

Innovation and technology in multi-modal supply chains

Lóri Tavasszy

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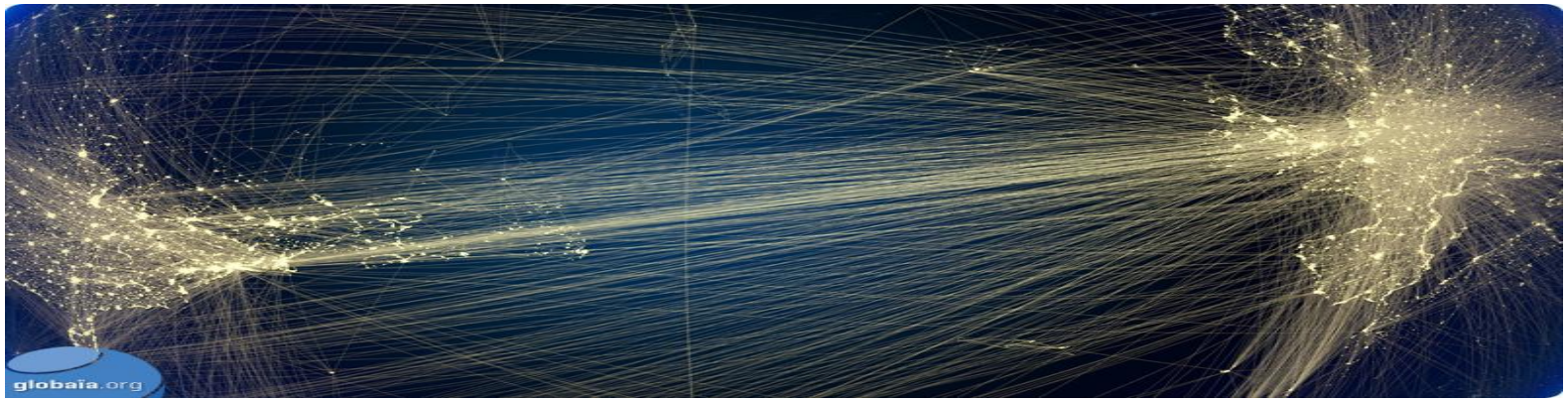
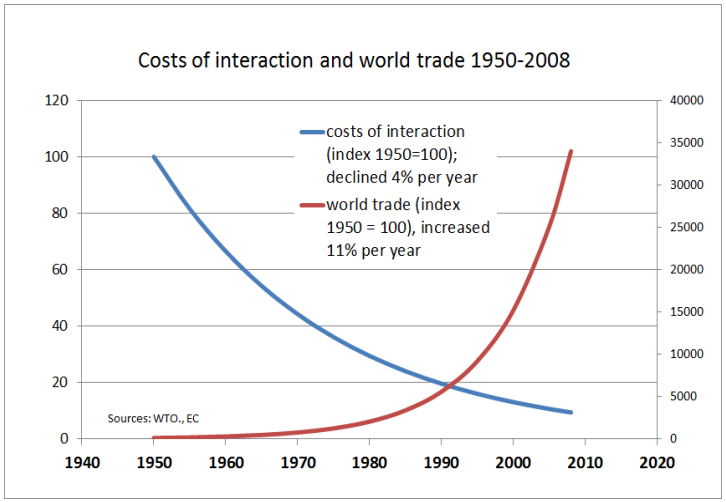
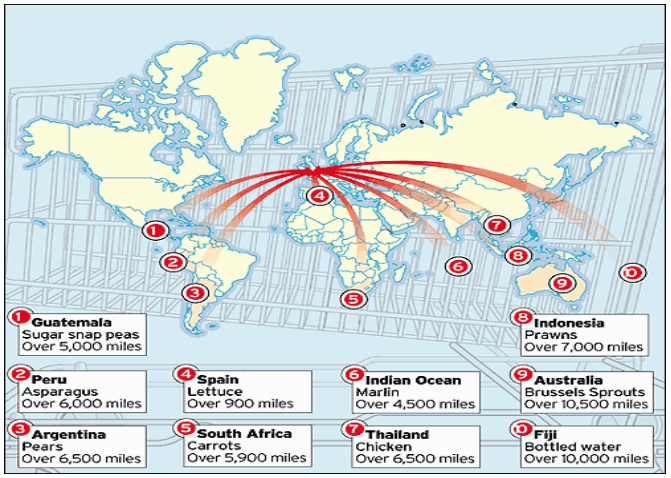


