Decision making for Shipping Network based on Adaptive Cumulative Prospect Theory

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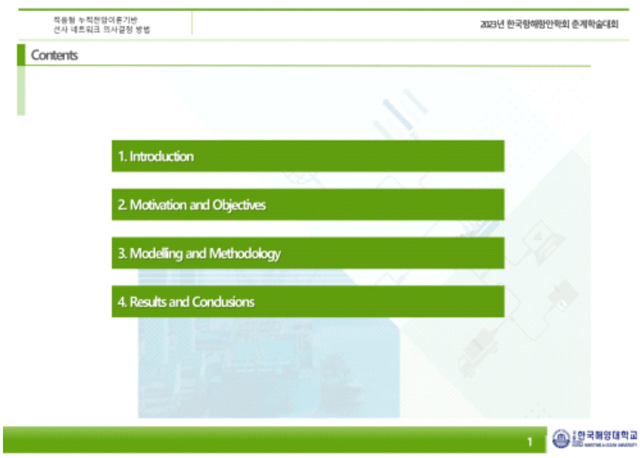
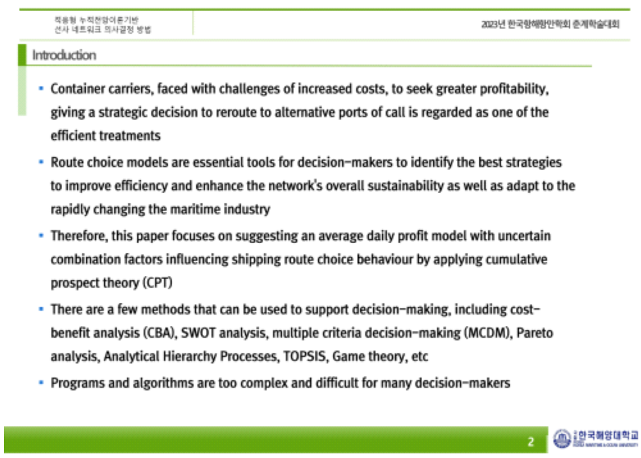
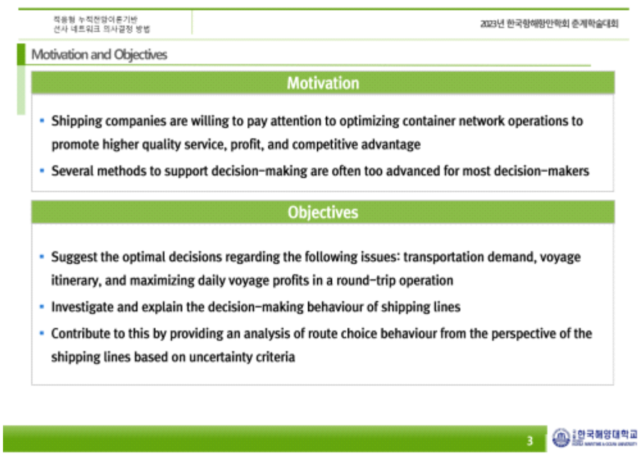
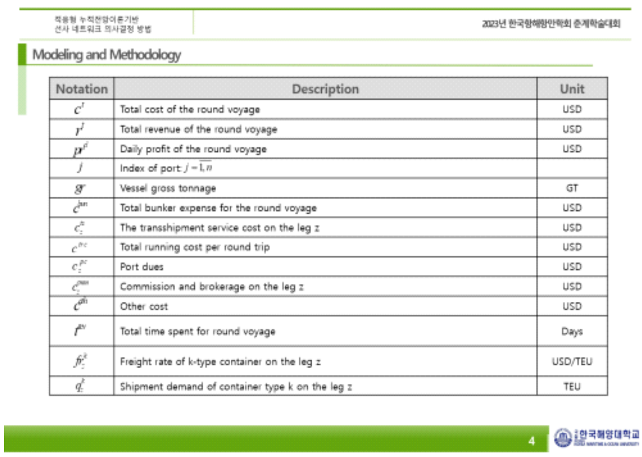
Abstract : *This paper aims to propose optimal method to assess and cumulate the daily profit for liner shipping to support the shipping lines in making optimal decision with the highest average daily profit. This paper not only explains the actual calculated results align with decision-makers' behavior from concepts indicated in cumulative prospect theory but also contributes to an easy-to-apply method for liner shipping network predictability in and provides optimal decision-making is helpful for shipping managers for the best effective selection of the most appropriate alternative under uncertainties.*

Key words : *Decision-making; Shipping network, Cumulative prospect theory, Daily profit model, Expected utility theory*









