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Decision-making under Risk: A Ship Sale and Purchase Problem by Utilizing Cumulative Prospect Theory

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Abstract

Decision-making is often performed intuitively, yet formal decision-making by logical reasoning is needed for crosschecking or advocating despite its being burdensome and comprehensive. Prescriptive and descriptive approaches have been introduced for formal decision-making. Former regards decision makers as, metaphorically, rational computers whereas latter considers the human perception of value and probability differentiating in case of loss and gain. To the best of our knowledge, no research has been conducted on a ship sale and purchase problem based on a descriptive method to explain human risk aversive nature, perception of value, and probability. This study is therefore unique in the academic literature. This research includes the presentation of formal decision-making, related approaches, methods, and theories, the application of cumulative prospect theory (CPT) on a ship sale and purchase problem. An empirical study has been created and modeled, including statistical data concerning fuel oil prices and freight rate profit margins. A voyage estimation based on the empirical study is performed, calculations are carried out by utilizing the expected value method and CPT. Results obtained are quite useful for a better understanding formal decision-making, prescriptive, and descriptive approaches, and interpreting status-quo in demand for bulk carriers.

Keywords: Sale and purchase, Bulk carrier, Formal decision-making, Cumulative prospect theory

1. Introduction

People frequently stand at the crossroads where they need to assess their alternatives and choose one that fulfills criteria as a good solution. Decision-making is therefore related to a particular problem, alternatives, consequences, and a set of subjective criteria. Even though decisions are made intuitively, enterprises, or companies require decisions to be made primarily for justification. There have been two approaches asserted for formal decision-making: rational and behavioral decision-making. Rational decision-making is prescriptive and handles each situation as involving every piece of information required; therefore, any problem could be solved solely by intelligence. Behavioral decision-making is descriptive and rather concerned with the human perception of value, gain, loss, or meaning of uncertainties and probabilities [1].

Decisions, alternatives, and states of nature are visualized by several methods, including decision tables, decision trees, or programming languages. A decision table comprises a stack of data that usually serves as a basis for knowledge acquisition. Its primary purpose is to present decision variables, states of nature, and consequences in a matrix form. Decision variables constitute rows and states of nature form columns where consequences correspond to the intersection of rows and columns. A decision tree is a useful tree-like representation of a complex problem comprising decision nodes, alternatives, and related consequences. It is constructed rightward, evaluated leftward, and made rightward. Programming language is an algorithm benefiting from computer languages to fulfill a certain assignment. Selection of the most suitable visualization method for formal decision-making is often related to the complexity of the problem in question,

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expectation, and ability of the practitioner. Programming languages are often too advanced for most decision makers; therefore, the option would generally be limited to decision tables and decision trees. A decision tree is the standard method for holistic and comprehensive decision-making where a decision table is more suitable for the first step for visualization of knowledge acquisition. The size of a decision table corresponding to a decision analyzed by a decision tree would be too large and unpractical [2]; therefore, common sense during formal decision-making is to construct a decision tree.

Despite a considerable growth of 4.1% in 2019, the highest since 2014, global maritime trade has been severely affected by the coronavirus pandemic. Maritime trade has encountered short- and long-term crises arising from changing status-quo due to the pandemic, reshaping of the supply chain, and globalization patterns. Even though freight rates were observed to increase between January and June 2020 compared to 2019 for most trade routes, rates and ship supply capacity have been rearranged and kept at a viability level to preserve the continuation of global maritime transportation. Therefore, risk assessment and formal decision-making are becoming an utterly higher priority [3]. Shipowners primarily rely on chartering their ships for cargo transportation as a business model during booming periods of shipping cycles. Yet, the global financial crisis of 2008 and the coronavirus pandemic revealed a fact once more that selling existing ships and purchasing new ones, if deemed profitable, would be a smart strategy as implemented by many shipowners from prominent countries in maritime trading. Selling and purchasing ships could provide a more robust growth for shipowners or shipping companies than solely positioning for cargo transportation if they would be in the right place at the right time [4]. However, shipping trade contains considerable uncertainties like fuel prices, transportation demand, global financial status, production rates, and freight rate profit margins; therefore, it is not always easy to foresee the shipping cycle and the right decision whether to hold, sell, or sell and purchase. Violent competition, demand for transportation of a particular commodity, and unpredictability would easily be the driving force for a shipowner to make formal decision-making for the subsequent action based on the subjective perception of value and probabilities of outcomes.

This study comprises four sections: expected value method, expected utility theory, prospect theory, and cumulative prospect theory (CPT), as explained in Section 2. CPT is opted for the context of this study as supported by the literature review. An empirical study structured over bulk carriers of different sizes is described in Section 3, with relevant data. Bulk carriers are preferred as objects of the empirical study because dry bulk freight rates have been quite volatile in the past three years due to disruptions caused by pandemic conditions and imbalances in supply and demand [3]. CPT is then applied to the empirical study, and results are analyzed. Implications and conclusions are presented in Section 4. This study is expected to be the first contribution in the academic literature by introducing a descriptive decision-making method like CPT on a ship sale and purchase problem and be a remarkable formal decision-making analysis example.

2. Research Design

This section includes a brief introduction to formal decision-making, prescriptive, and descriptive approaches, expected value, expected utility theory, prospect theory, and CPT. Historical and evolutionary relevance of these methods are elucidated. Decision-making and application of CPT on ship sale and purchase activities and shipbuilding industry are reviewed in the academic literature further in this section.

2.1. Expected Value, Expected Utility Theory, and Prospect Theory

Decision-making is defined as selecting a set of alternatives with no shared characteristics. Choosing an alternative would have consequences based on the state of nature or the possibilities. Decisions may be made in under certain, risky, or uncertain environments. Decision-making under conditions in which alternatives and their outcomes are known as decision-making under certainty. Decisions influenced by probabilities are referred to as risky decisions. In this context, the risk does not always imply danger but also an opportunity or a gain. Decision-making under uncertainty is a classification similar to that made under risk, yet whether probabilities are not known or alternatives, probabilities, or consequences are not cognized tacitly. The former is known as decisions made under ambiguity, and the latter is recognized as decisions made in ignorance [5].