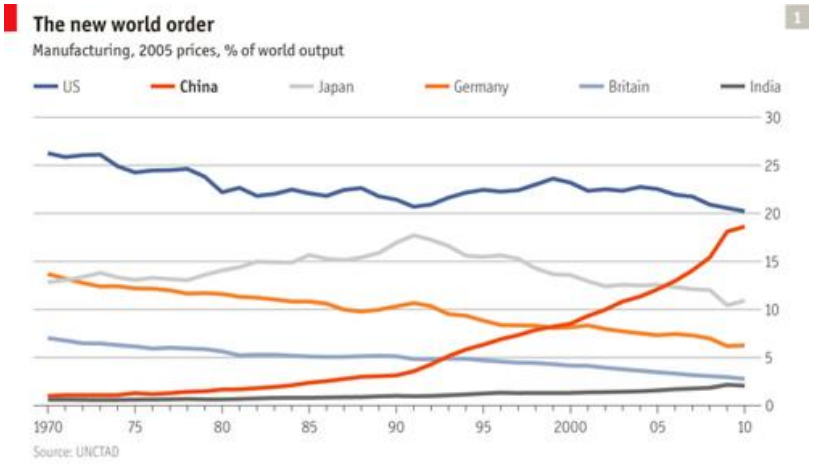
Contents

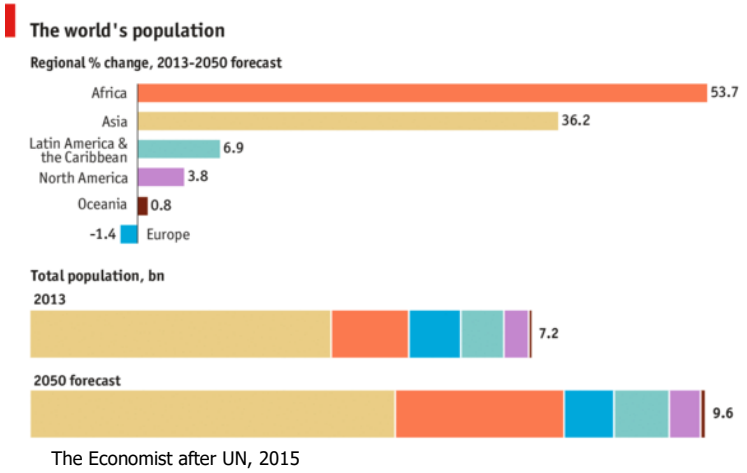
- Innovations
  - Mass-individualized logistics services
  - Network integration and synchronisation
  - Transport technology
  - Digitalisation in logistics planning and operations
- Implications for multimodal supply chains
  - Multimodality provides opportunities for network integration
  - Also, significant effect on overall network resilience
  - However, preconditions of ICT systems and transport technology to be met
- Balancing efficiency and resilience – some thoughts

