The Wind of Change: Maritime Technology, Trade, and Economic Development (2017)

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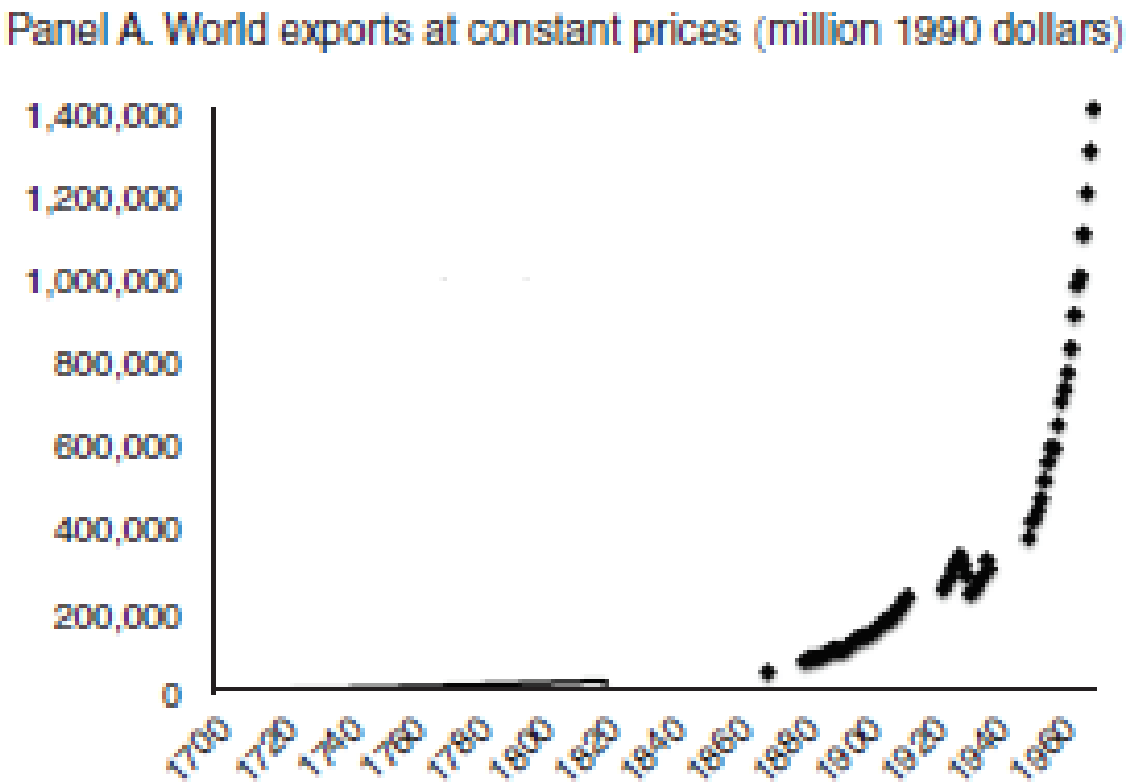
Birth of the first era of trade globalization 1870-1913.

1. Context
2. I. From Sail to Steam
   - The Sailing Vessels and The Steam Vessels
3. II. Data
   - Times, Rates, Trade, PcGDP, Population, U.R and Institutions
4. III. The Steamships and The Effects on Trade
   - The Shift from Sail to Steam
   - The Steamship and the First Wave of Globalization
5. IV. Trade and Economic Development
6. Conclusions

How did this tremendous increase in trade affect economic development?



How did this tremendous increase in trade affect economic development?

- This work isolates a causality channel by exploiting the fact that the introduction of the steamship in the shipping industry produced an asymmetric change in trade distances among countries.
- This study employs new trade data and a novel identification strategy to empirically investigate (i) the role of the adoption of the steamship in shaping the pattern of world trade in the nineteenth century and (ii)the effect of this tremendous increase in world trade on economic development.
- This paper is based on a large collection of data, as it uses three completely novel datasets that span the great majority of the world from 1850 to 1900.

Key findings

- Regressions of bilateral trade on shipping times by both sail and steam vessels.
- Provide a rough estimate of the impact of the steamship on world trade volumes.
- The effect of trade on development and urbanization is not necessarily positive.
- The effect of trade on economic development is beneficial for countries that are characterized by strong constraints on executive power.

Contribution

- Addresses a major identification issue: freight rates are endogenous because they are likely to be affected not only by technology but also by changes in economic activity or market structure.
- Contribute to the debate on the effects of trade on development.
- Contribute to the theoretical debate between neoclassical trade theories, in which comparative advantages are determined by technological differences and factor endowments, and new economic geography theories, in which countries derive part of their comparative advantage from scale economies.

The great majority of international trade in XIX Century was conducted by sea

Two competing technologies and their evolution in the second half of the century.

