Original Article

Seafarer market structure analysis of Korean merchant shipping in COVID-19[☆]

Yong An Park [a], Tsz Leung Yip [b], Sung Rye Hu [a], Hong Gyue Park [c],[*]

[a] Korea Maritime Institute, 26, Haeyang-ro 301 Beonji, Yeongdo-gu, Busan, South Korea
[b] Hong Kong Polytechnic University, 11 Yuk Choi Rd, Hung Hom, Hong Kong
[c] Chungnam National University, 99 Daehak-ro, Yuseong-gu, Daejeon 34134, South Korea

ABSTRACT

COVID-19 pandemic clearly demonstrates that seafarers are essential for sustaining world shipping services and global supply chain. Understanding the characteristics of supply and demand in seafarer market will be a solution for the bottleneck issues of seafarer change and shipping services. This paper explores the supply and demand of seafarer market in Korea and evaluates the effects of COVID-19 on both supply and demand sides of Korean seafarers by adopting regression models with panel data for the supply and time series data for the demand. First, this paper finds that the effects of COVID-19 are negative in the demand of Korean seafarer market even with the wider increase of tonnage of the Korean flagged ships in 2020. The demand shock seems to be resulted by the traveling restriction and stricter immigration measures to travellers after the announcement of COVID-19 pandemic. Second, supply in the regression models of panel data is affected negatively after declaration of the COVID-19 pandemic in 2020. The COVID-19 pandemic may trigger the hesitation of seafaring due to the travelling restriction and bottlenecks from seafarer changes onboard. Besides these findings, the correlation coefficients between the number of Korean seafarers of merchant ships and merchant fleet illustrate a diverse relationship between the two. The expansion of Korean ocean-going fleet is accompanied by the decrease of Korean seafarers on the Korean flag. The employment of foreign seafarers since 1992 has resulted in the continual decrease of ratings employment in the Korean flagged ships. The inflow of foreign deck officers in the Korean flagged ships after 2005 could lessen the officer deficiency caused by high separation rate of Korean deck officers. This inflow implies that seafarer market in a country not only affects global seafarer market in the world through the changes of seafarer supply and demand in the country, but is affected by the global market. The dual markets of Korean seafarers in ocean-going and coastal shipping present the following phenomena: severe aging of seafarers in coastal shipping and wider difference in welfare level of seafarers between the two. Further research on wage and career advancement of Korean seafarers would widen and deepen our understanding on seafarer market both for Korea and the rest of the world.

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1. Introduction

The days of COVID-19 pandemic clarify that seafarers are a key element for sustaining shipping services and global supply chain. The bottleneck of seafarer change by strict regulation of immigration and quarantine procedure strains the supply of shipping services and its quality directly and globally. Recently, we find a few studies on negative effects of the pandemic on work condition of seafarers onboard and productivity of maritime industries (De Beukelaer, 2021; Pauksztat et al., 2021; Pauksztat et al., 2022; Vandergeest et al., 2021). These focus mainly on the areas of analysis based on the issue of crisis in seafaring and harmful phenomena around seafarer change or shift, but do not delve into specific figures of seafarer labor market in order to discuss a holistic solution to the crisis of seafarer change. A global and domestic approach of seafarer market can deepen our understanding on urgent problems of seafarers supply in the days of the pandemic, and diverse labor problems around seafaring.

Some studies on seafarer market try to interpret phenomena around seafaring from the view of labor market even with limited analytic approach. While Glen (2008) estimated the supply and demand quantities of seafarers around the world, the study scrutinized further into the age profiles of seafarers in the U.K. It provided empirical evidence that the regional distribution of seafarers changed over time and the supply shifted from developed nations to developing economies. Silos et al. (2012) analysed trends of recruiting of seafarers in the world and found globalization and multinationality of seafaring for economic reasons of shipping companies: cost saving of seafarers. Analysis on land based jobs market as an alternative for seafaring implies that seafaring skills bolster a lot of maritime industries by supplying maritime expertize into those industries such as marine insurance and port operation (Gardner and Pettit, 1998).

Studies on the shortage of seafarers are likely to be linked to several problems of seafarer market in the pandemic. The shortage of seafarers has become a global issue behind the international seaborne trade. Tang and Zhang (2021) discussed a number of seafarer issues, but especially the global seafarer labor markets, and the reasons behind the shortage of seafarers. The seafarer market shows common trends of maritime labor market in developed countries: continual reduction of domestic seafarers, aging of seafarers, multinationalities of onboard of a ship (Progoulaki & Theotokas, 2010; Silos et al., 2012; Thai et al., 2013; Wu & Winchester, 2005). The seafarer market in Korea demonstrates a high rate of separation of deck officers after compulsory working onboard as a substitute for military service of Korean young men (Park, 2017).

There are many reasons behind seafarers quitting jobs in the ocean. Nguyen et al. (2014) discussed the shortage of seafarers from the perspective of Vietnam. Choe et al. (2021) asserted that the introduction of retirement pension system in Korea can attract new seafarers and different groups such as the group of service term of 30 years or longer, and the group of service term of under 30 years have different preference on the retirement pension system. Tang and Zhang (2021) provided the basis for an integrated framework of seafarer management. Seafaring is regarded as a dangerous profession. Li and Ng (2002) reviewed the safety of seafarers. On one hand, more international conventions come up from time to time to enhance the safety of life on ships. Many seafarers quit jobs in the ocean every year. Li et al. (2014) investigated the main factors of job satisfaction of Chinese seafarers in order to estimate the retention rate of seafarers. Based on the Structural Equation Modelling (hereafter SEM) method, they found that the career advancement is the most significant factor in job satisfaction, and other factors include salary and benefits, working environment and the feeling of social status. Accordingly, they further proposed some measures to increase the retention rate of seafarers.

