
1899 – *ARSTCNUS*. Washington: Government Printing Office, 1901.

APPENDIX B: SUEZ-AFFECTED COUNTRIES ACROSS TWO SAMPLES

In assessing the effects of the Suez Canal on the volume of trade, our preferred dataset was drawn from Jacks, Meissner, and Novy (2011). The sample comprises bilateral trade from 27 countries and 148 country pairs representing over 70% of world exports and GDP at the time. Figure B1 depicts the sample countries in either blue or red (that is, there is no data for the countries in grey). Countries in blue are those which have no bilateral trading relationships affected by the opening of the Suez Canal. Countries in red are those which have at least one bilateral trading relationships affected by the opening of the Suez Canal.

The sample countries included in the dataset are: Argentina, Australia, Austria-Hungary, Belgium, Brazil, British India, Canada, Ceylon, Denmark, Dutch East Indies, France, Germany, Greece, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, the Philippines, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the United States, and Uruguay.

Figure B1: Sample Countries in Jacks, Meissner, and Novy (2011)

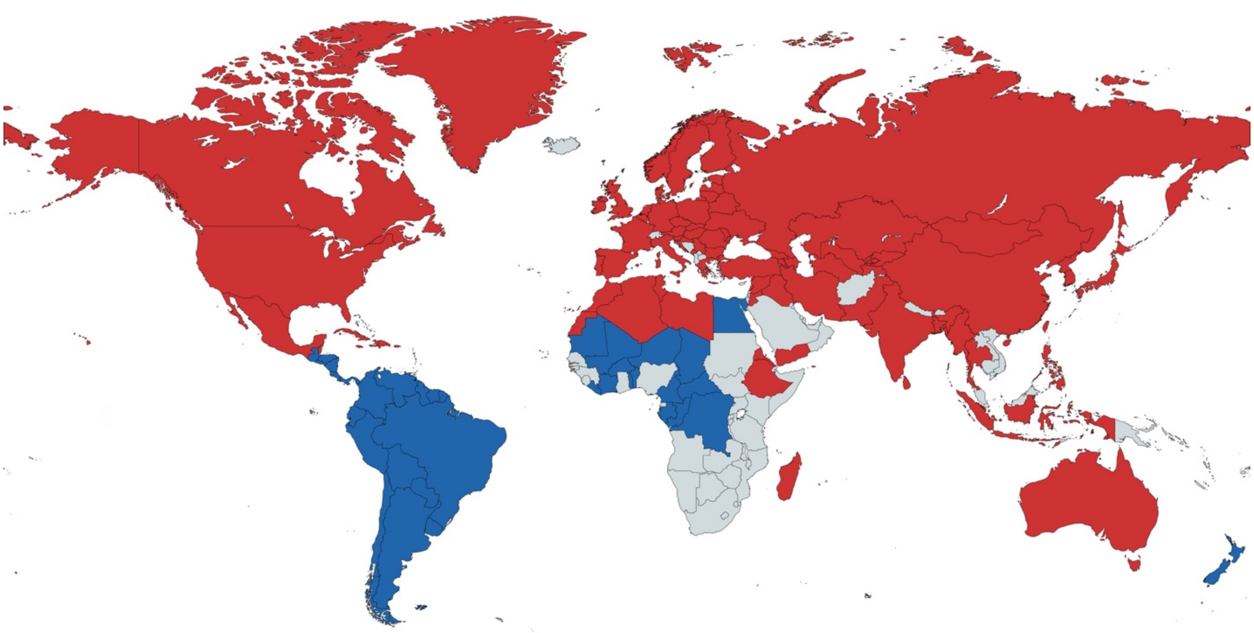


In assessing the effects of the Suez Canal on the composition of trade, we make use of a new data on bilateral bilateral, product-level exports from British India, the United Kingdom, and the United States in 1866, 1869, 1875, 1880, 1885, 1890, and 1899. The sample comprises exports from these three countries to one other along with 67 other destinations representing over 30% of world exports and GDP at the time.

Figure B2 depicts the sample destinations in either blue or red (that is, there is no data for the countries in grey). Destinations in blue are those which have no bilateral trading relationships affected by the opening of the Suez Canal. Destinations in red are those which have at least one bilateral trading relationships affected by the opening of the Suez Canal.

The sample destinations included in the dataset are: Abyssinia, Aden, Argentina, Austria Hungary, Azores/Madeira/Cape Verde Islands, Belgium, Bermuda, Bolivia, Brazil, British Australasia, British Guiana, British India, British West Indies, Bulgaria, Canada, Canary Islands, Central America, Chile, China, Colombia, Congo, Danish West Indies, Denmark, Dutch East Indies, Dutch West Indies/Dutch Guiana, Ecuador, Egypt, Falkland Islands, France, French Africa, French East Indies, French North American Possessions, French West Indies/ French Guiana, Germany, Gibraltar, Greece, Haiti/Dominican Republic, Hawaii, Italy, Japan, Korea, Liberia, Madagascar, Malta/Gozo/Cyprus, Mexico, Morocco, Netherlands, Paraguay, Persia, Peru, Philippine Islands, Portugal, Portuguese East Indies, Romania, Russia, Serbia, Siam, Spain, Spanish Africa, Spanish West Indies, Sweden/Norway, Tripoli, Turkey, United Kingdom, United States, Uruguay, and Venezuela.

Figure B2: Sample Destinations for Product-level Exports



APPENDIX C: NUMBERED LISTS OF SECTIONS AND DIVISIONS

Throughout the paper, we make use of commodity classifications drawn from the Standard International Trade Classification (SITC) Revision 2 for the following 10 sections and 66 divisions.

Code	Description
0	Food and live animals chiefly for food
1	Beverages and tobacco
2	Crude materials, inedible, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils, fats and waxes
5	Chemicals and related products
6	Manufactured goods classified chiefly by materials
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities and transactions not classified elsewhere in the SITC

Code	Description
00	Live animals chiefly for food
01	Meat and preparations
02	Dairy products and birds' eggs
03	Fish, crustacean and molluscs, and preparations thereof
04	Cereals and cereal preparations
05	Vegetables and fruit
06	Sugar, sugar preparations and honey
07	Coffee, tea, cocoa, spices, and manufactures thereof
08	Feeding stuff for animals (not including unmilled cereals)
09	Miscellaneous edible products and preparations
11	Beverages
12	Tobacco and tobacco manufactures
21	Hides, skins and furskins, raw
22	Oil seeds and oleaginous fruit
23	Crude rubber (including synthetic and reclaimed)
24	Cork and wood
25	Pulp and waste paper
26	Textile fibres (not wool tops) and their wastes (not in yarn)
27	Crude fertilizer and crude minerals
28	Metalliferous ores and metal scrap
29	Crude animal and vegetable materials
32	Coal, coke and briquettes
33	Petroleum, petroleum products and related materials

41	Animal oils and fats
42	Fixed vegetable oils and fats
43	Animal and vegetable oils and fats, processed, and waxes
51	Organic chemicals
52	Inorganic chemicals
53	Dyeing, tanning and colouring materials
54	Medicinal and pharmaceutical products
55	Oils and perfume materials; toilet and cleansing preparations
56	Fertilizers, manufactured
57	Explosives and pyrotechnic products
58	Artificial resins and plastic materials, and cellulose esters
59	Chemical materials and products, nes
61	Leather, leather manufactures, and dressed furskins
62	Rubber manufactures
63	Cork and wood, cork manufactures
64	Paper, paperboard, and articles of pulp, of paper or of paperboard
65	Textile yarn, fabrics, made-up articles, and related products
66	Non-metallic mineral manufactures
67	Iron and steel
68	Non-ferrous metals
69	Manufactures of metals
71	Power generating machinery and equipment
72	Machinery specialized for particular industries
73	Metalworking machinery
74	General industrial machinery and equipment, and parts of
75	Office machines and automatic data processing equipment
76	Telecommunications, sound recording and reproducing equipment
77	Electric machinery, apparatus and appliances, and parts
78	Road vehicles
79	Other transport equipment
81	Sanitary, plumbing, heating, lighting fixtures and fittings
82	Furniture and parts thereof
83	Travel goods, handbags and similar containers
84	Articles of apparel and clothing accessories
85	Footwear
87	Professional, scientific, controlling instruments, apparatus
88	Photographic equipment and supplies, optical goods; watches, etc
89	Miscellaneous manufactured articles
91	Postal packages not classified according to kind
93	Special transactions, commodity not classified according to class
94	Animals, live (including zoo animals, pets, insects, etc)
95	Armoured fighting vehicles, war firearms, ammunition, parts
97	Gold, non-monetary (excluding gold ores and concentrates)

APPENDIX D: POTENTIAL CONFOUNDERS

Proper identification of the Suez Canal's effects on trade volumes assumes a lack of potential confounders. Given simultaneous developments in the late 19th century, these might include the global extension of the telegraph network, declines in the duration of voyages under sail and steam, and the 1866 London banking crisis. A priori, we have no reason to suspect a geographic component to these forces wherein they were systematically correlated with Suez-affected country pairs, but we need to eliminate this econometrically as a possibility. To this end, we report the results of a number of robustness exercises along these lines.

Column 1 of Table D1 replicates our preferred estimate (Column 4, Table 1). Column 2 reports the results with the inclusion of a time-varying indicator variable for a telegraphic connection between country pairs. We use the first year of a common connection to London to define telegraphic connections from Bottomley, S. and B.D. Varian (2024), "Information Costs and Trade: Evidence from International Electric Telegraphy during the 'Golden Age' of Globalization". The coefficient on the telegraph suggests a connection resulted in a 28% increase in bilateral exports for affected country pairs. However, it is statistically insignificant. Most importantly, it has virtually no effect on the estimate for the opening of the Suez Canal.

Column 3 reports the results with the inclusion of voyage durations measured in days at sea. In Pascali (2017), each country pair is assigned four time-invariant values for voyage duration before/after the opening of Suez and under sail/steam. We combine these four variables into two vectors for sail and steam for each country pair over time with a single potential break point occurring in 1869. We then incorporate these in our benchmark specification. Doing so without our Suez indicator, the estimated coefficients are both of the expected sign (negative) but statistically insignificant. With the inclusion of our Suez indicator, only voyage duration under sail is of the expected sign: that is, longer voyage durations under steam are associated with higher levels of bilateral exports while all three independent variables of interest are statistically significant. The difference in estimates for voyage durations under sail and steam is likely related to the very high correlation between the two variables (0.95) and their high correlations with our Suez indicator (0.63 and 0.56, respectively).

Finally, Column 4 reports the results with the inclusion of a time-varying indicator for the 1866 London banking crisis. We follow Xu (2022) and consider whether the origin country in a country pair was exposed to the crisis and, thereby, whether domestic exporters suffered from a subsequent reduction in trade credit. Exposure to the banking crisis is associated with a large decline in bilateral trade flows (-46%). However, the coefficient is somewhat imprecisely estimated and is, thus, statistically insignificant whereas the Suez indicator remains positive and statistically significant.

In sum, while the Suez coefficients in Columns 2 through 4 differ in value, we note that all of them are positive and significantly different than zero while none of them are statistically significantly different from our baseline results in Column 1 or from one another.

Table D1: DiD estimates, potential confounders

	(1)	(2)	(3)	(4)
	High quality sample	With tele-graphs	With voyage times	With bank crises
Suez canal (= 1)	0.54	0.51	1.58	1.00
	(0.15)	(0.15)	(0.55)	(0.30)
	[3.65]	[3.51]	[2.85]	[3.35]
Telegraph (= 1)		0.25		
		(0.16)		
		[1.53]		
Voyage duration, sail (days)			-0.09	
			(0.03)	
			[3.03]	
Voyage duration, steam (days)			0.22	
			(0.11)	
			[1.99]	
1866 banking crisis (= 1)				-0.62
				(0.36)
				[1.74]
N of observations	7,899	7,899	6,507	7,899
Country-pair & year fixed effects	X	X	X	X
Time-varying exporter effects	X	X	X	X
Time-varying importer effects	X	X	X	X

PPML regression of bilateral trade up to 1900. Country-pair fixed effects are defined by the direction of export flows. Column 1 replicates our preferred estimate (Column 4 of Table 1). Column 2 reports the results with the inclusion of a time-varying indicator variable for a telegraph connection between country pairs. Column 3 reports the results with the inclusion of voyage durations under sail and steam measured in days at sea. Column 4 reports the results with the inclusion of a time-varying indicator for whether the origin country was exposed to the 1866 London banking crisis. Standard errors are in parentheses and clustered at the non-directed country-pair level. z-statistics are reported below the standard errors in brackets.

APPENDIX E: TRADE DIVERSION, GENERAL EQUILIBRIUM, AND WELFARE

Here, we use methods developed by Head and Mayer (2014) to assess the issue of trade diversion in the context of the general equilibrium and welfare impacts of the opening of the Suez Canal. Their code and analytical framework builds off of recent advances in applied and theoretical international trade using the gravity model. However, we treat the results presented here with a degree of caution, given some of the assumptions needed (in particular, using GDP less aggregate exports as a proxy for domestic trade) and questions regarding the underlying data (in particular, the validity of estimates of GDP prior to 1870).

To generate our results, we first calculate the "conditional general equilibrium" (CGE) impact on bilateral trade from a counterfactual world with no Suez Canal. CGE was introduced by Anderson and van Wincoop (2003) and refers to a projection in which expenditures and incomes are held constant but bilateral trade flows are allowed to change due to decreases or increases in bilateral trade costs. The difference between the relative effect discussed at length in the main text and CGE is that we allow for multilateral (or third-country) effects to operate. These multilateral effects matter since differential changes in the level of trade costs alter relative trade costs with all trading partners and, thus, alter relative trade costs for all other countries in the trading network (Anderson and van Wincoop, 2003).

