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Analytic Comparisons of Shipbuilding Competitiveness between China and Korea

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Abstract

Purpose – This research empirically proves that global shipbuilding industry leadership has moved to China from Korea.
Design/Methodology – Competitiveness is measured by AHP for the weights of comprehensive competitiveness, which is the output mixture of three attributive factors: shipbuilding technology, shipbuilding contract price, and export credit.
Findings – China is far ahead of Korea for standard vessels such as bulkers and containerships with competitiveness weights of 0.762 and 0.612, respectively, against 0.238 and 0.388 of Korea. Korea is maintaining its competitiveness only in LNG carriers (174k CBM) with a competitiveness weight 0.621. China and Korea have similar competitiveness for chemical carriers, complex vessels with a small hull size. The sources of Chinese competitiveness are shipbuilding contract price and export credit. With the majority share of standard vessel types in the world fleet, China will hold a bigger market share than Korea in the global shipbuilding industry in the forthcoming years.
Implications – The swing factors of market power are shipbuilding technology and contract price. If China fails to further develop shipbuilding technology for shipowners worried about the reliability of the Chinese-built vessels, shipowners may swing back to Korea. The rising Chinese labor cost will expedite this swing in the forthcoming competition.
Originality/value – To the best of the author's knowledge, this is the first paper that quantitatively examines the competitiveness of shipbuilding between China and Korea by comparing attributive factors for competitiveness.

Keywords: AHP, Export Credit, Industry Leadership, Shipbuilding, Ship Finance
JEL Classifications: F34, L98, N20

1. Introduction

Has global leadership gone to China in the global shipbuilding industry? If so, how far does the Chinese shipbuilding industry surpass Korea at present? While some contemporary research on shipbuilding industry argues that China has overtaken Korea in the global shipbuilding market (Hossain, Zakaria and Sarkar, 2017; Jiang Liping, Bastiansen and Strandenes, 2013; Mickeviciene, 2011), industrial data show mixed market power between Korea and China in terms of shipbuilding business volumes, such as new contracts, orderbook balance, and completion amount (Clarksons Research, 2019; UNCTAD, 2018). It is not easy to claim that China has irreversibly won the global shipbuilding market from Korea, despite research on the transition of industry leadership to China.

Although individual shipowners base shipbuilding contract decisions on shipyard comparisons rather than the nationality of builders, the competitive advantage of shipbuilding tends to be more country-specific than shipyard-specific (Ahn Young-Gyun, 2019; Cho Dong-Sung and Porter, 1986). The shipbuilding industry is at the center of

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government industrial and trade policies in these shipbuilding nations (Koenig, 2016). Accordingly, research on shipbuilding competitiveness has dealt with nation-specific strategies or governmental policies (Davids and Schippers, 2008; Ecorys, 2009; Jiang Liping, Bastiansen and Strandenes, 2013; Kim Byeong-Soo and Cho Keun-Tae, 2013; Lorenz, 2015; Stirling, 1985).

However, one characteristic of the shipbuilding industry is the recurrent shift of industry leadership throughout history (Cho Dong-Sung and Porter, 1986; Kim Byeong-Soo and Cho Keun-Tae, 2013; Park Jae-Chan and Roh Tae-Woo, 2014). Shipbuilding nations have emerged as global industry leaders, and then disappeared over time. A shipbuilding nation can hold a competitive advantage if it meets the shipbuilding needs of global shipowners (Kim Byeong-Soo and Cho Keun-Tae, 2013).

No one could deny the global leadership of the Korean shipbuilding industry during the 1990s and the recent peak of the shipping cycle right before the global financial crisis of 2008 (Bruno and Tenold, 2011; Shin June-Seuk and Lim Young-Mo, 2013). Before Korea, Japan dominated the shipbuilding market, in which it had overtaken European countries, including the UK (Poulsen and Sornn-Friese, 2011).

After China emerged as a major shipbuilding nation, many researchers attempted to examine if a change of leadership to China occurred in the global shipbuilding industry. However, it is not easy to identify the shift of global leadership in the contemporary shipbuilding industry due to mixed industrial data on the comparative market power between China and Korea.

In this research, a comparison of competitiveness will be tried for the two largest shipbuilding nations, Korea and China, to answer the research questions at the start of this section. This research is to empirically identify what factors are more important in soliciting new shipbuilding orders. The research will further compare the competitiveness of China and Korea for each factor to quantitatively detail the comprehensive competitiveness of the two countries. This research will ultimately find strategic insights for the two countries to utilize in order to enhance competitiveness.

The Analytic Hierarchical Process (AHP) was adopted in this research as a method that captures the judgement of independent shipbrokers, and quantitatively measures the competitiveness of the two shipbuilding nations. The outcome of the AHP will be interpreted from the perspective of the shifting history of global leadership in the shipbuilding industry.

