Graduate School of Management
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Technique development of maritime transportation service supplier selection

Master's Thesis by 2nd year student
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Concentration – International Logistics & Supply Chain Management

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St. Petersburg
2017

ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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Ключевые слова	морская цепочка поставок; контейнерные перевозки; выбор морского перевозчика; АПИС метод; экспертная оценка

ABSTRACT

Master Student's Name	Nadezhda Zapisova
Master Thesis Title	Technique development of maritime transportation service supplier selection
Main field of study	Master in Management
Year	2017
Academic Advisor's Name	Nikolay A. Zenkevich, Associate Professor
Description of the goal, tasks and main results	**Main goal**: technique development of multi-criteria selection of maritime transportation service supplier and application of results on the chosen case company **Research tasks**: • Define the criteria of maritime service supplier selection • Define the technique of maritime transportation service supplier selection • Apply the technique to the case company **Research results**: • Criteria of maritime transportation service supplier selection were defined • On the base of APIS method the technique of selection of maritime transportation service supplier was created • The technique was applied to maritime transportation service supplier selection for LLC Leaap
Keywords	maritime supply chain; containership transportation; maritime carrier selection; APIS method; expert evaluation

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Introduction

The current globalization level and the level of economic development as characteristics of contemporary business environment would be impossible to achieve without the support of logistics. Companies are expanding their operations and starting to be present globally in diverse countries and the necessity of effective maritime transportation is rising.

From the origins, this type of transportation has been dominant in international trade. More than 80% of global trade is carried by sea. Maritime transport also makes influence on industrial development by promoting trade and economic integration, supporting manufacturing growth.

Such problem as technique improvement of maritime transportation service supplier selection is one of the most crucial nowadays, with necessity of such service provider selection face variable range of companies – from the buyers of the product to the intermediaries of the maritime supply chain, freight forwarding companies. All the customers of maritime transportation need goods with less delivery time, less cost and adequate service level in order to increase their market competitiveness.

For the present day the literature covers the topic of criteria for maritime transportation service supplier selection, but it is evident that there is lack of method of prompt selection of the most suitable maritime transportation service supplier or carrier according to the particular situation (the certain order, the specific time frames and etc.).

Therefore, the main *objective* of this paper is to solve given problem and make technique development of multi-criteria selection of maritime transportation service supplier based on comparison of expert questionnaires and application of results on the chosen case company

In order to achieve the stated goal, the next *tasks* should be completed:

- Define the criteria of maritime service supplier selection
- Define the technique of maritime transportation service supplier selection
- Apply the technique to the case company

The current master thesis has the following structure: introduction, three chapters, each of those covers the tasks listed above, conclusion, references and appendices.

The introduction gives the overview of the paper, of the main goal and tasks and the relevance of the work. The first chapter is devoted to the theoretical perspectives of maritime supply chain creation. It covers the current state of the maritime supply chain, describes its main trends and main elements of the chain. Also the chapter provides with the literature review of the

criteria of selection of maritime transportation service supplier and finishes with the statement of the problem of such selection.

In the second chapter the research methodology is considered: methods for supplier selection are discussed and the most suitable one particularly for maritime transportation service supplier selection is stated. Moreover, the chapter covers the criteria of selection and illustrates the hierarchical system of characteristics based on which the selection decision is made. Also the implementation steps of the selection algorithm are given in detail.

The last chapter is devoted to the application of technique for a chosen freight forwarding company Leaap LLC in order to show how the method actually works. The managers of company's logistics department took place in the characteristics' estimation that gave an opportunity to gain the final results of supplier selection. Furthermore, the last chapter highlights the value of method utilization.

Conclusion explains once more how the tasks were achieved and what is the scientific and managerial application of current work and what are the future research opportunities and limitations. The list of references consists of the recently published articles together with the pillars of current supply chain literature. There are six Appendices that are devoted to the research methodology, and help to understand the use of chosen methods. They consist of the questionnaire and output information from the decision support system used to reach the stated goal of the Paper.

CHAPTER 1. THE PROBLEM OF MARITIME TRANSPORTATION SERVICE SUPPLIER SELECTION

1.1 Trends and definitions of maritime supply chain

Before the analysis of maritime supply chain it is necessary to give the definition of Supply Chain Management (further referred as SCM). Despite the high popularity of this concept generally accepted definition does not exist yet. Some researches understand SCM as a management philosophy in the first place, the main aim of which is to ensure that companies are properly set to maintain the material flow of resources and goods from supplier to customer (Lambert, 2014). Others define SCM as an implementation of given philosophy through business processes. Nevertheless, the material and information flows are not the only components of SCM, the other crucial part is creation of benefits. (Stock et al, 2010) They include three different outputs: development of efficiencies, satisfaction of customers and adding value. The interconnection among all three outputs work as follow:

- Organization of transportation on assembly line adds value to the product;
- The process of adding value is controlled by efficient management (addition in value should be greater than associated with it costs);
- Creation of operating synergy, improving of competitive advantages can be the way to achieve efficiency in managing;
- For that more data is required and extra flow of information is needed, that can be gained with the designing of supply chain network and closer cooperation with customers
- If customers' needs are analyzed and demand is determined, customer satisfaction can be reached.

So, supply chain management is considered as tool for potential optimization of supply chain adding value. The definition provided by Council of Supply Chain Management Professionals can be seen as a combination of different views on the concept: «SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies» (CSCMP.org, 2016)

Proposed definition includes term "logistics", however, the interrelation of SCM and logistics is not clearly defined. Larson and Halldorsson divide it into four possible perspectives: traditionalists' one that supposes SCM as a special type of logistics; intersectionist's distinguishes these two concepts based on the decision making level: strategic relatively to SCM

and tactic – to logistics; unionist perspective defines logistics as a part of SCM; re-labeling perspective, the one that is used as a basis for current thesis, states that SCM and logistics are total synonyms and can be used as a substitutes. (Larson and Halldorsson, 2004).

As an object of current work maritime supply chain will be considered as part of the whole supply chain. With the globalization of supply chain maritime transport has become an essential part of it. From the origins, this type of transportation has been dominant in international trade. More than 80% of global trade is carried by sea. (Ng & Liu, 2010). Maritime transport also makes influence on industrial development by promoting trade and economic integration, supporting manufacturing growth. (UNCTAD, 2016) From the end of 20th century various factors changed the shape of the industry, they include the emergence of markets, specialization of production activities, and global trade growth.

Maritime transportation, as a key part of logistics system, is in charge of carrying cargoes across the oceans and connects transportation linkages between shippers and consignees. This way of transportation should be fully integrated into the supply chain model in order for unnecessary costs, delays not to arise. (O'Leary-Kelly and Flores, 2002) The interaction of maritime logistics with some other parts of a logistics chain is presented in the Figure 1.1 below.

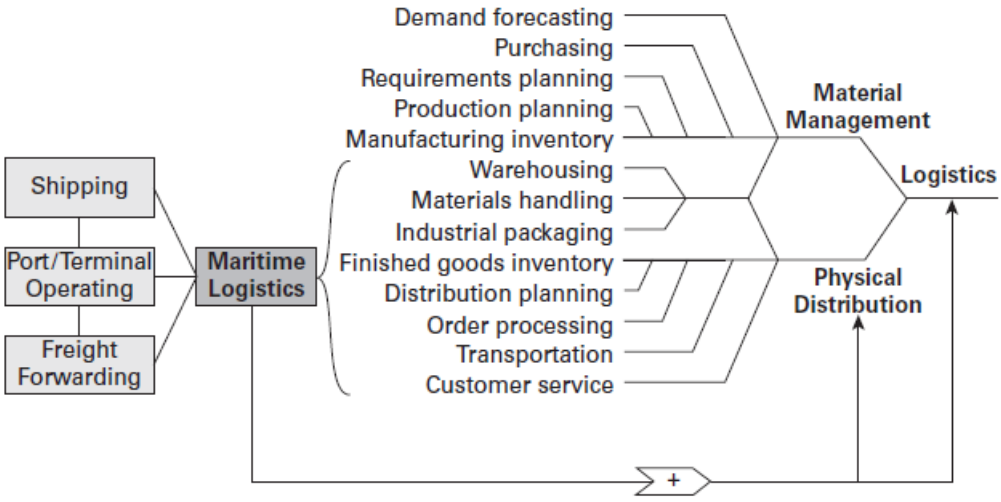

Figure 1.1 Maritime logistics in the entire logistics system

Source: Song and Panayides, 2012

Maritime supply chain is defined as the connected series of activities pertaining to shipping services which is concerned with planning, coordinating and controlling containerised cargoes from the point of origin to the point of destination'.(Lam, 2011) The main goal of the chain is to add value to the transported goods. In order explain the value of maritime logistics, the definition of the term "value" should be given. Thus, Anderson and Narus (1991) explain the

value as “the perceived worth in terms of the economic, technical, service and social benefits received by a customer firm in exchange for the price paid for a product offering”. The customers in the considered industry are mostly shippers who are looking for shipment services. The main criteria of their demand are low price, reliable service provider, flexibility and time of service provided. Therefore, the main value of maritime logistics for a customer includes lead time reduction as well as cost reduction and quality of service.

Each participant of the chain is responsible for some part of the process. Manufacturers, distributors, freight forwarders, shippers, terminal operators and other parties – all of them have individual role in the maritime transportation.

Maritime logistics system consists of primary and secondary operations. The primary ones include activities of main maritime operators – shipping lines, terminal operators, and freight forwarders. The secondary ones are supportive operations that assist the efficiency of the primary activities. As in every field of businesses there are some additional operations, for example financial support, human resource management or information technology systems. (Song and Panayides, 2012) As in the further chapters of the paper the emphasis will be made on relationships between players of the maritime supply chain, it is necessary to provide the overview of one of core parts of these relationships - the main documentations used in the considered industry.

Firstly, in maritime transportation players always face with such document as Bill of Lading (BL). (BusinessDictionary.com, 2016) Bill of Lading is a document issued by a shipping line to the owner of cargo. It serves several functions: averment that the cargo was loaded, some terms of the carriage contract, its conditions and it represents a document of title to the goods. BL can be issued after customs clearance and it is needed to be presents at the destination place in order to get the cargo. The information included in BL is the following: name and contacts of shipper, consignee and notify party; port of loading (POL) and port of delivery (POD) names; primary vessel name and voyage number; estimated time of departure (ETD) and estimated time of arrival (ETA); list of goods with its description such as weight, volume, number of packages etc.; freight term; free days number at POD.

Simple form of BL is Sea Waybill or Seaway. It becomes more and more popular nowadays. Main distinction is that the latter is not a document of title and there is no need for the document to be presented at the moment of goods release. As import formalities are completed, carrier can release the cargo to consignee. It is the way of switching to electronic data interchange and a great input in global trade development.

Booking note, another important document used in maritime logistics, is issued by the shipping line and contains the conditions of contract between the shipper and this line. It

specifies ports of discharge and loading, includes special handling information and cargo details. Packing list, next example of essential documentation, is created by the shipper for following accurate calculation after delivery of cargo to consignee. It contains detailed description of the cargo (weight, quantity, volume etc.)

Agreements between the seller and buyer, or consignor and consignee as parts of maritime supply chain are made according to different Incoterms' types (commercial terms in relation to International commercial law). The rules of Incoterms aim to clearly explain tasks, costs and risks associated with goods' delivery and transportation. These rules are governmentally accepted and practitioners all over the world interpret the terms in international trade in common way. Also Incoterms help to reduce uncertainty that is result of variety in the rules' interpretation.

In order to understand the structure of Incoterms and their functionality, some basic notions are necessary to be provided. Transport, delivery point, cost and risks are the most crucial ones. (Tan and Thoen, 2000) The goods' transportation includes three parts: from the seller's premises to the boarder of the country of origin; main part of transportation from the border of the country of origin to the border of destination country; from the boarder of destination country to the premises of buyer.

The second crucial basic notion is a delivery point that is important for the risk/costs transfer between the seller and buyer. Major delivery points are: the seller's depot door; the point where goods are cleared for export, and located in the custody; the point where goods are placed next to the ship; where they are placed on board; where the goods are at the order of origin country; where the goods are on board at destination point and are waited for import clearance; where the goods are at destination and cleared for import; the point at the buyer's depot door and waited to be cleared for import and, finally, cleared goods next to buyer's door point.

Cost, in its turn, contains all the expanses that are taken into account when making an agreement. Costs as an Incoterm notion, includes the next groups: direct cost of transportation of goods to the handing over to buyer (these costs can be spread between the parties and contain the cost for loading to the board of ship and unloading from it, cost for goods' delivery from seller's premises to the quay and from the board to the premises o buyer and cost for shipment itself); costs for export/import clearance – administrative charges, VAT and others; costs for service maintenance and its assistance; costs for insurance. (Tan and Thoen, 2000)

First time the list of Incoterms was published in 1936 and was updated on a periodic basis; the latest, 8th version was published in 2011 and called "Incoterms 2010". The term "Incoterms" itself is the International Chamber of Commerce' (ICC) trademark. It is necessary to

describe main of them. The list of most used types of Incoterms related to maritime logistics is the next (Iccwbo.org, 2016):

- Ex Works – maximum obligations are on buyer side, seller makes the cargo available at their premises
- Free Carrier (FCA) – seller delivers the goods (that is already cleared for export) at defined place
- Delivery Duty Paid (DDP) – seller is responsible for delivery goods to named place, but not for its unloading
- Free on Board (FOB) – before loading everything including risks and costs is "on seller", also the party is responsible for loading on vessel too.
- Cost and Freight (CFR) – step ahead than FOB Incoterm. Seller is responsible for payment of cost and freight to the port of destination. Risks passes to buyer when onboard the vessel
- Cost, Insurance and Freight (CIF) – seller is responsible for carriage of goods till the POD. Also insurance during the transit time is also paid by seller and etc.

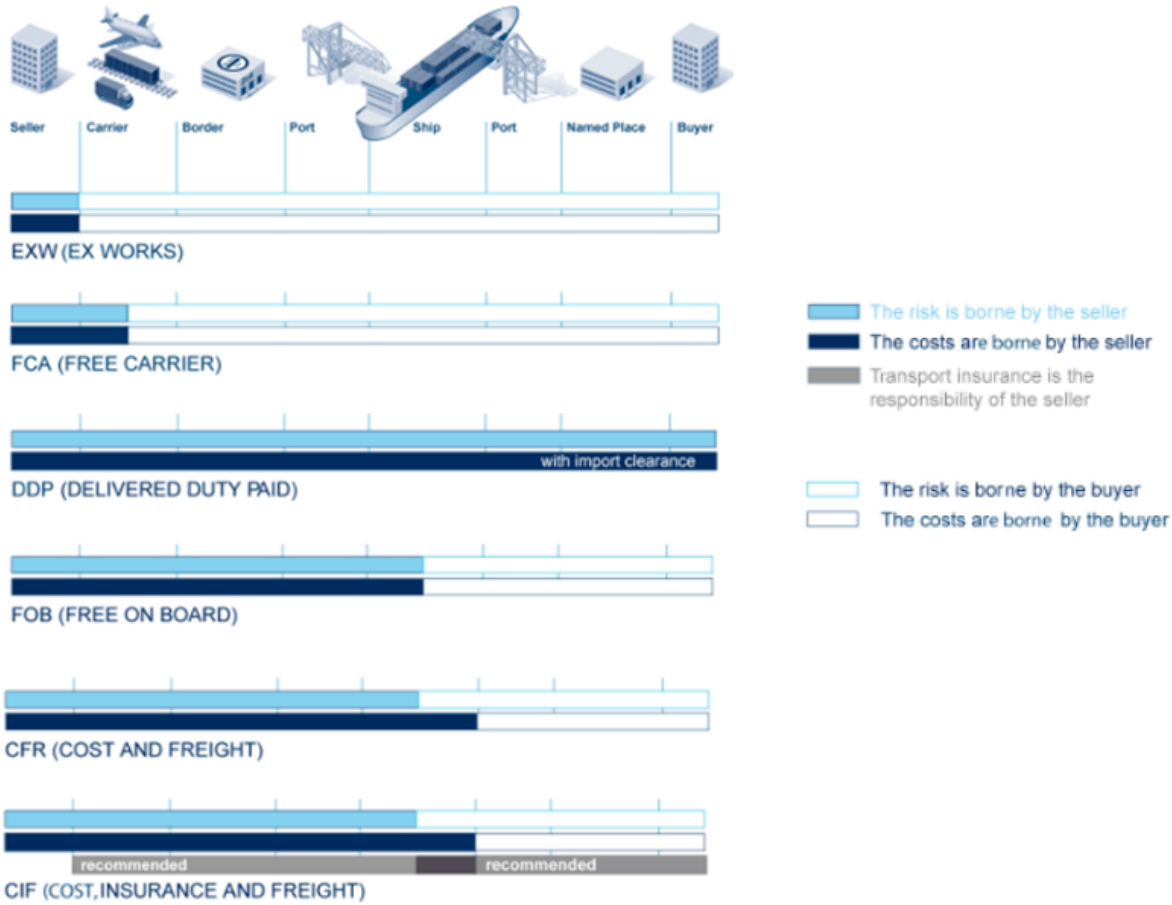

Figure 1.2 Incoterms: Seller/Buyer Risks, Costs and Obligations Transfer

Source: SeaRates, 2017

More demonstrably the listed Incoterms are explained on the Figure 1.2 above. Seller and buyer risks, costs and obligations transfer are shown according to the goods location in the supply chain – from seller to buyer with such elements as borders, ports and etc. As it can be seen, Incoterms cover three points of shipment – cost, control and liability. Each Incoterm defines concretely which of two parties pays which cost, controls which part of shipment and which risk takes.