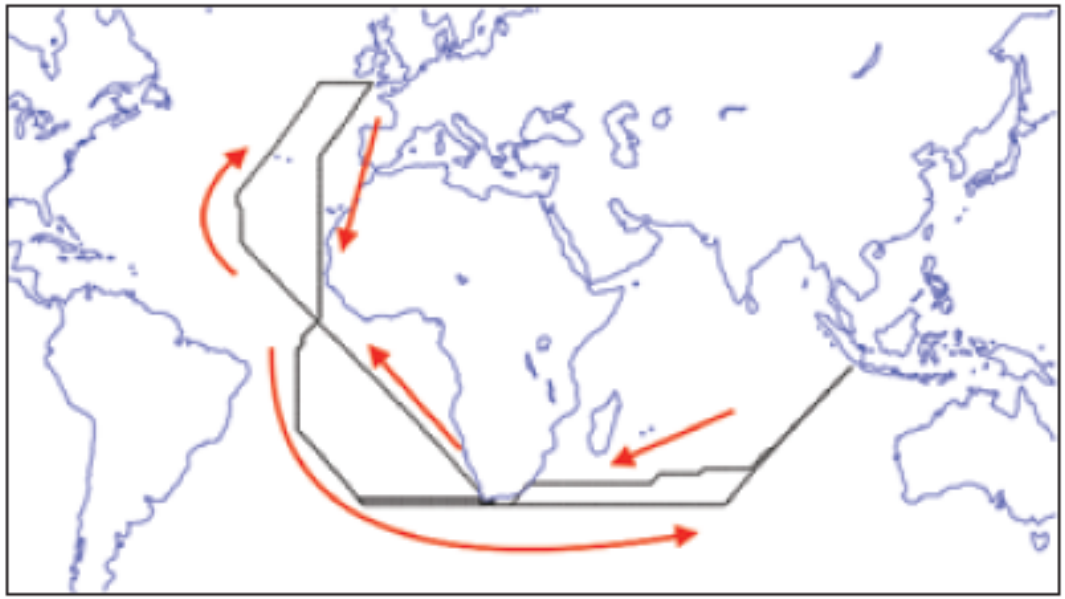


FIGURE 5. OPTIMAL ROUTES FOR SAILING VESSELS

Notes: The figure depicts the optimized routes by Clipper between England, Cape of Good Hope, and Java in the month of January.

The great majority of international trade in XIX Century was conducted by sea

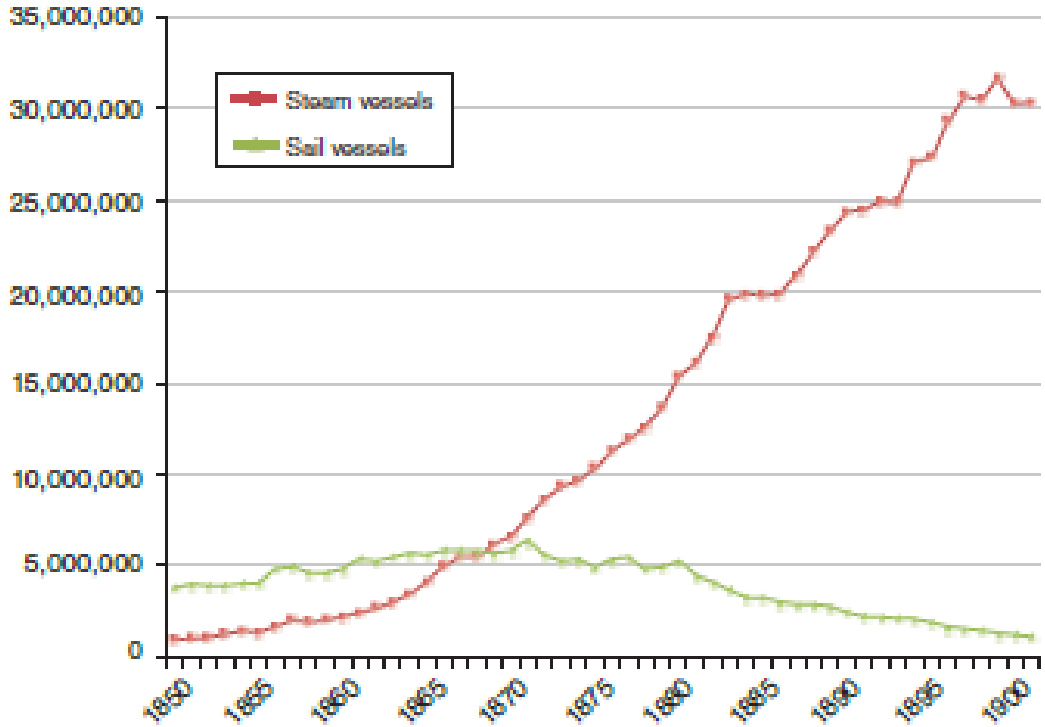


FIGURE 3. TOTAL TONNAGE OF BRITISH VESSELS ENTERED IN BRITISH PORTS FROM AND TO FOREIGN COUNTRIES AND BRITISH POSSESSIONS

(CIESIN), (NOAA), Newcastle Courant, Mitchell's Maritime Register, Angier and POLITY IV