This research will contribute to building understanding on the contemporary global shipbuilding industry via quantitative examination on the competitiveness of the Chinese and Korean shipbuilding industries. This research will provide academic researchers and policymakers with the current competition status of the global shipbuilding industry.

2. Literature Review

As China emerged as a major shipbuilding nation, research has tried to assess the competitiveness of Chinese shipbuilding against Korean shipbuilding. These competitiveness assessments are based either on shipbuilding business volumes, or the financial performance of major shipbuilders.

Most research argues that Chinese shipbuilding has surpassed Korea based on three business volume indices: annual new orders, completion of vessels, and orderbook balance (Ecorys, 2009; Hossain, Zakaria and Sarkar, 2017; Mickeviciene, 2011). Business volumes may not be a proxy to represent competitiveness because the current shipbuilding industry is going through a deep recession cycle with depressed shipbuilding prices and tight demand for new vessels (OECD, 2017). Moreover, the three indices of shipbuilding business are seesawing between Korea and China (Clarksons Research, 2019; UNCTAD, 2018).

Jiang Liping, Bastiansen and Strandenes (2013) empirically compared the competitiveness of the Chinese shipbuilding industry through the profit rate of Chinese shipyards over Korean and Japanese shipyards. The profit rate has been calculated with a fractional number of annual shipbuilding unit costs to contract price for the three shipbuilding countries. They argued that the Chinese shipbuilding industry outperforms competitors in the bulker and tanker sectors with high profit rates over Korea and Japan. Jiang Liping and Strandenes (2012) extended a similar empirical theory that Chinese shipbuilding is more competitive with a low labor cost advantage over Korean.

The theories of the research above were developed by analyzing the field data of labor costs in shipyards from 2000 to 2009. As the labor cost in China is drastically on the rise (OECD, 2017) and a portion of labor cost for high value-added ships has decreased (Ecorys, 2009), these theories may not be applicable for an explanation of the current competitiveness of the shipbuilding industry with historic financial data.

Other research has tried to compare the export competitiveness of these two countries in the shipbuilding industry through export indices such as the Trade Specialization Index (TSI), Revealed Symmetric Comparative Advantage (RSCA), Relative Competitive Position (RCP), and the ratio of unit price analysis (Koo Jong-Soon and Jia Yue-Wei, 2013; Lee Jung-Sun, 2012). These indices represent the position of a certain export product of a country by comparison to the sum of exports and imports of a product in a certain country over time (Amador, Cabral and Maria, 2011). For example, the Chinese RSCA of shipbuilding is the ratio of the export volume of vessels to the total exports of China. That is to say, the shipbuilding RSCA of China shows year-on-year changes of comparative advantages of vessels among other Chinese export products in the global market.

The RSCA of Korea does as well. Therefore, the indices cannot be proxies to compare competitiveness across countries. The Korean shipbuilding industry shows higher figures than China in shipbuilding RSCA for the whole research period, including the years 2000 to 2012 (Koo Jong-Soon and Jia Yue-Wei, 2013; Lee Jung-Sun, 2012). It is natural that the Korean shipbuilding industry has a high RSCA because Korea exports most completed vessels due to limited domestic demand (Brun and Frederick, 2017). A higher RSCA of the shipbuilding industry does not necessarily mean Korea is more competitive than China in the global shipbuilding market.

From the perspective of the Diamond Model (Porter, 1990), the comparison of competitiveness is more complicated for the shipbuilding industry. Factor conditions are assumed to be on the side of the Korean shipbuilding industry in terms of labor productivity (Brun and Frederick, 2017; Ecorys, 2009). High productivity is inclusive of a skilled workforce and efficiency in production. The demand conditions are in favor of China, with a high share of domestic orders at almost 30% for yearly new contracts against Korea, having a share of domestic orders fewer than 10% of yearly new contracts (Brun and Frederick, 2017; Cho Seong-Jae and Whang Kyung-Jin, 2016; Ecorys, 2009).

However, China is following Korea's footsteps in the aspects of firm strategy and structure, which diversify vessels toward high-end with advanced technologies (Ecorys, 2009; Li Xiang, 2015; Mickeviciene, 2011; Parc and Normand, 2016; Shin June-Seuk and Lim Young-Mo, 2013). Korea is one step ahead of China in related and supporting industries, such as engine technology and equipment (Brun and Frederick, 2017). Even though the Diamond Model can assess the competitiveness of each underpinning factor of an industry (Bakan and Doğan, 2012), it is not easy to compare comprehensive competitiveness for the shipbuilding industries of the two countries.

