IPIC 2023

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Physical Internet Conference

June 13-15, 2023
Athens, Greece

Synchromodal inventory replenishment under non-stationary demand using partial demand information

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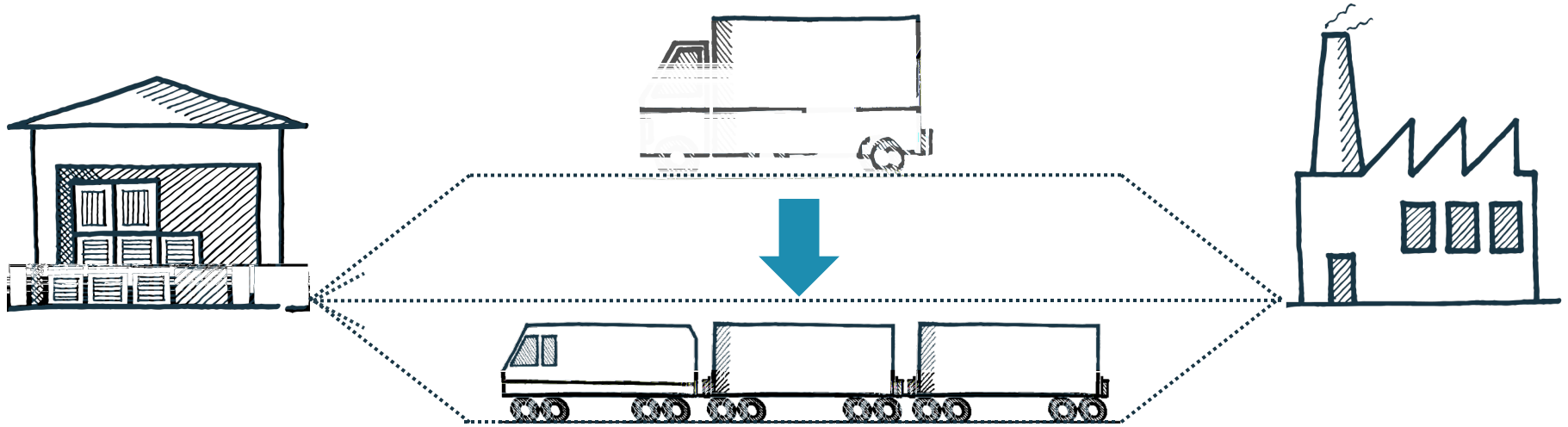
KU LEUVEN

13-15 JUNE 2023 Athens, Greece
www.pi.events/IPIC2023

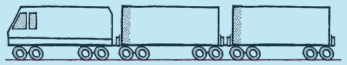
alice | Alliance for Logistics Innovation through Collaboration in Europe

Expanding the logistics Scope



Dual transport mode sourcing

RAIL



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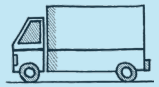
➢ **Low-cost base replenishment**

ROAD



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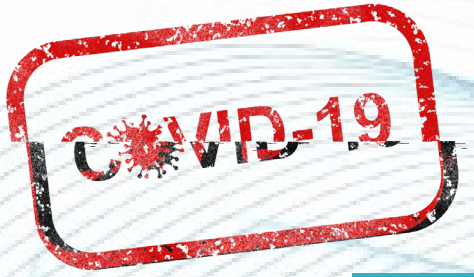
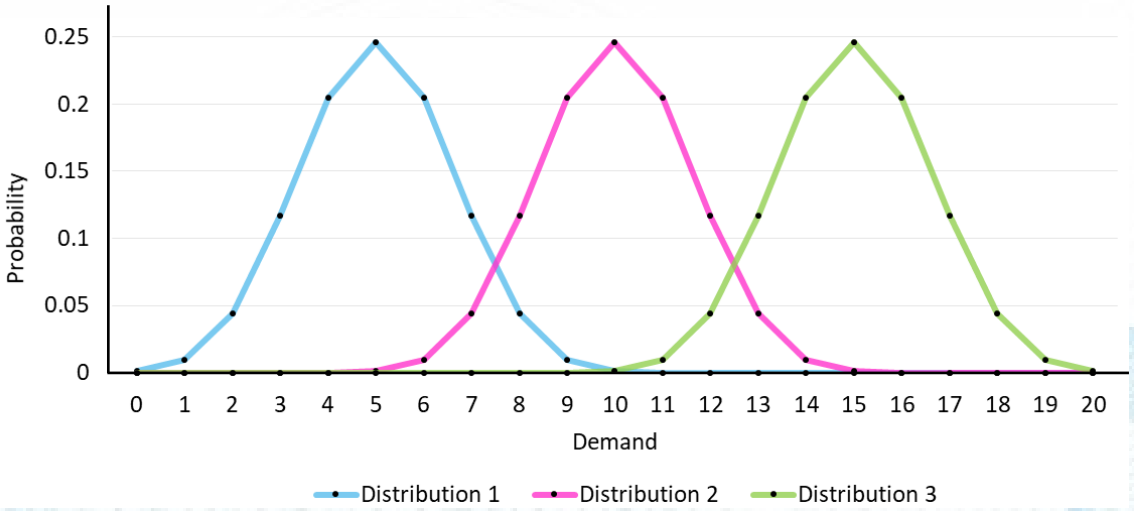
➢ **Urgent orders, volatile part of demand**