TABLE 1—DESCRIPTIVE STATISTICS

	Mean	Median	SD	Min	Max	Observations
Panel A. Unit of observation: country pair						
Optimized shipping time–steam–Suez closed	434.55	397.50	250.54	0.00	1,054.48	8,834
Optimized shipping time–steam–Suez open	391.85	370.59	214.43	0.00	941.17	8,834
Optimized shipping time–sail–Suez open	914.81	857.18	513.98	0.00	2,418.92	8,834
Optimized shipping time–sail–Suez closed	855.28	818.78	461.76	0.00	2,166.01	8,834
Great-circle distance (km)	8,608.95	8,395.63	4,785.40	0.00	20,007.44	8,834
Panel B. Unit of observation: port pair-year						
Freight rates (shillings per ton)	17.11	15.38	10.81	2.49	390.00	4,903
Voyage duration (hours)	1,302.86	1,104.00	939.18	48.00	4,272.00	3,026
Panel C. Unit of observation: country pair-year						
Bilateral exports ('000 £)	2.29	0.45	6.00	0.00	138.80	23,885
Panel D. Unit of observation: country-year						
Total exports (1990-$)	2.26e+09	7.36e+08	3.74e+09	2.70e+07	2.15e+10	344
Share nonagricultural exports	0.61	0.65	0.26	0.01	1.00	154
Per capita income (1990–intern.$)	1,751.99	1,547.23	1,022.24	411.24	4,850.00	344
Total population ('000)	20,987.48	4,214.00	51,781.21	70.00	401,108.00	344
Urbanization rate (city size > 50,000)	0.10	0.08	0.09	0.00	0.38	344
Urbanization rate (city size > 100,000)	0.08	0.06	0.08	0.00	0.36	344
Panel E. Unit of observation: country						
Constraints on the executive (1860)	3.49	3.00	2.38	1.00	7.00	37
Colony (1850)	0.24	0.00	0.43	0.00	1.00	37

The gravity model is an empirical workhorse in the trade literature. Trade between two countries is inversely related to the distance between them and positively related to their economic size.

$$(1)\ \ln(trade_{ijt}) = \ln(y_{it}) + \ln(y_{jt}) + \ln(y_{wt}) + (1-\sigma)\ln(\tau_{ijt} + \ln P_{it} + \ln P_{jt}) + \epsilon_{ijt}$$

$$(2)\ \ln(trade_{ijt}) = \beta_{steam,T}\ln(steamTIME_{ij}) + \beta_{sail,T}\ln(sailTIME_{ij}) + X_{ijt}\Gamma + \gamma_t + \epsilon_{ijt}$$

$trade_{ijt}$ denotes the exports from country i to county j.
y_{it} and y_{wt} are the GDP of country i and of the world.
τ_{ijt} is the bilateral resistance term.
P_{it} and P_{jt} are the country-specific multilateral resistance terms.
$steamTIME_{ij}$ and $sailTIME_{ij}$ are the sailing times from country i to country j.
X_{ijt} indexes a set of variables to control for the P and y terms in the original gravity equation.

TABLE 3—THE SHIFT FROM SAIL TO STEAM: SHIPPING TIMES AND EXPORTS

	log (export/population)				
	(1)	(2)	(3)	(4)	(5)
ln(steam dist) × *I*(year<=1860)	0.390	0.0712	0.978	0.661	—
	(0.421)	(0.439)	(0.658)	(0.687)	
ln(steam dist) × *I*(1861–1865)	0.222	−0.104	0.438	0.102	−0.0994
	(0.551)	(0.553)	(0.681)	(0.716)	(0.231)
ln(steam dist) × *I*(1866–1870)	−0.392	−0.714	−0.904	−1.197	−0.270
	(0.328)	(0.361)	(0.302)	(0.383)	(0.200)
ln(steam dist) × *I*(1871–1875)	−0.604	−0.926	−0.677	−0.988	−0.496
	(0.278)	(0.330)	(0.300)	(0.372)	(0.221)
ln(steam dist) × *I*(1876–1880)	−0.682	−1.004	−0.628	−0.940	−0.577
	(0.268)	(0.324)	(0.295)	(0.367)	(0.233)
ln(steam dist) × *I*(1881–1885)	−0.594	−0.927	−0.543	−0.868	−0.491
	(0.300)	(0.367)	(0.279)	(0.321)	(0.227)
ln(steam dist) × *I*(1886–1890)	−0.644	−0.979	−0.570	−0.898	−0.545
	(0.311)	(0.391)	(0.282)	(0.342)	(0.224)
ln(steam dist) × *I*(1891–1895)	−0.675	−1.008	−0.560	−0.889	−0.603
	(0.287)	(0.393)	(0.251)	(0.380)	(0.203)
ln(steam dist) × *I*(1896–1900)	−0.578	−0.912	−0.601	−0.931	−0.534
	(0.262)	(0.354)	(0.246)	(0.360)	(0.210)
ln(sail dist) × *I*(year<=1860)	−0.861	−0.784	−1.344	−1.265	—
	(0.395)	(0.392)	(0.674)	(0.674)	
ln(sail dist) × *I*(1861–1865)	−0.720	−0.634	−0.891	−0.797	0.141
	(0.550)	(0.542)	(0.690)	(0.701)	(0.267)
ln(sail dist) × *I*(1866–1870)	−0.327	−0.247	0.117	0.174	0.266
	(0.314)	(0.317)	(0.326)	(0.339)	(0.211)
ln(sail dist) × *I*(1871–1875)	−0.193	−0.122	−0.156	−0.0923	0.456
	(0.277)	(0.279)	(0.319)	(0.325)	(0.217)
ln(sail dist) × *I*(1876–1880)	−0.0958	−0.0249	−0.192	−0.126	0.556
	(0.270)	(0.270)	(0.313)	(0.320)	(0.226)
ln(sail dist) × *I*(1881–1885)	−0.118	−0.0347	−0.169	−0.0878	0.540
	(0.314)	(0.318)	(0.290)	(0.284)	(0.231)
ln(sail dist) × *I*(1886–1890)	−0.105	−0.0192	−0.139	−0.0505	0.599
	(0.315)	(0.323)	(0.284)	(0.282)	(0.217)
ln(sail dist) × *I*(1891–1895)	−0.0321	0.0527	−0.131	−0.0399	0.713
	(0.289)	(0.305)	(0.252)	(0.281)	(0.194)
ln(sail dist) × *I*(1896–1900)	−0.0873	−0.00152	−0.108	−0.0153	0.715
	(0.271)	(0.280)	(0.249)	(0.267)	(0.185)
ln (geo dist)		0.269		0.259	
		(0.192)		(0.190)	
Importer fixed effects	Yes	Yes	No	No	No
Exporter fixed effects	Yes	Yes	No	No	No
Year fixed effects	Yes	Yes	No	No	Yes
Pair fixed effects	No	No	No	No	Yes
Importer × year fixed effects	No	No	Yes	Yes	No
Exporter × year fixed effects	No	No	Yes	Yes	No
R^2	0.632	0.633	0.169	0.171	0.803
Observations	23,885	23,885	23,885	23,885	23,885

