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Synchromodality in the Physical Internet

Dual sourcing and real-time switching between transport modes

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IPIC, June 20th, 2018

Physical Internet

- Global warming issues
  - Reduce GHG emissions in order to reach the goals of the Paris Agreement (2015)
- Cause: current transport and logistics environment is unsustainable
  - Overuse of unimodal road transport
- Potential solution:
  - **Modal shift**
  - Change focus to alternative low carbon transport modes (e.g. rail transport, inland waterways)

Our contribution

- Impact of synchromodality concept on modal shift
  - Use of several transport modes simultaneously
  - Possibility to switch transport modes along route

  ➔ increase flexibility of intermodal transport

- Decision rule: How to determine which transport mode to use?

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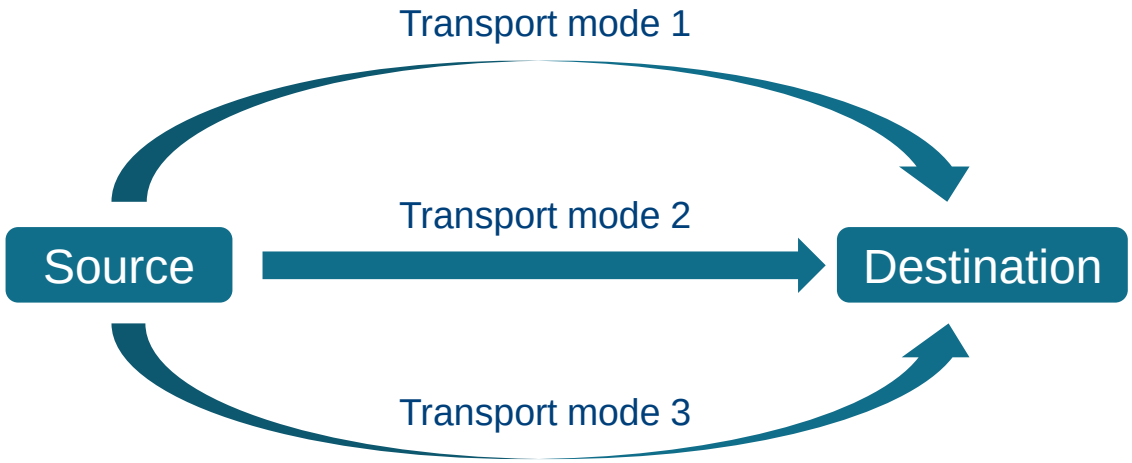
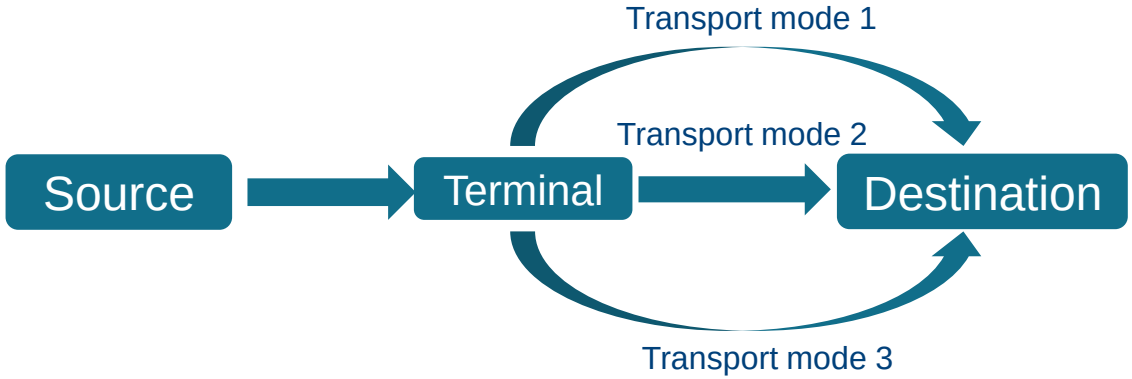
Two definitions of synchromodality

Dual sourcing
(Parallel usage)



