Endowment, Market Potential, and Spatial Dynamics of Industrial Locations: Evidence from Global Shipbuilding*

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Abstract

We compile a novel panel dataset of ship orders across 30 countries from 1896 to 2020 to examine the evolution of the global shipbuilding industry across time and space. We document a transition in the shipbuilding production location from European countries to Asian countries over the sample period. We further apply a panel error-correction model (ECM) to show that both relative capital endowment and market potential account for this transition in the long run, while market potential exerts a more significant influence on ship production in the short run.

Keywords: Market potential, factor endowment, shipbuilding industry, panel error-correction model

JEL Classification: F1, R12, R32, N70, N90

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1 Introduction

International industrial relocation has unequal impacts across countries, attracting considerable research from academics (Krugman 1991; Fujita et al. 1999) and policy institutions (Midelfart-Knarvik et al. 2004; Deichmann et al. 2008) to understand its determinants. Neoclassical trade theory attributes industrial location to factor endowments such as labor and capital abundance, while the new economic geography (NEG) literature suggests that market potential determines industrial location. Recently, many empirical studies have shown these two factors determine industrial locations within a particular country (Crafts and Mulatu 2005; Klein and Crafts 2012; Martinez-Galarraga 2012; Basile and Ciccarelli 2018). However, there is no empirical work on how these two factors drive industrial location on a global scale.

In this paper, we fill this gap by studying the evolution of the global shipbuilding industry across 30 countries from 1896 to 2020. The reasons for considering shipbuilding as an example of industry evolution across the world are three-fold. First, the significance of the shipbuilding industry is evident. Since the Age of Discovery in the 15th century, the development of transportation systems has been crucial for nations striving for political, military, and economic dominance. Since shipbuilding was the cornerstone of this system, it fueled both naval power growth and global trade expansion. However, critical questions about this industry remain unanswered, such as why the center of global shipbuilding has shifted across different countries and what factors contributed to these shifts.

Second, during our sample period, the industry has experienced remarkable growth and significant shifts in its geographical distribution, making it a compelling case for studying the determinants of an industry's spatial dynamics of production location, with a particular emphasis on factor endowments and market potential. Further, our research can potentially shed a light on the production location shifts of contemporary capital-intensive industries such as automotive industry (Bailey et al. 2010), chemical industry (Budde 2011), hard disk drive industry (Igami 2018) and semiconductor industry (Yeung 2022).

Third, countries have implemented industrial policies to stimulate their shipbuilding industries. For instance, China introduced the "Implementation Plan for Accelerating Structural Adjustment and Promoting Transformation and Upgrading of the Shipbuilding Industry" in 2013.[1] South Korea released "Plan for the Restructuring of the Shipping and Shipbuilding Industries" in 2016.[2] It is imperative for policymakers to understanding the key factors driving the production location shifts of shipbuilding industry when they evaluate such policies.

We apply a panel ECM to show that both relative capital endowment and market potential drive long-term ship production, while market potential exerts a more significant influence on ship production in the short run. This paper contributes to the literature employing the Heckscher-Ohlin factor endowment and NEG models to analyze the determinants of industrial locations in the long run. Previous studies like Crafts and Mulatu (2005) emphasize factor endowment's role in British industrial location from 1871-1931, while Klein and Crafts (2012) highlight market potential in U.S. manufacturing belts from 1880-1920. Further, Martinez-Galarraga (2012) and Basile and Ciccarelli (2018) find that both factors drove industrial location in Spain from 1856 to 1929 and Italy from 1871 to 1911, respectively. Different from these papers focusing on a single country, we contribute to this literature by examining industry location dynamics across the world for a long period (120 years), providing insights into the evolution of the global economic landscape.

2 Data and Descriptive Analysis

2.1 Data

We collect panel data on the shipbuilding industry across 30 countries from 1896 to 2020 (see Table A.1 for details on sample selection). Our sample data merge three datasets - ship order data, factor endowment data, and market potential data. The sample spans developed and developing countries across different continents. The time interval of our dataset is 5 years.[3]

Ship Order Data. This dataset comes from Clarksons Research, a ship-broking firm

[1]Source: https://www.gov.cn/gongbao/content/2013/content_2466570.htm.

[2]Source: https://www.fsc.go.kr/eng/pr010101/22134.

[3]Each sample year represents a five-year average. For example, 1900 represents the average of 1896 to 1900. Thus, the final sample spans 1900 to 2020, as used in subsequent sections.

based in the United Kingdom.[4] It contains yearly information on ship orders worldwide from 1896 to 2020. For each order, we observe the contract date, the Gross Tons, the year of production, the builder of the ship, and the builder's country. We use ship tonnage measured in gross tons for ship production because it is consistently recorded in each order while many orders lack monetary value.[5]

Factor Endowment Data. We consider two input factors in the analysis, capital and labor.[6] In particular, we use steel production and employment to measure capital and labor endowments, respectively. For each country and year, we collect steel production from the Steel Statistical Yearbook 1980-2020 and employment (proxy by working populations) from Penn World Table version 10.01.[7]

Market Potential Data. Following Harris (1954), the market potential is constructed as: $MP_{it} = \sum_j^J \frac{GDP_{jt}}{Dist_{ij}}$. We obtain GDP from the Maddison Project Database 2023, which provides real GDP per capita in 2011 dollars and the population that covers 169 countries up to 2020. We calculate distances using countries' latitudes and longitudes from CEPII.[8]

2.2 Summary Statistics

Table B.1 reports the summary statistics for key variables. On average, a country produces 3.61 million tons of ships every 5 years. We measure the relative capital endowment with the ratio between steel production to employment. Table B.1 shows that, on average, each sampled country has 0.60 metric tons of steel production per worker and a market potential of 12.91 billion dollars, based on Maddison's GDP data.