As far as liner shipping industry is concerned, such parties as seller of buyer usually delegate the process of logistics functions execution to some logistics operator. That makes possible to gain higher level of concentration on the core competencies of companies and helps to improve company's competitiveness and its operational processes. Hannon (2003) defined that such logistics operators can provide the logistics services in faster and cheaper way and it is the key reason for interest in their services.

According to the Krakovics at al. (2008), 1PL is a company that doesn't use the logistics services of another company and executes logistics by its own. 2PL company provides a simple range of logistics services, the example can be transportation or storage. 3PL companies that are mostly discussed in this Paper, are operators that offer wide range of logistics management and services. So, these third-party logistics providers have the next characteristics, according to Tezuka, 2011:

1. Integrated (multi-modal) logistics service providers
2. Service providers that are contract-based
3. Service providers that act as a consultants

Competent third-party logistics providers should be experts in coordination that makes possible for them to define reliable partners and manage goods flow in the most efficient way. Specialized 3PL providers can use the advantage of their built experience and accumulated know-how. Also experienced providers that have large customer base can be able to take part in logistics activities in more cost-efficient manner. In comparison with 2PL providers, 3PL ones go beyond logistics and offer customers value-added services, the ones that integrate parts of SC. Also they provide customized services that are specialized according to the needs of particular customer. This customization is always lead by costs and it is the basis for long-term cooperation between provider and customer and contractual nature of the relationships in the 3PL segment. The evolution of 3PL providers is represented by 4PL firms that are in charge of hiring other 3PL and 2PL and managing the end-to-end overall process; they operate as a single connection between a logistics service customer and the service operators.

There can be defined three main trends in liner shipping industry:

1. *Scale economy*.

This trend is explained by increased sizes of vessels (mega-sized container vessels) and more frequent shipments. As the industry is quite capital-intensive, such trend leaded to increase of entry and exit barriers for companies. (Notteboom, 2002). Global economic crises impacted negatively on the industry, while mega-sized vessels were trying to fill the space. In this time the capacity fell almost by 15% (Slack, 2010). The main struggle was to decrease the costs with the help of transforming the routings, leaving some unprofitable markets and etc. Despite this unfavorable conditions, the main players were still followed their goals and set directions; they moved on in construction of new mega-sized vessels.

Table 1.1. The order book of container vessels, 2011–2015.

Ship size in TEU	Scheduled delivery year					Total	Percentage (%) of current fleet
	2011	2012	2013	2014	2015		
<500	4	0	0	0	0	4	1.0
500–999	26	3	0	0	0	29	3.5
1,000–1,499	36	24	3	4	0	67	9.6
1,500–1,999	14	3	6	2	0	25	4.3
2,000–2,499	6	1	0	0	0	7	2.3
2,500–2,999	11	9	8	0	0	28	7.0
3,000–3,999	12	11	18	0	0	41	12.2
4,000–4,999	34	52	17	2	0	105	17.9
5,000–5,999	12	4	2	0	0	18	5.9
6,000–6,999	8	13	3	0	0	24	12.2
7,000–7,999	11	12	0	0	0	23	52.3
8,000–8,999	19	23	31	14	0	87	45.3
9,000–9,999	4	0	8	1	0	13	22.4
10,000+	40	59	38	15	3	155	203.9
Total	237	214	134	38	3	626	12.5

Source: Song, D. and Panayides, P. (2012).

As can be seen from the Table 1.1., the number of mega-sized vessels (with twenty-foot equivalent unit (further referred as TEU) more than 10 000) was more than 200% of existing global fleet. And as the trend of scale economy is still associated with the industry, this number is likely to be growing in future as well. But yet the problem of overcapacity exists. Demand is less than supply and is unable to fill the space provided. (Slack, 2010) The decision companies use is concentrating on major routes with high level of demand (represented by East Asia, North America and North Europe (Wang & Ng, 2011). As was mentioned, with necessity of high level of investments, the profitability is comparatively low that increases the competition in the industry. For shipping lines in order to stay competitive the choice of geographical market to be present in is crucial. Main player of the industry organized the next system – trans-continental vessels use several ports within some region for loading and unloading of the containers. At the

same time vessels of the less capacity, in their turn, take the containers to the destination point. (Slack, 2003)

2. *Restructuring*.

Another trend in the liner shipping industry that helps players to stay competitive on the market is horizontal integration (mergers and acquisitions, creating alliances). Liner shipping co-operation plays important role in the long-term sustainability of the companies. The most used type of alliances is strategic one. (Slack et al., 2002). The aim of latter is co-operation in the ships utilization on defined routes, vessel schedules and container coordination. Joint sales, marketing activities, assets ownership, profit sharing, management functions are not part of such alliances. There are other types of possible collaboration between liners, such as vessel- and slot-sharing agreements. They can be explained as exchange of vessel capacity between carriers or demand satisfaction by working together on particular route with optimization of schedules. sharing (Heaver, Meersman, & Van de Voorde, 2005).

Mergers and acquisitions represent closer integration between companies. Such full collaboration leads to more cost saving in comparison to slot-sharing process. Lei, Fan, Boile, and Theofanis (2008) The advantages of such practice also include:

- Protection of market shares
- Exchange of information and knowledge
- Improved perception of markets
- Wider geographical presence
- Cost reduction based on slot-sharing availability
- Stronger position on the market and etc.

Main objectives of entering alliances are to share the financial risks and gaining the power to expand. Nowadays almost all of companies of the industry are parts of particular alliances and only limited number of shipping lines is still playing alone. The Table 1.2 below shows the development of big three alliances through years.

3. Differentiation.

The third trend of maritime transportation is represented by differentiation of shipping lines, especially vertical integration – diversification of operation activities through the multimodal supply chain. The level of freight integration is increasing; lots of functions are under control of single companies. Some shipping lines take part in the operation of port terminals and inland transportation. Some of them even established logistical representative offices and subsidiaries, for example APL Logistics, OOCL Logistics and etc. These logistical branches can serve as service providers and have functions of freight forwarders, custom agents

and other parties of maritime supply chain (in more detail the participants of maritime SC will be discussed in the second part of this chapter). Integration of shipping lines also let shippers to save time for searching for different service suppliers.

The representative of integrated shipping line - Maersk Line – offers door-to-door services (Maersk Logistics), manages inland transportation, operations in container terminal. This allows Maersk to be a competitor to various freight forwarding companies in fulfilling the shippers' demand.

Table 1.2. Participants of big three strategic alliances

1996			
	Global Alliance	Grand Alliance	Hanjin/Tricon
Main partners	APL, Nedlloyd, MOL, OOCL, MISC	Hapag-Lloyd, NYK, NOL, P&OCL	Cho Yang, DSR/ Senator, Hanjin
Capacity (TEU)	209.645	255.705	199.404
No. of vessels	65	72	72
2000			
	New World Alliance	Grand Alliance	United Alliance
Main partners	APL-NOL, MOL, HMM,	Hapag-Lloyd, P&O Nedlloyd, OOCL, MISC	Cho Yang, DSR/ Senator, Hanjin
Capacity (TEU)	325.487	350.197	277.000
No. of vessels	90	93	85
2006			
	New World Alliance	Grand Alliance	CKYH
Main partners	APL, MOL, HMM	Hapag-Lloyd, OOCL, MISC Berhad, NYK Line	Hanjin, Yang Ming, K Line, COSCO
Capacity (TEU)	712.082	966.570	1.046.991
No. of vessels	223	Approx. 350	354
2010			
	New World Alliance	Grand Alliance	CKYH
Main partners	APL, MOL, HMM	NYK, Hapag-Lloyd, OOCL	Hanjin, Yang Ming, K Line, COSCO
Capacity (TEU)	1.161.468	1.187.607	1.548.508
No. of vessels	282	288	400

Sources: Midoro and Pitto (2000), Ferrari (2008), Slack et al. (2002),

The described trends demonstrate the complexity of the industry itself. Players try to struggle for customers, offer less price with greater number of services available, penetrate new markets and become leaders in existing ones. As the major players of the market are shipping lines, that operate as a maritime transportation service providers, the secondary but not minor players of the industry are the service support providers. The scopes of activities and main functions of the players of maritime supply chain will be discussed in the following part.

1.2. Main elements of maritime SC: freight forwarders and port/terminal operators

In order to observe the main players of maritime supply chain it is necessary to make an overview of process of the chain itself, as each of participants has its own roles and function in overall process.

As it was mentioned above, the customer of the service mainly is a shipper or a consignee. The party is using a service of freight forwarder or directly addresses to the shipping line. Freight forwarder, in its turn, gets the request of the shipper or consignee and connects with shipping line to provide the service. Shipping line is the customer of port/terminal operators. The process of these primary operations of maritime logistics system results in the added value to the main customer.

The process of secondary activities performed by logistics services includes the functions that support forwarding, shipping services and port operations. It can be an inventory management, warehousing, inland transportation, tracking services, packing, intermodal operations and etc. As was already stated in the first part of the chapter, additional activities such as human resource management, information and finance support tend to provide the better efficiency of the overall transportation system.

On the Figure 1.3 the main links of the chain are listed. The chain starts with the production site, or shipper/consignor site. Then the goods are transported to the port either by shipper itself of with the help of freight forwarder, shipping company and etc. Port agents, terminal operators, freight forwarders manage the port handling procedures before and after the voyage and shipping line executes the voyage itself. The next step is delivery the cargo to the consignee or buyer; it can be made either by consignee's own or with the help of freight forwarder, shipper and others.

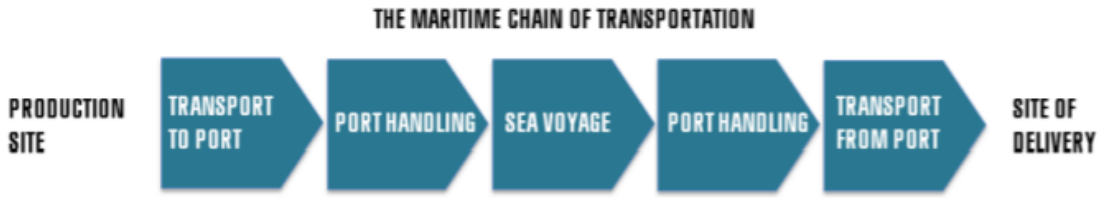

Figure 1.3 The maritime chain of transportation

Source: (Roslyng Olesen, 2015)

Thus, the main elements of maritime supply chain apart from shipping lines, are port/terminal operators and shipping lines. It is necessary to review the main activities of each primary player of the chain in detail.

1. *Port/terminal operators*

Port/terminal operators are engaged in global operation. PSA Corporation, DP World are examples of this type of players that are continuously expanding their operation all over the

world. Mostly ports are organized in terminals that are specialized according to types of cargos (general cargo terminals, liquid/dry bulk terminals, car/passenger terminals and etc.) (Roslyng Olesen, 2015). Ports secure cargo transfer from land-based transportation to sea-based transportation and in reverse. Also ports can be as private as public ventures as a combination of two.

Main private actors in ports are terminal operators. In order to take under control greater number of supply chain stages, shipping companies are taking control of terminals, especially the ones that have strategic location. Ports compete with other ports for market shares. (Roslyng Olesen, 2015). In its turn, freight forwarders, consignors and consignees, shipping lines and other elements use service provided by ports and terminal operators.

Crucial value adding factors for the considered party of maritime supply chain are: geographical location and services the party provides. Port location defines the maritime routes proximity, the distance to POD or POL and to production areas. Furthermore, if distance between POD and POL is short, it will lead to reduction in transportation time and in costs for the carrier. Frequent ship calls in ports will increase the transportation speed and, moreover, decrease the inventory holding costs based of less waiting time before the departure opportunity. Second value adding factor is the services provided by the port/terminal operator to attract customers.

Main services or functions of these operators include:

- Loading/offloading activities
- Delivery of goods via inland transportation
- Quality control
- Customizing and packing of goods
- Containers repair and maintenance
- Safety/security services
- Information and comunication

2. Freight forwarder (FF)

As an intermediary between the shipper or consignee and the shipping line, freight forwarder's main goal is to fulfill the demand of the shipper and support the made order. Working on the shipper's/consignee's behalf and having higher level of involvement and expertise, the freight forwarder has the next range of functions (Kokkinis, Mihiotis, & Pappis, 2006):

- Route arrangement for a customer

- Procurement of the suitable transport mode, i.e. road, rail, air or sea. From the list the less commonly used is the railway transport
- Arranging payment of freight
- Execution of documentation required for insurance or customs clearance
- Handle and control secondary logistics activities and offer stand-alone services (packing, warehousing, port agency and etc.)
- Deciding on the most suitable carrier (shipping line)

Working in close connection with shipper or consignee, FF can provide more value-added services and operate as third-party logistics service provider (3PLs) (Banomyong & Supatn, 2011). FF's profit is the difference between the price of order execution that customer pays and the costs of this execution. The various coalitions between FFs are in trend nowadays. It helps them get different advantages: higher profits because of improved quality of services (reliability, travel duration and etc.), economies of scale (decreasing cost due to larger volumes of cargo transported, consolidated load), more value added to services, more flexibility in transportation schedules and availability of multimodal transportation. (Gibson, Rutner, &Keller, 2002)

Main assets of FF are a wide network of carriers and deep knowledge of organizing the carriage. FF should have extensive knowledge of all markets they are presented in. They should be proactive in establishing representative offices or subsidiaries in other countries and have wide connections with local companies in order to offer better choices to their customers. (Korea Shipping Gazette, 2009). The United Nations Conference on Trade and Development (UNCTAD, 1995) has categorized freight forwarders in "ocean-based" Multimodal Transport Operators (MTOs) or Vessel Operating Multimodal Transport Operators (VO-MTOs), and those that do not operate vessels - Non-Vessel Operating Multimodal Transport Operators (NVO-MTOs).

If the value of service provided reduces the transactional costs on bigger amount than the service costs itself, than there is need in freight forwarder employment. So, the FF stays competitive when the price for its services is lower than the cost of arranging the same service by the other party on its own.

The knowledge of the freight rates, of niceties and specifications of each shipping line and overall expertise in the field help freight forwarders to choose the most suitable carrier for each particular order from the diversity of maritime transportation service suppliers that operate on the market.

1.3. Maritime transportation service suppliers: the problem of selection

The major role of shipping lines in maritime logistics is navigation on regional/global scale in order to carry the cargo to the necessary destinations. The examples of shipping lines can be some large companies as Maersk Line, APL or MSC, that have their offices all over the world and are currently expanding their operation processes. In comparison to huge players, small ones with little geographical presence specialize on some defined shipping routes. But in order to provide customers (that can be both shippers/consignees and freight forwarders) with diversified services they need to expand as well, and be present at least on the routes with the highest demand. (Oliver, 2005)

The networks of liner shipping tend to satisfy the demand in global transportation in terms of transit time, frequency and accessibility with the help of increasing routes quantity and vessel sizes. Shippers search for services between the needed ports of loading and ports of discharge and pay attention to the schedules, freight levels and port rotations. In the Figure 1.4 below the process of liner service design is briefly presented.

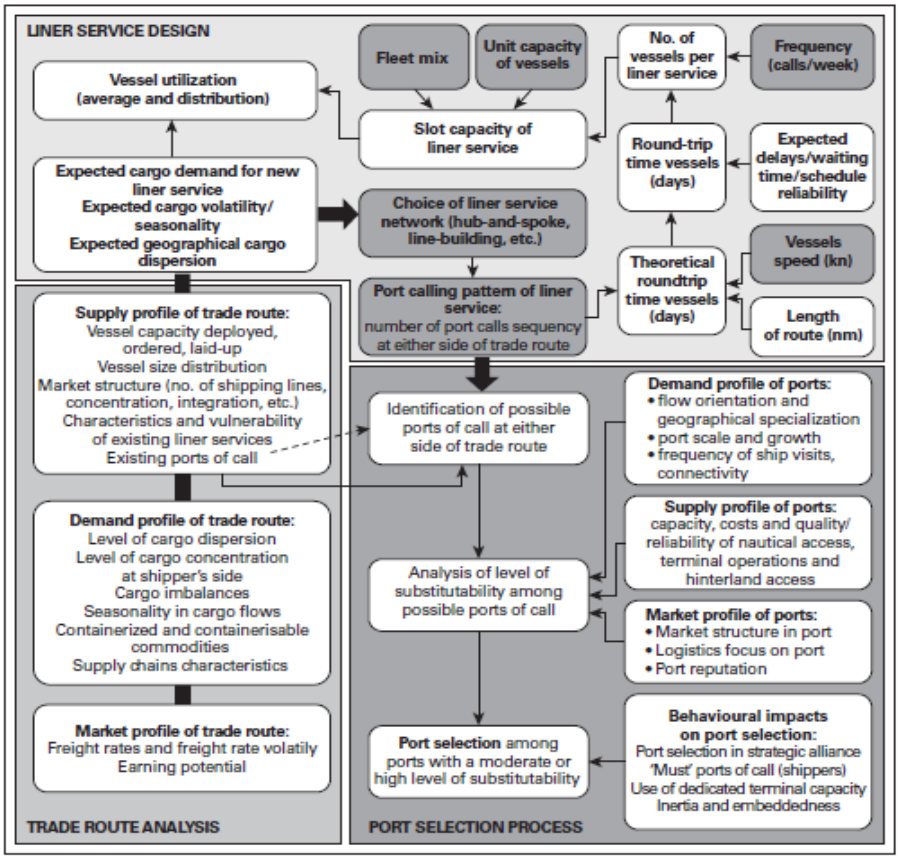

Figure 1.4 The process of liner service design

Source: (Song and Panayides, 2012)

First step of designing is analysis of targeted trade routes that is based on the market profile of the trade routes including supply and demand conditions. The goal of market analysis is estimation of potential of new services, the volatility and seasonability of demand – factors that influence the possible profitability of new services. The players seek to limit the number of port calls, increase the number of round trips and minimize the quantity of required vessels in fleet of company. At the same time, in some cases adding port calls can help to get the additional profit for a shipping line.