Intention to work onboard is another key factor in the seafarer market. Lu et al. (2018) investigated which maritime students would work onboard on the basis of the Knowledge, Attitude and Intention (KAI) model. They found that students' intention to work onboard is mainly encouraged by the attitude and reference group opinions or peer groups. However, they showed that the student's knowledge on seafaring is not a leading factor for students to work onboard.

We also find more rigorous but partial analysis of the Social Science aspects to incorporate seafarers' health, welfare, safety and labor market. Maritime literature on seafarers can utilize social science theory to underpin the seafarer activities (Pauksztat et al., 2021). Working onboard as seafarers can be explained by the safety behavior of seafarers in the framework of health belief model and emotional appeal theory (Yuen et al., 2020). They argued that the safety behavior can be developed if seafarers can judge the severity and probability for not complying with safety behavior. They proposed some schemes for shipping companies to motivate safety behavior such as education, training, mentorship, and media.

Maritime services are supported by skills and knowledge of seafarers. Fei (2018) reviewed major aspects of human resource management in the shipping industry and especially discussed the retention of seafarers in the industry. Tai (2016) drew the three stages of seafarer market in Hong Kong. The number of registered seafarers in Hong Kong reflected the global shipping economies compared to the local ones. Similar stages of development of seafarer market and the shortage of seafarers have been observed almost in all maritime economies around the world. The fatal threat in seafaring such as maritime piracies is also one of the many reasons for leaving jobs on ships (Wong & Yip, 2012).

If we specify the characteristics of labor market to conclude a solution to bottlenecks around seafaring, we might borrow a way of analysis of supply and demand in global seafarer market. The analysis would be reasonable for finding a solution to emerging issues around seafaring. Nevertheless, we are facing very few approaches on phenomena in global seafarers' labor market.

We focus on the investigation of Korea to represent the global seafarer market in the COVID-19. We explore the seafarer market through the analysis of demography data: the number of employments, inflow of and outflow of seafarers in and out of the Korean market, separation of seafarers, and aging trend. Second, empirical analysis is based on the exploration of supply and demand through linear regression models in the demand and panel data models in the supply analysis. The rest of this paper is structured as follows. The overall view on Korean seafarers including merchant and fishing seafarers is presented in Section 2. Major factors and trends of supply and demand of seafarer markets in Korean merchant shipping are discussed in Section 3. Section 4 includes a few characteristics of supply and demand, and empirical analysis of linear regression on supply and demand. Finally, discussion and policy recommendations of the paper are suggested in Section 5 and Section 6.

2. Description of seafarer market in Korea

The demand of seafarers comes mainly from Korean shipping business and partially from shipping business of foreign companies. The supply of seafarers in Korea is composed of Korean seafarers of deck officers, ratings, and foreign seafarers mainly of ratings.

2.1. Overall view on Korean seafarers

Korean seafarers onboard in merchant ships and fishing ships as well as foreign flagged ships have shown a continual decrease in number since the late 1980s as shown in Table 1. The number of Korean seafarers onboard has fallen from 106k in 1990 to 33k in 2020. Nevertheless, the number of Korean seafarers onboard in merchant ships has been around 16k in the same period, even with a slight fluctuation from 18k in 2018 to 16k in 2020 as shown in subtotal of Table 1. The number in fishing ships has decreased from 53k in 1990 to 15k in 2020, and the number in foreign flagged ships has plummeted from 36k to 2k during the same period. Meanwhile, the number of Korean seafarers on foreign flagged ships showed a continual increase from 795 in 1970–46,910 in 1989, but then has decreased ceaselessly to 2179 in 2020 (Korea Seafarers Welfare and Employment Center, 1991; Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center, 2021).

The decrease of Korean seafarers onboard is caused primarily by the continual separation of seafarers in ratings of merchant ships, seafarers in fishing ships, and seafarers in foreign flagged ships. In the Korean merchant ships, we find that Korean seafarers are the main source of deck officers onboard and Korean ratings have been superseded by foreigners. The next sub-section explores more deeply into the market of Korean seafarers in merchant ships.

Table 1
Number of Korean seafarers onboard.
Source: Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center (2019, 2020, 2021).

Year		1990	2000	2015	2018	2019	2020
Grand total	Total	105,667	52,172	36,976	35,445	34,123	33,565
	Officers	32,752	21,604	22,128	20,564	33,923	21,020
	Ratings	72,915	30,568	14,573	12,881	12,516	12,545
Ocean-going ships	Total	9487	6666	9308	7050	8079	8145
	Officers	4211	4014	7674	5861	6750	6759
	Ratings	5276	2652	1634	1189	1329	1386
Coastal ships	Total	6465	8016	7847	8060	8100	7915
	Officers	3017	4774	5942	6274	6479	6241
	Ratings	3448	3242	1905	1786	1621	1674
Merchant-shipping Sub- total	Total	15,952	14,682	17,155	17,689	16,179	16,060
	Officers	7228	8788	13,616	14,523	13,229	13,000
	Ratings	8724	5894	3539	3166	2950	3060
Fishing ships	Total	53,272	31,115	16,820	15,756	15,407	15,326
	Officers	12,144	8435	5826	6041	5996	5958
	Ratings	41,128	22,680	10,994	9715	9411	9368
Foreign flagged ships	Total	36,443	6375	3001	2579	2537	2179
	Officers	13,380	4381	2686	2388	2382	2062
	Ratings	23,063	1994	315	191	155	117

