Transportation Research Part A 135 (2020) 160–167

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Impact of the belt and road initiative on commercial maritime power

Kevin X. Li[a], Kun-Chin Lin[b], Mengjie Jin[c], Kum Fai Yuen[d], Zhongzhen Yang[e], Yi Xiao[a,*]

[a] *Ocean College, Zhejiang University, No. 1 Zheda Road, Zhoushan 316021, Zhejiang, China*
[b] *Department of Politics and International Studies, University of Cambridge, Alison Richard Building, 7 West Road, Cambridge CB39DT, United Kingdom*
[c] *Department of Logistics Management, School of Marketing and Logistics Management, Nanjing University of Finance and Economics, Nanjing, China*
[d] *School of Civil and Environmental Engineering, Nanyang Technological University, Singapore*
[e] *Faculty of Maritime and Transportation, Ningbo University, Ningbo 315211, China*

ARTICLE INFO

Keywords:
Maritime power
Commercial maritime power
Belt and road initiative
AHP
Entropy
China

ABSTRACT

Since the Belt and Road (B&R) Initiative was launched in 2013, China's investment in ports across the globe has promoted maritime connectivity, driven performance in shipping, and strengthened its commercial maritime power. With the objective of quantitatively evaluating a country's commercial maritime power, we develop an evaluation system based on the literature and the analytic hierarchy process (AHP)-entropy method. We analyze the evolution of 32 countries' commercial maritime power since the inception of the B&R Initiative. The main findings are as follows. First, our evaluation system of commercial maritime power consists of a hierarchy containing 4 components, 7 elements, and 32 factors. Second, the evolution of a country's commercial maritime power can be assessed. The results show that countries along the routes of the initiative show good performances in the evolution of commercial maritime power. Third, we find that Vietnam not China shows the highest average annual growth rate.

1. Introduction

Since the Belt and Road (B&R) Initiative promoted, from 2013 to 2018, China's direct investment in countries and regions along the routes of the initiative has exceeded $80 billion (Belt and Road Portal, 2019). This has proved beneficial to China. For example, investments in this vast maritime transport network have significantly increased China's Liner Shipping Connectivity Index (LSCI), showing that Chinese ports have built connectivity with more than 200 countries and 600 main ports in the world, ranking it first in the world. Kynge and Campbell (2019) state that China understands maritime influence and has improved its maritime power by expanding its port network. Similarly, Len (2015) believes that the B&R Initiative not only promotes maritime connectivity but also consolidates China's maritime power.

Regarding the definition of maritime power, the literature stresses that maritime power refers to the ability of a country to use the oceans for national advantage (Mahan, 2011; Gorshkov, 1977; DIRECTORATE, 1995). Furthermore, Till (2018) considers maritime power to not be simply about using the sea but also about the ability to influence the behaviors of others by what one does at sea or

* Corresponding author.
E-mail addresses: kxli@zju.edu.cn (K.X. Li), kcl35@cam.ac.uk (K.-C. Lin), mengjiejin@nufe.edu.cn (M. Jin), Kumfai.yuen@ntu.edu.sg (K.F. Yuen), yangzhongzhen@nbu.edu.cn (Z. Yang), zoeyxiao@zju.edu.cn (Y. Xiao).

https://doi.org/10.1016/j.tra.2020.02.023

Available online 18 March 2020

obtains from the sea. Mahan (2011) proposes six components of maritime power, which include geographical position, physical conformation, extent of territory, population, character of people, and character of the government. The above six components can be concluded as physical and political power. Subsequently, economic and naval force are introduced as new components of measuring maritime power, together with physical and political power (Kearsley, 1992; Sakhuja, 2011, Till, 2018). It can be concluded that physical, economic, naval and political power are the main determinants of a country's maritime power.

This study is not concerned with naval power and concentrates on commercial maritime power. Referring to the commercial maritime power, it appears on the book named "China's Rise to Commercial Maritime Power" and written by Heine (1989). This book does not define its concept but the contents are related on maritime policy, maritime relationships with international organizations, merchant marine, shipbuilding, ports and trade. As Sakhuja (2011) stressed the economic dimension of maritime power, it pivots on the state's ability to invest port infrastructure, build ships to conduct seaborne trade and to shape and conduct maritime business. In brief, we discuss the commercial maritime power mainly from the economic dimension of maritime power. The benefits of stronger commercial maritime power can be addressed from the perspectives of sea attributes and economic development. First, the earth's sea and land ratio is approximately seven to three; human beings can exploit maritime resources such as food, oil, and gas and exchange cargo, information, and ideas through maritime trade to satisfy basic demands and accumulate wealth. If a country has stronger commercial maritime power, it can obtain more benefits from the sea. Second, according to the International Chamber of Shipping, international trade plays an important role in economic development, as 90% of the world's trade volume is transported by sea. A country with stronger maritime power usually has the ability to promote its seaborne trade, which, in turn, promotes its economic development. In sum, with the growing importance of maritime power, more countries are keen to increase their maritime power to obtain more resources and benefits.