The conditional general equilibrium ratio of bilateral trade under a counterfactual without the Suez canal, is given by:

$$CGETI_{ij} = \frac{X'_{ij}}{X_{ij}} = exp\left[\beta_{Suez}(S'_{ij} - S_{ij})\right] \times \frac{\Omega_i}{\Omega'_i}\frac{\Phi_j}{\Phi'_j} = \hat{\phi}_{ij}\frac{\Omega_i}{\Omega'_i}\frac{\Phi_j}{\Phi'_j}$$

where X'_{ij} is the trade share under the counterfactual; baseline bilateral trade is given by X_{ij}; and Ω_i and Φ_j are transformations of the multilateral resistance terms/price indices from Anderson and van Wincoop (2003). We solve for these using income and trade shares and the contraction mapping algorithm provided by Head and Mayer (2014). The terms Ω'_i and Φ'_j are the new equilibrium values of these multilateral resistance terms when the observed Suez Canal indicator S_{ij} assigned a value of zero for all pairs that are connected by the canal. Finally, ϕ_{ij}-hat in the last term denotes the ratio of bilateral trade costs in the counterfactual, ϕ'_{ij}, relative to the baseline, ϕ_{ij}.

To calculate the initial values of the multilateral resistance terms, we use the country-pair fixed effects from the baseline gravity model using our high-quality sample plus our proxy for domestic trade (*GDP – EXP*). The median calculated value of $CGETI_{ij}$ implies that bilateral trade for Suez-affected country pairs was 1.358 times higher than that implied by the counterfactual with no Suez Canal. Trade diversion in this case is very minimal since bilateral exports between non-Suez-affected country pairs were 0.999 times the predicted value in the counterfactual with no Suez Canal.

We can also evaluate ϕ_{ij}-hat (again, the ratio of bilateral trade costs in the counterfactual relative to the baseline) in the context of full general equilibrium. This is given by:

$$GETI_{ij} = \frac{X'_{ij}}{X_{ij}} = exp\left[\beta_{Suez}(S'_{ij} - S_{ij})\right] \times \frac{\Omega_i}{\Omega'_i}\frac{\Phi_j}{\Phi'_j} \times \frac{Y'_i X'_j}{Y_i X_j} = \hat{\phi_{ij}}\frac{\Omega_i}{\Omega'_i}\frac{\Phi_j}{\Phi'_j}$$

The expression here varies from $CGETI_{ij}$ since it allows incomes, *Y*, and expenditures, *X*, to vary in the counterfactual. The solution for $GETI_{ij}$ is given by Head and Mayer (2014) who follow the "exact hat algebra" of Dekle, Eaton, and Kortum (2007). This approach also allows us to measure welfare as long as we are willing to assign a value to the elasticity of substitution between the output of different trade partners (here, we assume it is equal to -5).

The median calculated value of $GETI_{ij}$ implies that bilateral trade for Suez-affected country pairs was 1.366 times higher than that implied by the counterfactual with no Suez Canal. Again, trade diversion in this case is very minimal since bilateral exports between non-Suez-affected country pairs were 0.999 times the predicted value in the counterfactual with no Suez Canal. What is more, the median welfare effect is less than 1 percent for non-Suez- and Suez-affected pairs. Although this figure is quite small, it is consistent with the calculations by Head and Mayer (2014) which show a respective rise in welfare of just 0.5%, 0.4%, and 1.3% for sharing a common language, having a historical colonial link, and joining the EU in their post-1950 sample. Alternatively, the pairs that did not share a language, did not have a historical colonial link, and did not enter the EU have respective welfare losses of just 0.1%. Thus, factors which are estimated to have significant effects on bilateral trade flows tend to have much smaller welfare effects in relative terms when using aggregate models such as these since trade-to-gross output ratios are generally small.

Finally, we can speak to variation in the average general equilibrium effect of trade at the country pair level. Anderson and van Wincoop (2003) emphasize that in general equilibrium changes in bilateral trade cost must be gauged relative to the entire set of GDP-weighted trade costs and that the overall size of an economy matters. For economies where a large share of external trade is with countries connected by the Suez Canal, the effects are naturally expected to be largest. Indeed, this is the case for Japan which began trading heavily with Europe in this period but which traded relatively less with its East Asian neighbours and itself (Meissner and Tang, 2018). For places like British India with a high domestic trade share and a large share of external trade with Asia, the effective trade cost decline was somewhat smaller. In terms of trade diversion, we generally see very small effects. However, there are two interesting cases: Australia and British India had average declines in observed trade flows with non-Suez-affected partners of 7.8% and 3.7%, respectively. That is, both countries experienced post-Suez declines in trade shares with Asian partners and post-Suez increases in trade shares with European partners.

Appendix E references

Anderson, J.E. and E. Van Wincoop (2003), "Gravity with Gravitas: A Solution to the Border Puzzle." *American Economic Review* 93(1): 170-192.

Dekle, R., J. Eaton, and S. Kortum (2007), "Unbalanced Trade." *American Economic Review* 97(2): 351-355.

Head, K. and T. Mayer (2014), "Gravity Equations: Workhorse, Toolkit, and Cookbook." In *Handbook of International Economics, vol. 4*, Gopinath, Helpman, and Rogoff (Ed.s). Amsterdam: North Holland,131-195.

APPENDIX F: PROPORTIONAL DECLINES IN MARITIME DISTANCE BY COUNTRY PAIR

In Section 4.1.3, we use the maritime distances separating country pairs – both before and after 1869 – reported in Hugot and Umana Dajud (2016) to calculate the proportional decline in maritime distances following in the wake of Suez at the country-pair level. We then consider the differential effect of Suez on the basis of the smallest (first quartile) to largest (fourth quartile) proportional declines in maritime distances. Here, we simply report the values of the "Suez ratio" along with their corresponding (unique) country pairs.

British India-Italy	-0.5590
British India-France	-0.4837
British India-Spain	-0.4345
Belgium-British India	-0.4237
British India-Germany	-0.4137
Italy-Japan	-0.4000
British India-United Kingdom	-0.3850
British India-United States	-0.3850
British India-Netherlands	-0.3573
British India-Canada	-0.3466
Dutch East Indies-France	-0.3371
France-Japan	-0.3217
Japan-Spain	-0.3018
Japan-Portugal	-0.2511
Japan-United Kingdom	-0.2347
Japan-Netherlands	-0.2334
Belgium-Japan	-0.2333
Germany-Japan	-0.2333
Japan-Norway	-0.2264
Philippines-United Kingdom	-0.2264
Dutch East Indies-United Kingdom	-0.2229
Dutch East Indies-Netherlands	-0.2213
Belgium-Dutch East Indies	-0.2211
Australia-France	-0.1508
Canada-Dutch East Indies	-0.1000
Dutch East Indies-United States	-0.1000
Canada-Japan	-0.0700
Japan-United States	-0.0700
Australia-United Kingdom	-0.0610
Australia-Canada	-0.0500
Australia-United States	-0.0500
Australia-Belgium	-0.0381
Australia-Norway	-0.0372

APPENDIX G: EXCLUSION OF KEY COMMODITIES

Here, we consider the potentially outsized role played by three key commodities in the global economy of the late 19th century: coal, cotton, and opium. We do so by dropping their respective SITC codes when stacking and then collapsing the raw data. Mechanically, their exclusion increases the share of all other commodities. However, this may lead to non-obvious changes in our point estimates, given the large secular changes in the shares of these three commodities over time which we discuss below.

Beginning with coal, it has long been known that it played a large role not only in British trade but also for British shipping during this time. As Fletcher (1975) reports, coal represented over 85% of the total physical volume of British exports in 1913 but only 10% of their total value. Thus, its unique properties as both ballast and fuel might have had an undue impact on our previous results. Over our sample period, coal climbed from 2.7% of the total value of British exports in 1866 to 10.4% in 1899 while British India and the US had negligible coal exports during this period.

Likewise, cotton was not only a critical commodity for both British India and the US but also subject to wide swings in the sources of supply and demand. Thus, cotton fell from 44.2% of the total value of exports from British India in 1866 to 10.6% in 1899. For the US, cotton fell from 60.4% of the total value of exports in 1866 to 17.6% in 1899 while the UK had no cotton exports during this period.

Finally, opium constituted another linchpin for British India. Together with cotton, it constituted a majority of the value of its exports until at least 1880. And while opium's decline in export share was significant, it was not as dramatic as that for cotton. Thus, opium fell from 31.9% of the total value of exports from British India in 1866 to 18.9% in 1899 while the UK and the US had no opium exports during this period.

Here, we replicate Figures 5 through 7 in the main text, but now with our product-level bilateral export data purged of these three commodities. Figures E1 through E3 depict the results of this exercise for British India, the UK, and the US, respectively.

For British India, there is now no demonstrable effect on the share of non-manufacturing exports in Panel A of Figure G1 while the point estimate for manufacturing exports on Suez-affected routes declines even further (from -5.5 to -17.47 percentage points). This is mirrored in Panel B where there are now noticeable declines in sections 2 ("Crude materials, inedible, except fuels") and 5 ("Chemicals and related products") along with 6 ("Manufactured goods classified chiefly by materials"). However, Panel C highlights the same affected divisions as in Figure 5 except for the addition of 53 ("Dyeing, tanning and colouring materials") which replaces 29 ("Crude animal and vegetable materials") once opium is excluded.

For the UK, the DiD estimates in Figure G2 are largely unchanged from those depicted in Figure 6 of the main text. The only slight exception here is that section 3 ("Mineral fuels, lubricants and related materials") is no longer significant which naturally arises from the exclusion of coal. Given the relatively modest share of coal in UK exports, it is perhaps not surprising that our original results are – more or less – repeated here with 65 ("Textile yarn, fabrics, made-up articles, and related products") now as the only affected division.

For the US, there are now even more muted effects on the shares of non-manufacturing and manufacturing exports as seen in Panel A of Figure G3 with both coefficients being small in magnitude and statistically insignificant. As before, this primarily reflects – but also slightly obscures – a fair amount of churn in the non-manufacturing sector in particular. Whereas 01 ("Meat and preparations") and 04 ("Cereals and cereal preparations") decline as before, this is offset by increases in 12 ("Tobacco and tobacco manufactures") as before but also in 33 ("Petroleum, petroleum products and related materials") which replaces 26 ("Textile fibres and their wastes") once cotton is excluded.

In sum, excluding the three commodities of coal, cotton, and opium does indeed change the values of the some of the point estimates discussed in the main text. However, it does not materially affect the conclusion there that the number of affected divisions was collectively small in number. Previously, there were only nine divisions significantly at play as opposed to the eight divisions identified here.

Figure G1: DiD estimates for export shares by sector/section/division, British India

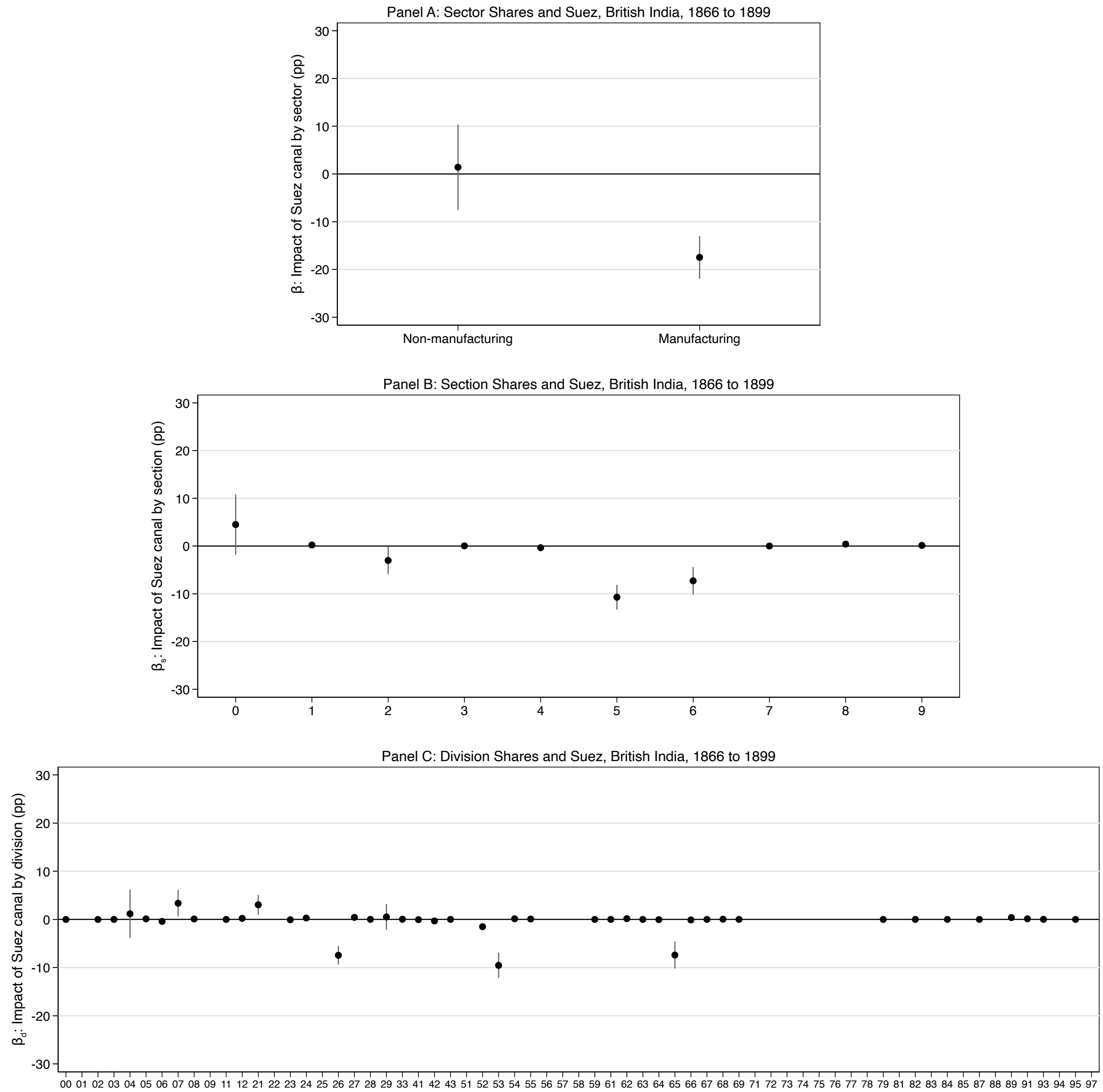


Figure G1 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from British India across all non-Suez- and Suez-affected destinations. It is equivalent to Figure 5 in the main text but excludes coal, cotton, and opium. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