Context: global growth & diversity of trade



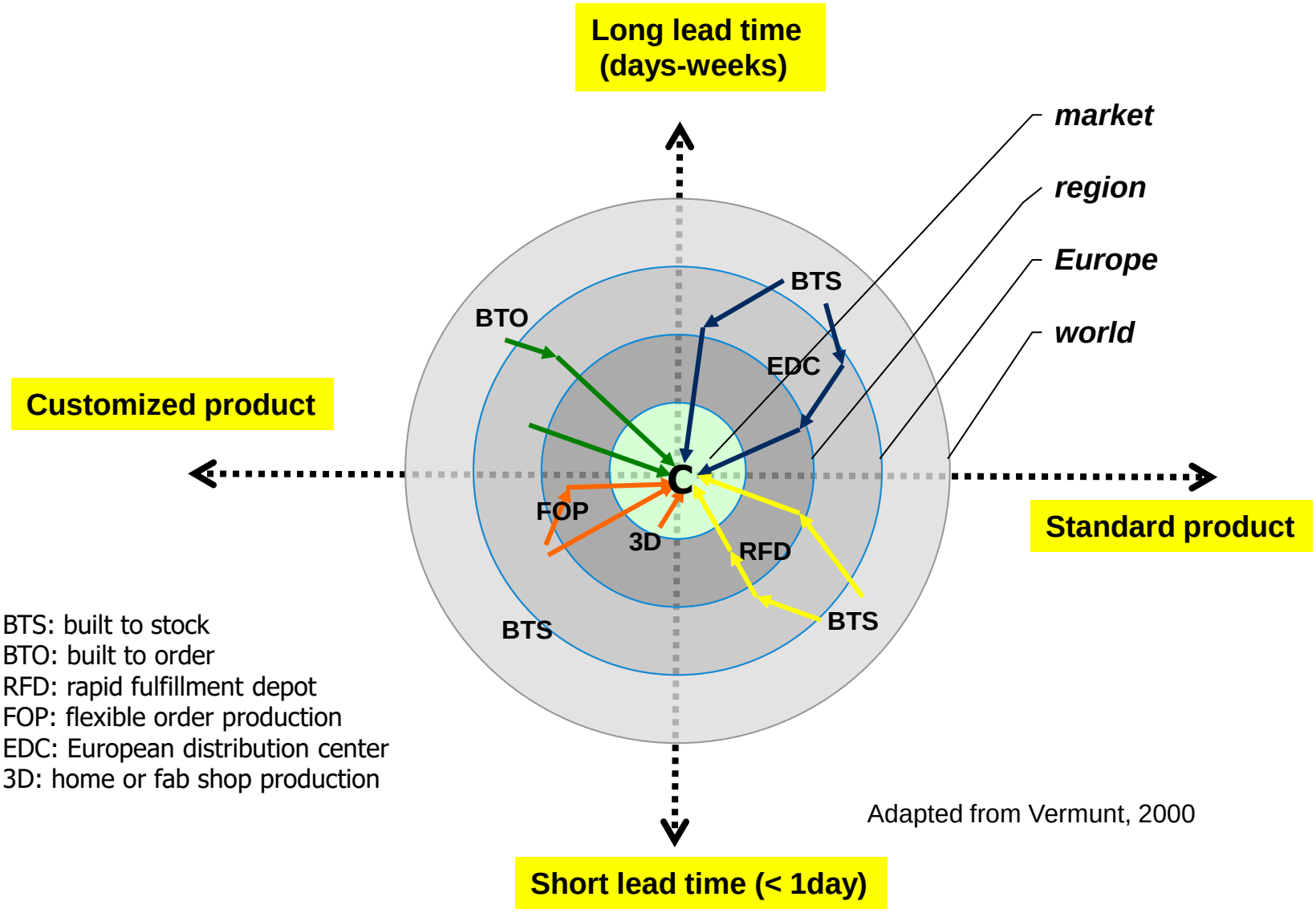






The Economist after UN, 2015

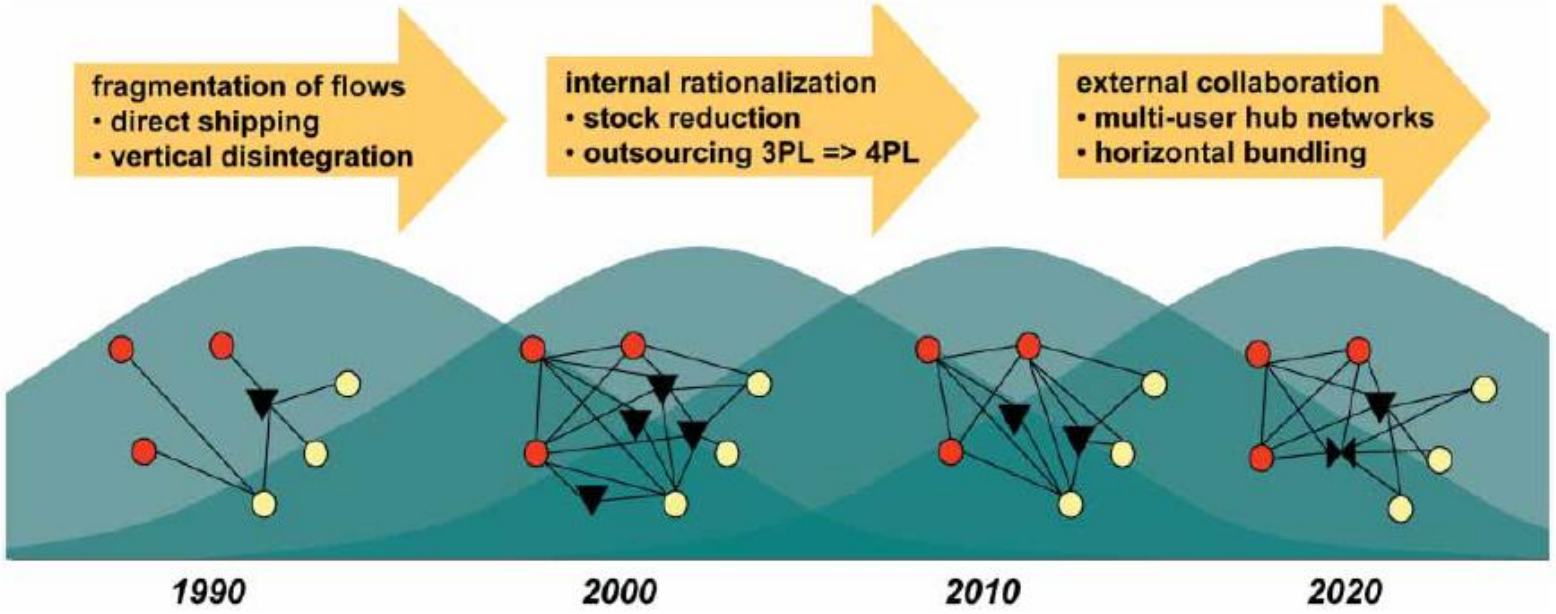
Mass-individualisation & global chains



BTS: built to stock
BTO: built to order
RFD: rapid fulfillment depot
FOP: flexible order production
EDC: European distribution center
3D: home or fab shop production