Consequently, this study explores the determinants of commercial maritime power by combining qualitative and quantitative approaches and ranking the main countries' commercial maritime power. The remainder of this paper is organized as follows. Section 2 presents a literature review related with commercial maritime power. Section 3 describes the methodology employed to identify and weigh factors influencing a country's commercial maritime power. Data description and empirical results are analyzed and reported in Section 4. Sections 5 and 6 present discussions and conclusions.

2. Literature review

The literature on maritime power can be divided into two areas. The first stream aims to identify the components of maritime power, not considering naval power, where the components have expanded from considering only physical characteristics to subsequently considering economic advantages, political influence and technological superiority as well. As shown in Table 1, geography, population, and government/political determinants are present in all models. This means that physical characteristics and political influence are the most basic components of maritime power. Economic is also considered a component of maritime power in the models of Gorshkov (1977), Kearsley (1992), Sakhuja (2011) and Till (2018). With the development of science and technology, technology is considered in the models of Sakhuja (2011) and Till (2018).

The second stream of literature emphasizes the evaluation of maritime power. Yin and Fang (2008) combine analytic hierarchy process (AHP) and weighted integration decision-making theory to construct a commercial maritime power evaluation index system at the national level. The system consists of a hierarchy containing eight indices as I factors, specifically maritime sustainable development, 49 indices asIIfactors, 151 indices as III factors, 229 indices as IV factors, 104 indices as V factors, and 57 indices as VI factors. This system, which was designed for China, is not appropriate to evaluate other countries due to industrial characteristics and data availability. Sakhuja (2011) combines Cline's (1993) national power equation and Mahan's (2011) maritime ideas, and emphasizes technological capability to build an equation to evaluate maritime power. However, the sub-factors of equation are not described fully, clearly and quantitatively. Kong (2016) combines Mahan's (2011) ideas and the United Nations Convention on the Law of the Sea and uses a cost-benefit analysis of 22 elements to evaluate China's sea power performance.

The aforementioned studies reveal that constituent elements of maritime power have been experiencing constant change with older elements (e.g., colony) being removed and new elements (e.g., technology) being introduced. In other words, the term "maritime power" is evolving to fit an ever-changing context by taking into account international legal regimes, social progress, and technological development. Furthermore, physical, economic, and political power also represent core components of commercial maritime power that can help countries improve seaborne trade and maritime connectivity simultaneously. Therefore, this study

Table 1
Components of maritime power in models.

Mahan (2011)	Gorshkov (1977)	Kearsley (1992)	Sakhuja (2011)	Till (2018)
• Geographical position • Physical conformation • Extent of territory • Population • Character of people • Character of the government	• Geography • Economics • Character of the leadership	• Physical (e.g., geography) • Economics (e.g., population size) • Political • Naval force • Missions	• Geography • Economic (e.g., population, resources) • Political • Technology • Military	• Population society and government • Maritime geography • Resources • Maritime economy • Other domains • Technology • Naval forces

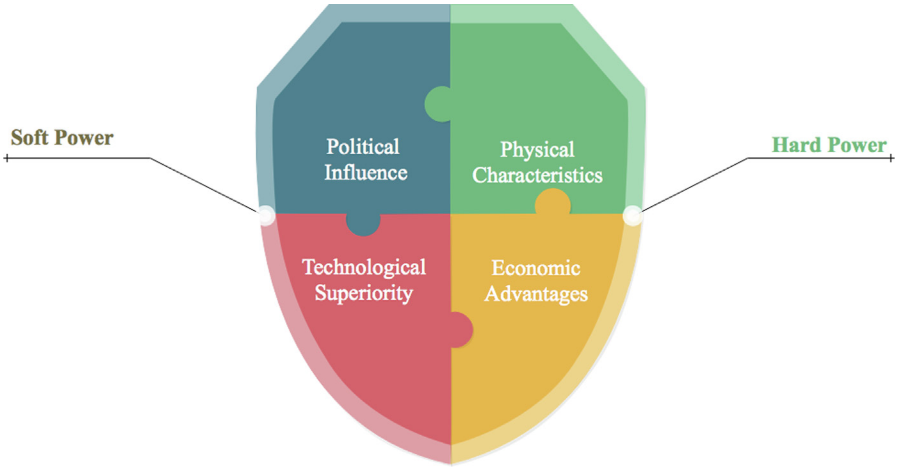

Fig. 1. Components of commercial maritime power.

intends to identify the determinants of commercial maritime power in the 21st century, build an evaluation system for commercial maritime power, and explore the evolution of international commercial maritime power in the context of the B&R Initiative.