The problem of port selection was considered in various studies, such as: Wiegmans et al (2008), Chou et al (2003), Song and Yeo (2004) and others. For example, Wiegmans et al (2008) assume that port selection decision is affected by the power balance of shipping lines alliances or the terminal capacity in various ports. The speed of vessel is determined by the technical features of the vessel itself, bunker price (Notteboom and Vernimmen, 2009), environmental issues and the capacity in the market.

Thus, the functions of shipping lines include the next ones:

- Providing the needed cargo space of ships
- Offering frequent schedules for maritime transportation
- Providing the possibility of on-line tracking and tracing and etc.

All existing maritime transportation service suppliers can be listed according to Twenty-foot equivalent unit capacity and number of container ships the company owes. This information about main carriers of the market together with the market share data can be found in the Table 1.3 below.

Table 1.3 Top 10 biggest container shipping companies ranked according to the capacity.

Rank	Company	TEU Capacity	# of ships	Market share
1	APM-Maersk	3,334,050	638	16.1%
2	Mediterranean Shg Co	3,009,976	500	14.5%
3	CMA CGM Group	2,216,916	449	10.7%
4	COSCO Shipping Co Ltd	1,732,875	314	8.3%
5	Hapag-Lloyd	1,023,359	173	4.9%
6	Evergreen Line	1,009,915	193	4.9%
7	OOCL	648,034	103	3.1%
8	NYK Line	606,562	111	2.9%
9	Yang Ming Marine Transport Corp.	577,049	101	2.8%
10	Hamburg Süd Group	568,219	108	2.7%

Source (Alphaliner.com, 2017) Current as of April 2017

Largest container ship operator, A.P. Moller–Maersk Group (further referred as Maersk), occupy the first place since 1996, now its market is around 16 % of market share. Main players of this Danish conglomerate are Maersk Line, Safmarine, and Damco. Maersk Line fleet is composes more than 90% of APM-Maersk Group's one. Second place of the list is taken up by MSC with almost 16% of market share. This private company operates all over the world. CMA CGM, a French company with headquarter in Marseille

There are multiple numbers of shipping lines available, and the matter of selection of shipping line as a maritime transportation service provider is not completely covered in the literature.

An impact of carrier's attributes on the shipper/carrier partnership is investigated in the work of Lu (2003), in which the author investigates the relationship between shipper's satisfaction and service factors of carriers. Lu considers three types of partnerships in transportation industry. First type is mostly a short-term relationship based on a contract; this type is the most common in the industry. The second Type also considers contractual relationship, but these contracts are of longer terms and require higher volume of investments and the scope of activities is larger as well. The carrier can gain more integration with shipper according to this type of partnership. The last, third type is not based on contract; the scope of activities is shared between parties and assets are able to be owned by parties jointly. Carriers that take part in such partnerships can be referred as third parties or 3PL providers.

The author defines seven factors with the help of factor analysis; the groups consist of carrier service attributes that have influence on shipper-carrier partnering relationships. Seven factors are listed as follows:

1. Time factor that includes prompt response to claims, transit time, sailing frequency, cargo space availability, accuracy of documentation process pick-up on time, reliability of advertised sailing and service coverage;
2. Price factor that includes freight rates, discount structure, flexibility in meeting rates of competitors and willingness to negotiate;
3. Warehousing services factor, the components of which are: storage service, packaging service, service of customs clearance and consolidation and inland transportation availability;
4. Factor of sales services with three items in it: knowledgeability of sales personnel, ability of them to handle different types of problems and sales representatives' frequency of calls to shippers;
5. A door-to-door factor contains the condition of containers and door-to-door service itself;

6. Information factor that includes the tracking/tracing ability and the interface of computer electronic data interchange interface;

7. Factor of advertising with two items included, in particular the availability of sailing schedules in magazines/ newspapers and a courtesy of inquiry.

As a result the study concludes that the most important attributes of carriers from the shippers' view are low damage/loss, availability of space, documentation accuracy, schedule reliability and courtesy of inquiry. (Lu, 2003)

Shippers considers several criteria when choosing the suitable carrier, some of them are discussed by Meixell and Norbis (2008). But the selection of service provider form the view of freight forwarders that are more professional experts and possess the deeper knowledge of market, that have branches in the various regions and are primary participants of maritime supply chain is not fully considered in the literature. Also there are multiple examples of criteria of selection; these criteria differ from study to study. Some of proposed criteria will be used in the current thesis as well.

Some sources consider the carrier selection as selection of 3PL providers. Aguezzoul (2014) studies the criteria used while selecting of such 3PL provider and after the analysis of a large number of papers the author makes a conclusion that a wide range of attributes are usually considered while making the decision. And this range more often includes costs, relationship, quality and variety of available services. The author sees the necessity of future research and suggests "more comprehensive conceptual frameworks that consider qualitative, quantitative, tangibles, intangibles, strategic and operational criteria".

Hong at al. (2004) places an emphasis on four criteria while choosing 3PL providers, they are, from the most important to the least important one respectively: service quality, rate level, service reliability and service speed.

But after the determination of criteria for selection of maritime service supplier authors don't propose the technique that can be used by freight forwarders or shippers to choose the most suitable shipping line according to the order specifications and importance.

As it was mentioned, over 80% of world merchandise trade volume is carried by sea and the volume of cargo transported by sea is increasing rapidly. Thus, for support of international trade and globalization the necessity of using maritime transportation becomes higher through years. Also companies are starting operations in different markets and for enabling of their larger scale production, geographic specialization, business expansion, generating higher demand by enlarging customers' base and, thus, businesses' competitiveness the proper transportation system is crucial and the use of maritime transportation service is needed.

Therefore, it becomes more and more difficult to simultaneously find the appropriate shipping line that will be perfectly suitable for every market and each particular order. Thus, the main objective of this paper is to solve given problem and make technique improvement of maritime transportation service supplier selection.

Conclusions on the Chapter 1

In the first Chapter of current thesis the overview of maritime transportation and its place in the overall supply chain was given. Main trends and principles of maritime supply chain were discussed, main elements of the chain - freight forwarders and port/terminal operators were reviewed.

The problem of selection of maritime transportation service suppliers was covered in the chapter together with the current technique of the provider's selection. Also the characteristics of these providers that are crucial to make a selection decision and that are under consideration in the sources of literature are analyzed.

Next chapter is devoted to the research methodology and completion of the main goal of current work – technique development of maritime transportation service supplier selection.

CHAPTER 2. TECHNIQUE OF MARITIME TRANSPORTATION SERVICE SUPPLIER SELECTION

2.1. Research methodology

Current research is aimed to achieve the next tasks:

- Define the criteria of maritime service supplier selection
- Define the technique of maritime transportation service supplier selection
- Apply the technique to the case company

In order to achieve the listed tasks the combination of quantitative and qualitative data collection techniques were used. The first stage of the analysis is data collection through in-depth interviews with representatives of freight forwarding companies.

2.1.1. In-depth interviews

The main purpose of interviews is the identification of characteristics that influence the maritime transportation service supplier selection.

The sample of companies will be chosen based on the industry companies operate in. With the problem of maritime transportation service supplier selection face as shipper/consignees as the intermediaries – freight forwarding companies. But as was told before, freight forwarders are more experienced in the field, have deeper knowledge of transportation niceties as they are primary parties in maritime transportation. Thus, in order to obtain more reliable data, in-depth interviews were with the representatives of freight forwarding companies, those, who are responsible for making selection decision on everyday basis.

Interview involves personal interaction and is a sophisticated process. The main reason of conducting an interview in comparison with others is the complexity of topic. Only via interview in-depth data can be obtained, because of possibility of inquiring questions during the interview, asking for comments and additional information about the topic. Also the reason can be based on the fact of existence of personal attitudes for specific issues, in the considered case – as the process of selection is well-known for respondents, they are able to give reliable opinion about the shipping line characteristics that are concerned during the selection.

In-depth interview is a qualitative research technique that involves conducting individual interviews with several respondents. (Boyce and Neale, 2016) It offers an opportunity to gain descriptive data about personal perceptions, opinions and views. The positive side of this method

is that it allows freedom for both parties (interviewer and interviewee) to touch additional topics, change the interview direction and provide more detailed data for the researcher. (B2B International, 2016) It is useful tool when there is necessity of detailed information in order to have more complete picture. The steps of this research methodology can be the next: identification of the respondents, identification of data needed, development of list of primary questions and possible additional ones; gathering and analysis of the obtained information.

According to the provided interviews with representatives of freight forwarding companies, the managers of maritime logistics department, who face with the problem of shipping line selection on everyday basis, the list of characteristics of service providers that influence the choice of shipping lines was defined. They are shown in hierarchical system on Figure 2.1. Also the criteria discussed in literature mentioned in the first chapter of current thesis, were taken into consideration while providing the interviews.

Characteristics are divided into three groups: time characteristics, price characteristics and custom service ones. Shall discuss each group individually:

1. Time characteristics:
    a. Frequency of sailing – the frequency with which the voyages on particular route are made. For the customer of service the higher frequency makes influence on the cost reduction, explained by the less inventory holding costs for goods that need to be delivered to the consignee. Also the less time interval is between the voyages, the faster goods will be delivered and received, and the more efficient the supply chain will function.
    b. Schedule reliability – how reliable is the vessel plan given by carrier:
        - No delays in sailing – the absence of delays in departure time of planned vessel and of redirection/relaying to the next vessel
        - Transit time – planned travelling time from port to port
2. Price characteristics:
    a. Freight rate – price of cargo delivery from one point to another.
    b. Willingness to negotiate price – to what extent the representatives of shipping line can decrease the price due to special reasons (it can be delay in sailing, due to which the delivery took too much time, cargo damage or some other reasons)
    c. Discount structure – does the carrier have special discount due to the huge volume per period and etc.

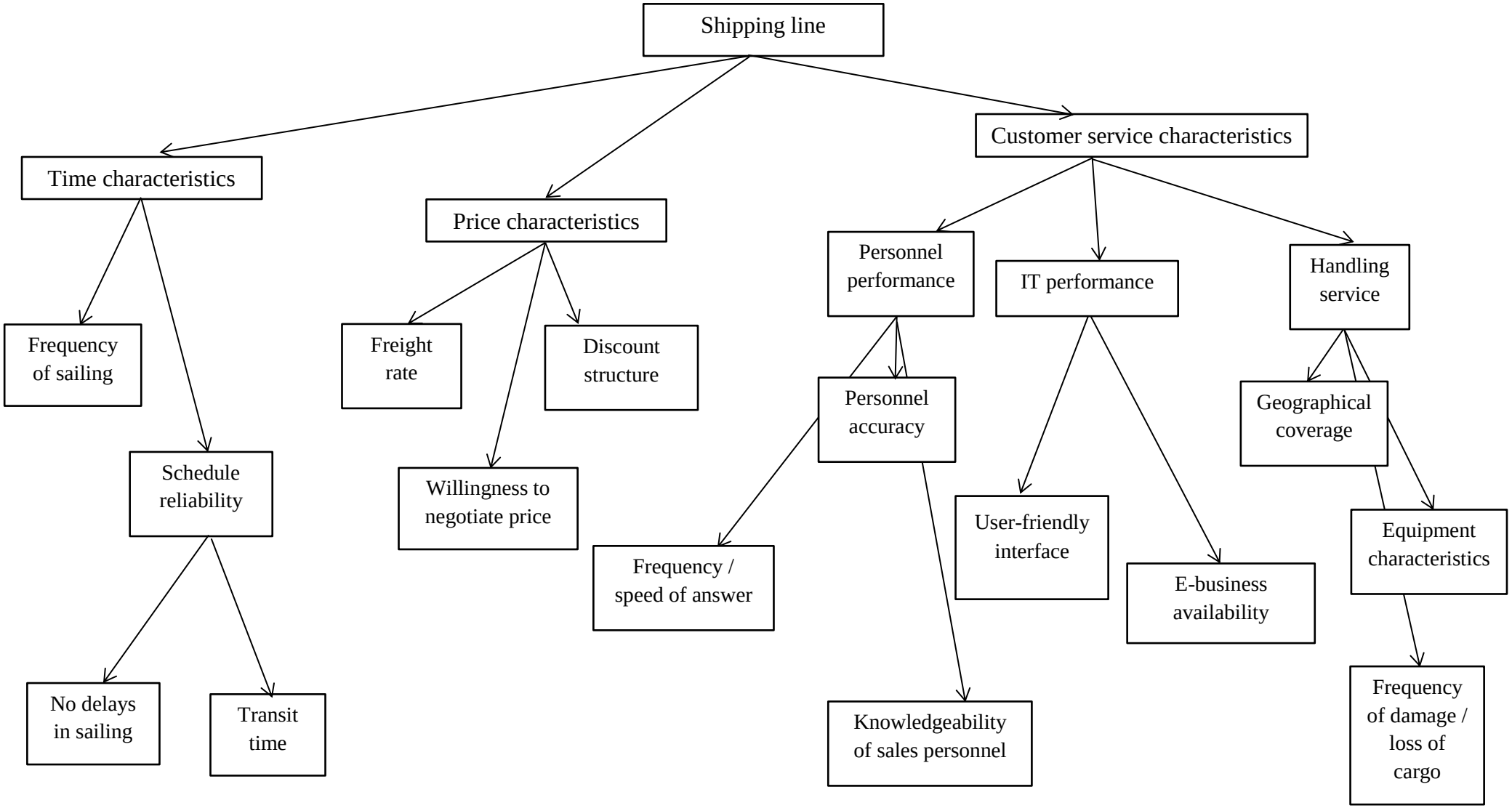

Figure 2.1 Hierarchical system of maritime transportation service suppliers' characteristics

3. Customer service characteristics:

a. Personnel performance:

- Frequency/speed of answer – in the case of necessity in the fast feedback from shipping line, do its representatives revert on time
- Personnel accuracy – the level of the correctness of personnel, how they manage to act in emergency, how many mistakes they make during the order processing
- Knowledgeability of sales personnel – the knowledge of all rates/routes/terminals and etc.

b. IT performance:

- User-friendly interface – as far as website of shipping line is concerned, how easily can user find all the necessary information
- E-business availability – the ability to define the cargo current location and previous/further movement information by pasting container, Bill of lading or booking number; the availability of routing finder, vessel schedules and etc.

c. Handling service:

- Geographical coverage – the existence of service on the necessary routes
- Frequency of damage/loss of cargo – how often were the cases of cargo damage or loss during the work with concrete shipping line
- Equipment characteristics – the quality of equipment provided, the availability of the necessary container type and etc.

The described characteristics represent the criteria for maritime service supplier selection and can be estimated by the expert in the field in order to make selection decision.

2.1.2 Expert survey

The next step will be an expert survey. This step is necessary to understand which characteristics from the created list are the most important ones and are the first to take into account while making the choice. These characteristics should be the ones which have more significant influence on the choice. The importance of factors will be evaluated by experts in the field – logistics managers of chosen freight forwarding companies. In order to have more reliable data about the importance of characteristics and collect the diverse opinion, representatives of several freight forwarding companies were chosen. Questionnaire was sent directly to the companies' representatives responsible for the choice of shipping line which will serve the transportation. The chosen companies operate in transportation services industry and their

operations are tightly connected with maritime transportation. The questionnaire was sent to the e-mails after the short conversation aimed to make sure that the targeted logistics managers are able to fill the questionnaire and comply with the requirements connected with the field of responsibilities and functions and knowledge of maritime transportation. The names of companies and names of respondents cannot be disclosed due to their requests.

Representatives of 10 companies filled the questionnaire; this number is enough for the estimation of characteristics' significance. The questionnaire is given in Appendix 1.

Respondents will evaluate the list of characteristics created as a result of first step according to their personal experience. First of all, the purpose of questionnaire was given and then given the main rules of the assessment. Questionnaire consists of characteristics combined in sense-group and respondents will evaluate each characteristic using 5-point Lakert scale. The highest evaluation, 5 point, will mean that the given characteristic is vital in making the decision, so have the greatest influence and importance; while 1 point will have the meaning that this specification is not really important in the process of supplier selection and is taken into account lastly. Each group of characteristics – time, price and customer service - is given separately for convenience of filling. In the end the contacts of author are given in the case of questions.

After collection of the responses the data was analyzed and the next results were obtained (results can be found in the Appendix 2.)

- Customer service characteristics play more important role in shipping line selection than price or time. At the same time price is more crucial than time according to the interviewees opinion
- Schedule reliability is more important for respondents that frequency of sailing; transit time – more than absence of delays
- For the price criteria the most essential is freight rate component, next is willingness to negotiate and the least essential is shipping line's discount structure.
- Considering the components of customer service characteristics, handling service plays more crucial role, while personnel performance is more critical than IT performance. Looking further in hierarchy – personnel accuracy is the main component of personnel performance and is followed by knowledgeability of sales personnel and frequency/speed of answer respectively. E-business, the ability of tracking, availability of schedules and etc., is almost twice more important in comparison with user-friendly interface of service provider's website. All respondents decided that the most important component of handling service is frequency of damage/loss of cargo, and only after that goes geographical coverage and equipment characteristics that both have equal level of importance.

