Conceptual Model of a Decentralized Transport Organization in the Increasingly Uncertain Transport Environment of the Physical Internet

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Agenda

- Introduction
- Problem Description
- Model Structure
- Model Components
- Summary

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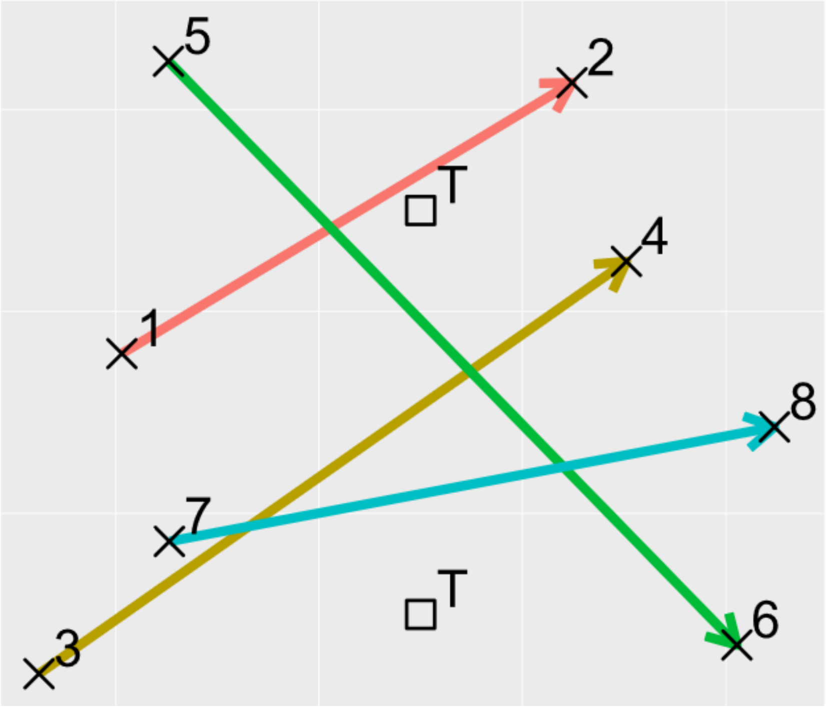
Introduction

- The freight transport sector is responsible for about 12.1% to Austrian GHG-Emissions and there is an dependency on oil products of more than 80% (BMWFW, 2015; Umweltbundesamt, 2017).
- The cost structure of logistic service providers is characterized by a high share of fixed costs and a low capital coverage (Lohre, 2007; Wittenbrink, 2014).
- Uncertainties in necessary deployment, poor personnel-planning and high flexibility requirements for the staff enforce precarious employment situations (Lohre et al. 2015; Arnold, 2008).
- There is an ongoing trend demanding high flexibility and increasing urgency from logistics service providers (Wittenbrink, 2014).
- Dynamic and digitized value chains will be more segmented, freight sizes are decreasing, value of freight is rising and quality requirements (punctuality, speed) are increasing (Scheucher, 2014; BMVIT, 2016; König et al., 2012).

Due to increasing volatility in the freight transport market, the transport sector is developing ecologically, economically and socially unsustainably (Montreuil, 2012).

Problem Description

- Time consuming transport mode choices and implementations of bundling concepts are more unlikely to be implemented due to rising transport urgencies.
- Rising volatility of freight transportation demand leads to under- and overcapacities, leading to lost sales and liquidity shortages at logistics service providers.
- A lack of planning competencies in an increasingly uncertain transport environment results in an unsecure work environment for drivers and logistics personnel.



To overcome these challenges, we propose a conceptual model for dynamically (re-)assigning transport requests to carriers within an abstract network of origins, destinations and hubs.