3. Methodology

Based on the literature review, our model of commercial maritime power includes four components including political influence, physical characteristics, economic advantages and technological superiority (see Fig. 1). To clearly address the identified components, we learn from the concept of state power, which includes both hard and soft power (Waltz, 2010). Specifically, hard power in our model includes population, natural resources, territory, and economic power. Unlike hard power, soft power is not based on the idea of force or coercion. It is the ability of a country to indirectly convince others to follow its goals and vision, including its culture, political values, and diplomatic policies (Nye, 2011). Hence, political influence and technological superiority can be considered a country's soft power, whereas physical characteristics and economic advantages can be considered its hard power.

Subsequently, maritime policy and engagement (A1) is applied to operationalize political influence. Maritime education and science and technology (A2) is chosen to operationalize technological superiority. Geography (A3), manpower (A4), and traffic condition (A5) are chosen to reflect physical characteristics. Merchant and fishery resources (A6) and maritime economy (A7) are applied to reflect economic advantages. Consequently, A1-A7 are considered elements of a country's commercial maritime power here. In addition, specific factors (e.g., B11, B12) are applied to measure each element (e.g., A1), which, in turn, is used to evaluate its corresponding component (e.g., political influence).

This study builds an evaluation system of commercial maritime power, aiming to help a country understand its ability to use the ocean to create economic opportunities, harness wealth, and increase social welfare. The proposed evaluation system includes political influence, technological superiority, physical characteristics, and economic advantages, all of which are identified and evaluated. Specifically, the system consists of a hierarchy containing 4 components, 7 elements, and 32 factors (see Table 2).

Weights of factors included in the evaluation system have to be dealt with using numerical coefficients based on the viewpoint of decision-makers. For this purpose, 50 experts were carefully selected to undertake the task in the first round of interviews. They were chosen from research institutes (51.9%), governments (30.8%), and companies (17.3%) dealing with maritime affairs. Subsequently, in the second round of interviews, 18 experts were asked to compare each pair of determinants in terms of their relative importance. Furthermore, we conducted a third round of interviews where the suggestions of 12 experts were analyzed.

3.1. Weighting the determinants of commercial maritime power

After confirming the evaluation system of commercial maritime power, we evaluate further the relative importance of the determinants, which can be achieved by employing AHP with entropy. The AHP-entropy method involves the following two steps: the first step is to calculate the subjective weights using the AHP, and then use the entropy method to determine the weights of the system, modify the subjective weights, and obtain the final comprehensive weights. This method can reduce subjectivity, correct the errors of weights calculated by the AHP, and improve any inaccuracy in the entropy method caused by insufficient sample data. Due to these advantages, the AHP-entropy has been widely applied in various fields. For example, Jiang and Chu (2001) apply the AHP-entropy method to evaluate the waterway net planning scheme. Freeman and Chen (2015) use the AHP and entropy weights to form compromised weights for establishing a green supplier selection index system.

The first step of the AHP-entropy method is to calculate the subjective weights using AHP. The AHP, developed by Saaty (1988), has been widely used in various fields such as government, business, industry, healthcare, shipbuilding, and education. It is a systematic process that is used to organize and analyze complex decisions thoroughly. For instance, Lee et al. (2014) use the AHP

Table 2
Framework of the evaluation system of commercial maritime power.