Adapted from Vermunt, 2000

Mass-individualization is enabled by collaboration

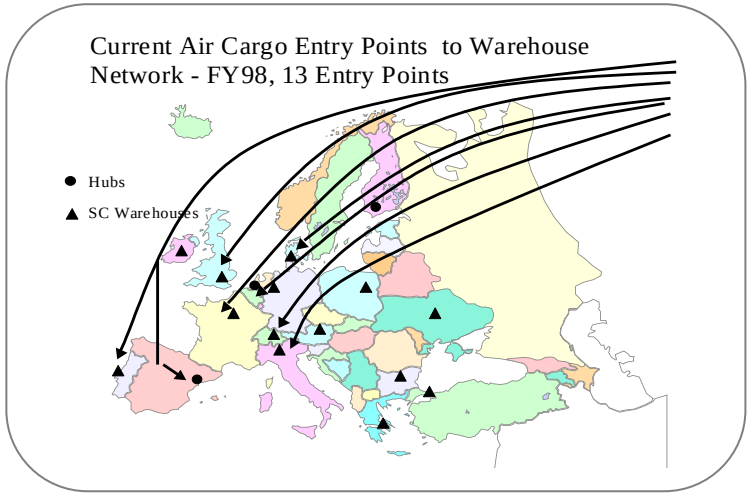


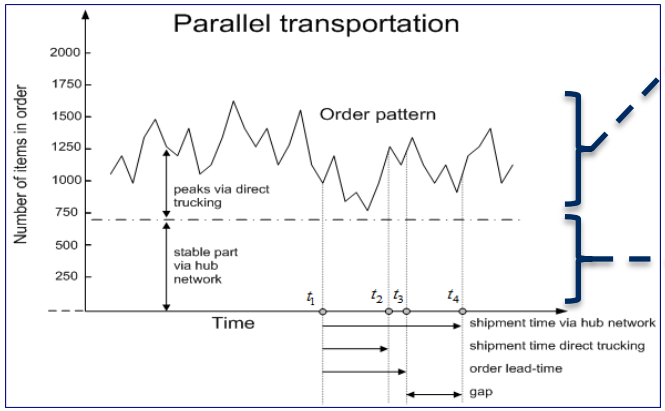
Tavasszy et al., 2012

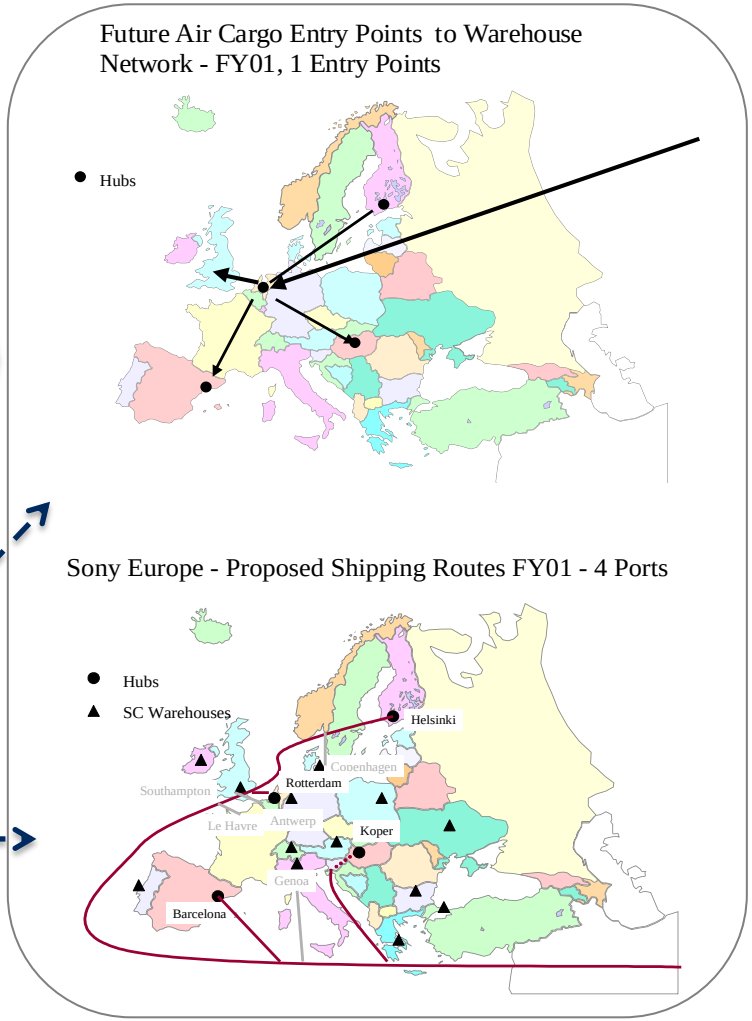
Hybrid supply networks

OLD

NEW

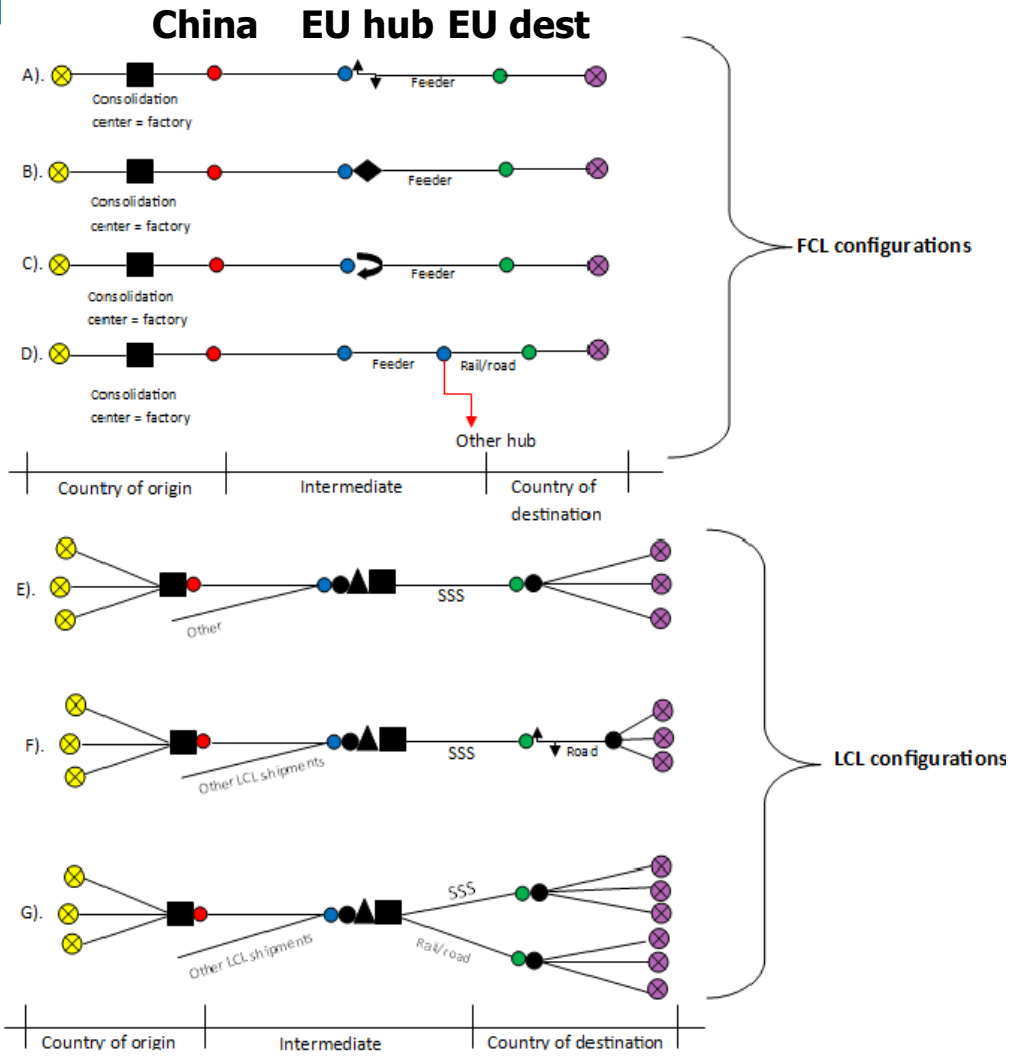


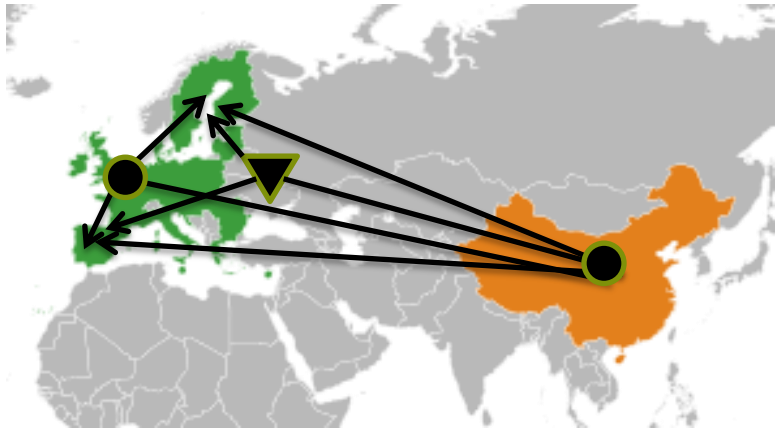




Source: Groothedde, 2005

Hybrid supply networks (2)



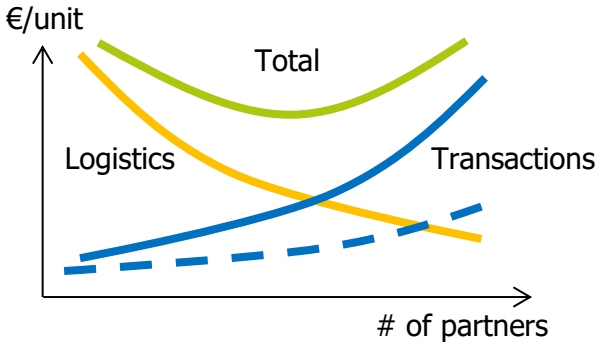


Legend:

- Consolidation/stuffing
- Warehousing
- Deconsolidation/stripping
- Transshipment/crossdocking (within terminal)
- Transshipment with stacking