In analyzing global competition in the shipbuilding industry, Shin June-Seuk and Lim

Young-Mo (2013) examined how major shipbuilding nations responded to recessions. Contrary to the strategies of Japan and Europe, China and Korea pursued aggressive behavior in their business volumes and shipbuilding facilities, even during the sharp decline after the global financial crisis of 2008. The findings imply that China and Korea are going to fiercely compete in the global shipbuilding industry in the coming years with expanded facilities. Due to the overlap of vessel types, the degree of competition will be further intensified.

The research of Lee Koung-Rae (2017b) investigated the competitive criteria of shipbuilding nations. He empirically captured the recognition of shipowners about shipbuilding countries in relation to placing new orders. The extracted criteria were arrayed into three categories which have sub-criteria.

- Shipbuilder Factors: shipbuilding technology & quality, delivery, and shipbuilding price
- Ship Finance Factors: ease of sourcing equity, availability of commercial loans, and development of bond market
- Export Credit Agency (ECA) Factor: export credit

The perception of shipowners has been calibrated through AHP on how the shipowners prioritized the importance of competitive factors in placing new orders. The competitive factors were narrowed down to three: technology & quality, shipbuilding price, and export credit.

Although research has attempted to explain the competition in shipbuilding between China and Korea, additional research is required to examine the comparative market power of the two nations from a different perspective.

3. Research Methodology and Modeling

3.1. Research Methodology: AHP

AHP is a quantitative research method devised by Thomas Saaty (Franek and Kresta, 2014) to help researchers and practitioners select the best solution out of several alternatives with multiple decision-making criteria. This method is a theory of measurement (Saaty, 1990) on priority, importance, preference, and so on, which are measured on a weighted scale to convert qualitative judgement to quantitative measurement. That is, decision-makers intuitively judge the criteria in order on a quantitative scale in which an alternative is ultimately selected to best fit a designated decision-making goal (Mu and Pereyra-Rojas, 2016). AHP is usually carried out with small sample sizes, such as more or less than 20 high-profile experts (Darko et al., 2018).

The AHP procedure takes hierarchical steps, in which a set of decision-making criteria is selected and arrayed under a goal of decision-making. Then, decision-makers are required to compare every two criteria to form Comparison Matrix A below. The entries of A are ratios of comparisons for every two criteria.

$$A = \begin{pmatrix} w_1/w_1 & \cdots & w_1/w_n \\ \vdots & \ddots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{pmatrix} = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix} \quad (1)$$

Then, Matrix A is multiplied by w, where $w = (w_1, w_2, \cdots, w_n)$ to calculate weight of each criterion in relative significance.

$$Aw = \begin{pmatrix} w_1/w_1 & \cdots & w_1/w_n \\ \vdots & \ddots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{pmatrix} \begin{pmatrix} w_1 \\ \vdots \\ w_n \end{pmatrix} = \begin{pmatrix} nw_1 \\ \vdots \\ nw_n \end{pmatrix} = nw \quad (2)$$

'Aw = nw' implies that n and w are the eigenvalue and eigenvector of A, respectively. The normalized principal eigenvector, p, can be also obtained by averaging across the rows of the normalized reciprocal Matrix A'.

$$A' = \begin{pmatrix} \frac{a_{11}}{a_{11}+a_{21}+\cdots+a_{n1}} & \cdots & \frac{a_{1n}}{a_{1n}+a_{2n}+\cdots+a_{nn}} \\ \vdots & \ddots & \vdots \\ \frac{a_{n1}}{a_{11}+a_{21}+\cdots+a_{n1}} & \cdots & \frac{a_{nn}}{a_{1n}+a_{2n}+\cdots+a_{nn}} \end{pmatrix} = \begin{pmatrix} a'_{11} & \cdots & a'_{1n} \\ \vdots & \ddots & \vdots \\ a'_{n1} & \cdots & a'_{nn} \end{pmatrix} \quad (3)$$

$$p_i = \frac{1}{n}\sum_{j=1}^{n} a'_{ij} \quad (4)$$

$$p = (p_1, p_2, \cdots, p_n) = \left(\frac{w_1}{w_1+w_2+\cdots+w_n}, \frac{w_2}{w_1+w_2+\cdots+w_n}, \cdots, \frac{w_n}{w_1+w_2+\cdots+w_n}\right) \quad (5)$$

However, by using the fact that the maximum eigenvalue of A (λ_{max}) is equal to n if and only if the matrix is consistent, Thomas Saaty proposed a Consistency Index (CI) (Wedley, 1993):

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (6)$$

Let IR be the Inconsistency Ratio of the comparisons, and RI be the Random Index drawn by Thomas Saaty through experiments (Wedley, 1993). If CI = 0, then A is perfectly consistent. Otherwise, if IR = $\frac{CI}{RI} \le 0.10$, then A is consistent enough. If IR > 0.10, A is seriously inconsistent.