Formal decision-making comprises prescriptive and descriptive approaches. Former considers decision-making as a rational process strictly bound to predefined prescriptions while latter studies systematic revelations between such rational individuals [6]. However, "rationality" has limitations. It is claimed that a decision maker lacks complete information and computational skills and thus is easily influenced by bias, fallacies, or makes the wrong choice. This natural boundary of human thinking is called bounded rationality [1].

Expected value is the most common prescriptive method in evaluating a decision. It has its origins back to the 17th century as introduced by famous mathematicians Pascal and Fermat that preferability of an alternative is related with the Equation (1), where p_i stands for probability and a_i for the payoff (i.e., consequence) that is usually defined in amount of money of the outcome “i” belonging to an alternative (a). This methodology is quite simple and straightforward [7].

$$EV(a) = \sum_{i=1}^{n} p_i \cdot a_i \quad (1)$$

Expected value lacks to include human attitude toward risky situations. Bernoulli had uncovered this argument with St. Petersburg Lottery, indeed a paradox, in the 18th century. In this paradox, one would be asked how much he/she would be eager to pay once to participate in a heads or tails game in which a fair coin is used. If the tails side comes up, the player will get a prize (say €2) where if heads are observed, the player will have a chance to play the game once more. If the coin were tossed for n times, the player would get €2^n. Even though the expected value of playing the game seems to be infinite, the common human mind would instantly, without deliberately considering, only be willing to pay very small amounts of money to participate in a game or even decline the offer. Bernoulli had clarified this phenomenon that an individual would intuitively place a personal rather subjective value on monetary outcomes; that is, the money in one’s pocket is more attractive when there is a probability of gaining even though the expected value of the game is too high. This value for human subjective perception is called “utility,” and the total outcome of the game is the expected utility [8]. Expected utility theory is asserted based on this phenomenon and is a prescriptive method in which decision maker’s choice is related to their risk-seeking or risk-averse nature [9]. Expected utility of an alternative is calculated as per Equation (2), where p_i is the probability, and the term $u(a_i)$ is the utility of a consequence. The utility function is related to decision maker’s subjective preferences and risk attitude. There is no specific way to formulize or standardize a subjective utility function.

$$EU(a) = \sum_{i=1}^{n} p_i \cdot u(a_i) \quad (2)$$

It is claimed that decision makers are likely to give more weight to losses than gains, and people become risk aversive in case of gaining and risk-seeking in case of losing [10]. Expected utility theory lacks to reflect this human behavior during decision-making, leading to the development of prospect theory. As introduced by Tversky and Kahnemann [11] in 1979, prospect theory is a descriptive approach in which outcomes of an alternative are evaluated based on a reference point, a subjective breakeven point defined by the decision maker. A gain or loss would be referred to according to deviation from that point. A weighting function presents the weight of probabilities, and a value function gives value of an outcome. Prospect value of an alternative is calculated as per Equation (3) where “a” is an alternative, a_i is an outcome, the term $v(a_i)$ is the value of an outcome as depicted by Figure 1, the term $w(p_i)$ is the weight of the probability as presented on Figure 2. V(a, p) is the prospect of an alternative [8].

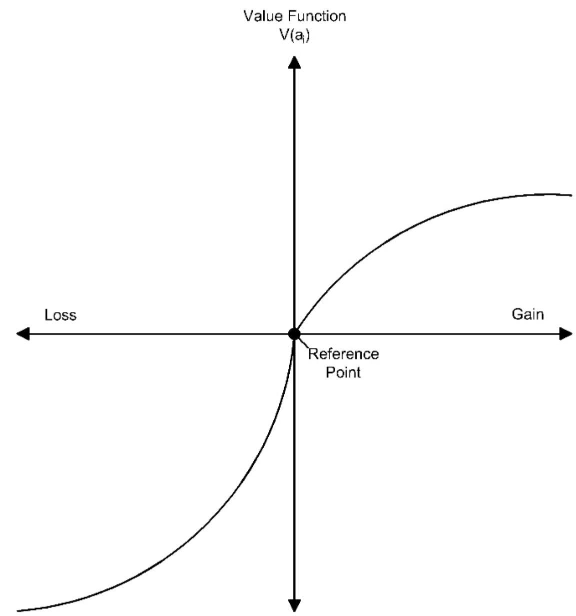

Figure 1. *Value function*

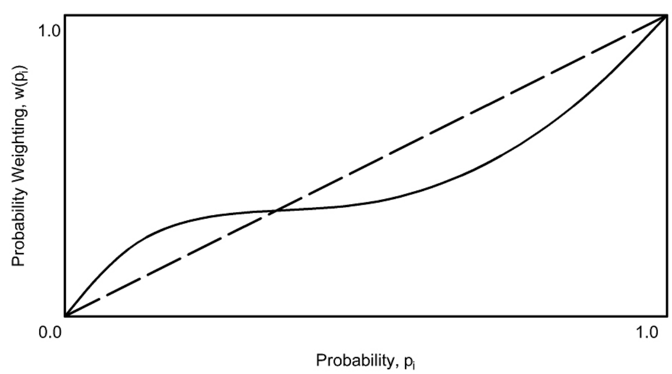

Figure 2. *Probability weight function*

$$V(a, p) = \sum_{i=1}^{n} w(p_i) \cdot v(a_i) \quad (3)$$

2.2. Cumulative Prospect Theory

CPT is a descriptive method used to describe decisions made under risk applicable for any number of outcomes. In this theory, different weights correspond to probabilities in the case of gains and losses. Value and weighting functions could be explained by diminishing sensitivity and loss aversion. This theory is also perfect for explaining the fourfold pattern of risk attitudes [11], as summarized in Table 1.

Table 1. *Fourfold pattern of risk attitudes [8]*

	Gains	Losses
Low probability	Risk-seeking	Risk-averse
High probability	Risk-averse	Risk-seeking

This theory assumes that an alternative arises from positive and negative outcomes in a total number denoted by "n." Outcomes are put in order first regarding gain or loss.