Real-time switching



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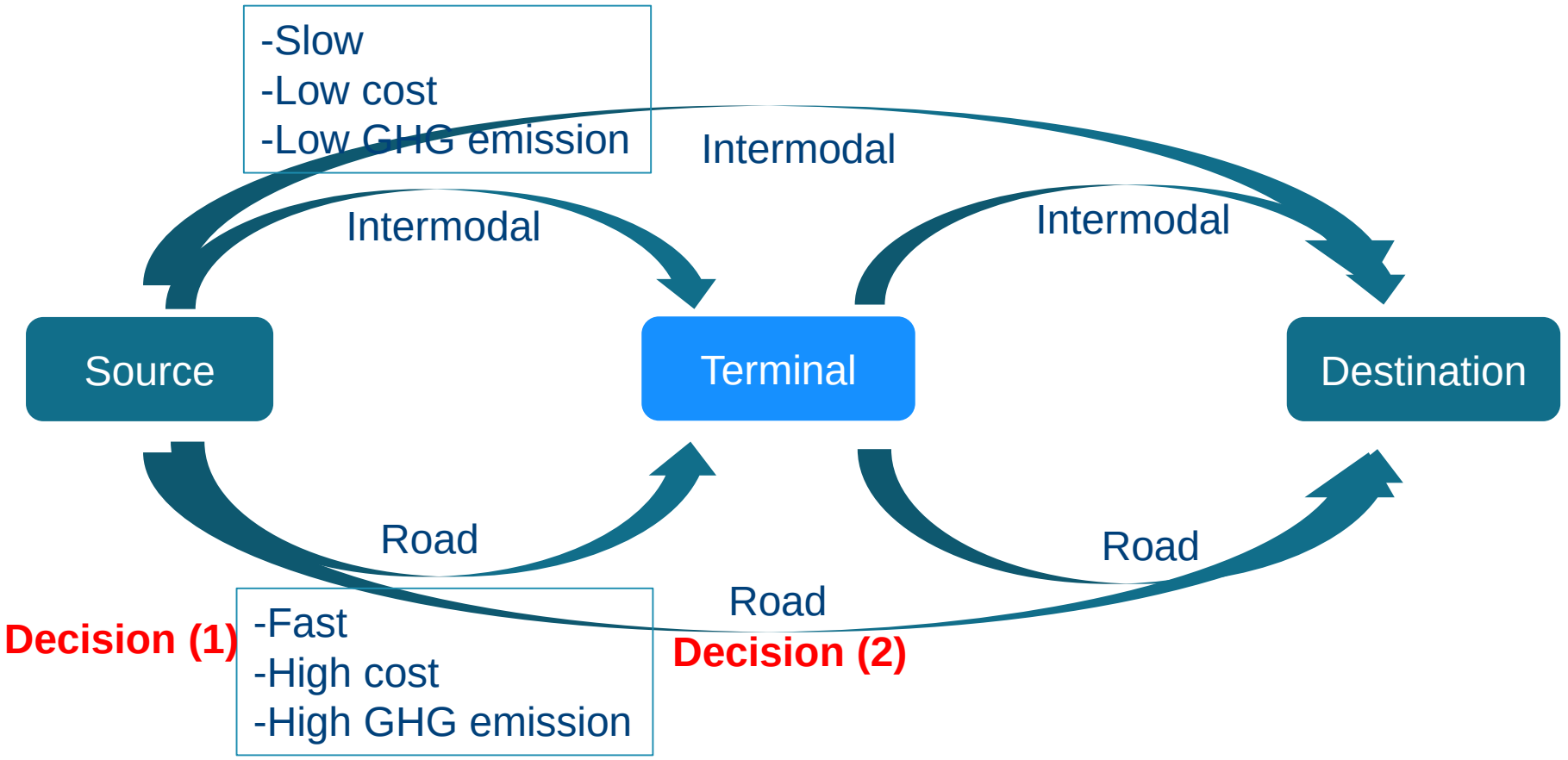
Our mode choice policy



