Hierarchical Representation of Decision-Making in Chartering a Vessel on a Voyage Charter

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Abstract. This paper presents a decision-making method (analytic hierarchy process) for choosing a charter option by means of a subjective preference vector. Analytic hierarchy process (AHP) is a rather general methodology for solving a broad range of weakly structured decision-making problems that combines a fairly simple mathematical method with the manager’s knowledge, experience, and imagination. This paper investigates AHP application by a manager who is not an expert in chartering. To describe the method, the paper presents a case study of chartering a vessel to freight bulky, heavy cargo.

1. Introduction

This paper investigates decision-making in chartering a vessel to transport bulky and heavy (general) cargo. It presents hierarchical decision-making based on analytic hierarchy process; the modeled problem consists in choosing one of various available charter options. The key goal herein is to enable continuous, consistent decision-making that minimizes the costs and maximizes compliance with the customer’s subjective preferences, which is the decisive factor in this particular case. One way this could be achieved is to use a managerial decision support system for more efficient choice of transport logistics for cargo delivery [1, 2].

With this in mind, we propose using analytic hierarchy process to choose the best charter option; this method involves analyzing the multi-criteria decision-making problem by the following algorithm:
- construct an hierarchy and a pairwise comparison matrix;
- determine the criteria to choose the best option for the voyage charter;
- generate a vector of local priorities and choose the optimal charter option to transport given cargo;
- for the modeled problem, noise the pairwise comparison matrix to simulate a situation where the manager is unable to correctly perceive the problem;
estimate the weights of all alternatives to see the resilience of AHP to managerial errors.

2. Cargo shipping: choice of transport and logistic planning

Consider making a freight transaction from the standpoint of process management; in this case, each charter preference on the part of the shipowner or charterer can be considered a specific situation. Therefore, when working with a particular charter model, the shipowner (the charterer) can model various strategies and tactics, the emerging or predicted situations, including projections as to how they are going to unfold.[3]. This approach helps negotiate terms and condition of carriage, adjust them for the parties’ preferences and prior experience of similar shipping, and predict the success of the voyage as early as making the charter [4].

The first step is always to structure the contract, i.e., define the type of contract in the context of specific requirements. These requirements can be legal, bank-imposed, or stemming from the existing customs, etc. The problem is that the Civil Code of the Russian Federation (CCRF) and other frameworks lack regulations concerning the structure and content of contracts. First, law does not define any official, “standard” form of contract. In this case, a Civil Code clause applies that guarantees the freedom of contract and the parties’ ability to enter into a contract in a form that may or may not be regulated by law or other legal acts, including a mixed form. Secondly, the terms and conditions of contract are determined at the parties’ discretion unless otherwise stipulated by law or other legal acts. That being said, a contract of carriage can be in any form. However, bank transactions sometimes require a standardized contract that contains parties’ details, preamble, subject matter, pricing, payment procedures, etc. Banks may refuse to accept fixture notes or charterparties as contracts. However, a charterparty is required if either party is a foreign entity, whether a charterer or a shipping company. Besides, there are certain customs that determine the structure, terms and conditions of contracts of carriage. [4].

Making any decision means making a choice. The greater the choice, the harder it is to find the optimal solution. How can one be sure that their charter party has the best possible terms and conditions? Preliminary contract drafting and estimation of voyage results as affected by the type of contract helps bargain and set terms and conditions of carriage by sea [5].

3. Research methods

Whether a decision is to be effective depends on the content of such decision and on the manager’s approach to its implementation. A great decision can be compromised by poor implementation. On the contrary, a poorly made decision can still be implemented despite its apparent ineffectiveness [6].

Analytic hierarchy process has several advantages over other methods for solving semi-structured problems: it uses highly visual models, the results are easy to interpret, the estimates to make are relative simple as well, the method is in line with the principles of systemic approach, the models have neither gaps nor redundancy, the estimates can be duplicated, the alternatives can be assessed by qualitative, subjectively defined criteria, and the method is overall resilient to inconsistency in managers’ judgments [7, 8].

AHP is based on: the principle of decomposition, which structures the problem as an hierarchy of ever simpler problems; the principle of pairwise comparison, which compares all possible combinations of the elements under consideration to assign a priority or a weight to each element in each group with respect to its objectives; the principle of hierarchical composition or synthesis that determines each group’s priorities on each level of the hierarchy [9-10].

Besides, the method relies on the following axioms:

1) Axiom of contingency: the priority of Alternative B over Alternative A equals 1 over the priority of Alternative A over Alternative A.

2) Axiom of homogeneity: on each level of a hierarchy, the compared elements should not differ significantly in terms of the feature under consideration; the range of variation must be the same for all paired estimates.
(3) Axiom of synthesis: higher-level assessments do not depend on lower-level assessments.

AHP as a method follows this algorithm: state the problem; build a hierarchy; run pairwise comparisons to evaluate the significance of alternatives; evaluate the local priorities of the compared elements; verify the consistency of local priorities; synthesize the solution hierarchically.