Losses are ranked from i=1 to i=m and gains from i=m+1 to i=n. Cumulative prospect value of an alternative is calculated as per Equation (4) [8].

$$CPT\ (a)_n = \sum_{i=1}^{m} v(a_i) \cdot w^{-}(p_i) + \sum_{i=m+1}^{n} v(a_i) \cdot w^{+}(p_i) \quad (4)$$

The risky alternative is then assessed by the sum of expected rank dependent utility of loss and gain outcomes and shown as CPT (a). Value function of the outcomes is determined based on the empirical two-part power function to reflect the common sense of human exception of value as per Equation (5) [8].

$$\begin{aligned} v(x_i) &= x_i^{0.88} \text{ for } x_i \geq 0 \\ v(x_i) &= -2.25 \cdot (-x_i)^{0.88} \text{ for } x_i < 0 \end{aligned} \quad (5)$$

The probabilities of ranked outcomes would be accumulated from left to right for losses and from right to left for gains. If the table is organized vertically, it would be from top to bottom for losses and vice versa for gains. The cumulated probabilities are then transformed by a probability transformation given by Equation (6) [8].

$$g(p) = \frac{p^{\delta}}{(p^{\delta}+(1-p)^{\delta})^{(1/\delta)}} \ (\delta=0.61 \text{ for gains}, \delta=0.68 \text{ for losses}) \quad (6)$$

The transformed accumulated probabilities are decumulated, and weighed probability of each outcome is obtained. Value and weighted probabilities are then multiplied for each outcome, summed up, and the CPT-value of the alternative is found [8].

2.3. Literature Review

Maritime trading is defined as the transportation of packaged or non-packaged commodities, material, goods, equipment, machinery, livestock, or passengers between ports on a local or global scale that is performed wholly or partly at sea and ocean [12]. It is highly influenced by the changes in financial trends, politics, globalization, and manufacturing. Besides harsh financial crises and political instability, maritime transportation is considered profitable for carrying commodities in high volume and long distances. It is also considered one of the most globalized businesses enabling fast cargo transportation between offshore companies, far regions, and countries. Furthermore, a close relationship between maritime trade and world gross domestic product reveals the vital importance of maritime transportation for the global economy [13].

Dry bulk cargo could be a homogenous, non-packaged solid carriage that is easily loaded, carried, and unloaded in large quantities into or from the holds of a vessel specialized for this purpose or storage [14]. Bulk carriers are vessels mainly designed to carriage such cargoes [15]. Common dry bulk cargoes are distinguished in the form of bauxite, bulk minerals, cement, chemicals and cokes, agricultural products, grains, ores, wood chips, refrigerated goods, livestock and animal products, unitized goods, wheeled and heavy units [16]. Bulk carriers could be utilized in liner or tramp shipping. In liner shipping, large vessels are employed on fixed routes and schedules, whereas in tramp shipping, smaller vessels in capacity are utilized in no fixed routes or schedules but to any destination depending on availability and profitability of opportunity. Most of the maritime transportation is performed via tramp shipping [17]. Significance of dry bulk cargo has been increasing over the last forty years in contrast to liquid bulk cargo. This could be explained by the growing appetite of financial regions in developing countries for coal and iron in the steelmaking process and industrial activities [13].

Decision-making for ship sale and purchase activities has attracted many researchers. Most preferred methods include but are not limited to real options analysis (ROA), analytic hierarchy process (AHP), and fuzzy analysis. Fuzzy methods are also combined with other approaches. Among these, ROA is one of the most favored method. One of the studies includes applying net present value (NPV) and ROA on a case study to reveal their differences. NPV considers the present value of investment whereas ROA scrutinizes uncertainty factors like dry bulk freight rate and ship price over an entire ship investment period. ROA also presents investors with different scenarios and options like abandoning or deferring the investment. The study reveals different results with NPV and ROA, highlighting the importance of uncertainty factors while involved in a ship sale and purchase decision-making process, noting that the study assumed subjective judgment of decision makers as neutral [18]. Along with ROA, fuzzy is also a highly appreciated method in which fuzzy algorithm is combined with ROA's primary purpose to deal with uncertainties that ship investment inherits. The hybrid method is analyzed through a case study from a shipping company [19]. Fuzzy set theory is applied to another study by evaluating the NPV of ships, profitability, and period of payback supported by a case study [20]. Fuzzy extended

Technique for Order Preference by Similarity to Ideal Solution (fuzzy-TOPSIS) Multi-Criteria Decision Analysis is a remarkable study practiced on a bulk carrier purchase process. Ship price, deadweight, energy consumption, engine power, age, and crane capabilities are defined as criteria for this purchase process based on questionnaires conducted with experts [21]. In another paper, the authors examined both financial and technical factors (e.g., speed, port entry limitations, etc.). They applied fuzzy-TOPSIS method for a better realistic approach for ship investment decision-making problems [22]. A combination of fuzzy and Monte-Carlo simulation is also created to decrease uncertainties inherited by variables. Based on historical data collected for panamax size bulk carriers, the model is evaluated to visualize the effects of length of the investment term, loan size, and freight based on predefined scenarios [23]. Apart from ROA and fuzzy, AHP is broadly preferred by researchers. In one of the studies, the authors defined three main criteria (business, market environment, and policy) and twelve sub-criteria for a second-hand ship sale and purchase decision-making problem. Pairwise comparison matrices are prepared as per questionnaires conducted with professionals and experts from the Korean shipping industry. It is found that the financial status of the market share, potential of new markets, and envisaged share of the market are the driving force of such a decision-making problem [4]. A separate study on Handymax and panamax cases depends on predefined market scenarios based on surveys made with financial and technical experts [24].

Based on the literature review, it is concluded that no research is encountered utilizing CPT on maritime trading and ship sale and purchase activities, but few studies are present on the shipbuilding industry. In a research, CPT is applied to define dry-docking interval of ship hull girders [25]. The authors state that dry-docking period for a ship involves uncertainties including different rates of corrosion growth, properties related to material and geometry, loading differences, and high correlation with the economical operation of the ship in question. They further claim that minimizing the expected life-cycle cost (MELC) method is eligible to be employed to determine the period. Yet, it cannot reflect the shipowner's attitude toward risky situations. The risk here is risk-averse by shortening the period to prevent possible structural damages due to corrosion or risk-seeking by extending the interval to reduce downtime during the dry-docking process. It is concluded that the period obtained by CPT could yield a shorter period than MELC. A similar study is performed on navigation safety improvement measures by utilizing CPT, claiming that such measures are usually taken by decision makers with bounded rationalities and highly regarded with their risk-averse or risk-seeking behavior. The authors defined the measures considered for shipping navigation safety investments, defined value function and probability weighting functions, mathematically modeled the problem and educed that CPT applies to such decision-making problems regarding terms like reference point and risk perception of decision makers [26].