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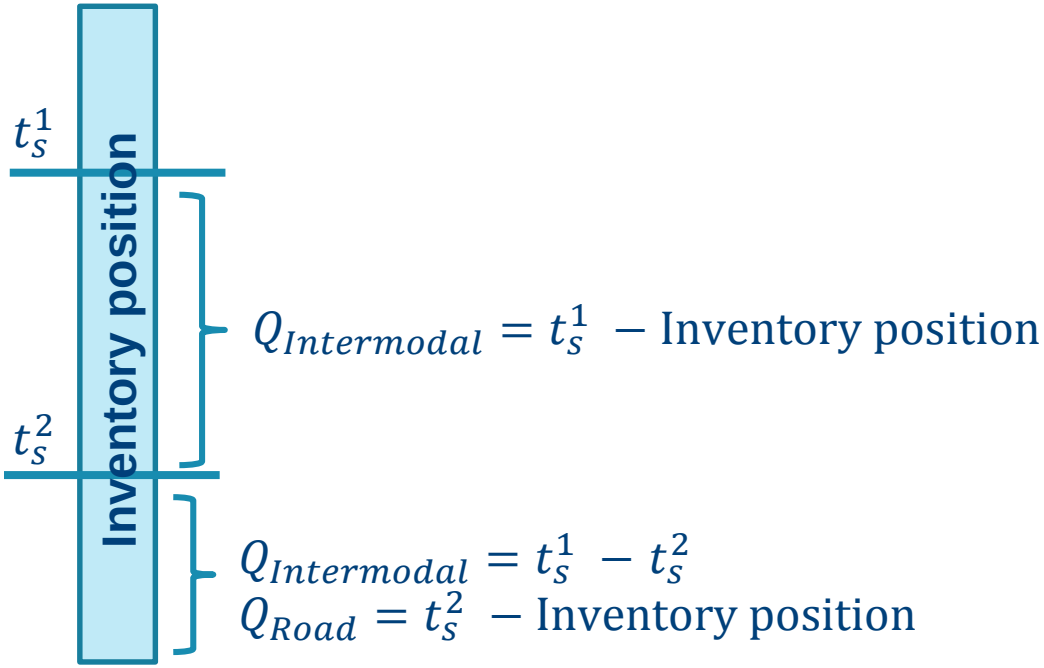
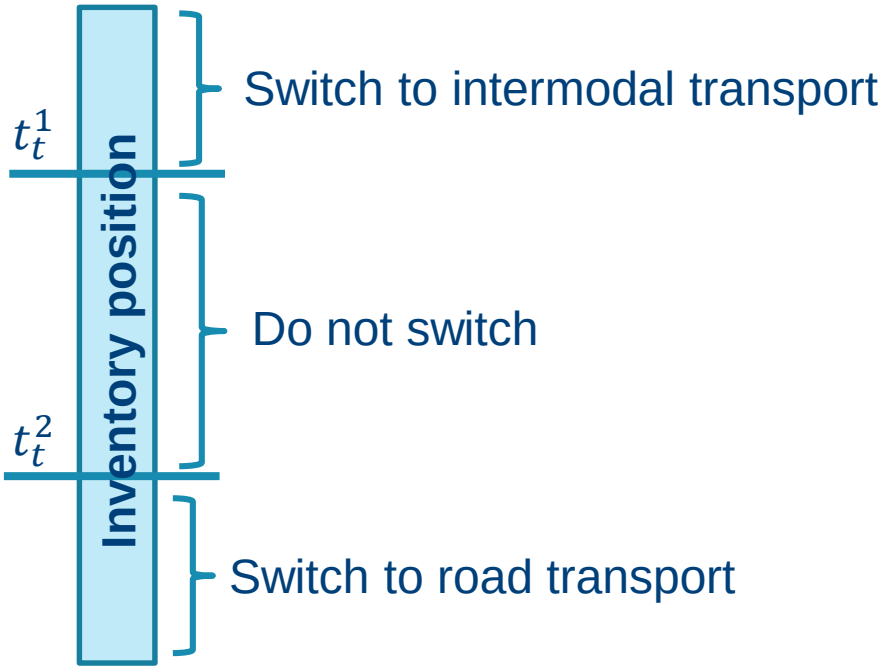
Decision (1): Which volumes are shipped by which transport modes at the source?