non-stationarity

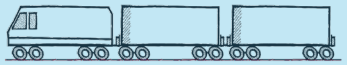


- non-stationarity



➢ More volatile demand flexible

RAIL



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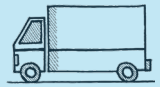
➢ **Low-cost base replenishment**

ROAD



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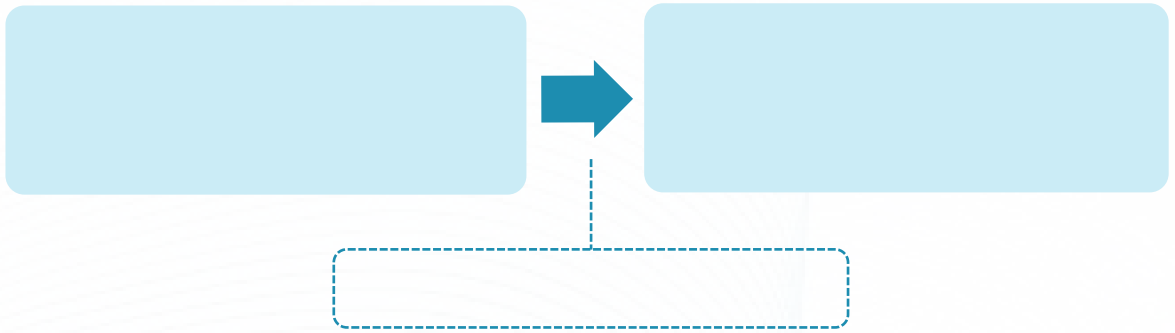
➢ **Urgent orders, volatile part of demand**