- Transshipment with interterminal transport
- Port of departure
- Hub
- Port of arrival
- Supplier
- Customer

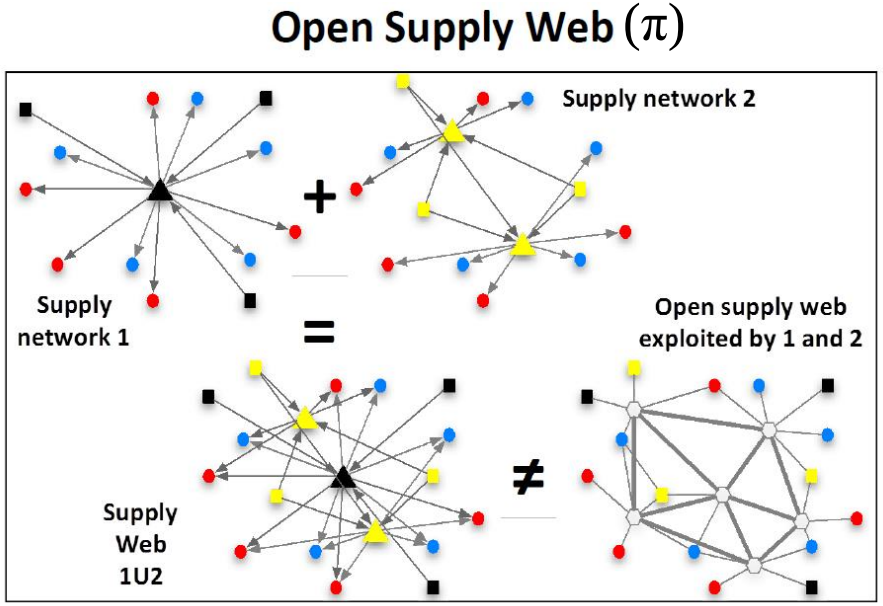
Bron: TNO / SeaconAZ project

Collaboration is enabled by decreasing transaction costs



Effect of ICT on logistics costs

- Number of links = n^2-n
- Optimal number of partners depends on balance of economies of scale and transaction costs
- ICT reduces transaction costs

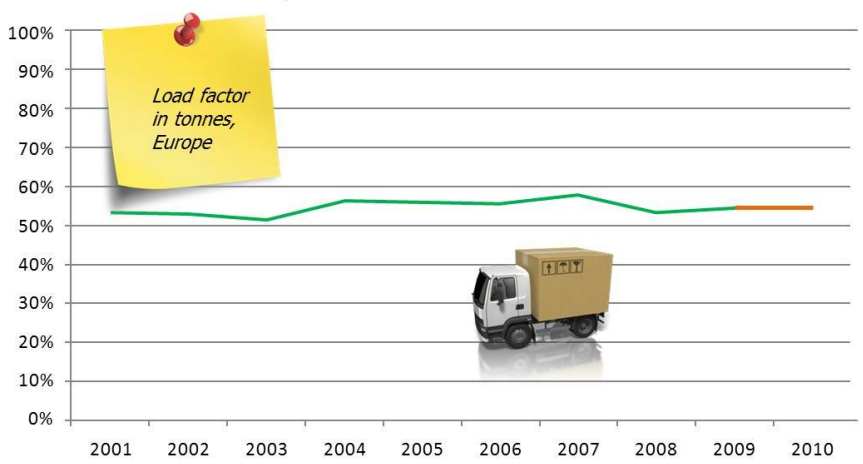


Source: Ballot E., O. Guodet & B. Montreuil (2011), Physical Internet enabled open hub network design for distributed networked operations, Proc. of SOHOMA 2011