2.1.3 Criteria assessment

After gathering the data about importance of one criterion under another, each criterion should be assessed by experts. Lakert 1-7 point scale can be used in order to estimate the value of each characteristic.

For time characteristics, for example, – the less time delivery takes the higher estimation respondent gives to the shipping line. So, the next explanation for the characteristics estimation can be given in Table 2.1 (considered only lower level of criteria hierarchy):

Table 2.1 Criteria assessment explanation

Criteria	**Assessment explanation (1-7 point Lakert Scale)**
Frequency of sailing	1 - not acceptable frequency; 3 – low frequency; 5 – good frequency; 7 – excellent frequency of sailing
No delays in sailing	1 – vessel sailing is always delayed; 3 – sailing is often delayed; 5 – delays happen seldom; 7 – absence of delays in sailing
Transit time	1 – unacceptable sailing time; 3 – too long time in transit; 5 – good transit time; 7 – very short transit time
Freight rate	1 – unacceptably high freight rate; 3 – high freight rate; 5 – average freight rate; 7 – low freight rate
Willingness to negotiate price	1 – Personnel is never able to negotiate price; 3 – price can be negotiated in very few cases; 5 – it is an often case that price can be reconsidered; 7 – every time you want to negotiate price, it can be done
Discount structure	1 – no discounts are possible; 3 – in very rare cases discount can be provided; 5 – discount structure exists but it is not often applicable; 7 – company has excellent discount structure
Frequency/speed of answer	1 – not acceptable speed of answer; 3 – low speed of answer; 5 – acceptable speed of answer; 7 – excellent speed of answer
Personnel accuracy	1 – personnel is always inaccurate; 3 – personnel makes mistakes very often; 5 – acceptable level of personnel accuracy; 7 – excellent accuracy of personnel
Knowledgeability of sales personnel	1 – personnel has unacceptable knowledge depth; 3 – sales personnel background is poor; 5 – sales personnel has good expertise in the field; 7 – excellent knowledgeability
User-friendly interface	1 – not acceptable interface; 3 – low quality interface; 5 – good interface; 7 – perfect interface
E-business availability	1 – nothing is offered online; 3 – some functions can be found; 5 – in very rare cases some information is unavailable; 7 – everything needed is available
Geographical coverage	1 – no service with needed routes; 3 – low number of routes is covered; 5 – good geographical coverage; 7 – excellent geographical coverage
Frequency of damage/loss of cargo	1 – unacceptable frequency; 3 – high frequency; 5 – very rare cases of damage/loss; 7 – no cases of damage/loss
Equipment characteristics	1 – not acceptable characteristics; 3 – low equipment characteristics; 5 – good quality of equipment; 7 – excellent equipment characteristics

The experts that estimated maritime transportation service suppliers by given list of characteristics should be chosen based on their expertise level in the field. This estimation can be made with the help of survey as well. After the assessment the list with grades according to the Lakert scale can be obtained for each characteristic. Then the next step is correct estimation of obtained results and the selection of shipping line.

For simplifying the procedure of assessment it should be mentioned that the assessment of not all of the characteristics is needed to be revised regularly. On the Figure 2.2 those characteristics of the hierarchical system that are relatively constant are bolded outlined in red.

As far as group of time characteristics is concerned, both frequency of sailing and transit time in comparatively constant. This information can be found on the websites of shipping lines and the changes in it are made rarely – in most cases the schedule is fixed on the season. Also it takes little time for revision of these characteristics.

Price, in its turn, is a more unstable quantity. General rate increase (GRI) can be implemented each month to the freight rate, and it is applied in practice by all shipping lines. Therefore, the assessment of freight rate should be revised monthly. Talking about the willingness to negotiate price from the maritime transportation service supplier side, it is mostly dependent on the cooperation between the parties and their built relationships. So, if something changed and there appear new reasons for price negotiation, this characteristic should be reestimated as well.

Two of three subgroups of customer service characteristics are relatively constant while personnel performance characteristics are the most changeable ones. It is based on the human nature and its unpredictability. Of course there is always a trend of how accurate the particular person can answer, how frequently you can get a feedback and etc, but the personnel of supplier's company can be replaced, and there is always unpredictability in working conditions, so this group of hierarchy should be reassessed regularly. But the IT performance, for example, is a relatively constant in estimation. The same situation is with handling service – the necessity to revise the assessment is raising on more rare basis.

As we consider several criteria that are unequally important for selection, this step should be represented by multi-criteria optimization method, concept of which will be discussed in next section. Also the most widespread existing methods of multi-criteria optimization will be observed as well as advantages and drawbacks of each of them. And finally, the most suitable method for sea carrier selection will be chosen.

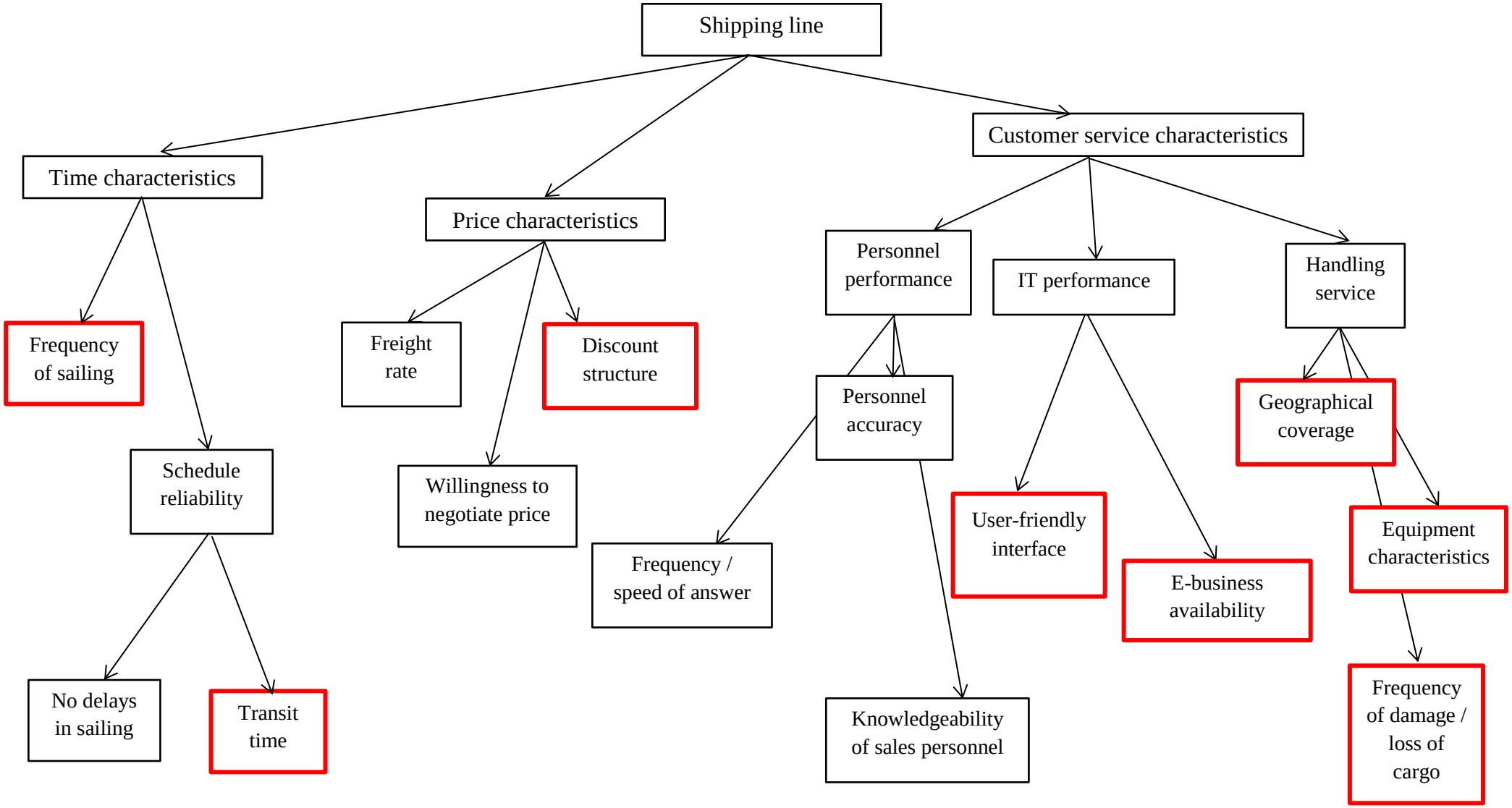

Figure 2.2 Relatively constant characteristics of hierarchical system

The overall research methodology used to achieve the goal of current Paper is described in the Figure 2.3 below:

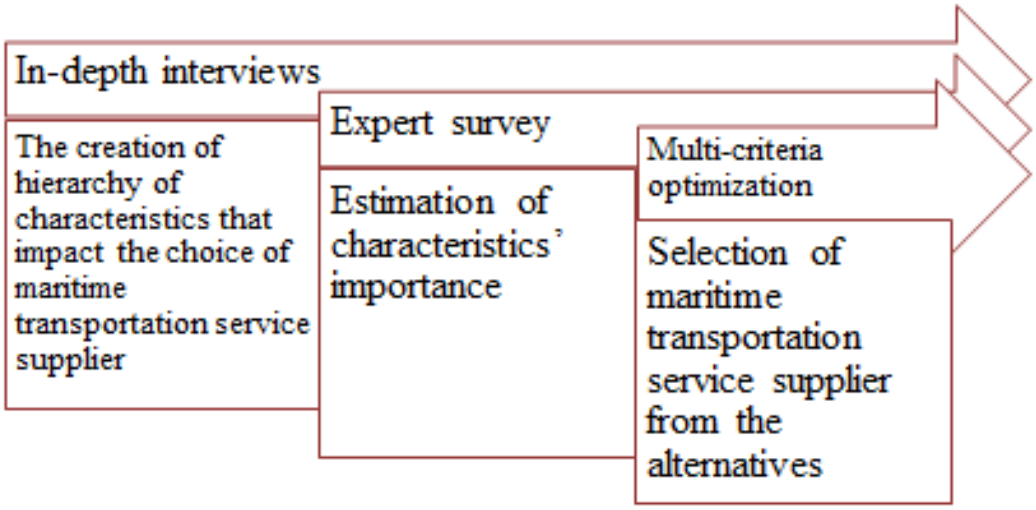

Figure 2.3 Overall research methodology

So, with the help of in-depth interviews the hierarchy of characteristics that impact the choice of maritime transportation service supplier selection is built, the importance of these characteristics is assessed by experts with the help of survey. And the final step is the selection of service provider on the basis of multi-criteria optimization, the various methods of which will be discussed further and the most suitable method will be applied for demonstration of technique working capability.

2.2. Multi-criteria optimization of SC element's selection

In comparison with situation with only single criterion existence, when generally the criterion like cost is the most important one and the supplier is chosen based on the least expensiveness (Timmerman, 1986), the multi-criteria optimization is more complex.

Crudely speaking, optimization means to choose the best option available from a diverse range of existing choices. It is difficult to do make because all the range of alternatives should be tested. Several concerns add the complexity such as: computational difficulties and limitation on computational resources, high number of constraints and objectives, restrictions regarding the algorithms' capabilities and others.

Multi-attribute decision-making (MCDM) techniques are the frameworks that goals to help a decision maker with provision of a recommendation of selection among some set of different alternatives with multiple criteria assessment. Numerous multiple-criteria decision-

making techniques exist, starting from elementary weighted averaging to some complex and quite difficult for implementation mathematical programming models. (Simić et al., 2016) The most widespread examples of such techniques are Analytic Hierarchy Process and Fuzzy Sets Theory. (Aguezzoul, 2014)

The utilization of mixed integer programming or multi-objective linear programming, as other examples of MCDM methods, involve huge amount of work and computation difficulties and, therefore, cost a lot of managerial time and there is no necessity for their detailed description.

Analytical Hierarchic Process method

In multi-criteria optimization each criterion is provided with a specific weight that demonstrates the level of importance of particular criterion. (Benyoucef, 2003) With different weight the AHP (Analytical Hierarchic Process) method can be used and it is the basic and the most suitable method for supplier selection, simplicity of which can be the reason of extensive use.

In AHP approach the weights are defined by a binary comparison method (Saaty, 1980) and the alternatives are prioritized with the use of multiple and sub-criteria. This method allows the Decision Maker (DM) to structure the problem in the hierarchical form that includes alternatives, goal and criteria of selection together with other factors. AHP offers a methodology to rank alternatives with regard to decision's judgements based on the level of importance of each criterion and the level to which it is met by particular alternative. (Benyoucef, 2003)

So the process starts with the determination of the importance of criteria. After that it is necessary to identify to which extent the alternatives achieve the each determined criteria. Managerial judgements are the base for the described approach; they are described as paired comparisons of units on the existing level of hierarchy according to the impact they make on the next, higher level. These comparisons show the relative importance of one unit or item under another in meeting goals.

Table 2.2 Estimation scale for AHP approach (Source: Benyoucef, 2003)

Verbal judgment or preference	Numerical rating
Extremely preferred	9
Very strongly preferred	7
Strongly preferred	5
Moderately preferred	3
Equally preferred	1
Intermediate values between two adjacent judgments (when compromise is needed)	2, 4, 6, and 8

In order to quantify managerial judgements standard scale is usually used in AHP approach (see Table 2.2 below). For better understanding the example can be provided: in the situation when the customer consider the personnel accuracy as strongly preferred under the frequency/speed of answer then the judgement will be quantified as 5. All criteria and sub-criteria should be judged in the same manner; the information is provided by the user of service.

The pairwise comparison for each item can be demonstrated by the pairwise comparison matrix. For n number of items that are necessary to be compared the n * (n-1) / 2 number of judgements is needed. It can be simply explained: the diagonal of matrix will be filled by 1's because each alternative is equally preferred by itself. Also the meanings of both sides – below and above the diagonal – are reciprocals of made judgement.

As the final stage of the approach the synthesis of linear convolution is pointed out on the priorities' hierarchy. Then the priorities of alternatives are estimated according to the main goal and the best alternative has the maximum value of priority. (Saaty, 1980) But nevertheless, the general output of AHP approach is "merely the relative importance weightings of criteria and sub-factors" (Simić et al., 2016) Thus, this method used by its own very seldom and will not show the accurate results needed for the current paper's goal achievement.

Fuzzy set theory

Another mostly used multi-attribute decision-making technique is a fuzzy set theory (Zadeh, 1965) accounts uncertainty and subjectivity in the multi-criteria selection process. It takes into account imprecision of human decisions while the model formulation and finding solution and makes possible to capture ambiguity and variety in a points of view of diverse evaluators' linguistic variables. Evaluation in the fuzzy environment takes place with allowance of uncertainty of evaluators' judgements and is expressed as a function of representation of a fuzzy set in which numbers show a subjective view of a decision maker.

According to Zadeh, the linguistic variable can be presented as a triangular fuzzy membership function (L, M, U), where L is a lower bound, M is a mean value of a triangle distribution and U is, correspondingly, an upper bound. The assessor can assume, from his own subjective point of view, his personal range of the linguistics variable and allocate numbers for these L, M and U respectively.

To explain the allocation in a simpler way, the Figure 2.4 is presented. As an example, if something is evaluated as very low/very poor, the person who evaluates can allocate 0 as a lower bound, 30 as a mean value and 60 as an upper bound.

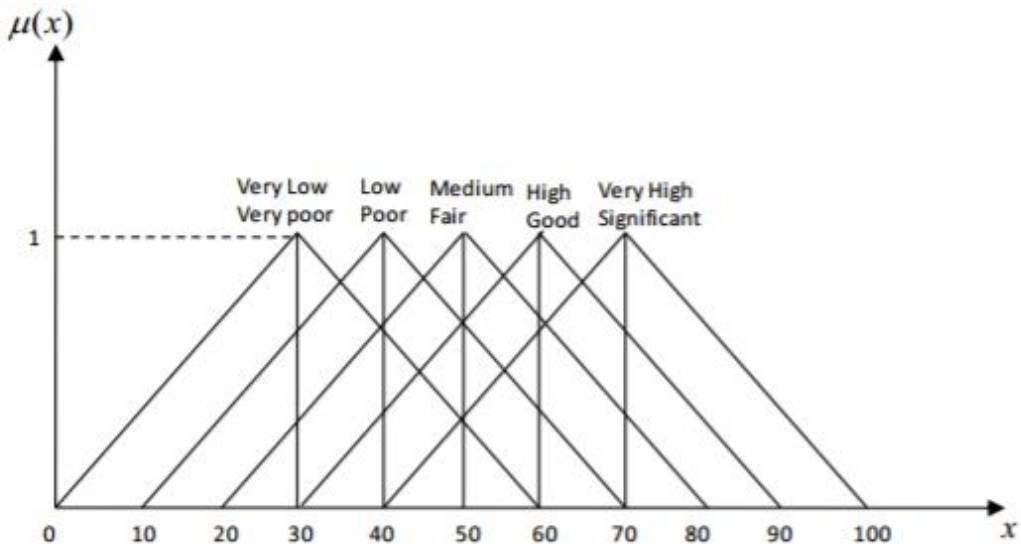

Figure 2.4 Triangle membership function of fuzzy set representation

Source: Karami and Guo, 2012

The Figure above also shows the measure of linguistic variable with the help of evaluation using 5-Point Lakert scale, with 1-very low, 2 – poor, 3 – medium, 4 – high and, finally, 5 – very high or significant; the measure is made based in the triangle membership function. More accurate evaluation is achieved by taking into account the possibility of difference among perception of each respondent.

