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ANTICIPATORY FREIGHT SCHEDULING IN SYNCHROMODAL TRANSPORT

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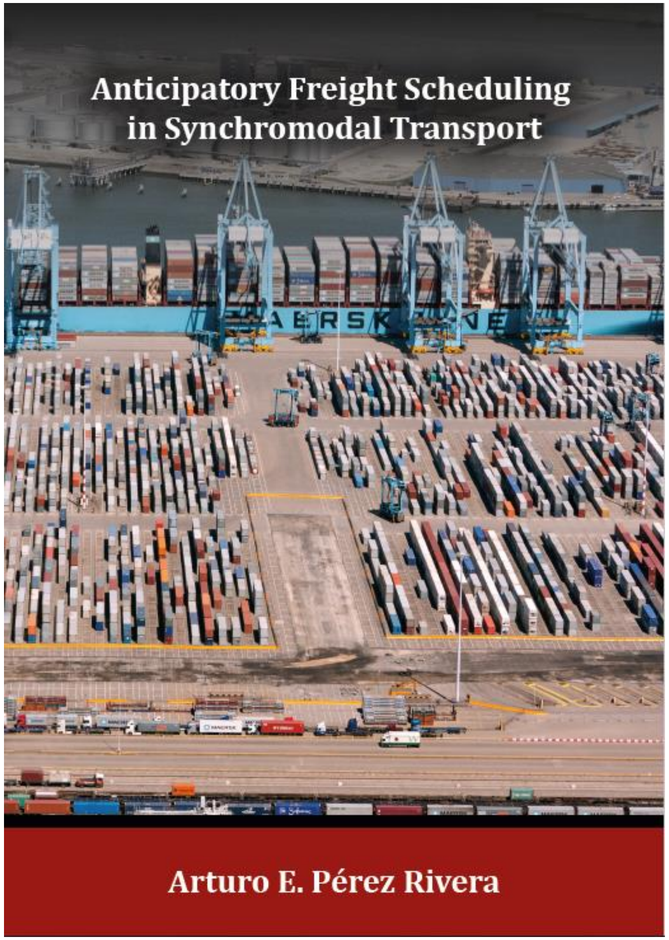
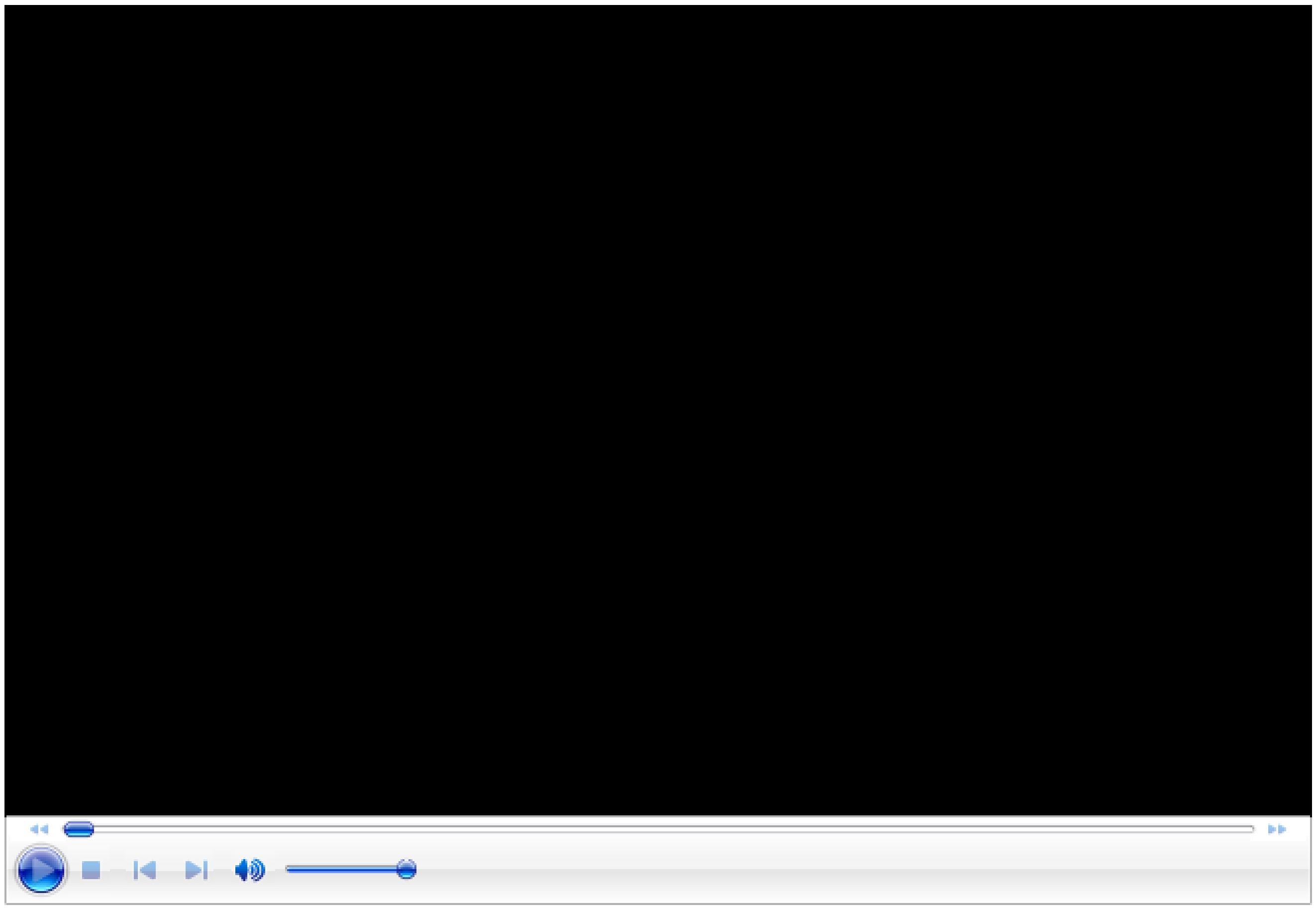


BACKGROUND – SYNCHROMODALITY

WHAT IS SYNCHROMODAL TRANSPORT?



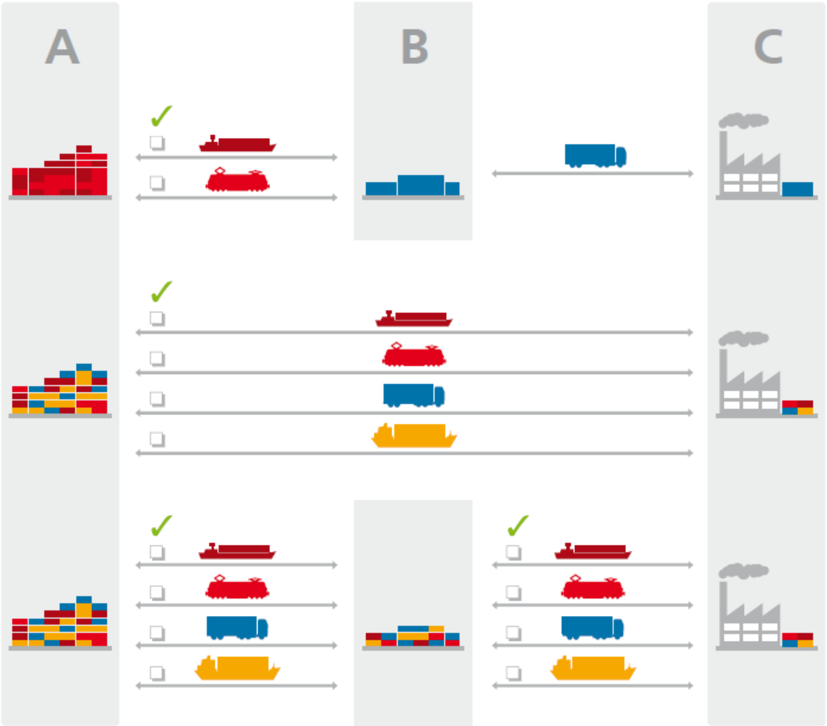
**Source of video: Dutch Institute for Advanced Logistics (DINALOG) www.dinalog.nl*

