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The Ship Management Firm Selection: The Case of South Korea

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Although extant literature has stressed importance of the use of ship management and identified the selection factors, relative evaluation of comprehensive selection factors is found to be lacking. This study aims to evaluate the overall performance and rank of the ship management firms by adopting an integrated model of Analytic Hierarchy Process (AHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) in order to support the critical decision making on SMF selection based on multiple criteria. This study contributes to enhancing the selection criteria of ship management firms by the ship-owners, and at the same time identifies the areas that the ship management firms require to improve their service standards. The result indicates that competency is the most important criterion, followed by cost, courtesy, organisation characteristics and image.

1. Introduction

Shipping is the backbone of global logistics and supply chain. Its nature is complex, so conducting shipping business requires expertise in a wide range of ship operations. Ship management industry is a well-established sector within and as an integral part of the value chain in the maritime industry has been operating in its own right for around half a century. Today, third party Ship Management Firms (hereafter SMF) account for 35% of the management of global shipping with SMF such as V-ships, Columbia Ship Management, Barber International, ASP Ship Management and Orient Ship Management as some of the leaders (Branch and Robarts, 2014).

With the growing prevalence of SMF, there is a need for studying their competitive position which currently lacks in academic research (Mitroussi, 2004a). The growth of a SMF represents a revolutionary change in the concept and practice of shipping business (Mitroussi, 2003).

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Over the last few decades a large number of ship owners have separated their ownership and control of vessels. Originally, management of ships was considered integral with its ownership, but, increasingly this activity has been outsourced. Harsh fiscal system of national registries and crew expenses were some of the major influences for this shift (Asuquo et al., 2014). Professionally run outsourced third-party ship management was also favoured by major oil firms during favourable trading periods (Klikauer and Morris, 2003) and by banks and financial institutions at times when ships were purchased in an opportune period and had to be involve SMF for operation (Klikauer and Morris, 2003; Panayides and Gray, 1999). Over the years the SMF themselves have also changed their structure and strategies due to the changing complexity of the job and fierce competition. Some have discarded the vertical structure to a more process-based one - “so called free-teams where technical, purchasing, crewing and/or accounts experts sit together in one organisational unit to serve a certain number of vessels” (Jahn and Bussow, 2013, p. 13).

SMF is defined as “professional, independent organisations which for a negotiated fee and with no shareholding ties with their clients undertake responsibility for the management of vessels in which they have no financial stake” (Mitroussi, 2003, p. 78). Jahn and Bussow (2013) broke down the operations of ship management into five core tasks: (1) technical management; (2) crewing; (3) quality and safety management; (4) procurement; and (5) financial management. Each of these is complex functions especially given the intricately regulated and globally dispersed nature of this industry.

From the ship owners’ stance, it is important to select the most appropriate SMF in order to save cost and rely on their expertise in ship operations. At the same time, competition in the ship management industry has been getting severe (Jahn and Bussow, 2013), resulting in a wider choice for ship owners. SMF thus need to be aware of the criteria, needs and preferences employed by ship owners for SMF selection so as to be more competitive and shape their marketing strategies (Panayides and Cullinane, 2002; Panayides, 2003). Currently, many SMF are conducting performance evaluation themselves. However, there is a lack of assessment of the clients’ cognitions in regard to SMF selection despite the fact that success of the SMF heavily relies on the relationships with ship owners (Panayides and Gray, 1997).

Although extant literature has stressed importance of the use of ship management and identified the selection factors, relative evaluation of comprehensive selection factors is found to be lacking. This issue is of paramount importance, because the dynamic structure of maritime firms puts pressure on the critical decision-making process in the range of complex challenges that get thrown at the ship managers (Hork, 2004). Accordingly, ship owners are faced with the complex task of choosing the most appropriate SMF which can deliver the administrative, commercial, technical and operational needs in the maritime industry (Kandakoglu et al., 2009). But in practice, the selection of the SMF appears to be largely based on the ship owners’ preferences. This preference model may consist of uncertainty as well as involve bias with subjective assessment (Wang et al., 2014). Identifying this gap our current study aims to provide an analysis by drawing on empirical work by evaluating the overall performance and rank of the SMF by adopting an integrated model of Analytic Hierarchy Process (AHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) in order to support the critical decision making on SMF selection based on multiple criteria. It is a first such attempt which we believe would contribute to enhancing the selection criteria of SMF by the ship-owners and at the same time identify the areas that the SMF require to improve their service standards.

The remainder of this paper is as follows. The next section reviews extant knowledge on this subject. Section 3 outlines a variety of criteria for selection of the SMF. The proposed methodology is explained in the section 4 followed by numerical illustration in Section 5. Finally, discussion and conclusion is provided.

2. Literature Review

SMF are considered as the backbone of commercial ship operation. The complexity of the task of ship management requires highly trained professionals who are required to deliver a range of different management services which not only involves the ship’s day-to-day operation but also a wide range of value added services. There are a number of good reasons why ship-owners prefer to employ professional SMF for these tasks. Firstly, early growth of outsourcing ship management was considered to overcome the disadvantages of the unfavourable fiscal regimes of national registries and excessive crew costs (Bajpaee, 2009). Secondly, for small ship owners to achieve economies of scale in ship operation, dedicated SMF were a better option than to attempt to manage the ships in-house (Panayides and Cullinane, 2002). Thirdly, some ship owners with a clear motive in the vessels’ sale and purchase value rather than in running a business of ship operation consider ships as financial asset. For them, delegating ship operation to professional SMF was often the only option (Panayides and Gray, 1997).

Mitroussi (2003) investigated the forces in the process of the separation of ownership and control of vessels so as to provide parameters, which are viewed as conducive to the strategic decision to employ third party ship management. Later, Mitroussi (2004a) explored ship owners’ perspectives regarding reasons for turning to ship management and factors influencing the choice of SMF in the UK and Greece. Interestingly, Mitroussi (2004b) examined the role of organisational characteristics of ship owning firms (e.g. firm size, type and age) in the use of third party ship management, and argued that those factors play a pivotal role in the selection of the professional SMF. Similarly, Cariou and Wolff (2011) found that ship owners’ decisions to outsource is greatly determined by the characteristics of the vessels’ age, type and size and the those of the ship owners’ country of domicile and fleet size.

