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A Study on the Priority Analysis of Government Support Policies for SOx Emission of Ships

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Abstract : *IMO has enacted a convention that air pollution due to emissions of ships and sulfur oxides emissions should be significantly reduced by 2020. Based on the current support policies, this work intended to draw up the government support plans required by the shipping companies. Analytic Hierarchy Process analysis was done with factors derived from brainstorming and literature studies. The analysis results showed that the cost factor was generally the most important criterion and the Financial Aid was relatively more important within this cost factor. The policy implications for the regulation of sulfur oxides emissions was provided.*

Key words : *AHP(Analytic Hierarchy Process), Policy, Finance, SOx, Eco-Friendly Ship*

1. Introduction

According to IMF statistical data, Korea GDP level as of 2018 is 1,693.2 trillion dollars, which means the world's 12th largest economy(International Monetary Fund, 2018). International transactions are mostly conducted through maritime transport. This is expected to increase steadily in the future. It can be predicted that the amount of pollutants generated from ports and ships will also increase. The amount of SOx emitted from ships correspons to 11.4 percent of domestic air pollution and the problem of air pollution from ships is the same in the international community(Lee et al., 2017). Environmental problems are becoming an important issue as the volume of logistics by ships globally increases.

IMO(International Maritime Organization) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of maritime and atmospheric pollutions by ships. The Marine Environment Protection Committee(MEPC) addresses environmental issues under IMO's remit. This includes the control and prevention of ship-source pollution covered by the MARPOL(Maritime Pollution) treaty. The enforcement under this tready that sets up an upper limit reference from 3.5% to 0.5% will be in effect as of January 1, 2020.

In response to this enforcement, shipping company and shipbuilders are researching new fuels, ships, equipment and so on. The government has developed relevant legal provisions and prepared various support plans to cope with such changes. It is unfortunate that the research on realistic support policies for these issues is scarce.

Therefore, we examine the current status SOx policy support through brainstorming process with experts and seek additional support alternatives. Also, this work aims to provide substantive suggestions as to the priority evaluations for each derived factor.

2. Circumstances

IMO adopted the MARPOL convention for the regulation of sulfur oxide emissions. The convention can be divided into six categories and the Annex concerning air pollution is VI by IMO(2018). MARPOL Annex VI is an agreement to restrict substances such as SOx and NOx, which are major contributors to air pollution. It sets strict standards as shown in Table 1. ECA(Emision Control Area) includes such regions as North America and the Caribbean(IMO, 2011). We can see that ECA strongly limits SOx emission.

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Table 1 Regulations on sulfur oxides emission

Name	Agreement	Details	Enforcement Date
IMO	MARPOL 73/78 Annex VI	• Convention on the discharge of air pollution from ships • NOx 6-10% reduction • Limited to 4.5% of ECA excluded sectors • Limited to 1.5% of ECA's sulfur oxides emissions	2005
	MARPOL 73/78 Annex VI Amendment	• Changes in SOx related content • Changed existing SECA to ECA • Ozone layer structure book material record of outside port transport • 2011 Shipbuilding diesel engine regulations strengthened • Strengthen standards for sulfur content reduction • Volatile organic compound management plan	2008
MEPC 280(70)	-	• Limit ship's sulfur oxides to 0.5% since 2020	2016

Source : Im, 2010 ; IMO, 2008, 2016

The government is currently in the process of providing financial support, such as eco-ship purchase support, subsidies for scrapped ships and tax exemption. And the government is also evaluating policies for coastal SOx emissions.

2.1 Scrubber

The scrubber is a device for removing sulfur oxides. It serves to reduce sulfur oxides by using water. Scrubber is being used in many places and has begun to be widespread as an environmentally friendly device. The scrubber installation is highly preferable, because the current high-sulfur fuel can be used in scrubber installed ships.

There are 3 different types of the marine scrubber: an open, a closed, and a hybrid type(American Bureau of Shipping, 2018). The open type uses external sea water to reduce sulfur oxides, but the closed type uses fresh water. The hybrid type uses seawater and f resh water alternately depending on the situation. However, the scrubber requires an installation space, resulting in a change in the conventional ship draft, DWT, equilibrium. The location and space for installation are different depending on the types of scrubber.

2.2 MGO(Marine Gas Oil)

Unlike scrubbers and LNG propulsion vessels, low-sulfur oil can be operated without any additional equipment. However, low-sulfur fuels are more costly than existing ship fuels and can present threats to the engines of vessels that are critical to the vessel, and there are also risks such as fires. The problem of the supply of low-sulfur oil from existing oil refineries is also influencial on the choice of shipping companies. MGO is expected to experience price differences due to production and blending.