ANTICIPATORY SCHEDULING IN SYNCHROMODALITY

FLEXIBILITY IN ***MODE***, ***PATH***, AND ***TIME*** OF TRANSPORT

For LSPs, the flexibility of synchromodal transport:

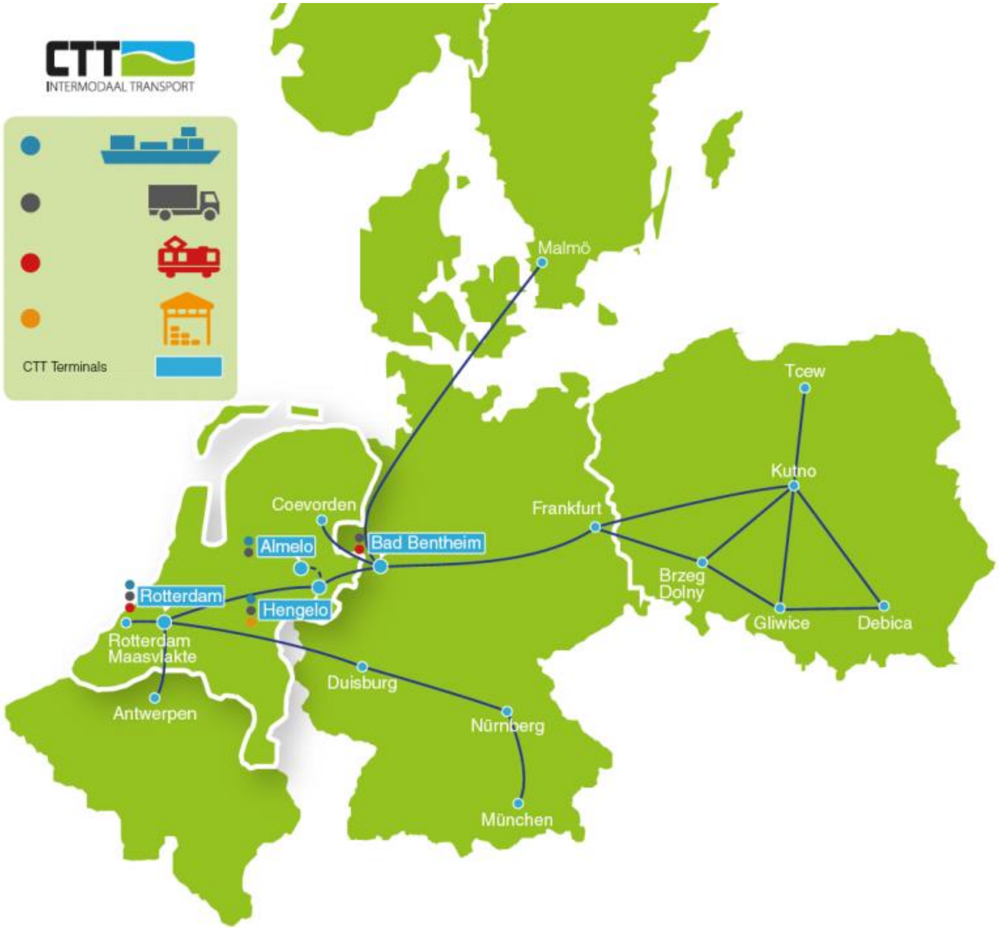
1. ***Provides new consolidation opportunities***
2. ***Requires network-wide and multi-period performance focus***



**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

MOTIVATION – LOGISTICS SERVICE PROVIDER IN TWENTE

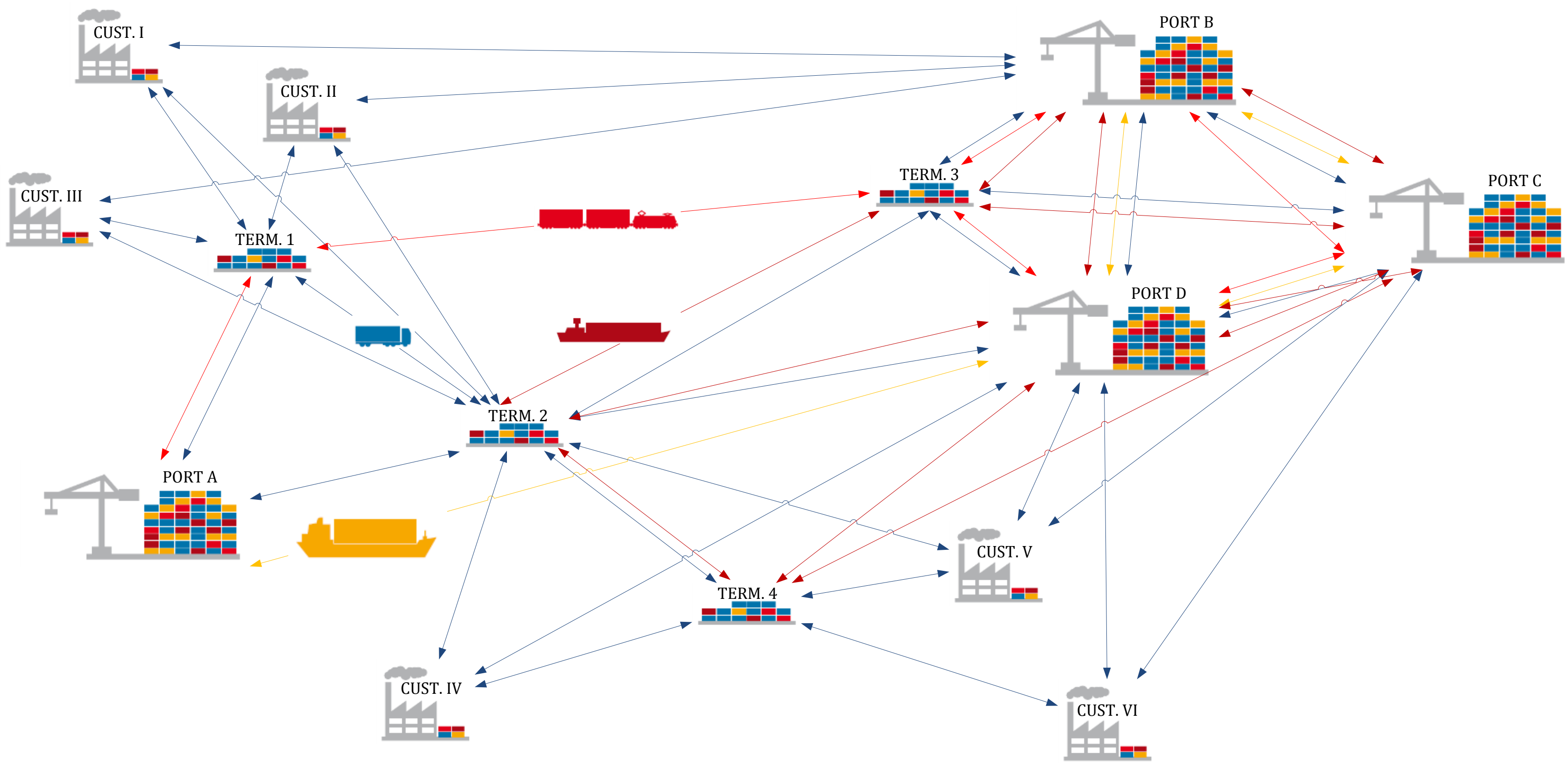
TRANSPORT OF CONTAINERS TO/FROM THE HINTERLAND