Dual-base stock policy



Decision (2): Whether or not to switch between transport modes at the terminal

Two-threshold policy



Simulation study: Input data

Based on real business case	
Demand distribution	Gamma distribution
Lead time distribution	Beta distribution

Representative cost parameters: Base case	
Transport cost	Road transport: 0.0424 euro per unit per km
	Intermodal transport: 0.0303 euro per unit per km
Handling cost	50 euro per switch
Inventory cost	6 euro per unit per day
Backlog cost	114 euro per unit per day

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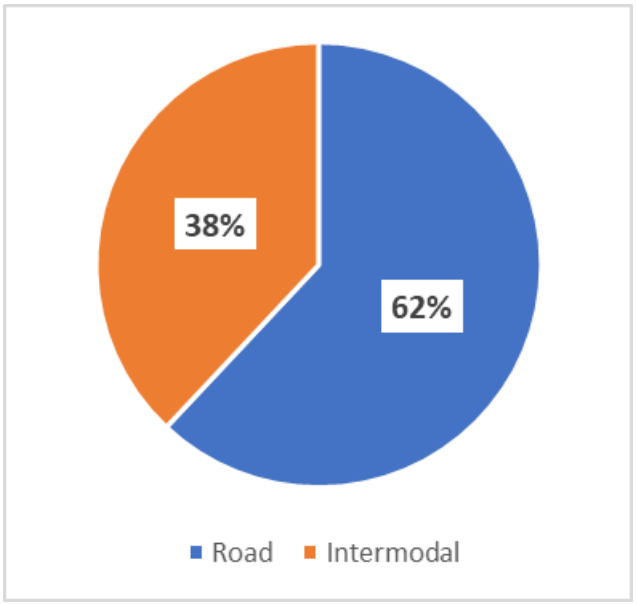
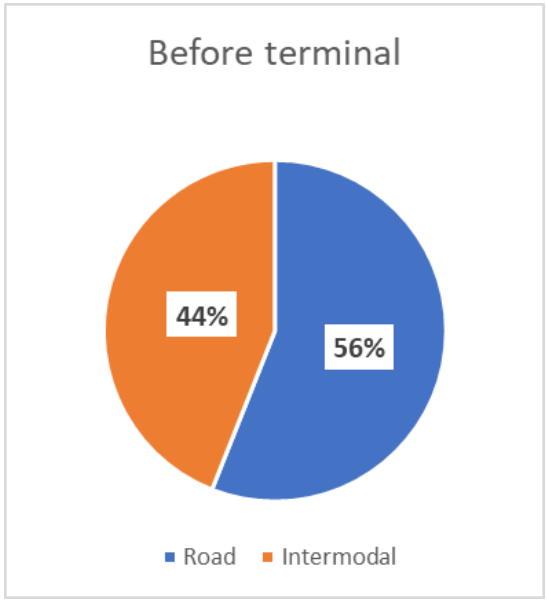
Results: Finding (1)

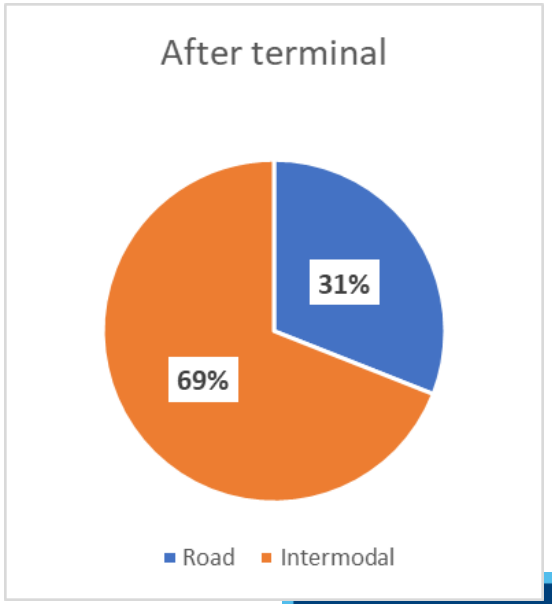
Real-time switching:
(1) increases the share of **intermodal** transport,
especially after the terminal
(2) allows a cost reduction

Dual sourcing



Dual sourcing + Real-time switching





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Sensitivity analysis

Representative cost parameters: Base case	
Transport cost	Road transport: 0.424 euro per unit per km
	Intermodal transport: 0.303 euro per unit per km
Handling cost	50 euro per switch
Inventory cost	6 euro per unit per day
Backlog cost	114 euro per unit per day