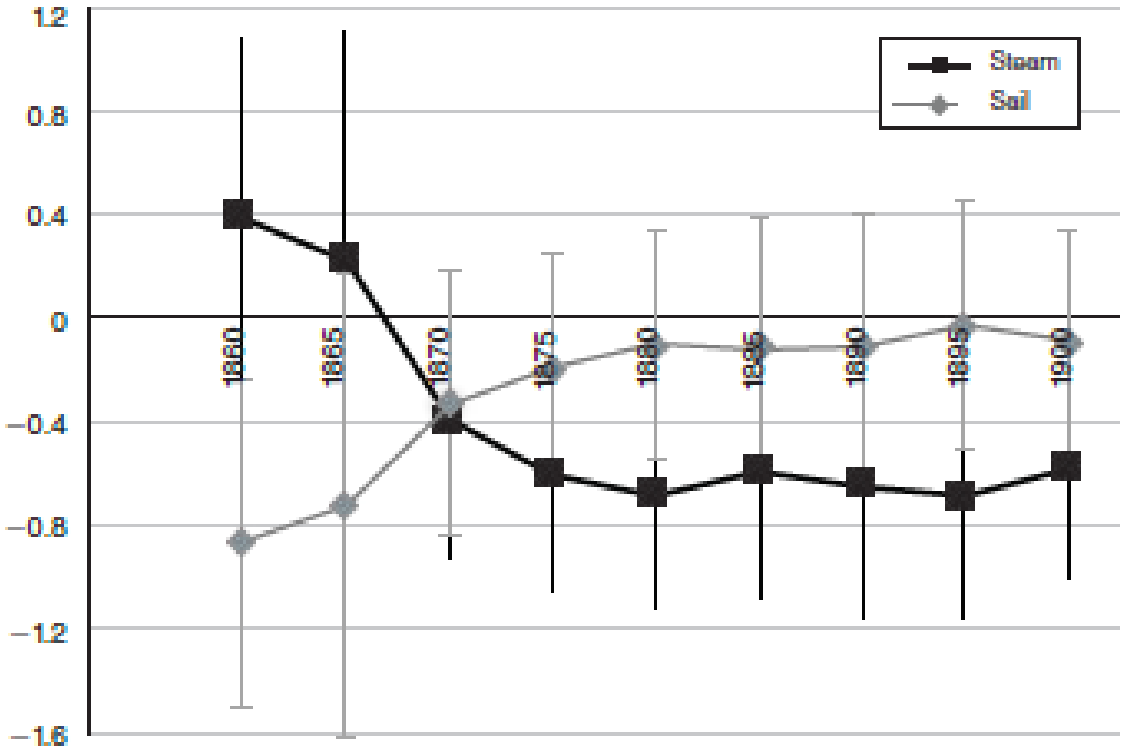


FIGURE 6. THE CHANGE IN THE ELASTICITY OF TRADE WITH RESPECT TO SHIPPING TIMES BY SAIL AND STEAM VESSELS (*Estimates from a Gravity Model with Importer, Exporter, and Year Fixed Effects*)