3. Empirical Study

This section generates an empirical study to apply the expected value method and CPT to a ship sale and purchase problem. The problem is primarily defined, and alternatives to the decision are rendered. A decision tree is subsequently structured. Data related to the problem is gathered, tabulated, and statistics for states of nature are analyzed to reach probabilities inherited by alternatives. A voyage estimation is performed to calculate the payoff values of each consequence of alternatives. CPT is finally implemented in the empirical study, and results are discussed.

3.1. Purpose

Different results are generally expected through prescriptive and descriptive approaches used on the same formal decision-making problem. This deviation is more obvious in maritime trade, where the perception of value is dramatically subjective and decisive. The primary purpose of this empirical study is to apply a descriptive formal decision-making method to a shipowner's sale and purchase problem then subsequently compare the results with those obtained by a prescriptive method. Expected value method and CPT are deemed suitable for such a problem in which the shipowner is to decide whether to continue trading with his existing ship or conduct a sale and purchase process. Within this research, Alternative a_1 is to keep existing bulk carriers, Alternative a_2 is to sell the existing ship and purchase two smaller bulk carriers, and Alternative a_3 is to sell the existing ship and purchase three smaller bulk carriers. Figure 3 presents decision tree created for the empirical study.

3.2. Data

Data for six bulk carriers are gathered to be benefited from the decision-making problem within the context of this empirical study. Ship no: 1, 2, and 5 are taken identical for ease of calculation. Table 2 summarizes ship data.

Notably, a shipowner's sell and purchase decision is highly related to the owner's financial status, fluctuations in commercial fleet, local, regional and global production and trading capacity, cargo transportation demand, and change in oil price and freight rate [4]. However, in this study, only fuel oil price, and freight rate profit margin will be considered as probabilities for calculation.

It was recorded in 2019 that the most prominent countries in global bulk trade are located in the Southeast Asia region. Some champions of global bulk trade in that year situated in the region and their shares in global trade are China (53% of steel export, 51% of steel import, 72% of iron ore export, 19% of coal import), Australia (57% of iron ore import), Indonesia (35% of coal export) [3]. Forty months of statistics for Singapore oil prices are preferred to reflect status-quo in bulk trading for the context of the study and examined in Table 3 for determining fuel of probabilities [29]. IFO380 interval values are determined considering the minimum and maximum values of the statistics in Table 3.

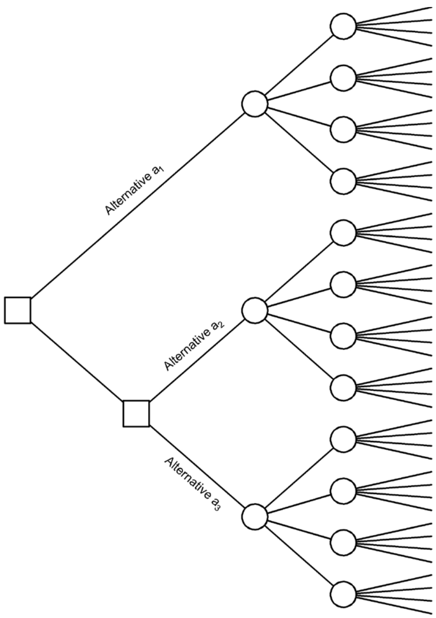

Figure 3. *Decision tree established for the empirical study*

Although freight rate is agreed upon by the contracting parties through performing a comprehensive financial analysis taking into consideration cargo, transportation mode, distance, and handling capabilities of ports, this rate is assumed as being highly influenced by local, regional, and global political or economic factors, transportation demand, and financial situation, especially while the determination of freight rate profit margin. Hence Baltic dry index (BDI) is a useful source while calculating the margin. BDI is described as average daily freight rates from member shipowners chartering ships traveling across different sea routes carrying various dry bulk cargoes [30]. BDI is published by the Baltic exchange located in London. BDI is also a significant reference indicating useful knowledge concerning global dry bulk shipping. BDI and global trade are consequently directly proportional [31]. Sixty months

Table 2. *Ship data and alternatives for empirical study [27,28]*

	a_1	a_2		a_3		
Ship designation	**Existing ship**	**Ship no: 1**	**Ship no: 2**	**Ship no: 3**	**Ship no: 4**	**Ship no: 5**
Deadweight (tons)	171,900	73,630	73,630	52,050	32,083	73,630
Gross tonnage (tons)	88,000	40,230	40,230	29,407	19,730	40,230
Cargo capacity (m^3)	187,000	90,624	90,624	65,181	40,656	90,624
Speed (knots)	15.1	14.4	14.4	14.7	14	14.4
Estimated value (in million $)	24	12	12	7.5	4.5	12
Fuel oil consumption (tons/day)	58.3	38.45	38.45	27.6	23.7	38.45
Diesel oil consumption (tons/day)	4.5	2.5	2.5	1.7	1.2	2.5
Gear consumption (tons/day)	0	0	0	2	2	0
Daily running costs	$6,600	$5,200	$5,200	$4,800	$4,300	$5,200
Load port expenses	$73,000	$55,000	$55,000	$40,000	$23,000	$55,000
Discharge port expenses	$68,000	$52,000	$52,000	$38,500	$21,500	$52,000
Other expenses	$5,500	$4,000	$4,000	$3,000	$2,500	$4,000

Table 3. *Fuel oil price probabilities [29]*

IFO380 interval	Average value of IFO380 interval	Probability %
$200-$300	$251	23%
$300-$400	$357	36%
$400-$500	$433	38%
$500-$600	$508	3%

of BDI statistics are deemed satisfactory to reflect of status-quo in bulk trading for the context of the study and considered probabilities in Table 4 [32]. BDI interval values are determined considering the minimum and maximum values of the statistics in Table 4.