Source of artwork: Combi Terminal Twente B.V. www.ctt-twente.nl

ANTICIPATORY SCHEDULING IN SYNCHROMODALITY

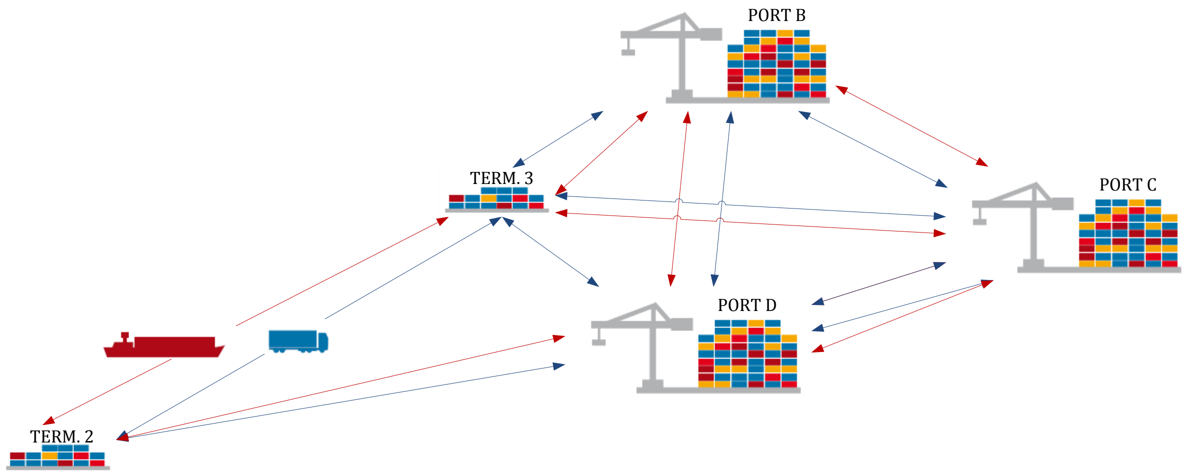
FOUR PERSPECTIVES FOR A MULTI-MODAL TRANSPORT NETWORK



*Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).

I – LONG-HAUL ROUND-TRIP TRANSPORT

THE PROBLEM



Balance the consolidation and postponement of freight transport through ***time***.

**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

I – LONG-HAUL ROUND-TRIP TRANSPORT

OUR APPROACH

1. ***A Markov Decision Process (MDP) model*** to capture the dynamic and stochastic nature of the problem.
2. ***An Approximate Dynamic Programming (ADP) heuristic*** to approximate the costs of postponement in large instances.

Table 2.2: *Three sets of features for the long-haul round-trip costs*

Feature type	Features 1	Features 2	Features 3
All post-decision state variables (18)	•	•	•
All post-decision state variables squared (18)	•	-	-
Count of MustGo destinations (1)	•	•	•
Number of MustGo freights (1)	•	•	•
Product of MustGo destinations and MustGo freights (1)	•	-	-
Count of MayGo destinations (1)	•	•	•
Number of MayGo freights (1)	•	•	•
Product of MayGo destinations and MayGo freights (1)	•	-	-
Count of Future destinations (1)	•	•	•
Number of Future freights (1)	•	•	•
Product of Future destinations and Future freights (1)	•	-	-
Indicator MustGo freights per destination (3)	-	•	-
Indicator MayGo freights per destination (3)	-	•	-
Indicator Future freights per destination (3)	-	•	-
Number of all freights (1)	•	•	•
Constant (1)	•	•	•

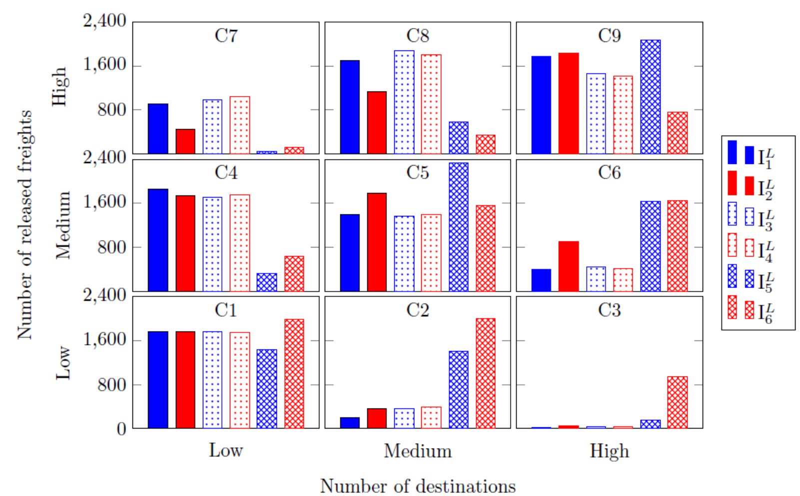


Figure 3.1: *Categorization of the 10,000 sampled states of the Instances I_1^L to I_6^L*

I – LONG-HAUL ROUND-TRIP TRANSPORT

NUMERICAL RESULTS

Calibration Phase

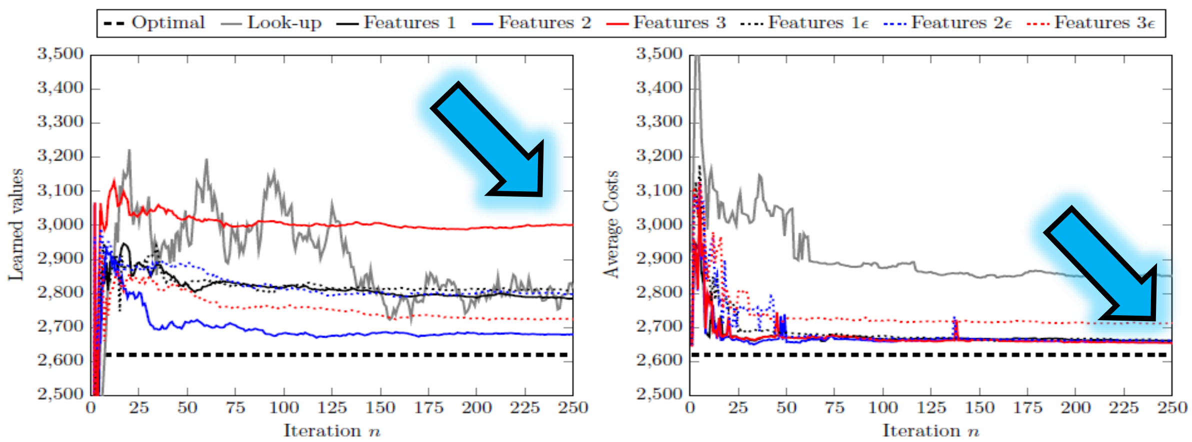


Figure 2.3: *Learned values (left) and average cost performance (right) of the ADP algorithm for the different sets of features for State 2 of the single-trip problem.*

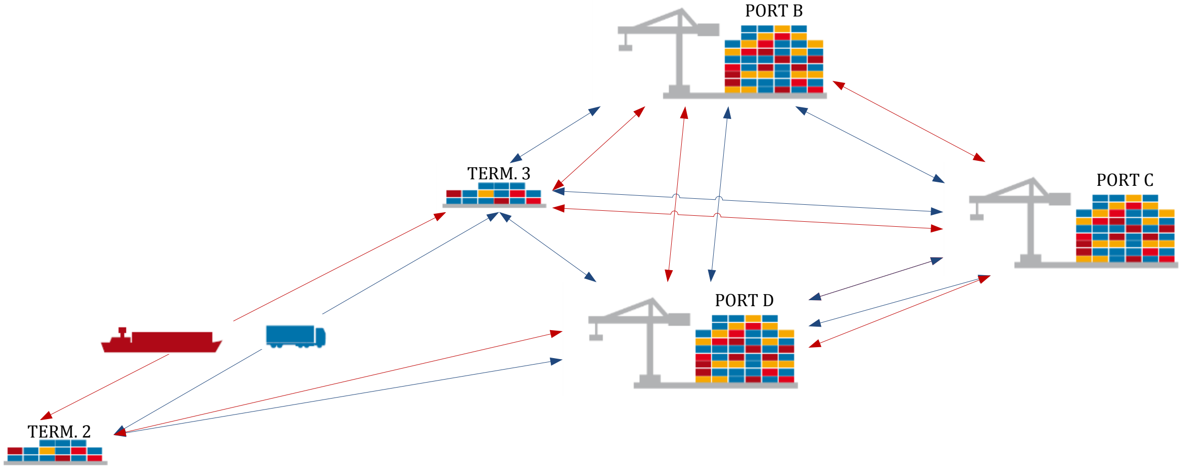
Evaluation Phase

Table 3.4: *Confidence intervals (at 95%) of the difference between the benchmark policy and the ADP policy*