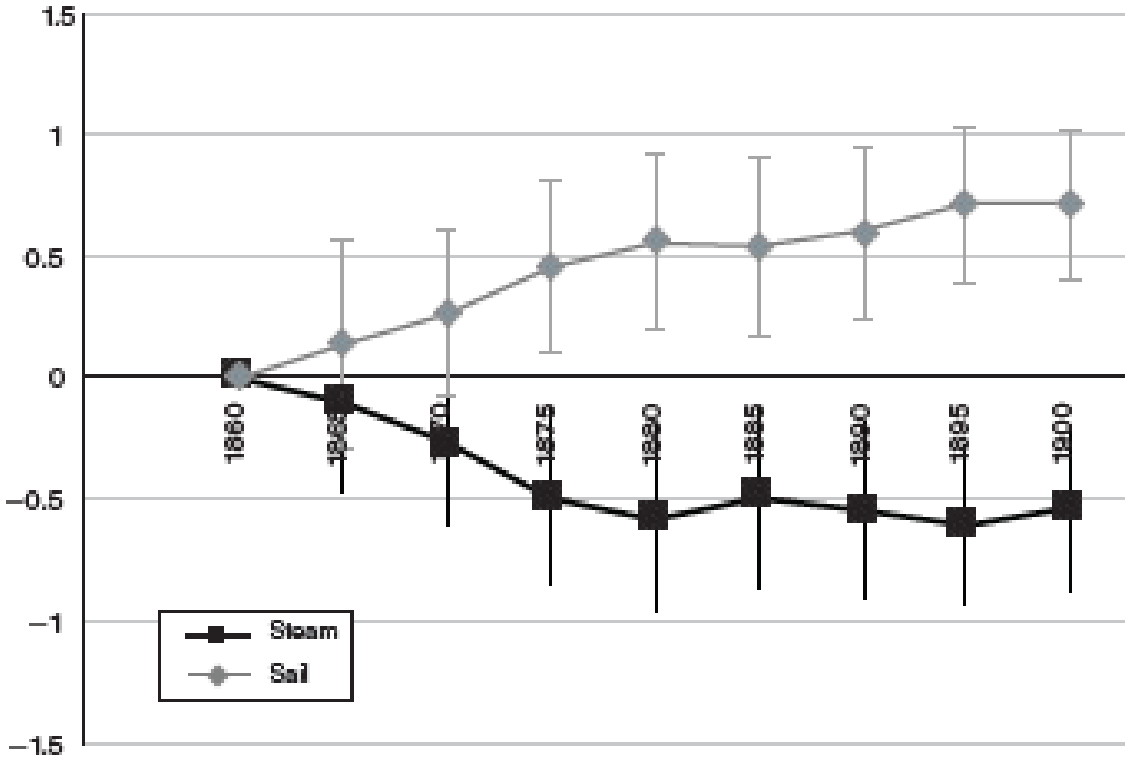


FIGURE 7. THE CHANGE IN THE ELASTICITY OF TRADE WITH RESPECT TO SHIPPING TIMES BY SAIL AND STEAM VESSELS (*Estimates from a Gravity Model with Importer × Year and Exporter × Year Fixed Effects*)

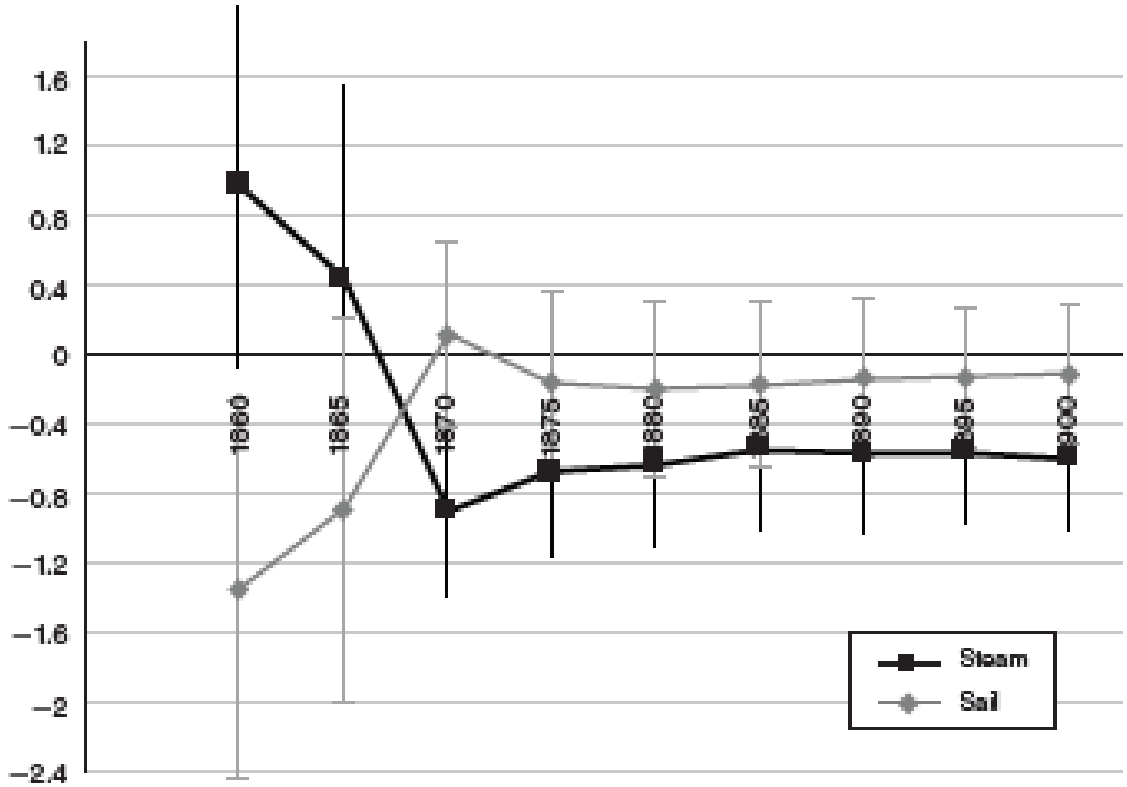


FIGURE 8. THE CHANGE IN THE ELASTICITY OF TRADE WITH RESPECT TO SHIPPING TIMES BY SAIL AND STEAM VESSELS (*Estimates from a Gravity Model with Country-Pair and Year Fixed Effects*)