Panayides and Cullinane (2002) used interviews and mail surveys and found that SMF selection and performance evaluation and their relative importance was a matter of ship mangers’ perceptions and customers’ views. Panayides and Gray (1999) tried to identify whether professional SMF actively apply intangible resource-advantage theories in practice with a sample of 98 SMF located in the UK and Cyprus. Their focus was on the intangible resources such as SMF’s capability of establishing, developing and maintaining stable long-term relationships with customers. Asuquo et al. (2014) attempted to develop the selection of ship management services based on analytic hierarchy process (AHP) with a case of the Bibby Line shipping company. Nevertheless, their selection criteria including price, reputation, location, experience, technical expertise and relationship appears to be oversimplified. In another study, Celik (2009) focused on identifying how different leading SMF were involved in establishing an integrated process management system in SMF but not in the context of their selection by the ship owners.

Notwithstanding an extensive body of literature on ship management generally and some on selection of SMF in particular, no study has applied the range of different task carried out by the SMF and added them as the selection criteria. In this study we propose to address this gap by including a range of these criteria and applying them scientifically. In the following section the selection criteria are discussed.

3. Criteria for Ship Management Firm Selection

In the context of third party logistics outsourcing studies, the most cited reasons for outsourcing logistics services include cost saving, logistics service improvement, focus on core competencies, increasing productivity, upgrading information technology capabilities, reacting to changes in the regulatory environment and complexity of operating in a just-in-time environment (Rajesh et al., 2011). In land-based industries it is possible that suitable third party logistics providers are not found owing to excessive cost or even competencies (De Boer et al., 2006).

In the ship management context, due to the heterogeneity of SMF's different locations world-wide and services covered, selecting SMF with the adequate qualities is a demanding task (Asuquo et al., 2014). Recognising selection of SMF is crucial because it can lead to customer attraction and retention (Panayides and Cullinane, 2002). The various selection factors were derived from the extant literature and revised to reflect the nature of the ship management industry. The criteria shown in prior research are cost, competency, courtesy, organisation characteristics and image which are discussed in turn.

3.1. *Costs*

Costs involve vessel operating costs, management fees, cheap consumables, economies of scale and crew fee. Ship owners aim to minimise cost of operation for higher profit. The importance of cost minimisation is particularly high in this business as they have no power to control freight rates, i.e. their income, which is determined by supply and demand of goods and other factors (Mitroussi, 2013, 2003). The crucial task for effective SMF is therefore to reduce operating costs possibly by providing fiscal advantages from economies of scale (Spruyt, 1994). From the ship owner's point of view, by outsourcing ships to SMF, the running costs related to vessel operation could be fixed and thus budgeted. It would be plausible that ship owners choose the SMF who offer cheap management fees, although the management fees are a relatively small portion of the total operational cost (Rialand et al., 2014). In this regard many logistics and ship management studies stressed that the cost is not a foremost important factor, but it is the quality of service that they offer (Panayides and Cullinane, 2002).

3.2. *Competency*

The next and possibly the deciding characteristics for SMF selection could be the breadth of the competences held by the SMF. Competency is associated with safe operation of vessels, problem solving ability, technical ability, information technology, skilled crew manning, effective legislation, ship management know-how database, crew training system, value-added service, and storing and maintenance. Sletmo and Holste (1993) acknowledged that shipping managers no longer retain competitiveness based on absolute cost advantage, differentiation and concentration on niche markets, but specific competence involved in ship operation. The competency leads the ship owners to prefer SMF who can provide the widest range of services with particular reference to improved safe operation of vessels (Gunton, 1997). Since the implementation of the ISM (International Safety Management) code in 1998, the modified standards of STCW (Standards of Training, Certification and Watchkeeping for Seafarers) in 1995, the Oil Pollution Act 1990, the provision of ISPS (International Ship and Port Facility Security), additional expertise is required to comply with the range of maritime regulations, resulting in more demands for employing professional SMF (Asuquo et al., 2014; Branch and Robarts, 2014). In order to prevent negative consequences such as loss of life, injuries, damage to ship, machinery, cargo and other third parties, recently, the concern with regard to safety is moving towards benchmarking 'quantification of safety' offered by the SMF. They need to establish, monitor and publish key performance indicators to their potential clients for business (Mitroussi, 2013).

Competitive SMF are also expected to provide both problem solving and technical ability, since specialised vessels and markets can be managed only when staffs both ashore and at sea have specific knowledge and expertise (Mitroussi, 2004a). The regular technical maintenance of ships and related consumables can lengthen the ship's life and mitigate risks during the voyage. In many cases, technical ability may entail life cycle management of vessels (Jahn and Bussow, 2013). For example, dedicated superintendents are committed to all dry docking and major maintenance across the fleet, which can be regarded as a service based on core competency drawn on technical ability (Jahn and Bussow, 2013).

Although the adoption rate of information technology systems such as Electronic Data Exchange is still low in the maritime sector (Bhardwaj, 2013; Lam and Zhang, 2014), information technology with sophisticated computerised maintenance systems facilitates interchange of information amongst dispersed offices and better level of maintenance offered for on board equipment (Mitroussi, 2003). Accordingly, the degree of information technology provided is seen as one of the drivers of ship management outsourcing, although its adoption requires substantial investments and skilled labour (Mitroussi, 2004a). For instance, the use of Planned Maintenance systems as a central information system not only can reduce unnecessary calls and emails, but also build a central task list for staffs on board and onshore (Jahn and Bussow, 2013). By using such systems, it can be possible that ship management know-how database in regard to the effective vessel management, accumulated ship management skills and experience, particular ship owners' preferences and sales strategies is accumulated. These may be considered as intangible dynamic capabilities.

Employing certified and knowledgeable ship crew at the right time in this dynamic industry is yet another challenge for the SMF. Those who provide in-house crew training are seen to add value and are often favoured over others. The large SMF thus tend to aim for a pool of crews and integrated crew training systems for their clients with higher safety concerns and capable of manning the more technically challenging vessels (Jahn and Bussow, 2013).