Elements	Factors	Weights
A1. Maritime Policy and Engagement	B11. Maritime national relation regulations (No.)	0.17889
	B12. Participation in international conventions and organization s (No.)	0.10292
	Total	0.28181
A2. Maritime Education and Science &Technology	B21. Maritime education faculty and researchers (No.)	0.03519
	B22. Maritime education and S&T institutions (No.)	0.02615
	B23. Maritime students (No.)	0.03152
	B24. Maritime R&D expenditure (USD)	0.01949
	B25. Maritime S&T research projects (No.)	0.00531
	B26. Maritime scientific theses published (No.)	0.01180
	B27. Patents in maritime S&T (No.)	0.02026
	Total	0.14972
A3. Geography	B31. Coastline (km)	0.11310
	B32. Water area (km^2)	0.04914
	B33. Exclusive economic zone (km^2)	0.07331
	Total	0.23555
A4. Manpower	B41. National populations (No.)	0.05682
	B42. Labor force (No.)	0.02734
	B43. Manpower reaching military age annually (No.)	0.02404
	Total	0.10820
A5. Traffic Condition	B51. Container port traffic (TEU)	0.02187
	B52. Inland waterways (km)	0.01298
	B53. Pipelines for oil & gas (km)	0.00896
	B54. Terminals (No.)	0.00756
	B55. Logistics performance index (LPI)	0.00694
	B56. Liner shipping connectivity index (LSCI)	0.00539
	Total	0.06370
A6. Merchant and Fishery Resources	B61. Merchant maritime (No.)	0.01657
	B62. Seafarer (No.)	0.01094
	B63. Ship owner (No.)	0.01208
	B64. Shipbuilding (gross tonnage)	0.01259
	B65. Natural gas proved reserves (cum)	0.00431
	B66. Crude oil proved reserves (bbl)	0.00771
	B67. Fisher (No.)	0.00568
	B68. Capture production (ton)	0.00590
	Total	0.07578
A7. Maritime Economy	B71. Trade volume (USD)	0.04742
	B72. Reserves of foreign exchange and gold (USD)	0.02107
	B73. Marine insurance (%)	0.01673
	Total	0.08522

Sources: all the elements and factors selected in the evaluation system are based on the literature review (e.g. Yin and Fang, 2008; Wegge, 2011; Mahan, 2011; Sakhuja, 2011; Germond, 2015; Till, 2018**) and official websites (e.g. the World Bank, Central Intelligence Agency, United Nations Conference on Trade and Development).**

method to identify and weigh the factors influencing a country's shipping competitiveness and shipping policy. Tseng and Cullinane (2018) apply fuzzy AHP to rank categories of criteria of influencing the shipping operators' choices. Similarly, Zhang and Lam (2019) apply fuzzy AHP to identify and rank the importance of each barrier in maritime organizations. The AHP method involves the following two steps. In the first step, the decision problem is decomposed and its hierarchy built. To this end, respondents are required to explore the problem from general to specific levels, during which each element of the hierarchy is analyzed independently and then expressed in a multi-layered structure. Referring to this principle, commercial maritime power is set as the ultimate goal in this study, whereas elements and factors are set as the first and second levels to reflect the ultimate goal. For example, the first-level elements, relating to merchant and fishery resources (A6), are aspects of commercial maritime power. The second-level factors relate to vessels (B61), seafarers (B62), ship owners (B63), shipbuilding (B64), natural gas proved reserves (B65), offshore oil proved reserves (B66), fishermen (B67), and capture production (B68), representing the value of merchant and fishery resources. In the second step, each factor's weight, $v_{j,}$ is calculated. The basic idea is that the more important factors should be given greater weights to reflect their impact on commercial maritime power. For this purpose, a comparison matrix is formed after comparing each pair of factors and their maximum eigenvalue is derived to calculate the consistency rate. When the consistency rate is less than 0.1, we accept the weights allocated to each influential factor.

The second step of the AHP-entropy method is to use the entropy method to modify the subjective weights. According to Cropper (1986), entropy, as proposed by Rudolf Clausius, was initially used to describe the degree of uniformity of an energy distribution. Shannon (1948) introduced entropy into information theory and called the uncertainty of information source signals information entropy. The bigger the entropy weight, the smaller the information capacity, and the higher the uncertainty of information, and vice versa. Accordingly:

Let the decision matrix (D) be:

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}$$

where x_{ij} denotes the index value in strategy i of index$j$.

Using entropy to define the weight of indices includes four steps. The first step is to calculate the contribution degree of strategy$i$ to index $j$as y_{ij}:

$$y_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}, i = 1, 2, \cdots n; j = 1, 2, \cdots m \tag{1}$$

The second step is to calculate the entropy e_j of index$j$, namely, summing the contribution degree of all strategies to index$j$:

$$e_j = -\frac{1}{ln^n} \sum_{i=1}^{n} y_{ij} ln^{y_{ij}}, 0 \le e_j \le 1 \tag{2}$$

When the contribution degree of each strategy to one index is uniform, e_j tends to be one, which means that this index has no effect on the decision, and vice versa.