The applications of AHP are widely found in the areas of engineering, finance, education, science, and management. (Darko et al., 2018; Emrouznejad and Marra, 2017; Mardani et al., Jusoh et al., 2015; Vaidya and Kumar, 2006). AHP is the most frequently used methodology among the multicriteria decision-making approaches (Mardani et al., 2015).

AHP is also the most frequently adopted research method in the area of maritime transport (Shi Wenming and Li Kevin, 2017). The popularity of AHP as a research method is in applications with a small sample size, consistent outputs, and simplicity of interpretation (Darko et al., 2018).

Delphi is similar to AHP in terms of involving high-profile experts in decision making. However, an empirical study proved that AHP is superior to Delphi as a research method thanks to the features of hierarchical process of AHP, which guides decision makers to hold on to the given goal and attributes of the goal in the course of decision making (Lai, Wong and Cheung, 2002).

Since Thomas Saaty originated the idea (Saaty, 1994), AHP weaknesses such as the consistency problem, order of alternatives through eigenvector, and others have been addressed over time by many researchers (Emrouznejad and Marra, 2017).

3.2. Research Modelling and Data Collection

To answer the research questions, the goal of AHP is set as the 'competitiveness of shipbuilding between China and Korea.' The attributes of competitiveness are arrayed into three simple criteria: shipbuilding technology, shipbuilding contract price, and official export credit. The decision-making criteria are selected mainly from the research of Lee Koung-Rae (2017b).

The shipbuilding technology factor encompasses production technology and the specifications embedded in completed vessels. Production technology should be something that ensures increasing productivity of the shipbuilding process. Product features are defined as competitive advantages that guarantee the best efficiency in fuel consumption and full compliance with the requirements of regulators, such as the International Maritime Organization (IMO) and state port authorities. Product features include the reliability of the vessels.

Shipbuilding contract price has been the strongest competitive factor in the recurrent shifting history of shipbuilding leadership (Bruno and Tenold, 2011; Cho Dong-Sung and Porter, 1986). Shipbuilding contract price is, of course, based on shipbuilding costs. The material cost is not considered in this research because materials could be procured on the global market (Brun and Frederick, 2017). Official export credit is an attributive factor for shipbuilding competitiveness by easing the funding efforts of shipowners in sourcing the large sums of money for new vessels.

A preliminary AHP questionnaire was prepared with the three attributes of competitive advantages for peer review by a focus group, composed of three sales directors from Korean shipbuilders and two independent newbuilds shipbrokers from the USA. The focus group recommended the survey be conducted with different vessel types in consideration of the different degrees of difficulty in construction. The focus group suggested four vessel types: Containership (14,000TEU), LNG carrier (174k CBM), Capesize bulker, and Chemical carrier.

The degree of difficulty in construction is not distinguished clearly among the four vessel types, but in terms of Cargo Containment System (CCS) and Cargo Handling System (CHS), an LNG carrier (174k CBM) could be said to be the most difficult vessel type to build. The Capesize bulker is comparatively easy to build, along with the Containership (14,000TEU) despite the size of the hull.

According to the properties of cargo loaded/unloaded of carrying vessels, different CCS and CHS are required. For instance, bulk carriers are perceived as standardized products (Jiang et al., 2013) which require reasonable shipbuilding technology.

An LNG Carrier (174k CBM) needs the most complex workmanship in construction due to the explosive properties of LNG and the size of the hull, followed by chemical carriers. Chemical carriers require considerable workmanship due to sensitive cargo such as industrial chemicals and petroleum products, even though its small hull size ranges from 5k to 35k deadweights.

After the survey sheets had been emailed to the independent newbuilds shipbrokers, 16 replies were collected from March to September of 2018. Newbuild shipbrokers are those individuals or companies that act as intermediaries between shipowners and shipbuilders for newbuilds with current market knowledge in return for a fee on transactions. Shipbrokers are commissioned to value vessels by shipowners or shipping financiers for the publication of financial statements or collateral value checks (Stopford, 2013) Therefore, independent newbuild brokers were deemed more fit for providing comprehensive insights into this research than shipowners that usually belong to a certain specific sector of the shipping market such as the tanker sector, bulker sector, or containership liner.

The repliers have 17.5 years of work experience on average in the shipbroking business out of 25.3 years of working on average in the shipping or shipbuilding industry. The respondents have stayed in the shipping industry or shipbuilding industry during the troughs of 1990s and the current shipbuilding business cycle. Accordingly, they are assumed to have the expertise to answer the AHP questionnaire.