In addition, competitive SMF are also required to liaise effectively with the regulators (Gunton, 1997). Timely and appropriate exchange of information with regulators and their representatives around the world save significant amount of time and effort on inspection and control. In short, the list of duties that SMF are required to deliver are diverse of which some are considered core functions but several others are considered as value added. Increasingly, the competition in the business of SMF has been centred on the range of value added activities that they have been able to offer. It corroborates Bajpaee's (2009) argument in the online industry magazine, how value creation is the key to success in the ship management.

3.3. *Courtesy*

Courtesy is presented by professionalism, flexibility, communication, reliability, responsiveness, customer relationship management. Professionalism stemmed from high level of experience and skills (e.g. acquired from operating a special type of vessels) is crucial in fulfilling the role of SMF (Bajypee, 2009). Reliability in vessel operation and delivery are considered important factors when selecting SMF, since scheduled and reliable vessel operation make it possible to keep on top of the business needs. Flexibility to respond to instant customer requirements is also vital (Asuquo et al., 2014). When facing unexpected situations such as vessel breakdown, SMF need to have the power to fix the malfunctions and facilitate returning to normal voyage. Sometimes, this may include 'knowing' the right set of organisations in a remote part of the world which would be able to carry out the repairs and conduct the requisite surveys. Although customers' demand is beyond the contractual agreements, it is considered a professional hazard and an implicit requirement (Panayides and Gray, 2009). Furthermore, ship owners can benefit from suitable responsiveness at the demand of the customers particularly due to high level of uncertainty. As a ship's schedule may change at a short notice SMF are required to offer prompt responses to customer inquiries on areas such as vessel positions, estimated time of arrival and cargo conditions (Lam and Zhang, 2014). By interacting with customers effectively, it encourages the latter to stay in long-term contract with the ship owners.

Increasingly the charterers of the ship tend to communicate directly with the ships and the ship managers using modern information technology system (Jahn and Bussow, 2013; Dickie, 2014). Bajypee (2009) contended that Customer Relationship Management (CRM) is necessary for ship managers to satisfy the customers and maximise the value creation. It shortens the communication channel, making it more effective by providing faster response and instant outcome (Panayides and Gray, 1999).

3.4. *Organisation Characteristics*

Organisational characteristics are detailed by company location, number of vessels managed, ship ownership, network of suppliers, portfolio complexity of ship management fleet, office coverage worldwide, nationality of managers, and company age. Mitroussi (2003) argued that organisational characteristics such as company's size, type and age play an important role in choosing strategic decisions to outsource the ships to SMF. Location is a critical factor since the geographical coverage may be instrumental in operating different ship owners' requirements (Asuquo et al., 2014). The location of SMF may sometimes get determined by the location of ship owners. Positioned close to the ship-owners is often considered favourable as it adds to the convenience, while at other times geographical proximity to major crew centres, ship parts/ supplies and ship stores may act in favour of the choice of the SMF (Panayides and Gray, 1997). Various networks of suppliers may also enable SMF to achieve economies of scales and enhance ship operations by sourcing consumables and storing in bulk. In Mitroussi's (2004a) empirical study, nationality of managers and office location in this global business was seen as decisive variables when selecting an SMF.

Experience in the provision of the ship management service can be regarded as a crucial factor when ship owners look for potential SMF. A wider range of expertise offered in the ship management fleet portfolio may influence the ship owners' selection priority in that the ship owners may achieve the desired diversification of their business profile (Mitroussi, 2004a).

3.5. *Image*

Image provides an umbrella to dominate reputation, personal recommendation, and corporate social responsibility. Reputation of the SMF also helps facilitate customer relationship which attracts more ship owners (Asuquo et al., 2014). Mitroussi (2004a) found that most ship owners viewed the SMF's reputation as an important factor, whilst Panayides and Cullinane (2002) revealed that 'recommendation' was critical for the SMF selection.

Finally, conforming to global standards in operation and to the acceptance of Corporate Social Responsibility (CSR) has also seeped in the business of SMF. In 2012, European Union started discussing emission trading scheme pertaining to a system for monitoring, reporting and verification of emissions based on fuel consumption of vessels, whilst IMO introduced measures to reduce CO2 emissions of ship operations, so called Ship Energy Efficiency Management Plan (SEEMP) and Energy Efficiency Operation Indicator (EEOI) (Jahn and Bussow, 2013). Ship management is slowly but proactively adopting CSR and sustainability philosophy (Mitroussi, 2013). Some endeavours to protect the environmental activity have started helping SMF to differentiate itself from its rivals (Panayides and Gray, 1997). It has an impact on the SMF's image and attracts ship owners' willingness to employ them (Lam and Zhang, 2014).

The discussion thus suggests the need for a high degree of professionalism from today's SMF who are able to deliver a complex range of tasks. Since the late 1980s, SMF were seen to hold the potential to make the industry safer and more environmentally aware. As SMF began to grow in popularity and thus in number, there were questions raised about the variation in the standard of service with some providing cheap management services and used as shields by unscrupulous ship owners (Spruyt, 1994). By the end of 1980s the difference between the leading organisations and those at the other end of the spectrum was growing which prompted some of the leaders to form a 'private club' with high professional standard through self-regulation. In 1991 it led to the formation of the International Ship Management Association (ISMA) and later renamed as InterManager which laid down the highest professional standard in this business. The features discussed in this review greatly overlap with those earmarked by ISMA and thus being members of this exclusive club meant that the SMF complied with the highest standards in the industry. The role of ISMA merely reiterates the point that selection of appropriate SMF from the ship owner's point of view and being competitive in the business from the SMF's point of view are not new issues. Considering this, it is our objective in this paper to provide a sound and comprehensive technique to determine the selection process (InterManager, 2015).

4. Advanced Evaluation Method for SMF Selection

Considering the above issues and the range of factors that goes in the selection of the SMF, it can be viewed as a typical Multi-Criteria Decision Making problem (MCDM) under uncertainty. The MCDM problems can be often assessed imprecisely due to uncertain and incomplete data related to different quantitative and qualitative determinants (Yang et al., 2009). In order to tackle the problems, it needs sophisticated tools that are already proven to be successfully applicable for dealing with MCDM problems under uncertainty. In the MCDM practical applications, a number of linear weighting techniques (i.e. AHP and TOPSIS) have been successfully applied (Bottani and Rizzi, 2006; Wang and Chang, 2007). These techniques are based on the principle of the higher the weights/ performance ratings, the more desirable the alternatives. The weights/performance ratings assigned to criteria are mostly obtained through subjective judgements and the scores are synthesised as a single value for each alternative to select the best solution from the alternatives. In this study, a hybrid approach of AHP and fuzzy TOPSIS for solving MCDM problems under fuzzy environment is applied to address the choice of SMFs.

