On distance decay in Port Choice

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The problem

- In Marseille at IAME conference I present a model of Port Choice Problem.

The best possible way!
Modeling the problem using graph theory

- The connected weighted graph.
- Usually the problem is considered as a Multiple Criteria Decision Making problem (MCDM).
- But we considered it as a discrete optimization problem.
The task

- To serve all $C_l$, through one port $P_j$, over one or more $P_i$ from all $S_k$ in the way that the total weight of the graph is minimal.
- With other words: We want to find the vertex $P_j$ for which the sum of lengths of shortest paths to some of chosen vertices from given connected graph is minimal.

\[ W = \sum_i \left( \sum_k w_{S_kP_i} + w_{P_iP_j} \right) + \sum_l w_{P_jC_l} \]

- As many researchers stated before, costs are not the only criterion in the decision-making process.
- Therefore, mathematical programming models that include only costs are not able to explain the actual port choices of decision makers.
The trade off

- Factors such as opportunistic behaviour, preferences about the port location, port operation efficiency and others are at least equally important. These factors are considered subjective factors.
- Their influence on the decision will be quantitatively defined as a preference rate (PR). The result has to be a trade off between cost and preference rate.
- We presume that the trade off can be expressed as

\[ w' \rightarrow \frac{1}{PR} \cdot w \]
Solving the optimization problem

- To solve a problem we modeled it as Mixed Integer Linear Programming (MILP) model.
- The defined problem is at first glance similar to well known Hub and Spoke concept pioneered by Delta Airlines back method in 1955.
- In order to find an optimal solution of our problem we used a slightly modified hub and spoke model. We add some additional constraints and formulate the Mixed Integer Linear Programm as follows.
The data and calculation

- To get the data we have made a survey of several logistics providers, shippers, shipping lines and retailers.
- We used a separate questionnaire for departing and destination side.
- We have calculated preference rates using AHP method.

<table>
<thead>
<tr>
<th>Koper</th>
<th>Rijeka</th>
<th>Barcelona</th>
<th>Rotterdam</th>
<th>Hamburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,195</td>
<td>0,180</td>
<td>0,170</td>
<td>0,235</td>
<td>0,220</td>
</tr>
<tr>
<td>Singapore</td>
<td>Hong Kong</td>
<td>Busan</td>
<td>Kaohsiung</td>
<td>Port Klang</td>
</tr>
<tr>
<td>0,32</td>
<td>0,20</td>
<td>0,20</td>
<td>0,18</td>
<td>0,10</td>
</tr>
</tbody>
</table>
Results (An impact of input parameters to the final result)

Figure: An impact of input parameters to the final result, $\Delta$overall result in % / percentage of change.
The ranking

1. Preferance rate.
2. Land transport cost.
3. Sailing time.
4. Port Charges.
The breakthrough

▶ But at the IAME conference Thiery Vanelislander presented their paper with slightly opposite results. He claimed that the shippers give the most relative importance to port cost.

▶ This seems to be in conflict with our results and put a question mark behind our model.

▶ But it is not so!

Our most important thesis is: **our model is good!**
Our second most important thesis is: *when comparing ports with relatively small distance between themselves, the importance of the influencing factors is different than if the ports are relatively very distant with each other.*

In our study we compared the ports very distant with each other. But Thierry presented a study of the ports with small distance between themselves.

And the result:

- we have tested our model with their data.
The modifications of the model

But first we slightly modified the model.

- In order to test 4 different decision factors: preference rate \( (PR) \), port costs \( (PC) \), land distance between destination ports and consumption points \( (LD) \) and sailing time between origin and destination ports \( (ST) \) we the following logic.

\[
w' \rightarrow \frac{1}{PR} \cdot (PC + LD + ST)
\]

- If the values of each decision factor for selected destination ports decreased or increased for a certain percentage the objective value \( W' \) changes as well.

- But how much
Extreme 1 - ports are close to each other

\[ ST_1 \approx ST_2, \ LT_1 \approx LT_2, \ PC_1 \neq PC_2 \]

\[ \Delta ST \approx \Delta LT \ll \Delta PC \]
Extreme 2 - ports are distant

\[ \Delta ST \approx \Delta LT >> \Delta PC \]
The methodology of analysis

1. In order to compare results between different ports selection alternatives we standardized decision factors values.

\[ SDF_j = \frac{DF_j - DF_{\text{min}}}{DF} \]  \hspace{1cm} (1)

2. We used standardized decision factors values to calculate MILP.

3. We decreased or increased a decision factors values for a certain percentage and observe the objective value \( W' \).
The results

Randomly generated data: Extreme 1 (BLUE) AND Extreme 2 (GREEN).
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The results on REAL DATA

- We compared the following ports: Koper, Rijeka, Trieste, Venice, Ravenna, Rotterdam, Hamburg and Bremerhaven.

- We devided them into three scenarios:
  - West EU: Rotterdam, Hamburg and Bremerhaven.
  - North Adriatic: Koper, Rijeka, Trieste, Venice and Ravenna.
  - All ports: Koper, Rijeka, Trieste, Venice, Ravenna, Rotterdam, Hamburg and Bremerhaven.
The results on REAL DATA

Changing PR for selected port Dj

- **W (standardized & normalized)**
  - Range: 0 to 1
  - Values: 0.8 to 0.2

- **Percentage(%) of change in PR**
  - Range: -20 to 20

Legend:
- Blue: West-Central EU ports
- Green: Adriatic ports
- Red: All ports
The results on REAL DATA

b) Changing Port Costs (PC) for selected port Dj

$W$ (standardized & normalized) vs. Percentage(%) of change in PC

- Blue line: West-Central EU ports
- Green line: Adriatic ports
- Red line: All ports
The results on REAL DATA

Changing Land Distances (LD) between selected port Dj and consumption points

- West-Central EU ports
- Adriatic ports
- All ports

W (standardized & normalized)

Percentage(%) of change in LD
The results on REAL DATA

Changing Sailing Time (ST) between origin ports O_i and selected destination port D_j

- **W** (standardized & normalized) vs. Percentage(%) of change in ST
Some acknowledgments:

- To professor Anthony Chin from National University of Singapore to come to Singapore.
- To my research team.

"Come So Far, Yet Still So Far To Go"

Thank you very much for your attention.