The third step is to calculate the difference coefficient g_j of index x_j. g_j refers to the degree of inconsistency of contribution degree of index$j$:

$$g_j = 1 - e_j \tag{3}$$

The fourth step is to calculate w_j, the normalized weight of index$j$:

$$w_j = \frac{g_j}{\sum_{j=1}^{p} g_j} \tag{4}$$

Finally, the comprehensive weight (β_j) is calculated as follows:

$$\beta_j = \frac{v_j w_j}{\sum_{j=1}^{m} v_j w_j}, j = 1, 2, \cdots m \tag{5}$$

3.2. Establishing the calculation equation of commercial maritime power

After calculating the weight of each index, we establish the calculation equation to obtain the synthesized evaluation index of each country's commercial maritime power. As suggested, the weighted sum model is the best known and simplest method for evaluating a series of alternatives according to a number of decision criteria (Alanazi et al., 2013). Using this method, the score of an alternative is equal to the weighted sum of its evaluation ratings, and the weights represent the importance of each attribute. Notably, the weighted sum model is applicable only when the alternatives for different criteria are mutually dependent and compensable (Triantaphyllou, 2000). In this case, the problem being discussed meets the condition above, β_j as the comprehensive weight denotes the relative importance of the criterion and e_{jk} is the standardized performance value of an alternative for attribute j. Then, the ultimate score is:

$$C_k = \sum_{j=1}^{m} \beta_j * e_{jk} \tag{6}$$

Here, all the indices are positive; that is, the higher the values, the better they are.

4. Empirical analysis

4.1. Weights of elements and factors

The weights of seven elements are calculated based on the AHP-entropy method as shown in Fig. 2. We can clearly see that maritime policy and engagement (0.2818) is the most important element in determining a country's commercial maritime power, followed by geography (0.2356) and maritime education and science and technology (0.1497). The results are consistent with Spykman's (2017) findings, who argues that geography is the most fundamentally conditioning factor because of its relative permanence in his writings on geography and foreign policy (Cole, 2016).

Similarly, the weights of the 32 factors are calculated. Accordingly, the ultimate weight of each factor is calculated by multiplying each element's weight by each factor's weight in the respective element group. From Table 2, we can clearly see that the most important three factors are maritime national relation regulations (0.17889), coastline (0.1131), and participation in international conventions and organizations (0.10292).

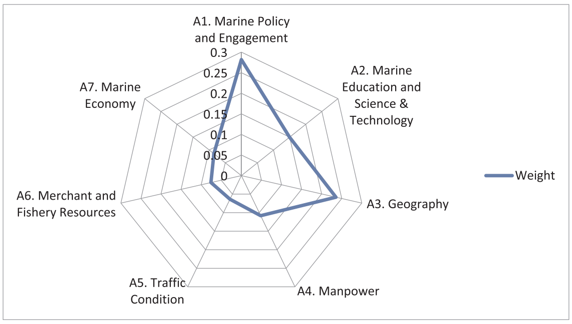

Fig. 2. Weights of elements.

4.2. Data collection

Table 2 shows the data sources used to obtain the evolution of a country's commercial maritime power since 2013. Considering data availability and some elements (A1, A2, A3 and A4) not easy to alteration, we measure the evolution of a country's commercial maritime power by calculating A5, A6 and A7. Specifically, A5 was obtained from information from the Central Intelligence Agency (CIA), World Bank, and United Nations Conference on Trade and Development (UNCTAD). A6 is derived from information from the CIA, the Clarkson databases, the Food and Agriculture Organization (FAO), and UNCTAD. A7 is obtained from information from the CIA, the United Nations Comtrade database, and the International Union of Marine Insurance (IUMI). Finally, we select countries with strong commercial maritime power or countries with advanced maritime technology or key investment countries that are part of the B&R Initiative. The commercial maritime power of 32 countries is calculated and compared.

Table 3
The evolution of countries/regions' commercial maritime powers.