An AHP is a suitable application when comprising the importance or rating of a criterion against that of other criteria at the same level in the hierarchy decision tree (Saaty, 1980). The weights of criteria in the fuzzy TOPSIS can be obtained using pair-wise comparisons or simple rating methods (Chen, 2000). However, the latter does not cater for the assurance of the assessment consistency between the criteria (Yang et al., 2011). An AHP method makes the judgements more reliable through consistency ratio investigation (Saaty, 1980). In order to obtain the relative weights, a number of selected experts are approached to respond to a question such as “which criteria should be emphasised more in a SMF selection, and by how much more?” A series of pairwise comparisons are conducted based on the Saaty’s nine-point scale ranging from 1 (equal) to 9 (extreme). The consistency of the pairwise judgements is obtained by calculating a consistency ratio (CR). Where the value of CR is greater than 0.1 which indicates an inconsistency in the pairwise judgements. Therefore, the judgements should inform an acceptable level with the CR of 0.10 or less.

A fuzzy set theory is a powerful tool in dealing with vagueness of human thoughts and expressions in making decisions (Zadeh, 1965). It permits vague information, knowledge and concepts to be used in an exact mathematical manner. Normally, in a fuzzy environment, the assessment grades (i.e. linguistic terms) for criteria are expressed by fuzzy numbers (i.e. triangular or trapezoidal fuzzy numbers) rather than crisp numbers. Furthermore, the fuzzy set theory can be easily combined with other methods for selection issue.

A TOPSIS method is well suited to modelling with multiple conflicting objectives and sub objectives to determine the ranking order of alternatives (Hwang and Yoon, 1981). After introduced the conventional TOPSIS (Hwang and Yoon, 1981), its usage has been extended to the fuzzy environment (i.e. FTOPSIS) (Yang et al., 2011). Basically, TOPSIS/FTOPSIS is grounded in the intuitive principle that the alternatives have the shortest geometric distance from a Positive-Ideal Solution (PIS) and the longest geometric distance from a Negative-Ideal Solution (NIS). The PIS, comprised of the best attainable values of the criteria, increases the benefit criteria and reduces the cost criteria, whilst the NIS, formed by the worst attainable values of the criteria, increases the cost criteria and reduces the benefit criteria. The advantages of the TOPSIS are demonstrated as (1) a sound logic that represents the rationale of human choice (2) a unique visualisation of the alternatives on a polyhedron (3) a scalar value that accounts for the best and the worst alternative choices simultaneously (4) a simple calculation process (Wang and Chang, 2007; Madjid and Adel, 2011). Due to these reasons, a modified form of the MCDM methodology, TOPSIS/FTOPSIS, has been applied by many researchers in various applications such as a recruiting problem (Chen, 2000), a supplier selection problem (Chen et al., 2006), a 3PL selection problem (Bottani and Rizzi, 2006), a strategic alliance partner selection problem (Büyüközkanan et al., 2008), customer behavioural patterns (Chamodrakas et al., 2009), a vessel selection framework (Yang et al., 2011) and a logistics tool selection framework (Büyüközkanan et al., 2012).

In this framework, the weighting technique, AHP, is applied to assign the weights to criteria, while the fuzzy theory makes it possible to tackle imprecise evaluation of each SMF’s performance against the defined criteria, whilst the TOPSIS is used to determine ranking order of the SMF through the Euclidean distance from the positive and negative ideal solutions. Based on the references proposed by Chen (2000) and Yang et al. (2011), this study develops the FTOPSIS approach as the following seven steps.

Step 1. Identify a list of criteria and determine their linguistic terms and corresponding fuzzy numbers.

Step 2. Construct fuzzy decision matrix using aggregated average values obtained by individual fuzzy performance rating of each alternative with respect to each criterion.

Step 3. Construct normalised fuzzy decision matrix.

Step 4. Define fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS).

Step 5. Calculate the weights of criteria using an AHP.

Step 6. Calculate the weighted distance to the FPIS and FNIS.

Step 7. Calculate closeness coefficient.

5. Application of Fuzzy-TOPSIS on Ship Management Firm Selection

This far studies on selection of SMF have concentrated on a few countries such as UK (Panayides and Gray, 1999; Mitroussi, 2004a; Asuquo et al., 2014), Greece (Mitroussi, 2004a), and Cyprus (Panayides and Gray, 1999). Also these have not applied the range of different selection criteria that we have argued here. This study therefore aims to extend the boundaries on this topic both by including a wider range of criteria for choosing the most competitive SMF as well as by situating the study in the context of Korea as SMF competitiveness has not been explored in this geographical region.

Korea has played a pivotal role in the maritime industry as an economy that handled the fourth largest global container port throughput of approximately 23 million TEU in 2013 and owned the fifth largest fleet in terms of DWT with leading container shipping lines such as Hanjin Shipping and Hyundai Merchant Marine and the second largest shipbuilding industry globally (Seo et al., 2015). Considering the role of Korea in the shipping market, this study aims to use a Korean Shipping Company. Such case study approach has been adopted in previous studies (Bhattacharya, 2012; Celik et al., 2009; Bottani and Rizzi, 2006) and aims to identify the determinants for SMF selection from the perspective of a shipping company.

The case shipping company, established in 1982, own asset $4152 billion (sales: $2222 billion) and 91 vessels (11,377,266 DWT) under control (owned and long-term chartered) as of 31th December 2014, making them one of the leaders in the shipping industry in Korea. Its main business areas include sea transportation (crude oil, petroleum products, LNG, LPG, and dry bulk) and ocean bunkering. Its headquarter is located in Seoul, whilst the branch Offices are dispersed in several countries such as UK, Singapore, Japan, China, U.S. and Philippines. In the past it managed ships and crews owned by them ‘in-house’. However, increased complexity and innovative technology in ship operations prompted them to outsource it to SMF for total ship management services and are in search of suitable SMF. This paper performs a model with of SMF alternatives (A1, A2, A3, and A4), which are the largest SMF in terms of the number of employees and vessels. This framework helps to cover the range of criteria to find the most competitive SMF by setting the scope of the decision model.