[4]This data source is also used in various studies on shipbuilding in academic research, such as Kalouptsidi (2014).

[5]See Appendix A.2 for additional explanations for using this output measure.

[6]According to Lorenz (1991), labor and steel were the primary components of total ship construction costs. In the 1960s Europe and Japan, labor and steel accounted for 20%, respectively.

[7]Supplementary data sources are listed in Appendix A.3.

[8]Details on constructing the variable can be found in Appendix A.4.

2.3 Stylized Facts

2.3.1 Ship production across space over time

Panel (a) of Figure 1 shows the global ship production from 1900 to 2020. Ship production maintained a steady level before 1980 but experienced substantial growth thereafter, peaking at about 400 million tons in 2015.

Panel (b) of Figure 1 shows the evolution of the global ship production center. Ship production center was initially dominated by European countries and the United States from 1900 onwards. However, from the mid-20th century onwards, the center of shipbuilding gradually shifted toward Asia. Japan emerged as a shipbuilder post-World War II, surpassing the United Kingdom by 1965. South Korea strategically developed its shipbuilding industry in the 1980s, gaining substantial market shares in 2000. Since 2005, China has become a major shipbuilding giant, currently holding about 40% of global orders.

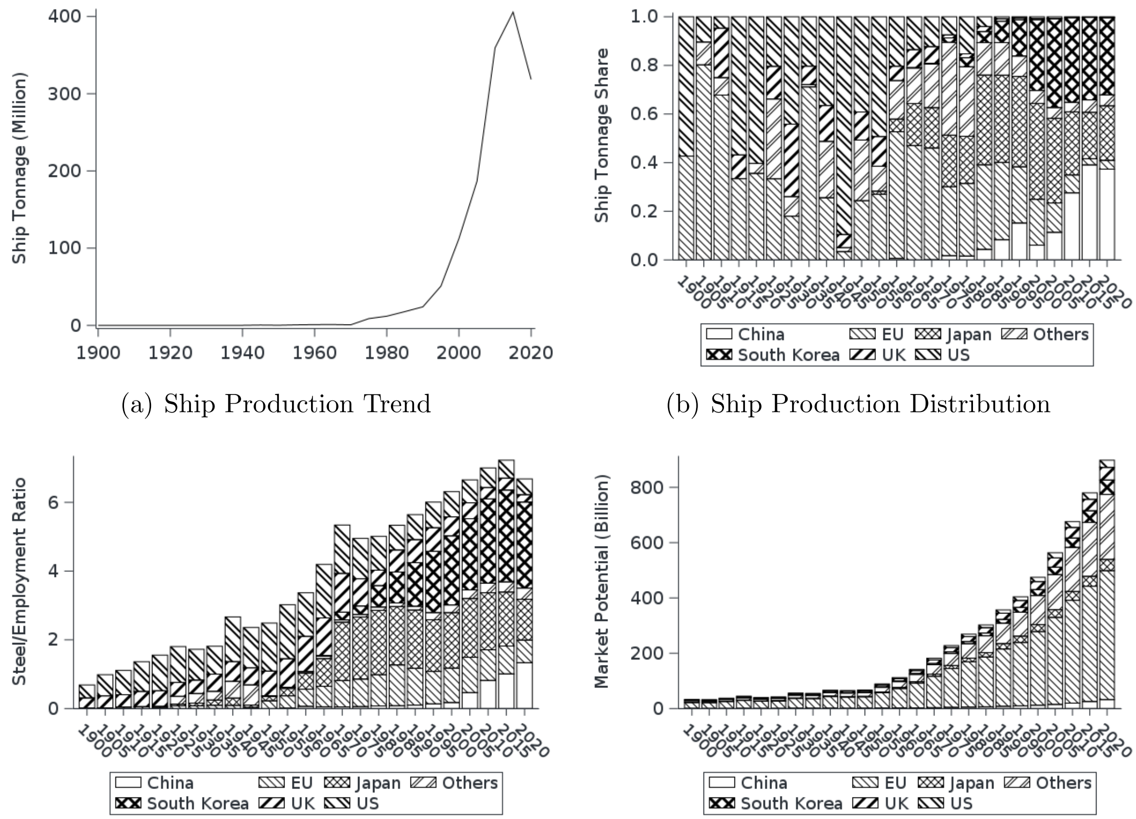
2.3.2 Distribution of factor endowment and market potential

Figure 1 (c) depicts the distribution of relative capital endowment across regions from 1900 to 2020. Initially, the United Kingdom and the United States led relative capital endowment in 1900, but by the 1960s, Japan took over. Currently, China, South Korea, and Japan display high relative capital endowments.

Panel (d) of Figure 1 reveals the growth and evolution of market potential across regions from 1900 to 2020. We find a notable overall increase in market potential during this period. Initially, European countries exhibited higher market potential in 1900. However, starting from the 1970s, Japan and South Korea began a gradual rise in their market potential. Since 2000, China's market potential has also demonstrated a steady increase.