State	I_1^L	I_2^L	I_3^L	I_4^L	I_5^L	I_6^L
C1	[-7.0%,-4.8%]	[-9.6%,-7.5%]	[-10.3%,-8.4%]	[-6.1%,-4.9%]	[-1.3%,0.0%]	[-5.9%,-4.5%]
C2	[-9.7%,-8.4%]	[-13.1%,-11.6%]	[-4.8%,-3.3%]	[-3.6%,-1.8%]	[-1.2%,0.1%]	[-11.6%,-10.4%]
C3	[-2.7%,-1.2%]	[-7.2%,-6.1%]	[-9.1%,-7.4%]	[-3.8%,-2.4%]	[0.5%,1.7%]	[-7.7%,-6.7%]
C4	[-16.0%,-13.8%]	[-26.5%,-24.6%]	[-6.2%,-4.1%]	[-12.5%,-11.2%]	[-2.2%,-0.7%]	[-8.4%,-7.6%]
C5	[-15.9%,-14.3%]	[-2.0%,-0.9%]	[-10.5%,-8.8%]	[-26.5%,-25.3%]	[-1.0%,0.1%]	[-10.3%,-9.2%]
C6	[0.5%,2.1%]	[-5.1%,-3.9%]	[-4.5%,-3.1%]	[-11.1%,-10.0%]	[-2.6%,-1.4%]	[-8.2%,-7.3%]
C7	[-4.7%,-4.0%]	[-4.3%,-3.0%]	[-25.0%,-23.5%]	[-0.6%,0.4%]	[-12.2%,-9.8%]	[-7.9%,-6.8%]
C8	[-2.9%,-1.7%]	[-17.1%,-16.3%]	[-2.5%,-1.6%]	[-7.5%,-6.7%]	[-0.9%,-0.2%]	[-3.7%,-2.9%]
C9	[-1.5%,-0.3%]	[1.8%,2.8%]	[-5.4%,-3.5%]	[-11.4%,-10.7%]	[3.9%,5.4%]	[-7.9%,-7.2%]

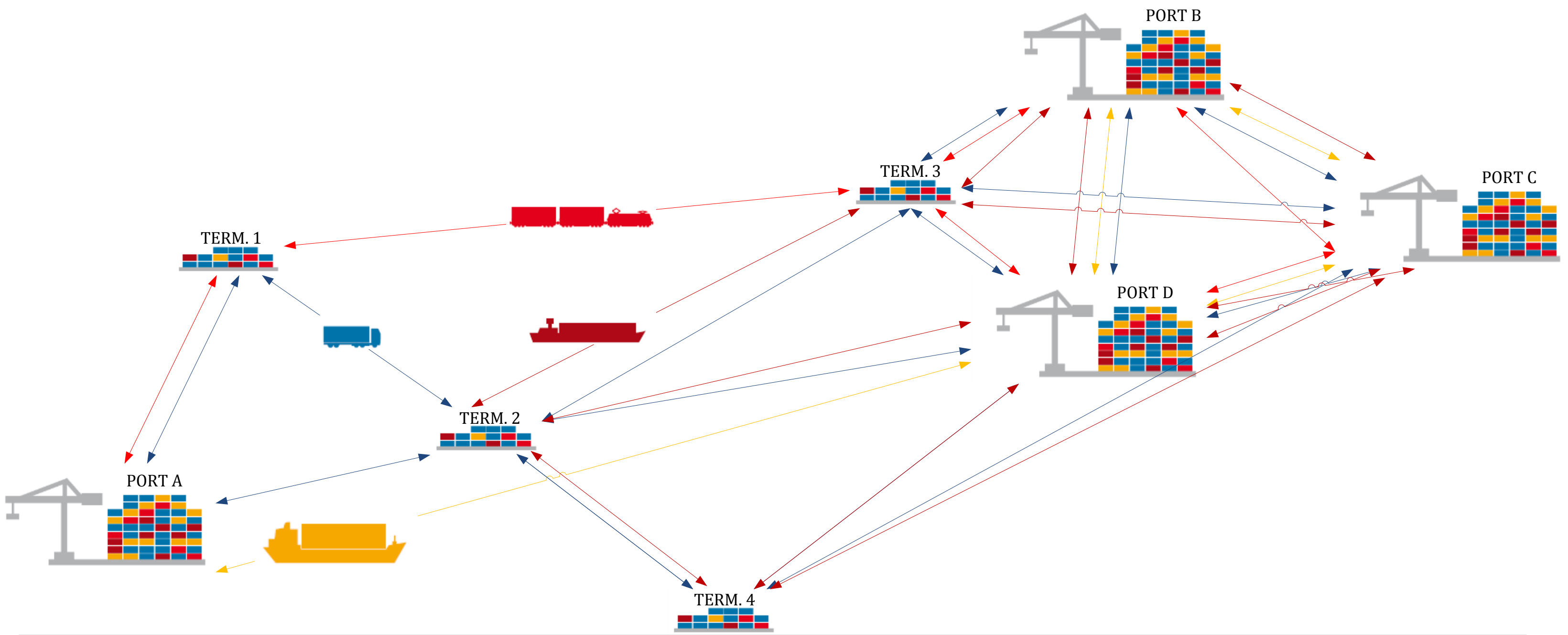
I – LONG-HAUL ROUND-TRIP TRANSPORT

THE PROBLEM



**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

II – LONG-HAUL MULTI-TRANSFER TRANSPORT
THE PROBLEM



Balance the consolidation and postponement of freight transport through ***time and space***.

**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

II – LONG-HAUL MULTI-TRANSFER TRANSPORT

OUR APPROACH

1. ***An MDP model and a Mixed-Integer Linear Program (MILP)*** to capture the time-space evolution of the transport network.
2. ***An ADP heuristic with Reinforcement Learning constructs*** to solve the exploration vs. exploitation dilemma.

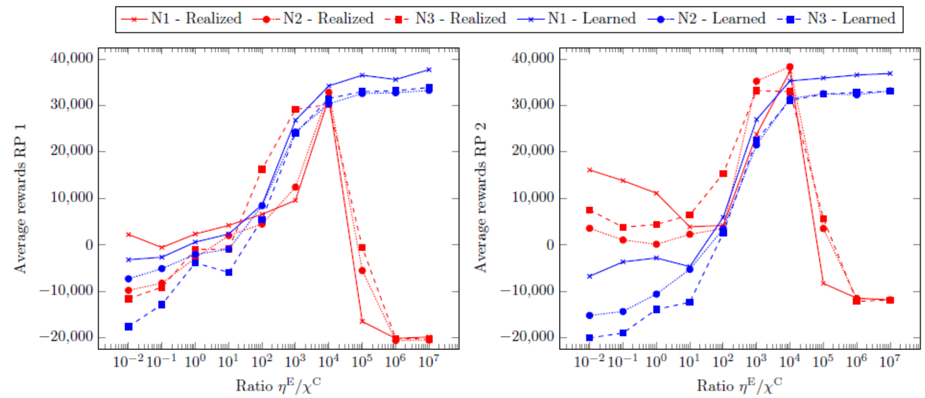


Figure 4.5: *Comparison of average rewards (over all modifications) under different ratios η^E/χ^C*

