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Synchromodal transport re-planning:
an Agent-Based Modelling approach

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Dispatch project:

Digital Twin for Synchromodal Transport

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Optimization algorithm from the LSPs' point of view

Optimization algorithm from the shipper's point of view

Simulation model from LSPs' point of view

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Simulation model

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- **What?** Agent-Based simulation of Synchromodal Transport
- **Scope:** Regional-level
- **Decision horizon:** Short-term
- **Prespective:** Logisitcs service provider
- **Logistics operations:** Centralized and decentralized
- **Goal**: to transport orders from their origins to the destinations within the time window, while minimizing the costs and emmissions.

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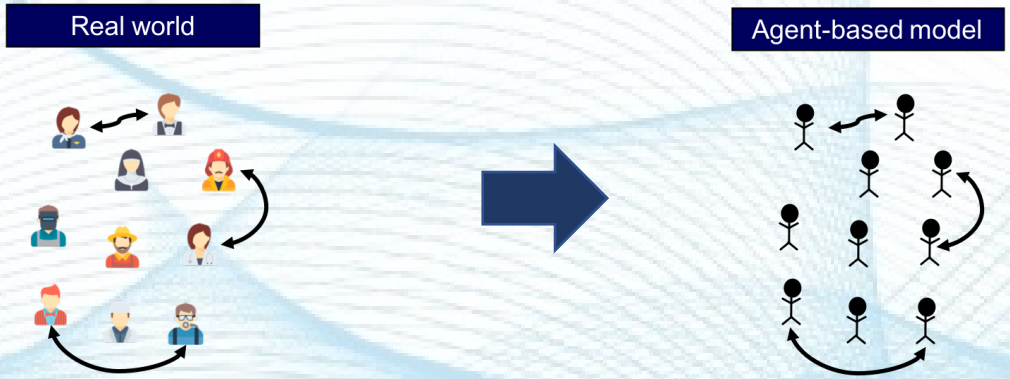
Main research questions to be answered:

- Can ST contribute to freight modal shift by making a difference in economic and environmental costs, flexibility, reliability, and capacity utilization in compare with conventional multi-modal transport planning?
- Can horizontal collaboration between actors (in addition to vertical collaboration) improve the functioning of the ST system?

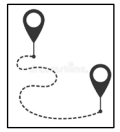
Methodology

Using **Agent-Based Modeling (ABM),** we study the behavior of multiple actors involved in a synchromodal transport system and their interactions, as well as the impact of their behavior on the entire network.



➔ Provides the flexibility and adaptability to design heterogeneous actors that interact with each other!

main agents in our model

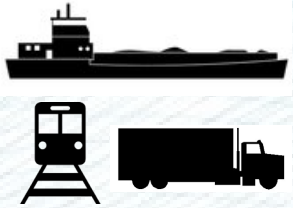


Origins,Destinations

Multimodal terminals

Depots

LSPs



Vehicles

Orders (containers)