***Table 4.** Probabilities of BDI intervals [32]*

BDI interval	Probability %
0-625	16%
625-1,250	48%
1,250-1,875	31%
1,875-2,500	5%
BDI: Baltic dry index	

3.3. Voyage Estimation

Voyage estimation is the budgetary calculation performed to acquire the return of a voyage by subtracting the total expenses of the voyage from gross income. The terms and conditions regulating the relevance between the charterer and the shipowner are prescribed in an agreement called charter party [33]. Freight rate determined based on a voyage estimation and agreed upon by the parties is also given in the charter party [13]. Even non-profitable agreements could be signed for specific reasons like having the ship loaded while being navigated to subsequent profitable cargo locations or for dry-docking purposes etc. [15]. A basic voyage estimation for a merchant vessel could be carried out via formulation given between Equations (7) and (22) below. Voyage estimation is performed within the context of this study to obtain payoff values of each consequence of alternatives given in the decision-making problem stated in the empirical study and adhere to the assumptions given below.

W_C = Cargo capacity, tons, refer to Equation (7).

S_C = Cargo capacity, m^3, refer to Table 2.

ρ = Cargo density, taken as 577 tons/m^3 for grain [34].

W_B = Bulk cargo, tons, refer to Equation (8).

%U = Cargo capacity utilization ratio (i.e., taken as 0.9 as per envisaged by statistical analysis of ship data).

T_{SEA} = Duration of voyage at sea, days, refer to Equation (9).

X_L = Laden distance, nautical miles (i.e., X_L is the distance between departure and arrival ports. It is assumed that the shipowner would trade distance of 3,583 miles between Port Hedland, Australia, and Lianyungang, China [35]).

X_B = Ballast distance, nautical miles (i.e., X_B is the distance traveled without cargo, on ballast condition. Assumed as 950 nautical miles as envisaged by statistical analysis of ship data).

V_S = Speed of the ship, knots, refer to Table 2.

T_{PORT} = Duration of voyage at port, days, refer to Equation (10).

H_D = Departure port cargo handling capacity, assumed as 40,000 tons/day for Port Hedland, Australia [36].

H_A = Arrival port cargo handling capacity, assumed as 15,000 tons/day for Lianyungang, China [36].

T = Total duration of the voyage, days, refer to Equation (11).

FR_B = Breakeven freight, USD ($) (i.e., FR_B is the freight rate just compensating the costs of charter, zero-profit point), refer to Equation (12).

$D_{R/C}$ = Daily running cost, USD ($), refer to Table 2.

C_{BULK} = Bulk Cargo, tons.

%C = Commission (%), assumed as 3% as obtained by statistical analysis of ship data.

%FR = Freight tax (%) (No freight tax is envisaged).

FR = Freight rate, USD ($), refer to Equation (13).

$\%K_P$ = Freight rate profit margin (%), as obtained by statistical analysis of ship data, refer to Table 5.

E_P = Total port expenses, USD ($), refer to Equation (14).

E_L = Load port expenses, USD ($), refer to Table 2.

E_D = Discharge port expenses, USD ($), refer to Table 2.

E_C = Canal expenses, USD ($) (No canal expense is envisaged).

E_O = Other expenses, USD ($), refer to Table 2.

E_B = Bunker costs, USD ($), refer to Equation (15).

$P_{F/O}$ = Fuel oil price, USD ($), refer to Table 3.

$P_{D/O}$ = Diesel oil price, USD ($), taken as $550 that is the average of the last forty months.

$FC_{F/O}$ = Fuel oil consumption, tons/day, refer to Table 2.

FC_G = Gear consumption, tons/day, refer to Table 2.

$FC_{D/O}$ = Diesel oil consumption, tons/day, refer to Table 2.

E_{CM} = Commission expenses, USD ($), refer to Equation (16).

E_{FT} = Freight tax expenses, USD ($), refer to Equation (17).

E_T = Total expenses, USD ($), refer to Equation (18).

R_G = Gross revenue, USD ($), refer to Equation (19).

R_N = Net revenue, USD ($), refer to Equation (20).

$D_{T/C}$ = Daily time charter rate, USD ($), refer to Equation (21).

$D_{N/P}$ = Daily net profit, USD ($), refer to Equation (22).

Table 5. *Assumed freight rate profit margin, $\%K_P$*

BDI interval	Freight rate profit margin, $\%K_P$
0-625	80%
625-1,250	107%
1,250-1,875	118%
1,875-2,500	125%
BDI: Baltic dry index	

$$W_c = S_c \times \quad (7)$$

$$W_B = W_C \times \%U \quad (8)$$

$$T_{SEA} = \frac{(X_L + X_B)}{(V_S \times 24)} \quad (9)$$

$$T_{PORT} = \left(\frac{W_B}{H_D}\right) + \left(\frac{W_B}{H_A}\right) \quad (10)$$

$$T = T_{SEA} + T_{PORT} \quad (11)$$

$$FR_B = \frac{\left(E_B + E_P + (D_{R/C} \times T)\right)}{\left((C_{BULK} \times (1 - \%C)) - \%FR\right)} \quad (12)$$

$$FR = FR_B \times \% K_P \quad (13)$$

$$E_P = E_L + E_D + E_C + E_O \quad (14)$$

$$E_B = (T_{SEA} \times FC_{F/O} \times P_{F/O}) + (T \times FC_{D/O} \times P_{D/O}) + (T_{PORT} \times FC_G \times P_{D/O}) - \left[\frac{X_B}{(V_S \times FC_{F/O})}\right] \times FC_{F/O} \times P_{F/O} \quad (15)$$

$$E_{CM} = R_G \times \%C \quad (16)$$

$$E_{FT} = R_G \times \%FR \quad (17)$$

$$E_T = E_B + E_{CM} + E_P + E_{FT} \quad (18)$$

$$R_G = (\%FR \times W_B) \quad (19)$$

$$R_N = R_G - E_T \quad (20)$$

$$D_{T/C} = \frac{R_N}{X_L} \quad (21)$$

$$D_{N/P} = D_{T/C} - D_{R/C} \quad (22)$$

3.4. Application of Expected Value Method and Cumulative Prospect Theory

There are forty-eight combinations (i.e., consequences) in the empirical study as calculated according to Equation (23), where n_i, n_A, $n_{F/O,}$ and n_{BDI} represents several consequences, alternatives, fuel oil price probabilities as given in Table 3, and probabilities of freight rate profit margin as indicated in Tables 4 and 5.