Prior to finalising questionnaire in order to ensure appropriateness of a hierarchical model and questionnaires by reflecting professionals' opinions, we had a number of meetings with four senior practitioners in the case company, as well as with five senior professionals in Korea Ship Management Association, three ship owners who outsource their vessels to SMF, and three academics in the area of shipping management. The above 15 experts arguably provided the necessary expertise base in this subject and were deemed to have sufficient knowledge to judge on AHP questionnaire to derive the relative weights of all criteria. An interactive discussion amongst them pertaining to judgements on each pairwise comparison was conducted to ensure the assessment consistency. TOPSIS questionnaires were collected from the four senior practitioners in top management level of the above case study company.

5.1. *Relative Weights of Decision Criteria*

The judgements of seven among 15 evaluators have verified with the CR of 0.10 or less. Generally, the value of CR is greater than 0.1 and the evaluators need to revise their pairwise judgements. Therefore, 7 judgements presenting consistent input data, which are sufficient to provide a reasonable AHP outcome (Bottani and Rizzi, 2006; Büyüközkan et al., 2012) are used to derive the weights of the criteria.

The weights judged by seven evaluators on the five criteria (i.e. cost, competency, courtesy, organisation characteristics and image) at the second level that represent the priorities in the pairwise comparison matrix are obtained as 0.247, 0.367, 0.165, 0.150, 0.072 respectively. Competency is considered to be the most important criterion and followed by cost. Similarly, the weights of the bottom level criteria can be obtained. It is noteworthy that the weights obtained are local weights at the same level. Further computation has been conducted to obtain normalised weights of the bottom level criteria by multiplying their local weights with the ones of their associated upper level criteria. For instance, the normalised weight of 'vessel operating cost' can be obtained as 0.81 (=0.247 (the local weight of cost) × 0.330 (the local weight of vessel operating cost)). Consequently, the local weights of all criteria and the normalised weights of the bottom level criteria are shown in Table 1.

5.2. *Performance Ratings of Ship Management Firms Using Fuzzy-TOPSIS*

The five linguistic variables including 'very poor', 'poor', 'fair', 'good' and 'very good' for criteria and their Corresponding Triangular Fuzzy Numbers (TFNs) are determined as shown in Table 2 (Wang and Chang, 2007). Then, the evaluators use the linguistic variables to evaluate the performance rating of four SMF. The four senior managers (representing the group of decision makers) in top management level of the above case company took part in evaluating process. The fuzzy decision matrix of each SMF with respect to each criterion is shown in Table 3.

The next step is to establish a normalised fuzzy decision matrix. The normalised fuzzy decision matrix $R = [r_{ij}]_{m\times n}$, where the TFNs of each criterion in matrix R is $0 \leq r_{ij} \leq 1$, can be obtained. The maximum value for *benefit criteria* and the minimum value for *cost criteria* (Table 3) are separately used to normalise TFNs and the results are presented in Table 4. For example, the maximum TFN of four SMF with respect to C4(B) in Table 3 is 9.5, hence, the normalised TFNs of all alternatives with respect to C4(B) can be obtained through divided by 9.5. On the other hand, the minimum TFN of four SMF with respect to C1(C) is 5.5 that can be used as a numerator to normalise the TFNs of all alternatives with respect to C1(C). Similarly, the normalised TFNs of other criteria can be obtained.

In the TOPSIS approach, the criteria can be classified either into benefits (B) and costs (C), hence the most suitable SMF represents the higher score at benefits criteria and the lower score at costs criteria. In this framework, four criteria (i.e. vessel operation costs (C1), management fees (C2) cheap consumable (C3), and crew fees (C5)) can be belonged to the *costs (C)*, but others are obviously considered as *benefits (B)*.

Table 1
The local and normalised weights of criteria

	LW	NW
Costs	0.247	-
Vessel operating costs (C1)	0.330	0.081
Management fees (C2)	0.184	0.045
Cheap consumables (C3)	0.102	0.025
Economies of scale (C4)	0.132	0.033
Crew fee (C5)	0.252	0.062
Competency	0.367	-
Safe operation vessels (C6)	0.172	0.063
Problem solving ability (C7)	0.109	0.040
Technical ability (C8)	0.095	0.035
Information technology (C9)	0.051	0.019
Skilled crew manning (C10)	0.159	0.058
Effective legislation (C11)	0.070	0.026
Ship management knowhow data base (C12)	0.074	0.027
Crew training system (C13)	0.131	0.048
Value-added service (C14)	0.052	0.019
Storing & maintenance (C15)	0.088	0.032
Courtesy	0.165	-
Professionalism (C16)	0.284	0.047
Flexibility (C17)	0.124	0.020
Communication (C18)	0.138	0.023
Reliability (C19)	0.197	0.032
Responsiveness (C20)	0.146	0.024
Customer relationship mgmt. (C21)	0.111	0.018
Organisation characteristics	0.150	-
Location (C22)	0.070	0.011
Number of vessels managed (C23)	0.152	0.023
Ship ownership (C24)	0.072	0.011
Network of suppliers (C25)	0.182	0.027
Complexity ship mgmt. portfolio(C26)	0.230	0.034
Office worldwide (C27)	0.119	0.018
Nationality of managers (C28)	0.098	0.015
Company age (C29)	0.076	0.011
Image	0.072	-
Reputation (C30)	0.432	0.031
Personal recommendation (C31)	0.279	0.020
Corporate social responsibility (C32)	0.289	0.021

Table 2
Linguistic variables and their corresponding TFNs

Linguistic variables	Corresponding triangular fuzzy numbers
Very poor (VP)	(0, 1, 3)
Poor (P)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very good (VG)	(7, 9, 10)

Note: The linguistic variables and their corresponding TFNs are defined based on Wang and Chang (2007).