So, the Fuzzy sets approach is processed as follows. It assumes that ${S_{ij}}^k$ is the total average evaluation of, for example, service supplier *i* under criterion *j* by the respondent *k.* With evaluation as "very low" (that was in example before), this evaluation will be expressed as ${S_{ij}}^k = \left({LS_{ij}}^k, {MS_{ij}}^k, {US_{ij}}^k\right) = (0, 30, 60)$. In the situation with more than one respondent, the assessment will be made according to the method proposed by Buckley (1965). Assuming that the evaluation is made by *m* respondents, the valuation will be calculated the next way:

- ${LS_{ij}}^k = (\sum_{k=1}^{m} {LS_{ij}}^k)/m;$
- ${MS_{ij}}^k = (\sum_{k=1}^{m} {MS_{ij}}^k)/m$
- ${US_{ij}}^k = (\sum_{k=1}^{m} {US_{ij}}^k)/m$

Received aggregated fuzzy evaluations should be converted into the "normal", non-fuzzy performance value. According to Karami and Guo (2012), there is a number of possible ways to solve this problem and the most widespread approaches are a-cut Method, Mean-of-Maximum and Center-of-Area. The authors suggest to use the Center-of-Area one and by calculation of - $(\left[US_{ij} - LS_{ij}\right) + (MS_{ij} - LS_{ij})]/3) + LS_{ij}$ - the best non-fuzzy performance or BNP value can be reached.

Unfortunately, the Fuzzy sets approach is too complicated and time consuming to implement. Also in most academic articles the fuzzy approach is not used alone but used with combination with other existing methods. It can be explained by the drawbacks of the approach. The first one lays in the fact that the rules of membership functions' combining are not perfectly robust. Furthermore, the main disadvantage in the use of this method in current paper is that the rules give the same importance to all factors, and it is completely inappropriate for current research.

DSS APIS

For the estimation of complex multi-criteria alternatives' preference exists a flexible decision support system (DSS) APIS (Aggregated Preference Indices System) – that represents a convenient "software for making decisions under uncertainty with the use of nonnumeric, inexact, and incomplete information". (Hovanov, 1998)

Objects for selection are the alternatives, one of which the operator of the software should select. The value of the alternatives can be named as a quality of complex object and this quality DSS APIS is assessing. The opportunity to use the system can include the next cases:

- Alternatives are difficult to compare based on absence of unified criteria
- There is not enough numeric information or there is not precise data
- Too sophisticated object of assessment and the determination of indices for comparison is too complex
- The estimation should be based on expert's opinion
- The sources of information are with different level of reliability
- The estimation should be made with the help of decomposition or hierarchical system

The principle of the decision support system is based on the aggregated indices method and can be implemented by a computer calculation. DM can define the process by himself together with alternatives and attributes selection (the composition of attributes determines the alternative; the number of attributes or characteristics is finite).

APIS is based on a method of aggregates (SMEs), substance of this method is a "convolution" of several grades or evaluations of some object into a one evaluation – an indicator synthesizing other individual indicators (they can be the qualitative characteristics, for example safety, reliability, efficiency and etc. of various multiparameter objects; individual expert opinions; different goods and services; organizational decisions and so on).

The following steps can illustrate the construction of a composite indicator. (Hovanov, 2005). First of all, a vector x = $(x_1, \dots, x_m)$ of baseline characteristics should be formed. Each

characteristic is competent for a complete assessment of an object's quality. Secondly, a certain vector $q = (q_1, \dots, q_m)$ of individual indicators is formed, it is a function q_i = q(x_i; i), i= 1,…, m of characteristics of an object with use of *m* criteria. Next step is selection of synthesizing function - *Q*(*q*), that is associated with individual indicators' vector' aggregated estimation *Q* = *Q(q).* This estimation characterizes the overall object. After that the value of the parameter vector should be determined - $w = (w_1, \dots, w_m)$. It can be described as the weight or the level of influence of $q_1, \dots, q_m$ on the equation *Q*.

In simpler way the method can be described as three stages of composite index definition:

1) determination of a vector selected indicators $q = (q_1, \dots, q_m)$;

2) selection of the synthesis function *Q = Q(q) = Q(q;w)*;

3) formation of the weight vector $w = (w_1, \dots, w_m)$.

One of the most important stages is the choice of "weights", because often it is impossible to know exactly the numerical values of the level of importance of characteristics. In such case of inexact, incomplete and non-numeric information APIS is very helpful. (Hovanov, 2005)

The systems implemented with the help of APIS, calculating estimates $\overline{w_i}$(I) and their accuracy $s_i(I)$ and reliability *p(i, j; I)* of the pairwise dominance are displayed by the so-called APIS-chart for weighting factors. The next input data is needed for APIS to determine the final aggregated indicator (Hovanov, 2005):

- information about the values $x_i^{(j)}$, *i = 1,…,m; j = 1,…,k*; m baseline characteristics of x_i for the k objects that describe vectors baseline characteristics $x^{(j)}$ = ($x_1^{(j)}$,…, $x_m^{(j)}$), j = 1,…,k
- information about the choice of increasing and decreasing functions $q_i = q_i\ (x_i)$ and their parameters (MIN_i, MAX_i, P_i,) to generate values for $x_i^{(j)}$ baseline characteristics x_1,…,x_m, values $q_i^{(j)}$, *i = 1,…,m; j = 1,…,k* and individual indicators $q_1, \dots, q_m$ for objects;
- non-numeric (ordinal), non-accurate (interval) and non-complete weight information and summary metrics.

After the all described above information is inserted, APIS is calculating "output" information that includes the following: information about values $\overline{w_i}$(I) of the weights about their accuracy $s_i(I)$, *i = 1,…,m* and reliability *p(i, j; I)* , *i, j = 1,..,m* and information of values $\overline{Q_i}$(I) of aggregates, their accuracy $S_i(I)$, *j = 1,..,k* and reliability *P(j, l; I)* , *j, l = 1,..., k* . (Hovanov, 2005) The key benefit of decision support system is its ability to process different types of uncertain information.

Therefore, APIS gives aggregated indices for all branches of hierarchy that visually represent each alternative. Estimated value of preference of each alternative is a numeric function that can be seen as a single preference index that, in its turn, is used as a criterion for the selection justification at each stage of further comparison and preference estimation. Thus, DSS requires determining all individual preference indices to define aggregated index for alternatives estimation. Alternatively stated, the aggregated preference index is a combination of the assessment of individual preference indices. (Hovanov, 1998)

The system also considers the importance or significance of indices during the estimation process. This importance is presented by weight coefficients that are used as input parameters for APIS. Generally speaking, there can be defined four main steps of the method:

1. Forming a set of alternatives and fixation of attributes
2. Construction of single preference indices
3. Selection of aggregated function
4. Estimation of values of weight-coefficients

For the considered problem of maritime transportation service supplier selection the described DSS APIS method is the most appropriate one. It will allow overcoming the limitations regarded to gathered information and number of responses. Also it satisfies the conditions of study – it will help to gain the needed result for comparison of suppliers, because the tool supports the decision of such complex practical problems with existence of multiple criteria under uncertainty. The accuracy of estimations is proven by the standard deviation of the mean value, the diagrams as an output of the software shows the confidence intervals and the software ranks the alternatives at final stage. The steps of utilization of DSS APIS will be described in the next paragraph, as part of implementation steps of shipping line selection algorithm.

2.3. Implementation of maritime transportation service supplier selection technique

After the criteria of maritime transportation service supplier selection were defined with the help of in-depth interview, the hierarchical system of the supplier's characteristics was given and the importance of each characteristic was estimated by the survey, the estimation of each criterion should be made. For better illustrative purpose three shipping lines were chosen and assessed by author of current Paper by 1-7 Lakert scale (the criteria assessment explanation was given in the Table 2.1 earlier). The result of assessment can be seen in Table 2.3 below.

Table 2.3 Characteristics assessment (Author, 2017)

	Shipping line A	**Shipping line B**	**Shipping line C**
Time characteristics:			
Frequency of sailing	5	7	6
Schedule reliability:			
No delays in sailing	4	6	5
Transit time	6	4	4
Price characteristics:			
Freight rate	4	5	5
Willingness to negotiate price	5	4	3
Discount structure	3	5	4
Customer service characteristics:			
Personnel performance:			
Frequency/speed of answer	4	6	3
Personnel accuracy	6	5	4
Knowledgeability of sales personnel	4	6	4
IT performance:			
User-friendly interface	4	5	7
E-business availability	4	6	5
Handling service:			
Geographical coverage	4	5	3
Frequency of damage/loss of cargo	5	6	6
Equipment characteristics	5	5	6

The provided information is enough for APIS software to accurately calculate aggregated indicator. As can be pointed out (see Figure 2.1), there are three main groups of characteristics and four groups of sub-characteristics, without calculation of which it is impossible to estimate the grades for the main groups. Thus, firstly the four groups of sub-characteristics were estimated by APIS software and the aggregated preference indices were calculated (Table 2.4)

Table 2.4 Aggregated preference indices for sub-characteristics (Appendix 4)

	Schedule Reliability	**Personnel Performance**	**IT Performance**	**Handling service**
Shipping line A	0,755	0,652	0	0,0825
Shipping line B	0,245	0,692	0,837	0,835
Shipping line C	0,122	0	0,622	0,835

At a first glance it can be concluded that Shipping line A is a leader in schedule reliability, while has unacceptable IT performance together with handling service. Shipping line B and C have equal result of handling service characteristic, while Shipping line B wins in personnel performance and IT performance. But as far as sub-characteristics are concerned, it is impossible to make conclusions on particular maritime transportation service provider selection without looking on the higher level of characteristics' hierarchy.

For calculation of primary characteristics the result of previous estimations are taken and the next aggregated preference indices were created for each main group (Table 2.5).

As it can be pointed out, Shipping line A offers service with the best time characteristics, but is too costly to use and the service it provides it quite poor in comparison with one that other two shipping lines provide with. Also Shipping line B is step ahead according to the rest of main groups of characteristics, but the difference between the aggregated preference indices of Shipping line B and Shipping line C is not too huge.

Table 2.5 Aggregated preference indices for main groups of characteristics (Appendix 4)

	Time Characteristics	**Price Characteristics**	**Customer Service Characteristics**
Shipping line A	0,755	0,3	0,2617
Shipping line B	0,3917	0,850	0,9082
Shipping line C	0,1225	0,7	0,7222

As it can be pointed out, Shipping line A offers service with the best time characteristics, but is too costly to use and the service it provides it quite poor in comparison with one that other two shipping lines provide with. Also Shipping line B is step ahead according to the rest of main groups of characteristics, but the difference between the aggregated preference indices of Shipping line B and Shipping line C is not too huge.

Therefore, no one provider is better than other according to the all three main characteristics groups and there is no clear understanding which service provider should be selected. That is the reason for final round of APIS estimation to be realized. The result can be found in Table 2.6 below.

Table 2.6 Aggregated preference estimations for alternatives (Appendix 3)

	Aggregated Preference Estimation	**Rank**
Shipping line A	0,1061	3
Shipping line B	0,9391	1
Shipping line C	0,6407	2

According to the result conducted, the Shipping line B should be selected, taking into account all characteristics estimations and the level of their importance for making decision. APIS gives rank 1 to this alternative. Indeed the Figure 2.5 below proves this decision.

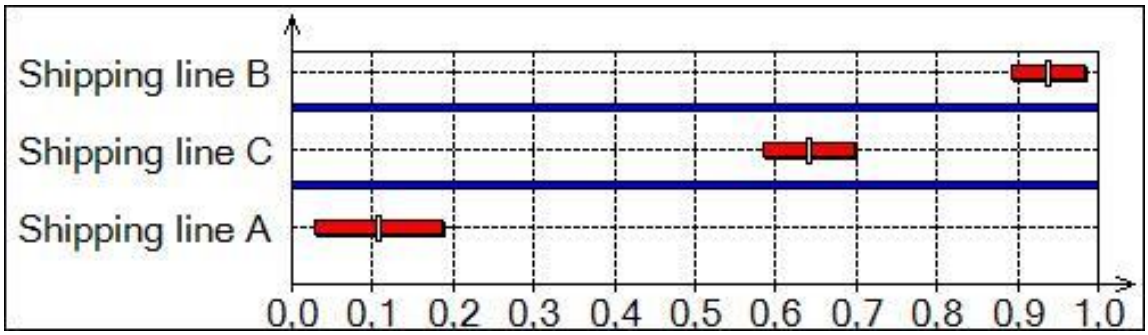

Figure 2.5 Aggregated preference indices visualization (Appendix 3)

On the Figure 2.5 above we can see red and blue intercepts of a straight line. Abscissa of a midpoint of a red intercept of straight line –or a red interval – shows an average estimation of a correspondent object. At the same time the length of this red interval equals to the doubled standard deviation of the given index. It should be specified that the longer this red interval is, the more risky the alternative index estimation is. An abscissa of a blue interval's right end shows the reliability for dominance relation between neighboring index estimations. (Hovanov, 2005).

For the Shipping line B the standard deviation is only 0,045, while for Shipping line C and A – 0,0556 and 0,0785 respectively.

Thus, in the considered case the selection decision is clear – among three alternatives Shipping line B should be chosen, because it has the highest aggregated preference index and the standard deviation of the calculated index is the lowest.

Conclusions on the Chapter 2

The technique of maritime transportation service supplier selection is provided in the current Chapter. The stages of the technique are explained. As a method of multi-criteria optimization DSS APIS was chosen, while advantages and drawbacks of AHP approach and Fuzzy set theory are discussed.

An example of the selection of maritime transportation service provider with detailed demonstration of implementation steps of the technique are covered in the chapter for more simple interpretation and understanding of the selection process.

The next chapter will discuss the transportation services industry and will provide with technique application on the case company.

CHAPTER 3. MARITIME TRANSPORTATION SERVICE SUPPLIER SELECTION FOR LEAAP LLC CASE

3.1. Leaap business and transportation services industry: the problem of selection of maritime transportation service supplier

The logistics company Leaap Group was established in October 1990 in India as a body corporate. The main field of business is cargo forwarding and shipping services. The list of main company's activities is the next:

- Warehousing and distribution
- Project planning and execution
- Tracking/monitoring shipments
- International freight forwarding
- Broker (custom house agent)
- Multi-modal transport operator and etc.

Leaap provides solutions in various industries and markets, door-to-door control and management in retailing, automobile industries, pharmaceuticals and etc. It provides temperature controlled shipments as well as handling oversized cargos.

There are several parts of Leaap group and it is worth to describe characteristics of the sphere of company's activities based on two key parts:

Leaap International Private Ltd **–** the company provides such services and products as: ocean freight, trucking service, air freight, rail transportation, warehousing, cargo insurance, agriculture-cool chain for vegetables and fruits, customs house broking, end-to-end logistics and freight forwarding solutions.

Leaap Gulf LLC (UAE) – is also the provider of various logistics solutions: pharmaceutical logistics, tobacco handling, warehousing and distribution. The company mostly provides solution in Africa and CIS countries. Headquarter is located in Dubai, that gives the opportunity to work with China and India as well and give access to African countries that offer prospects of growing. The company has good relations with shipping lines, manufacturers, other forwarders and carriers.

Nowadays Leaap is a well-known brand with huge opportunities to grow. Despite the described offices in India and United Arab Emirates, it has one in Russia and a network of agents worldwide, so the coverage of business of Leaap group is the entire globe.

Leaap LLC is a Russian branch of Leaap Group that operates for last decade in Russian transportation service industry and, as a part of Group, has an advantage of such strong connections with Indian market mostly and other geographical markets.

The Russian transportation services industry group has strong performance during last years. The industry is expected to slow slightly but still provide strong growth over the forecast period. (Marketline.com, 2017)

Figure 3.1 Russian transportation services industry value forecast $ billion, 2016-21

Source: Marketline.com, 2017

As it can be seen from the Figure 3.1 below, the industry is planned to grow steadily during next 5 years; that gives companies the opportunity for future development, for offering wider range of services and enlarging customer base.

It order to stay competitive the inner logistics strategy and the supply chain itself should be working properly. And the matter of the transportation service provider is very essential for the appropriate functioning of the system.

As was discussed in first chapter, freight forwarder acts as an intermediary between the shipping line as maritime service supplier provider and other elements of maritime supply chain. The freight forwarding company should provide consignee (good receiver) or consigner (good producer) or even other logistics companies that are intermediaries as well with a service that usually includes route arrangement, suitable transport mode procurement, arrangement of freight payment, selection of the most suitable carrier and etc.

The decision of selection is an important part because it directly influences the service level of freight forwarder. In the case if the selection was made correctly, the good would be delivered on time (and, for example, the production process of buyer's company will not be

interrupted and, thus, the revenues will not be lost), with the most adequate price (that also highly important concerning the revenue) and with better service (without loses, with accurate documents filling and etc.). Therefore, the carrier selection decision is of high importance base on the fact, that the prosperity of many elements of maritime supply chain is fully dependent on this decision.

It is necessary to give an overview how shipping lines are selected nowadays.

First of all, arise the need of maritime transportation, for example one supplier in India signed an agreement to sell specified volume of product to the consignee in Russia. But as both players represent the manufacturing companies, they have lack of knowledge how the transportation should be organized, what documents are necessary to prepare and how the whole process should look like.

Thus, they need the help of professional, the freight forwarding company that will arrange the process properly. In some cases some "input" conditions or even constraints exist. In the new booking that freight forwarding company gets the main information is listed, such as: POL and POD, the Incoterm under which the shipment will be made (the mostly used Incoterms were given in first chapter), the parties' data (consignee, shipper and some notifies). Also as a condition for a shipment can be some freight idea, if this is important for consignee or shipper. After gaining all the necessary information for shipping line selection, the freight forwarder needs to choose the proper carrier.