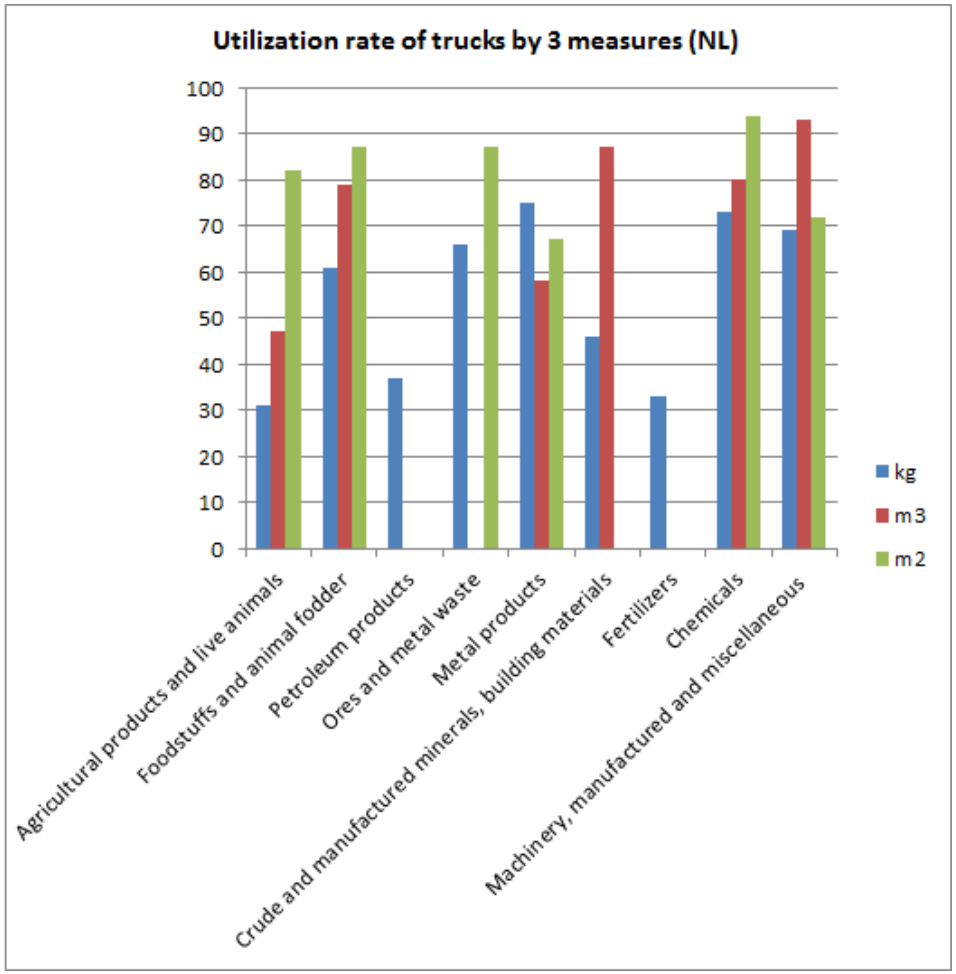
Efficiency increase potential

Are we at peak efficiency in road transport?

- When measured in weight: no (43%)
- In m^2 or m^3: very close…

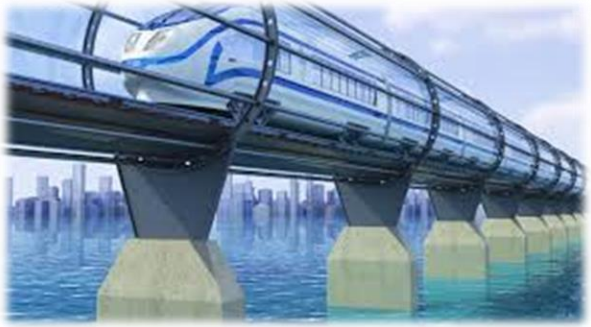


- *Consolidation opportunities across modes of transport will be important*



Source: Davydenko et al., 2015

Transport technology innovations



Transport technology: directions

- **Autonomy**
  - Trucks and platoons
  - Rail AGV
  - Waterborne
  - Drones
  - Warehousing

Strong reduction of transport costs promised
Many legal barriers
Interfacing with non-automated systems?
How to manage mixed regimes?
Can we exploit digitalization for resilience?