$$n_i = n_A \times n_{F/O} \times n_{BDI} \quad (23)$$

Daily net profit, $D_{N/P}$ of the consequences (i.e., payoff values) are indicated by column "a_i" of Tables 6-8 for a_1, a_2, a_3, respectively. Outcomes are ordered from the lowest outcome positioned at the top and highest at the bottom of the tables to comply with the CPT methodology [8]. Probabilities of these outcomes are also arranged according to the rank of outcomes. The column "$v(a_i)$" in the tables represents the prospect value of these outcomes as per Equation (5). Probabilities described in Tables 3 and 4 are presented by the columns "p(IFO)" and "p(BDI)," respectively. The column "p_i" is the multiplication of p(IFO) and p(BDI) to yield probabilities of consequences where p(BDI) and p(IFO) are considered independent. The probabilities of p_i are cumulated from top to bottom for losses and from bottom to top for gains and stated in the column "Cumul." [8]. Cumulated probabilities are transformed as per Equation (6), given in the column "Transf." and decumulated analogously to the way they are cumulated. Multiplication of decumulated probabilities in the column "Decum." and values shown by the column "$v(a_i)$" are called CPT values and given in the column "CPT" of the tables. The sum of all CPT values of consequences of an alternative is given in the row "CPT(a)." Expected values of the consequences are also calculated. The values in the column "a_i" are multiplied by the values in the column "p_i" according to the expected value approach as per Equation (1), and the obtained value is entered into the column "$EV(a_i)$." Sum of these values is mentioned in the row "EV(a)."

Two-digit accuracy is deemed sufficient for presenting the results where thirteen-digit accuracy is used during calculations.

3.5. Result of the Empirical Study

Prescriptive and descriptive analyses conducted for alternatives are respectively shown in Figure 4 and Figure 5. These figures are a continuation of the decision tree given in Figure 3. Different results are obtained via the expected value approach and CPT as calculated by two-part power function as shown in Equations (5) and (6).

Table 6. *CPT and EV calculation of the alternative a_1*

i	a_i	$v(a_i)$	p(BDI)	p(IFO)	p_i	*Cumul.*	*Transf.*	*Decum.*	CPT	$EV(a_i)$
-4	-$6,496	-5,097	16%	3%	0.48%	0.48%	2.57%	2.57%	-131	-$31
-3	-$6,004	-4,756	16%	38%	6.08%	6.56%	13.43%	10.86%	-517	-$365
-2	-$5,499	-4,402	16%	36%	5.76%	12.32%	19.48%	6.05%	-267	-$317
-1	-$4,805	-3,910	16%	23%	3.68%	16.00%	22.67%	3.19%	-125	-$177
1	$1,682	690	48%	23%	11.04%	84.00%	64.38%	9.01%	63	$186
2	$1,925	777	48%	36%	17.28%	72.96%	55.38%	10.34%	81	$333
3	$2,102	840	48%	38%	18.24%	55.68%	45.04%	9.33%	79	$383
4	$2,274	900	48%	3%	1.44%	37.44%	35.71%	0.73%	7	$33
5	$4,325	1,584	31%	23%	7.13%	36.00%	34.98%	3.75%	60	$308
6	$4,949	1,784	31%	36%	11.16%	28.87%	31.23%	6.64%	119	$552
7	$5,404	1,927	31%	38%	11.78%	17.71%	24.59%	10.23%	198	$637
8	$5,847	2,065	31%	3%	0.93%	5.93%	14.36%	1.19%	25	$54
9	$6,006	2,115	5%	23%	1.15%	5.00%	13.17%	1.67%	36	$69
10	$6,874	2,381	5%	36%	1.80%	3.85%	11.50%	3.28%	79	$124
11	$7,505	2,573	5%	38%	1.90%	2.05%	8.22%	6.38%	165	$143
12	$8,120	2,757	5%	3%	0.15%	0.15%	1.84%	1.84%	51	$12
EV(a)=$1,944										
CPT(a)=-77										
EV: Enterprise value, CPT: Cumulative prospect theory, BDI: Baltic dry index										

Table 7. *CPT and EV calculation of the alternative a_2*

i	a_i	$v(a_i)$	p(BDI)	p(IFO)	p_i	Cumul.	Transf.	Decum.	CPT	$EV(a_i)$
-4	-$10,732	-7,929	16%	3%	0.48%	0.48%	2.57%	2.57%	-204	-$52
-3	-$9,903	-7,387	16%	38%	6.08%	6.56%	13.43%	10.86%	-803	-$602
-2	-$9,053	-6,826	16%	36%	5.76%	12.32%	19.48%	6.05%	-413	-$521
-1	-$7,883	-6,044	16%	23%	3.68%	16.00%	22.67%	3.19%	-193	-$290
1	$2,759	1,067	48%	23%	11.04%	84.00%	64.38%	9.01%	97	$305
2	$3,169	1,205	48%	36%	17.28%	72.96%	55.38%	10.34%	125	$548
3	$3,466	1,304	48%	38%	18.24%	55.68%	45.04%	9.33%	122	$632
4	$3,757	1,400	48%	3%	1.44%	37.44%	35.71%	0.73%	11	$54
5	$7,095	2,449	31%	23%	7.13%	36.00%	34.98%	3.75%	92	$506
6	$8,147	2,765	31%	36%	11.16%	28.87%	31.23%	6.64%	184	$909
7	$8,913	2,993	31%	38%	11.78%	17.71%	24.59%	10.23%	307	$1,050
8	$9,659	3,212	31%	3%	0.93%	5.93%	14.36%	1.19%	39	$90
9	$9,853	3,269	5%	23%	1.15%	5.00%	13.17%	1.67%	55	$113
10	$11,316	3,692	5%	36%	1.80%	3.85%	11.50%	3.28%	122	$204
11	$12,378	3,996	5%	38%	1.90%	2.05%	8.22%	6.38%	255	$235
12	$13,415	4,289	5%	3%	0.15%	0.15%	1.84%	1.84%	79	$20
EV(a)=$3,201										
CPT(a)=-125										
EV: Enterprise value, CPT: Cumulative prospect theory, BDI: Baltic dry index										