Figure G2: DiD estimates for export shares by sector/section/division, UK

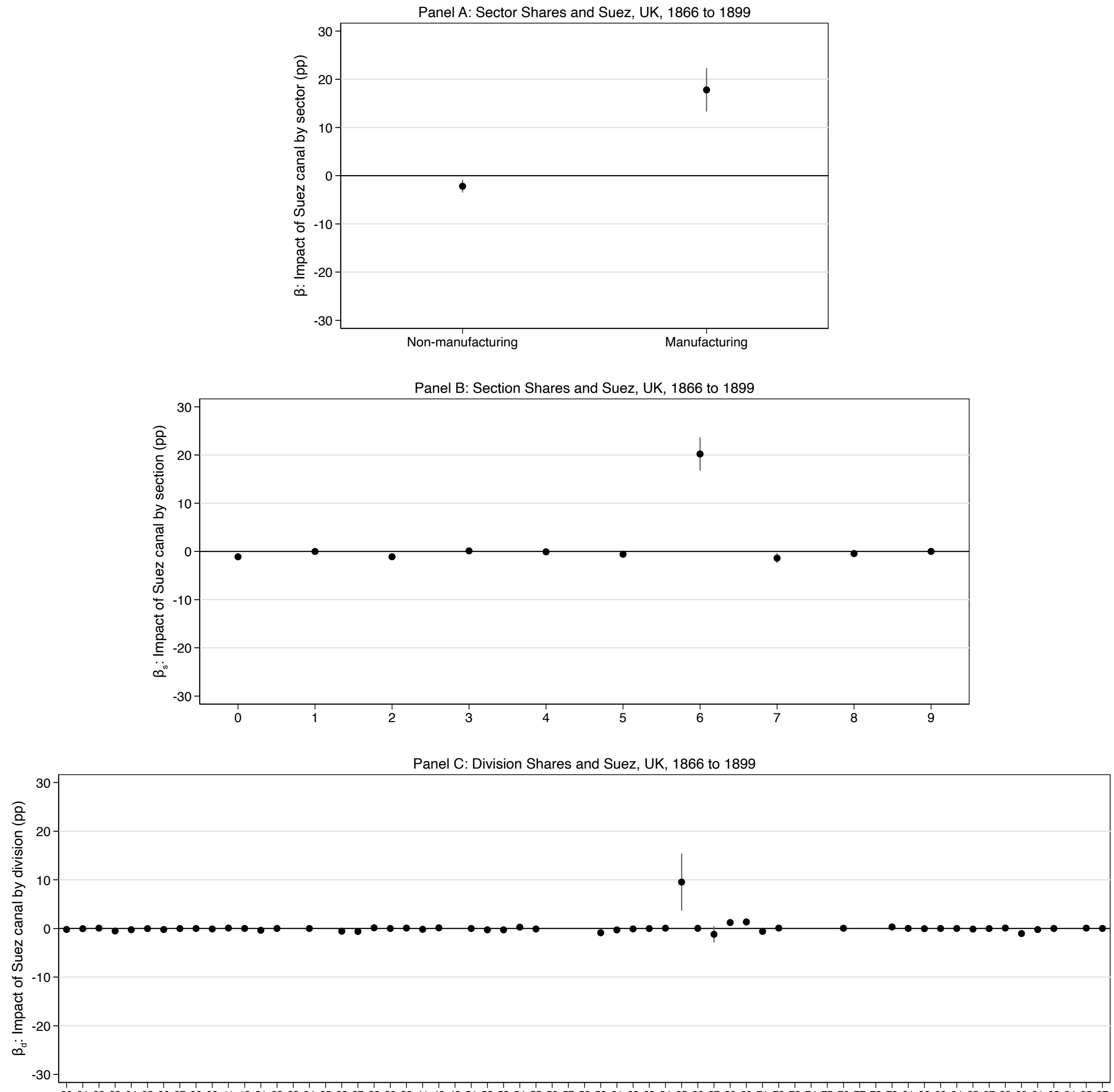


Figure G2 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from the United Kingdom across all non-Suez- and Suez-affected destinations. It is equivalent to Figure 6 in the main text but excludes coal, cotton, and opium. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

Figure G3: DiD estimates for export shares by sector/section/division, US

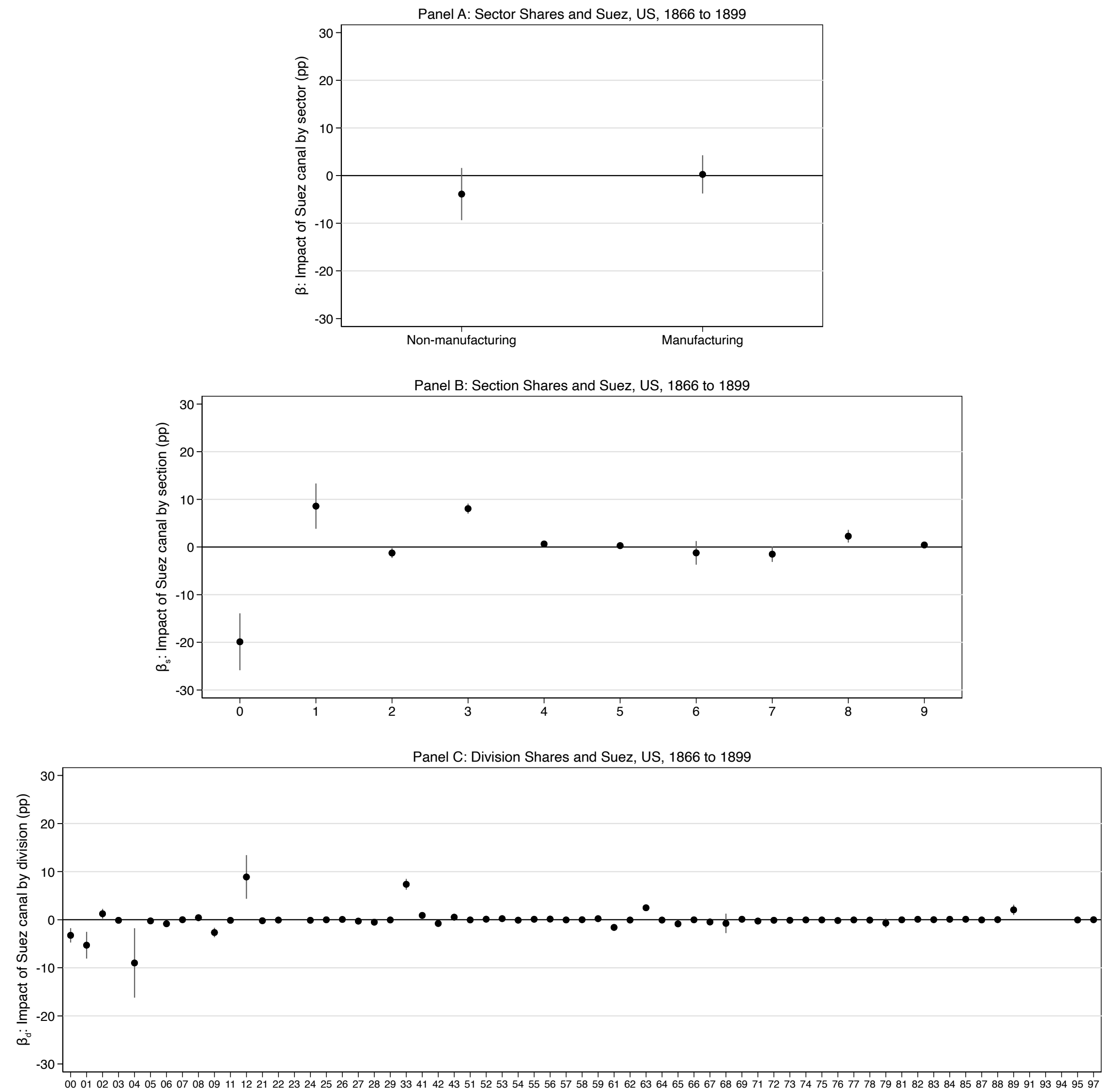


Figure G3 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from the United States across all non-Suez- and Suez-affected destinations. It is equivalent to Figure 7 in the main text but excludes coal, cotton, and opium. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

APPENDIX H: THE EXTENSIVE MARGINS OF TRADE

As Panels C, F, and I of Figure 4 show, there were also potentially informative changes in the extensive margins of trade as the fraction of non-zero cells at the origin-destination-section level increased from 1866 to 1899. In order to assess the potential role of Suez's opening in this process, we run a set of two-way fixed effects probit regressions of the following form:

$$probit(Y_{ijkt}) = \alpha_i S_{ijt>1869} + \gamma S_{ij} + \delta_t + \varepsilon_{ijkt}$$

where Y_{ijkt} equals to one if an origin country (i) exports to a destination (j) in a particular section (k) and year (t). Thus, the indicator variable, S_{ij}, simply delineates whether a destination was ever affected by the Suez Canal. In unreported results, we run the same specifications using conditional logit or linear probability models, yielding virtually identical results to those reported below.

Panel A of Table H1 reports the average marginal effects of this difference-in-differences exercise. Column 1 does so for the full sample of 16,080 observations, finding the opening of the canal was associated with a statistically significant 5% higher chance of exporting activity at the section level for Suez-affected routes across all origin countries. Columns 2 through 4 do so on a country-by-country basis. Statistically, the strongest marginal effects come from British India with a 7% higher chance of exporting activity and a z-score of 2.47 (which is highly significant at the 1% level). Quantitatively, the largest average marginal effects come from the United Kingdom with a 11% higher chance of exporting activity and a z-score of 1.56 but which is not statistically significant even at the 10% level. The marginal effects for the United States are negative but not statistically significant.

Panel B of Table H1 repeats this exercise but does so by aggregating the treatment up to the destination-country level. That is, it now evaluates Y_{ijt} which equals to one if an origin country (i) exports to a destination (j) in a particular year (t), leaving all other variables and the probit specification otherwise the same. For British India, the average marginal effects are quantitatively and statistically negligible. The average marginal effects for the United Kingdom is but statistically insignificant. In combination, the two panels imply that the increase in the probability of export activity from British India likely came from an increase in the number of exported products but not necessarily the number of export destinations.

Table H1: DiD probit estimates for non-zero observations

Panel A

	(1) Full sample	(2) British India	(3) United Kingdom	(4) United States
Suez canal (= 1)	0.05	0.07	0.11	-0.06
	(0.03)	(0.03)	(0.07)	(0.04)
	[1.83]	[2.47]	[1.56]	[1.69]
N of observations	16,080	5,360	5,360	5,360
Suez-affected route fixed effect	X	X	X	X
Year fixed effects	X	X	X	X

Panel B

	(1) Full sample	(2) British India	(3) United Kingdom	(4) United States
Suez canal (= 1)	0.03	0.00	0.15	-0.07
	(0.04)	(0.06)	(0.09)	(0.06)
	[0.65]	[0.05]	[1.64]	[1.16]
N of observations	1,608	536	536	536
Suez-affected route fixed effect	X	X	X	X
Year fixed effects	X	X	X	X

Table H1 reports the results of probit regressions for the years from 1865 to 1900. The dependent variable in all columns is an indicator taking the value of one for non-zero trade flows. The first reported figures are the average marginal effects. The columns report the results of single regressions including an indicator for whether a country pair was affected by the opening of the Suez Canal. Panel A reports the results using origin-destination-section cells. Panel B reports the results using origin-destination cells. Standard errors are in parentheses and clustered at the country-pair level. z-statistics reported below the standard errors in brackets.

APPENDIX I: GLOBAL GROSS TONNAGE & SHARES BY MEANS OF PROPULSION

There is a very large literature in economic history which addresses the transition from sail to steam in maritime propulsion and its consequent effects on world economic activity. Here, rather than try to summarize this literature, we simply outline the main trends in global gross tonnage and the shares of sail and steam in this period of transition.

Thus, Figure I1 depicts the global gross tonnage for sail versus steam, drawn from Jacks and Stuermer (2021). To be clear, this figure makes no correction for the increased speed of steam over sailing ships nor for their increasing speed over time. That is, unlike some of the literature, we do not scale up the figures for steam tonnage by an arbitrary factor (generally around two) to account for the fact that steamships could carry more cargo in a year.

There we see that at the global level steam was dwarfed by sail in 1860. And while both grew considerably in the 1860s, the rate of growth for steam was greater. After consolidation through much of the 1870s, steam in particular began to grow at a fast rate. Consequently, global gross tonnage under sail peaked in 1886 with a somewhat drawn out decline through the 1890s. In this regard, it should borne in mind that ships – even those under sail – are large fixed capital investments, a perspective which rationalizes why outmoded vintages of technology like sail tend to linger for much longer than is perhaps appreciated.

Figure I2 places the sail-to-steam transition in wider perspective by considering the shares of global gross tonnage by means of propulsion, inclusive of not only sail/steam but also oil and over the longer period from 1860 to 1960. Thus, we can see 1886 also marked the year in which global gross tonnage under steam surpassed that under sail. Additionally, the figure highlights the symmetric process by which the share of steam declined in the face of propulsion by oil, particularly during and after World War I. Finally, Figure I2 shows that sail surprisingly lingered until the 1950s (with the last active sailing ship being retired in 1958), a process which was mirrored by steam (with the last active steamship being retired in 1990).