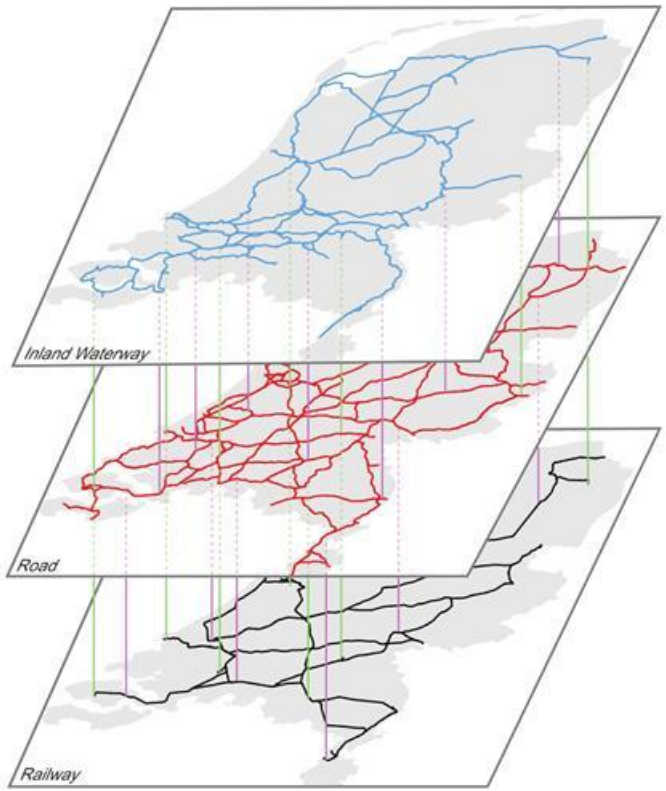
- **Integration**
  - Flexible chassis systems
  - Terminal technology
  - Foldable containers
  - Modularization

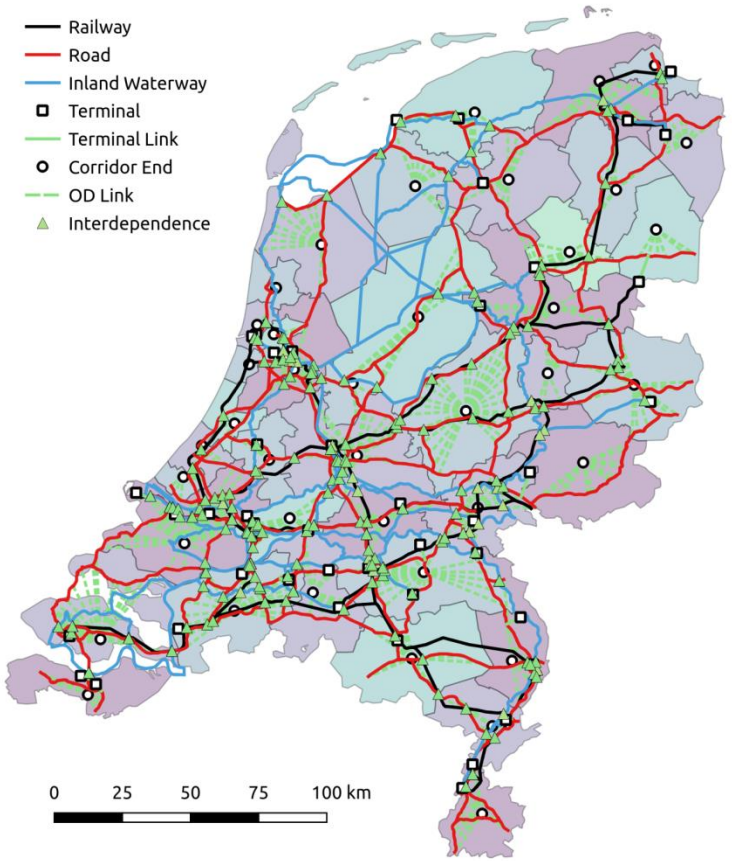
Reducing asset intensity of systems
Critical for functioning of intermodal systems
Transshipment still a major cost burden
Low feasibility under regular conditions
Disruption risk not part of business models

- **Propulsion**
  - Electrification
  - Space travel
  - Maglev
  - Sail ships

Major changes imminent but uncertain
Energy transition is leading change
Transition in transport system is vulnerable
Niche vs. mass solutions

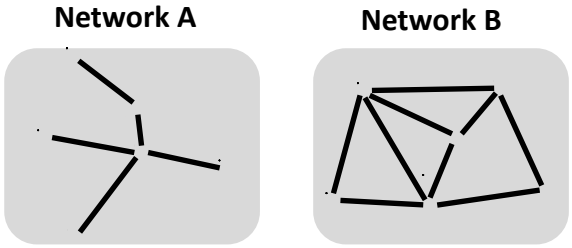
Integration: from multimodal to intermodal