In general freight forwarding companies, especially ones that specialize on the maritime transportation, already should have connections with shipping lines based on the experience they have in transportation service accomplishments. Sometimes this cooperation with carriers gives the company sustainable competitive advantage in comparison with their rivals. And the conditions of transportation service with some shipping lines (like the discount structure, the accuracy of personnel or any other characteristics) are familiar for the company.

Thus, when the order for transportation is received, the problem of selection arises. The company should clarify the time frames for a particular route that each carrier offers, the frequency of sailing from POL in each shipping line, the freight rates of each shipping line and whether it will be able to get a discount or negotiate the price in some situation of emergency. It should analyze the reliability of schedule for each shipping line and also take into account the personnel performance (if there were some issues with accuracy before). Also it should be identified whether the exact shipping line has services for particular route and etc.

In reality it takes several days even to access the "supply" for particular customer's "demand" and obtain all the needed data from each shipping line, compare it and decide what is the most suitable choice in current situation.

Therefore, with the proposed technique of maritime transportation service supplier selection the problem of selection will be solved in an efficient way, the description how it functions will be given on the example of Leaap LLC case. The technique can be applied to any company that faces the need of shipping line selection and has the necessary knowledge to make the choice on its own.

3.2. Maritime transportation service supplier selection tool for Leaap LLC case

Leaap company is not satisfied with the current way of transportation suppliers' selection. Currently company closely works with three shipping lines - MSC, Maersk and CMA CGM - and faces with the necessity of choice among these suppliers in most cases.

These three shipping companies are the TOP-3 in capacity (the ratings was gives in Table 1.3 in first chapter of current thesis). Maersk occupies first place with approximately 16% of market share. MSC is the second with 14,5% of market and CMA CGM is the third in the rating with 10,7%. In total, if all three companies would be considered, they have almost half of the global market share (around 41%). The advantage of cooperation with these three shipping lines lies in the fact that these companies have wide range of routes all over the world and have huge geographical coverage. Moreover, they can gain economy on scale because of enormous volumes of cargo transported daily. And thus, the freight rate is comparatively small on certain routes in comparison with smaller carriers like Evergreen line or NYK line, for instance.

The criteria of selection were defined, the hierarchical system of the supplier's characteristics was given and the importance of each characteristic was estimated in previous chapters. The current task is the application of selection technique to the Leaap company.

Three mentioned above suppliers were assessed by the logistics representative of the company, who permanently has the need of shipping line selection as a part of his work process. The assessment was done by 1-7 Lakert scale (the criteria assessment explanation was given in the Table 2.1 earlier) and the results are given in Table 3.1 below. The scoring was done subjectively, according to the existing relationships with maritime transportation service suppliers and the results should be applicable only to the Leaap company, while the method itself can be used by each company that faces the same problem of selection.

Table 3.1 Characteristics assessment for Leaap case

	MSC	**Maersk**	**CMA CGM**
Time characteristics:			
Frequency of sailing	6	5	4
Schedule reliability:			
No delays in sailing	3	6	6
Transit time	6	5	7
Price characteristics:			
Freight rate	6	5	4
Willingness to negotiate price	7	6	6
Discount structure	6	4	4
Customer service characteristics:			
Personnel performance:			
Frequency/speed of answer	6	4	5
Personnel accuracy	3	6	6
Knowledgeability of sales personnel	5	6	6
IT performance:			
User-friendly interface	6	5	7
E-business availability	4	6	5
Handling service:			
Geographical coverage	4	5	3
Frequency of damage/loss of cargo	5	6	6
Equipment characteristics	5	5	6

It can be seen from the expert's assessment of characteristics that Maersk and CMA have quite common evaluation. Also according to his experience, MSC line is good if price is concerned, it has better grades for all three sub-characteristics – discount structure, willingness to negotiate price and the freight rate. While the concerned line assessed worse in comparison with other two alternatives in regard to service characteristics and time characteristics.

The provided information is enough for APIS software to accurately calculate aggregated indicator. Firstly the four groups of sub-characteristics were estimated by APIS software and the aggregated preference indices were calculated (Table 3.2)

Table 3.2 Aggregated preference indices for sub-characteristics (Leaap case, Appendix 6)

	Schedule Reliability	Personnel Performance	IT Performance	Handling service
MSC	0,245	0,1061	0,122	0
Maersk	0,3775	0,8939	0,755	1
CMA CGM	1	0,9469	1	0,5

At first it might be concluded that CMA is a leader in schedule reliability, personnel performance together with IT performance. While Maersk has the highest possible value of handling service assessment but loses the game to CMA with other three sub-characteristics. As fare as MSC line is concerned, it has the lowest aggregated preference indices regarding all four sub-characteristics considered. But as far as only sub-characteristics are concerned, it is impossible to make conclusions on particular maritime transportation service provider selection without looking on the higher level of characteristics' hierarchy.

For calculation of primary characteristics the result of previous estimations (Table 3.2) are taken and the next aggregated preference indices were created for each main group (Table 3.3):

Table 3.3 Aggregated preference indices for main groups of characteristics for Leaap case (Appendix 6)

	Time Characteristics	Price Characteristics	Customer Service Characteristics
MSC	0,245	1	0
Maersk	0,2555	0,3081	0,9529
CMA CGM	0,755	0,0926	0,6919

As it can be pointed out, MSC is good only by price characteristics, but offers unacceptably poor service and loses other two suppliers in time characteristics. CMA CGM, in its turn, has the best value of index for time characteristics, but other two groups of criteria have worse value in comparison with Maersk.

Therefore, according to the all three main characteristics groups and there is no clear understanding which service provider should be selected because there is no provider who has the best results in each group. That is the reason for final round of APIS estimation to be realized and result is presented in Table 3.4 below.

Table 3.4 Aggregated preference estimations for alternatives for Leaap case (Appendix 5)

	Aggregated Preference Estimation	**Rank**
MSC	0,2778	3
Maersk	0,6843	1
CMA CGM	0,5535	2

The software provided with Aggregated Preference Estimation for each of three alternatives and gave the rank to each of them. So, according to the output information of APIS, Maersk index is the highest and ranked the first. The second place occupies CMA CGM line, with not too less index estimation. In comparison with first two, MSC line is assessed with more than twice less index value and thus, is ranked as third alternative.

According to the result conducted, the Maersk should be selected, taking into account all characteristics estimations and the level of their importance for making decision.. Nevertheless it is necessary to make a look on the Figure 3.2 below.

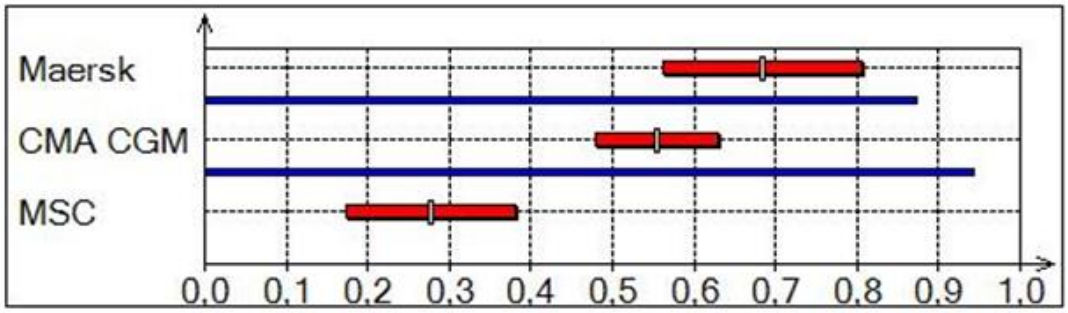

Figure 3.2 Aggregated preference indices visualization for Leaap case (Appendix 4)

On the figure we can see red and blue intercepts of a straight line. Abscissa of a midpoint of a red intercept of straight line –or a red interval – shows an average estimation of a correspondent object. At the same time the length of this red interval equals to the doubled standard deviation of the given index. It should be specified that the longer this red interval is, the more risky the alternative index estimation is. An abscissa of a blue interval's right end shows the reliability for dominance relation between neighboring index estimations. (Hovanov, 2005).

As can be seen from the APIS visualization – the shipping line with the highest value of aggregated preference estimation – Maersk – has the highest standard deviation meaning of 0,1203 (see Appendix 5). This value is almost twice higher than CMA CGM's one (0,0744). But even with the worst-case scenario the aggregated preference estimation of Maersk will be higher

than the same estimation of CMA. At the same time the standard deviation of MSC line 0, 1039 that is almost the same as of first alternative – that shows that MSC is the worst choice in the current case, because it has the worst index value and, in the meantime, high standard deviation assessment. Thus, in the considered case the selection decision is clear – among three alternatives Maersk should be chosen.

Thus, with the help of offered technique the managers of LLC Leaap reduced the time spending on the selection of the most suitable maritime transportation service supplier. As Maersk's handling service is the best from the other alternatives, it shows the advantage gained by the company with the decision of selection this carrier. Also the company gains an opportunity to minimize expenses connected with the weak service provided, for example, if in this case it would choose MSC. So, with the help of provided technique the company minimized its risks connected with maritime transportation.

Conclusions on Chapter 3

The technique of maritime transportation service supplier selection that was provided in the second chapter was applied on the case company Leaap, the freight forwarder. Also the transportation industry was overviewed in order to demonstrate the problem of supplier selection.

The selection decision was made from the list of three alternatives. The results interpretation is provided in details. According to given application to the freight forwarding company other members of the industry can easier implement the same steps in order to solve the given problem.

Conclusion

Current section will provide the main results and conclusions of the master thesis, an overview of the paper and will demonstrate the managerial implications of the topic and its scientific relevance.

The goal of the paper was technique development of multi-criteria selection of maritime transportation service supplier based on comparison of expert questionnaires and application of results on the chosen case company. This goal was achieved successfully by the introduction of such multi-criteria optimization decision support system as APIS for selection of element of maritime supply chain.

The overall developed technique of maritime transportation service supplier selection is structured as follows: firstly the attributes of maritime carrier selection should be determined, after the attributes' metrics should be specified. The next step is the design of hierarchical structure of characteristics of maritime carrier, collection of data and its processing in DSS APIS. The final stage is the interpretation of results for their further application

The described technique was tested on the Leaap LLC, company operating in the transportation service industry. As the company faces with maritime carrier selection on everyday basis, the necessity of suitable technique that would help with the proble of selection is crusial. So, as a result of technique implementation, all steps were completed and the most suitable maritime transportation service provider was chosen.

Results of the master thesis can be formulated as follows:

- The technique for maritime transportation service supplier selection was designed
- The hierarchical system of characteristics was created
- The importance of each characteristic was estimated
- The multi-criteria optimization tool was proposed as part of technique
- The techquique was applied to the chosen case company – Leaap LLC

From the *theoretical* point of view, particular work fills the gap of not developed framework of maritime transportation service supplier selection. Despite the criteria of such selection are covered in the literature, as was mentioned in the first chapter of current thesis, there is no existing methodology that can be implemented in real conditions by the managers.

From the side of business, the *practical* side, with the help of designed framework of selection it becomes possible for managers of the logistics companies who meet the underlined problem to achieve the next advantages:

- Reduce the time spending on the selection of proper shipping line

- Decrease the costs connected with the selection
- Minimize expenses which are correlated with the weak service provided
- Maximize the opportunity of the most suitable maritime transportation supplier selection

Nevertheless, there can be found some *limitations* of current study. They are mostly connected with the possibility of application of the proposed technique. First of all it should be mentioned, that the term “maritime transportation service supplier” is connected with the field of containership maritime transportation. So, the supplier is a sea carrier, or a shipping line as an element of maritime supply chain, that provides the transportation services from port of origin to port of destination.

Moreover, the developed technique is suitable for companies of maritime transportation service industry, because otherwise with lack of expertise in the field, it would be not possible to make an evaluation of the discussed characteristics.

As *future research opportunities*, proposed technique of maritime supply chain element selection can be developed and implemented for selection of other elements of the transportation service industry. An example can be the selection of freight forwarders as third-party logistics providers. Also as it was covered in the second chapter, some characteristics of maritime transportation service suppliers, that make influence on the selection decision, are either relatively constant or need to be revised on regular basis. It can serve as possibility for future research, as the simplifying of characteristics assessment and development the technique itself will lead to reduction of time spent on selection

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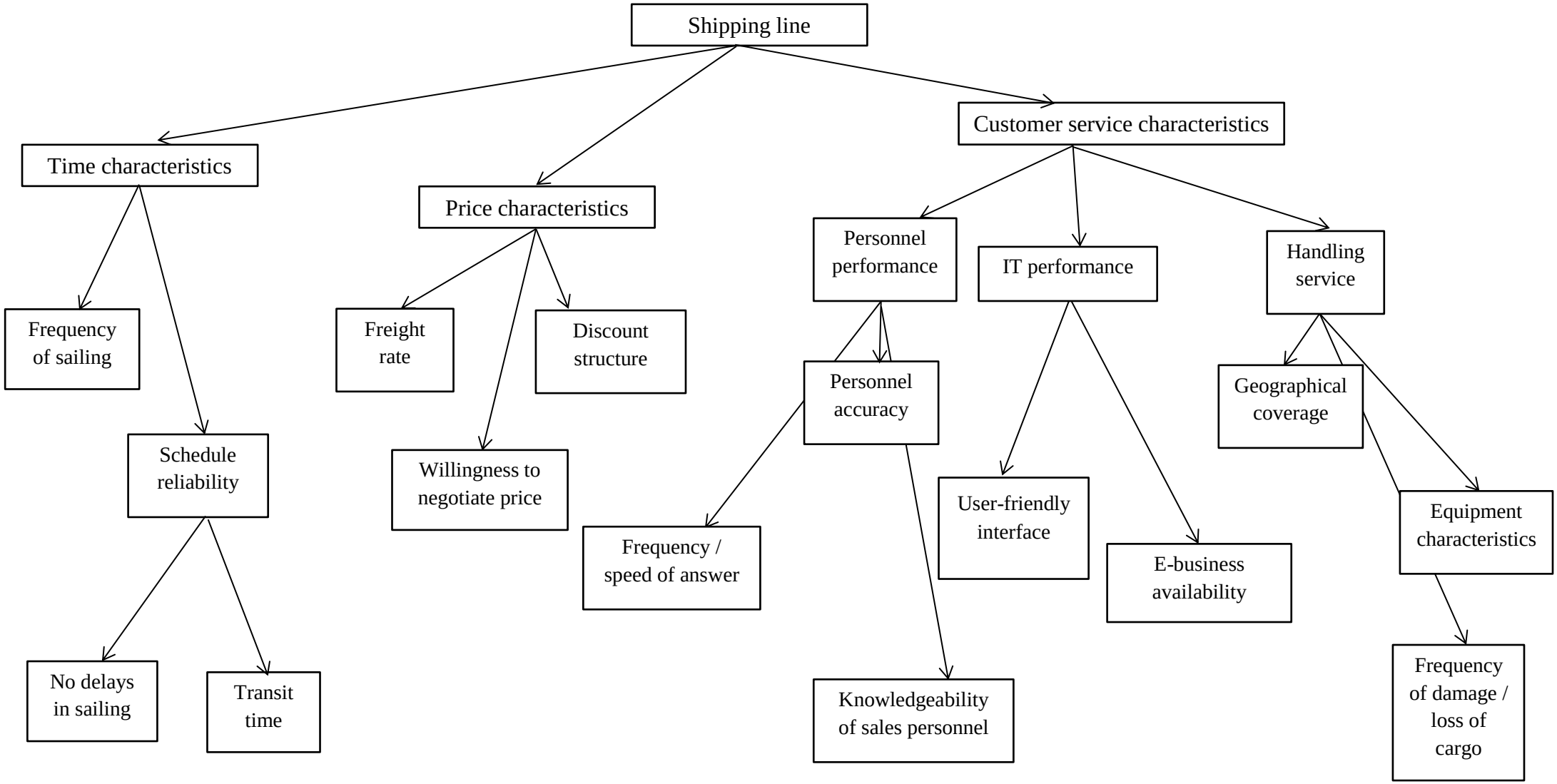
Appendix 1. Questionnaire for assessment of criteria importance

Questionnaire for maritime transportation logistics managers.

Dear respondent!

This survey is conducted in the purpose of master thesis carried out by the Graduate School of Management. Received data will be used by the researcher to develop the method of choice of maritime transportation supplier. The researcher of the study ensures confidentiality of the information.

At first you will see a diagram with the maritime transportation service supplier selection criteria. The next step will be the evaluation of characteristics by 5-point scale, in which 1 means the least influence/importance and 5 – the greatest influence/importance.