Their business locations are well distributed in six countries: the UK (5), China (3), Korea (3), the USA (3), Singapore (1), and Greece (1). They are serving shipowners outside their geographical business locations in reflection of internationality of the shipping industry. Each reply went through a consistency check with an upper limit 0.10 of IR.

The pairwise comparisons of every two factors were carried out to calculate the ratios of importance of the attributes in the competitiveness of shipbuilding. Finally, all replies were synthesized to produce the overall weight tables, Table 1 and Table 2, in the discussion section below.

4. Discussion

4.1. Comparative Importance of Competitive Factors

The shipbuilding contract price is regarded as a prime factor for the competitiveness of the selected vessel types, except for the LNG carrier (174k CBM). This output of AHP is seemingly reflecting the norm that other than special purpose ships, most vessels are common commodities that could be easily replaced with equivalent vessels in the market (McCleery, 2016).

For the low weight of the technology factor for the Capesize bulker, it is assumed that bulkers are very standardized vessels (Ecorys, 2009; Lorenz, 2015) with low deviation in construction technology . As for the Containership (14,000TEU), the weight of export credit is very high at 0.341, which presumably implies the capital burden on the containership liners to purchase a string of several vessels to serve each route (Notteboom, 2016).

Table 1. Importance of the Attributive Factors for Competitiveness

Competition Factors by Vessel Type	Technology	Contract Price	Export Credit
Containership (14,000TEU)	0.275	0.384	0.341
LNG Carrier (174k CBM)	0.618	0.217	0.165
Capesize Bulker	0.100	0.613	0.287
Chemical Carrier	0.358	0.400	0.242

The importance of shipbuilding price has been proven by the recurrent shift history of the global leader nations in the shipbuilding industry (Cho Dong-Sung and Porter, 1986). Although shipowners recently have tried to upgrade the specifications of their fleets with cutting-edge technology and high quality (Angelicoussis, 2016), their intention seems to exploit the lower prices of shipbuilding in a recession market.

The recession of the shipping industry increases the importance of the shipbuilding contract price (Bruno and Tenold, 2011). The capital cost on vessel investments is estimated around 30%, on average, of the total operating costs of a shipping company (Lee Koung-Rae, 2016). External debt is required on a large scale in fleet expansion, which is escalating the burden of interest for financing and financial covenants. such as a loan to value clause on a high leverage ratio. That is, the contract price is a starting point for profitability and the financial robustness of a shipping company for the long useful lifetime of the purchased vessels.

Therefore, the contract price factor is regarded as highly important for the competitiveness of the shipbuilding industry.

However, due to incremental regulations on pollution and safety at sea, the technology of shipbuilding can be factored for certain vessel types, such as product tankers serving major oil companies. Shipbuilding technology could be a strong selling point to shipowners concerned about quality service for customers (Scorpio Tankers, 2018). However, these shipowners would only be a tiny portion of the shipping industry, and may not impact a large shipbuilding market share. Shipbuilding technology could be considered important for vessels which have difficulties in construction due to different CCS and CHS. Those vessel types with a high degree of difficulty in construction also share a tiny portion in the deadweight of the world fleet.

Export credit is a decisive competitive factor in the competitiveness race in the global shipbuilding industry, with the weight ranging up to 0.341 in importance. Official export credit has been a competitive tool in the shipbuilding industry among shipbuilding nations (Stopford, 2013). With the retreat of commercial banks from the ship finance market (Lee Koung-Rae and Pak Myong-Sop, 2018), the importance of ECA has increased in newbuilds contracts, in which ECA financing is coupled with the shipping loans of commercial banks (Evensen, 2016).

The importance of export credit shows a reverse relationship with the importance of the shipbuilding technology factor in Table 1. Shipping companies with strong balance sheets tend to highly regard the importance of shipbuilding technology (Lee Koung-Rae, 2017b). Therefore, it is induced that shipping companies with financial strength have access to other financing sources, along with export credit.

Further, the comprehensive competitiveness on the far-right column of Table 2 was drawn by combining the weights of the attributive factors in Table 1 and the output of the comparisons of competitiveness between China and Korea for each attributive factor in the middle columns of Table 2. Chinese shipbuilders are assumed to obviously surpass Korean shipbuilders in the bulker and containership sectors, while Korea has a competitive advantage in LNG carriers (174k CBM). The two nations are similar in competitiveness for Chemical Carriers.