	2013	2014	2015	2016	2017	AAGR
Vietnam	13,997,902,052	17,934,608,434	19,195,565,163	20,497,251,248	24,403,261,667	0.149
Philippines	7,302,704,157	8,348,833,359	8,233,467,583	8,870,255,592	10,234,810,627	0.088
Bangladesh	4,122,226,233	5,376,629,105	5,503,698,804	5,349,479,448	5,289,029,614	0.064
Sri Lanka	1,427,960,374	1,635,493,110	1,559,769,193	1,567,553,148	1,751,008,986	0.052
Australia	29,331,990,826	28,878,950,673	24,733,010,652	27,752,713,905	31,768,155,430	0.020
Spain	31,580,370,384	32,741,924,336	28,813,865,676	29,051,081,835	33,272,157,419	0.013
Thailand	25,982,644,816	26,281,783,827	24,106,146,081	24,063,949,891	26,860,208,330	0.008
Pakistan	6,617,650,513	7,001,861,172	6,829,869,019	6,025,882,985	6,720,659,657	0.004
China	290,445,000,355	309,074,337,791	280,433,601,581	262,632,490,802	292,870,313,507	0.002
New Zealand	4,321,491,229	4,595,193,586	3,879,125,252	3,914,182,886	4,357,357,411	0.002
Korea, South	58,074,105,705	59,809,058,203	53,454,130,378	50,604,346,058	58,122,267,126	0.000
Canada	54,807,169,813	57,076,463,758	52,123,079,613	51,819,777,443	54,231,608,762	−0.003
Turkey	21,127,337,375	21,771,046,032	19,007,244,553	18,495,636,049	20,825,508,820	−0.004
Germany	130,892,011,602	133,334,117,423	117,313,964,080	117,962,331,001	128,362,434,762	−0.005
Sweden	16,658,237,026	16,880,945,644	14,424,323,868	14,555,418,022	15,867,160,757	−0.012
Italy	52,399,215,121	51,910,357,555	45,035,078,246	45,036,924,895	49,898,612,862	−0.012
Russia	257,899,830,273	252,661,318,316	174,070,922,571	236,773,681,868	243,634,376,054	−0.014
Indonesia	33,150,522,365	31,739,559,330	28,898,697,842	27,728,097,903	30,568,875,909	−0.020
Singapore	42,602,414,356	42,692,718,623	35,728,938,328	35,070,720,937	39,137,955,686	−0.021
Japan	100,226,477,034	98,030,679,884	85,370,158,947	85,096,290,457	91,668,647,474	−0.022
India	53,928,668,471	49,549,923,150	44,668,744,840	42,162,872,421	49,245,147,698	−0.022
France	63,001,324,367	61,563,890,693	53,339,071,212	52,895,322,449	57,483,960,937	−0.023
UK	61,023,186,562	60,948,650,025	55,794,894,577	53,659,142,757	55,540,090,276	−0.023
Saudi Arabia	76,545,187,039	78,049,133,782	68,234,145,002	65,772,334,997	66,966,965,659	−0.033
Chile	8,704,136,721	8,323,216,302	7,137,630,979	6,970,906,924	7,605,218,138	−0.033
South Africa	10,558,309,874	10,266,430,828	8,903,276,862	8,135,903,612	9,207,590,309	−0.034
Netherlands	57,549,242,400	57,573,116,085	44,714,861,915	44,137,379,142	49,599,225,754	−0.036
United States	239,041,495,271	242,522,231,489	231,540,596,218	226,304,066,593	201,257,268,600	−0.042
Belgium	48,070,085,420	44,429,705,463	36,962,832,247	37,045,646,441	40,213,181,432	−0.044
Brazil	32,513,471,336	31,368,645,026	26,530,409,480	24,950,457,483	27,084,475,922	−0.045
Norway	21,681,176,375	21,379,488,016	17,889,810,245	17,026,859,480	18,009,885,045	−0.045
Malaysia	33,697,899,702	33,981,159,156	30,016,927,334	24,086,033,347	26,844,003,571	−0.055

Data source: author calculations.

4.3. Evaluating the evolution of commercial maritime power

Based on the evaluation framework and composite index equation, we are able to calculate the average annual growth rate (AAGR) of the main 32 maritime countries since the B&R Initiative (see Table 3). During the period 2013 to 2017, the highest AAGR in commercial maritime power appears in Vietnam not China, followed by Philippines, Bangladesh, Sri Lanka, Australia, Spain, Thailand, Pakistan, China and New Zealand. The above countries benefit from the B&R Initiative and improve in commercial maritime power. Except for South Korea, which remains stable in terms of commercial maritime power, the other remaining countries show a reduction in commercial maritime power of different magnitudes. Among them, the highest average decrease is seen in Malaysia, followed by Norway, Brazil, Belgium, and the USA.

The evolution of international commercial maritime power since the B&R Initiative's launch in 2013 can be summed up as follows. First, China does not benefit the most in strengthening its commercial maritime power. Based on the performance of A5, A6 and A7, it can be concluded that China shows better performance in container port traffic (B51) and LPI (B55), which indicates that infrastructure investments sponsored by the Silk Road Fund are, indeed, improving its transport network and, subsequently, improving physical characteristics. In addition, China shows better performance in merchant maritime (B61), shipbuilding (B64), natural gas proved reserves (B65), crude oil proved reserves (B66), and capture production (B68). However, trade volume (B71) is unstable and reserves of foreign exchange and gold (B72) has decreased. To some extent, this means that in the context of the B&R Initiative, China is trying to optimize its industrial and economic structure to achieve the sustainable development of its economy. Second, countries along the routes of the initiative invested by China benefit the most. In specific, Vietnam as the main beneficiary promote in container port traffic (B51), LPI (B55) and LSCI (B56), merchant maritime (B61), shipbuilding (B64), and trade volume (B71). Similarly, Philippines, Sri Lanka, and Pakistan show better performance, especially in LSCI (B56), shipbuilding (B64), and trade volume (B71). Spain shows better performance in shipbuilding (B64), trade volume (B71), reserves of foreign exchange and gold (B72), and marine insurance (B73). Third, from 2013 to 2017, although the AAGR of South Korea is zero, South Korea shows worse performance in physical characteristics and economic advantages, especially in LPI (B55), LSCI (B56), and shipbuilding (B64); Malaysia shows worse performance in political influence and economic advantages, especially in merchant maritime (B61), shipbuilding (B64), natural gas proved reserves (B65), reserves of foreign exchange and gold (B72) and marine insurance (B73); Belgium shows worse performance especially in the number of terminals (B54); and the USA shows worse performance especially in the reserves of foreign exchange and gold (B72) and marine insurance (B73).