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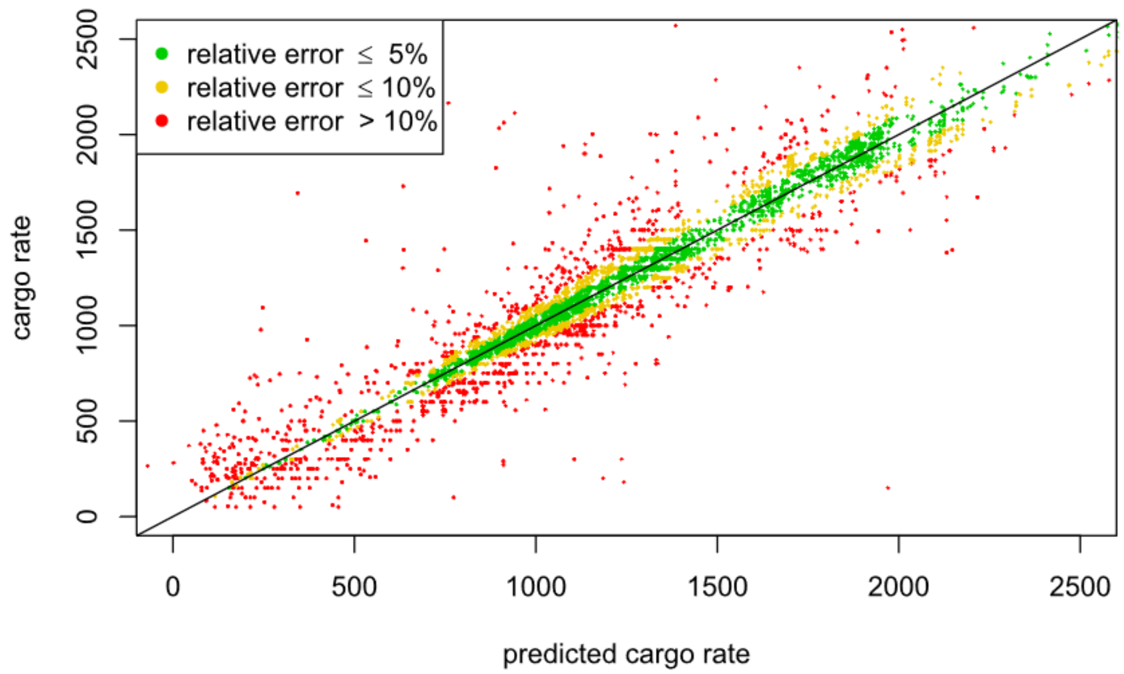
Model Structure

- Component 1: Estimate the Structure of Cargo Rates
  - A pricing model to evaluate the expected costs of different transport variants between origins, destinations and hubs in an abstract transport network.
- Component 2: Plan the Assignment of Transport Requests
  - A routing model to optimize the assignments of the transport requests in order to generate cost minimal freight flows through the network.
- Component 3: Continuously Optimize the Assignment of Transport Requests
  - A planning algorithm to continuously update the transport routes of all requests when new transport requests are added or framework conditions are changed (e.g. time windows).

Decentral Transport Organization Model

Component 1: Estimate structure of cargo rates

- We propose a two-stage regression model for the use case of a freight forwarder.
  - First stage regression parameters:
    - Start and end region
    - Distance
    - Cargo type
    - Transhipment (yes/no)
    - Number of way stops
    - Truck driver’s country of origin
  - Second stage regression parameters:
    - Predicted costs of the first stage regression
    - Degree of loading
    - Distance