2.3.3 Relationship between ship production and market potential and factor endowment

Figures 1 (a) and (b) show a significant growth in ship production from 1900 to 2020, shifting from Europe to Asia. Figures 1 (c) and (d) show similar growth and evolution in factor endowments and market potential during this time. This indicates positive relationships



(a) Ship Production Trend

(b) Ship Production Distribution

(c) Factor Endowments Distribution

(d) Market Potential Distribution

Figure 1: Trend and Spatial Distribution of Main Variables

Notes: The figure shows the global trend and distribution of our key variables of ship producers from 1900-2020. Sample countries are categorized into 6 groups: China, Japan, South Korea, the United Kingdom, the United States, European countries, and others.

between ship production and both factor endowment and market potential, suggesting that countries with higher relative capital endowment and market potential tend to produce more ships. The following section discusses our empirical methodology to examine these relationships.

3 Empirical Analysis

3.1 Empirical Model

We propose an equation of ship production as follows :

$$\ln y_{it} = \gamma_{0i} + \gamma_{1i} \ln(\frac{f_{it}^k}{f_{it}^l}) + \gamma_{2i} \ln MP_{it} + \epsilon_{it} \tag{1}$$

where ship production y_{it} of country i in year t depends on its relative capital endowment, $\frac{f_{it}^k}{f_{it}^l}$, and market potential, MP_{it}. γ_{0i} is a country-specific intercept term. ϵ_{it} is the error term.

We test for data series stationarity in Appendix B.2. The results indicate that the data series are either in I(0) or I(1) stationary processes. Our model is specified in Autoregressive Distributed Lag, ARDL(1,1,1) form:

$$\ln y_{it} = \theta_{1i} \ln y_{i,t-1} + \lambda_{0i} \ln(\frac{f_{it}^k}{f_{it}^l}) + \lambda_{1i} \ln(\frac{f_{it-1}^k}{f_{it-1}^l}) + \delta_{0i} \ln MP_{it} + \delta_{1i} \ln MP_{i,t-1} + \alpha_i + \epsilon_{it} \tag{2}$$

The error-correction formulation is:

$$\Delta \ln y_{it} = \beta_{0i} \Delta \ln(\frac{f_{it}^k}{f_{it}^l}) + \beta_{1i} \Delta \ln MP_{it} + \phi_i (\ln y_{it-1} - \gamma_{0i} - \gamma_{1i} \ln(\frac{f_{it-1}^k}{f_{it-1}^l}) - \gamma_{2i} \ln MP_{it-1}) + \alpha_i + \epsilon_{it} \tag{3}$$

In Eq. 3, the short-run and the long-run elasticities, βs, and γs, are of primary interest. If they are positive, higher relative capital endowment and market potential promote ship production. ϕ_i is the error correction term, the adjustment parameter towards the long-run equilibrium. Following Blackburne and Frank (2007), we use the mean group (MG), pooled mean group (PMG), and dynamic fixed effect (DFE) approaches to estimate Eq. 3.

3.2 Empirical Results

In this section, we first present the baseline results. Then we conduct robustness checks including alternative measurements of market potential and alternative estimation strategies. Finally, we divide the samples into three groups by continent to explore the heterogeneity.

3.2.1 Baseline Results

Columns 1, 2, and 3 of Table 1 present the PMG, MG, and DFE results for ship production in tonnage, respectively. Based on the Hausman test, the DFE estimator is preferred. In the DFE results, both relative capital endowment and market potential significantly impact ship production in the short and long term. Specifically, a 1% increase in relative capital endowment results in a 5.3% growth in long-run ship production, while a 1% increase in market potential leads to a 2.3% growth in long-run ship production. In the short run, however, we find a more significant effect of market potential on ship production compared to relative capital endowment. The error-correction term is highly significant, indicating a strong long-run relationship with a fast adjustment rate, around 55.6% in 5 years, corresponding to a half-life of about 4.3 years.

3.2.2 Robustness Checks

Columns 4-5 of Table 1 present robustness checks using alternative measures of market potential and relative capital endowment. Column 4 employs Alternative Market Potential, and column 5 shows Alternative Endowment which uses population as a proxy of labor endowment. We consider population is a more exogenous measure than employment, which helps mitigating endogeneity concerns regarding the potential effect of ship production on labor endowment. In both sets of robustness checks, the impact of relative capital endowment and market potential on short- and long-term ship production is consistent with the results in column 3.

To further address the potential reverse causality concern, where the relative capital endowment and market potential might be influenced by ship production, we employ the lagged values of these variables as instruments and estimate the short-run coefficients using the System GMM approach. The findings from the System GMM estimation are consistent with the baseline results, supporting the baseline results.[9]

[9] See Appendix B.3 for details.

3.2.3 Heterogeneity

Columns 6-8 display the DFE estimates by continent (Europe, Asia, and the Americas). Our findings indicate that long-term ship production is significantly influenced by both relative capital endowment and market potential, but only market potential affects ship production in the short term. On one hand, shipbuilders can adjust ship production using existing technology in response to demand shifts driven by changes in market potential in the short and long term. On the other hand, ship production does not respond to relative capital endowment in the short term because they may need to incur cost and time to adjust their technology leveraging a higher relative capital endowment. Notably, among the three regions, the coefficient of market potential for Asian countries is larger, reflecting that the growth in ship production in countries like China and South Korea primarily stems from the increase in market demand compared to European and American countries.