Figure I1: Global Gross Tonnage (m) by Means of Propulsion, 1860 to 1900

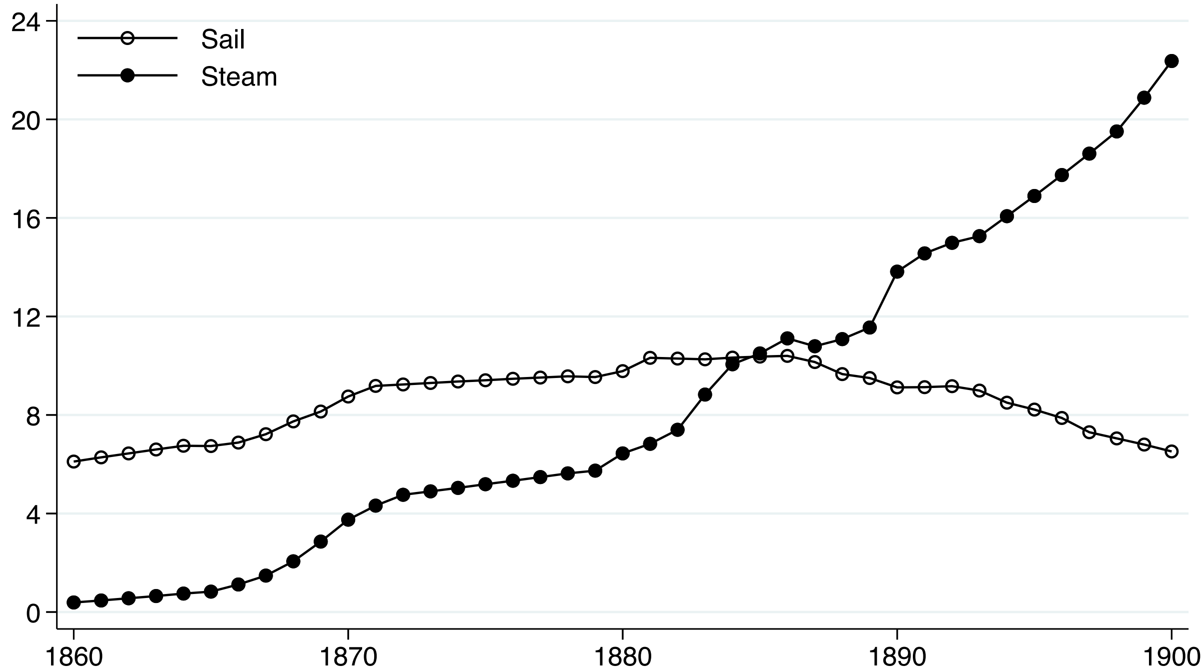
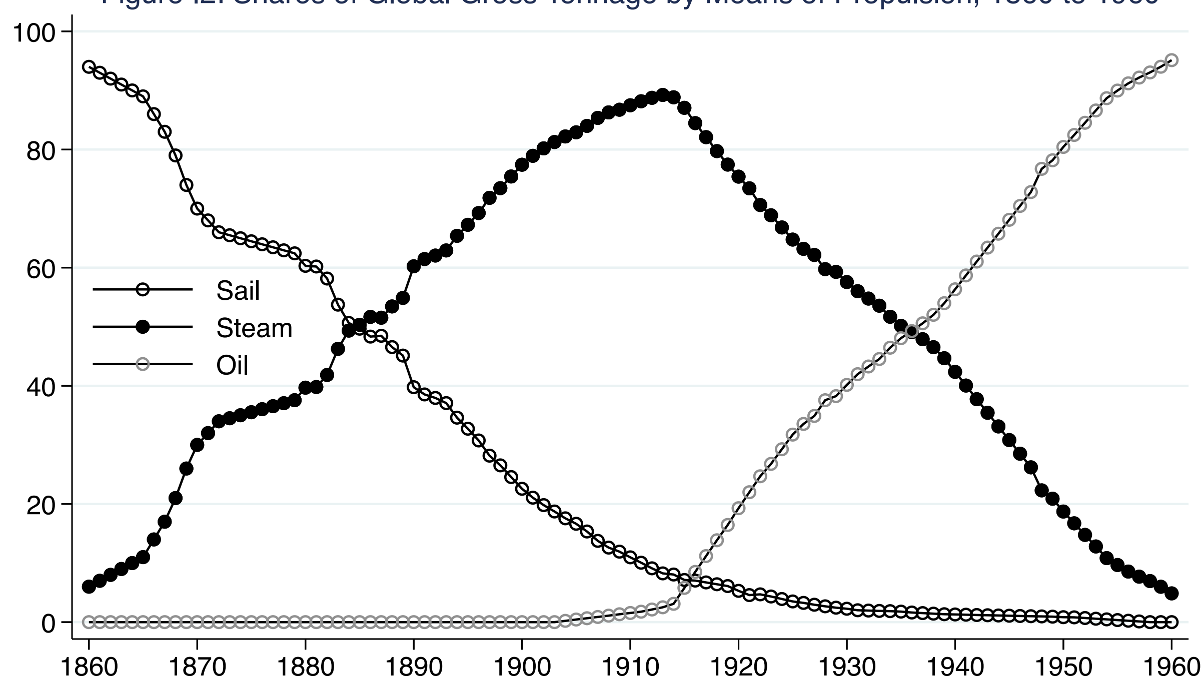


Figure I2: Shares of Global Gross Tonnage by Means of Propulsion, 1860 to 1960



APPENDIX J: SHIPPING COST CALCULATIONS

Following Harley (1972), we assume that all routes use the most efficient technology available. Using data from *Mitchell's Maritime Register*, he assumes that sailing ships have an average (time-invariant) speed of 4.0 knots (p. 281f) while steamships have an average speed that increases from 5.5 knots in 1856 to 7.0 knots in 1890. On this basis, we argue that at any given point of time, all variation in shipping costs across routes for both sailing and steamships arises from variation in distance, conditional on ship size. Necessarily, the opening of the Suez Canal dramatically altered shipping costs through its effect on maritime distances. For each route, we calculate shipping costs in UK shillings on the basis of two measures of shipping capacity: (1) per ton of carrying capacity and (2) per ton of usable cargo space. The latter measure takes into account that steamers needed to carry coal as fuel which necessarily limited their cargo space.

Capital costs

Capital costs for sailing ships are simply determined by the purchase price per gross ton multiplied by an annual rate of return to take depreciation, insurance, management, profit, and repairs into account. Harley sets this to 30%, following Giffen (1882). Ship prices per gross ton are taken from the engineering firm of Stephen and Sons Limited of Glasgow (Harley 1972, p. 233f.). For ship sizes, we take route- and year-specific averages from the *Annual Statement of the Trade and Navigation of the United Kingdom* (various years).

Calculating capital costs for steamships is more involved, because cargo capacity, coal consumption, displacement, and speed played off one another. From the technical literature, Harley (1972, p. 214) refers to the Admiralty constant (A) to establish the relationship between engine power, displacement of a ship, and speed:

$$A = \frac{D^{2/3}V^3}{IHP}$$

where *D* is displacement, *V* is speed in knots, and *IHP* is indicated horsepower. Assuming a proportional relationship between displacement and hull weight and calculating the weight of coal as a function of indicated horsepower, we can calculate the cost of the ship (engine plus hull) for a given cargo capacity, level of steam technology, and route-specific distance.[21]

The prices for engines and hulls are taken from several sources including Stephen and Sons Limited and Maywald (1956). Data on coal consumption is taken from several contemporary

[21] Formally, the relationship is

$$D = (F + DH) + \frac{D^{2/3}V^3}{A} + \left(\frac{D^{2/3}V^3}{A}C\frac{d}{V}\right)$$

where *F* is cargo capacity (ship size), *H* is hull size, *C* is coal consumption per IHP, and *d* is distance. This relationship can be approximated using a Taylor series expansion.

engineering sources (Harley 1972, p. 274, fn 20) while route- and year-specific ship sizes are from the *Annual Return on Trade and Navigation*. The annual return for steamships is set slightly higher than for sailing ships at 35%, following Giffen (1882). Note that coal consumption per IHP is declining from 5.0 pounds per IHP in 1855 to 1.6 lbs per IHP in 1890. (Harley 1972, p. 219, p. 273). Thus, this reduced the cost of capital but even more so the cost of coal as discussed below.

Labor Costs

We use data on man-ton ratios, ship size, and wages to calculate labor costs. We follow Harley and use wage data from Bowley (1895). We update his data on man-ton ratios with more recent work by Sager (1989) and Kaukiainen (1995) as Harley (1972) acknowledges that his data on crew sizes "are undoubtedly the worst figures here" (p. 277). It is broadly understood that steamships had larger crew size than sailing ships, due to the need for an engine crew. We follow Sager's man-ton ratios for sailing ships together with data on ship sizes and adjust this for steamships as suggested by Kaukiainen (1995).

Coal

The calculation of the cost of coal for steamships is, in comparison, relatively straightforward: given the state of technology in a particular year (measured in terms of coal consumed per IHP per hour) and data on distances and steaming speed, we can calculate coal consumption per day by route. This can be multiplied by the average f.o.b. export price at Cardiff, Newport, and Swansea from Harley (1972, p. 278) to derive the cost of coal per route. The majority of coal used on British steamships was Welsh, even after coal mining was established in other quarters such as India and South Africa, due to its cleaner burn and higher caloric content (Barak, 2022; Gray, 2018). However, the question remains where that coal was purchased and loaded.

In the 19th century, countries like the UK suffered from an imbalance in terms of the physical volumes of traded goods as they exported high value, less bulky goods and imported low value, more bulky goods. Consequently, coal was often used as ballast (Allan, 2020; Jevons, 1866; Palmer, 1979) with lower than average outward freight rates which were effectively subsidized by higher homeward freight rates (Klovland, 2006). To give a sense of the scale of this phenomena, Fletcher (1975) reports that whereas coal represented 10% of the total value of British exports in 1913, it took up over 85% of the total physical volume of the same. However, due to high costs of loading and unloading coal, Harley argues that it was rarely profitable for UK-originated ships to use coaling stations along the way and even less so over time with the advent of more efficient steam engines.

In the absence of systematic data on coaling station activity, we assume that steamships from the UK carried enough coal for the outward journey. For the homeward journey, we assume that coal is purchased at the foreign port at the prevailing price for Welsh coal plus the freight to reach the Mediterranean side of the Suez Canal (Port Said). Steamships would refuel after passage to Port Said to save on canal dues which were assessed partially on tonnage and on coal prices which were cheaper at Port Said. It should be noted that both improvements in steam technology and the reduction in distance due to Suez's opening reduced the cost of steamships in two ways. First, they directly reduced coal consumption and hence the cost of purchasing coal. Second, they freed up more cargo space which previously would have been used for bunkering coal. To account for these changes, we calculate all shipping costs per ton of carrying capacity and per ton of available cargo space, which is simply carrying capacity less tonnage dedicate to hauling coal.

Loading/unloading time in ports, transit fees/times for the Suez Canal

Finally, we need to take into account that both sailing and steamships had to spend several days in ports due to the cumbersome process of loading and unloading cargoes. We follow Harley and assume that loading/unloading time depended on ship size at an average rate of cargo clearance of 400 tons per day (Hamilton, 1883; Harley, 1972, p. 280). However, bulk loading of coal was typically faster than this, and increasingly so over time. Based on Barak (2015) and Gray (2018), we assume an average rate of cargo clearance of 70 tons per hour for coal.

In the case of steamships, there was also the additional monetary cost for canal transit fees plus the additional opportunity cost for the time it took to transit the canal (as the canal is still subject to congestion given physical limitations on passage). We use transit times reported in Worms (1911). Notably, these were decreasing due to constant improvement in the canal's operation over time. Regarding transit fees, Hansen and Tourk (1978) argued that for a listed, profit-maximizing firm like the Suez Canal Company, fees should have been set to be just below the cost-saving to merchants for avoiding the route around the Cape of Good Hope. However, transit fees actually stayed below this threshold and were reduced over time, notably after Disraeli's purchase of the Khedive's 44% stake in 1875. Consequently, we use the passage fees per ton reported in Worms (1911).

Validation of shipping cost calculations

While our cost calculations demonstrate sensible patterns as discussed in Section 5, they are necessarily based on multiple assumptions so here we validate our approach by comparing them to observed freight rates. We use freight data from Jacks and Pendakur (2010). We are able to match our calculated shipping costs to observed freight rate data in UK shillings per ton for nine trade routes, originating in the southwest of the UK and destined for the following ports: Aden, Bombay, Buenos Aires, Cape Town, the Caribbean, Egypt (Alexandria and Port Said) Hong Kong, the North Atlantic (Halifax and New York), Hong Kong, and San Francisco. As quoted freight rates rarely distinguish between sail and steam, we assume arbitrage/competition between the two types of ships which is easily rationalized in the context of the tramp shipping trade.

To test the validity of our approach, we first regress observed freight rates on the average across sail and steam of our shipping cost calculations for a ton of carrying capacity by route and year. To ease interpretation, we focus on the outward journey from the UK. We then consider a specification using the average across sail and steam of our shipping cost calculations for a ton of cargo space by route and year. The results of this exercise are reported in Panel A of Table I1 below. Next, we use the minimum calculated cost of sail and steam for a ton of carrying capacity and for a ton of cargo space by route and year as regressors. The results of this exercise are reported in Panel B of Table I1 below.

Regardless of specification, our shipping cost calculations predict observed freight rates remarkably well. With no other controls save a constant term, they capture 93% of the variation in freight rates. With respect to levels, we find that observed freight rates are always roughly 20% higher than our calculated shipping costs. This is plausible as we must assume like Harley (1972) that all steamers use the best available technology.

Table J1: Validation exercises for calculated shipping costs

Panel A: Average shipping costs across sail/steam

	(1)	(2)
Per ton of carrying capacity	1.26	-
	(0.20)	
	[6.29]	
Per ton of cargo space	-	1.24
		(0.20)
		[6.21]
N of observations	315	315
Adjusted R^2	0.93	0.93

Panel B: Minimum shipping costs across sail/steam

	(1)	(2)
Per ton of carrying capacity	1.33	-
	(0.20)	
	[6.60]	
Per ton of cargo space	-	1.30
		(0.20)
		[6.43]
N of observations	315	315
Adjusted R^2	0.93	0.93

Appendix J references

Allan, C. J. (2020), "Coal as a Freight, Coal as a Fuel: A Study of the British Coal Trade 1850-1913." M.Sc. Thesis, Durham University.