Table 8. *CPT and EV calculation of the alternative a_3*

i	a_i	$v(a_i)$	p(BDI)	p(IFO)	p_i	Cumul.	Transf.	Decum.	CPT	$EV(a_i)$
-4	-$13,314	-9,585	16%	3%	0.48%	0.48%	2.57%	2.57%	-247	-$64
-3	-$12,286	-8,931	16%	38%	6.08%	6.56%	13.43%	10.86%	-970	-$747
-2	-$11,232	-8,253	16%	36%	5.76%	12.32%	19.48%	6.05%	-500	-$647
-1	-$9,782	-7,308	16%	23%	3.68%	16.00%	22.67%	3.19%	-234	-$360
1	$3,424	1,290	48%	23%	11.04%	84.00%	64.38%	9.01%	117	$378
2	$3,932	1,457	48%	36%	17.28%	72.96%	55.38%	10.34%	151	$679
3	$4,300	1,576	48%	38%	18.24%	55.68%	45.04%	9.33%	148	$784
4	$4,660	1,692	48%	3%	1.44%	37.44%	35.71%	0.73%	13	$67
5	$8,804	2,961	31%	23%	7.13%	36.00%	34.98%	3.75%	112	$628
6	$10,109	3,344	31%	36%	11.16%	28.87%	31.23%	6.64%	223	$1,128
7	$11,057	3,618	31%	38%	11.78%	17.71%	24.59%	10.23%	371	$1,303
8	$11,983	3,883	31%	3%	0.93%	5.93%	14.36%	1.19%	47	$111
9	$12,228	3,953	5%	23%	1.15%	5.00%	13.17%	1.67%	67	$141
10	$14,040	4,464	5%	36%	1.80%	3.85%	11.50%	3.28%	147	$253
11	$15,357	4,831	5%	38%	1.90%	2.05%	8.22%	6.38%	309	$292
12	$16,642	5,184	5%	3%	0.15%	0.15%	1.84%	1.84%	96	$25
EV(a)=$3,971										
CPT(a)=-150										
EV: Enterprise value, CPT: Cumulative prospect theory, BDI: Baltic dry index										

Former reveals expected values of alternatives as $3,971>$3,201>$1,944, indicating preference of prescriptive approach as $a_3>a_2>a_1$ where latter yields the CPT values of alternatives as -77>-125>-150 representing preference of descriptive approach as $a_1>a_2>a_3$. Different sequences of alternatives obtained via the expected value method and CPT are far from being unexpected and could theoretically be explained by the fact that the latter considers the human perception of value and risk aversive nature, while the former lacks to include the human sense of risk aversion and favors the alternative with the highest outcome. More excitingly, this study and its result could excellently be referred to uncover human sense behind the current situation in maritime bulk trading that high demand for capesize [i.e., large bulk carriers between 110,000 and 200,000 deadweight tonnage (DWT)] under uncertain pandemic conditions led BDI to its peak of a 13-year period despite the losses recorded in panamax (i.e., bulk carriers smaller than capesize of 80,000-110,000 DWT) and handysize (i.e., small bulk carriers between 10,000-40,000 DWT) [37-39].

4. Implications and Conclusion

Maritime trading is perceived as the easiest way to transport commodities in high volume through long distances and as a profitable business for maritime traders, shipowners, and related parties. However, it is vulnerable to uncertainties, namely global financial status, political or economic incidents, rate of production, and demand for transportation.

Individuals make decisions for institutions with bounded rationalities under uncertain conditions. Managerial decision-making processes heavily depend on a manager or an executive's intuition and are regarded as swift to solve problems practically. Formal decision-making introduces systematic methods for decision-making that are often required to handle more complex issues, advocate against others, or reconcile related parties despite being judged as effortful and complicated. Formal decision-making is usually executed through prescriptive or descriptive approaches. Expected value method and expected utility theory are prescriptive whereas prospect theory and CPT are descriptive approaches. It is disputable to judge whether prescriptive or descriptive approach is better than the other, yet it could be estimated that descriptive approaches are more advanced in reflecting human behavior.

Although researchers in the literature broadly examine decision-making for maritime trading and ship sale and purchase activities using methods such as NPV, ROA, AHP, and fuzzy analysis, there is a need for an academic contribution to be provided by conducting a study based on a descriptive method representing human attitude toward risky situations, perception of the value of gain and loss,