Table 2. Competitiveness of the Attributes between China and Korea

Competition Factors	Comparison by Factor: Technology		Price		Export Credit		Comprehensive Competitiveness	
Nations	China	Korea	China	Korea	China	Korea	China	Korea
Containership (14,000TEU)	0.174	0.826	0.805	0.195	0.728	0.272	0.612	0.388
LNG Carrier (174k CBM)	0.139	0.861	0.706	0.294	0.667	0.333	0.379	0.621
Capesize Bulker	0.400	0.600	0.861	0.139	0.735	0.265	0.762	0.238
Chemical Carrier	0.168	0.832	0.782	0.218	0.673	0.327	0.549	0.451

4.2. Shipbuilding Technology and Contract Price

Korea is perceived as much more competitive in shipbuilding technology over China for the selected vessel types according to the AHP results of Table 2. The prominence of shipbuilding technology in Korea has been supported by R&D spending and a skilled workforce (OECD, 2015). Superior shipbuilding technologies provide shipowners with financial benefits in terms of fuel consumption, operational reliability, vessel maintenance costs, damage claims, and insurance costs (Unni, 2016). The gap of shipbuilding technology between the two nations is proven by vessel insurance claims. Chinese-built vessels have a 90% higher frequency of claims for vessel insurance (MacDonald, 2016).

The gap in technology cannot be compared quantitatively between the two shipbuilding countries due to a limited availability of industrial data. Because shipbuilding technology encompasses the totality of the construction process and the quality of completed vessels, such data cannot be obtained in the industry or academic research. Nonetheless, Korea is said to have acquired a competitive advantage in welding, painting, and hull lining over China, according to separate email interviews with the shipbrokers who replied to the AHP questionnaire.

Welding in bow and stern construction is the determinant of vessel quality. The perfection of welding in a curved block can be ascertained even by unaided eyes. As for painting, a special coating technology is an imperative technology for product tankers, such as chemical carriers. Hull lining technology is also a factor to determine the competitiveness of shipbuilding in that a superior engineering capacity enables the efficient operation of vessels with less friction against the water in navigation with more available cargo space. The competitiveness of Korea in such technologies comes from the shipbuilding skills of an experienced workforce. Contrary to the attitude of the workforce in the Korean shipbuilding industry, Chinese shipbuilding workers have high mobility and not enough time to build expertise (Cho Seong-Jae and Whang Kyung-Jin, 2016).

Even though Korea is much more competitive than China in shipbuilding technologies, Korea is behind China in comprehensive competitiveness for most of the selected vessel types, other than the LNG carrier (174k CBM). As the UK and Japan, having superior technology, were caught by the following shipbuilding nations (Bruno and Tenold, 2011; Stirling, 1985), Korea has been overtaken by China in comprehensive competitiveness. It is interpreted that shipowners are less sensitive to shipbuilding technology for standardized vessel types (Ecorys, 2009; Lorenz, 2015). However, with the implementation of rigorous regulations, such as the Energy Efficiency Design Index of IMO and low sulfur emissions, the technology factor may be more regarded by shipowners in selecting a shipbuilding nation in the coming years (Zheng, Hu and Dai, 2013).

China is rapidly narrowing the technology gap by following Korea's development of the shipbuilding industry by focusing on high-value vessel types (Ecorys, 2009; Li Xiang, 2015; Mickeviciene, 2011; Nan Zhong, 2016). China has favorable demand conditions (Porter, 1990) based on the public orders (Sea Europe, 2018) from state-owned shipping companies, which take on the world's largest seaborne trade originating from or destined for China (UNCTAD, 2018). Chinese shipyards may have opportunities to construct complex and large vessels like LNG carriers (174k CBM) and mega containerships over 20,000TEU through the public orders by which the Chinese shipyards acquire and build the technologies to compete with overseas rivals (Porter, 1990).

The gap in shipbuilding technology may also be additionally filled by the principle of technology transference between neighboring countries (Diamond, 2005). The transmission of technology is often carried out by industrial espionage. It is alleged that crucial data such as R&D, design techniques, and technology have leaked from Korean shipyards to competitor companies abroad (Sea Europe, 2016). The speed and amount of technology transmission could be fast in consideration of the immediate neighboring relationship of China and Korea, along with industrial espionage through external storage devices and emails.

However, shipbuilding technology is intertwined with shipbuilding costs, which become the base of the shipbuilding contract price. For example, the electric welding method replaced riveting to push the US shipbuilding industry to the top (Gilbert, 1942). The electric welding method sped up the shipbuilding process and reduced the consumption of steel, which lowered the shipbuilding contract price (Lorenz, 2015).

The collapse of shipbuilding industries in Europe was mainly attributed to the price competitiveness of the then emerging shipbuilding nation, Korea, in the 1980s (Stirling, 1985). Similarly, Korea is assumed to have given way in its global industry leadership to China, who has emerged as a major shipbuilding nation with low labor costs. The emergence of China as a major shipbuilding nation is attributed to low labor costs (Jiang and Strandenes, 2012; Jiang et al., 2013). For example, while the labor productivity of Chinese shipyards reaches less than 50% of that of Korean shipyards, the wage in Chinese shipyards is only 20% of that in Korean shipyards for block fabrication, ultimately lowering 30% of costs in the block works (Cho Seong-Jae and Whang Kyung-Jin, 2016).