Table 1: Baseline results

	$\Delta\ln(Tonnage)$							
	Baseline			Alternative MP	Alternative Endowment	Subsample		
	PMG	MG	DFE	DFE	DFE	Europe	Asia	Americas
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Long-run coefficients								
$\ln(\frac{f^k_{it-1}}{f^l_{it-1}})$	1.067***	-2.766	5.334***	5.396***	8.513***	5.235***	5.012**	3.340*
	(0.402)	(2.979)	(1.042)	(1.132)	(1.831)	(1.672)	(2.102)	(1.792)
$\ln MP_{it-1}$	-0.179	1.572*	2.267***	2.667***	2.268***	2.166***	2.697***	1.895***
	(0.168)	(0.934)	(0.372)	(0.508)	(0.406)	(0.594)	(0.949)	(0.461)
Short-run coefficients								
$\Delta\ln(\frac{f^k_{it}}{f^l_{it}})$	3.871	2.253	2.405**	2.445**	3.737**	1.414	3.330	3.629
	(7.801)	(6.337)	(1.096)	(1.132)	(1.742)	(1.237)	(3.627)	(4.509)
$\Delta\ln MP_{it}$	4.862	-1.348	6.237***	6.583***	6.337***	5.398**	7.270***	5.695**
	(3.660)	(3.538)	(1.352)	(1.992)	(1.307)	(2.656)	(1.707)	(2.720)
ECT	-0.545***	-0.927***	-0.556***	-0.538***	-0.534***	-0.510***	-0.627***	-0.578***
	(0.122)	(0.069)	(0.075)	(0.072)	(0.073)	(0.088)	(0.147)	(0.136)
Hausman test	2.01							
(PMG vs. MG)	[0.365]							
Hausman test			54.05					
(PMG vs. DFE)			[0.000]					
N	415	415	415	415	415	211	147	57

Notes: Alternative MP utilizes the GDP per capita index supplemented by Maddison's GDP. Further details are in the Appendix A.4. Alternative Endowment uses population as labor endowments instead of employment. Standard errors are in parentheses. P-values are in brackets. *** p<0.01, ** p<0.05, * p<0.1.

4 Conclusion

This paper examines the geographical dynamics of the shipbuilding industry across the globe using panel data spanning 1896 to 2020 across 30 countries. Our results from panel ECM show that both relative factor endowment and market potential play a pivotal role in shaping the evolution of shipbuilding industry locations in the long term. However, in the short term, only market potential has a positive and significant effect on ship production.

References

Basile, Roberto, and Carlo Ciccarelli. "The location of the Italian manufacturing industry, 1871–1911: a sectoral analysis." *Journal of Economic Geography* 18, no. 3 (2018): 627-661.

Bailey, David, Alex De Ruyter, Jonathan Michie, and Peter Tyler. "Global restructuring and the auto industry." *Cambridge Journal of Regions, Economy and Society* 3, no. 3 (2010): 311-318.

Blackburne III, Edward F., and Mark W. Frank. "Estimation of nonstationary heterogeneous panels." *The Stata Journal* 7, no. 2 (2007): 197-208.

Budde, Florian. "Chemicals' changing competitive landscape." *McKinsey & Company on Chemicals* (2011): 4.

Crafts, Nicholas, and Abay Mulatu. "What explains the location of industry in Britain, 1871–1931?." *Journal of Economic Geography* 5, no. 4 (2005): 499-518.

Deichmann, U., Lall, S. V., Redding, S. J., and Venables, A. J. "Industrial Location in Developing Countries." *World Bank Study Observer*, 23, no. 2 (2008), 219–246.

Fujita M., Krugman, Paul, and Venables, Anthony, (1999). The Spatial Economy. Cities, Regions and International Trade. Cambridge: MIT Press.

Harris, Chauncy D. "The, Market as a Factor in the Localization of Industry in the United States." *Annals of the association of American geographers* 44, no. 4 (1954): 315-348.

Igami, Mitsuru. "Industry dynamics of offshoring: The case of hard disk drives." *American Economic Journal: Microeconomics* 10, no. 1 (2018): 67-101.

Kalouptsidi, Myrto. "Time to build and fluctuations in bulk shipping." *American Economic Review* 104, no. 2 (2014): 564-608.

Klein, Alexander, and Nicholas Crafts. "Making sense of the manufacturing belt: determinants of US industrial location, 1880–1920." *Journal of Economic Geography* 12.4 (2012): 775-807.

Krugman, P., (1991). Geography and Trade. Cambridge, MA: MIT Press.

Lorenz, Edward H. "An evolutionary explanation for competitive decline: the British shipbuilding industry, 1890–1970." *Journal of Economic History* 51, no. 4 (1991): 911-935.

Martinez-Galarraga, Julio. “The determinants of industrial location in Spain, 1856–1929.” *Explorations in Economic History* 49, no. 2 (2012): 255-275.

Midelfart-Knarvik, Karen Helene, Henry G. Overman, Stephen J. Redding, and Anthony J. Venables. The location of European industry. *European Integration and the Functioning of Product Markets* (2004): 113-170.