In general, hierarchical representation of a decision-making problem can be made in AHP as a model that generalizes the problem on higher levels of the hierarchy and resolves it in greater detail on lower levels; the uppermost level usually represents the key goal. Lower levels describe how the preceding level of hierarchy is formed or how it breaks down into elements [11, 12].

4. Research results

Let us now consider in detail making a decision on which voyage charter to pick. The fundamental distinguishing feature of this type of chartering is that the shipowner actually remains in full control of the operation and use of their ship(s), and thus bears all the commercial risks and operating costs while the contract is in force. One exception that can be made consists in the charterer bearing the costs associated with the handling of particular cargo, e.g., its separation, stowing, or the entire complex of handling operations, which correspondingly affects the carriage fees [13].

The authors hereof analyzed voyage charters that carry bulky and heavy cargo to determine the following contract-of-carriage assessment criteria [13]:

1. Vessel specifications, which affect the cargo insurance premium: Cargo hatch opening size (H), flag (Fl), and year of construction (YC).

For any case of shipping, the sender (the seller) or the buyer (depending on the contract) needs to insure the cargo against damage or loss in carriage by sea. Vessel specifications affect the premium. This is why the charter specifies the gross register tonnage, the age, the flag, and the Register Class. When chartering a vessel older than 15 years, the charterer needs to demand that the charterparty specify the expiry dates of the Register documents, the insured amount per CASCO hull and machinery (H&M), and the name of the Shipowners’ Club (Protective & Indemnity, P&I). Should any claims be filed against the vessel, the Club should make a bank guarantee so as to avoid detention of the vessel and thus guarantee timely delivery of cargo.

2. Specifications that determine whether the agreed cargo handling operations are possible: number of hold decks (ND), the availability of vessel cranes (AVC), the normal speed Customary Quick Despatch (CQD3) conditions. Port customs are a charter clause that demands handling operations to be done as customary without specifying the exact time rates.

3. Freight payment: Freight (F); any delay of the freight payment from the moment cargo is fully loaded is highly undesirable for the shipper, it increases both the risk of losing freight due to losing the cargo or the vessel, and the risk of losing part of freight due to currency devaluation or the charterers’ bankruptcy. Besides, reception of freight after unloading makes it difficult to utilize the pledge to extract the necessary payments. Losses due to delayed freight payment can considered equal to the total interest accruable on a bank loan equal to the amount of freight accepted for the duration of the voyage.

Choice of a charterparty for a voyage charter presents four forms that mainly differ in terms of the amount of work, the life of contract, and the number of vessels involved. Detailed terms and conditions of contract between a shipowner and a charterer are a development of the basic forms of voyage charters:

1. **single voyage charter** takes the form of a transaction in which a single vessel is chartered to transport specific cargo between two or more ports.

2. **round-trip voyage charter.** The charterer loads the vessel in both direction of carriage. In essence, these are two separate transactions that are made simultaneously, i.e., it formally consists in two consecutive voyages made to carry (normally non-identical) cargo between different ports.

3. **consecutive voyage charter** differs from single voyage charter in that it covers two or more similar voyages.
(4) **general contract charter.** In this case, the charterer hires the shipowner with its own or leased tonnage. The shipowner undertakes to transport a specific weight of cargo in several consignments over a specific timeframe. In adding to making a usual contract of carriage by sea, the parties agree upon the so-called **contractual terms and conditions**, including the total cargo, the deadlines, the size of consignments, and the deadline to ship each consignment. Terms and conditions may be set forth differently, but the meaning of the agreement remains the same [13].

The authors made a hierarchy and calculated the elements of preference eigenvectors for each criterion on the analyzed set of alternatives in order to synthesize the decision rule. Let us to build a hierarchy, see Figure 1, and calculate elements of preference eigenvectors for each criterion on the analyzed set of alternatives in order to synthesize the decision rule [14].

![Figure 1. Hierarchy for choosing the best voyage charter option.](image)

Criteria for evaluation of alternatives: find the normalized values of the eigenvector for each criterion that represent the significance of alternatives: 1 for equivalent significance, 2 for slight priority, 3 for weak priority, 4 for moderate priority, 5 for significant priority, 5 for substantial priority, 7 for strong priority, 8 for very strong priority, and 9 for unconditional priority. Let us compare the criteria on the first level of the hierarchy, see Table 1. Find the normalized elements of the eigenvector for each criterion; these elements should represent the significance of the alternatives [15].

Analyze the choice criteria and estimate the significance of alternatives by these criteria to make pairwise comparison matrices where each alternative is a combination of the type of contract and its criterial conditions [15].

**Decision rule synthesis and calculating the global priority vector.** Now find the normalized elements of the global priority eigenvector that determines the remote weights of the alternatives against the preference vector of the transport service customer (shipper, charterer). [16].