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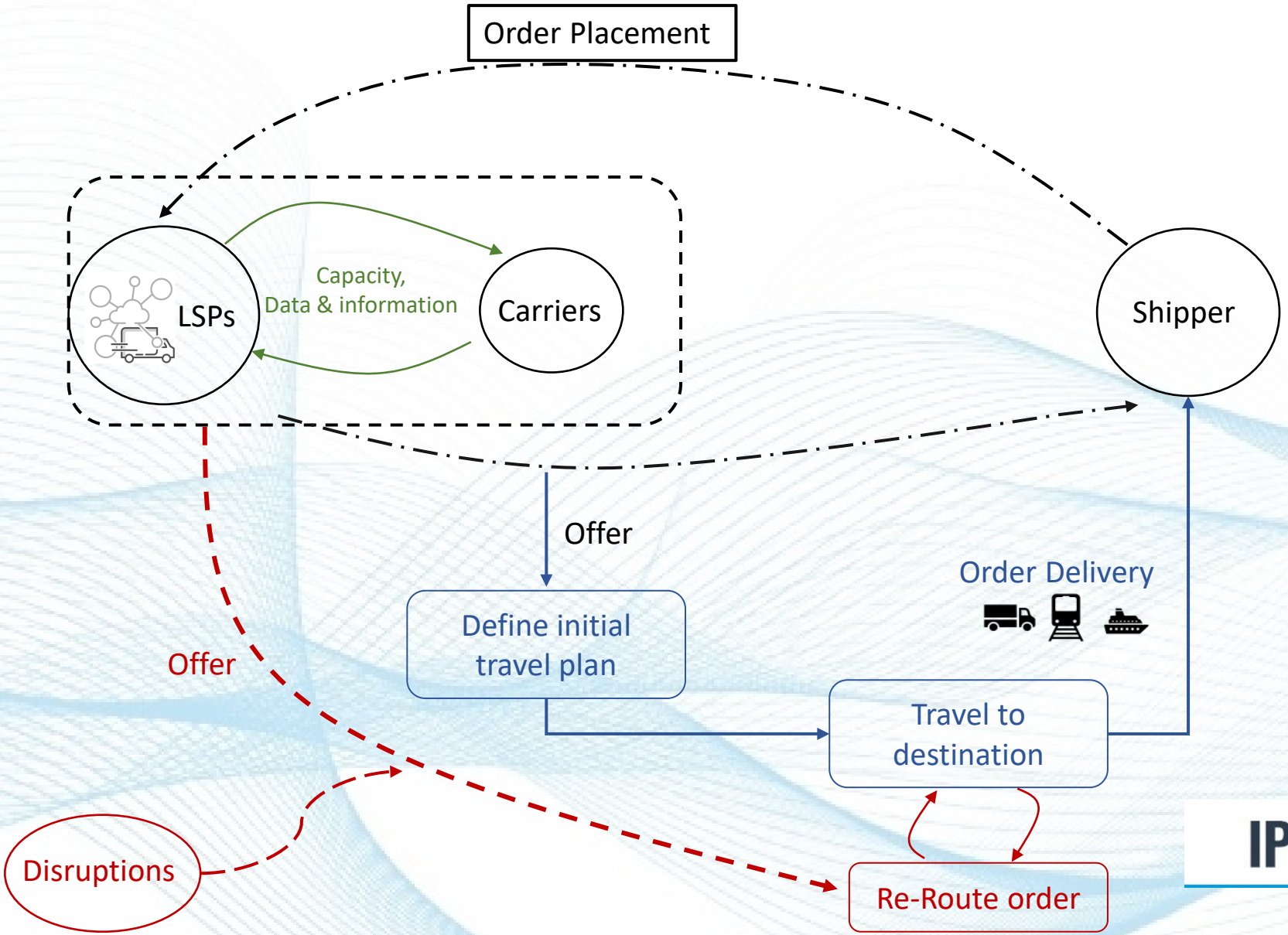
Model’s assumptions

- A regional-level logistics network;
- LSP’s prespective;
- Multiple LSPs operating; all the lsps are multimodal;
- Each LSP works with multiple shippers;
- Combination of long haul and short haul;
- Orders arrive stochastically;each order= 1 container;
- One way delivery; all the orders are met;
- Three modes of transport: Roads and Rails, Inland Water Ways;
- Trucks: fleets of trucks (limited), and external (unlimited);
- External trucks without depots or returning time;
- One order per truck;
- Orders take shortest path (according to time, cost, emmissions or a combination);
- New tasks can be inserted in between a scpecific truck plan;
- The price per each mode of transport is a function of distance.

Model’s assumptions



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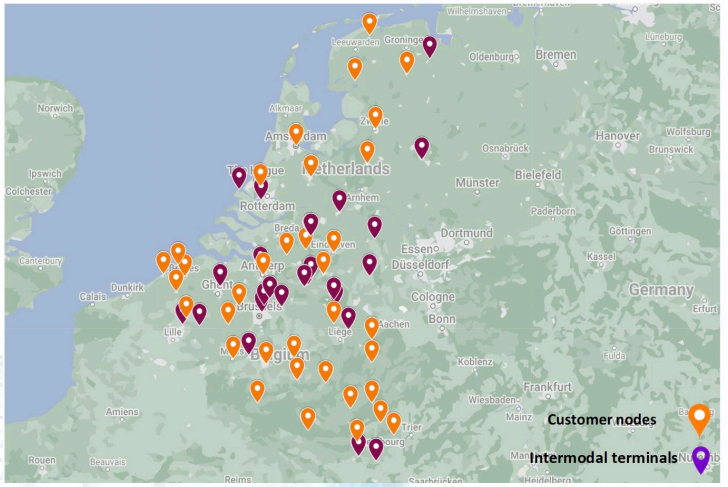
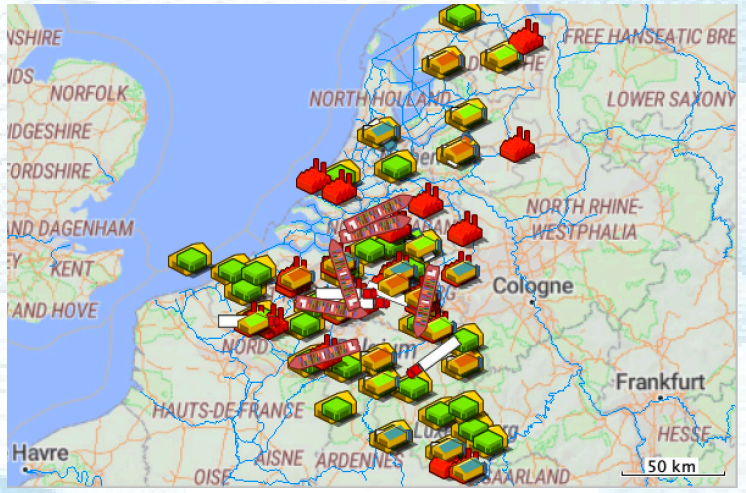
Case Study