Yeung, Henry Wai-chung. “Explaining geographic shifts of chip making toward East Asia and market dynamics in semiconductor global production networks.” *Economic Geography* 98, no. 3 (2022): 272-298.

Appendix A Data Appendix

A.1 Sample Countries

We select the top 30 countries in terms of their rankings in the share of ship tonnage from 1896 to 2020. To obtain the share of ship tonnage, we first calculate the total ship tonnage for each country throughout our sample periods. Then, we compute the share with the total ship tonnage. The list of sample countries, their shares, and continents are reported in Table A.1.

Table A.1: Top 30 Countries in Terms of Total Tonnage Share

Country/Area	Share of Tonnage	Continent
South Korea	0.316	Asia
China	0.275	Asia
Japan	0.259	Asia
Germany	0.018	Europe
the Philippines	0.014	Asia
Singapore	0.011	Asia
Italy	0.010	Europe
Taiwan, China	0.009	Asia
Denmark	0.007	Europe
United States	0.007	the Americas
Poland	0.007	Europe
Croatia	0.006	Europe
Finland	0.005	Europe
Netherlands	0.005	Europe
Spain	0.005	Europe
Vietnam	0.005	Asia
Romania	0.005	Europe
Norway	0.005	Europe
France	0.005	Europe
Turkey	0.004	Asia
Brazil	0.003	the Americas
Russia	0.003	Europe
Indonesia	0.002	Asia
Malaysia	0.002	Asia
India	0.002	Asia
United Kingdom	0.002	Europe
United Arab Emirates	0.001	Asia
Ukraine	0.001	Europe
Bulgaria	0.001	Europe
Canada	0.001	the Americas

Note: The assignment of countries or areas to specific continents follows "Standard Country or Area Codes for Statistical Use" published by the UN Statistics Division.

A.2 Ship Tonnage

This appendix provides several justifications for using tonnage instead of value as a measure of output in the shipbuilding industry:

- **Historical Use and Tradition.** Tonnage has long been the standard metric in maritime and shipbuilding literature (Crowther 1973; Hengst and Koppies 1996; Arnold 1999; Buxton et al. 2015). Historically, ship tonnage was associated with the ship's carrying capacity, a crucial measure for trade and naval power. This tradition has persisted, making tonnage a key indicator for assessing industry output.

- **Standardization and Comparability.** Tonnage provides a standardized and stable physical measure of ship size and capacity, allowing for consistent comparisons across various types of vessels over time. Given the diversity of ships - ranging from cargo ships to tankers, container vessels, and military craft - comparing their monetary values directly can be challenging. Moreover, ship values are often volatile, influenced by factors such as material costs and exchange rates. In contrast, tonnage provides a more stable benchmark, independent of these fluctuating market dynamics.

- **Indicator of Production and Market Shares.** The measurement of production and market shares in the shipbuilding industry is more accurately reflected by the tonnage of ships produced, rather than their monetary value. Higher tonnage not only indicates increased shipbuilding activity but also implies greater infrastructure utilization and higher labor engagement. Thus, tonnage serves as a reliable indicator for assessing the industry's capacity and overall health. In existing economic literature, ship tonnage is regarded as a key metric for measuring the intensive margin of ship production (Hanlon 2020) and market shares (Kalouptsidi 2018; Gourdon 2019). Furthermore, Barwick et al. (2021) show that ship prices are a function of tonnage, further indicating ship tonnage as a key determinant of ship value.

A.3 Supplementary Data Sources

Table A.2: Variables and Data Sources

Country/Area (Sample Period)	Variable	Year	Data Source
Brazil	Steel	1950-1955	Steel Statistical Yearbook 1959
(1950-2020)		1960	the National Materials Capabilities Data v.2021 (NMCD 2021)
		1965	UN Statistical Yearbook 1970
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	Penn World Table version 10.01 (PWT 10.01)
Bulgaria	Steel	1965	Intenrnational Historical Statistics 1750-2010: Europe
(1965-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1965	Bulletin of the United States 1913
		1970-2020	Penn World Table version 10.01 (PWT 10.01)
China	Steel	1955-1960	International Historical Statistics 1750-2010:Africa, Asia and Oceania
(1955-2020)		1965	UN Statistical Yearbook 1970
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1955-2020	PWT 10.01
Canada	Steel	1925-1965	International Historical Statistics 1750-2010: Americas
(1925-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1925-1945	Statistics Canada
		1950-2020	PWT 10.01
Croatia	Steel	1995-2020	Steel Statistical Yearbook 1999-2020
(1995-2020)	Employment	1995-2020	PWT 10.01
Denmark	Steel	1950-1965	European Historical Statistics 1750-1970
(1950-2020)		1970-2005	Steel Statistical Yearbook 1978-2010
		2010-2015	NMCD 2021
	Employment	1950-2020	PWT 10.01
Finland	Steel	1950-1965	European Historical Statistics 1750-1970
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
France	Steel	1950-1965	European Historical Statistics 1750-1970
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
Germany	Steel	1950-1965	European Historical Statistics 1750-1970
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
India	Steel	1950-1965	International Historical Statistics 1750-2010:Africa, Asia and Oceania
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
Indonesia	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01

Table A.2: Variables and Data Sources (Continued)

