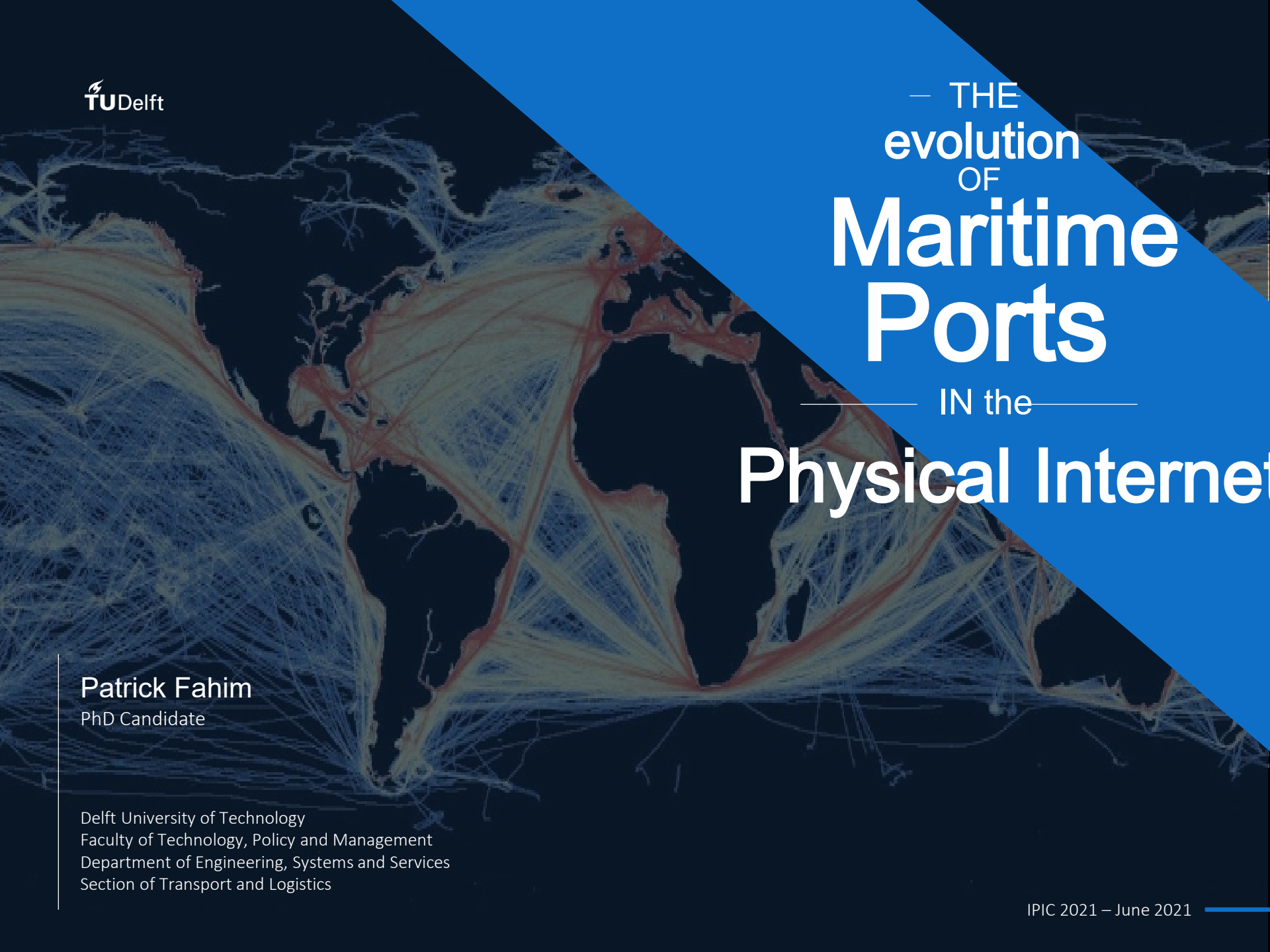

THE evolution OF Maritime Ports IN the Physical Internet

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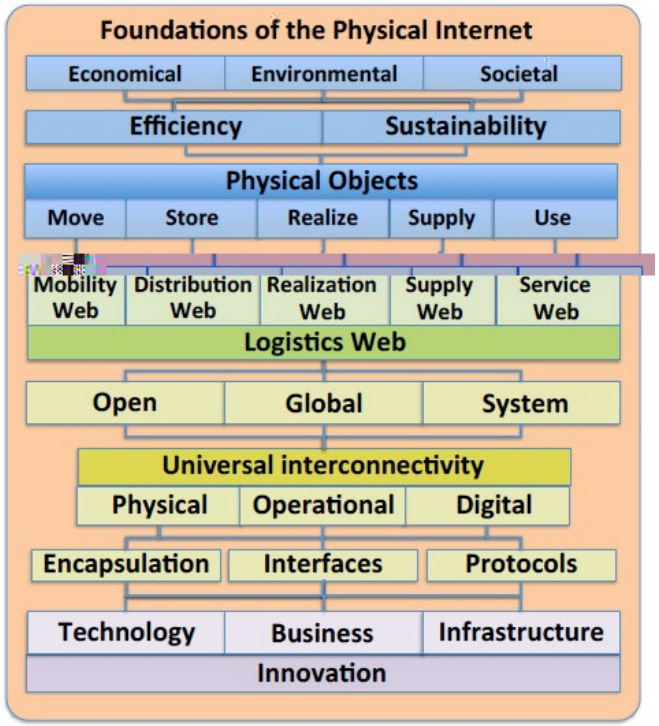
Physical Internet (PI) & PORTS



Montreuil, B., Meller, R.D., & Ballot, E. (2013). Physical internet foundations. In: Service