The regional-level instance:

- 62 nodes: 27 intermodal terminal, 35 only truck access;
- 96 train services (each consisting of one or more legs);
- 80 barge services (each consisting of one or more legs);
- Capacity of 60 TEU for each train, 105 TEU for each barge;
- 3 LSPs;
- 500 orders/day- stochastic~ Poisson distribution (500);
- Service cancellation rate: 1 event/day- for barges and trains;
- Service delay rate: 4 event/day- for barges and trains;
- Delays [15- 60] mintues ;
- Each simulation run corresponds to 10 days of simulated time;



the GIS view of the studied network



the GIS view of the studied network in AnyLogic environment

Scenarios

3 levels of relations between LSPs

- Competitive;
- Collaborative;
- Centralized.

2 responsive scenarios toward disruptions

- Conventional re-routing;
- Flexible re-routing.

Scenario	Scenarios' name	(Re)routing strategy	LSP relation
S1	Conv-Comp	Conventional	Competitive
S2	Conv-Coll	Conventional	Collaborative
S3	Conv-Cent	Conventional	Centralized
S4	Flex-Comp	Flexible	Competitive
S5	Flex-Coll	Flexible	Collaborative
S6	Flex-Cent	Flexible	Centralized

Case Study- cnt'd

To Evaluate:

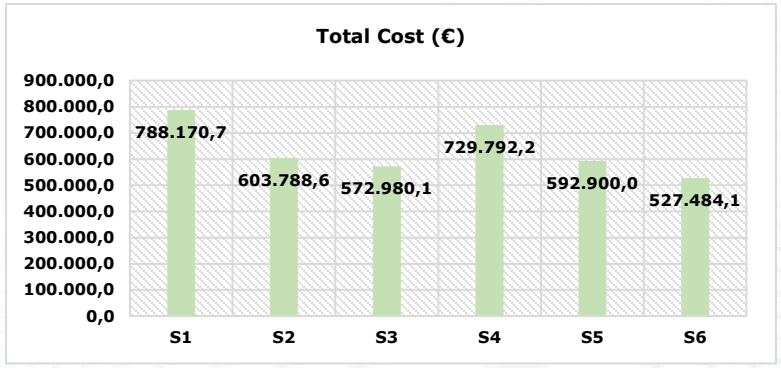
- Total costs;
- Emmission costs ;
- Orders late delivery
- Modal split;
- Resource utilization.

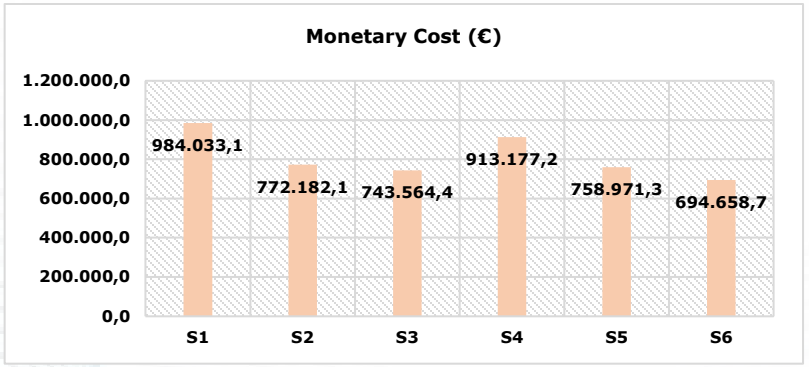
To reduce the the impact of stochasticty

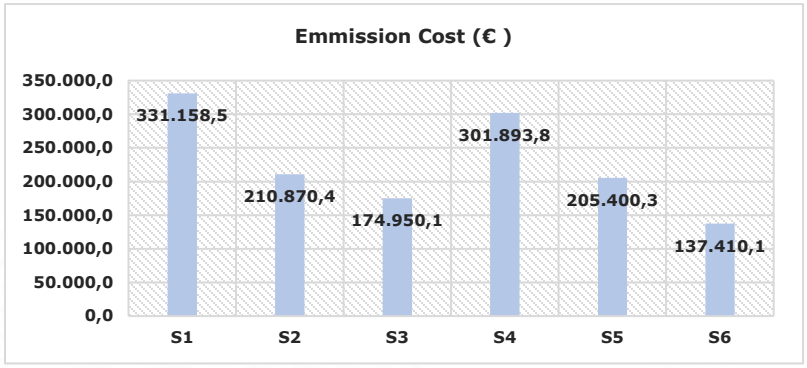
- Multiple replications;
- Number of replications decided by Anylogic
- Min=2, Max= 20;
- Minimum confidence level= 90% (for the total cost)
- Error = 0.005