Barak, O. (2015), "Outsourcing: Energy and Empire in the Age of Coal, 1820–1911." *International Journal of Middle East Studies* 47(3): 425-445.

Barak, O. (2022), *Powering Empire: How Coal Made the Middle East and Sparked Global Carbonization*. Berkeley: University of California Press.

Bowley, A. L. (1895), "Changes in Average Wages (Nominal and Real) in the United Kingdom between 1860 and 1891." *Journal of the Royal Statistical Society* 58(2): 223-285.

Fletcher, M.E. (1975), "From Coal to Oil in British Shipping." *Journal of Transport History* 3(1): 1-19.

Giffen, R. (1882), "The Use of Import and Export Statistics." *Journal of the Statistical Society of London* 45(2): 181-296.

Gray, S. (2018), *Steam Power and Sea Power*. London: Palgrave Macmillan.

Hamilton, J. (1883), "The Speed and Form of Steamships Considered in Relation to Length of Voyage." Transactions of the Royal Institution of Naval Architects 24: 256-289.

Hansen, B. and K. Tourk (1978), "The Profitability of the Suez Canal as a Private Enterprise, 1859-1956." *Journal of Economic History* 38(4): 938-958.

Harley, C.K. (1972), *Shipbuilding and Shipping in the Late Nineteenth Century*. Ph.D. Dissertation, Harvard University.

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

Jevons, W.S. (1866), *The Coal Question*. London: Macmillan and Company.

Kaukiainen, Y. (1995), "Tons and Tonnages: Ship Measurement and Shipping Statistics, c. 1870-1980." *International Journal of Maritime History* 7(1): 29-56.

Klovland, J. T. (2006), "A Repeat Sailings Index of Ocean Freight Rates for the 1850s." *Discussion Paper SAM 40*, Norwegian School of Economics.

Maywald, K. (1956), "The Construction Costs and the Value of the British Merchant Fleet, 1850 – 1938." *Scottish Journal of Political Economy* 3(1): 44-66.

Palmer, S. (1979), "The British Coal Export Trade, 1850-1913." In *Volumes not Values: Canadian Sailing Ships and World Trades*, Alexander and Olmer (Ed.s). Newfoundland: Memorial University of Newfoundland, 333-354.

Sager, E. W. (1989), *Seafaring Labour: The Merchant Marine of Atlantic Canada, 1820-1914*. Kingston: McGill-Queen's University Press.

UK Parliamentary Papers (various years), *Annual Return on Trade and Navigation*. London.

Worms (1911), Supplement to *Worms & Coy's Suez Canal Weekly Shipping List*. London.

APPENDIX K: COUNTRY-PAIR SHIPPING COST & VOYAGE DURATION CALCULATIONS

Here, we illustrate that the same forces at work for the averages discussed in the main text were present at the country-pair level. We also provide a comparison of our shipping cost calculations to the voyage duration calculations of Pascali (2017) which emphasizes that our series demonstrate a larger amount of variation, particularly over time.

Figures K1 and K2 depict the evolution of calculated shipping costs across sail versus steam propulsion and for British India/UK (a Suez-affected route) versus the UK/US (a non-Suez-affected route). In Figure K1, calculated shipping costs between British India and the UK decreased by 24% for sail and by 66% for steam. In Figure K2, calculated shipping costs between the UK and the US decreased by 21% for sail and by 45% for steam. Calculated shipping costs for British India/UK were always higher than the UK/US, regardless of the means of propulsion or year. But the average premium for British India/UK over the UK/US did decline from 239% in 1860 to 157% in 1890. Importantly, the two series for shipping costs under steam converged to the respective series for shipping costs under sail: by 1890, shipping costs via steam were lower than those sail for both British India/UK and the UK/US.

Figure K3 considers the ratio of steam-to-sail shipping costs for British India/UK and the UK/US. Thus, in 1860, steam shipping was 57% and 26% higher than sail, respectively. The relative cost of steam was higher for British India/UK than the UK/US up to 1869. These ratios declined over time with steam shipping consistently being cheaper than sail from 1870 for British India/UK and 1875 for the UK/US. Immediately after the opening of the Suez Canal in 1869, the relative cost of shipping by steam fell in general, but did so even more dramatically for British India/UK: the relative cost of steam was now higher for the UK/US.

In contrast, we also consider the calculated voyage duration for the same routes taken from Pascali (2017). There, each country pair is assigned four values for voyage duration before/after the opening of Suez and under sail/steam. We combine these four variables into two vectors for sail and steam for each country pair over time with a single potential break point occurring in 1869. Figures K4 and K5 depict the evolution of calculated voyage durations across sail versus steam propulsion and for British India/UK (a Suez-affected route) versus the UK/US (a non-Suez-affected route), respectively. In Figure K4, voyage durations for British India/UK decreased by 18% for sail and by 40% for steam, solely due to the opening of the Suez Canal in 1869. The former result is, of course, at odds with the fact that the navigational hazards of the canal and Red Sea precluded the use of sailing ships along this route for all intents and purposes. In Figure K5, voyage durations between the UK and the US did not change for either sail or steam.

Finally, Figure K6 considers the ratio of steam-to-sail voyage durations for British India/UK and the UK/US. Thus, there is a completely flat profile for the UK/US given the underlying data in Figure K5 while the ratio for British India/UK demonstrates a single break point in 1869 wholly associated with the opening of the Suez Canal.

Figure K1: Shipping Costs for Sail and Steam for British India/UK, 1860 to 1890

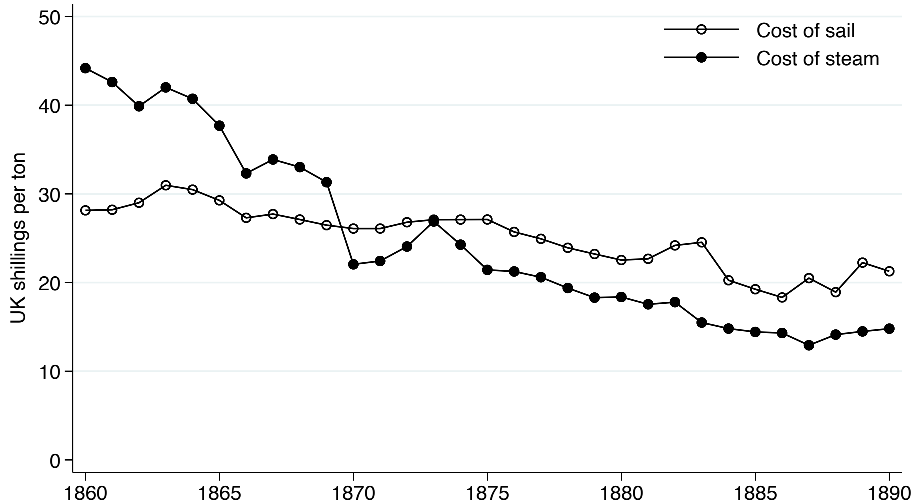


Figure K2: Shipping Costs for Sail and Steam for UK/US, 1860 to 1890

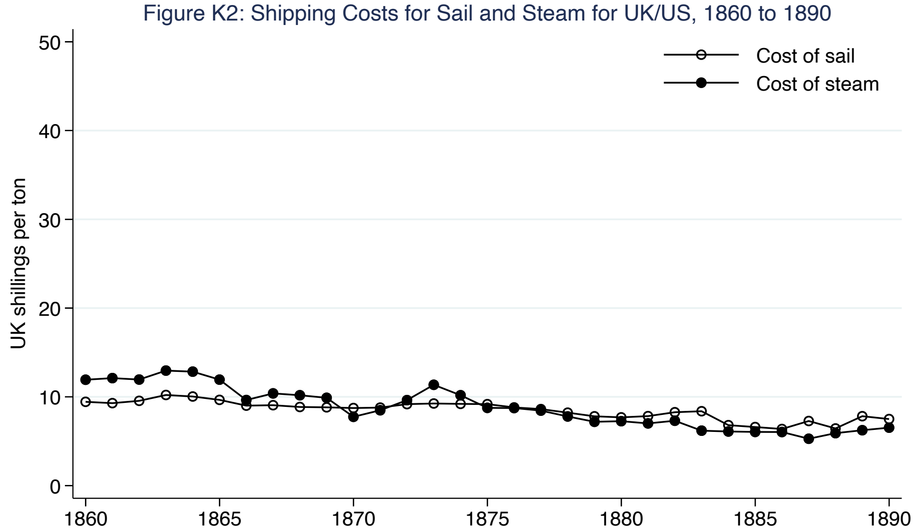


Figure K3: Shipping Cost Ratios (Steam to Sail), 1860 to 1890

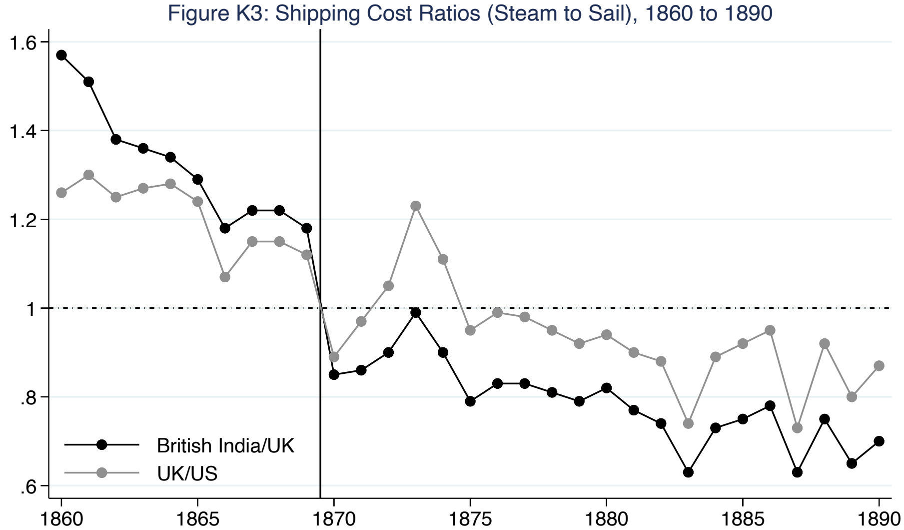


Figure K4: Shipping Times for Sail and Steam for British India/UK, 1860 to 1890

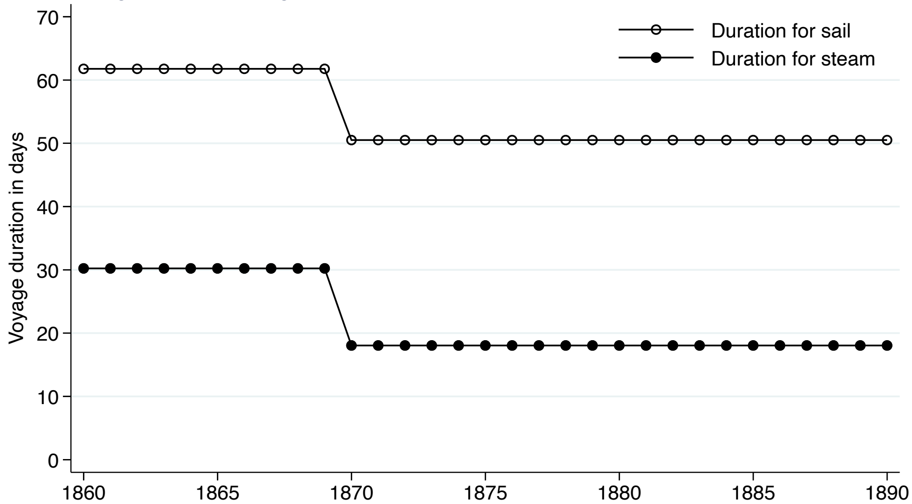


Figure K5: Shipping Times for Sail and Steam for UK/US, 1860 to 1890

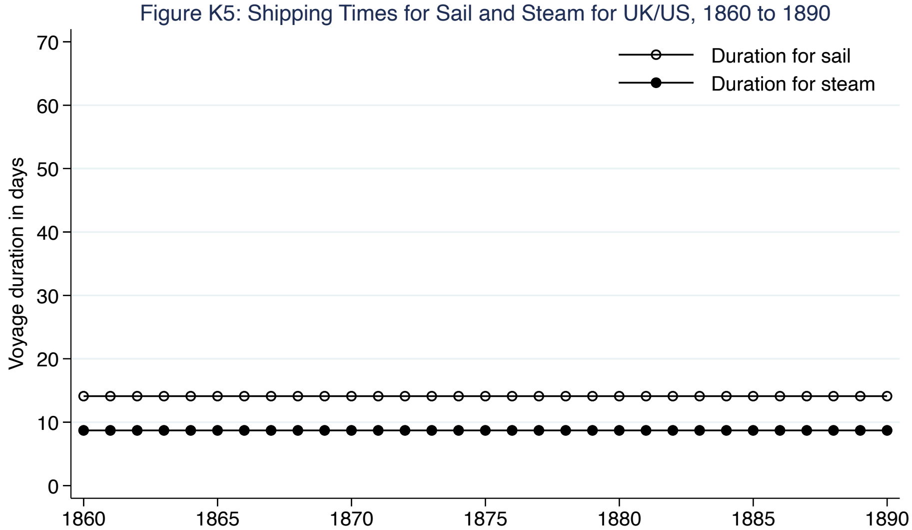
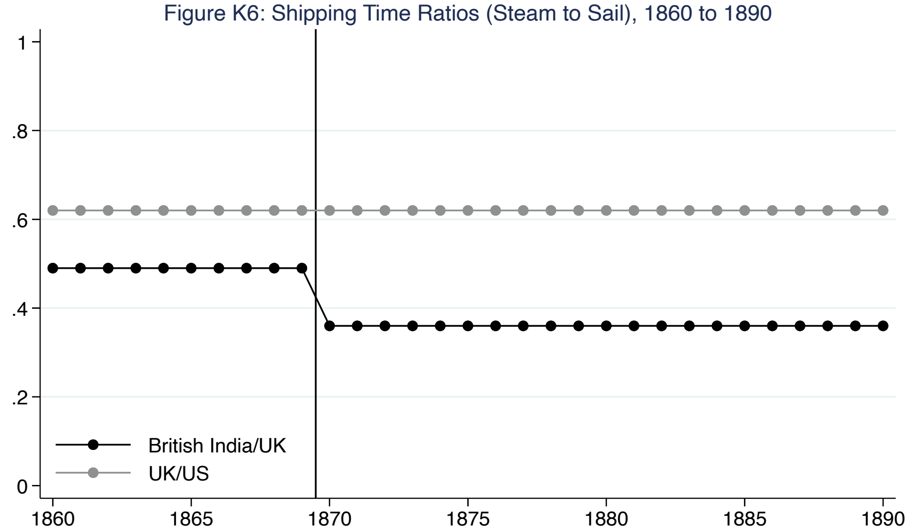


Figure K6: Shipping Time Ratios (Steam to Sail), 1860 to 1890



References

Adams, J.Q. (1971), "The Impact of the Suez Canal On India's Trade." *Indian Economic and Social History Review* 8(3): 229-240.