To synthesize the global priorities, construct a special-form matrix in Table 2.
Table 1. Normalizing the elements of the priority eigenvector for the first level of the hierarchy.

| Criteria | 3T | Fl | F | CQD | ND | AVC | YC | Eigenvector |
|----------|----|----|---|-----|----|-----|----|-------------|
| 3T       | 1  | 1  | 1/3 | 1/3 | 1/5 | 5   | 3   | 0.08        |
| Fl       | 1  | 1  | 1/3 | 1/3 | 1/5 | 5   | 3   | 0.08        |
| F        | 3  | 3  | 1   | 1   | 1/3 | 7   | 5   | 0.19        |
| CQD      | 3  | 3  | 1   | 1   | 1/3 | 7   | 5   | 0.19        |
| ND       | 5  | 5  | 3   | 3   | 1   | 9   | 7   | 0.39        |
| AVC      | 1/5| 1/5| 1/7 | 1/7 | 1/9 | 1   | 1   | 0.03        |
| YC       | 1/3| 1/3| 1/5 | 1/5 | 1/7 | 1   | 1   | 0.04        |

Table 2. Global priority synthesis.

| Alternative          | Criteria   | Eigenvector | λ (∑K:Α) |
|----------------------|------------|-------------|-----------|
| General contract     | 0.04       | 0.03        | 0.19      | 0.08     | 0.08   |
| Round trip           | 0.06       | 0.07        | 0.12      | 0.04     | 0.42   |
| Consecutive voyages  | 0.26       | 0.15        | 0.15      | 0.04     | 0.15   |
| Single voyage        | 0.12       | 0.27        | 0.60      | 0.19     | 0.19   |

Based on the obtained vectors, the best voyage charter option for bulky and heavy cargo are single voyage charter and consecutive voyage charter for this particular case.

Now consider a situation where the manager is unable to correctly analyze the problem, e.g., due to lack of experience, awareness, and time to do research. In this case, test the priority vector estimates for resilience to the poorly done work [17].

For the modeled problem, let us noise the pairwise comparison matrix. Let us see validate the conformity of the obtained matrix; should the conformity ratio be exceeded, repeat the operation and add the before and after weights to Table 3.

The analysis returns the following: in case of the manager’s error, the weights change by 0.04 for ∆= ±2, 0.3 for ∆= ±3, and 0.4 for ∆= ±4 on average. At ∆= ± 4, the ranking of alternatives changes.

We may therefore conclude that analytic hierarchy process is resilient to managerial errors at up to ∆= ± 3.

Let us investigate AHP application by a manager who is not an expert in chartering. We shall also see how the final decision is affected by the arrangement in the hierarchy [18-19].

Table 3. Comparison of weights for different noise levels.

| Alternative         | Weight, no noise | Weight at Δ= ± 2 | Weight at Δ= ± 3 | Weight at Δ= ± 4 |
|---------------------|------------------|------------------|------------------|------------------|
| General contract    | 0.12             | 0.0930           | 0.103            | 0.112            |
| Round trip          | 0.19             | 0.1717           | 0.156            | 0.173            |
| Consecutive voyages | 0.34             | 0.3608           | 0.372            | 0.411            |
| Single voyage       | 0.35             | 0.3745           | 0.378            | 0.304            |

To analyze the issue, let us model a situation where the manager completely lacks any knowledge of their voyage charter options, i.e., the choice if absolutely random.

Generate a pairwise comparison matrix to obtain the weights; run 100 iterations of estimates [20]. Table 4 shows the average weights for each alternative.
Table 4. Average values of weights for alternatives.

| Alternative          | Weight, no noise | Average weight in randomly generated pairwise comparison matrices |
|----------------------|------------------|---------------------------------------------------------------|
| General contract     | 0.119            | 0.246                                                         |
| Round trip           | 0.189            | 0.239                                                         |
| Consecutive voyage   | 0.337            | 0.255                                                         |
| Single voyage        | 0.353            | 0.259                                                         |

Random generation of pairwise comparison matrices leads us to the following conclusions:
- in analytic hierarchy process, the method for choosing a voyage charter option does not affect the result;
- even if the manager lacks basic knowledge, they still can get good results. The solution shows that multiple iterations of random matrix generation return results where weights in all alternatives tend to converge [20].

5. Conclusions
This paper shows how analytic hierarchy process could help make a decision when choosing between different voyage charter options for carriage of general (bulky and heavy) cargo. Notably, the commercial terms and conditions of the charter constitute the key part of the contract; however, choosing the right type of contract does affect the charterer’s or the shipper’s satisfaction with such terms and conditions.

Once the choice criteria are defined, the parties need to fine a compromise, i.e., the points where their interests match best. These points are referred to as subjective preference vectors.

Some chartering specialists believe experience and intuition alone are enough to be successful in the freight market. Of course, experience and intuition are necessary for effective freighting; however, parties may lack such experience in today’s market. Mathematical tools of the systemic approach and multi-criteria nature of the decision-making problem help find such terms and conditions that enable the best contractual relations. These vectors also help predict how events will unfold should external factors be engaged, which will undoubtedly facilitate decision-making in chartering.

The method is tested herein on a case of GENCON conditions, 1994 rev., from the standpoint of the charterer.

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