- Anylogic stopped after 6 replications

Numerical experiment- results

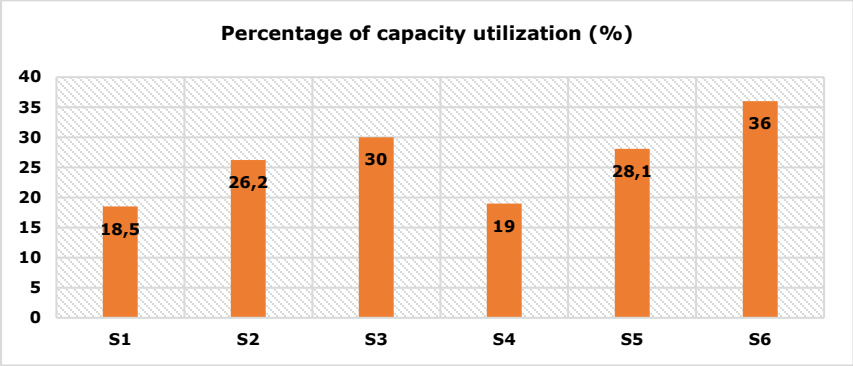


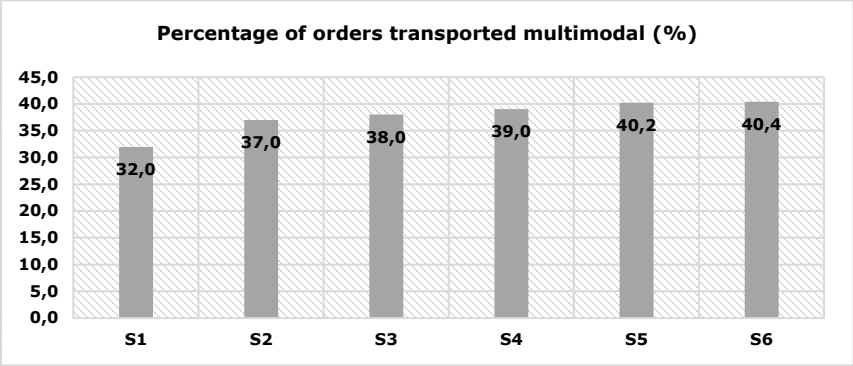


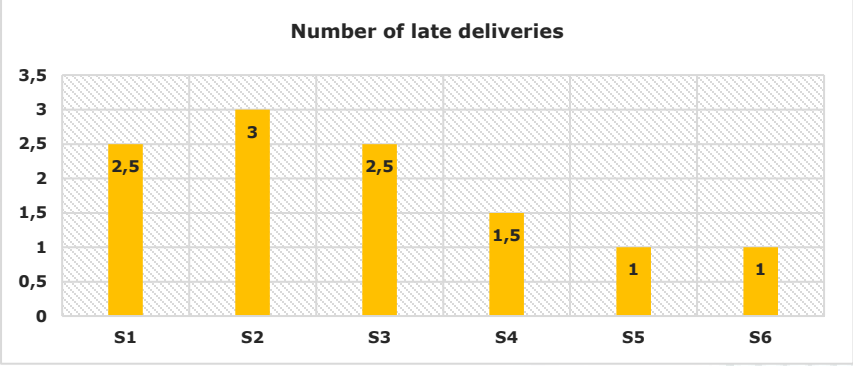


- The total cost in S1(BAU) ~ 48% higher S6 (ST); the cost efficiency of ST in compare with BAU;
- Flexible scenarios (S4,S5,S6) result in lower costs than the same scenarios in conventional approach (S1,S2,S3)- for emissions, monetary, and total costs;
- In the competitive scenarios (S1 and S4) the monetary are considerably (between 16% to 24%) higher than in the other scenarios- LSPs bear significant amount of costs if they opt for a competitive approach and do not collaborate with other LSPs.

Numerical experiment- results







- The highest share of capacity utilization is associated with the cases that a central operator manages all the capacities (S3, S6) and subsequently to the collaborative scenarios (S2, S4), where LSPs opt for collaboration with each other;
- Around 32%- 40% of the orders are transported at least in one leg by railways or inland waterways;
- In the scenarios without flexibility(S3, S1, S2), after disruptions, the number of late deliveries is larger- in the cases more related to ST (S4, S5, S6), the reliability is higher.

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Any Questions?

Let’s connect!

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