Baer, W. (1956), "The Promoting and the Financing of the Suez Canal." *Business History Review* 30(4): 361-381.

Barak, O. (2022), *Powering Empire: How Coal Made the Middle East and Sparked Global Carbonization*. Berkeley: University of California Press.

Belmar, J. (2023), "Trade and Structural Change: Evidence from Colombia and The Panama Canal 1851-1973." Brown University.

Dedinger, B. and P. Girard (2017), "Exploring Trade Globalization in the Long Run." *Historical Methods* 50(1): 30-48.

Donaldson, D. (2018), "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure." *American Economic Review* 108(4-5): 899–934.

Dzanic, D. (2016), "The Civilizing Sea: The Ideological Origins of the French Mediterranean Empire, 1789-1870." Ph.D. Thesis, Harvard University.

Fajgelbaum, P. and S.J. Redding (2022), "Trade, Structural Transformation, and Development." *Journal of Political Economy* 130(5): 1249-1318.

Fally, T. (2015), "Structural Gravity and Fixed Effects." *Journal of International Economics* 97(1): 76-85.

Fletcher, M.E. (1958), "The Suez Canal and World Shipping, 1869-1914." *Journal of Economic History* 18(4): 556-573.

Fletcher, M.E. (1975), "From Coal to Oil in British Shipping." *Journal of Transport History* 3(1): 1-19.

Fouquin, M. and J. Hugot (2016), "Two Centuries of Bilateral Trade and Gravity Data." *CEPII Working Paper 2016-14*.

Galiani, S., L.F. Jaramillo, and M. Uribe-Castro (2022), "Free-Riding Yankees: Canada and the Panama Canal." *NBER Working Paper 30402*.

Girard, L. (1966), "Transport." In *The Cambridge Economic History of Europe, vol. VI*, Habakkuk and Postan (Ed.s). Cambridge: Cambridge University Press, 212-273.

Harley, C.K. (1971), "The Shift from Sailing Ships to Steamships, 1850–1890." In McCloskey (Ed.), *Essays on a Mature Economy: Britain after 1840.* London: Methuen, 215-234.

Harley, C.K. (1972), *Shipbuilding and Shipping in the Late Nineteenth Century*. Ph.D. Dissertation, Harvard University.

Head, K. and T. Mayer (2014), "Gravity Equations: Workhorse, Toolkit, and Cookbook." In *Handbook of International Economics, vol. 4*, Gopinath, Helpman, and Rogoff (Ed.s). Amsterdam: North Holland,131-195.

Huber, V. (2015), *Channelling Mobilities: Migration and Globalisation in the Suez Canal Region and Beyond, 1869–1914*. Cambridge: Cambridge University Press.

Hugot, J. and C. Umana Dajud (2016), "Trade Costs and the Suez and Panama Canals." *CEPII Working Paper 2016-29*.

Issawi, C. (1982), *An Economic History of the Middle East and North Africa*. London: Routledge Press.

Jacks, D.S., C.M. Meissner, and D. Novy (2010), "Trade Costs in the First Wave of Globalization." *Explorations in Economic History* 47(2): 127-141.
Jacks, D.S., C.M. Meissner, and D. Novy (2011), "Trade Booms, Trade Busts, and Trade Costs." *Journal of International Economics* 83(2): 185-201.
Jacks, D.S., K.H. O'Rourke, and A.M. Taylor (2020), "The Gravitational Constant?" *NBER Working Paper 27904*.
Jacks, D.S. and K. Pendakur (2010), "Global Trade and the Maritime Transport Revolution." *Review of Economics and Statistics* 92(4): 745-755.
Jacks, D.S. and M. Stuermer (2021), "Dry Bulk Shipping and the Evolution of Maritime Transport Costs, 1850-2020." *Australian Economic History Review* 61(2): 204-227.
Jacks, D.S. and J.P. Tang (2021), "International Transactions: Trade and Immigration, 1870-2010." In *The Cambridge Economic History of the Modern World, vol. II*, Broadberry and Fukao (Ed.s). Cambridge: Cambridge University Press, 471-500.
Juhasz, R. and C. Steinwender (2018), "Spinning the Web: The Impact of ICT on Trade in Intermediates and Technology Diffusion." *NBER Working Paper 24590*.
Maurer, S. and F. Rauch (2023), "Economic Geography Aspects of the Panama Canal." *Oxford Economic Papers* 75(1): 142–162.
Meissner, C.M. and J.P. Tang (2018), "Upstart Industrialization and Exports: Evidence from Japan, 1880–1910." *Journal of Economic History* 78(4): 1068-1102.
Meissner, C.M. and C. Xu (2022), "US Trade Performance, 1866-1914: A View from New Granular Data."
Nourse, J.E. (1884), *The Maritime Canal of Suez, from Its Inauguration, November 17, 1869, to the Year 1844 prepared under Orders of the Bureau of Navigation*. Washington: GPO.
Øiestad, S. (2019), *Do Maritime Anti-corruption Efforts Affect Economics? An Analysis of Waiting Time in the Suez Canal*. M.Sc. Thesis, Norwegian School of Economics.
Pascali, L. (2017), "The Wind of Change." *American Economic Review* 107(9): 2821-2854.
Philips' Centenary Mercantile Marine Atlas: Specially Designed for Merchant Shippers, Exporters and Ocean Travellers, 13th Edition (1935). London: Philip & Son.
Piquet, C. (2004), "The Suez Company's Concession in Egypt, 1854—1956." *Enterprise and Society* 5(1): 107-127.
Rabino, J. (1887), "The Statistical Story of the Suez Canal." *Journal of the Royal Statistical Society* 50(3): 495-546.
Santos Silva, J.M.C. and S. Tenreyro (2006), "The Log of Gravity." *Review of Economics and Statistics* 88(4): 641–658.
Sargent, A.J. (1918), *Seaways of the Empire*. London: A. & C. Black Limited.
Steinwender, C. (2018), "Real Effects of Information Frictions: When the States and the Kingdom Became United." *American Economic Review* 108(3): 657-96.
The Economist (1869), "The Suez Canal." 27(1369), November 20.
Xu, C. (2022), "Reshaping Global Trade: The Immediate and Long-Run Effects of Bank Failures." *Quarterly Journal of Economics* 137(4): 2107–2161.
Yousri, A.R. (1968), "The Suez Canal and the Trends of British Trade to and from the Middle and the Far East in the Period 1854–1966." Ph.D. Thesis, University of St. Andrews.

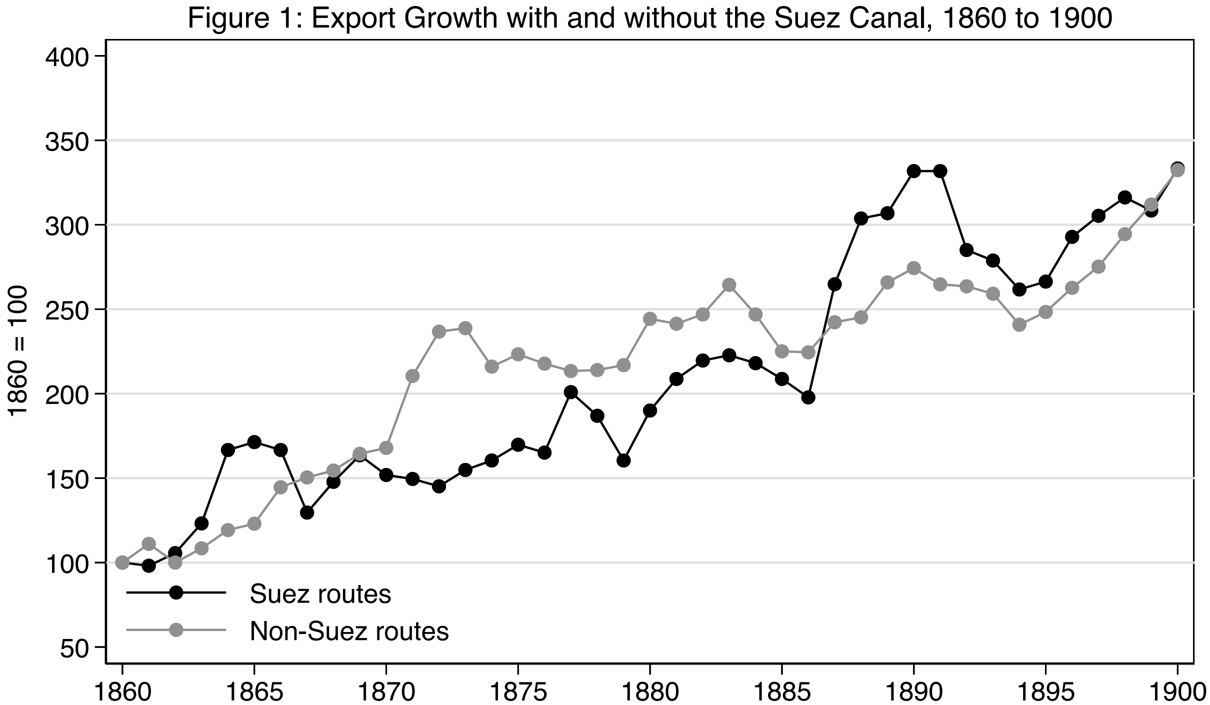


Figure 1 depicts the nominal value of total exports across non-Suez- and Suez-affected routes with values normalized to 100 in 1860.

Figure 2: Event Study on Suez's Opening, 1860 to 1900

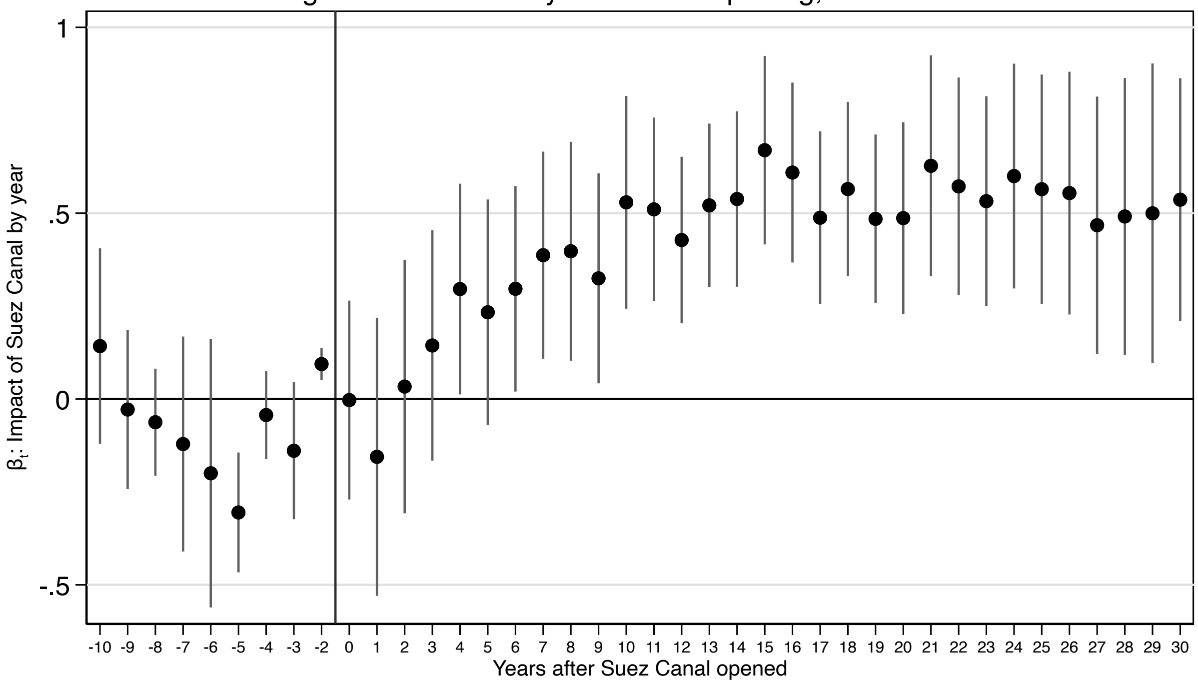


Figure 2 depicts an event study on bilateral trade up to 1900 using PPML. The underlying structural gravity equation includes country-pair, time-varying exporter, time-varying importer, and year fixed effects. Country-pair fixed effects are defined by the direction of export flows. Bars depict 95% confidence intervals. Standard errors are clustered at the country-pair level.