Shipping line
Time characteristics
Price characteristics
Customer service characteristics
Frequency of sailing
Schedule reliability
Freight rate
Discount structure
Willingness to negotiate price
Personnel performance
IT performance
Handling service
Personnel accuracy
Geographical coverage
Equipment characteristics
Frequency / speed of answer
User-friendly interface
E-business availability
No delays in sailing
Transit time
Knowledgeability of sales personnel
Frequency of damage / loss of cargo

Kindly answer on following questions:

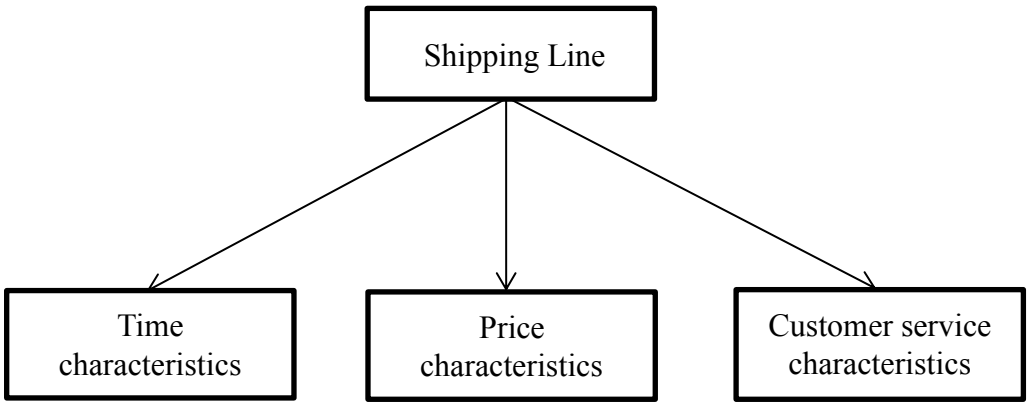
Each shipping line can be described by the list of characteristics:

1) Time characteristics

2) Price characteristics

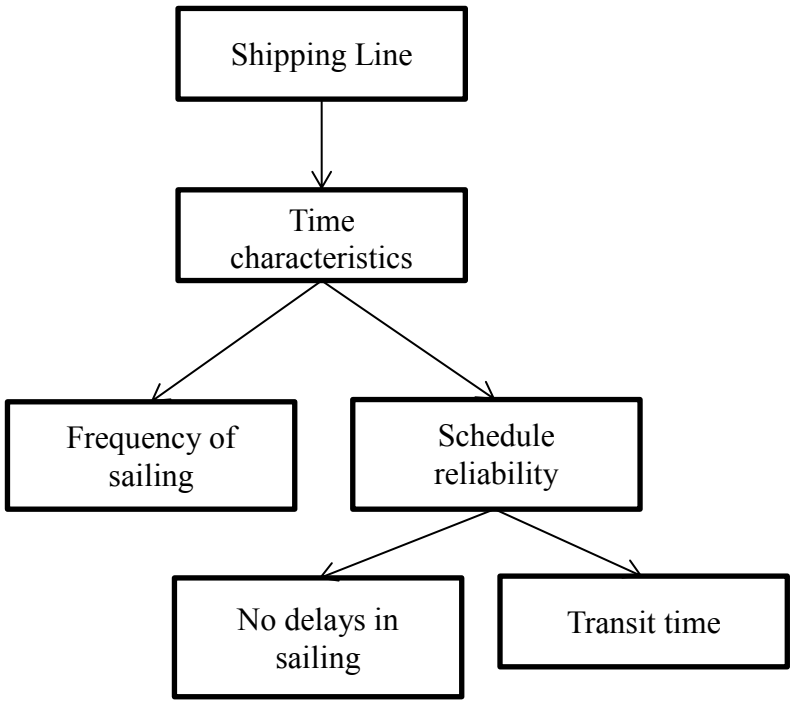
3) Customer service characteristics

1. Please spread 100 points between the characteristics above basing on their importance



Groups of characteristics	**Scores**
Time characteristics	
Price characteristics	
Customer service characteristics	

2. Please rate by a 5-point scale the degree of influence of each of the **Time characteristics** on the shipping line selection.

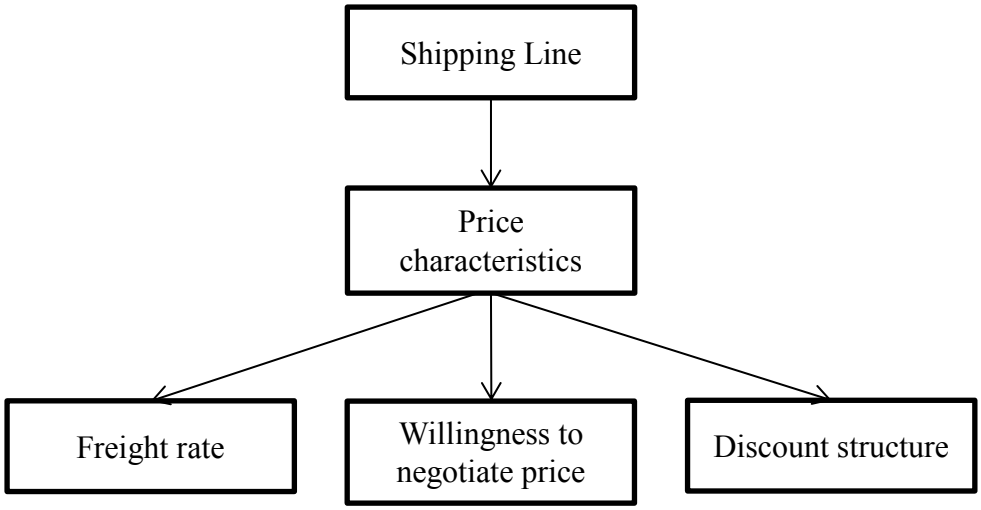


	Time characteristics				
	1	2	3	4	5
Frequency of sailing					
Schedule reliability					

Please rate by a 5-point scale the importance degree of the elements that determine the characteristic **Schedule reliability**

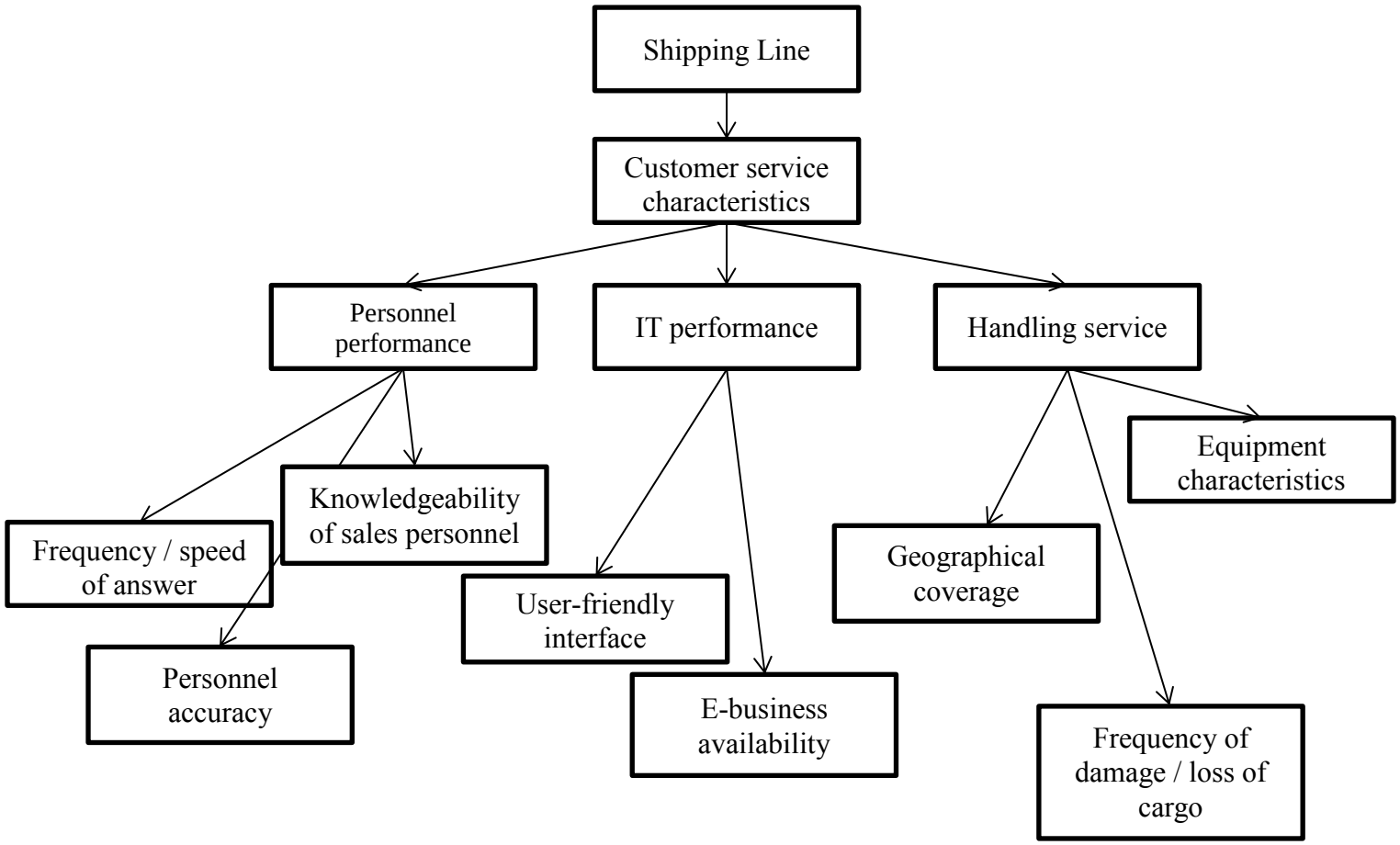
	Schedule reliability				
	1	2	3	4	5
No delays in sailing					
Transit time					

3. Please rate by a 5-point scale the degree of influence of each of the **Price characteristics** on the shipping line selection.



	Price characteristics				
	1	2	3	4	5
Freight rate					
Willingness to negotiate price					
Discount structure					

4. Please rate by a 5-point scale the degree of influence of each of the **Customer service characteristics** on the shipping line selection.



	Customer service characteristics				
	1	2	3	4	5
Personnel performance					
IT performance					
Handling service					

Please rate by a 5-point scale the degree of importance of the elements that define the characteristic **Personnel performance**

	Personnel performance				
	1	2	3	4	5
User-friendly interface					
Personnel accuracy					
Knowledgeability of sales personnel					

Please rate by a 5-point scale the degree of importance of the elements that define the characteristic **IT performance**

	IT performance				
	1	2	3	4	5
User-friendly interface					
E-business availability					

Please rate by a 5-point scale the degree of importance of the elements that define the characteristic **Handling service**

	Handling service				
	1	2	3	4	5
Geographical coverage					
Frequency of damage / loss of cargo					
Equipment characteristics					

Thank you for your valuable answers. All responses will become the basis of conducted research.

Contact information:

Zapisova Nadezhda

mob: 8-911-…

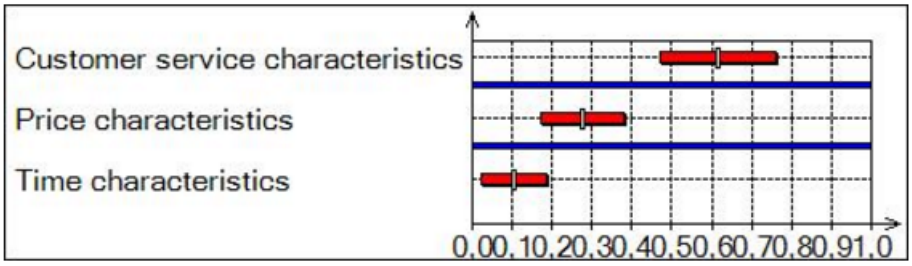
e-mail: Zapisova.nadya@gmail.com

Appendix 2. Characteristics' importance – results of questionnaire

Respondents / Criteria	1	2	3	4	5	6	7	8	9	10	Sum	Sum/N (weights)
Time characteristics	25	25	30	20	20	25	25	35	40	35	280	0,280
Frequency of sailing	4	4	5	3	5	4	4	5	5	4	43	0,462
Schedule reliability	5	5	5	5	5	5	5	5	5	5	50	0,538
No delays in sailing	4	5	4	5	5	5	5	4	4	4	45	0,479
Transit time	5	5	5	4	5	5	5	5	5	5	49	0,521
Price characteristics	30	25	30	30	40	30	45	35	30	25	320	0,320
Freight rate	5	5	5	5	4	5	5	5	5	5	49	0,398
Willingness to negotiate price	4	4	3	3	4	5	4	4	4	5	40	0,325
Discount structure	3	4	3	3	2	4	4	4	3	4	34	0,276
Customer service characteristics	45	50	40	50	40	45	30	30	30	40	400	0,400
Personnel performance	4	4	5	4	4	3	4	4	4	5	41	0,336
Frequency/speed of answer	4	4	4	3	3	2	3	4	4	4	35	0,276
Personnel accuracy	5	5	5	5	4	5	4	5	5	5	48	0,378
Knowledgeability of sales personnel	4	5	5	4	4	4	4	5	5	4	44	0,346
IT performance	3	3	4	3	3	3	2	3	3	4	31	0,254
User-friendly interface	2	3	2	2	3	2	3	3	2	3	25	0,342
E-business availability	5	5	5	4	5	4	5	5	5	5	48	0,658
Handling service	5	5	5	5	5	5	5	5	5	5	50	0,410
Geographical coverage	3	2	4	4	4	3	4	4	4	3	35	0,292
Frequency of damage/loss of cargo	5	5	5	5	5	5	5	5	5	5	50	0,417
Equipment characteristics	4	4	3	3	4	3	3	4	4	3	35	0,292

Appendix 3. Output information from APIS Technique for maritime transportation supplier selection

Weight-coefficients estimations visualization



Statistics of admissible weight-coefficients values

Weight of index	Min	Max	Mean	StDev	Rank
w(Time characteristics)	0,0000	0,3200	0,1061	0,0785	3
w(Price characteristics)	0,0100	0,4900	0,2778	0,1039	2
w(Customer service characteristics)	0,3500	0,9900	0,6161	0,1415	1

Weight-coefficients dominance reliability

PW(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	0,0000	0,0000	0,0000
w(Price characteristics)	1,0000	0,0000	0,0000
w(Customer service characteristics)	1,0000	1,0000	0,0000

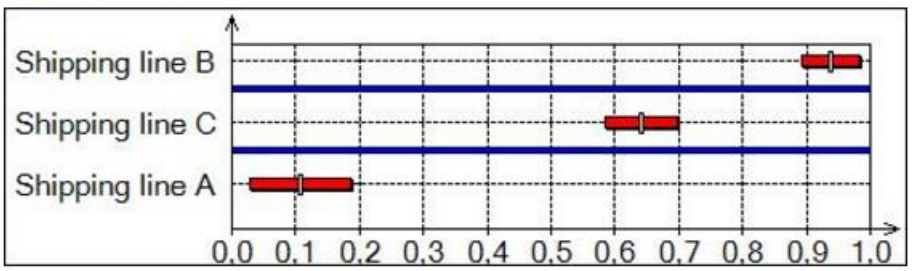
Weight-coefficients covariance

WCOV(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	0,0062	0,0015	-0,0077
w(Price characteristics)	0,0015	0,0108	-0,0123
w(Customer service characteristics)	-0,0077	-0,0123	0,0200

Weight-coefficients correlation

WCORR(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	1,0000	0,1895	-0,6934
w(Price characteristics)	0,1895	1,0000	-0,8388
w(Customer service characteristics)	-0,6934	-0,8388	1,0000

Aggregated preference indices visualization



Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,0000	0,3200	0,1061	0,0785	3
Q(Shipping line B)	0,8165	1,0000	0,9391	0,0450	1
Q(Shipping line C)	0,4892	0,7195	0,6407	0,0556	2

Aggregated preference indices dominance reliability

PQ(i,j)	Q(Shipping line A)	Q(Shipping line B)	Q(Shipping line C)
Q(Shipping line A)	0,0000	0,0000	0,0000
Q(Shipping line B)	1,0000	0,0000	1,0000
Q(Shipping line C)	1,0000	0,0000	0,0000

Aggregated preference indices covariance

QCOV(i,j)	Q(Shipping line A)	Q(Shipping line B)	Q(Shipping line C)
Q(Shipping line A)	0,0062	-0,0035	-0,0044
Q(Shipping line B)	-0,0035	0,0020	0,0025
Q(Shipping line C)	-0,0044	0,0025	0,0031

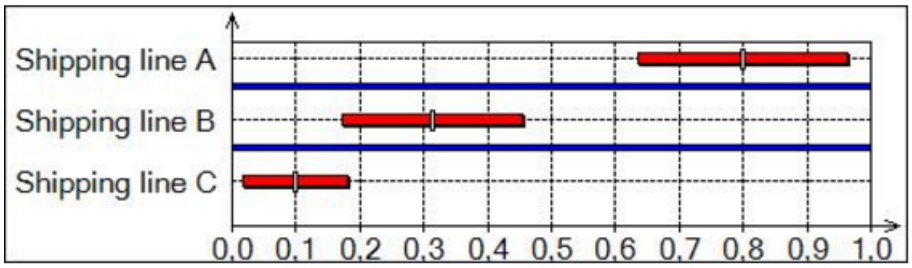
Aggregated preference indices correlation

QCORR(i,j)	Q(Shipping line A)	Q(Shipping line B)	Q(Shipping line C)
Q(Shipping line A)	1,0000	-1,0000	-0,9996
Q(Shipping line B)	-1,0000	1,0000	0,9996
Q(Shipping line C)	-0,9996	0,9996	1,0000

Appendix 4. Additional output from APIS Technique for maritime transportation supplier selection

1) Time Characteristics

Aggregated preference indices visualization

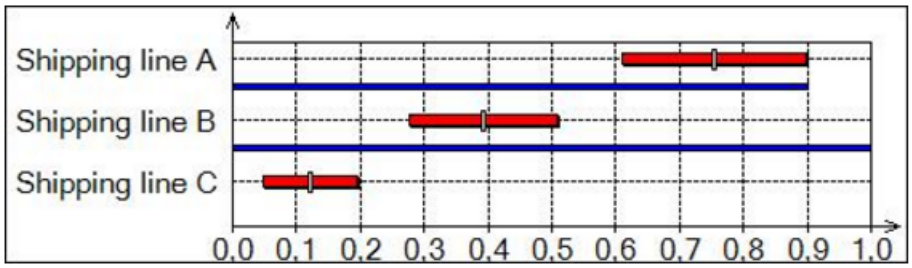


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,6000	1,0000	0,8000	0,1633	1
Q(Shipping line B)	0,1429	0,4857	0,3143	0,1399	2
Q(Shipping line C)	0,0000	0,2000	0,1000	0,0816	3