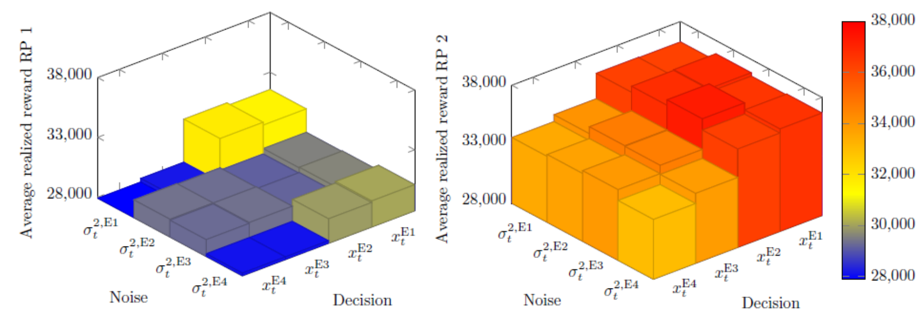
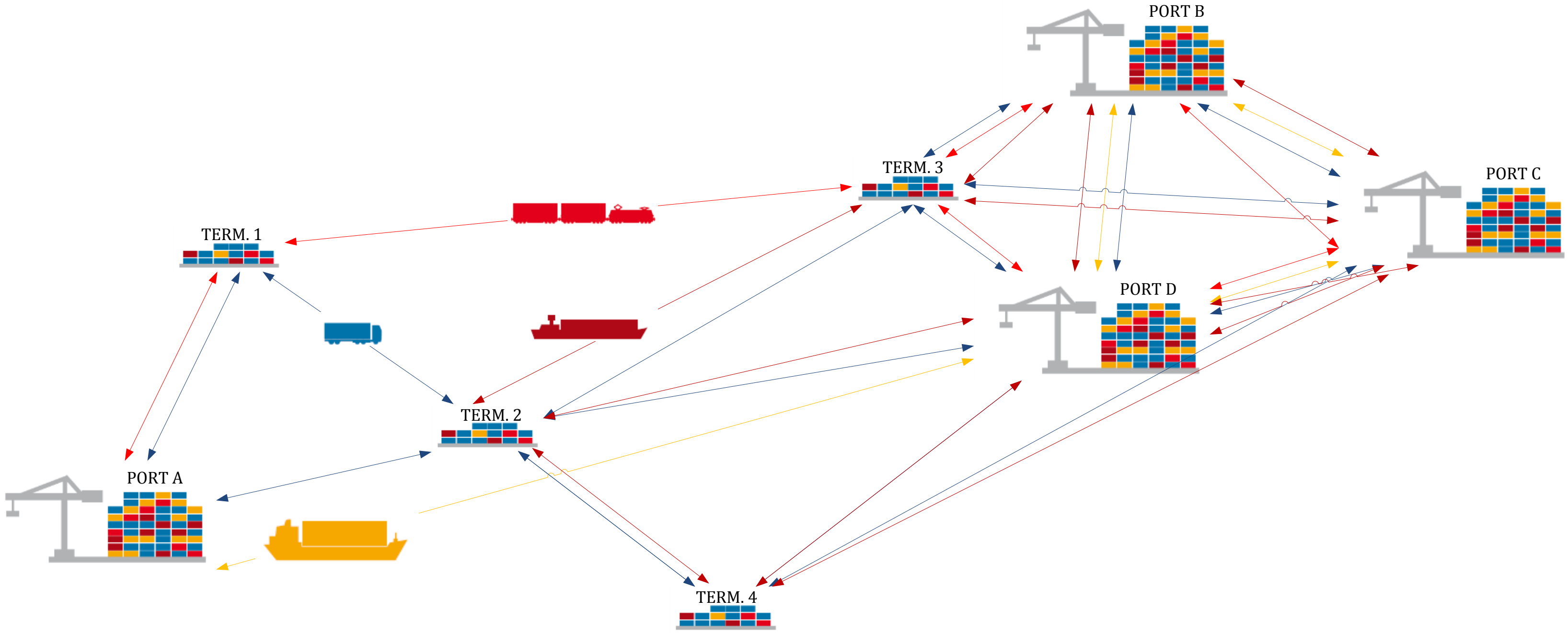


Figure 4.6: *Comparison of average rewards (over all networks) for our proposed VPI modifications*

II – LONG-HAUL MULTI-TRANSFER TRANSPORT

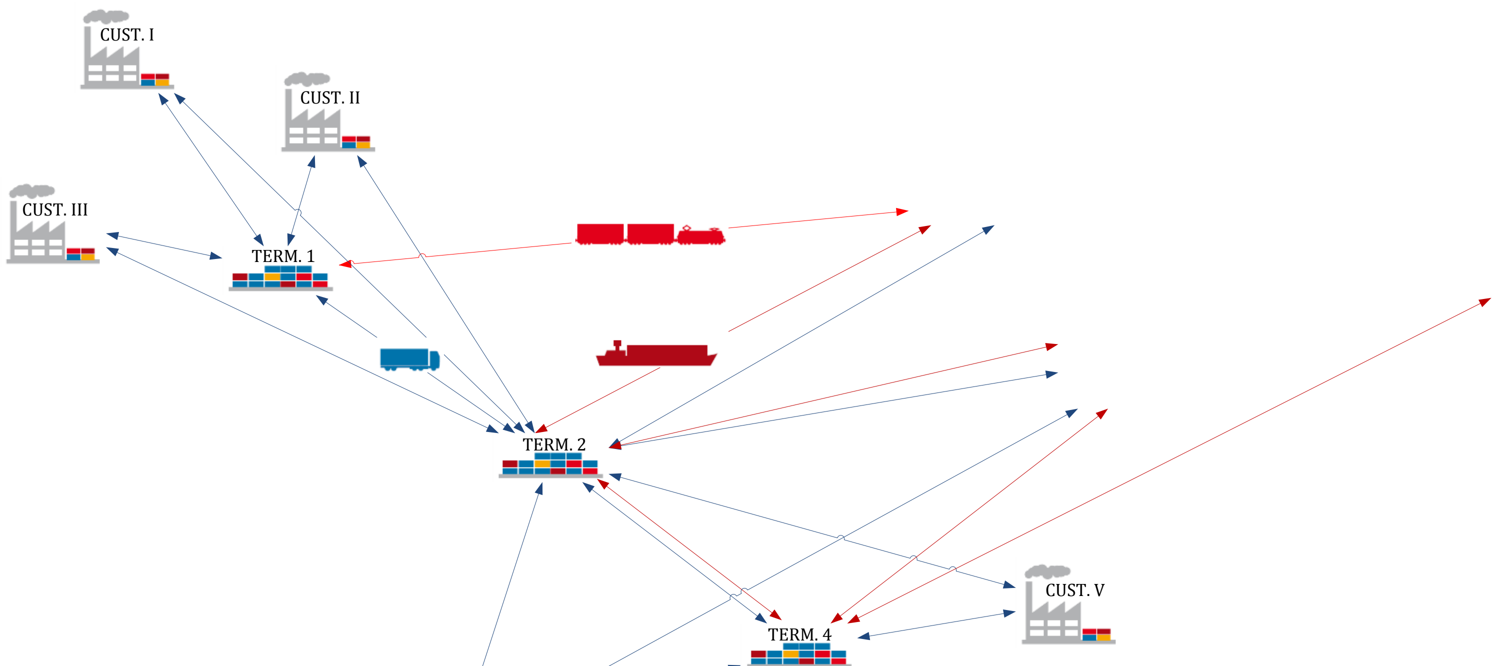
THE PROBLEM



**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

III – MULTI-TERMINAL DRAYAGE TRANSPORT

THE PROBLEM



Balance the immediate routing costs and the ***terminal assignment*** costs.

**Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).*

III – MULTI-TERMINAL DRAYAGE TRANSPORT

OUR APPROACH

1. ***A Mixed Integer Linear Program (MILP)*** to represent the rich vehicle routing problem and terminal assignment problem.
2. ***A Matheuristic (MH) with iterative MILP adaptations (polytope cuts)*** to solve the MILP for large instances.