5. Discussion

Understanding a country's commercial maritime power is important as it can help a country form a better picture of its relative commercial maritime power compared with others. In addition, it can identify weaknesses, suggest ways to address them, and formulate a feasible plan to strengthen commercial maritime power.

As identified in the evaluation system, the most important element is maritime policy and engagement. China has implemented the B&R Initiative and is striving to use the ocean for communication, transportation, exchange, and cooperation, which can be beneficial and improve its commercial maritime power as well as that of some B&R Initiative countries. However, it cannot be said that the commercial maritime power of the countries that China has heavily invested in will increase for certain due to a diversity of influencing factors. For instance, in 2015, although China and Malaysia signed the Memorandum of Understanding on the establishment of the China–Malaysia port alliance, a milestone of the B&R Initiative, Malaysia's commercial maritime power decreased mainly due to a reduction in its natural gas proved reserves and reserves of foreign exchange and gold.

There are two main limitations to this research as follows. First, to compare each country's commercial maritime power, we needed to choose readily measurable factors to establish an evaluation system, and the 32 factors are not enough to give a full account of commercial maritime power, especially in terms of technological progress and economic development. In the future, a country that intends to build an evaluation system of commercial maritime power can update this based on the existing system and its national conditions. Second, due to data availability, we only evaluate the evolution of commercial maritime power based on the A5, A6 and A7 not the specific value for each country's commercial maritime power. By overcoming these two limitations, future research could calculate and rank a country's commercial maritime power and could help a country pinpoint strategies to improve its commercial maritime power.

It is worth noting that calculating the average annual growth rate not the absolute value of measuring countries' evolution of commercial maritime powers is significant to evaluate the impact of the B&R Initiative. And because of this, we find that most countries along the routes of the Initiative benefit from China's maritime policy, especially in the performance of maritime transport and trade. Our next study aims to explore the impact of maritime transport efficiency on trade under China's B&R Initiative, further to verify the impact of B&R Initiative especially for countries making agreements with China.

6. Conclusion

In this study, we built an evaluation system for commercial maritime power and evaluated the evolution of international commercial maritime power since the B&R Initiative in 2013. The main findings are as follows.

First, this study assesses the definition and determinants of commercial maritime power. Commercial maritime power in the 21st century can be described as the ability of a country to use the ocean for communication, transportation, exchange, and cooperation to accumulate wealth directly and influence the behaviors of others indirectly. The determinants of commercial maritime power comprise four components: political influence, technological superiority, physical characteristics, and economic advantages.

Second, our evaluation system of commercial maritime power consists of 4 components, 7 elements, and 32 factors. The weights of the seven elements are sequentially as follows: maritime policy and engagement (0.2818), geography (0.2356), maritime education and science and technology (0.1497), manpower (0.1082), maritime economy (0.0852), merchant and fishery resources (0.0758), and traffic condition (0.0637); and among the 32 factors, the top three are maritime national relation regulations (0.17889), coastline (0.1131), and participation in international conventions and organizations (0.10292). By using the AHP-entropy method, a country's commercial maritime power is calculated by weighted sum model. The results show that Vietnam, Philippines, Bangladesh, Sri Lanka, Australia, Spain, Thailand, Pakistan, China and New Zealand show better performance in the evolution of commercial maritime power since the B&R Initiative's launch in 2013. More importantly, the average annual growth rates of Vietnam, Philippines, Bangladesh, Sri Lanka, Australia, Spain, Thailand, Pakistan are higher than China. Most of them show good performance due to the improvement of port infrastructure.

Overall, most countries along the routes of B&R Initiative benefit from the investment of China, and their commercial maritime powers become stronger than before. Accordingly, governments can look at how they can alter their policies to improve their commercial maritime power performance.