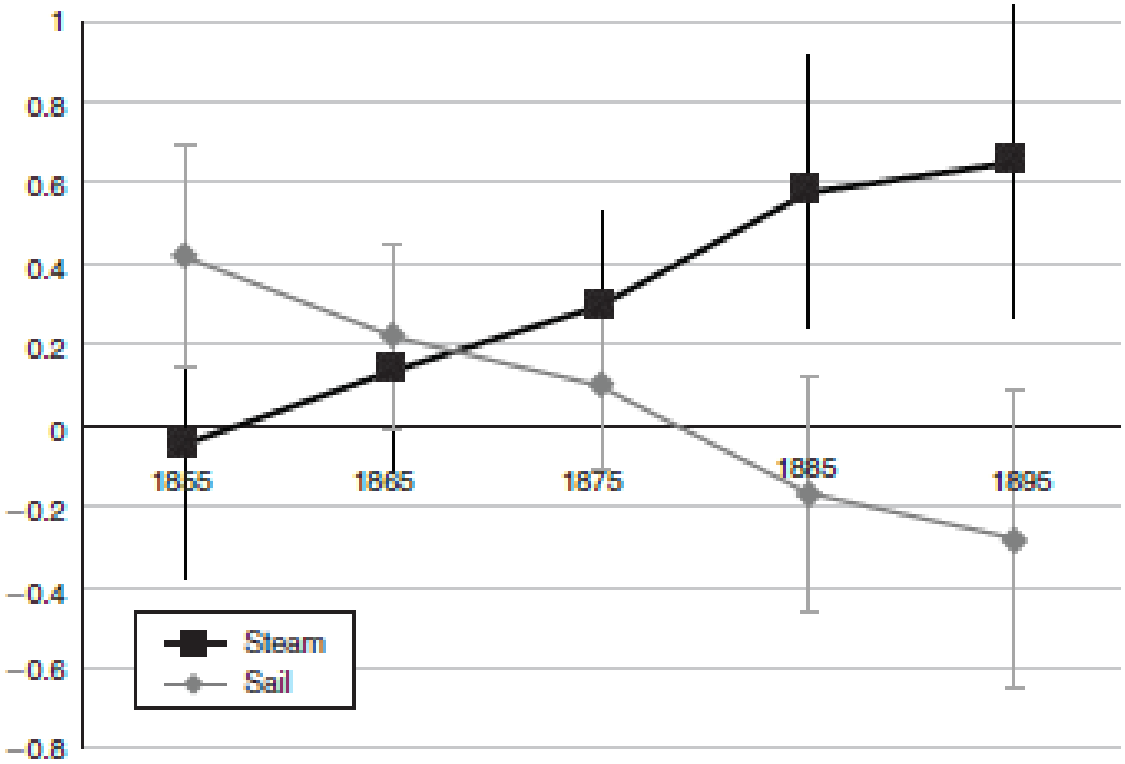


FIGURE 9. THE CHANGE IN THE ELASTICITY OF FREIGHT RATES WITH RESPECT TO SHIPPING TIMES BY SAIL AND STEAM VESSELS (*Estimates from a Gravity Model with Country of Destination, Product, and Year Fixed Effects*)

$$(3)\ \ln(freight_{ijpt}) = \beta_{steam,T} \ln(steamTIME_{ij}) + \beta_{sail,T} \ln(sailTIME_{ij})$$

$$+ X_{ijpt}\Gamma + \gamma_t + \epsilon_{ijpt}$$

$$(4)\ \Delta \log T_i = c + \alpha \Delta \log Dist_i + \upsilon_i$$

$$(5)\ \Delta \log Dist_i = \sum_{j \neq i} w_j [\ln(steamTIME_{ij}) - \ln(sailTIME_{ij})].$$

$freight_{ijpt}$ is the average freight rate from port i to port j for product p in year t .
x_{ijpt} indexes a set of control variables.
γ are year fixed effects.
c is the intercept.
$\Delta \log T_i$ log-change.
$\Delta \log T_i$ average change in shipping times across all trading partners.