Country/Area (Period)	Variable	Year	Data Source
Italy	Steel	1900-1965	European Historical Statistics 1750-1970
(1900-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1900-1945	Bank of Italy-Historical time series on labour and capital stock in Italy, 1861-2017
		1950-2020	PWT 10.01
Japan	Steel	1900	NMCD 2021
(1900-2020)		1905-1960	International Historical Statistics 1750-2010:Africa, Asia and Oceania
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1900-1940	Honda (1997)
		1945	Long-Term Economic Statistics (LTES) Database (Japan)
		1950-2020	PWT 10.01
Malaysia	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01
Netherlands	Steel	1950-1965	International Historical Statistics 1750-2010: Europe
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
Norway	Steel	1950-1965	European Historical Statistics 1750-1970
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
the Philippines	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01
Poland	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01
Romania	Steel	1950-1965	European Historical Statistics 1750-1970
(1960-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
Russia	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01
Singapore	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1970-2020	PWT 10.01
South Korea	Steel	1955-1960	International Historical Statistics 1750-2010: Africa, Asia and Oceania
(1955-2020)		1965	UN Statistical Yearbook 1970
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1955-2020	PWT 10.01
Spain	Steel	1900-1915	European Historical Statistics 1750-1970
(1900-2020)		1920	NMCD 2021
		1950-1965	European Historical Statistics 1750-1970
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1900-1945	Maluquer de Motes (2021)
		1950-2020	PWT 10.01
Turkey	Steel	1950-1960	International Historical Statistics 1750-2010: Africa, Asia and Oceania
(1950-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01
Taiwan, China	Steel	1950-1955	UN Statistical Yearbook 1959
(1955-2020)		1960	NMCD 2021
		1965	UN Statistical Yearbook 1970
		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1950-2020	PWT 10.01

Table A.2: Variables and Data Sources (Continued)

Country/Area (Period)	Variable	Year	Data Source
United Arab Emirates	Steel	1990-2020	Steel Statistical Yearbook 1980-2020
(1990-2020)	Employment	1990-2020	PWT 10.01
Ukraine	Steel	1985	Shatokha (2016)
(1985-2020)		1990	Valentin and Couronne (2004)
		1995-2020	Steel Statistical Yearbook 1980-2020
	Employment	1985-2020	PWT 10.01
United Kingdom	Steel	1900-1965	European Historical Statistics 1750-1970
(1900-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1900-1945	Bank of England-A millennium of macroeconomic data
		1950-2020	PWT 10.01
United States	Steel	1900-1965	International Historical Statistics 1750-2010: Americas
(1900-2020)		1970-2020	Steel Statistical Yearbook 1980-2020
	Employment	1900-1945	Historical Statistics of the United States 1789-1945
		1950-2020	PWT 10.01
Vietnam	Steel	1970-2020	Steel Statistical Yearbook 1980-2020
(1970-2020)	Employment	1950-2020	PWT 10.01

Note: International Historical Statistics 1750-2010: Africa, Asia and Oceania provide the output of steel ingots and castings instead of crude steel.

A.4 Market Potential Measurement

Following Harris (1954), the market potential is constructed as $MP_{it} = \sum_{j=1}^{J} \frac{GDP_{jt}}{Dist_{ij}}$. $Dist_{ij}$ is the great circle distance in kilometers between the capitals of countries i and j. Own distance is obtained by $Dist_{ii} = \frac{2}{3}\sqrt{\frac{area_i}{\pi}}$. We obtained the land area information for the ship production countries from the World Bank, covering data from 1961 to 2020. To account for any variations in land area over the years, we used the average land area over this period.

Our GDP data are mainly from the Maddison Project Database 2023, supplemented by the GDP per capita index from Barro and Ursúa (2008) for robustness checks. Maddison's database spans GDP per capita and population data for countries up to 2020, while Barro and Ursúa (2008) provide GDP per capita index data for 42 countries up to 2009, with 2006 as the base year. We select our trading partners based on Maddison's top 20 countries with the highest GDP in 1900, 1960, and 2020, resulting in a total of 27 trading partners. Table A.3 presents the list of countries and the corresponding years for which data are available.[10]

We construct two main measurements to define our market potential variable. Market Potential is constructed using GDP data only from the Maddison Project Database 2023.

[10]We exclude the Former USSR and Czechoslovakia as they do not exist currently.

This metric is derived by multiplying GDP per capita by population.[11] For robustness checks, we construct Alternative Market Potential by employing the GDP per capita index developed by Barro and Ursúa (2008). We compute GDP per capita by multiplying the GDP per capita index by the GDP per capita data in 2006 obtained from Maddison and subsequently multiplying this result by the population also sourced from Maddison to obtain the GDP for the years before 2010. For the years 2010 to 2020, we utilize GDP data directly from Maddison.[12] We report the summary statistics for Market Potential and its alternative measurement in Table B.1. Additionally, we further construct a second Alternative Market Potential which is to address occasional missing values in Maddison for certain countries and years by incorporating GDP information from Barro and Ursúa (2008). Specifically, we compute GDP growth rates using the GDP index from Barro and Ursúa (2008), and we fill in missing values by extrapolating GDP using these growth rates into the subsequent periods. We find that the results using this alternative measurement of market potential are similar to the baseline.