Orientation in Holonic and Multi Agent Manufacturing and Robotics. Springer, Berlin, Heidelberg, pp. 151–166.

Main RQ:

How can maritime ports effectively anticipate on the expected developments towards the PI?

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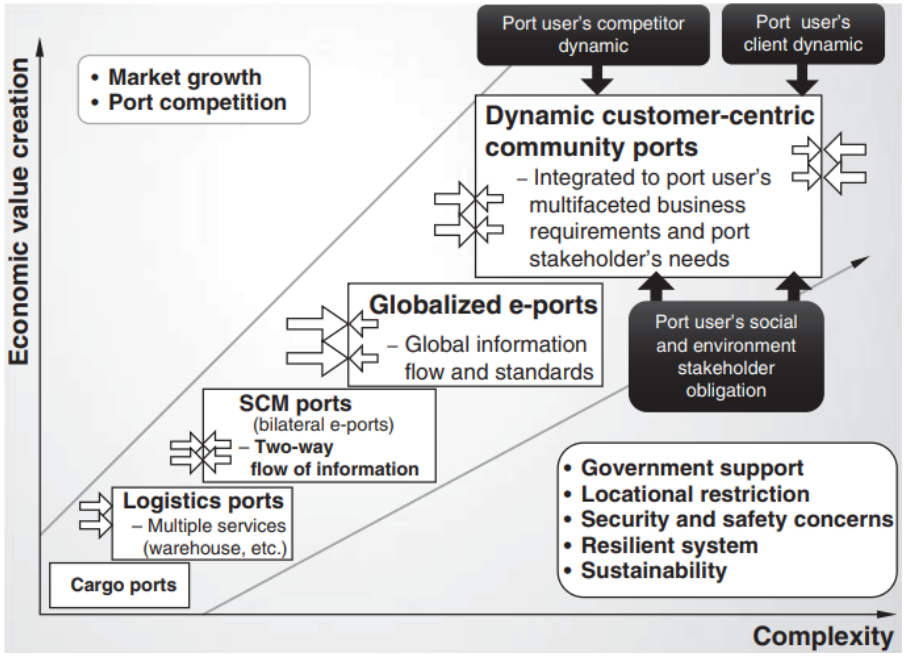
Port evolution