TABLE 4—THE SHIFT FROM SAIL TO STEAM: SHIPPING TIMES AND FREIGHT RATES

	log (freight rate)		
	(1)	(2)	(3)
ln(steam dist) × *I*(1855–1860)	−0.0492	−0.0128	—
	(0.199)	(0.187)	
ln(steam dist) × *I*(1861–1870)	0.135	0.173	0.105
	(0.156)	(0.151)	(0.173)
ln(steam dist) × *I*(1871–1880)	0.287	0.331	0.170
	(0.146)	(0.145)	(0.196)
ln(steam dist) × *I*(1881–1890)	0.575	0.620	0.426
	(0.201)	(0.189)	(0.241)
ln(steam dist) × *I*(1891–1900)	0.652	0.705	0.494
	(0.234)	(0.232)	(0.238)
ln(sail dist) × *I*(1855–1860)	0.420	0.403	—
	(0.165)	(0.156)	
ln(sail dist) × *I*(1861–1870)	0.225	0.206	−0.125
	(0.138)	(0.131)	(0.144)
ln(sail dist) × *I*(1871–1880)	0.109	0.0853	−0.176
	(0.129)	(0.127)	(0.163)
ln(sail dist) × *I*(1881–1890)	−0.164	−0.188	−0.415
	(0.176)	(0.168)	(0.204)
ln(sail dist) × *I*(1891–1900)	−0.279	−0.311	−0.540
	(0.222)	(0.219)	(0.205)
ln(geo dist)		−0.0407	
		(0.0973)	
Country of destination fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
Route fixed effects	No	No	Yes
Product fixed effects	Yes	Yes	Yes
R^2	0.306	0.306	0.0294
Observations	4,903	4,903	4,903

Notes: The table reports OLS estimates. The unit of observation is a port pair in a certain year. The dependent variable is the log freight rate. Standard errors (reported in parentheses) are two-way clustered (country of destination and year).

TABLE 5—GEOGRAPHICAL ISOLATION AND TRADE

	log change export/GDP			log change export/population		
	(1)	(2)	(3)	(4)	(5)	(6)
log-change distance (to all countries)	−1.008 (0.663)			−1.737 (0.480)		
log-change distance (to United Kingdom)		−0.792 (0.469)			−1.422 (0.341)	
log-change distance (to top five trading countries)			−1.498 (0.874)			−2.469 (0.662)
Intercept	−0.177 (0.582)	−0.00547 (0.436)	−0.0416 (0.441)	−0.389 (0.419)	−0.141 (0.308)	−0.100 (0.331)
R^2	0.0912	0.115	0.113	0.214	0.270	0.225
Observations	25	24	25	50	49	50
Weighted (by log population)	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports OLS estimates. The unit of observation is the country. The dependent variable is the log-change of either export/GDP or export/population of the country between 1850 and 1905. log-change distance is the weighted average of the log changes in shipping times between the country and the other countries of the world generated by the introduction of the steamship (see equation (5) in the main text). Robust standard errors are reported in parentheses.

$$(6)\ \log(Y_{it}) = \gamma \log(T_{it}) + \gamma_i + \gamma_t + \upsilon_{it}$$

Y_{it} is per capita GPD.
T_{it} is either the export-to-GPD ratio or the per capita exports of country i.
To identify tha causal effect, this equations is estimated using 2SLS.
The author isolates the geographic component of country i's exports to its trade partner j in year t using the following formula:

$$(7)\ \log PT_{ijt} = \beta_{steam,t} \ln(steamTIME_{ij}) + \beta_{sail,t} \ln(sailTIME_{ij})$$

The geographic component of a country's total exports is then computed:

$$(8)\ \log PT_{it} = \sum_{j \neq i} w_j \log PT_{ijt}$$

TABLE 6—TRADE AND DEVELOPMENT

	log per capita GDP							
	(OLS) (1)	(2SLS) (2)	(2SLS) (3)	(OLS) (4)	(2SLS) (5)	(2SLS) (6)	(OLS) (7)	(OLS) (8)
Panel A								
log (export/GDP)	−0.054	−0.200	−0.187					
	(0.031)	(0.087)	(0.094)					
log (export/pop)				0.137	−0.250	−0.230		
				(0.038)	(0.136)	(0.142)		
log predict. export							−0.215	−0.194
							(0.109)	(0.112)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	344	344	344	344	344	344	344	344
F		26.50	24.98		16.77	16.56		
Weighted	No	No	Yes	No	No	Yes	No	Yes
Panel B								
log predict.		1.075	1.038		0.860	0.844		
Export		(0.387)	(0.377)		(0.340)	(0.334)		

Notes: The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of per capita GDP. "log predict export" is constructed according to equation (8). Observations are un-weighted in columns 1, 2, 4, 5, and 7 and weighted by the log-population of the country in 1860 in the other columns. Panel A reports the second-stage estimates. *F* is the Kleiberg-Paap Wald *F*-statistics for weak identification. Panel B reports the first-stage estimates. Standard errors (reported in parentheses) are two-way clustered (country and year) corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation.

TABLE 7—TRADE, POPULATION, AND URBANIZATION RATES

	log (Population)			log (Urban pop (>50,000))			log (Urban pop (>100,000))		
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log (export/GDP)	−0.243	−1.041	−0.972	−0.013	−0.065	−0.061	−0.243	−0.069	−0.068
	(0.074)	(0.196)	(0.177)	(0.013)	(0.035)	(0.037)	(0.074)	(0.049)	(0.049)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	344	344	344	344	344	344	344	344	344
F		26.50	24.98		26.50	24.98		26.50	24.98
Weighted	No	No	Yes	No	No	Yes	No	No	Yes

Notes: The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of population (columns 1–3) or the log of the population share living in cities with more than either 50,000 citizens (columns 4–6), or 100,000 citizens (columns 7–9). Observations are un-weighted in columns 1, 2, 4, 5, 7, and 8 and weighted by the log-population of the country in 1860 in columns 3, 6, and 9. *F* is the Kleiberg-Paap Wald *F*-statistics for weak identification. Panel B reports the first-stage estimates. Standard errors (reported in parentheses) are two-way clustered (country and year) corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation.