Figure 3: Trade Costs with and without the Suez Canal, 1870 to 1900

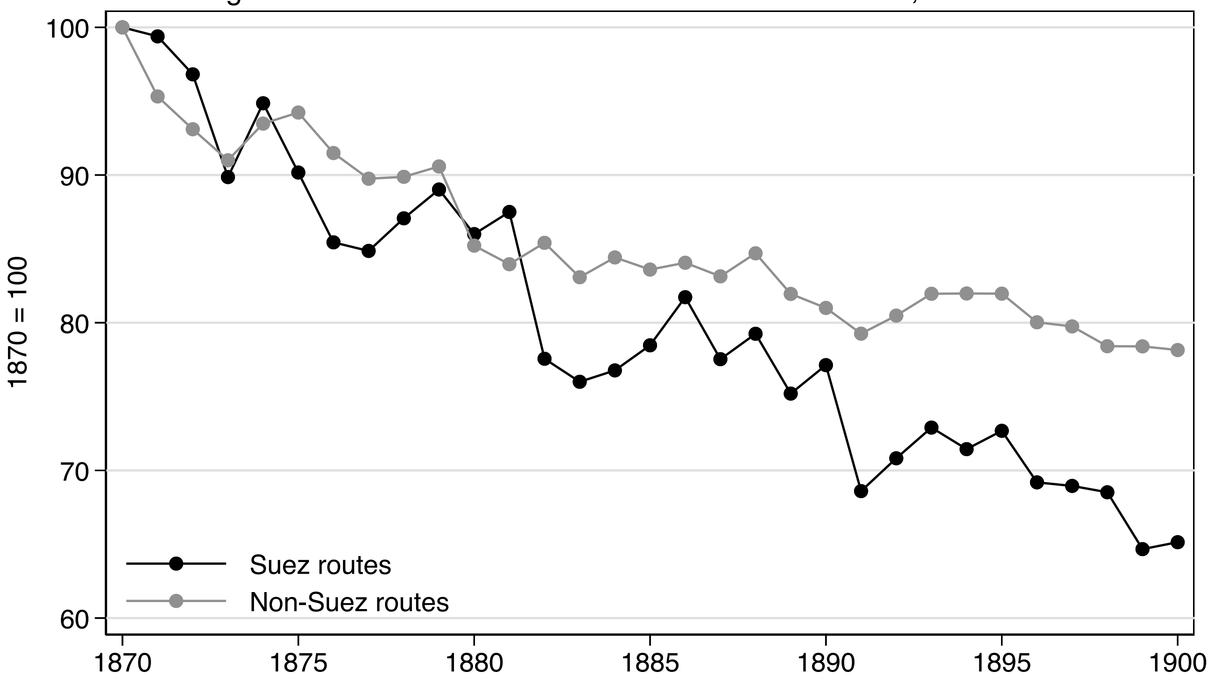


Figure 3 depicts the evolution of average bilateral trade costs across non-Suez- and Suez-affected routes with values normalized to 100 in 1870, calculated using the data and expression for trade costs found in Jacks, Meissner, and Novy (2011).

Table 1: DiD estimates for bilateral trade, baseline results

	(1)	(2)	(3)	(4)
	1860 to 1900	1850 to 1900	1865 to 1900	High quality sample
Suez canal (= 1)	0.56	0.50	0.56	0.54
	(0.18)	(0.16)	(0.15)	(0.15)
	[3.14]	[3.16]	[3.79]	[3.65]
N of observations	10,413	12,268	9,439	7,899
Country-pair & year fixed effects	X	X	X	X
Time-varying exporter effects	X	X	X	X
Time-varying importer effects	X	X	X	X

Table 1 reports the results of PPML regressions on bilateral trade up to 1900. Columns 1 through 3 vary the sample years while Column 4 uses data from 1865 to 1900 and "high quality" selection criteria as explained in the text. Country-pair fixed effects are defined by the direction of export flows. Standard errors are in parentheses and clustered at the country-pair level. z-statistics reported below the standard errors in brackets.

Table 2: DiD estimates, robustness on different samples

	(1)	(2)	(3)	(4)
	JMN (2011)	Pascali (2017)	F & H (2016)	D & G (2017)
Suez canal (= 1)	0.54	0.31	0.46	0.22
	(0.15)	(0.09)	(0.13)	(0.11)
	[3.65]	[3.51]	[3.48]	[2.04]
N of observations	7,899	16,363	24,795	27,363
Country-pair & year fixed effects	X	X	X	X
Time-varying exporter effects	X	X	X	X
Time-varying importer effects	X	X	X	X

Table 2 reports the results of PPML regressions on bilateral trade for the years from 1865 to 1900. Column 1 reports our baseline results from Table 1 using Jacks, Meissner, and Novy (2011). Columns 2 through 4 are the results using the alternative datasets discussed in Section 4.1. Country-pair fixed effects are defined by the direction of export flows. Standard errors are in parentheses and clustered at the country-pair level. z-statistics reported below the standard errors in brackets.

Table 3: DiD estimates, heterogeneity analysis on British metropole trade

	(1) JMN	(2) Pascali	(3) F & H	(4) D & G
Suez canal (= 1)	1.10	0.51	0.62	0.42
	(0.38)	(0.09)	(0.15)	(0.17)
	[2.92]	[5.40]	[4.00]	[2.41]
Suez canal * British metropole trade (= 1)	-0.62	-0.32	-0.32	-0.34
	(0.35)	(0.13)	(0.14)	(0.23)
	[1.76]	[2.50]	[2.24]	[1.47]
N of observations	7,899	16,363	24,795	27,363
Country-pair & year fixed effects	X	X	X	X
Time-varying exporter effects	X	X	X	X
Time-varying importer effects	X	X	X	X

Table 3 reports the results of PPML regressions on bilateral trade for the years from 1865 to 1900. Column 1 through 4 report the results from a specification including the interaction of indicator variables for the Suez Canal being open and trade to or from the United Kingdom. Country-pair fixed effects are defined by the direction of export flows. Standard errors are in parentheses and clustered at the country-pair level. z-statistics reported below the standard errors in brackets.

Table 4: DiD estimates, heterogeneity analysis on "Suez factor"

	First quartile (smallest)	Second quartile	Third quartile	Fourth quartile (largest)
"Suez factor" (= 1)	1.10	1.71	3.48	0.33
	(0.19)	(0.24)	(0.36)	(0.16)
	[5.81]	[7.03]	[9.57]	[2.15]
N of observations	7,899			
Country-pair & year fixed effects	X			
Time-varying exporter effects	X			
Time-varying importer effects	X			

Table 4 reports the results of PPML regressions on bilateral trade for the years from 1865 to 1900. The columns report the results of a single regression which includes the interaction of indicator variables for the Suez Canal being open and the four quartiles of the distribution of the "Suez factor" variable. Country-pair fixed effects are defined by the direction of export flows. Standard errors are in parentheses and clustered at the country-pair level. z-statistics reported below the standard errors in brackets.

Figure 4: Total exports, manufacturing shares, and extensive margins of trade

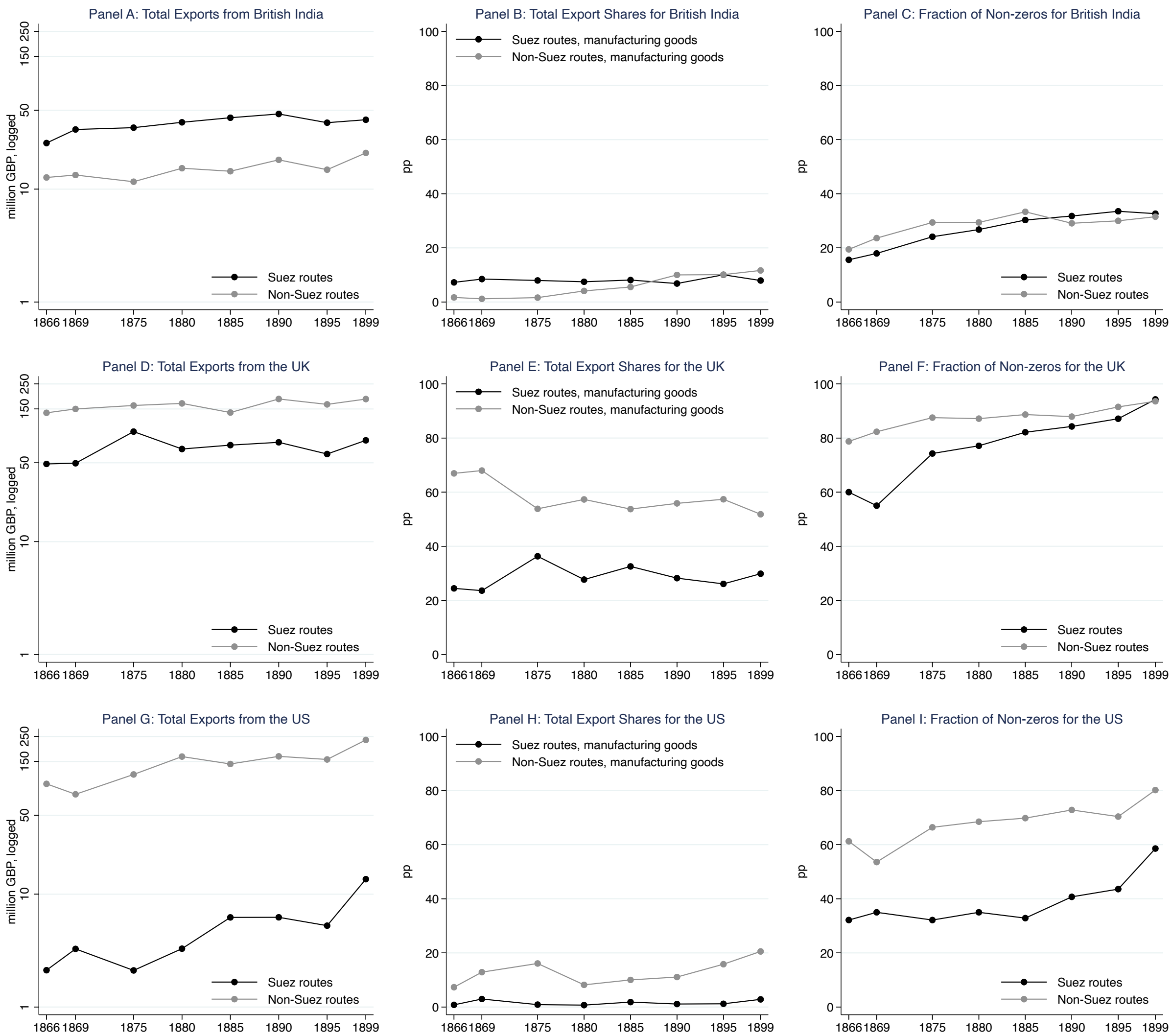


Figure 5: DiD estimates for export shares by sector/section/division, British India

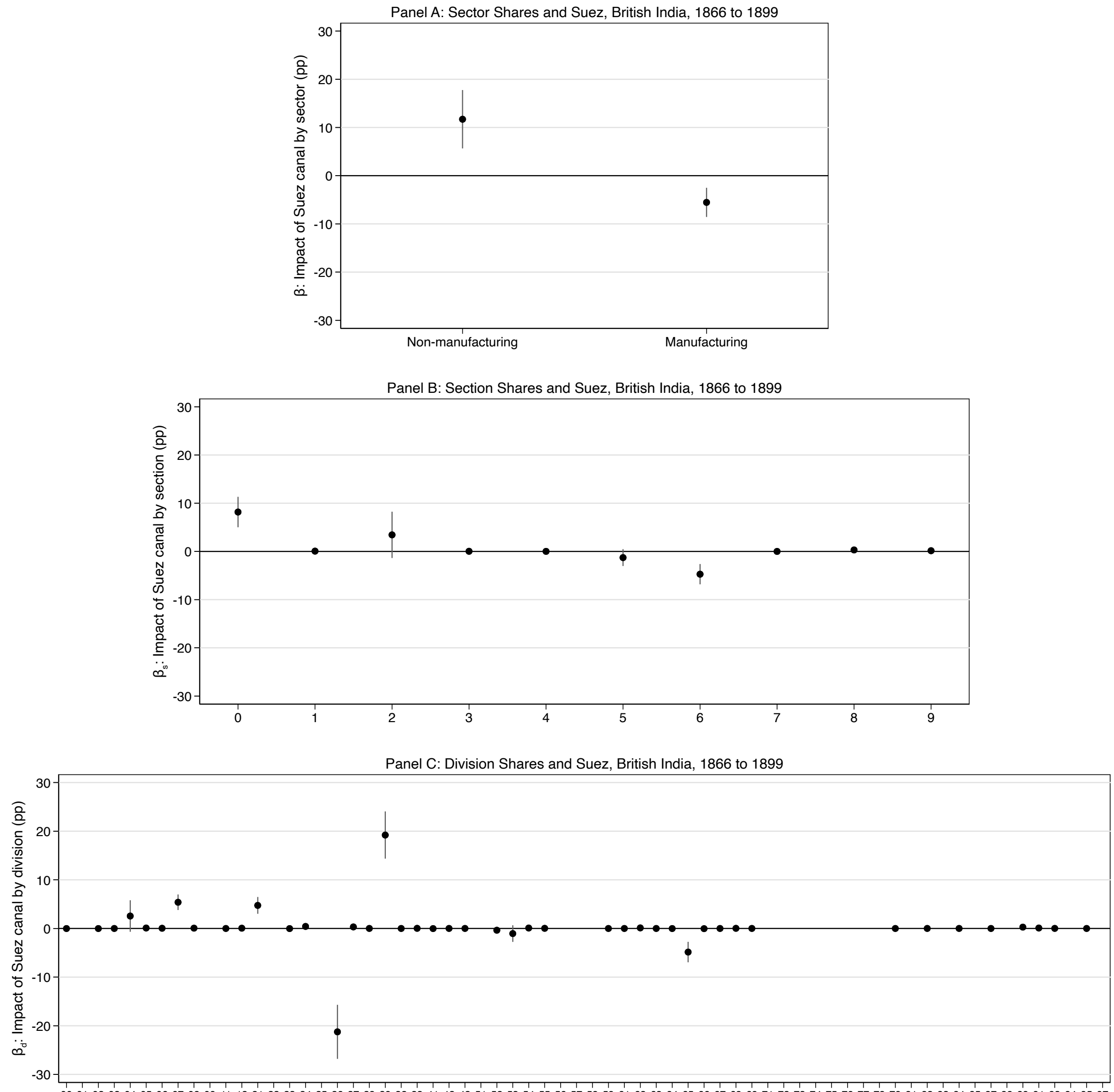


Figure 5 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from British India across all non-Suez- and Suez-affected destinations. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