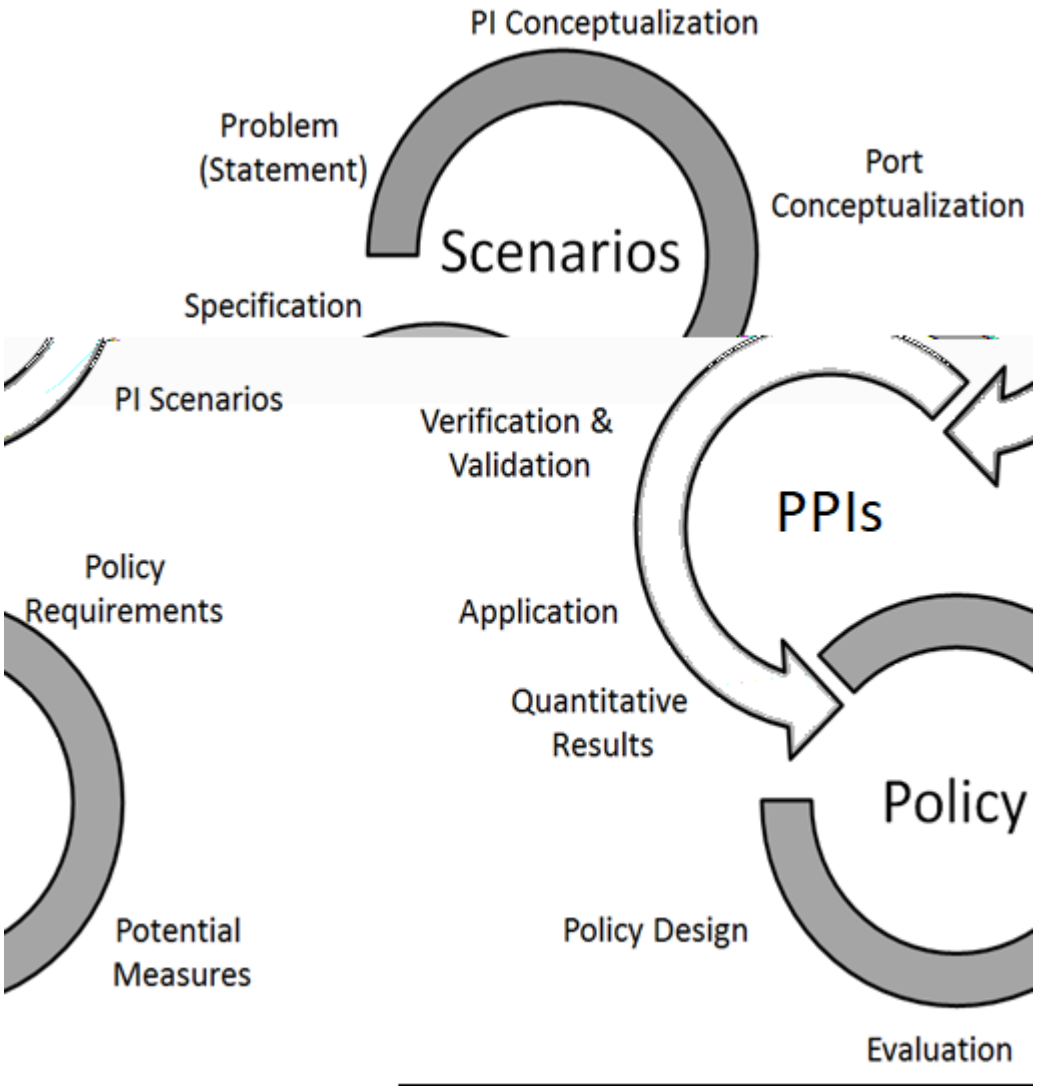
Lee, P. T. W., & Lam, J. S. L. (2016). Developing the fifth generation ports model. In *Dynamic shipping and port development in the globalized economy* (pp. 186-210). Palgrave Macmillan, London.