TABLE 8—TRADE AND ECONOMIC DIVERGENCE

Dependent variable: log per capita GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log export/GDP	−0.400	−0.395	−0.241	−0.219				
	(0.180)	(0.182)	(0.0961)	(0.0987)				
log export/population					−0.419	−0.407	−0.260	−0.227
					(0.217)	(0.219)	(0.122)	(0.122)
log export/GDP × above mean GDP 1850	0.248	0.254						
	(0.143)	(0.141)						
log export/GDP × above top 25pc GDP 1850			0.161	0.157				
			(0.0691)	(0.0693)				
log export/population × above mean GDP 1850					0.185	0.189		
					(0.114)	(0.112)		
log export/population × above top 25pc GDP 1850							0.117	0.110
							(0.0532)	(0.0512)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	5.385	5.404	14.33	14.71	4.026	4.012	9.954	11.17
Observations	318	318	318	318	318	318	318	318
Weighted	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The table reports 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of per capita GDP. Above mean GDP 1850 (above top 25 pc GDP 1850) is a dummy equal to 1 if the per capita GDP in the country was above the average (the top twenty-fifth percentile) per capita GDP across all countries in the sample in 1850. Observations are un-weighted in columns 1, 3, 5, and 7 and weighted by the log-population of the country in 1860 in columns 2, 4, 6, and 8. *F* is the Kleiberg-Paap Wald *F*-statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

$$(9)\ \log(Y_{it}) = \alpha_0 \log T_{it} + \alpha_1 \log T_{it} \times Exec_i + \gamma_i + \gamma_t + \upsilon_{it}$$

where $Exec_i$ is a measure of the constraints on the decision-making power of the chief executives. The first stage of the 2SLS estimates is given by the following system of equations:

$$(10)\ \log T_{it} = \theta_{11} \log PT_{it} + \theta_{12} \log PT_{it} \times Exec_i + \gamma_i + \gamma_t + \epsilon_{1it}$$

$$(11)\ \log T_{it} \times I(Exec_i) = \theta_{21} \log PT_{it} + \theta_{22} \log PT_{it} \times Exec_i + \gamma_i + \gamma_t + \epsilon_{2it}$$

TABLE 9—TRADE AND DEVELOPMENT: THE ROLE OF LOCAL INSTITUTIONS

	Per capita GDP			Population		
	(OLS) (1)	(2SLS) (2)	(2SLS) (3)	(OLS) (4)	(2SLS) (5)	(2SLS) (6)
log export/GDP	−0.178	−0.398		−0.322	−1.357	
	(0.0412)	(0.119)		(0.112)	(0.289)	
log export/population			−0.292			−1.349
			(0.114)			(0.238)
log export/GDP	0.0295	0.0675		0.0274	0.123	
× exec constraints	(0.00973)	(0.0208)		(0.0161)	(0.0575)	
log export/population			0.0412			0.101
exec constraints			(0.0114)			(0.0322)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
F		11.98	10.18		11.98	10.18
Observations	344	344	344	344	344	344
Weighted	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is either the log of per capita GDP or population. Exec constraints is the score in the POLITY IV variable constraints on the executive in 1860. The excluded instruments are constructed according to equations (10) and (11). Observations are weighted by the log-population of the country in 1860. *F* is the Kleiberg-Paap Wald *F*-statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

TABLE 10—TRADE, IDENTIFICATION, AND URBANIZATION: THE ROLE OF LOCAL INSTITUTIONS

	Share nonagricultural exports		Urban pop (>50,000)		Urban pop (>100,000)	
	(OLS) (1)	(2SLS) (2)	(OLS) (3)	(2SLS) (4)	(OLS) (5)	(2SLS) (6)
log export/GDP	−0.0313	0.0156	−0.0312	−0.115	−0.0372	−0.127
	(0.0461)	(0.0849)	(0.0129)	(0.0555)	(0.0150)	(0.0680)
log export/GDP	0.0140	0.0149	0.00499	0.0173	0.00474	0.0190
× exec constraints	(0.00700)	(0.0126)	(0.00165)	(0.00736)	(0.00201)	(0.00702)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	153	153	344	344	344	344
F		3.286		11.98		11.98
Weighted	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports 2SLS estimates. The unit of observation is country-year. The dependent variable is either the log of the share of nonagricultural exports (columns 1 and 2), or the log of the population share living in cities with more than 50,000 citizens (columns 3 and 4), or 100,000 citizens (columns 5 and 6). Exec constraints is the score in the POLITY IV variable constraints on the executive in 1860. Observations are weighted by the log-population of the country in 1860. *F* is the Kleiberg-Paap Wald *F*-statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Conclusions

- The adoption of the steamship had a major impact on patterns of international trade worldwide.
- Only a small number of countries, characterized by more inclusive institutions, benefited from trade integration.
- Globalization was the major driver of the economic divergence between the rich and the poor portions of the world in the years 1850–1900.
- The increase in international trade had heterogeneous effects on local economic development (actually, these effects were negative for the majority of countries) and increased inequality across nations.