Table 3
The fuzzy decision matrix

	C1 (C)	C2 (C)	C3 (C)	C4 (B)	C5 (C)	C6 (B)	C7 (B)	C8 (B)
A1	(5.5, 7.5, 9.25)	(5.5, 7.5, 9.25)	(4.5, 6.5, 8.5)	(4, 6, 8)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(5, 7, 9)
A2	(6.5, 8.5, 9.75)	(5.5, 7.5, 9)	(4.5, 6.5, 8.25)	(4, 6, 7.75)	(5, 7, 8.75)	(6.5, 8.5, 9.75)	(6, 8, 9.5)	(6, 8, 9.5)
A3	(7, 9, 10)	(5.5, 7.5, 9.25)	(4, 6, 7.75)	(6, 8, 9.5)	(5.5, 7.5, 9.25)	(7, 9, 10)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)
A4	(5.5, 7.5, 9.25)	(5.5, 7.5, 9.25)	(4.5, 6.5, 8.25)	(4.5, 6.5, 8.25)	(6, 8, 9.5)	(6.5, 8.5, 9.75)	(6, 8, 9.25)	(6.5, 8.5, 9.75)
	C9 (B)	C10 (B)	C11 (B)	C12 (B)	C13 (B)	C14 (B)	C15 (B)	C16 (B)
A1	(5.5, 7.5, 9.25)	(5.5, 7.5, 9)	(3, 5, 7)	(3.5, 5.5, 7.5)	(4, 6, 8)	(3.5, 5.5, 7.5)	(3.5, 5.5, 7.25)	(6.5, 8.5, 9.75)
A2	(4.5, 6.5, 8.25)	(6, 8, 9.5)	(5, 7, 8.75)	(5, 7, 8.75)	(5, 7, 8.75)	(4.5, 6.5, 8.25)	(4, 6, 7.75)	(6.5, 8.5, 9.75)
A3	(5.5, 7.5, 9.25)	(6, 8, 9.5)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(5.5, 7.5, 9.25)	(5.5, 7.5, 9.25)	(7, 9, 10)
A4	(5.5, 7.5, 9)	(6, 8, 9.5)	(5, 7, 8.75)	(5, 7, 8.75)	(5.5, 7.5, 9)	(4.5, 6.5, 8.25)	(6, 8, 9.5)	(5.5, 7.5, 9.25)
	C17 (B)	C18 (B)	C19 (B)	C20 (B)	C21 (B)	C22 (B)	C23 (B)	C24 (B)
A1	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(6.5, 8.5, 9.75)	(5.5, 7.5, 9.25)	(1.75, 3.5, 5.5)	(4, 6, 8)	(2.5, 4.5, 6.5)
A2	(5.5, 7.5, 9.25)	(5.5, 7.5, 9.25)	(6, 8, 9.5)	(6, 8, 9.5)	(5.5, 7.5, 9.25)	(3, 5, 7)	(5, 7, 8.75)	(2.5, 4.5, 6.25)
A3	(5.5, 7.5, 9.25)	(6.5, 8.5, 9.75)	(7, 9, 10)	(7, 9, 10)	(6, 8, 9.5)	(5.5, 7.5, 9.25)	(5, 7, 8.75)	(5, 7, 8.5)
A4	(5, 7, 8.75)	(5.5, 7.5, 9)	(5.5, 7.5, 9)	(6, 8, 9.5)	(5, 7, 8.75)	(5, 7, 8.5)	(3.5, 5.5, 7.25)	(4, 6, 7.75)
	C25 (B)	C26 (B)	C27 (B)	C28 (B)	C29 (B)	C30 (B)	C31 (B)	C32 (B)
A1	(5.5, 7.5, 9)	(5, 7, 8.75)	(3, 5, 7)	(1.25, 3, 5)	(1, 2.5, 4.5)	(6, 8, 9.5)	(6, 8, 9.5)	(5, 7, 8.75)
A2	(5.5, 7.5, 9.25)	(4.5, 6.5, 8.5)	(3, 5, 7)	(3.5, 5.5, 7.25)	(2.5, 4.5, 6.25)	(5.5, 7.5, 9.25)	(5, 7, 8.75)	(3, 5, 7)
A3	(6.5, 8.5, 9.75)	(6, 8, 9.5)	(4.5, 6.5, 8.5)	(5.5, 7.5, 9.25)	(5.5, 7.5, 9.25)	(7, 9, 10)	(5.5, 7.5, 9.25)	(4.5, 6.5, 8.5)
A4	(6, 8, 9.5)	(5.5, 7.5, 9.25)	(3, 5, 7)	(3.5, 5.5, 7.25)	(3.5, 5.5, 7.25)	(5, 7, 8.75)	(4.5, 6.5, 8.25)	(3.5, 5.5, 7.25)