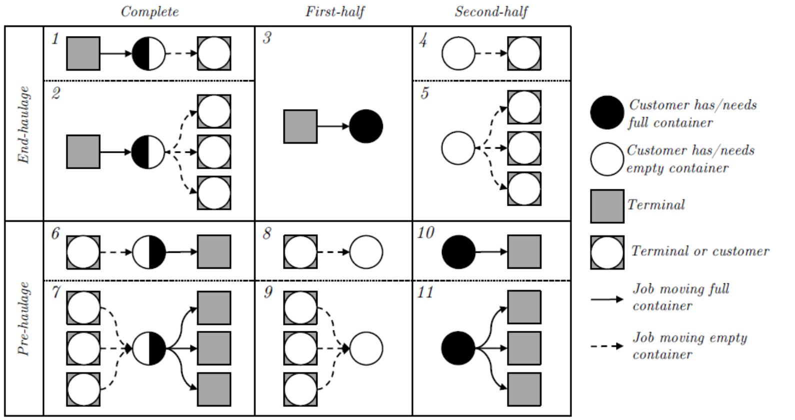


Figure 5.1: *Possible job configurations in synchromodal transport*

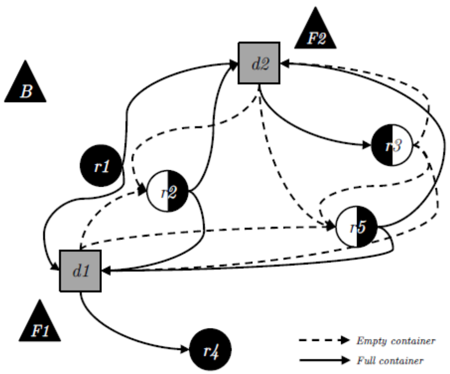


Figure 5.5: *Example* $\mathcal{G} = (\mathcal{V}, \mathcal{A})$

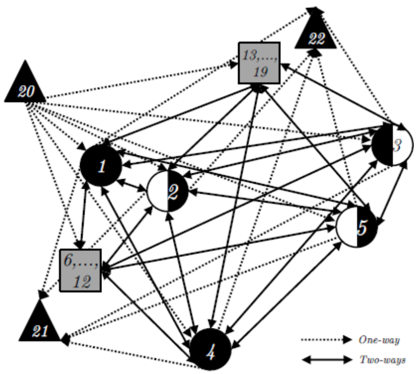


Figure 5.6: *Example* $\mathcal{G}' = (\mathcal{V}, \mathcal{A}')$

III – MULTI-TERMINAL DRAYAGE TRANSPORT

NUMERICAL RESULTS

Static MH

Table 5.2: *Total costs for various MILP adaptations*

Instances	BH	MILP	VIs	TWPP	MHO 1	MHO 2	MHO 3
C1	77,960	77,926	77,960	76,924	76,829	77,926	75,189
C2	52,904	52,882	52,904	52,049	51,841	52,078	50,802
R1	111,087	111,078	110,904	107,649	107,254	107,647	107,736
R2	50,500	50,435	50,500	50,497	50,255	50,500	50,378

Dynamic MH

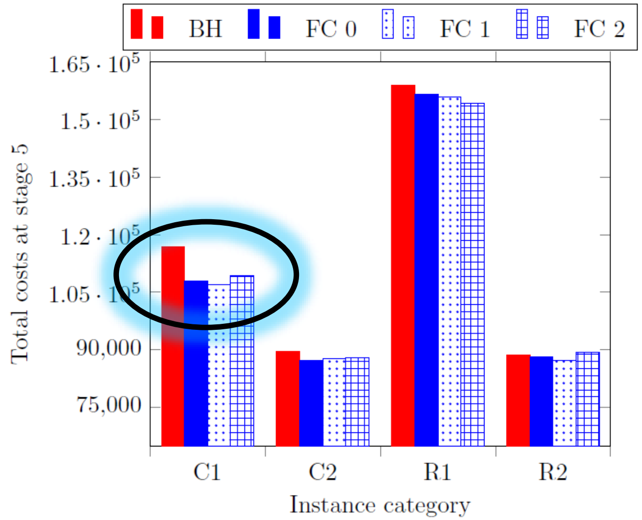


Figure 5.3: *Comparison FCs at last stage*

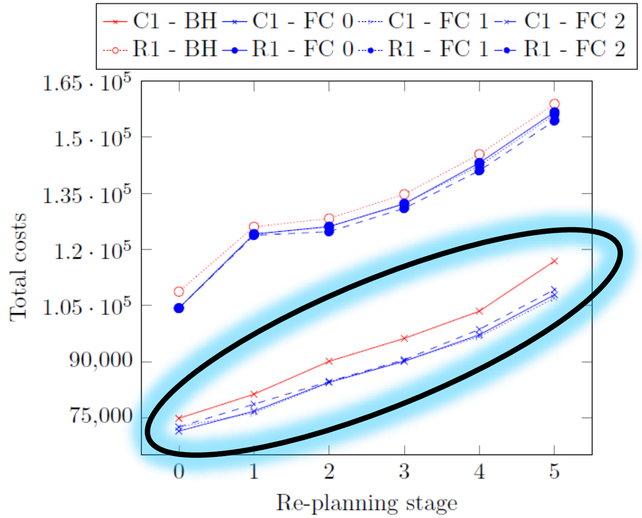
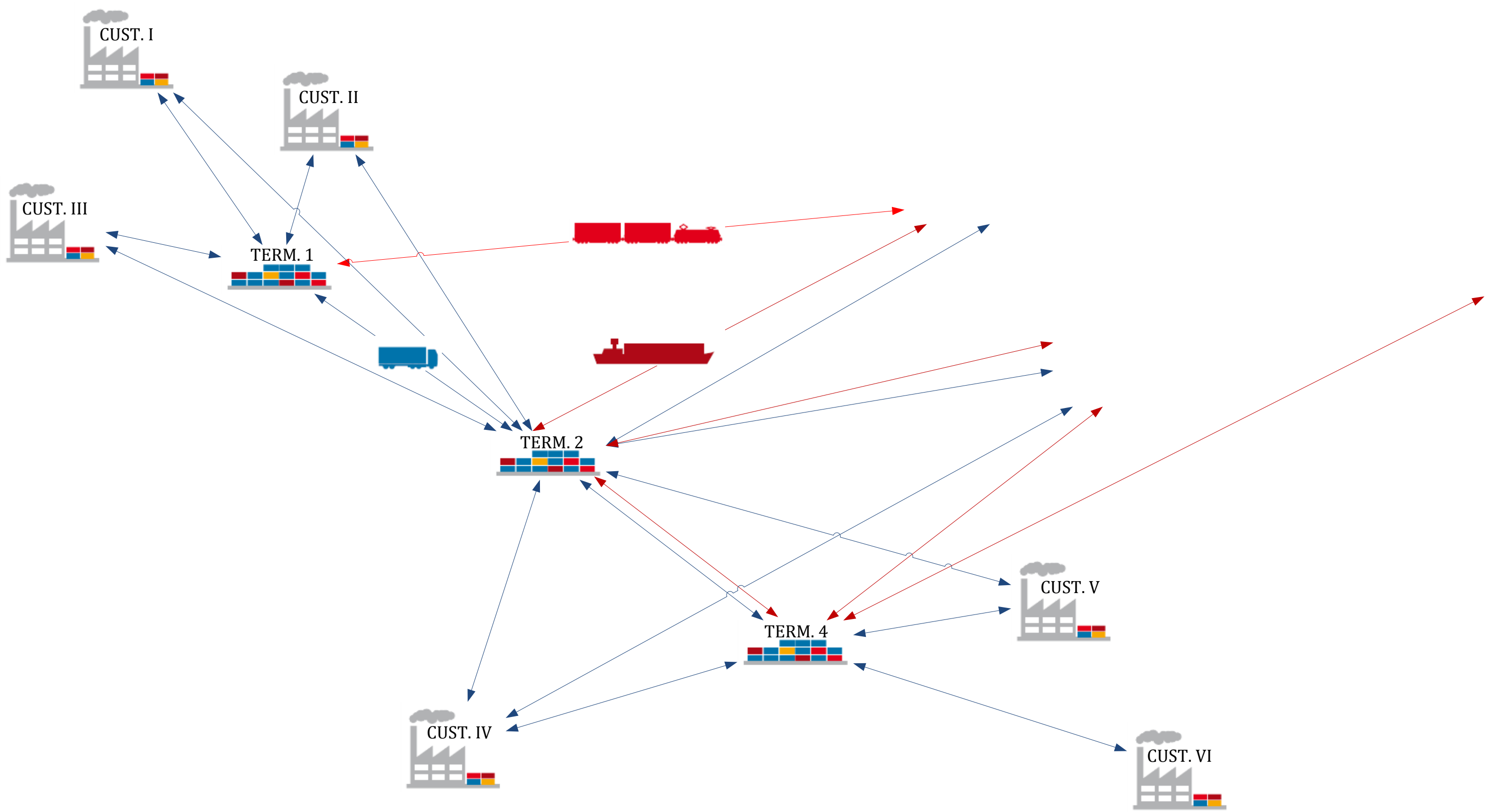