2.3 LNG fuel ship

LNG propulsion ship refers to a ship that replaces existing ship fuel with LNG. For existing vessels, it is necessary to reduce the sulfur content to 0.1 when they are passing ECA. Therefore, Herdzik, J(2011) said that various fuels should be loaded or the engine should be adjusted as needed.

LNG-propelled vessels are able to reduce this fuel operations and are increasing by an average of 26% per year(Lee et al., 2018). These have been widely used for ferries and other vessels, but now it is said that shipping companies are ordering LNG-propelled container vessels.

LNG-propelled vessels are used in many areas. These vessels are widely used on routes to Europe in the United States. Environmentally friendly ship-related equipment has been developed due to the revitalization and stability of eco-ships. Currently, the POSCO company is preparing for the standardization of LNG storage tanks developed by POSCO. In addition, a method for supplying fuel from LNG carriers is under consideration, and LNG is supplied using a tank lorry in Korea(Jang et al., 2015).

The government announced the construction of a repair shipbuilding cluster and the LNG bunkering plan at the

Table 2 Criteria for Priority Analysis

Criteria	Subcriteria	Author	Detail
Cost Factor	Financial Aid	Kim et al.(2017), Park et al.(2016), Han(2014)	Financial aid for ship replacement or purchase
	Loan Benefit	Ministry of Oceans and Fisheries(2016), Park et al.(2016)	Provide low interest rate and reduce borrowing capacity
	Tax Favor	Korea Marine Equipment Research Institute(2016)	Reduce acquisition tax
	Incentive	Im et al.(2010), Kim et al.(2014)	Provide subsidies for scrapped ships to motivate overage ship to change eco-friendly ship
Operation Factor	Professional Manpower Training	Jang et al.(2011), Park et al.(2016)	Eco-friendly ship and equipment professional manpower training
	Education and Training	-	Retraining sailors
	Research and Development	Han(2014), Kim et al.(2013)	Eco-friendly ship research and development
	Equipment Development	Choi et al.(2017)	Eco-friendly equipment development
Support Factor	Business Support	-	Equipment change, ship purchase, vessel sales support
	Provision of Information	-	Regulation and information is rapid dissemination
	Counseling Service	-	Regulation transition counseling service
	Community	-	Shipping company community formation
Policy Factor	Expansion Management Plan	-	Support management of the central government and related government agencies, expand management strategies such as strengthening the role of ministries concerned
	Construction Cluster	Im et al.(2010), Korea Marine Equipment Research(2016), Park et al.(2016)	Ship repair industry, ship building, equipment construction cluster
	Construction Infrastructure	Lee et al.(2016), Kim et al.(2014), Park et al.(2016)	Build LNG bunkering and AMP(Alternative Maritime Power), construction infrastructure
	Government Support	Lee et al.(2016)	Support agency expand support

Busan New Port for the revitalization of LNG vessels and formed an organization to train R&D specialists and environmentally friendly ship-related personnel. ISO(2017) enacted ISO 20519 to facilitate shipbuilding and provided training programs for crew members based on international standards for bunkering procedures on LNG carriers.

3. Research Model and Analyses

3.1 Factor Derivation and Research Model

This study is for priority analysis of support policies for SOx emission from ships. We conducted a survey and analyzed it by AHP(Analytic Hierachy Process) that Saaty(1987) proposed. AHP is a very effective method to consider the important factors such as objectives, targets, standards, and conflicting alternatives. Each factor was derived before analyzing the priority of support policies for shipping sulfur oxides emission control. The 16 detailed subcriteria was derived by literature research and expert interviews. The results of the four top criteria comprised of Cost Factor, Operating Factor, Support Factor, and Policy Factor are shown in Table 2.

As previously mentioned, in order to investigate the priority of regulation-related support policies for shipping sulfur oxides emissions, the overall criteria were classified

into upper criteria and lower subcriteria. Cost Factor was classified into Financial Aid, Loan Benefit, Tax Favor, and Incentive. Operating Factor was divided into Professional Manpower Training, Education and Training, Research and Development, and Equipment Development. The Support Factor consisted of Business Support, Provision of Information, Counseling Service, and Community. The Policy Factor was classified into Expansion Management Plan, Construction Cluster, Construction Infrastructure, and Government Support. The detailed hierarchical structure of the research is as Fig. 1.