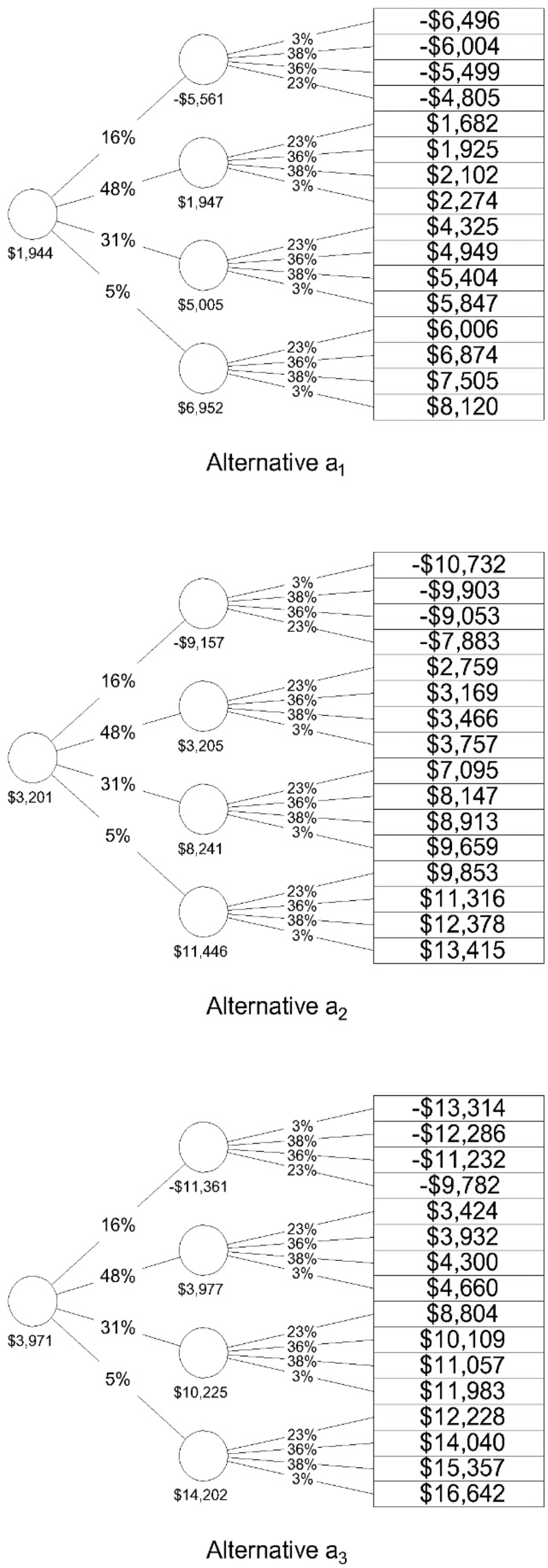

Figure 4. *Expected values of alternatives*

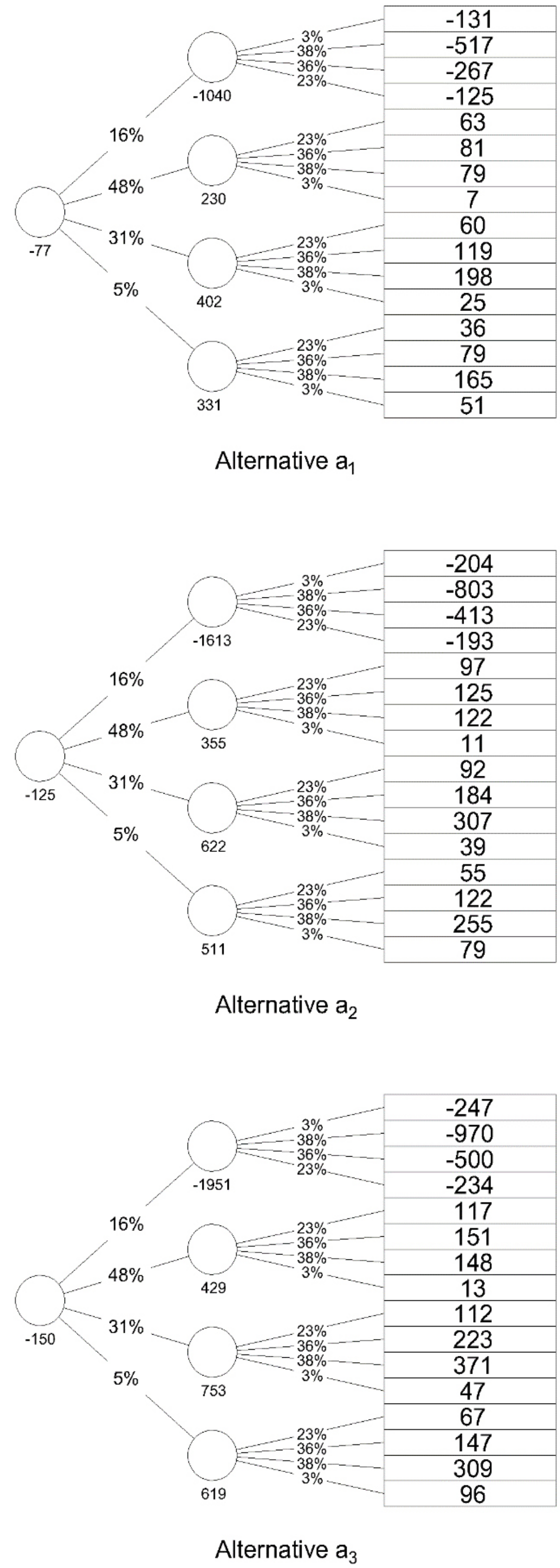

Figure 5. *CPT values of alternatives*

CPT: Cumulative prospect theory

and different meanings of probabilities could not be left unanswered. This research contributes to the enriched academic literature by explaining the human perception of value and risks underlying existing conditions of ship sale and purchase activities using a descriptive formal decision-making method by CPT. The descriptive result obtained via this study under prescribed assumptions revealed that trading with larger ships would seem by common human risk aversive nature more preferable than to sell the existing ship, purchase and trade with smaller ones especially considering uncertainty factors affecting maritime trading. This valuable finding is also supported via evidence provided in the results of the empirical study by referring to the preference of capesize against handysize bulk carriers as obtained from examining the current situation of maritime trading.

There are limitations of this study. First, it is concerned with uncertainty factors. States of nature include uncertainty of fuel oil price and freight rate profit margin that is considered highly related with the BDI and keeping any other parameters constant for ease of calculation. It is recommended to extend the scope of this work by defining other relevant uncertainties like shipowners' financial status, fluctuations in the commercial fleet, local, regional and global production, trading capacity, and cargo transportation demand in addition to fuel price and freight rate profit margin. Sub-indices related to BDI could further be considered for obtaining more accurate results. Second, it is advisable for enthusiastic researchers interested in the study to perform questionnaires or surveys on professionals involved in ship sale and purchase decision-making processes to strengthen the results obtained via formal decision-making methods. Finally, researchers are urged to apply CPT by empirical two-part power value function and enrich the analysis by data obtained from such questionnaires.

Authorship Contributions

Concept design: A. Güngör, Data Collection or Processing: A. Güngör, B. Barlas, Analysis or Interpretation: A. Güngör, B. Barlas, Literature Review: A. Güngör, Writing, Reviewing and Editing: A. Güngör, B. Barlas.

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