Figure 5.4: *Performance of best FC per stage*

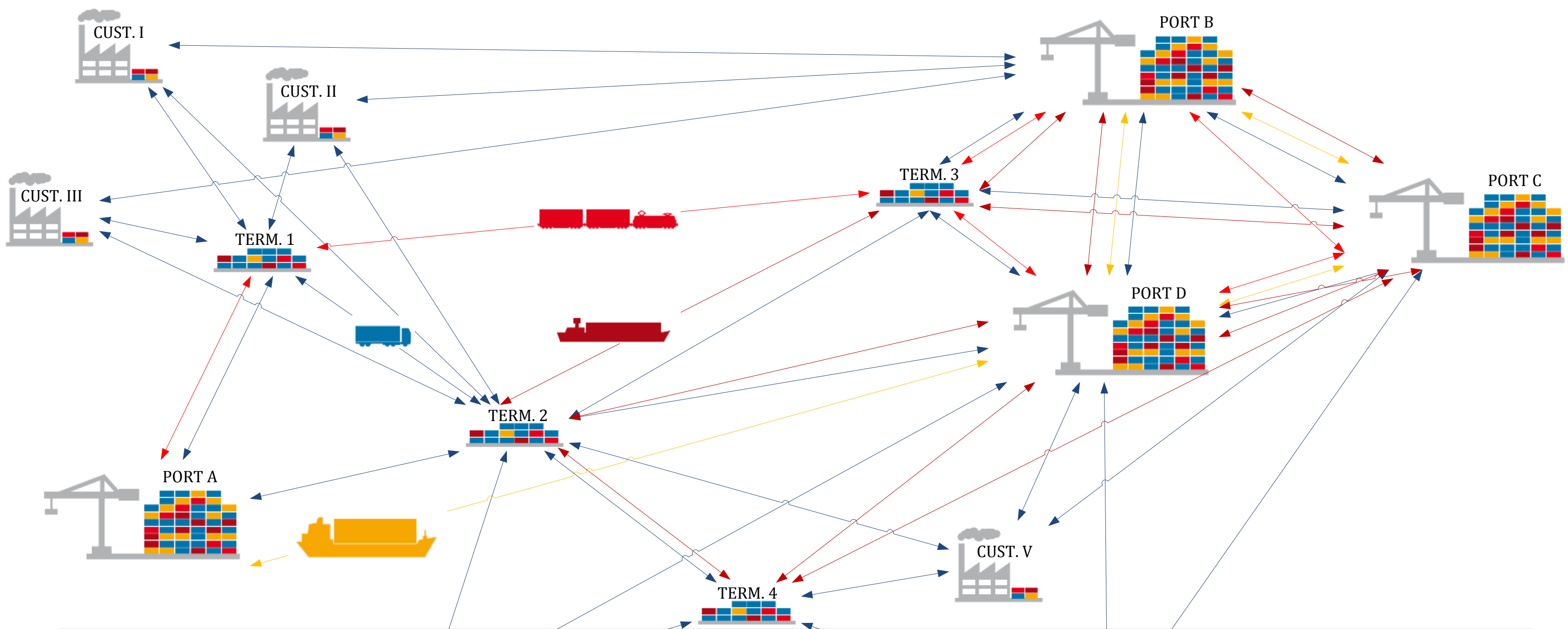
III – MULTI-TERMINAL DRAYAGE TRANSPORT
THE PROBLEM



Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).

IV – INTEGRATED LONG-HAUL AND DRAYAGE

THE PROBLEM



Balance long-haul and drayage transport
network-wide through time.

*Source of artwork: Europe Container Terminals "The future of freight transport". www.ect.nl

IV – INTEGRATED LONG-HAUL AND DRAYAGE

OUR APPROACH

A simulation-based integration of the ADP algorithm and the matheuristic to capture the recursive relation between drayage operations and long-haul transport.

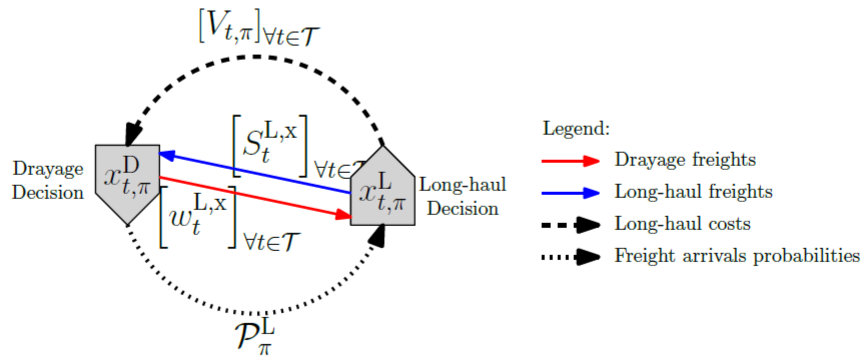


Figure 6.3: *Components of the recursion between drayage and long-haul decisions*