2.2. Growth of trade, Korean sea power, and role of Korean merchant seafarers

The Korean economy and its foreign trade have shown a significant growth since the 1970s. Foreign trade in particular recorded a phenomenal increase in the 1970 s and the 1980 s. The amount of foreign trade soared from 2.8 billion in 1970–39.82 billion US dollars in 1980 and then 134.8 billion US dollars in 1990 (International Monetary Fund, 1997). It continues to increase in the 2000s and the 2010s: 686.6 billion in 2010 and 980 billion US dollars in 2020 (International Monetary Fund, 2018).

The registered merchant fleet of Korea also shows an incessant increase during the same period from 1970 to 1990: from 0.846 million gross tonnage to 4.1 million gross tonnage to 7.1 million gross tonnage (Korea Maritime Institute, 2005). However, the fleet size shows a decrease after the mid of 2010s due to the downfall of Korean liner shipping. The Korean merchant fleet registered in Korea expanded into 42.2 million in 2014, but then decreased to 39 million in 2018, and then recovered widely to 49.0 million gross tonnage in 2020 (Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center, 2021).

The authors have collected extensive data on the number of Korean seafarers and the merchant fleet of Korea from 1991 to 2020. Since Korean economy experienced a crisis of foreign exchange market in 1998, the authors have divided the period from 1991 to 2020 into two periods: the first from 1991 to 1998, and the second period from 1999 to 2020. In addition, we also scrutinize the correlation in the period from 2010 to 2020 in order to track the recent trends in the seafarer market.

The correlation coefficients between the number of Korean seafarers of merchant ships and the registered merchant fleet as shown in Table 2 show a diverse relationship between the two: very weak negative from 1991 to 1998 as shown in Table 2; positive from 1999 to 2020; and negative correlation from 2010 to 2020. The correlation coefficients between the number of Korean seafarers on ocean-going ships and the registered ocean-going merchant fleet demonstrate a difference from the previous coefficients: negative from 1991 to 1998; positive from 1999 to 2020; and weak negative from 2010 to 2020. Even though the Korean ocean-going fleet expanded from 9.2 million in 1991–12.6 million tonnage in 1998, the number of seafarers in Korean ocean-going ships decreased from 8.9 thousand to 7.8 thousand during the same period. In coastal shipping, the correlation coefficients display a different pattern from the previous markets: positive from 1991 to 1998, no correlation from 1999 to 2020, and weak from 2010 to 2020.

3. Factors and trends of demand and supply in labor market

In the labor market of Korean merchant seafarers, we find additional factors affecting the market. These factors include the inflow of foreign seafarers into the Korean market from the global sources and outflow of Korean merchant seafarers into the foreign market. Therefore, Korean market has been affected by the trends of global seafarer market.

3.1. Inflow of foreign seafarers

Foreign seafarers started working onboard in the Korean flagged ships from 1992 partially due to the agreement between seafarer union and shipping companies in Korea, and with tacit understanding of Korean government on the agreement (Jeon, 2017). The seafarer labor market in Korea is liberalized more after 1992: additional allowance of foreign officers onboard and introduction of foreign seafarer quota by shipping company in 2005, and expansion of employment of foreign ratings in 2007.

The number of foreign seafarers onboard in merchant ships in Korea was 12,196 in 2020: 2850 of deck officers and 9346 of ratings. If we include the number of foreign seafarers onboard in Korean merchant ships into the labor market, we could find that the correlation coefficients between the number of seafarers of Korea

Table 2
Correlation coefficients between Korean seafarers and Korean fleets.
Sources: Authors elaboration on the data of Korea Maritime Institute (2005, 2008, 2019), Korea Seafarers Welfare and Employment Center (1991), and Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center (2021).

	Korean seafarers of merchant ships / merchant fleet	Korean seafarers of ocean-going merchant ships / merchant ocean-going fleet	Korean seafarers of coastal merchant ships / coastal merchant fleet
1991–1998	-0.291	-0.873	0.873
1999–2020	0.765	0.786	-0.116
2010–2020	-0.491	-0.383	-0.305

Table 3
Correlation coefficients between Korean and foreign seafarers, and Korean fleet.
Data sources: Authors elaboration on the data of Korea Maritime Institute (2005, 2008, 2021), Korea Seafarers Welfare and Employment Center (1991), and Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center (2021).

Period	Seafarers of merchant ships / Merchant fleet	Seafarers of ocean-going merchant ships / Merchant ocean-going fleet
1991–1998	0.652	0.638
1999–2010	0.971	0.971
2010–2020	0.586	0.585

merchant ships and registered Korea merchant fleet, as figured in Table 3 shows positive relationship between the two: positive from 1991 to 1998; strong positive from 1999 to 2020; and weak positive from 2010 to 2020. If we narrow the analysis of correlation coefficients into the ocean-going shipping, we find a similar level of coefficients with merchant shipping in the three periods as listed in Table 3.

This positive relationship means that Korean seafarer labor market was liberalized in the 1990s, and it became more open after the exchange crisis in 1998. The expansion of Korean merchant fleet in the 2000s and the 2010s is supported by the employment of foreign seafarers.