While the shipbuilding price factor has the highest weight in importance for the competitiveness for the selected vessel types in Table 1, the competitiveness of the Chinese shipbuilding price is perceived multiple times higher than that of the Korean shipbuilding price in Table 2. The price competitiveness of China is up to six times higher than Korea for the Capesize bulker. The difference in price competitiveness for the Containership (14,000TEU) is also approximately four times in favor of China.

Therefore, the comprehensive competitiveness of China is perceived as higher than that of Korea for the selected vessel types, apart from the LNG carrier (174k CBM). The strong Chinese competitiveness in bulkers and containerships has led China to be a major shipbuilding nation in business volume. Both vessel types occupied 55.6% of the world fleet at sea at the end of 2017, while gas carriers only took a 3.3% share (UNCTAD, 2018). This is the reason that Korea has smaller business volumes, even with a greater competitiveness in shipbuilding technology.

Korea could have pursued a strategy of positive price deviation with technological and managerial powers (Jiang Liping, Bastiansen and Strandenes, 2013). However, competitiveness through excellence is no longer an effective strategy for Korea due to Chinese advancement in high value-added vessel types. China has been following the footsteps of Korea in the development of shipbuilding technology for high value-added vessels (Brun and Frederick, 2017; Bruno and Tenold, 2011; Ecorys, 2009; Jiang and Strandenes, 2012; Jiang Liping, Bastiansen and Strandenes., 2013; Tsai, 2011).

By the way, overall wages in China have increased 14% in compounded annual growth rate over the past 10 years (OECD, 2017). The rising costs of labor are driving labor-intensive factories into the heartland of China and away from the coasts (Harney, 2008) where the Chinese shipbuilding industry is located. However, it is not possible to move the shipbuilding industry into the heartland because the industry is a large scaled plant industry based on a cluster of numerous suppliers. On the other hand, Korea has experienced only a slight change in labor cost over the past 10 years (OECD, 2017). Moreover, Korea has a high rate of automation in shipbuilding (Park Jae-Chan and Roh Tae-Woo, 2014) with the highest density of robots per worker in the world (Acemoglu and Restrepo, 2018; Deutsche Bank, 2018). Automated shipbuilding requires less steel work (Andritsos and Perez-Prat, 2000), reducing construction time and costs. Korea endeavors to further facilitate automation technology in shipbuilding (Min Keh-Sik, 2008). The use of robots helped Korean shipyards decrease the shipbuilding workforce in recent years in the course of shipyard restructuring (Sea Europe, 2018).

4.3. Official Export Credit

The export credit of the Chinese shipbuilding industry was perceived as far more competitive than that of the Korean shipbuilding industry in the AHP investigation. The competitiveness of export credit of Korea is 50% below Chinese competitiveness for each vessel type based on the normalized comparison in Table 3. The difference in the competitiveness in export credit matters in comprehensive competitiveness between the two nations because the weight of export credit is considerable in importance, ranging up to 0.341 among the three competitive factors in Table 1.

Table 3. Normalized Weights of Export Credit Competitiveness

Shipbuilding Nations	Containership (14,000TEU)	LNG Carrier (174k CBM)	Capesize Bulker	Chemical Carrier
China	1.000	1.000	1.000	1.000
Korea	0.374	0.499	0.361	0.486

Assurance of the availability of large-scale ship finance (Parc and Normand, 2016) is a critical competitive advantage in the midst of the retreat of commercial banks in the ship finance markets. Whereas newbuilds of vessels require significant debt (Drobetz et al., 2013) with longer tenor which have been provided by conventional shipping banks (Paun and Topan, 2016; Stopford, 2013), shipping banks tightened underwriting attitudes due to the recession in the shipping industry (Lee Koung-Rae and Pak Myong-Sop, 2018) and banking regulations (ECB, 2014; Rosa, 2013; US EXIM, 2018). Therefore, ECA involvement is in huge demand in the ship finance market. The share of ECA financing is estimated to be around 20% of the global ship finance market (Lee Koung-Rae, 2017a).

In the meantime, ECAs in shipbuilding nations are actively involved in the supply of ship finance to acquire new orders (Lee Koung-Rae, 2017a/2017b). The ship finance of ECAs is either filling the funding gap or inducing commercial shipping banks to join shipping loan syndicates. The ECAs of the two nations are the frontmost providers of ship finance. China formally recognizes the China EXIM bank and Sinosure as its official ECAs, but the China Development Bank (CDB) also provides export credit (US EXIM, 2018; Zhang Xiaomin, 2012) in the form of buyer's credit of ship finance. Korea has the Korea EXIM bank and K-SURE as its official ECAs. Contrary to China, the Korea Development Bank is not as active as the CDB in providing export credit for shipbuilding industry.