3.2 Respondent Characteristics of Survey Data

This survey was conducted over seven days from September 11th to September 17th, 2018. In the questionnaire of 40 participant collected from shipping companies, we used 36 participant after excluding untrustworthy responses for analysis. In the AHP analysis, consistency can be confirmed by utilizing the C.R(Consistency Ratio) value. It is a value obtained by dividing C.I(Consistency Index) by R.I(Random Index). Generally, it is judged to be consistent when it is smaller than 0.1(Kim and Kang, 2002). As all C.R values in this questionnaire is less than 0.1, it is sure that this survey is reliable. We were able to confirm the characteristics of the respondents through the response of many respondents. First of all, 10 deputy general manager replied the questionnaire, and 6 assistant manager and 6 general manager participated. In the case of employment history, the respondents that replied more than 10 years occupied the highest frequency of 17 participant. Details are as Table 3.

3.3 Empirical Analysis

The analysis of the top criteria showed Cost Factor(0.578), Operating Factor(0.158), Policy Factor(0.135), and Support Factor(0.130). The relative importance of the Cost Factor was highest compared to other factors. Within the Cost factor, the relative importance of the detailed subcriteria were analyzed in the order of Financial Aid(0.481), Loan Benefit(0.272),

Table 3 Responses to job classification status

	Frequency	Percent	Accumulation Percentage
Staff	3	8.3	8.3
Manager	2	5.6	13.9
Assistant Manager	6	16.7	30.6
Section Head	3	8.3	38.9
Deputy General Manager	10	27.8	66.7
General Manager	6	16.7	83.3
Executive	6	16.7	100.0
Total	36	100.0	-
Less Than 3 Years	8	22.2	22.2
More Than 3~Under 6	5	13.9	36.1
More Than 6~Under 10	6	16.7	52.8
More Than 10 Years	17	47.2	100.0
Total	36	100.0	-

Source : Author's calculations

Tax Favor(0.143), and Incentive(0.005). The priority of Financial Aid was particularly high. This is an item about whether it is possible to support the replacement or purchase of a ship, which is a factor that is highly evaluated relative to the Loan Benefit or Tax Favor. To cope with the sulfur oxides emission regulations, we should implement the new or modified methods for ships, which is very costly if the ship is newly built. It is because the cost burden is a

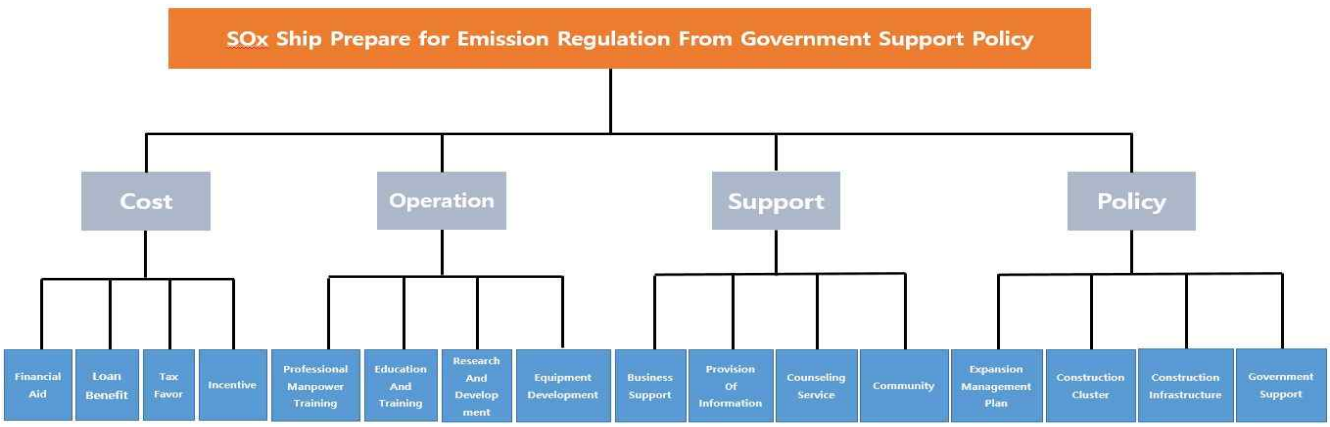

Fig. 1 Hierarchical structure model

very sensitive issue for the operation of the company.

The analysis of the top criteria showed that the second highest was Operating Factor. The subcriteria and relative importance within this Operating Factor were Professional Manpower Training(0.412), Education and Training(0.260), Research and Development(0.178), and Equipment Development(0.150). The result showed that the training related subcriteria were relatively important, because the burden of using the newly added equipment was projected. Also it reflects that the training of specialist personnel is an essential factor for the stable operation of the ship and the need for re-training of the existing crew is increasing.