3.2. Outflow: employment of Korean seafarers by foreign flagged ships

The Korean seafarers on foreign flagged ships have contributed a lot to the Korean economy by earning hundred million dollars to the country since the late 1970s. The number of Korean seafarers on foreign flagged ships was 45 thousand in 1987 at the peak and continued to fall to 2177 in 2020 as illustrated in the bottom of Table 1: 17 thousand officers and 30 thousand ratings in 1987, and 2062 officers and 117 ratings in 2020 (Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center, 2021). The annual average amount of earnings of seafarers, which includes ship management costs, increased from 9.82k in 1987–243k US dollars in 2020 (Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center, 1991, 2021).

The tendency of decrease of Korean rating and officer employment in foreign flagged ships, and the elevation of annual average earnings mean that the attractiveness of Korean seafarers in the global seafarer market has lowered since the late 1980 s. Nevertheless, Korean officers still have competitive advantage especially in the global ship management market. The influx of foreign seafarers in the Korean seafarer market into the Korean flagged ships is another simultaneous aspect of the decrease of Korean seafarer employment in foreign flagged ships.

3.3. Aging

The structure of supply and demand of Korean seafarer also affects the distribution of age groups. The inflow of foreign seafarers, particularly ratings, might interrupt the labor supply of young seafarers in the Korean flagged ships, and increase the separation rate of Korean officers after graduation of educational institutions. The average age of Korean seafarers in Korean merchant shipping soared from 44.0 in 2001–50.0 in 2015, and slightly down to 49.4 in 2020(Fig. 1): from 47.1 to 57.3 and to 56.9 in ratings; and from 41.9 to 48.2 and to 47.8 in deck officers in the same period.

If we divide Korean merchant shipping activities into ocean-going and coastal shipping, we find that Korean seafarers in ocean-going shipping are overall younger than those in coastal shipping. The average age of Korean seafarers in ocean-going shipping has changed from 40.0 years in 2001–44.7 years in 2015 and to 45.1 years in 2020; in coastal shipping from 47.3 years to 56.4 years and to 56.1 years in the same period.

A more severe tendency of aging in seafarers of coastal shipping demonstrates the dual and complicated aspects of Korean seafarer market. First, the aging in seafarers of coastal shipping is a general phenomenon both in officers and ratings. This means that the welfare level of seafarers of coastal shipping including wage is lower than that of ocean-going ships and that of on-shore jobs. Second, the Korean seafarer market in merchant shipping has focused gradually on employment of officers rather than employment of ratings in Korea.

4. Empirical analysis: effects of the COVID-19 on demand and supply

4.1. Empirical analysis on seafarer demand

4.1.1. Characteristics of seafarer demand

Demand of Korean seafarers in merchant ships depends on maritime business both in Korea and foreign countries. First, Korean shipping industry as a main player in maritime business includes ocean-going and domestic coastal shipping. Second, shipping business in foreign countries potentially affects the employment quantity of Korean seafarers. Third, related maritime services such as tug services, pilotage services, port operation, ship finance and maritime insurance also change the Korean seafarer market in merchant ships through the process of career advancement.

Seafarers' Act of Korea describes the necessary number of seafarers ships, which is consistent with working hours, time to rest, condition of qualified seafarers, and provision of meals in ships (Article 65 of Seafarers' Act). In addition, Article 107 of Seafarers' Act of Korea regulates master plan of seafarers which includes employment of foreign seafarers.

Therefore, the demand of Korean seafarers from Korean maritime business has been decided by different factors: the number of the Korean flagged ships, the size of ships, the necessary number of seafarers per ship, Korean policy on the employment of foreign seafarers, and the content and course of career advancement. A temporary employment contract of Korean seafarers by Korean shipping companies for a definite period such as six months adds a complication to the demand (Jeon, 2017). The rate of regular employment of Korean seafarers in the Korean flagged ocean-going and other ships operated by Korean ocean-going shipping companies as listed in Table 4 records 57.5 % in 2016, although it fluctuates each year. Temporary employment of Korean seafarers would lower the welfare level in comparison with the level of other jobs on shore.

Fig. 2 illustrates the average number of Korean and foreign seafarers in the Korean flagged ships in 2008 and 2020. First, it shows a decrease in demand for Korean seafarers. Korean seafarers per ship decreased from 9.1 in 2008–6.4 in 2020. Contrarily, foreign seafarers per ship increased from 7.0 in 2008–11.2 in 2020 as listed in Fig. 2; officers from 0.8 to 2.6 and ratings 6.2–8.6 in the same period. When considering the increase of the Korean flagged ships from 23.6 of 845 no. in 2008–46.3 million gross tonnage of 1092 no. in 2020, we find that the increase of the Korean flagged ships resulted mainly in the additional employment of foreign seafarers in the same period.
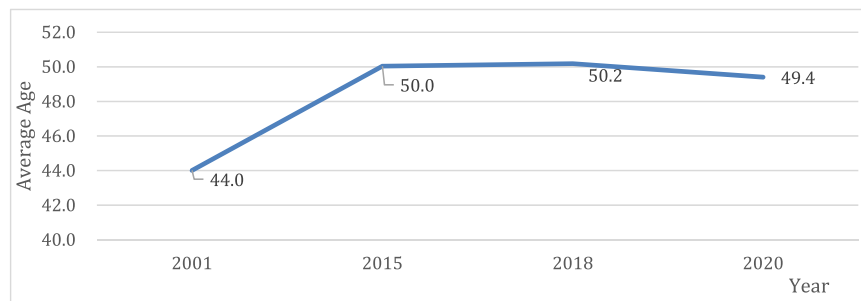
Fig. 1. Average age of Korean seafarers in the Korea flagged ships.
Data sources: Authors elaboration on the data of Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center (2002, 2016, 2019, 2021).