Table A.3: Potential Trading Partners

Resources	Sample Periods	Potential Trading Partners
Maddison	1900-2020	Argentina, Australia, Austria, Belgium, Brazil, Canada, France, Germany, India, Indonesia, Italy, Japan, Mexico, Netherlands, Russia, Spain, Sweden, Switzerland, United Kingdom, United States
	1900, 1915, 1930-1940, 1950-2020	China
	1915, 1950-2020	Iran, Saudi Arabia
	1905-1940, 1950-2020	Egypt
	1900, 1910-1940, 1950-2020	Poland
	1915-2020	South Korea
	1915, 1925-2020	Turkey
Barro and Ursúa (2008)	1900-2009	Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Egypt, France, Germany, India, Indonesia, Italy, Japan, Mexico, Netherlands, Russia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
	1915-2009	South Korea

Note: The table lists the periods and countries for which data is available from Maddison and Barro and Ursúa (2008). South Korea lacks GDP data in both sources prior to 1915. The GDP in each period is the average value from year t-5 to year t.

[11]The Maddison Project Database 2023 includes GDP per capita data for Russia only before 1950. Therefore, we supplement the population data for Russia before 1950 using Kumo et al. (2007).

[12]Barro and Ursúa (2008) do not provide the GDP per capita index for Iran, Poland, and Saudi Arabia, so their GDP are obtained directly from Maddison.

Appendix B Supplementary Results

B.1 Summary Statistics

Table B.1: Summary Statistics

Variables	Mean	P(50)	SD	Min	Max	Observations
Tonnage of Ships (Million)	3.607	0.195	17.16	0	158.5	415
Relative Capital Endowment	0.595	0.499	0.538	0	2.671	415
Market Potential (Billion)	12.91	9.630	10.57	0.692	51.97	415
Alternative Market Potential (Billion)	14.32	11.50	10.29	1.926	51.97	415
Alternative Relative Capital Endowment	0.266	0.211	0.252	0	1.366	415

Note: All variables except (Alternative) Relative Capital Endowment in year t are computed using their average value from year t-5 to year t.

B.2 Unit Root and Co-integration Tests

Table B.2: Panel Unit Root Tests

Variables	IPS ($Z_{\tilde{t}}$ Statistic)	Fisher-type (Phillips-Perron; Z Statistic)
Panel A: Non-stationarity		
Log Tonnage of Ships		
Level	-5.9949***	-7.7829***
First-difference	-16.8965***	-31.2182***
Log Relative Capital Endowment		
Level	4.4663	4.3184
First-difference	-5.4122***	-7.3220***
Log Market Potential		
Level	8.2565	6.9619
First-difference	-14.7631***	-25.0090***
Log Alternative Market Potential		
Level	13.9197	8.0045
First-difference	-7.4131***	-9.8695***
Log Alternative Relative Capital Endowment		
Level	4.4164	4.0356
First-difference	-6.5452***	-9.0903***

Note: We present the Im–Pesaran–Shin and Fisher-type (Phillips-Perron) unit-root tests on each variable in levels and first differences, suitable for unbalanced panel data. The null hypothesis is all panels contain unit roots. Demean is included.

Table B.3: Panel cointegration Tests

Variables	Pedroni	Westerlund
Tonnage of Ships/Relative Capital Endowment/Market Potential		
Modified Phillips-Perron t	-6.7310***	
Phillips-Perron t	-11.7288***	
Augmented Dickey-Fuller t	-13.4141***	
Variance ratio		-4.6649***
Tonnage of Ships/Relative Capital Endowment/Alternative Market Potential		
Modified Phillips-Perron t	-6.2792***	
Phillips-Perron t	-9.8461***	
Augmented Dickey-Fuller t	-12.0175***	
Variance ratio		-4.4043***
Tonnage of Ships/Alternative Relative Capital Endowment/Market Potential		
Modified Phillips-Perron t	-7.1413***	
Phillips-Perron t	-12.6068***	
Augmented Dickey-Fuller t	-11.1647***	
Variance ratio		-4.3089***

Note: We present panel cointegration test results between ship production in tonnage, relative capital endowment, and market potential, between ship production in tonnage, relative capital endowment, and alternative market potential, and between ship production in tonnage, alternative relative capital endowment, and market potential. The null hypothesis is no co-integration. Demean is included.

B.3 System GMM

To address the potential endogeneity concerns that the relative capital endowments and market potential may be driven by ship production, we employ lags of the relative capital endowments, market potential, and ship production - both in their original values and first-difference values - as GMM-style instrumental variables to instrument for the endogenous variables $\Delta\frac{f_{it}^k}{f_{it}^l}$ and ΔMP_{it}. Specifically, we begin by estimating the error correction term using the DFE long-run estimates as follows:

$$ECT_{it-1} = \ln y_{it-1} - (\gamma_{0i} + \gamma_{1i}\ln(\frac{f_{it-1}^k}{f_{it-1}^l}) + \gamma_{2i}\ln MP_{it-1}) \tag{B.1}$$

Then, we estimate the following equation using System GMM (Blundell and Bond 1998):

$$\Delta \ln y_{it} = \beta_{0i}\Delta\ln(\frac{f_{it}^k}{f_{it}^l}) + \beta_{1i}\Delta\ln MP_{it} + \beta_{2i}ECT_{it-1} + \alpha_i + \epsilon_{it} \tag{B.2}$$

The results are presented in Table B.4. In column 1, the first lags of relative capital endowment, market potential, and ship production, both in levels and first-differences, are employed as GMM-style instruments. The results indicate that market potential and relative capital endowment have positive short-run impacts on ship production, but only that of market potential is significant. The error correction term is highly significant, with an adjustment rate of approximately 43.5% over five years. These findings align with the baseline results, reinforcing that market potential plays a more significant role in influencing short-run ship production than relative capital endowment.