Note: (B): *benefit* criteria; (C): *cost* criteria

Table 4
The normalised fuzzy decision matrix

	C1 (C)	C2 (C)	C3 (C)	C4 (B)	C5 (C)	C6 (B)	C7 (B)	C8 (B)
A1	(0.59, 0.73, 1)	(0.59, 0.73, 1)	(0.47, 0.62, 0.89)	(0.42, 0.63, 0.84)	(0.51, 0.59, 0.77)	(0.65, 0.85, 0.98)	(0.67, 0.87, 1)	(0.51, 0.72, 0.92)
A2	(0.56, 0.65, 0.85)	(0.61, 0.73, 1)	(0.48, 0.62, 0.89)	(0.42, 0.63, 0.82)	(0.57, 0.71, 1)	(0.65, 0.85, 0.98)	(0.62, 0.82, 0.97)	(0.62, 0.82, 0.97)
A3	(0.55, 0.61, 0.79)	(0.59, 0.73, 1)	(0.52, 0.67, 1)	(0.63, 0.84, 1)	(0.54, 0.67, 0.91)	(0.7, 0.9, 1)	(0.67, 0.87, 1)	(0.67, 0.87, 1)
A4	(0.59, 0.73, 1)	(0.59, 0.73, 1)	(0.48, 0.62, 0.89)	(0.47, 0.68, 0.87)	(0.53, 0.63, 0.83)	(0.65, 0.85, 0.98)	(0.62, 0.82, 0.95)	(0.67, 0.87, 1)
	C9 (B)	C10 (B)	C11 (B)	C12 (B)	C13 (B)	C14 (B)	C15 (B)	C16 (B)
A1	(0.59, 0.81, 1)	(0.58, 0.79, 0.95)	(0.31, 0.51, 0.72)	(0.36, 0.56, 0.77)	(0.41, 0.62, 0.82)	(0.38, 0.59, 0.81)	(0.37, 0.58, 0.76)	(0.65, 0.85, 0.98)
A2	(0.49, 0.7, 0.89)	(0.63, 0.84, 1)	(0.51, 0.72, 0.9)	(0.51, 0.72, 0.9)	(0.51, 0.72, 0.9)	(0.49, 0.7, 0.89)	(0.42, 0.63, 0.82)	(0.65, 0.85, 0.98)
A3	(0.59, 0.81, 1)	(0.63, 0.84, 1)	(0.67, 0.87, 1)	(0.67, 0.87, 1)	(0.67, 0.87, 1)	(0.59, 0.81, 1)	(0.58, 0.79, 0.97)	(0.7, 0.9, 1)
A4	(0.59, 0.81, 0.97)	(0.63, 0.84, 1)	(0.51, 0.72, 0.9)	(0.51, 0.72, 0.9)	(0.56, 0.77, 0.92)	(0.49, 0.7, 0.89)	(0.63, 0.84, 1)	(0.55, 0.75, 0.93)
	C17 (B)	C18 (B)	C19 (B)	C20 (B)	C21 (B)	C22 (B)	C23 (B)	C24 (B)
A1	(0.67, 0.87, 1)	(0.67, 0.87, 1)	(0.65, 0.85, 0.98)	(0.65, 0.85, 0.98)	(0.58, 0.79, 0.97)	(0.19, 0.38, 0.59)	(0.46, 0.69, 0.91)	(0.29, 0.53, 0.76)
A2	(0.56, 0.77, 0.95)	(0.56, 0.77, 0.95)	(0.6, 0.8, 0.95)	(0.6, 0.8, 0.95)	(0.58, 0.79, 0.97)	(0.32, 0.54, 0.76)	(0.57, 0.8, 1)	(0.29, 0.53, 0.74)
A3	(0.56, 0.77, 0.95)	(0.67, 0.87, 1)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.63, 0.84, 1)	(0.59, 0.81, 1)	(0.57, 0.8, 1)	(0.59, 0.82, 1)
A4	(0.51, 0.72, 0.9)	(0.56, 0.77, 0.92)	(0.55, 0.75, 0.9)	(0.6, 0.8, 0.95)	(0.53, 0.74, 0.92)	(0.54, 0.76, 0.92)	(0.4, 0.63, 0.83)	(0.47, 0.71, 0.91)
	C25 (B)	C26 (B)	C27 (B)	C28 (B)	C29 (B)	C30 (B)	C31 (B)	C32 (B)
A1	(0.56, 0.77, 0.92)	(0.53, 0.74, 0.92)	(0.35, 0.59, 0.82)	(0.14, 0.32, 0.54)	(0.11, 0.27, 0.49)	(0.6, 0.8, 0.95)	(0.63, 0.84, 1)	(0.57, 0.8, 1)
A2	(0.56, 0.77, 0.95)	(0.47, 0.68, 0.89)	(0.35, 0.59, 0.82)	(0.38, 0.59, 0.78)	(0.27, 0.49, 0.68)	(0.55, 0.75, 0.93)	(0.53, 0.74, 0.92)	(0.34, 0.57, 0.8)
A3	(0.67, 0.87, 1)	(0.63, 0.84, 1)	(0.53, 0.76, 1)	(0.59, 0.81, 1)	(0.59, 0.81, 1)	(0.7, 0.9, 1)	(0.58, 0.79, 0.97)	(0.51, 0.74, 0.97)
A4	(0.62, 0.82, 0.97)	(0.58, 0.79, 0.97)	(0.35, 0.59, 0.82)	(0.38, 0.59, 0.78)	(0.38, 0.59, 0.78)	(0.5, 0.7, 0.88)	(0.47, 0.68, 0.87)	(0.4, 0.63, 0.83)

Based on the classification, the FPIS (A^+) and FNIS (A^-) are determined, respectively. The TFNs in the normalised fuzzy decision matrix are defined in the interval $[0,1]$, hence the FPIS (A^+) and FNIS (A^-) are defined as follows:

$$A^+ = [(0,0,0),(0,0,0),(0,0,0),(1,1,1),(0,0,0),(1,1,1),\dots\dots\dots$$
$$\dots\dots\dots\dots\dots,(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1),(1,1,1)]$$

$$A^- = [(1,1,1),(1,1,1),(1,1,1),(0,0,0),(1,1,1),(0,0,0),\dots\dots\dots$$
$$\dots\dots\dots\dots\dots,(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0),(0,0,0)]$$

Next step is to obtain the weighted distance. First, the distance measurement of each SMF to FPIS (A^+) and FNIS (A^-) is measured and the example of the alternative 1 (A1) with respect to criterion 1 (vessel operating costs: C1) is shown as follows:

$$d_1^+ = d(v_{11}, v_1^+) = \sqrt{\frac{1}{3}[(0.59-0)^2 + (0.73-0)^2 + (1-0)^2]} = 0.7940$$

$$d_1^- = d(v_{11}, v_1^-) = \sqrt{\frac{1}{3}[(0.59-1)^2 + (0.73-1)^2 + (1-1)^2]} = 0.2802$$

Similarly, the distances of the SMF with respect to other criteria can be derived. Then, the weighted distance of the A1 with regard to all criteria is obtained and the distances and weighted distances of all alternatives against all criteria are calculated in the similar way.

$$s_1^+ = \sum_{j=1}^{32} d_1^+ w_j = 0.4147$$

$$s_1^- = \sum_{j=1}^{32} d_1^- w_j = 0.6458$$

Lastly, a closeness coefficient is required to determine the ranking order of all SMF and the example of the A1 is shown as:

$$CC_1 = \frac{s_1^-}{s_1^+ + s_1^-} = \frac{0.6458}{0.4147 + 0.6458} = 0.6089$$

The closeness coefficient of the other 3 SMF can be obtained in a similar way and the results are shown as follows:

$$CC_2 = 0.6196, CC_3 = 0.6902, CC_4 = 0.6280$$

The SMF can be ranked in terms of their closeness coefficient value. A SMF with a closeness coefficient close to 1 indicates the best one. On the other hand, a SMF with a closeness coefficient far from 1 means the longest distance from the FPIS (A^+) and the shortest distance from the FNIS (A^-). The ranking order of the 4 SMF is identified as follows:

$$A3 > A4 > A2 > A1$$

On the grounds of the results, candidate A3 representing the largest closeness coefficient value is selected as the most suitable SMF, followed by candidate A4 and A2, while A1 is the poorest SMF (Table 5). Despite the ranking, the result also indicates that the overall performance evaluations of the four alternative SMFs are not significantly different given that the four selected SMFs are top companies in shipping management in the world.