4.1.2. Data collection of demand

First, authors collect the data of time-series of seafarer demand in Korea: number of Korean and foreign seafarers on the Korean flag from 1991 to 2020. The authors also collect the statistics of the Korean flagged vessels: numbers of ocean-going and coastal vessels of the Korean flag, and their tonnages. Since Korean seafarers have been working on foreign flagged vessels since the 1960 s, the authors collect the Korean seafarer statistics of foreign flagged vessels.

The costs of seafarer employment for shipping include their wage and welfare costs. The authors collect the data on wage of seafarer from 1991 to 2020. The alumni of first year after graduation of maritime educational institutions are appointed overall as a 3rd class deck officer or engineering officer in Korea. The authors decided to choose the wage of 3rd class deck office as a representative wage of Korean seafarers on the Korean flag.

4.1.3. Empirical analysis on demand

The authors find a very basic model of labor demand function in a Econometrics context, which considers wage as a basic variable with other ones at the same time (Wooldridge, 2019). From this introductory model of labor demand, the authors develop a function of seafarer demand as in Eq. (1), which includes independent variables: number of vessels or tonnage of vessels of the Korean flag, relative wage of a 3rd class deck officer to average wage of university degree of manufacturing industries (rwageof1: RW in Eq. 1), and a dummy variable indicating the effects of COVID-19 in 2020.

$$SF_{dt} = c + a_1 V_t + a_2 RW_t + a_3 Dummy_t + e_t \qquad (1)$$

where,

SF_{dt}: Seafarer demand in t year.

c: Constant term.

V_t: Number of vessels or tonnage of vessels.

RW_t: Relative wage of a 3rd class deck officer to average wage of university degree of manufacturing industries.

$Dummy_t$: Dummy variable in t year.

e_t: error term of a function.

Empirical models include linear regression models (M11, M12, and M13) and log linear models (M14, M15, and M16) as shown in Table 5. The models use the number of Korean seafarers (M11, M15 and M16) and foreign seafarers on the Korean flag as a dependent variable. The models of M13, M14, M15, and M16 use a dummy

variable indicating the effects of COVID-19 in 2020. Demand in M12, M13, and M14 mean the sum of Korean and foreign seafarers: the number of Korean seafarers in M15 and M16. M16 considers Korean seafarers in coastal shipping and foreign seafarers in the Korean flag.

The Model of M12 illustrates that tonnage of the Korean flagged vessels explains better for the variation of demand of seafarers on the Korean flag than number of the Korean flagged vessels in M11. M12 shows higher R^2 and t-statistics of coefficients than M11: 0.96 and 0.89; 26 and 15. The coefficients of dummy variable indicating effects of COVID-19 in M13 and M15 are negative and statistically significant. The negative effects of COVID-19 on demand of seafarer market in Korea seems to be caused by the traveling restriction and stricter immigration measures to travellers. After the announcement of COVID-19 pandemic by the World Health Organization (hereafter WHO) in the mid-March in 2020, countries with stricter immigration measures increased.

All models in the Table 5 except M11 show insignificant coefficients of relative wage level of seafarers. This implies that the demand of seafarers is not varied strictly with the wage of seafarers, but linked to tonnage and number of the Korean flagged vessels.

4.2. Empirical analysis on seafarer supply

4.2.1. Characteristics

In Korea, seafarers have been trained and educated through various institutions, including main academic organizations of training officers: the Korea Maritime and Ocean University, the Mokpo National Maritime University, the Busan National Maritime High School, the Incheon National Maritime High School, the Wando Fisheries High School and the Ocean Polytechnic Course (two years training course of Korea Maritime Institute of Maritime and Fisheries Technology). The Korean officers onboard in ocean-going ships registered in Korea exceeded 6000 for the first time in 2010 and continued to rise gradually till the mid of 2010 s(Table 6). After the mid of 2010 s, the number of Korean officers onboard declined from 6634 in 2015–5883 in 2020.

In detail, the supply of Korean seafarers in the labor market is decided by two main factors: the number of qualified seafarers and second and willingness to work onboard. For example, the case of Korean officers clearly demonstrates that the number of graduates from the maritime academic institutions, qualified as a deck officer,

Table 4
Regular employment in ocean going ships in 2016.
Data source: Korea Shipowners' Association (2016).