The competitiveness of ECAs can be compared in three respects: overall business volume, maximum repayment term, and financing cost. China EXIM has much bigger shipping loan assets at 17.0 billion US dollars as of the end of 2017 than Korea EXIM, at 10.1 billion US dollars (Weltman, 2018). The size of China EXIM financing is unprecedentedly large for individual shipping projects, such as a deal of 2 billion dollars for merchant vessels like LNG carriers and mega containerships. (Keating, 2016). However, the annual business volume of K-SURE, a Korean pure-cover ECA, is slightly larger than that of Sinosure, a Chinese pure-cover ECA (Lim Yang-Hyun, 2017; Zhang Qinnan, 2017).

Tenors over 12 years are frequently observed in the shipping loans of China EXIM (Crichton, 2016; Li Xiang, 2015; Torquato, 2016). On the other hand, as for ECAs of an OECD member country, Korea EXIM and K-SURE have no single case of ship finance beyond 12 years for the maximum repayment term in compliance with the OECD arrangement (OECD, 2018). The financing costs are not possibly compared between two countries due to the limitation of published data on pricing for individual transactions, but Chinese ECAs are in a position to be more flexible in pricing compared to Korean ECAs referring to the OECD arrangement in pricing for individual shipping projects.

In summation, Chinese ECAs are more competitive in all the three aspects. Chinese export credit is, by and large, assumed more aggressive in risk appetite and pricing than Korean ECAs (US EXIM, 2017). Moreover, because China EXIM and Sinosure are mandated to support China's 'One Belt One Road' initiative (US EXIM, 2017), they are going far ahead of their counterparties in Korea in competitiveness.

5. Conclusion

This research empirically proves that China has a comprehensive competitive advantage over Korea in construction of Capesize bulkers and Containerships (14,000 TEU), which represent the standard and large vessel types. China has 0.762 and 0.612, respectively, of the competitive weight for the two vessel types against 0.238 and 0.388 for Korea. Korea is competitive in the LNG carrier (174k CBM), a complex and large vessel type. Korea has 0.621 of the competitive weight in the vessel type for the LNG carrier (174k CBM). The two shipbuilding countries are similar in competitiveness for Chemical carriers, complex in construction with a small-scale size.

The comprehensive competitiveness is the market power of a shipbuilding nation on the grounds of the mixture of shipbuilding technology, shipbuilding contract price, and export credit. China has a competitive advantage in shipbuilding contract price, regarded as a prime competitive factor for all selected vessel types, except LNG carrier (174k CBM). Even though Korea is more competitive than China in shipbuilding technology for all selected vessel types, Korean shipbuilding is behind the Chinese in market power, other than LNG carrier (174k CBM), due to the low importance of shipbuilding technology in competitiveness. Official export credit is a reinforcing factor for China's greater competitiveness. China provides a greater amount of export credit with a longer tenor than Korea.

China is more competitive than Korea for standard vessel types, regardless of vessel size. In consideration of the majority share of standard vessels such as bulkers and containerships in the world fleet, China is obviously the global shipbuilding leader. China seems to continue its competitive advantage against Korea in these vessel types for a considerable time in consideration of the gap of comprehensive competitiveness of shipbuilding price and export credit. Accordingly, China will have bigger shipbuilding business volumes than Korea for the coming years. Korea surpasses China in shipbuilding business volumes only for LNG carriers, which are a tiny share of the world fleet.

Because China and Korea have pursued an irrational expansive strategy in shipbuilding facilities with the overlap of the focusing vessel types, i.e. high value-added ships, the forthcoming competition will be fiercer than ever between the two countries.

Chinese competitiveness is subject to the development of shipbuilding technology and control of the labor cost, which is on the rise. In the coming years, if China fails to comfort shipowners worried about the reliability of Chinese-built vessels regarding incremental regulations on the environment and safety, shipowners will swing back to Korea. The rising Chinese labor cost will expedite the swing in the forthcoming competition between China and Korea. For Korea to recover industry leadership, it needs to increase shipbuilding productivity to counter the cheap labor costs of China. Without improvement in productivity to counter cheap Chinese labor costs, Korea will follow the failures of the UK and Japan, who have lost their dominant market shares in the global shipbuilding industry, even with advanced shipbuilding technology. Korea is also required to expand export credit provisions to match China in terms of financing volume and longer tenor.

The contributions of this research lie in quantitatively examining the competitiveness of shipbuilding between China and Korea by comparing the attributive factors for competitiveness. This research provides academic researchers and industrial policymakers with the contemporary competition status between China and Korea.

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