Additionally, we report the results of Arellano-Bond tests for AR(1) and AR(2) and find that the first-differenced error term shows first-order autocorrelation but no second-order autocorrelation. Further, we report the results of the Hansen test, which has the p-values at 1, indicating that the null hypothesis cannot be rejected. These results suggest that the instruments used are valid.

Table B.4: System GMM Results

	(1)
$\Delta \ln(\frac{f_{it}^k}{f_{it}^l})$	2.318
	(2.119)
$\Delta \ln MP_{it}$	7.958***
	(2.226)
ECT	-0.435***
	(0.077)
Arellano-Bond test for AR(1)	-2.72
	[0.007]
Arellano-Bond test for AR(2)	1.17
	[0.240]
Hansen test	27.73
	[1.000]
N	415

Note: Column 1 utilizes the first lag of the relative capital endowments, market potential, and ship production as GMM-style instruments. Arellano-Bond test for AR(1) and AR(2) test for zero autocorrelation in first-differenced errors. The null hypothesis of the Hansen test is that the instruments are valid. Standard errors are in parentheses. P-values are in brackets. *** p<0.01, ** p<0.05, * p<0.1.

B.4 References

Arnold, Anthony J. ““Of Not Much Significance?” the Inclusion of Naval and Foreign Business in the UK Shipbuilding Output Series, 1825–1914.” *International Journal of Mar-*

itime History 11, no. 2 (1999): 61-85.

Barro, R. J., Ursúa, J. F. "Macroeconomic Crises since 1870." *Brookings Papers on Economic Activity,* 2008 (1), 255-350.

Barwick, Panle Jia, Myrto Kalouptsidi, and Nahim Bin Zahur. *Industrial Policy Implementation: Empirical Evidence from China's Shipbuilding Industry.* Washington, DC, USA: Cato Institute, 2021.

Blundell, Richard, and Stephen Bond. "Initial conditions and moment restrictions in dynamic panel data models." *Journal of econometrics* 87, no. 1 (1998): 115-143.

Bulletin of the United States Bureau of Labor Statistics. Washington: G.P.O., 1913. Print.

Buxton, Ian, Roy Fenton, and Hugh Murphy. "Measuring Britain's merchant shipbuilding output in the twentieth century." *The Mariner's Mirror* 101, no. 3 (2015): 304-322.

Crowther, Simeon J. "The Shipbuilding Output of the Delaware Valley, 1722-1776." *Proceedings of the American Philosophical Society* 117, no. 2 (1973): 90-104.

Gourdon, Karin. "An analysis of market-distorting factors in shipbuilding: The role of government interventions." (2019).

Hanlon, W. Walker. "The persistent effect of temporary input cost advantages in shipbuilding, 1850 to 1911." *Journal of the European Economic Association* 18, no. 6 (2020): 3173-3209.

Harris, Chauncy D. "The, Market as a Factor in the Localization of Industry in the United States." *Annals of the association of American geographers* 44, no. 4 (1954): 315-348.

Honda, Gail. "Differential structure, differential health: industrialization in Japan 1868-1940." In *Health and welfare during industrialization,* pp.251-284. University of Chicago Press, 1997.

Hengst, Sjoerd, and J. D. M. Koppies. "Analysis of competitiveness in commercial shipbuilding." *Journal of ship production* 12, no. 02 (1996): 73-64.

Kalouptsidi, Myrto. "Detection and impact of industrial subsidies: The case of Chinese shipbuilding." *The Review of Economic Studies* 85, no. 2 (2018): 1111-1158.

Kumo, Kazuhiro, Takako Morinaga, and Yoshisada Shida. "Long-Term Population Statistics for Russia." Tokyo: Russian Research Center, Hitotsubashi University (2007).

Maluquer de Motes, Jordi. "España en la economía mundial. Series largas para la economía española (1850-2015)." (2021).

Mitchell, Brian R., ed. *European historical statistics, 1750-1970.* Springer, 1975.

Mitchell, Brian, ed. *International historical statistics, 1750-2010.* Palgrave/Macmillan, 2013.

Shatokha, Volodymyr. "The sustainability of the iron and steel industries in Ukraine: challenges and opportunities." *Journal of Sustainable Metallurgy* 2, no. 2 (2016): 106-115.

United Nations Department of Economic and Social Affairs (1961). *Statistical Yearbook 1959, Eleventh Issue.* United Nations.

United Nations Department of Economic and Social Affairs (1972). *Statistical Yearbook 1970, Twenty-second Issue.* United Nations.

United States. Bureau of the Census, and Social Science Research Council (US). *Historical statistics of the United States, 1789-1945: a supplement to the Statistical abstract of the United States.* US Government Printing Office, 1949.

Valentin, Gilles, and Caroline Couronne. "Domination by the largest." *Steel Times International* 28, no. 7 (2004).