Types of ships / Item		Regular employment			Rate of regular employment
	Seafarers	Seafarers onboard	Reserved seafarers	Total	
Ocean-going ships	9378	4067	1328	5395	57.5 %
Coastal ships	7850	642	101	743	9.4 %

Note: Regular employment means the employment of continual period of one year and over.
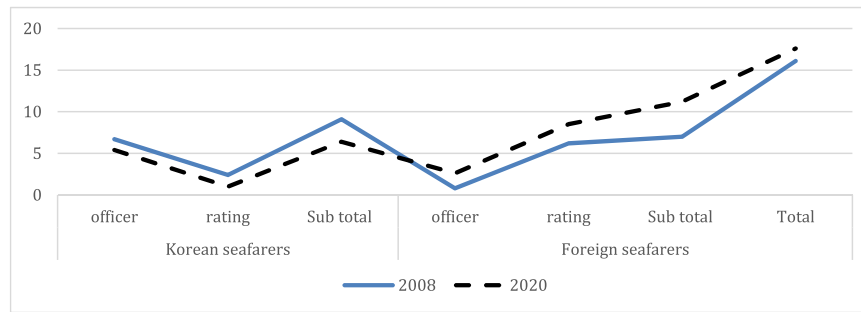
Fig. 2. Average number of Korean seafarers and foreign seafarers per ship.
Data source: Ministry of Oceans and Fisheries and Korea Seafarers Welfare and Employment Center (2008, 2021).

engineering officers as well as the boarding rate of officers in the seafarer labor market decide the quantity of qualified officers.

Although the number of graduated officers each year, as shown in Table 7, fluctuates around 1100. The boarding rates of each graduated officer group in 2020 show a gradual and continual decrease in accordance with the periods after graduation from 81.6 % of the officer group graduated in 2020–23.6 % in 2011(Table 7). We find that a wider drop of boarding rate from 75.4 % of group of 2017 graduation to 56.4 % in 2016 (Table 7): from 56.4 % in 2016 to 34.0 % in 2015. This means that the fifth and the sixth year in seafaring are critical for male officers to finish the duty on seafaring instead of compulsory army service.

4.2.2. Data collection of seafarer supply

The Korea Seafarers Welfare and Employment Center surveys seafaring statistics every year of alumni from maritime educational institutions for 10 years from one year to 9 years after graduation. The data of alumni of maritime educational institutions covers total statistics ranging from 1255 of group graduated in 2011–1057 in 2015 as shown in Table 8. The numbers of seafarers onboard, on reservation, and the number alumni are separated from seafaring. The authors collect the data of alumni of maritime educational institutions for 6 years from 2015 to 2020 for those graduated from 2011 to 2015 (Table 8). The empirical analysis uses two dummies: one for effects of COVID-19 and the other for ending year of compulsory military services for Korean young men. The seafaring for 5 years gives the alumni an exemption from compulsory military service.

The alumni data in Table 8 gives us a basic element to build a panel data of supply in Korean seafarer market. Although a panel data of Korean seafarer market from the view of shipping companies is more of a sophisticated tool for understanding demand side, it is harder to build a panel data of demand since the authors cannot approach the data of each demand: demand of Korean and foreign seafarers in ocean going and domestic coastal shipping, demand of each grade of seafarers, wage and welfare costs of Korean and foreign seafarers in ocean going and domestic coastal shipping, and other variables.

Table 6
Korean officers onboard in the ocean-going Korean flagged ships.
Source: Author elaboration on the data of Korea Seafarers Welfare and Employment Center.

Year	2009	2010	2011	2012	2013	2014
Number	5848	6158	6233	6383	6680	6617
Year	2015	2016	2017	2018	2019	2020
Number	6634	6143	6102	5861	5872	5883

4.2.3. Empirical analysis on supply

While empirical models of demand deal directly with number of seafarers as an indicator of demand, the models of supply side use the boarding rate of each alumni group from 2011 to 2015 each year from 2015 to 2020 as an indicator of supply. Since the number of each alumni group is fixed overall, the boarding rate decide the quantity of supply.

Labor supply can be interpreted as a participation or participation ratio of a specific labor force (Greene, 2012). The authors build a simple function of seafarer supply in the Korea flagged ships as listed in Eq. 2, which includes boarding rate as an indicator of supply. The function includes passed year after graduation, unemployment ratio at age from 25 to 29 years or overall unemployment ratio in Korea, and relative wage of a 3rd class deck officer to average wage of university degree of manufacturing industries as independent variables. The function uses the two dummy variables: one for the effects of COVID-19 and the other for ending year of compulsory military services.

$$BR_{at} = c + a_1 Y_{at} + a_2 UN_t + a_3 RW_t + a_4 Dummy_{1t} + a_5 Dummy_{2t} + e_{at}$$
(2)

where,

BR_{at}: Boarding rate of a alumni group in t year.

c: Constant term.

Y_{at}: Passed year after graduation of a alumni group in t year.

UN_t: Unemployment ratio at the age from 25 to 29 years or overall unemployment ratio in Korea in t year.

Table 5
Regression results on seafarer demand in Korea market.

Item /Model	M11	M12	M13	M14	M15	M16
Independent variable /Dependent variable	Number of Seafarers Coefficients					
Number of vessels	6.96*** (15)	-	-	-	-	-
Tonnage of vessels	-	0.43*** (26)	0.45***	0.48***	0.10***	2.03***
rwageof1	41.54*	-7.57	-6.79	0.03	0.52	0.07
dummy	-	-	-4333***	-0.02	-0.06*	-0.26
_cons	56.02	11,809***	11,325***	-0.09	8.78***	-12.05***
R²	0.89	0.96	0.98	0.98	0.70	
(Prob. > F) Or (Prob. > χ²)	0.00	0.00	0.00	0.00	0.00	0.00

Note: *: significant at 10 %; **: significant at 5 %, ***: significant at 1 %. Prob. means probability. The number in parentheses means t-value.

Table 7
Rates of onboarding rate of Korean officers by year of graduation in 2020.
Data sources: Korea Seafarers Welfare and Employment Center (2021); Alumni Statistics of Educational Institutes in Merchant Shipping and Fishing.