Table 5
The closeness coefficient and rank of 4 SMF

SMF	s_i^+	s_i^-	CC_i	Ranking
A1	0.4147	0.6458	0.6089	4
A2	0.4032	0.6569	0.6196	3
A3	0.3295	0.7339	0.6902	1
A4	0.3944	0.6657	0.6280	2

6. Concluding Remarks

The study empirically assessed the overall performance and rank of the SMF by adopting an integrated model of AHP and Fuzzy TOPSIS so as to support the critical decision making on SMF selection under multiple criteria. The result suggests that the best alternative SMF revealed according to CC_i values (Table 5) is A3 followed by the SMF A4 and A2. In contrast, A1 is assessed to be the least competitive SMF which has the lowest performances in most criteria. The possible explanation would be that in reality A3 is the largest SMF in terms of employees and vessel management. Additionally, it has the widest cover of services including technical management, purchasing, crewing and/or accounts, quality and safety management, chartering, freight management, surveys, voyage planning and estimates, insurance, sale and purchase, bunkering, vessel operations, consultancy, ship building and shipping finance.

Based on the results, it is possible for us to provide the strengths and weaknesses of the four target SMF and strategic suggestions. The result shows that A3 is superior to other alternatives overall but is less competitive against six sub-factors such as cheap consumables, crew, storing and maintenance, flexibility, personal recommendation, and CSR. Accordingly, managers of A3 can recognise the particular areas for improvement so as to enhance their competitiveness. On the other hand, A4 has its strength in management fees, technical ability, skilled crew manning, and storing and maintenance, but lacks economies of scale, problem solving ability, information technology, communication and reliability. The SMF should not only take into account of competency of ship and crew management and reasonable costs, but also be aware that organisational characteristics and image can be other sources of competitiveness.

In first hierarchy, according to local and normalised weights of criteria (Table 1), it is uncovered that competency is the most important criterion, followed by cost, courtesy, organisation characteristics and image. The result is in line with Branch and Robarts's (2014) finding that ship owners have strived to ensure the quality assurance by relying on SMF's competency in crewing and technical/commercial ship management as a major driving force of the SMF expansion during the last three decades. Interestingly, cost is the second important factor of SMF selection. It is plausible that one of the major rationales behind outsourcing is to take advantage of reduced costs and economies of scale in vessel operations. This finding is consistent with general argument in logistics research that when it comes to third-party logistics provider selection, a manufacturer is likely to outsource its logistics function due to logistics provider's economies of scale in transportation (Kumar and Singh, 2012). In the sub-hierarchy, the result indicates that vessel operating costs, safe operation of vessels, crew fee, skilled crew manning, crew training system, professionalism, and problem solving ability are viewed as the most important factors in selecting SMF.

In this study, TOPSIS has been successfully adopted to implement the SMF selection framework in real case applications. The application for the selection framework is in particular useful in dealing with following advantages. First, TOPSIS presents the ranking of the SMF in terms of their overall performance with respect to multiple criteria as well as a single criterion's ranking and performance rate. This feature enables to identify the strengths and weaknesses of the SMF and offers insights to the SMF to find optimal strategies to improve their performance. Second, we use a weighted distance measurement rather than the weighted normalised decision matrix. This approach represents the calculation process in a simplified manner. Third, the TOPSIS has proven to be a sound approach in dealing with MCDM problems which the previous studies have done little with on the selection of the most suitable SMF, particularly in the regions out of EU.

Outsourcing ship management has become a common practice for ship owners due to increasing complexity of shipping business. Accordingly, the SMF selection would play a vital role in the shipping industry. Even in the period of steady growth of SMF, the extant literature has overlooked SMF selection issues using empirics in a systematic way. By employing an AHP-Fuzzy TOPSIS methodology, this study has firstly established a benchmarking framework for SMF in the Korean context in order to appraise the SMF selection issues. It provides both shipping companies and SMFs with valuable insights as this framework allows them to (1) better understand customers' preference during MCDM; (2) identify current strengths and weaknesses of their firms; (3) better appreciate the conditions and status of their competitors; and (4) improve competitiveness and customers' satisfaction by adjusting their strategies based on the relative importance of factors, which are reflected by customers' perception. From the ship owners' perspective, decision making of choosing the most suitable SMF has been a demanding task due to a lack of objectivity and quantification. Accordingly, this framework of an AHP/Fuzzy TOPSIS may not only provide the identification of SMF selection factors, but also guide them to determine the weights to be applied to SMF selection, thus removing the difficulty and uncertainty in judging the most appropriate SMF.

Nonetheless, this study has some limitations. First, we considered the criteria as an independent nature, but the SFM selection framework may require an essential understanding of the cause-effect relationship among the influencing criteria. Second, the relative weights of criteria were obtained using a crisp AHP instead of fuzzy AHP. Should linguistic variables for weighting process be considered in the future work, it is important to consider the use of fuzzy numbers or fuzzy AHP to reflect the uncertainty and imprecision issue. Third, with regard to the difficulty of collecting quantitative data this framework used only qualitative criteria. In order to tackle the data collection issue, it needs to adopt a powerful assessment tool capable of conducting the framework with data in uncertainty. For instance, a fuzzy evidential reasoning (FER) could be a suitable approach to deal with missing data problems. Finally, this study is drawn from samples in Korea which may have some typical nuances. A follow-up study involving a wider selection of case companies from different parts of the world would strengthen the application of this methodology

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