Strategic Joint Design and Pricing in a Multimodal Hinterland Network: The Extended Gate Operator Perspective

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Introduction

The extended gate concept is introduced from deep sea Container Terminals to increase their competitive position by enhancing the connectivity of the ports with close and distant contestable hinterland.

A set of inland terminals act as extended gates of the port, where a customer can pick up or drop of a container as if directly to a seaport, and are connected with the seaport terminals with high capacity, sustainable frequent connections(barge, train).

ECT's Extended Gates Hinterland Network

Problem Definition

The TOC implementing the extended gate concept has to design an optimal hinterland network by determining:

- The locations of the extended gates (existing inland terminals or new inland terminals)
- The capacity of the corridors
- The frequency of connections in each corridor
- The tariffs for containers passing through the extended gates

The above design factors can affect the profitability of the TOC in several ways:

- Total costs structure is dominated by economies of scale
- The Tariffs and Frequency of connections affects flows passing through the extended gates.

Model Formulation

We formulate this problem as a bi-level mathematical problem.

- In the first level, the net revenues of the TOC implementing the extended gate concept are maximized.(Revenues – Fixed and Variable Costs of Operating Connections)
- In the second level, the total logistics costs faced by the users of the network are minimized.(Transportation Costs, Handling Costs)
- Demand in Commodities (OD, Amount of Flows, Total Time requirements)
- Total transport time: dependent on frequency of Connections
- Cost of Corridors: Economies of Scale

Solution Methodology

- NP hard Problem
- MIP equivalent formulation solved by CPLEX
  - High Calculation times even for medium instances
- Novel Algorithm Development
  - Solve a series of "easy" linear and MIP problems
- Algorithm Evaluation
  - Instances: (30 Nodes – 60 Commodities)
  - Computation Time:
  - CPLEX: Mean=481sec, St.D. =526sec
  - Algorithm: Mean=5.35 sec, St.D.=0.4 sec
  - Obj. Value Average Gap=2%

Main Results

Modelling Contributions:

- Capture tradeoffs among revenue management, Economies of Scale and user time constraints.
- Extension current models which assign each commodity to only one route in the network.
- Algorithm provides high quality solutions inconsiderably less calculation time with low variability.

Managerial Contributions:

- Incorporating revenue management in the usual network design models yields better solutions in terms of profitability. (Bi-level ND vs Hub and Spoke models)

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