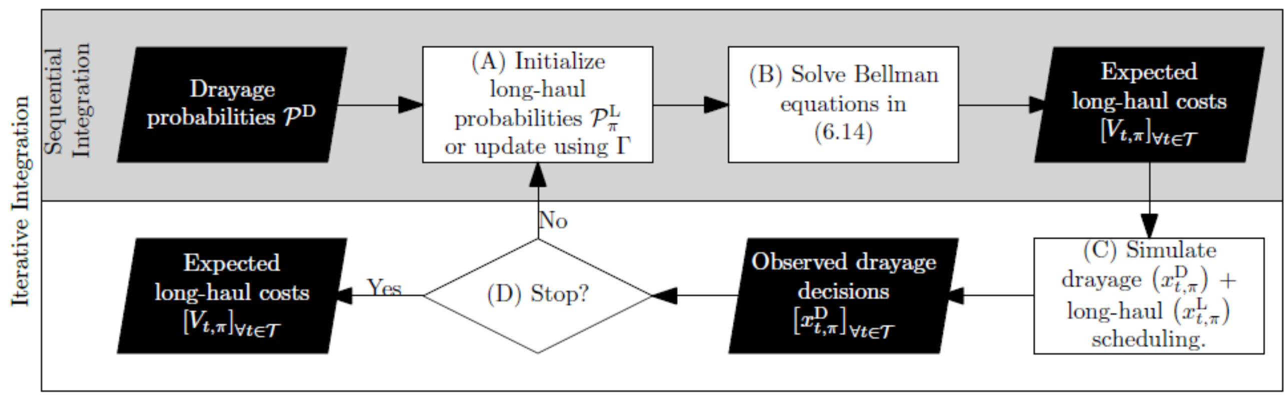


Figure 6.4: *Proposed solution methods to the integrated scheduling model*

IV – INTEGRATED LONG-HAUL AND DRAYAGE

NUMERICAL RESULTS

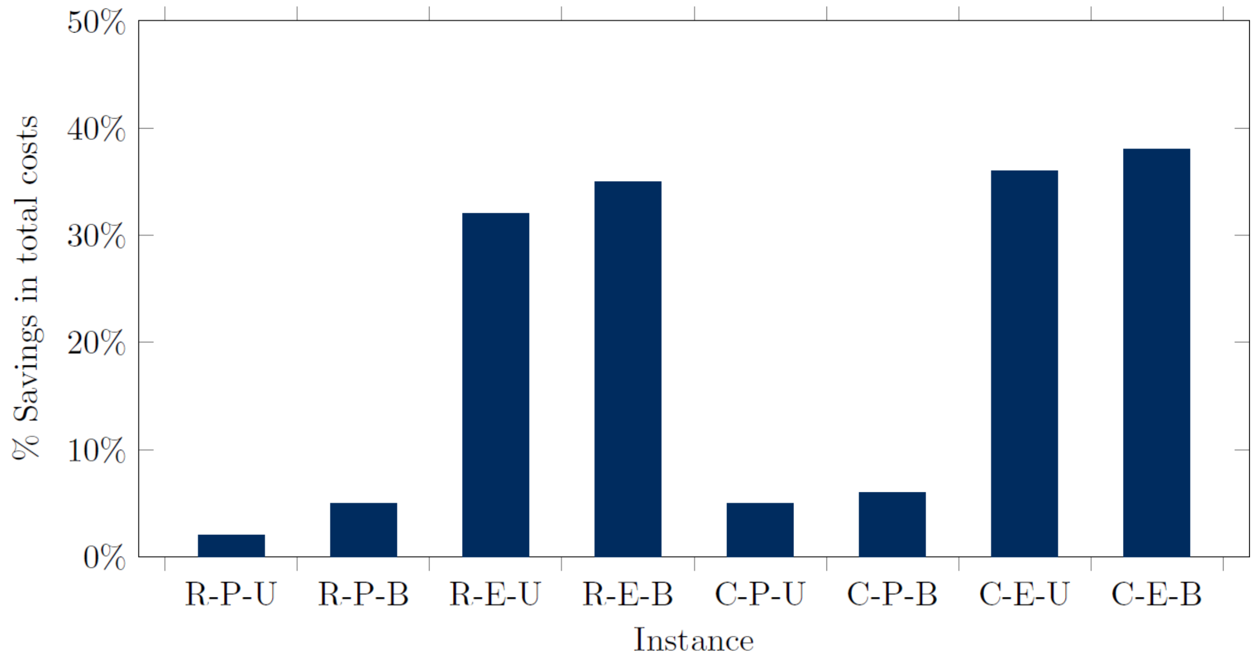
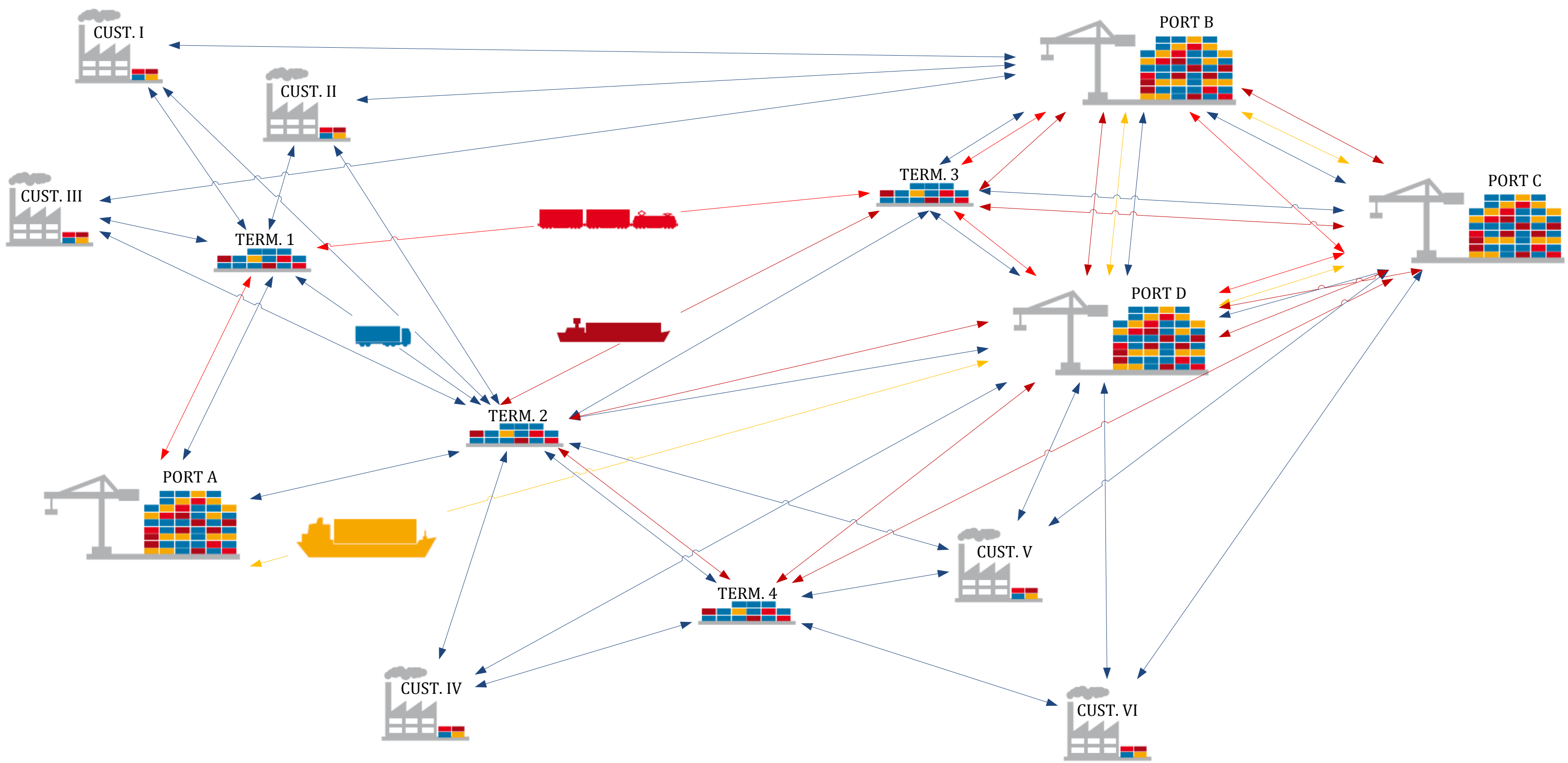


Table 1: Percentage difference with the benchmark in normal drayage-cost setup

Instance	R-P-U	R-P-B	R-E-U	R-E-B	C-P-U	C-P-B	C-E-U	C-E-B
Long-haulCosts	-10%	-14%	-63%	-65%	-14%	-13%	-63%	-65%
DrayageCosts	17%	18%	33%	32%	16%	12%	21%	22%
Long-haulUtilization	4%	1%	-55%	-55%	5%	0%	-56%	-55%
Pre-haulageClosest	-21%	-27%	-82%	-81%	-37%	-35%	-81%	-82%

ANTICIPATORY SCHEDULING IN SYNCHROMODALITY

FOUR PERSPECTIVES FOR A MULTI-MODAL TRANSPORT NETWORK



Source of artwork: European Container Terminals (ECT) – The future of freight transport (2011).

RAISING AWARENESS THROUGH SERIOUS GAMES

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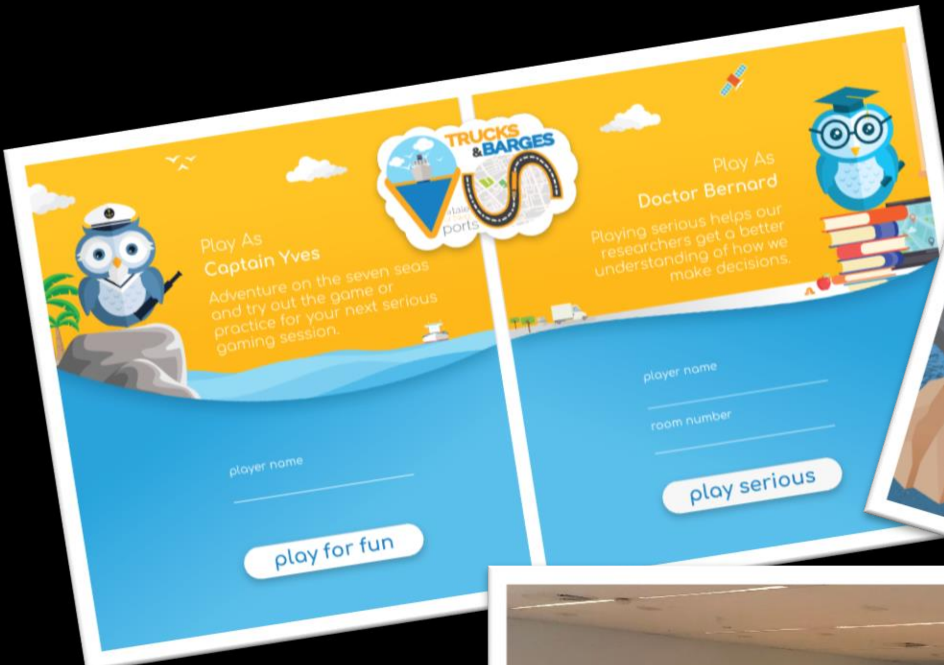

WHAT TO REMEMBER

We study four different perspectives on scheduling freight in synchromodal transport, and ***propose anticipatory methods to take advantage of the flexibility in synchromodality***.

- ***Anticipating on future scheduling decisions*** in synchromodal transport ***pays off the most with pre-announced freights that have long-time windows***, and the least with urgent freights and balanced networks.

- ***Integrating anticipatory decisions*** of drayage and long-haul transport improves the performance of the network as a whole, but ***might sacrifice the performance of one of the processes***.

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THANKS FOR YOUR ATTENTION!