Figure 6: DiD estimates for export shares by sector/section/division, UK

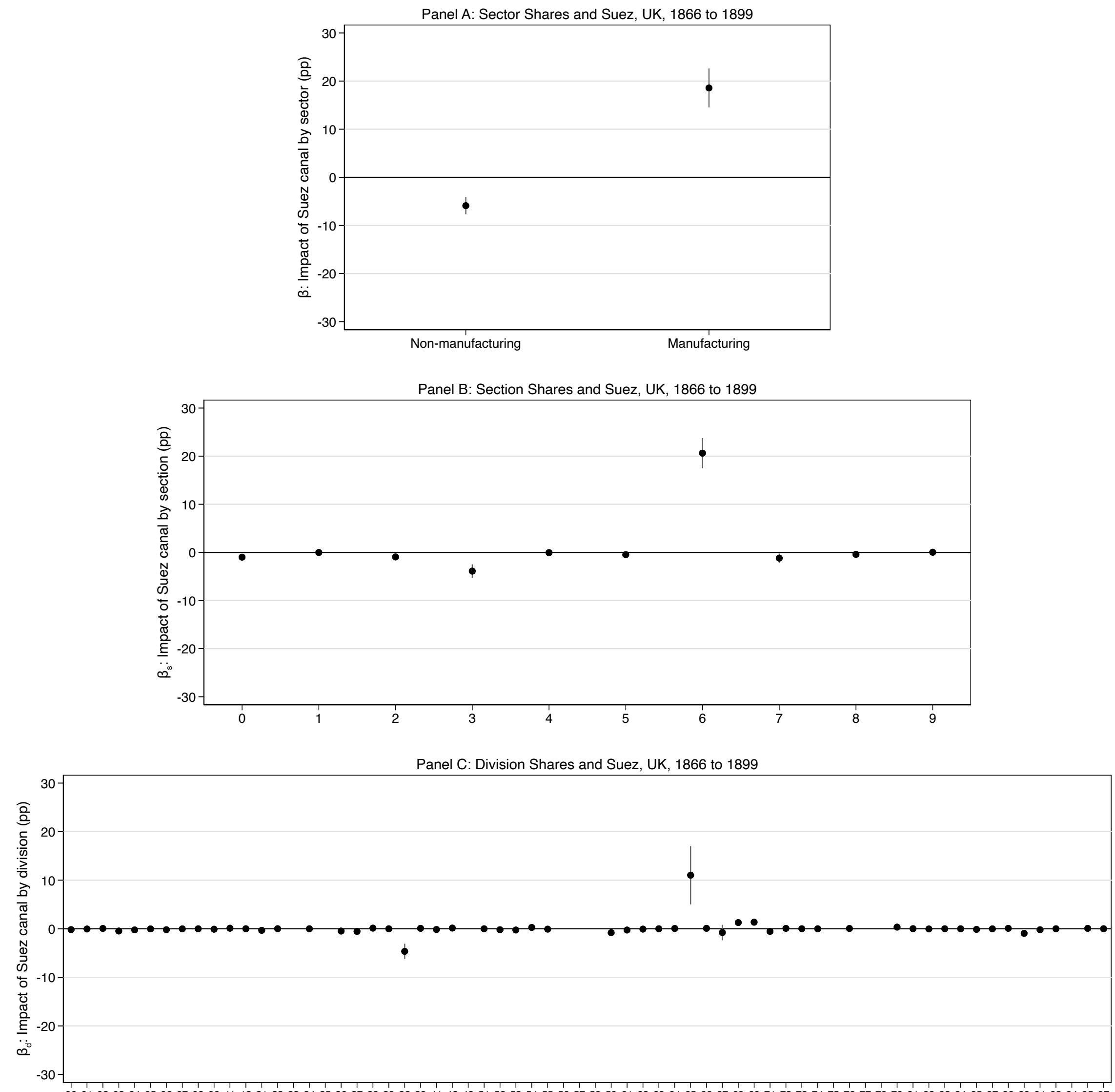


Figure 6 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from the United Kingdom across all non-Suez- and Suez-affected destinations. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

Figure 7: DiD estimates for export shares by sector/section/division, US

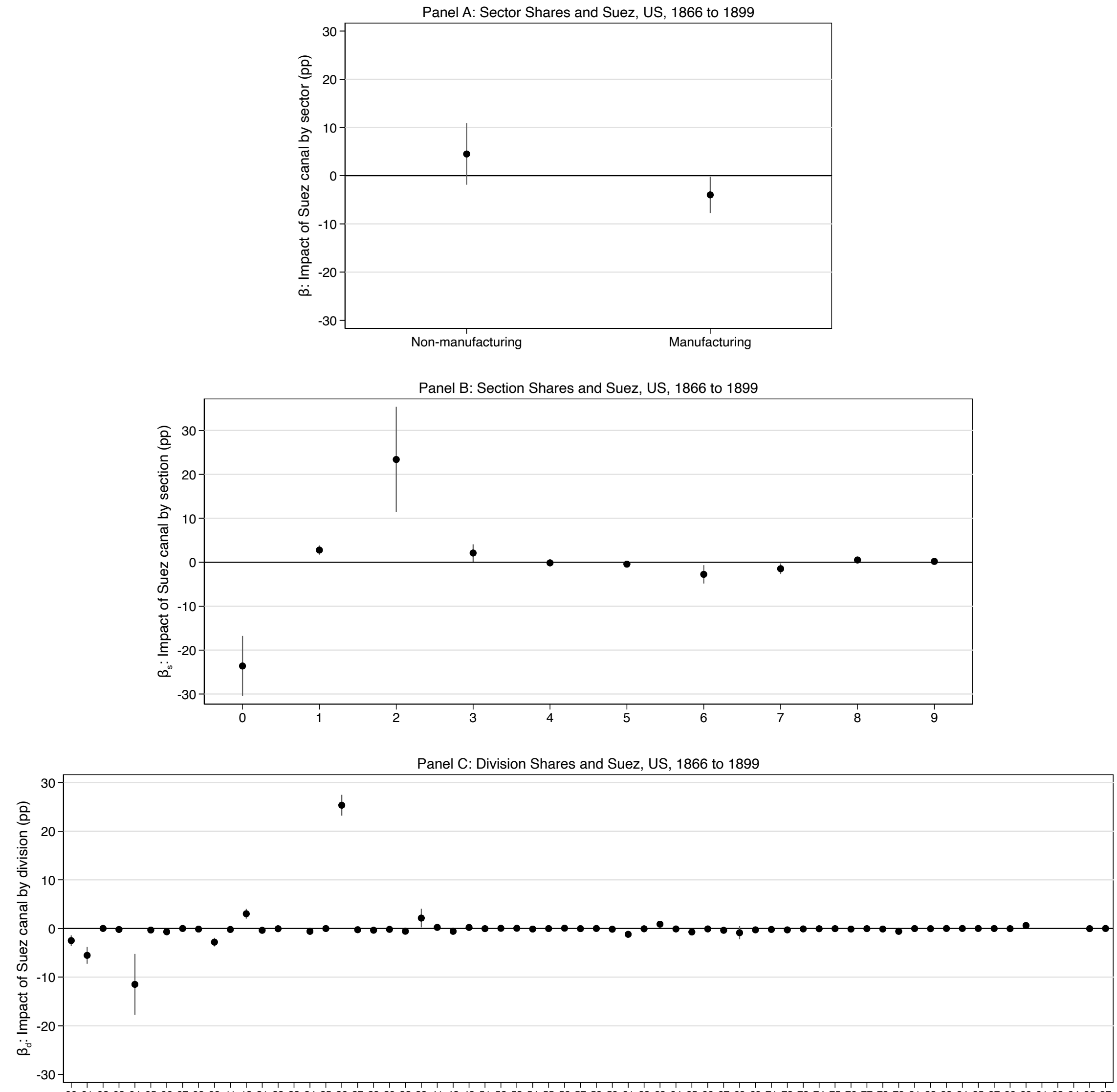


Figure 7 depicts point estimates of the effects arising from the opening of the Suez Canal and associated confidence intervals for a set of difference-in-differences regressions. The latter are ran with two-way fixed effects along with a post-1869 Suez indicator on the shares of total exports from the United States across all non-Suez- and Suez-affected destinations. The figure drills down in succession from the level of the manufacturing/non-manufacturing sectors (Panel A) to 10 SITC one-digit sections (Panel B) and then 66 SITC two-digit divisions (Panel C).

Figure 8: Shipping Costs for Sail and Steam, 1860 to 1890

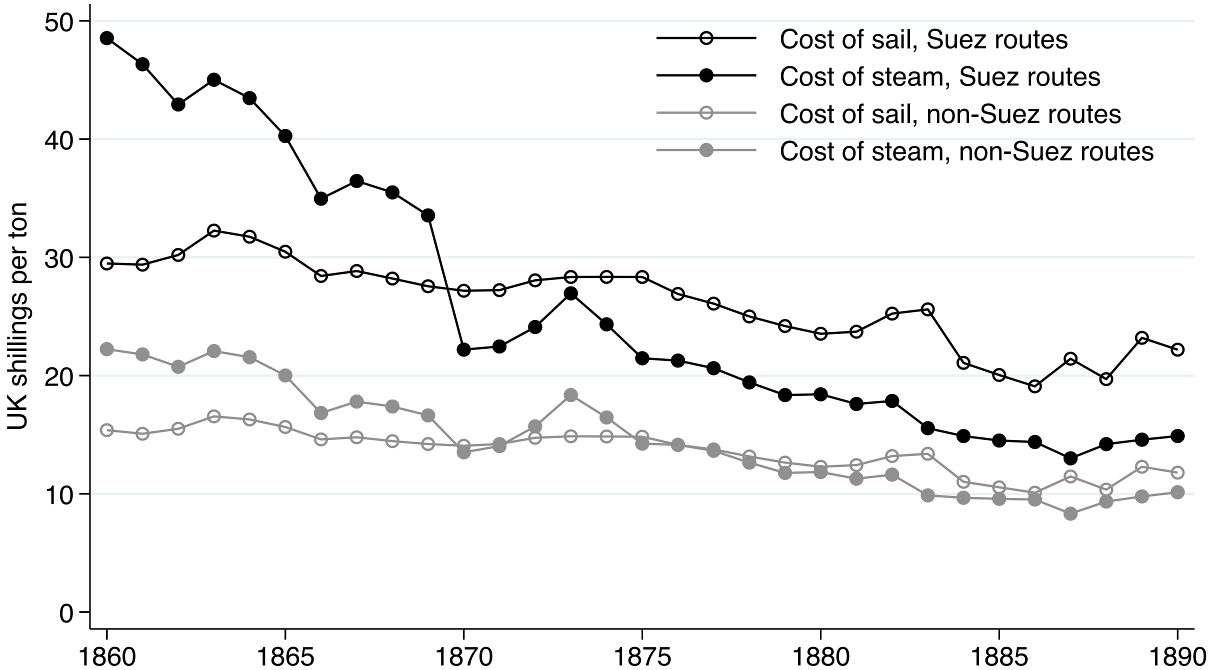


Figure 8 depicts the evolution of calculated shipping costs across non-Suez- and Suez-affected routes and across sail and steam, using the methodology of Harley (1972).

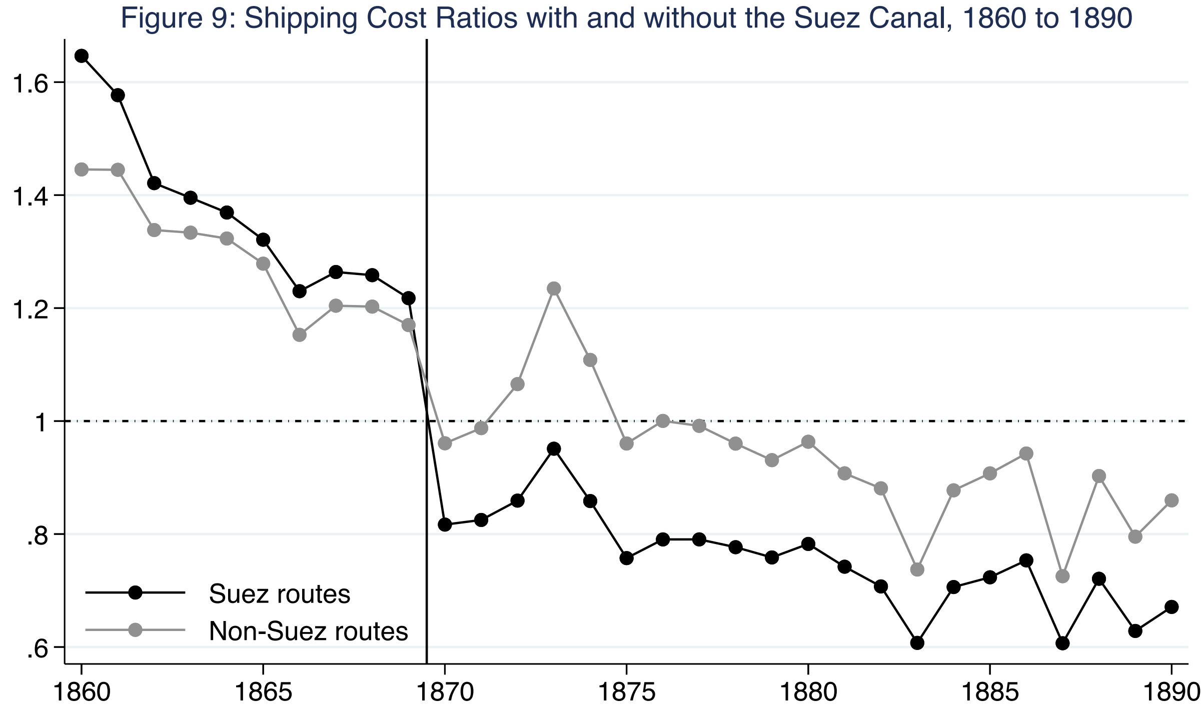


Figure 9 depicts the ratio of calculated shipping costs for steam versus sail across non-Suez- and Suez-affected routes, using the methodology of Harley (1972).