Year of graduation	Graduated students	Onboard	Reserved work force	Boarded sailors	Boarding rate (%)	Number of separations	Separation rate (%)
2011	1225	179	110	289	23.6	936	76.4
2012	1011	177	126	303	30.0	708	70.0
2013	1043	165	114	279	26.7	764	73.3
2014	1079	199	123	322	29.8	757	70.2
2015	1057	192	167	359	34.0	698	66.0
2016	1141	277	366	643	56.4	498	43.6
2017	1091	420	403	823	75.4	268	24.6
2018	1116	580	235	815	73.0	301	27.0
2019	1186	617	230	847	71.4	339	28.6
2020	1175	657	302	959	81.6	216	18.4

Table 8
Graduate groups at the panel data of the alumni.
Data sources: Korea Seafarers Welfare and Employment Center (2021); Alumni Statistics of Educational Institutes in Merchant Shipping and Fishing.

Graduation Year	2011	2012	2013	2014	2015
Number of alumni	1255	1011	1043	1079	1057

RW_t: Relative wage of a 3rd class deck officer to average wage of university degree of manufacturing industries in t year.

$Dummy_{1t}$: Dummy variable for the effects of COVID-19.

$Dummy_{2t}$: Dummy variable for the effects of ending year of compulsory military services.

COVID-19.

e_{at}: error term of a alumni group in t year.

The study uses linear regression models (M21, M22, and M23) and log linear models (M24 and M25) as listed in Table 9. Since the authors collect the panel data of each alumni group of officers, the models of regression are based on it.

The main methods of handling panel data include fixed effects model, random effects model, and generalized least squares estimation (Greene, 2012; Wooldridge, 2019). The authors adopt different methods of panel data model in the supply of Korean seafarers (Table 9): fixed effects model in M21 and random effects model in M22, M23, M24, M25. All models show statistically and significantly negative coefficients of the variable of period after graduation. The unemployment ratio demonstrates positive coefficients in M21, M24 and M25. The unemployment ratio means the unemployment ratio at the age group from 25 to 29 years in Model 21 and 24; the overall unemployment ratio in Korea in M25. Those models imply that the higher the employment ratio on shore, the higher the boarding rate. The relative wage of a 3rd class deck officer to average wage of university degree of manufacturing industries has positive coefficients in M23 and M25. While the demand of Korean seafarers is not varied strictly with wage of seafarers but linked significantly to the tonnage or number of the Korean flagged vessels as shown in

Table 5, the supply demonstrates a strict relationship between the supply and the wage level.

The coefficients of dummy variable (Dummy1) indicating effects of COVID-19 in all models as shown in Table 9 are negative and statistically significant. This negative effects of COVID-19 on supply of seafarer market in Korea seems to be caused by the hesitation of Korean seafarers to work onboard in the COVID-19 pandemic, stricter immigration measures in seafarer change in the world, and worse work condition in ships than that of other jobs on shore. The coefficients of dummy variable (Dummy2) indicating ending year of compulsory military services are negative in M23, M24, and M25. After fulfilling the imperative periods of seafaring for military services, Korean seafarers have a tendency to separate from ships.

5. Discussion and policy implications

The market of Korean seafarers demonstrates the continual decrease of Korean seafarers onboard since the late 1980s, and diminished attractiveness of seafarers than other jobs on shore in Korea. The Korean seafarer market is also exposed to the changes in the global market through the inflow of foreign seafarers into the Korean market and outflow of Korean merchant seafarers into foreign market. This means that seafarer market in a country would interact with the foreign markets through the inflow and outflow of national and foreign workforce in the country. Since the inflow of foreign seafarers is mainly of ratings, Korean officers could have been employed around 7000 in Korean merchant ships in the late 2010 s. The high separation rate of Korean officers displays a complicated aspect of the market. Although shipping companies and Korean seafarers agreed to employ foreign officers in the 2000 s, the interaction between merchant seafarers in Korea and global market is an inevitable phenomenon.

It is fair to say that Korean seafarer market is clearly divided into Korean and foreign workers, and they are again divided into permanent and temporary positions. Despite the fact that Korean government invests so much resources on education and training of

Table 9
Regression results on seafarer supply in Korea market.

Item /Model	M21	M22	M23	M24	M25
Independent variable /Dependent variable	Boarding rate Coefficient				
Year after graduation	-8.02** (−2)	-4.62** (−4)	-4.59** (−4)	-0.29** (−2)	-0.29** (−2)
Unem2529	3.99*	3.42	-	1.04**	
Unem	-	-	119.43	-	13.46*
rwageof1	-0.9	0.76	4.05**	2.79	12.40**
Dummy1	-19.14***	-19.32***	-19.29***	-0.33***	-0.34***
Dummy2	5.28	-4.11	-37.65*	-0.22*	-1.21**
_cons	160.01	10.22	-739.33	-10.41	-69.61
R^2	0.90	0.93	0.93	0.84	0.84
(Prob. > F) Or (Prob. > χ^2)	0.00	0.00	0.00	0.00	0.00

Note: *: significant at 10 %; **: significant at 5 %; ***: significant at 1 %. Prob. means probability. Unem denotes the unemployment rate.

seafarers, they are significantly wasted somewhere in the market structure between the heavy inflow of foreign workers and widespread reluctancy on seafarer as an occupation among new generation in Korea.