The subcriteria and relative importance within Policy Factor were Government Support(0.317), Expansion Management Plan(0.305), Construction Cluster(0.196), and Construction Infrastructure(0.182). Analysis of the detailed items of Policy Factor showed that the priority for Government Support was the highest. The Government Support, which means expanding support through agencies such as the Korea maritime finance corporation, has a high impact on shipping companies than the other subcriteria within Policy Factor. It seems that the activities such as supporting related infrastructures and fostering clusters have an indirect impact on the operation of shipping companies. In the preparation process for sulfur oxides emission regulations, shipping companies are more aware of the need for immediate realistic and direct support.

Finally, the Support Factor consisted of Business Support(0.456), Provision of Information(0.289), Counseling Services(0.146), and Community(0.109). Compared to other subcriteria, the priority of Business Support was very high. Business Support means the support for equipment replacement, ship purchase, and sale. It especially supports service for foreign language interpretation and expertise. In a preliminary interview, we had an impression that most companies except large corporations did not fully understand SOx emission regulations. If you purchase new equipment and vessels to prepare for sulfur oxides emission regulations, additional work would be added to the current ship operation. Therefore, it is considered that the shipping companies highly evaluate the priority of Business Support.

The subcriteria with higher priorities regarding overall combined weight were Financial Aid(0.278), Loan Benefit(0.157), Tax Favor(0.083), Professional Manpower Training(0.065), and Incentive(0.060). It can be seen that all of the subcriteria except for the Training of the Manpower, which is the fourth rank, are the items included in the Cost Factor. As mentioned earlier, shipping companies inevitably feel burdensome with the need for additional costs in operating businesses. In particular, the priorities analyzed in the order of Financial Aid, easing of loan qualification requirements, interest Loan Benefit, and acquisition tax reduction support was cost related items that could alleviate the operating burden of shipping companies. In the subcriteria

Table 4 The results of the importance evaluation of sulfur oxides emission regulation

Criteria		Subcriteria	Relative Importance	Compound Weight
Cost Factor	0.578	Financial Aid	0.481	0.278
		Loan Benefit	0.272	0.157
		Tax Favor	0.143	0.083
		Incentive	0.105	0.060
Operation Factor	0.158	Professional Manpower Training	0.412	0.065
		Education and Training	0.260	0.041
		Research and Development	0.178	0.028
		Equipment Development	0.150	0.024
Support Factor	0.130	Business Support	0.456	0.059
		Provision of Information	0.289	0.038
		Counseling Service	0.146	0.019
		Community	0.109	0.014
Policy Factor	0.135	Expansion Management Plan	0.305	0.041
		Construction Cluster	0.196	0.027
		Construction Infrastructure	0.182	0.025
		Government Support	0.317	0.043

Source : Author's calculations

of Support Factor, the Counseling Service(0.019) and the Community(0.014) ranked 15th and 16th respectively, with very low relative priorities. The need for Counseling Services related to the implementation of regulations and support related to the formation of communities among shipping companies was lower than other subcriteria.

4. Result

Internationally, environmental problems are emerging as important issues. As the ship is getting bigger, cargo transactions between countries are becoming more frequent. As a result, the negative impact of pollutants emitted from ships on the environment is increasing and environmental problems are emerging as international issues.

The Paris agreement was adopted in December 2015 at the Paris climate agreement, including regulation of shipping and aviation The most commonly used fuel is diesel, which produces harmful substances in the diesel and emits various chemicals and substances such as NOx and SOx. It affects the human body such as asthma, respiratory disease, heart disease, lung cancer, and premature birth. According to IMO ship sulfur oxides regulations, carriers should discharge their ship sulfur oxides emissions to less than 0.5% from January 1, 2020. These are the same all over the world, and existing shipping companies are looking for ways to replace them. Surveys were conducted on shipping companies and we prioritized related factors through AHP analysis.

The shipping companies in Korea, which is surrounded by seas on three sides and has a high share of port transportation, must obey the regulation on the emission of sulfur oxides, which ultimately adds to the burden on shipping companies. Currently, some policies are in place to support shipping companies, but realistic support for shipping companies is urgent.

The role of the government and related organizations is essential to complement these overall problems and support their competitiveness. It is important to constantly revise support policies and implement planned support. This study will contribute to establish new policies and support measures by conducting research on the realistic needs of shipping companies.

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