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Modeling and Methodology

Notation	Description	Unit
c_z^{pc}	Port charges on the leg $z(z \in Z)$ of round route	USD
c_z^{inv}	Inventory cost on the leg$z(z \in Z)$ of round route	USD
c_z^{cmm}	Commission fees on the leg $z(z \in Z)$	USD
c_z^{br}	Broker fees on the leg $z(z \in Z)$	USD
c^{oth}	Other cost of round route	USD
c^{dv}	Daily running cost of a vessel	USD
c_j^{anc}	Anchorage dues in USD charged by port authorities for the use of anchorage facilities in port j	USD
c_j^{d}	Custom declaration fees are charged by customs authorities for the use of the anchorage facilities in port j	USD
c_j^{cl}	Clearance fees in port j	USD
r_j^{ton}	Tonnage due rate in port j	USD
r_j^{nav}	Navigation rate is calculated based on gross tonnage for each nautical mile	USD
d_j^{nav}	The distance in nautical mile when the vessel travels through navigable port j	Days
r_j^{pb}	Daily berth rate per day is charged per day for the use od berth	USD/TEU
d_j^{be}	Number of days in berth	Days

Modeling and Methodology

Notation	Description	Unit
	Number of tugboat use to support the ship in entering and leaving the port j safety	USD
	Tugboat measurement of power in horse power	USD
	Mooring / unmooring price in port j	USD
	Quarantine, disinfection fees in port j	USD

- Assumptions

- Vessel is assumed to be parallel, to follow the same route, and to have a capacity that is adapted to transport demand
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- Assume that the freight rate is adjusted to increase or decrease together for all
- Fuel consumption during operation is assumed to be stabilized

Modeling and Methodology

- The average daily profit function

$$pr^d = \frac{(\sum_{z \in Z} c_z^v + \sum_{z \in Z} c_z^{pc} + c^{bun} + \sum_{z \in Z} c_z^{ts} + \sum_{z \in Z} c_z^{cmm} + c^{oth}) - \sum_{k \in K} \sum_{z \in Z} (fr_z^k * q_z^k)}{t^{tcv}}$$

- Voyage total cost function

$$c^t = \sum_{z \in Z} c_z^v + c^{bun} + \sum_{z \in Z} c_z^{pc} + \sum_{z \in Z} c_z^{ts} + \sum_{z \in Z} c_z^{cmm} + c^{oth}$$

Methodology

Modeling and Methodology

- Total time spent for round voyage

$$t^{tcv} = \frac{\sum_{z \in Z} d_z}{24 * v^{as}} + 2 * \sum_{j=1}^{n} m_j^t + \sum_{j=1}^{n} (\frac{q_j^l}{r_j^l} + \frac{q_j^d}{r_j^d}) \quad (3)$$

- Port dues

$$c_j^{pc} = c_j^{ton} + c_j^{nav} + c_j^{pit} + c_j^{ber} + c_j^{tug} + c_j^{m/u} + c_j^{qrt} + c_j^{anc} + c_j^{d} + c_j^{c} \quad (4)$$

- Total running cost for a round voyage

$$c^{trc} = c^{dv} * t^{tcv}$$

- Total bunker cost for a round voyage

$$c^{bun} = s^{tcv} * f^{fo} * c^{fo} + t^{tcv} * f^{o} * c^{do} \quad (5)$$

- The total transshipment cost

$$\sum_{z \in Z} c_z^{ts} = \sum_{z \in Z} (q_z^{ts} * u_z^{ts}) \quad (6)$$

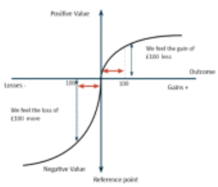
Modeling and Methodology

- Concepts of Prospect Theory

1) Losses loom large than gains
- People are loss-averse
- Individuals dislike losses more than equivalent gains they are more willing to take risks to avoid a loss
- People need help making optimal choices

2) Diminishing sensitivity
- People focus on ratios rather than absolute values

3) Evaluation is relative to a neutral reference point
- For financial outcomes, the usual reference point is the your current status (Status Quo)
  ▷ Outcomes better than the reference point are gains
  ▷ Outcomes below the reference point are losses



<Prospect Theory>

Modeling and Methodology

- The prospect of an alternative

$$v(a, p) = \sum_{i=1}^{m} w(p_i) * v(a_i)$$

$v(a, p)$: Prospect of an alternative
$w(p_i)$: The weighting of the alternative of the probability.

- Value function of an outcome

$$v(a_i) = \begin{cases} a_i^{0.88} & a_i \geq 0 \\ -2.25(-a_i)^{0.88} & a_i < 0 \end{cases}$$

- "The weighting of the probability function"

$$w^+(p) = p^\gamma / [p^\gamma + (1-p)^\gamma]^{1/\gamma} + \hat{\alpha}$$

$$w^-(p) = p^\delta / [p^\delta + (1-p)^\delta]^{1/\delta} + \hat{\beta}$$

γ=0.61 (for gains);
δ=0.69 (for losses)

- The cumulative prospect of outcome

$$CPV(a)_v = \sum_{i=1}^{m} v(a_i) * w^-(p_i) + \sum_{i=m+1}^{n} v(a_i) * w^+(p_i)$$

Losses are ranked from $i = 1$ to $i = m$
Gains are ranked from $i = m+1$ to n

$v(a_i)$: The value of outcome
a : An alternative
a_i : An outcome

- The expected utility value of each alternative

$$EV(x) = \sum_{i=1}^{n} p_i * x_i$$

Where: $\sum_{i=1}^{n} p_i = 1$

i : Alternative
n : Number of alternative payoffs
p_i : Probability of alternative
x_i : Payoff of an alternative