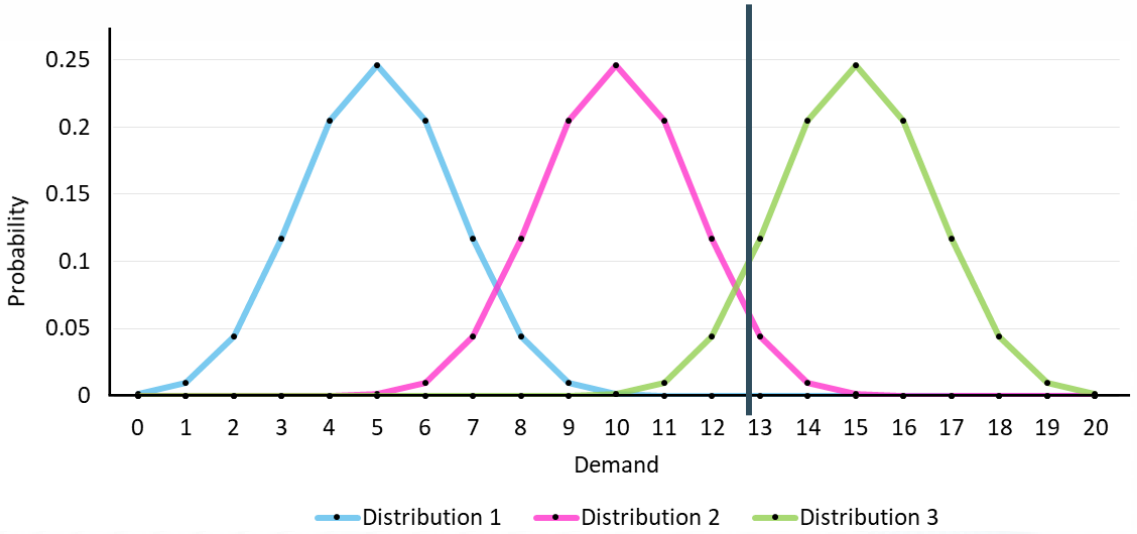
slow

fast and slow

slow

fast and slow



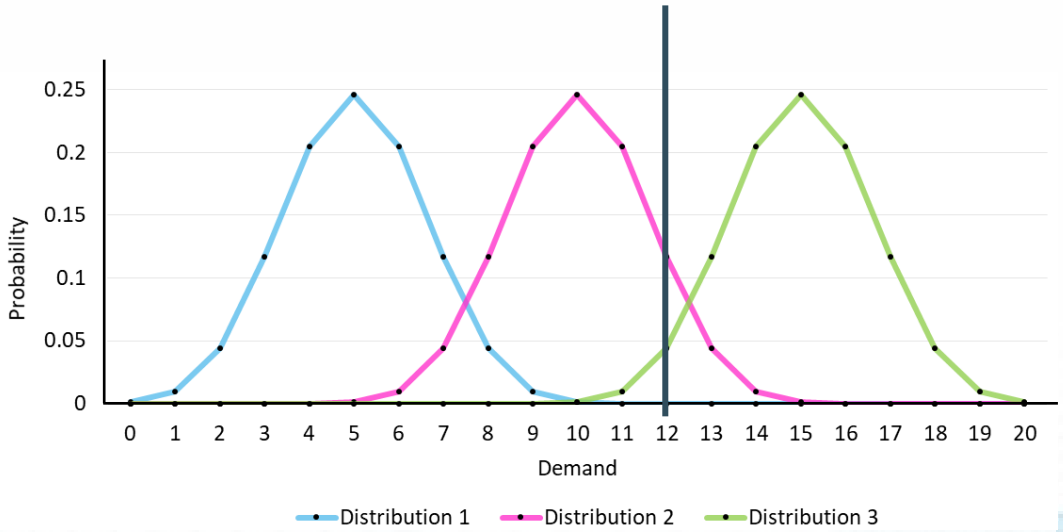


- *not*
- *can*

→ **partial information**

➢ **partially observable Markov decision process**

Example



Period t

Belief

Belief

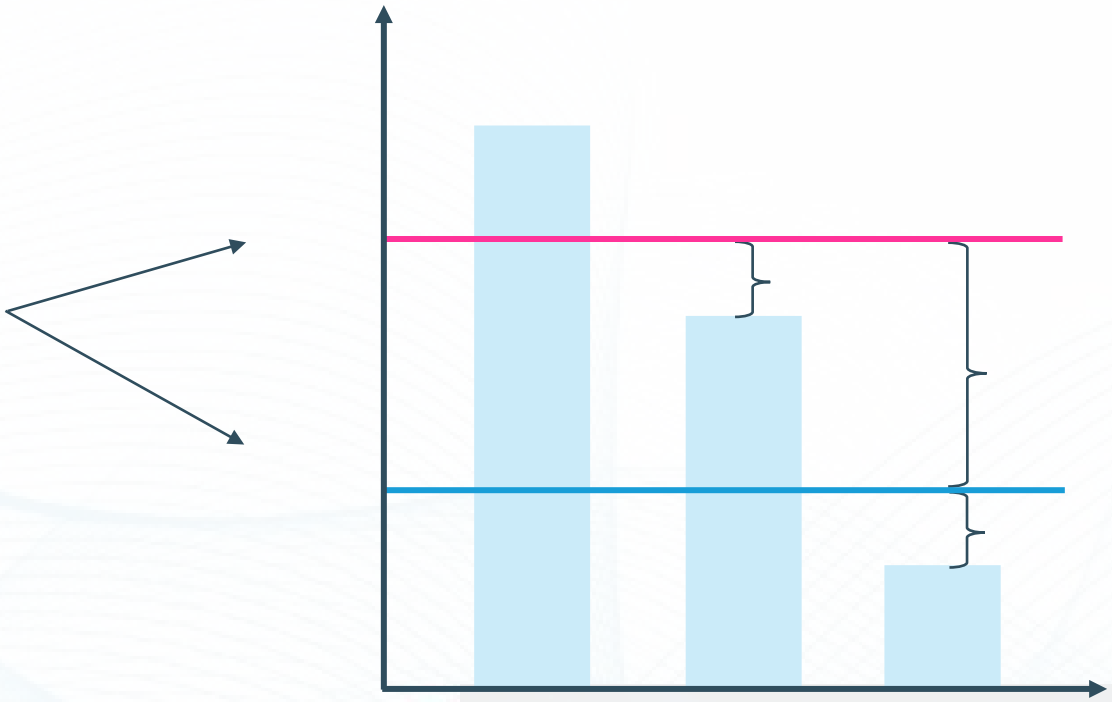
Period t+1

Example

- _____ short-term orders on fast and slow source
- _____
- _____: minimize sourcing costs and inventory mismatch costs
-