Considering the fact that shipping is a bloodstream for Korean economy which relies heavily on global economy and global business, it is highly suggested that the stabilization of jobs must be guaranteed for sustainable growth of the overall industry. This leads to the necessity of establishment of maritime legislation of safety rules for temporary workers, and setting up modified regulation on hiring foreign seafarers and their minimum wages policy in Korea and the rest of the world. If the current system continues without changes, the situation is about the get bad to worse because it is more natural from employers' standpoint in terms of market flexibility. Moreover, improvements on quality of working condition and welfare policy onboard must be supported by the government. This is also highly connected to the public's perspective on maritime occupation as dangerous and barely preferred occupational choice in life. Thus, it requires careful attention on the long-term future of Korean labor market of shipping and reshaping the culture and perception on the business of the general public. This might be the starting point of the rebuilding plan of Korean shipping industry after the sudden demise of Hanjin Shipping in 2017.

We have identified two scenarios in which promoting seafarers can become promising. That is, the demand for seafarers will increase after the travelling restriction and the immigration control due to Covid-19. The Korean government might expect foreign seafarers fulfil the demand in the labor market of Korean seafarers, especially when a large number of the Korean flagged ships are operated every day and when the number of Korean seafarers is low. In our study using historical data, the effect of having foreign seafarers is to further reduce the Korean seafarers. If this is the case, further efforts to attract foreign seafarers would only result in a reduction of Korean seafarers in the Korean labor market.

Seafarers are critical in times of inevitable labor shortages. The labor market of Korean seafarers is an example of this global issue. Incentives to promote national seafarers are worthwhile. To have more reliable supply of national seafarers, one solution is consistent education. Particularly, it is critical to encourage young people so that domestic market of seafarers can share the supply of young seafarers. Other factors, such as poor economy, can hinder young people to join seafarer market. It is clear that the government and other stakeholders have important roles to play as well in retaining existing seafarers in the labor market.

It is noted that seafarer shortage problems have been studied in other contexts, such as fatigues, training. One of the key distinguishing characteristics in this study is the perspective taken: the current study only examines one single open market which is Korea labor market of seafarers. As such, there might be a possibility to apply some of the ideas in this study to other open markets, although we can foresee some key differences between Korea and other flag states.

The seafarer market in Korea is affected negatively in both supply and demand by the COVID-19. Since the decrease in the supply and demand brings the bottlenecks in seafarer change and work shift in ships, the shock of the COVID-19 in the market will worsen the work condition onboard of seafarers in ships and may trigger other side effects in negative marine accidents. Hence, the Korean government has been facing policy needs of task force to handle the bottlenecks in seafarer change and work shift in multiple ships and different ports around the world. Moreover, international cooperation and introduction of agreement on seafarer change and work shift in a similar case can improve the quality of welfare of seafarers onboard.

6. Conclusions

Main findings of the paper include a few aspects of Korean seafarer market. First, the correlation coefficients between the number of Korean seafarers of merchant ships and registered merchant fleet illustrate a diverse relationship between the two. In case of ocean-going shipping, the coefficients show a negative sign. This means that the expansion of Korean ocean-going fleet is accompanied by the decrease of Korean seafarers. Second, Korean shipping companies as customers in the market has been trying to diversify the sources of supply by employing foreign seafarers: ratings in the first step in the early 1990s and officers in the second step in the 2000 s. Third, high separation rate of qualified graduate worsens the unstable supply of officers in the market and hinders the supply of high qualified officers. Fourth, the aging phenomenon of Korean seafarers is caused by a lower welfare level of seafarers including wage than other jobs on shore and mainly worsened the domestic coastal seafarer market.

The main findings suggest some policy implications. A specific and dynamic policy on supply and demand of Korean seafarers would be helpful to the development of sustainable structure of Korean seafarer market. An exact counting of demand of foreign seafarers in merchant shipping and deeper understanding of multinationality in the market might help Korean seafarers and shipping companies to prepare for changes in the near future. The Korean government should develop some policy tools to lower the high separation rate such as welfare tools.

The results of regression models on supply and demand in Korean seafarer market demonstrate dynamic aspects of the market. First, the analysis on demand illustrates the tonnage of the Korean flagged vessels effectively explains the variation of demand for seafarers on the Korean flag ships than the number of the Korean flagged vessels. Second, the effects of COVID-19 on the demand in models are negative and statistically significant. Third, the relative wage of seafaring to the wage of jobs on shore explains also the change of supply but cannot illustrate a clear impact in the demand. Fourth, the finishing of compulsory military service for young male officer in Korea is an important factor to vary the boarding rate of Korean seafarers.

Hence, the study contributes to the literature on seafarer market by analysing simultaneously both supply and demand from the view of Labor Economics. Also, it suggests that a seafarer market in a country interacts with foreign markets, and it adjusts itself to changes of internal and external environments. Thirdly, the study provides an analytic tool of supply and demand in the form of functions to the literature. This may allow us to expect more research in the field of global seafarer market in the near future.

This study can be further improved by additional investigation on Korean seafarer market. The data on the promotion of Korean seafarers onboard and career advancement in accordance with the period onboard would improve our understanding of supply and demand of Korean seafarers. The study could also be enhanced when delving into the study on welfare and wage level of Korean merchant seafarers in the Korean domestic and foreign markets. A comparison between welfare levels in both markets would shed a brighter light on the analysis of seafarer markets in Korea and the rest of the world.

Declaration of Competing Interest

None.

Acknowledgements

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