Research Questions & Design Cycles

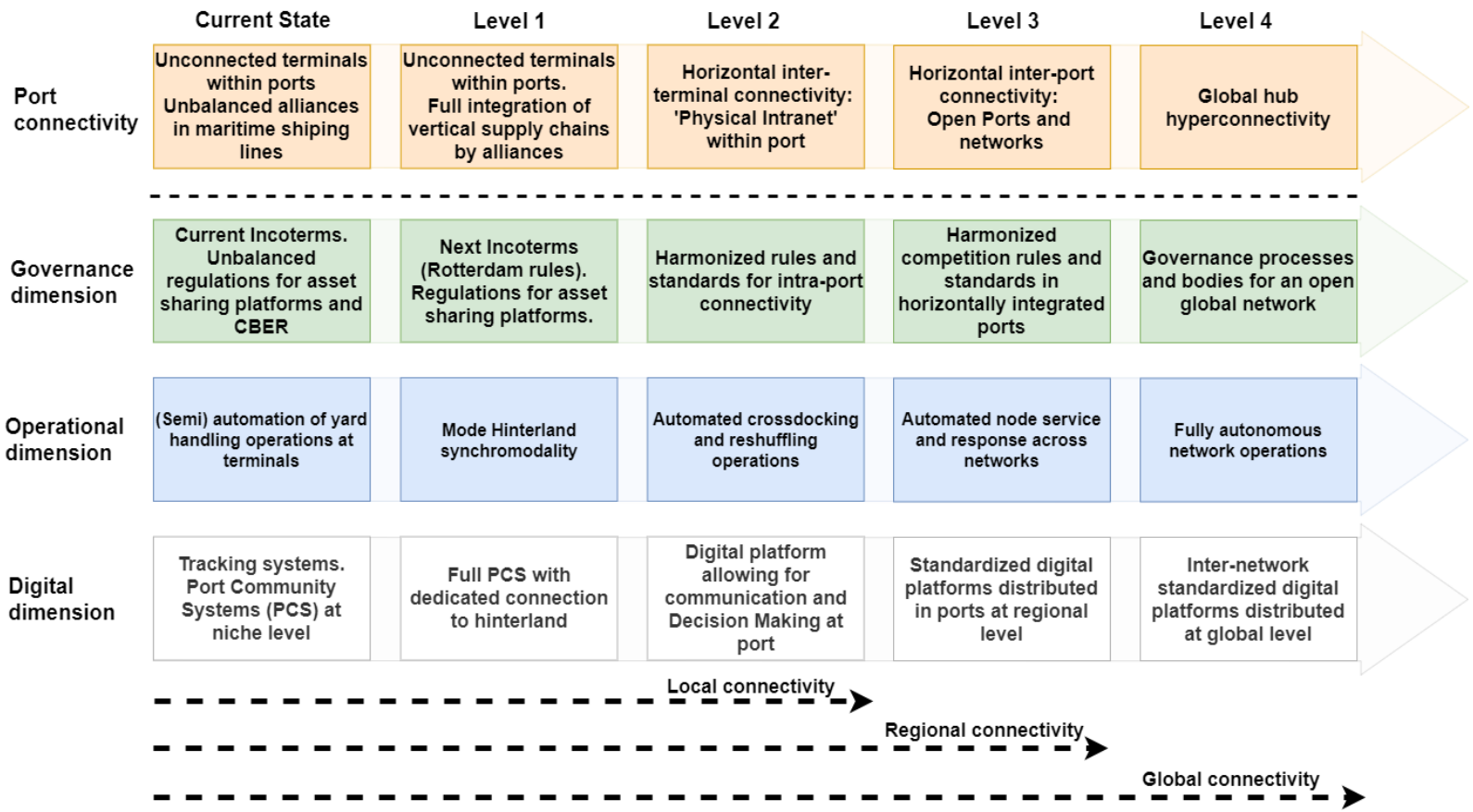
RQ1:
What are the scenarios for the development of ports towards the PI?

RQ2:
How will port users in the PI evaluate port performance and select the most suitable port?