➔ Total: 25 scenarios

Sensitivity analysis

Cost parameter	Min	Start value	Max
Road transport cost	0.0318	0.0424	0.0606
Intermodal transport cost	Not adapted	0.0303	Not adapted
Handling cost	Not adapted	50	Not adapted
Inventory cost	2	6	20
Backlog cost	38 (CSL = 95%) 98 (CSL = 98%)	114 (CSL = 95%) 294 (CSL = 98%)	380 (CSL = 95%) 980 (CSL = 98%)

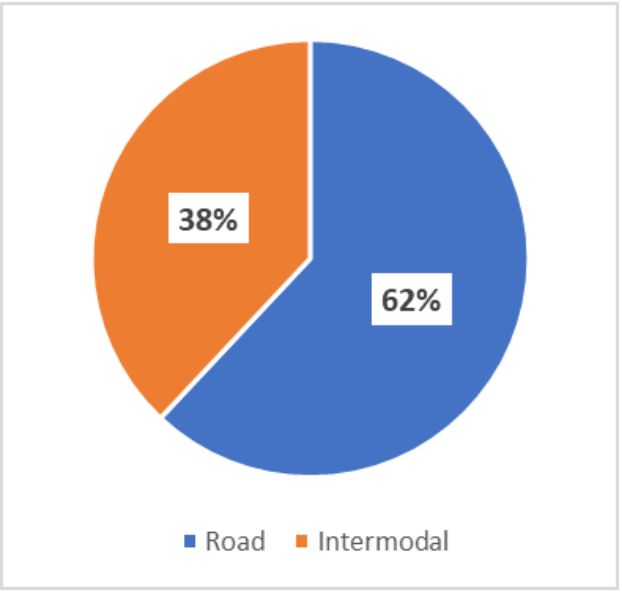
➔ Total: 25 scenarios

Results: Finding (2)

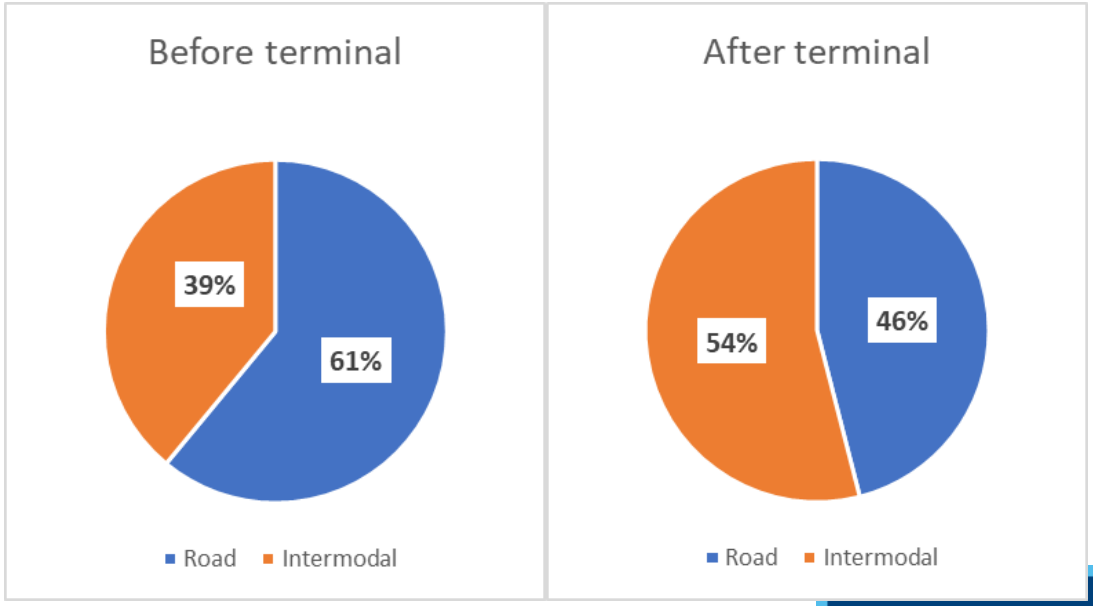
When the ratio transport vs. inventory costs is low, the terminal is mainly used to **slow down** orders.