Flexible short-term orders:

Adapted to belief



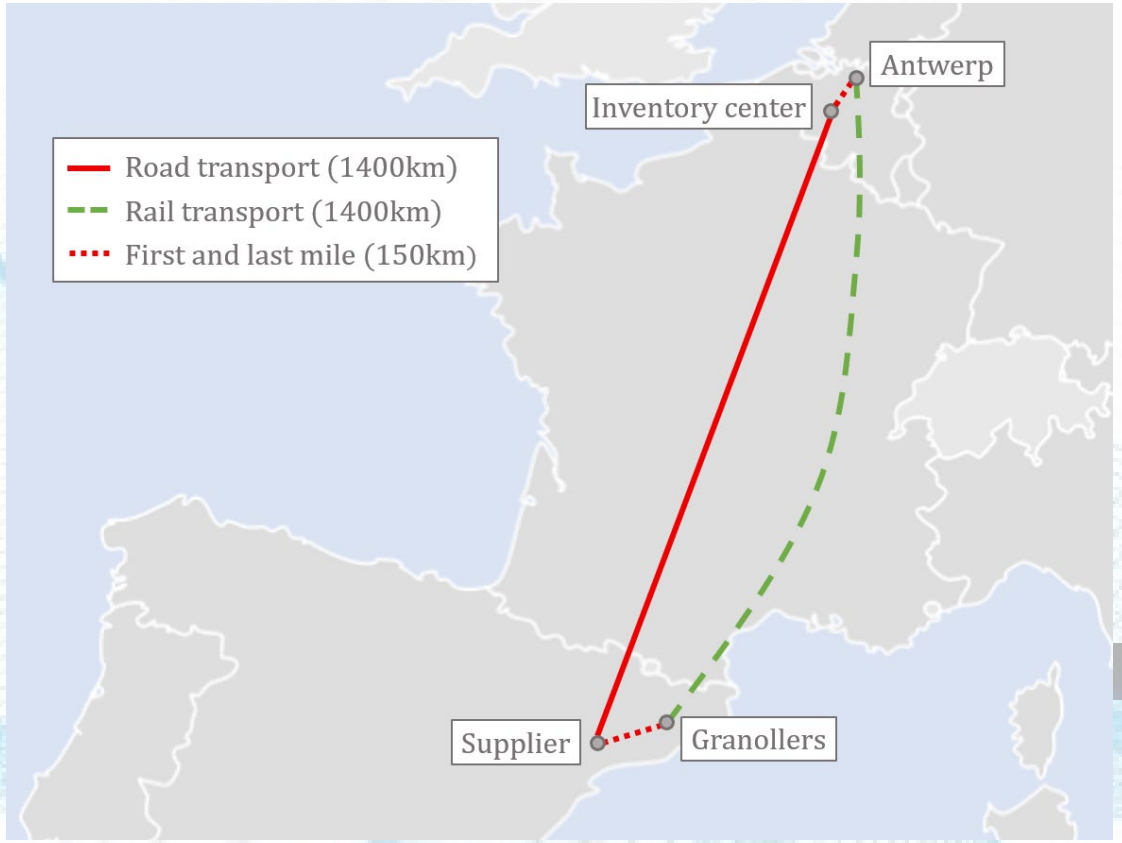
slow

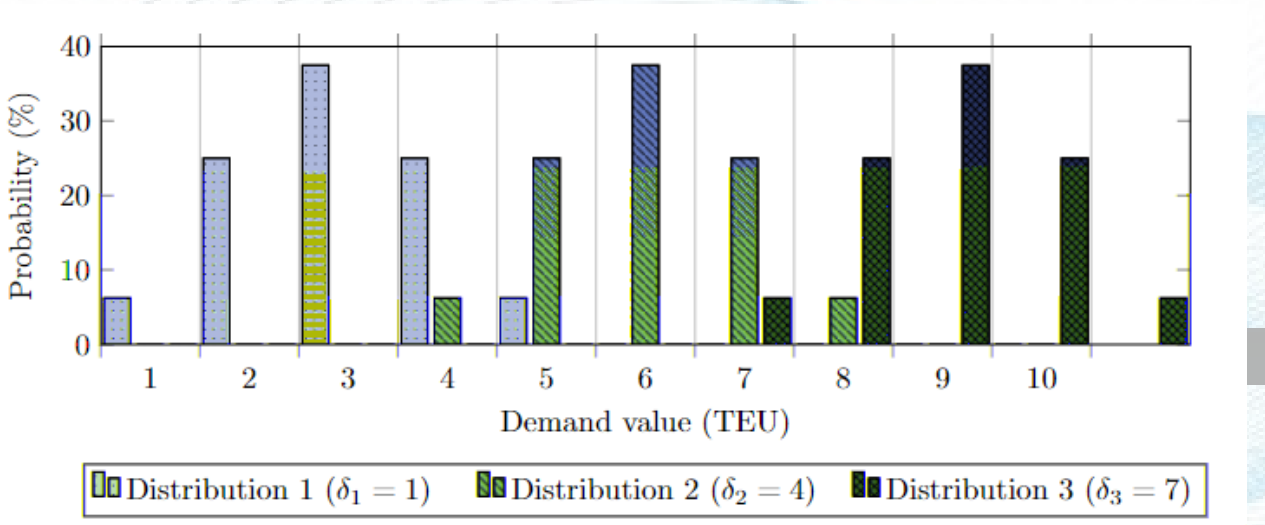
fast and slow

Long-term decision stage

- Bisection search

Short-term decision stage

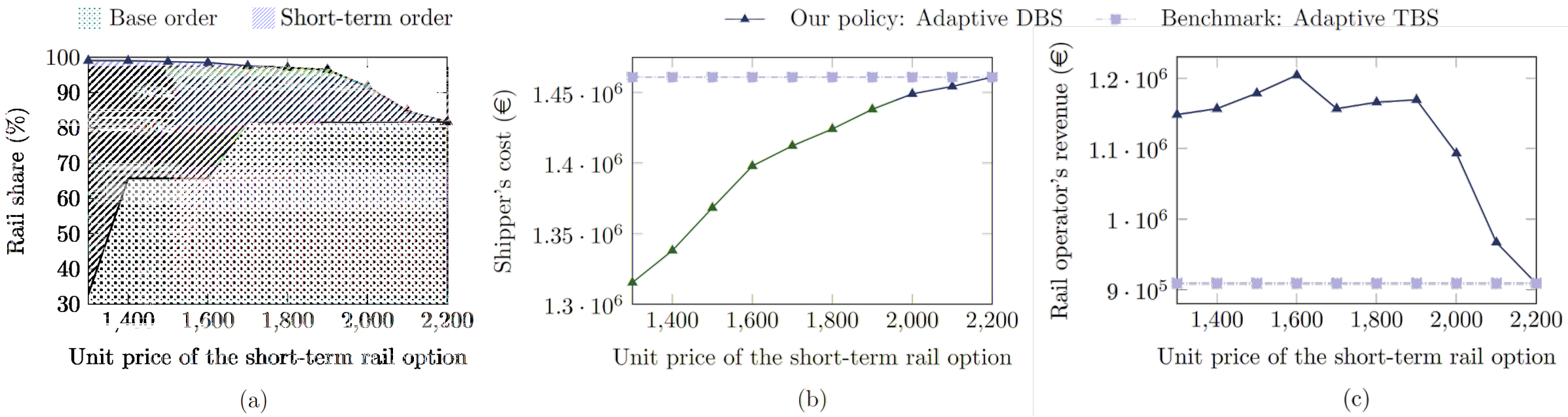

Antwerp
Inventory center
Road transport (1400km)
Rail transport (1400km)
First and last mile (150km)
Supplier
Granollers


Probability (%)
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Demand value (TEU)
Distribution 1 ($\delta_1 = 1$)
Distribution 2 ($\delta_2 = 4$)
Distribution 3 ($\delta_3 = 7$)

Our policy	Benchmark: Adaptive tailored base-surge	
	✓	
	✓	
	No flexible slow orders	
	✓	
Our policy vs. Benchmark		

- Flexible rail orders can capture the non-stationarity
- emission reductions
- without negative impact

Our policy	Benchmark: Adaptive tailored base-surge
Stable order on rail transport	


Base order
Short-term order
Rail share (%)
100
90
80
70
60
50
40
30
1,400
1,600
1,800
2,000
2,200
Unit price of the short-term rail option
(a)
Our policy: Adaptive DBS
Benchmark: Adaptive TBS
Shipper's cost (€)
$1.45 \cdot 10^6$
$1.4 \cdot 10^6$
$1.35 \cdot 10^6$
$1.3 \cdot 10^6$
1,400
1,600
1,800
2,000
2,200
Unit price of the short-term rail option
(b)
Rail operator's revenue (€)
$1.2 \cdot 10^6$
$1.1 \cdot 10^6$
$1 \cdot 10^6$
$9 \cdot 10^5$
1,400
1,600
1,800
2,000
2,200
Unit price of the short-term rail option
(c)

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