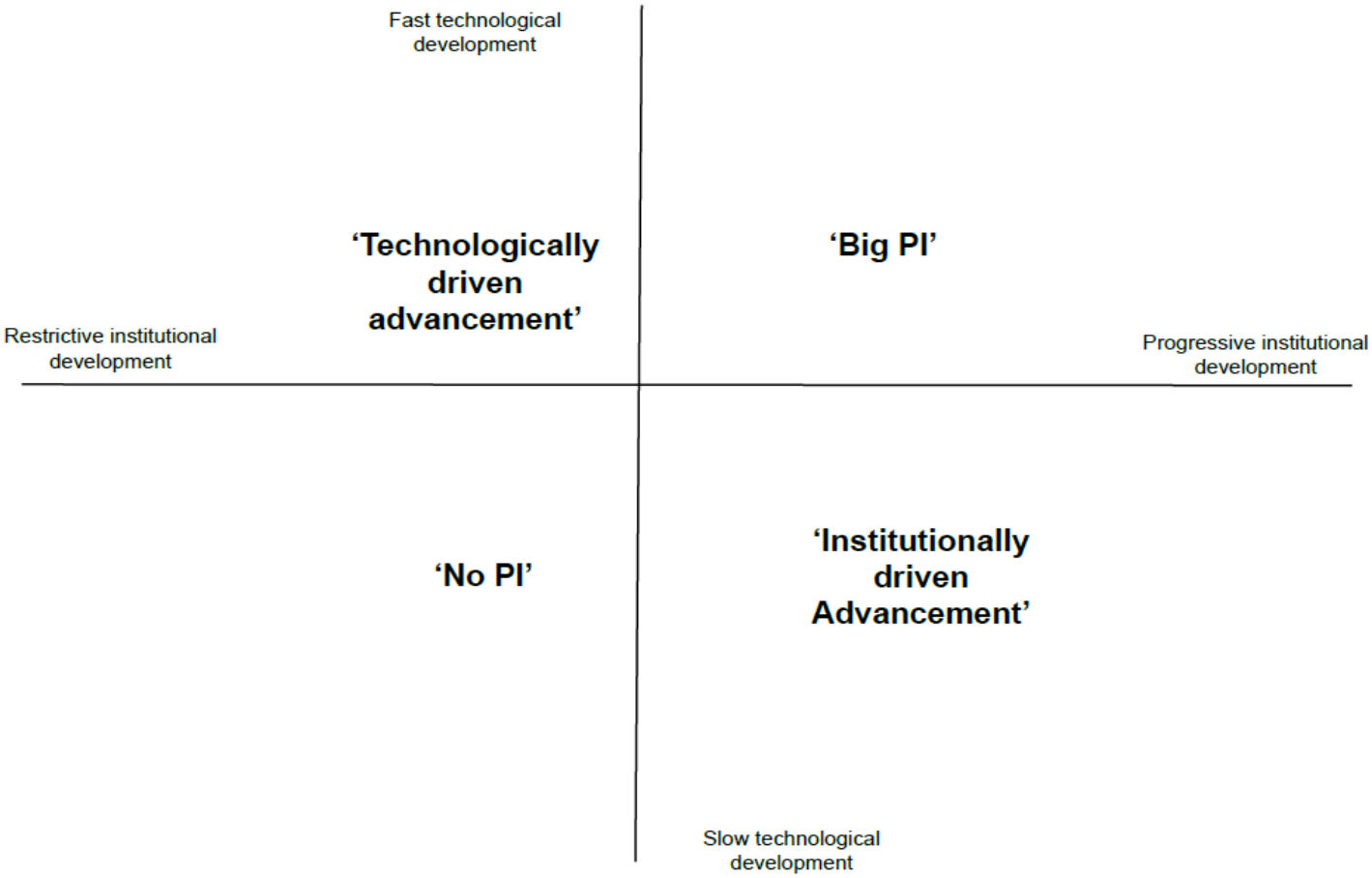
RQ3:
Which policy recommendations can be made to ports?