CRediT authorship contribution statement

Kevin X. Li: Supervision, Conceptualization, Funding acquisition. **Kun-Chin Lin:** Funding acquisition, Writing - review & editing. **Mengjie Jin:** Writing- review & editing, Data curation. **Kum Fai Yuen:** Writing - review & editing. **Zhongzhen Yang:** Writing - review & editing. **Yi Xiao:** Writing- original draft, Formal analysis, Data curation.

Acknowledgements

This study was supported in part by the Korea Foundation [RG94770], University of Cambridge and Zhejiang University Education Foundation Global Partnership Fund.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2020.02.023.

References

Alanazi, H.O., Abdullah, A.H., Larbani, M., 2013. Dynamic weighted sum multi-criteria decision making: Mathematical Model. Int. J. Mathem. Statist. Invention 1 (2), 16–18.
Belt and Road Portal, 2019. https://www.yidaiyilu.gov.cn/jcsj/dsjkydyl/79860.htm, (accessed: 9 January, 2020).
Cropper, W.H., 1986. Rudolf Clausius and the road to entropy. Am. J. Phys. 54 (12), 1068–1074.
Cline, R.S., 1993. The power of nations in the 1990s: a strategic assessment. University Press of America.
Cole, B., 2016. China's quest for great power: Ships, oil, and foreign policy. Naval Institute Press.
Freeman, J., Chen, T., 2015. Green supplier selection using an AHP-Entropy-TOPSIS framework. Supply Chain Manage.: Int. J. 20 (3), 327–340.
DIRECTORATE, O.N.S.D., 1995. The fundamentals of British maritime doctrine. H.M.S.O, London.
James Kynge, Chris Campbell, Amy Kazmin & Farhan Bokhari. How China rules the waves. https://ig.ft.com/sites/china-ports/, (accessed: 8 August, 2019).
Gorshkov, S.G., 1977. The sea Power of the State. The Sea power of the state. Survival 19 (1), 24–29.
Germond, Basil, 2015. The geopolitical dimension of maritime security. Mar. Policy 54, 137–142.
Heine, I.M., 1989. China's Rise to Commercial Maritime Power. Greenwood Press, Westport, Connecticut.
Jiang, Y., Chu, Z.Y., 2001. Application of AHP-entropy evaluation & decision model for comprehensive evaluation of waterway net planning. Port Waterway Eng. 6, 008.
Kearsley, Harold John, 1992. Rethinking maritime power theory. Comparat. Strategy 11 (2), 195–211.
Kong, Z., 2016. Making of a Maritime Power. Springer, Singapore.
Len, Christopher, 2015. China's 21st Century Maritime Silk Road initiative, energy security and SLOC access. Maritime Affairs: J. Natl. Maritime Found. India 11 (1), 1–18.
Lee, C.B., Wan, J., Shi, W., Li, K., 2014. A cross-country study of competitiveness of the shipping industry. Transp. Policy 35, 366–376.
Mahan, A. T. The influence of sea power upon history, 1660-1783. Read Books Ltd, (2011).
Nye, Joseph S., 2011. The Future of Power. New York, N.Y.: Public Affairs. p. 84. ISBN: 9781586488925.
Saaty, T.L., 1988. What is the analytic hierarchy process? In: Mathematical models for decision support. Springer, Berlin, Heidelberg, pp. 109–121.
Sakhuja, V., 2011. Asian Maritime Power in the 21st Century: Strategic Transactions China, India and Southeast Asia.
Shannon, C.E., 1948. A note on the concept of entropy. Bell Syst. Tech. J 27 (3), 379–423.
Spykman, Nicholas J., 2017. America's strategy in world politics: the United States and the balance of power. Routledge.
Triantaphyllou, E., 2000. Multi-criteria decision making methods. In Multi-criteria decision making methods: A comparative study. Springer, Boston, MA, pp. 5–21.
Till, Geoffrey, 2018. Seapower: A guide for the twenty-first century. Routledge.
Tseng, P.H., Cullinane, K., 2018. Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model. Marit. Policy Manage. 45 (4), 422–438.
Waltz, Kenneth N., 2010. Theory of international politics. Waveland Press.
Wegge, Njord, 2011. Small state, maritime great power? Norway's strategies for influencing the maritime policy of the European Union. Mar. Policy 35 (3), 335–342.
Yin, K.D., Fang, S.M., 2008. Maritime power evaluation system. Economic Science Press.
Zhang, X., Lam, J.S.L., 2019. A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: case of maritime organizations. Marit. Policy Manage. 46 (7), 781–801.