E.g. transport cost differential = 20%

Dual sourcing



Dual sourcing + Real-time switching

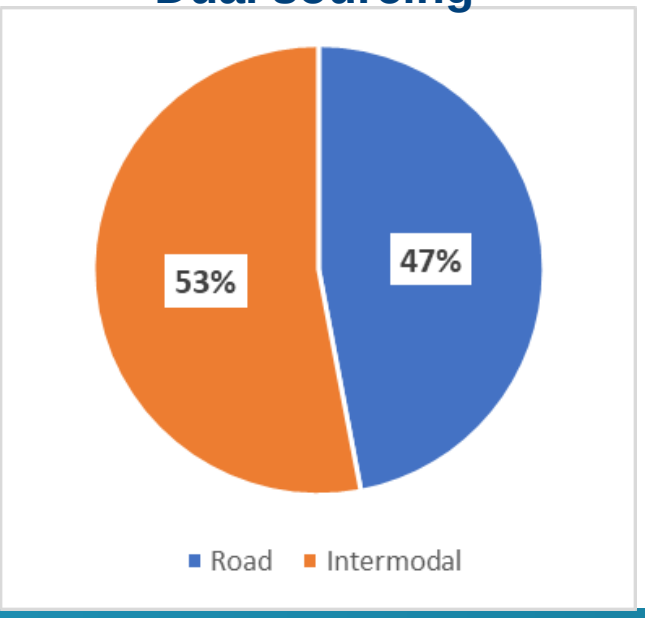


Results: Finding (3)

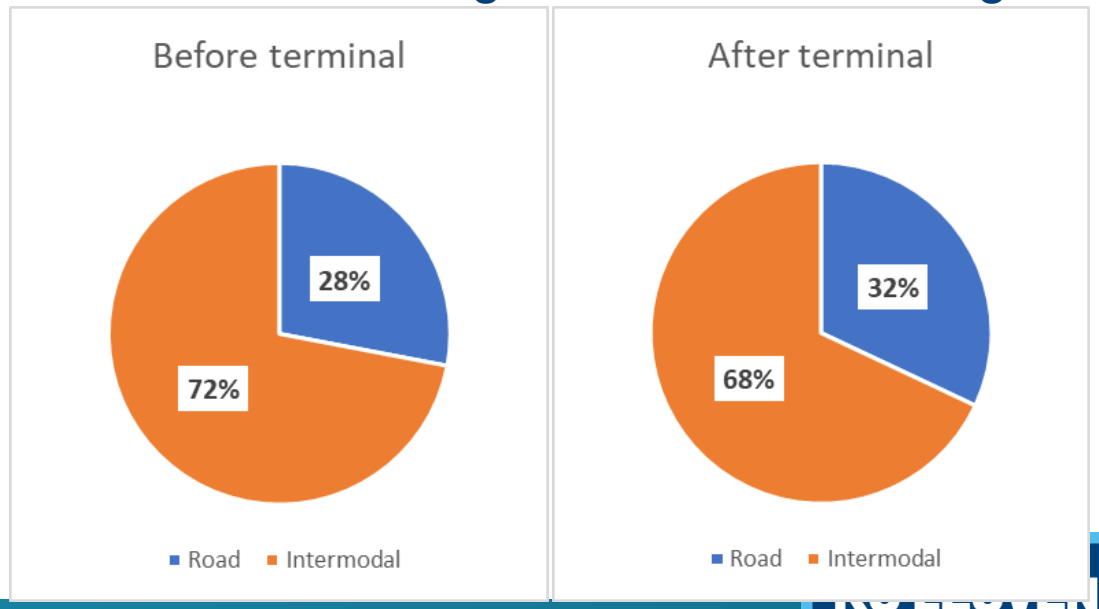
When the ratio transport vs. inventory costs is high, intermodal transport is used more frequently before the terminal and the terminal is used to **speed up** orders.

E.g. high transport cost differential = 75%

Dual sourcing



Dual sourcing + Real-time switching



Results: Sensitivity analysis

1. Real-time switching increases the share of **intermodal** transport, especially after the terminal, and allows a cost reduction.

2. When the ratio transport vs. inventory costs is low, the terminal is mainly used to **slow down** orders.

3. When the ratio transport vs. inventory costs is high, intermodal transport is used more frequently before the terminal and the terminal is used to **speed up** orders.

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