2) Price characteristics

Aggregated preference indices visualization

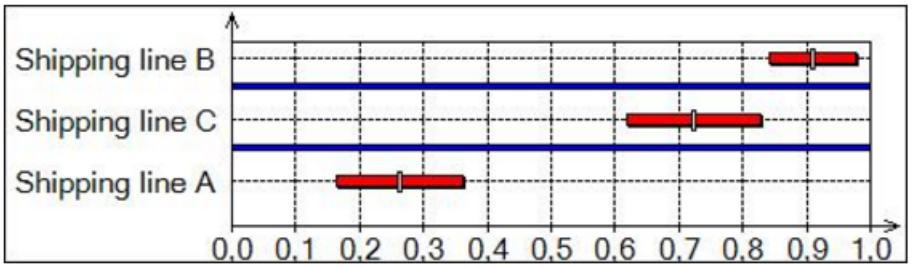


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,5100	1,0000	0,7550	0,1443	1
Q(Shipping line B)	0,1943	0,5891	0,3917	0,1163	2
Q(Shipping line C)	0,0000	0,2450	0,1225	0,0722	3

3) Customer service characteristics

Aggregated preference indices visualization

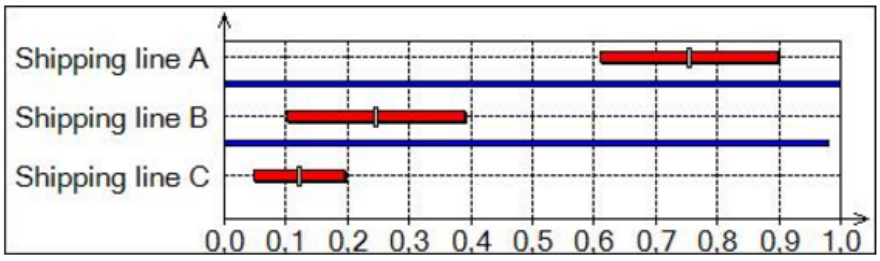


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,0094	0,4617	0,2617	0,0979	3
Q(Shipping line B)	0,7232	1,0000	0,9082	0,0679	1
Q(Shipping line C)	0,5100	0,9900	0,7222	0,1039	2

4) Schedule reliability

Aggregated preference indices visualization

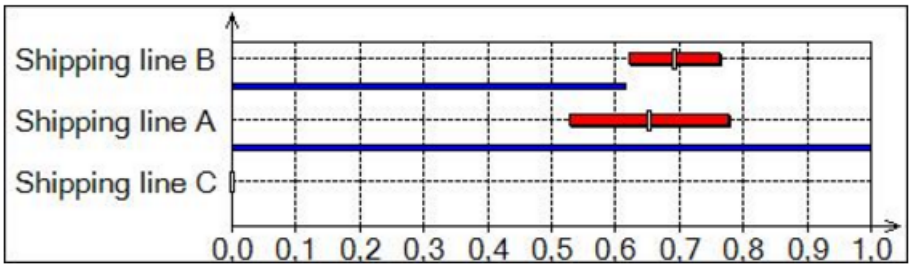


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,5100	1,0000	0,7550	0,1443	1
Q(Shipping line B)	0,0000	0,4900	0,2450	0,1443	2
Q(Shipping line C)	0,0000	0,2450	0,1225	0,0722	3

5) Personnel performance

Aggregated preference indices visualization

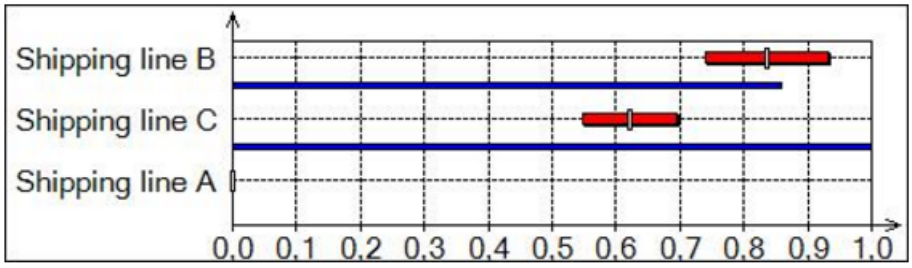


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,4533	0,9900	0,6515	0,1248	2
Q(Shipping line B)	0,5050	0,8250	0,6919	0,0708	1
Q(Shipping line C)	0,0000	0,0000	0,0000	0,0000	3

6) IT performance

Aggregated preference indices visualization

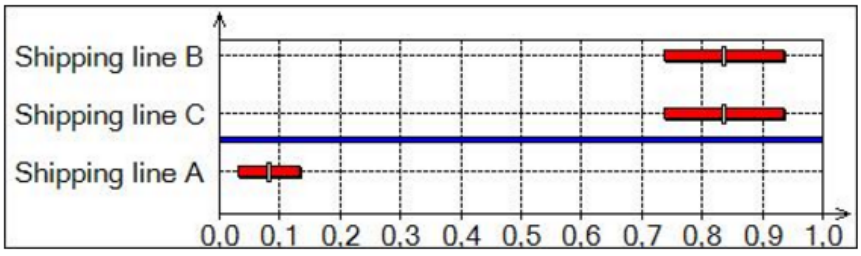


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,0000	0,0000	0,0000	0,0000	3
Q(Shipping line B)	0,6733	1,0000	0,8367	0,0962	1
Q(Shipping line C)	0,5000	0,7450	0,6225	0,0722	2

7) Handling service

Aggregated preference indices visualization

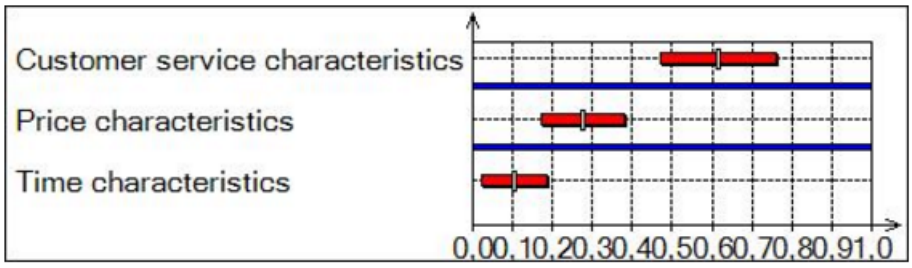


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(Shipping line A)	0,0000	0,1650	0,0825	0,0491	2
Q(Shipping line B)	0,6700	1,0000	0,8350	0,0981	1
Q(Shipping line C)	0,6700	1,0000	0,8350	0,0981	1

Appendix 5. Output information from APIS Technique for maritime transportation supplier selection for Leaap LLC case

Weight-coefficients estimations visualization



Statistics of admissible weight-coefficients values

Weight of index	Min	Max	Mean	StDev	Rank
w(Time characteristics)	0,0000	0,3200	0,1061	0,0785	3
w(Price characteristics)	0,0100	0,4900	0,2778	0,1039	2
w(Customer service characteristics)	0,3500	0,9900	0,6161	0,1415	1

Weight-coefficients dominance reliability

PW(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	0,0000	0,0000	0,0000
w(Price characteristics)	1,0000	0,0000	0,0000
w(Customer service characteristics)	1,0000	1,0000	0,0000

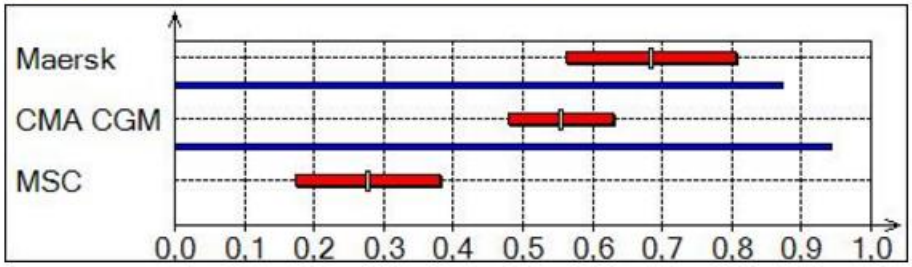
Weight-coefficients covariance

WCOV(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	0,0062	0,0015	-0,0077
w(Price characteristics)	0,0015	0,0108	-0,0123
w(Customer service characteristics)	-0,0077	-0,0123	0,0200

Weight-coefficients correlation

WCORR(r,s)	w(Time characteristics)	w(Price characteristics)	w(Customer service characteristics)
w(Time characteristics)	1,0000	0,1895	-0,6934
w(Price characteristics)	0,1895	1,0000	-0,8388
w(Customer service characteristics)	-0,6934	-0,8388	1,0000

Aggregated preference indices visualization



Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0100	0,4900	0,2778	0,1039	3
Q(Maersk)	0,4351	0,9924	0,6843	0,1203	1
Q(CMA CGM)	0,3703	0,7189	0,5535	0,0744	2

Aggregated preference indices dominance reliability

PQ(i,j)	Q(MSC)	Q(Maersk)	Q(CMA CGM)
Q(MSC)	0,0000	0,0000	0,0576
Q(Maersk)	1,0000	0,0000	0,8727
Q(CMA CGM)	0,9424	0,1273	0,0000

Aggregated preference indices covariance

QCOV(i,j)	Q(MSC)	Q(Maersk)	Q(CMA CGM)
Q(MSC)	0,0108	-0,0097	-0,0074
Q(Maersk)	-0,0097	0,0145	0,0051
Q(CMA CGM)	-0,0074	0,0051	0,0055

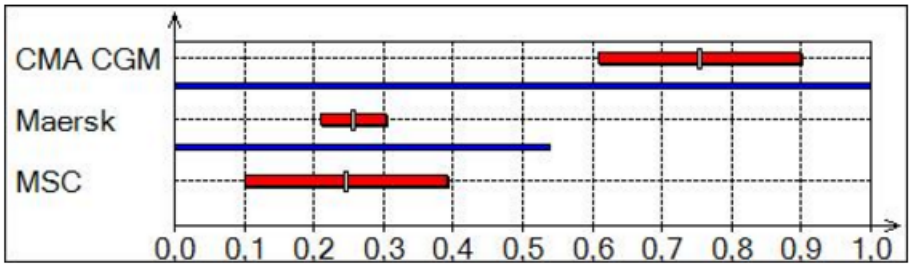
Aggregated preference indices correlation

QCORR(i,j)	Q(MSC)	Q(Maersk)	Q(CMA CGM)
Q(MSC)	1,0000	-0,7794	-0,9589
Q(Maersk)	-0,7794	1,0000	0,5697
Q(CMA CGM)	-0,9589	0,5697	1,0000

Appendix 6. Additional output from APIS Technique for maritime transportation supplier selection for Leaap LLC case

1) Time Characteristics

Aggregated preference indices visualization

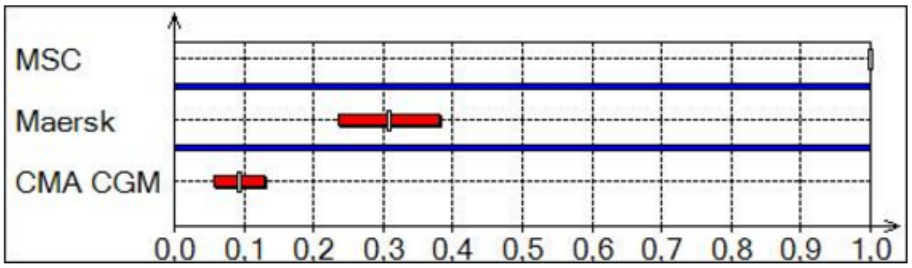


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0000	0,4900	0,2450	0,1443	3
Q(Maersk)	0,1762	0,3348	0,2555	0,0467	2
Q(CMA CGM)	0,5100	1,0000	0,7550	0,1443	1

2) Price characteristics

Aggregated preference indices visualization

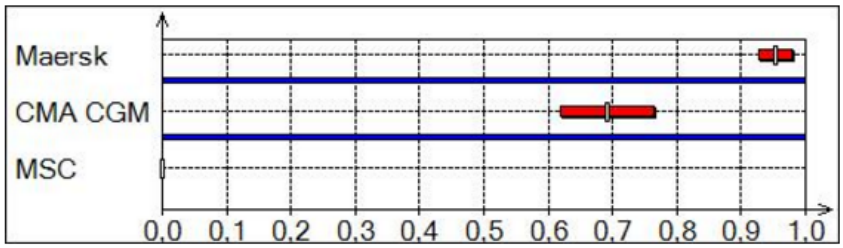


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	1,0000	1,0000	1,0000	0,0000	1
Q(Maersk)	0,1750	0,4950	0,3081	0,0708	2
Q(CMA CGM)	0,0033	0,1633	0,0926	0,0346	3

3) Customer service characteristics

Aggregated preference indices visualization

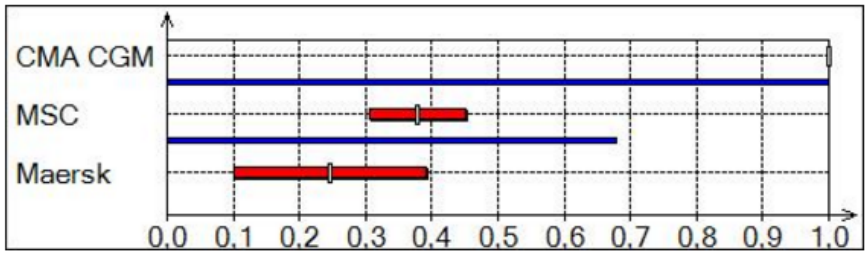


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0000	0,0000	0,0000	0,0000	3
Q(Maersk)	0,8899	0,9994	0,9529	0,0240	1
Q(CMA CGM)	0,5050	0,8250	0,6919	0,0708	2

4) Schedule reliability

Aggregated preference indices visualization

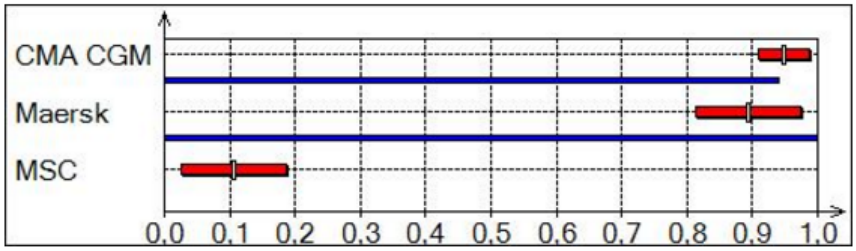


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,2550	0,5000	0,3775	0,0722	2
Q(Maersk)	0,0000	0,4900	0,2450	0,1443	3
Q(CMA CGM)	1,0000	1,0000	1,0000	0,0000	1

5) Personnel performance

Aggregated preference indices visualization

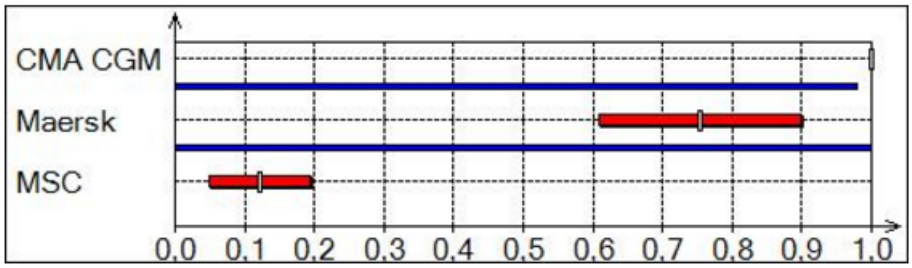


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0000	0,3200	0,1061	0,0785	3
Q(Maersk)	0,6800	1,0000	0,8939	0,0785	2
Q(CMA CGM)	0,8400	1,0000	0,9469	0,0392	1

6) IT performance

Aggregated preference indices visualization

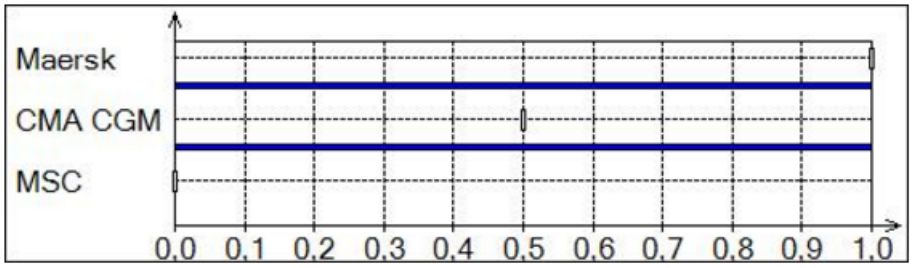


Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0000	0,2450	0,1225	0,0722	3
Q(Maersk)	0,5100	1,0000	0,7550	0,1443	2
Q(CMA CGM)	1,0000	1,0000	1,0000	0,0000	1

7) Handling service

Aggregated preference indices visualization



Statistics of alternatives aggregated preference estimations

Aggregated index of alternative	Min	Max	Mean	StDev	Rank
Q(MSC)	0,0000	0,0000	0,0000	0,0000	3
Q(Maersk)	1,0000	1,0000	1,0000	0,0000	1
Q(CMA CGM)	0,5000	0,5000	0,5000	0,0000	2