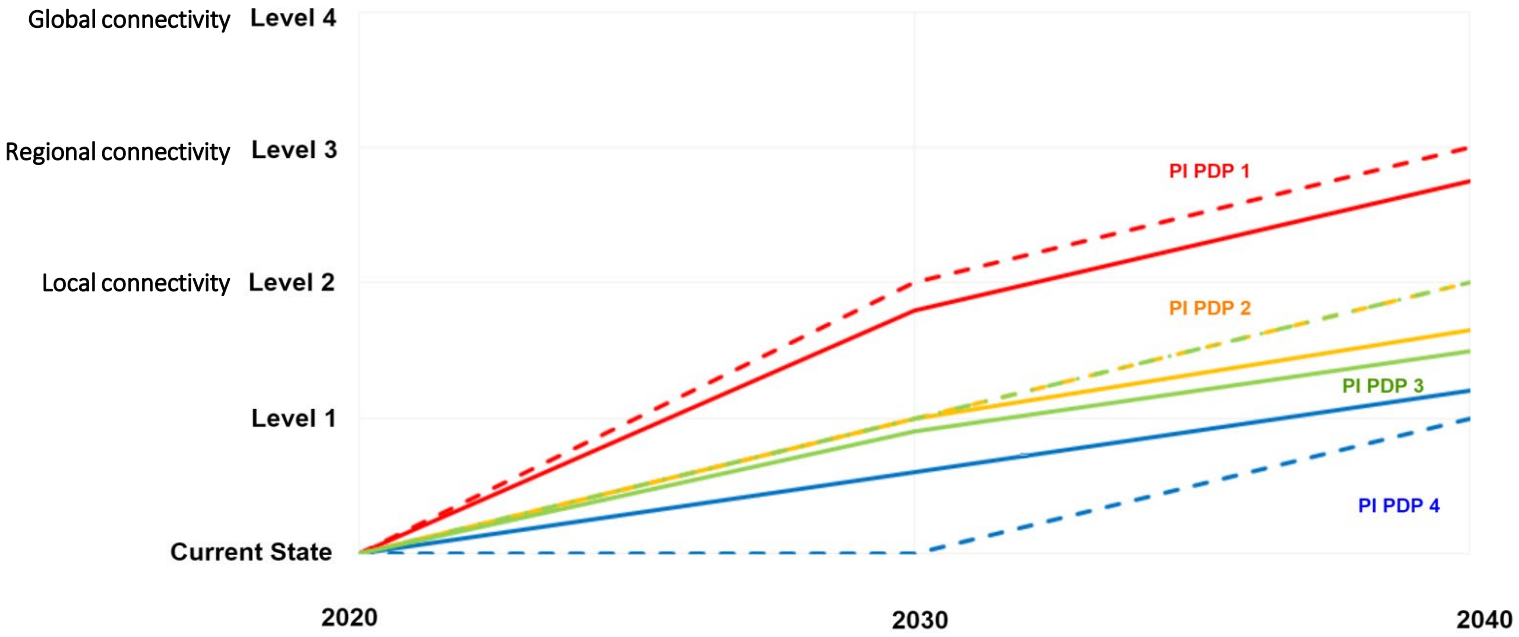
PI Port Framework



Scenario development (RQ1)



PI Port Development Paths (PI PD



Continuous lines = Mean
Dashed lines = Median

- Online Delphi survey among port experts and the PI community members (ALICE)
- Global connectivity will not be reached by 2040!
- "Worst" scenario, level 1 is not surpassed

Port Performance Indicators (RQ2)

PPIs of PI Ports	Description
Port Operations	**Effectiveness of the port operations**, including the speed, reliability, flexibility, responsiveness, and quality of operations.
Costs	**Costs of port operations for users** (port duties, terminal handling charges, cost of services).
Digital Connectivity	Hardware (e.g. sensors) and software (IT systems) to help port users **connect to the port and other services allowing seamless digital integration** into the supply chains.
Physical Network Connectivity	**Physical connectivity of the port** to the maritime side and hinterland from a network perspective.

Weights?

→ Determined by using Multi-criteria Decision-analysis (MCDA) / Best-Worst Method (BWM)

Importance of PPIs in scenarios

KPI \ Scenario	Big PI	Institutionally driven	Technologically driven	No PI
Port Operations	0,20	0,24	0,26	0,30
Costs	0,23	0,25	0,27	0,36
Digital connectivity	0,33	0,24	0,24	0,13
Physical network connectivity	0,24	0,27	0,23	0,21
	1	1	1	1

Overall:

- (Digital) Connectivity becomes more important towards the PI
- Operations and Costs become less important towards the PI
- Tech and Institutionally driven, balanced importances

Policy Directions (RQ3)

Policy direction	Description
Transport Infrastructure	**Invest in port infrastructure** to improve its accessibility and enlarge its capacity.
(PI) Standardisation	Contribute to the advancement of administrative, nautical, legal, digital, and functional standardisation.
Advanced Terminal Areas	Develop (PI) container reshuffling of and logistics value added services areas in the port.
ICT Hardware	Invest in the installation and implementation of sensors and wireless communication technologies in the port.
Information systems and information exchange platforms (IS&IEP)	Develop accessible and interoperable information systems and information exchange platforms for the port community for seamless supply chain integration. Improve the smart functionalities of these systems.
Sustainability Management	Monitor and control safety and security, air and water quality, and other nuisances. Comply with environmental and work condition regulations, and traffic measures.

effectiveness of Policy Directions

Policy \ Scenario	Big PI	Institutionally driven advancement	Technologically driven advancement	No PI
Transport Infrastructure	0,15	0,15	0,13	0,23
(PI) Standardization	0,21	0,20	0,23	0,18
Advanced Terminal Areas	0,14	0,15	0,13	0,16
ICT Hardware	0,17	0,18	0,17	0,15
Information systems and Information exchange platforms	0,24	0,24	0,25	0,18
Sustainability Management	0,09	0,08	0,09	0,10
	1	1	1	1

Overall:

- Sustainability Management least effective
- Advanced terminal areas and ICT hardware are similarly effective

Big PI, Institutionally and Tech driven:

- IS&IEP most effective policy, followed by (PI) Standardization, while Transport Infra, ATA and ICT-H similarly effective

No PI: Transport Infrastructure effective, while IS&IEP and Standards less effective

Conclusions

- Fully functioning global PI not to be expected by 2040, even in the “best” scenario

- Connectivity PPIs become more important towards the PI, while Costs and Operations become less important

- In the more developed scenarios towards the PI, ports should focus on:
  - the development of Information Systems and Information Exchange Platforms
  - the development of global (PI) standards (protocols and interfaces)

Future research

- Develop dynamic policy roadmap with concrete action plan
- Develop a (global) network design to determine the freight flows in the different scenarios
- Port Community Systems in the PI?