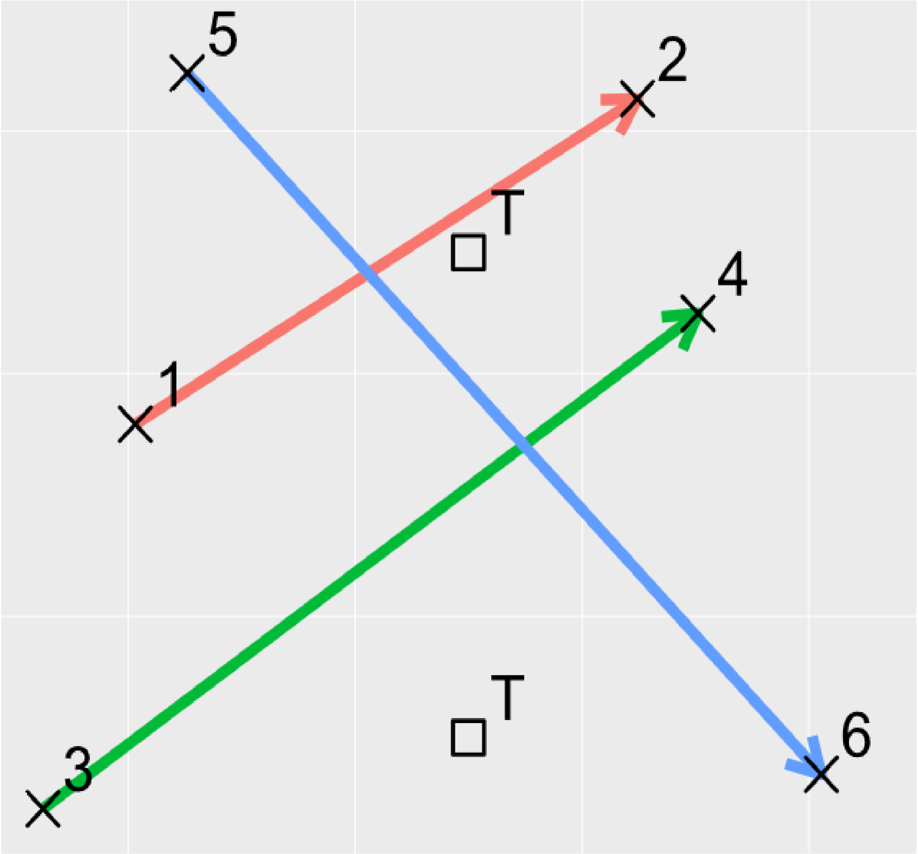


In our use case the model has a median absolute prediction error of 3.42%.

Decentral Transport Organization Model

Component 2: Plan Assignment of Transport Requests

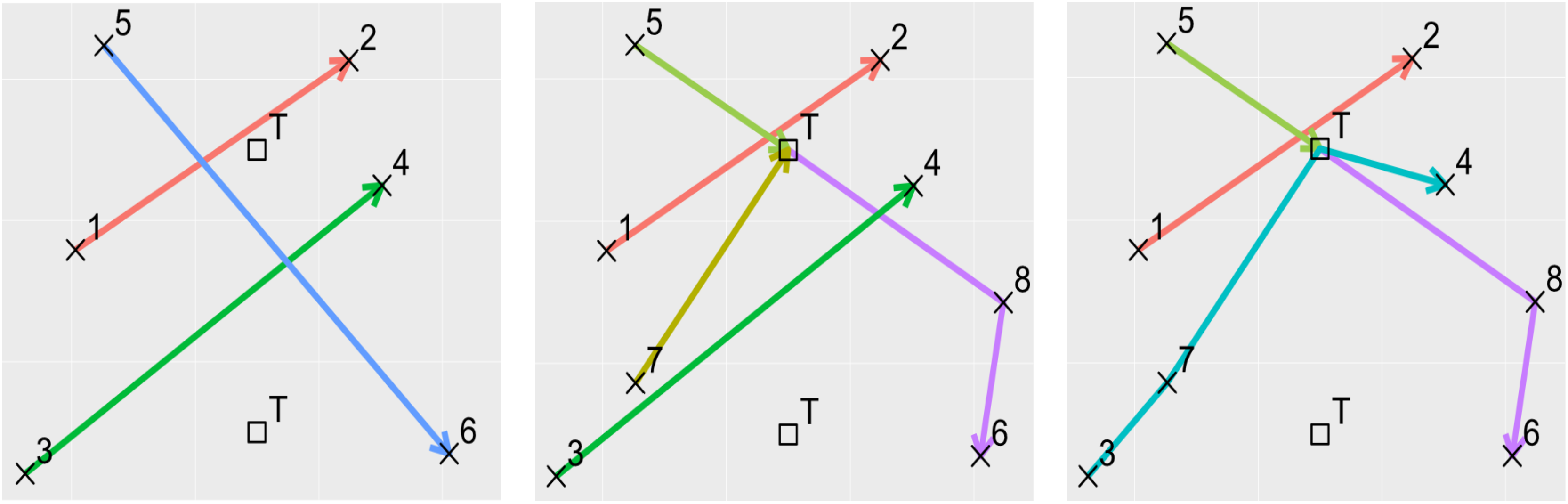
- To determine the most cost efficient way to assign transport orders to a set of carriers in a network of hubs, we have to solve a Pickup and Delivery Problem with Transshipments (PDPT).
- The cost of each transport is thereby determined by the transport pricing model.
- We use the genetic algorithm proposed by Danloup et al. (2018).



Decentral Transport Organization Model

Component 3: Update assignments of transport requests

- To optimize the assignment of transport requests, we estimate the expected transport costs iteratively.
- By updating the assignment of transport orders, the freight forwarder is able to quantify the costs of a new request.
- Furthermore, the forwarder is able to evaluate changing time windows.



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Summary

- We developed a model that allows the continuous planning of freight flows in an abstract network of origins, destinations and hubs.
- The model for estimating the cargo rates delivers good results:
  - The median absolute prediction error is only 3.42%.
  - The third quartile of the absolute prediction errors is 7.08%.
- We demonstrated the feasibility of our approach to quantify the costs caused by additional transport requests and changing time windows.

- Future research steps:
  - Evaluation of the overall bundling potential of our conceptual model
  - Analysis of the generated economic, ecological and social potential

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