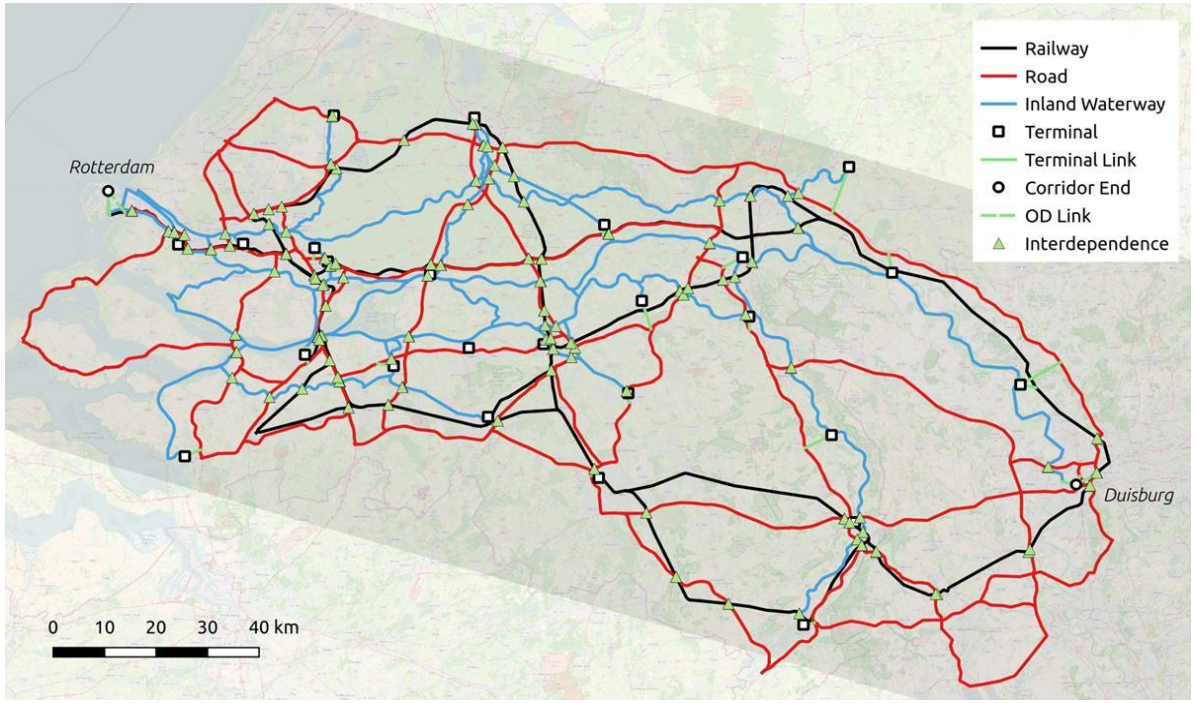




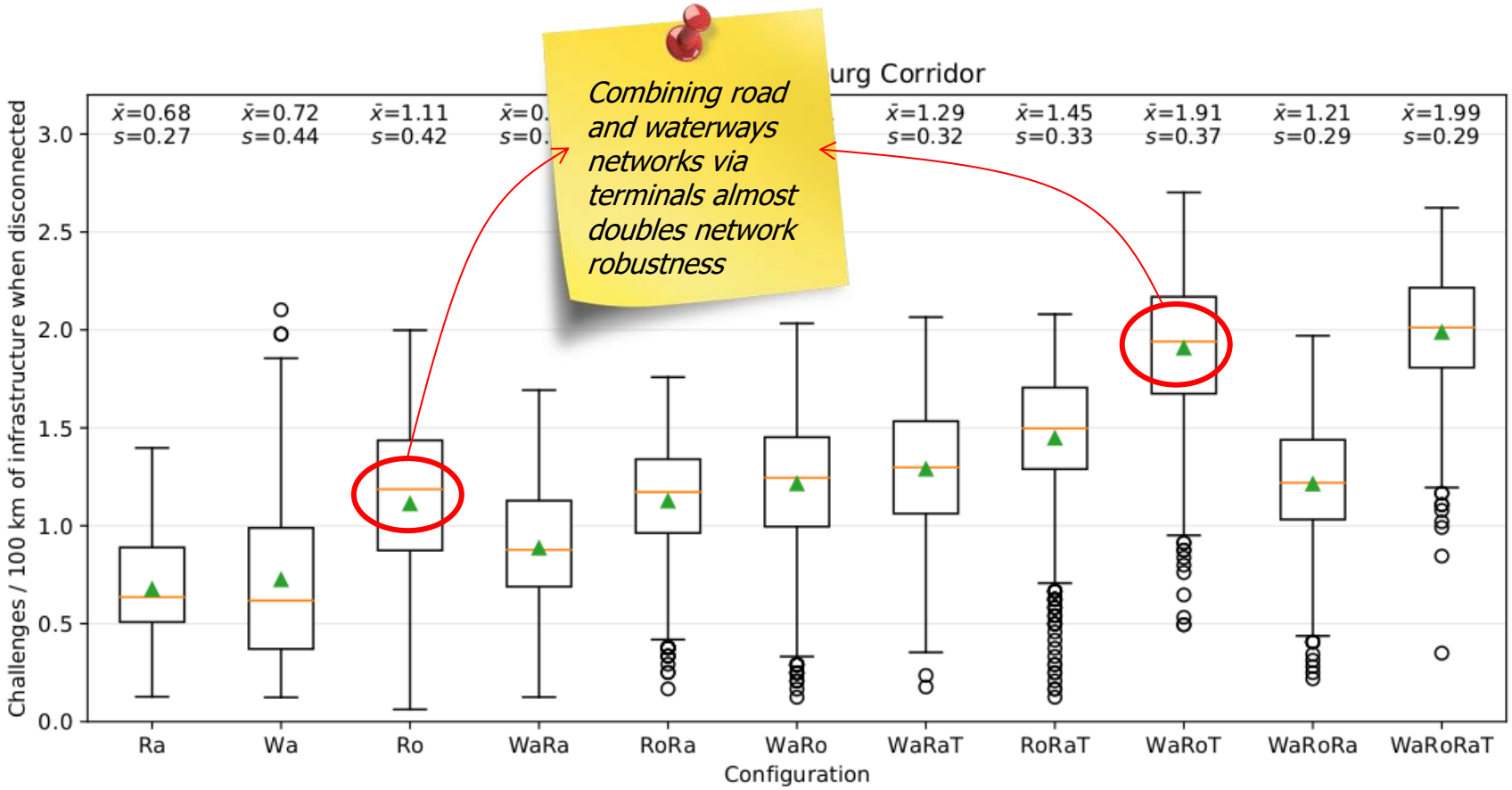
Intermodal networks & robustness

Robustness *is a measure of a system's ability to keep a certain functionality despite changes in the behaviour of its components or its environment .*
Here: measured in number of challenges before disconnected (Van Dam, 2017)



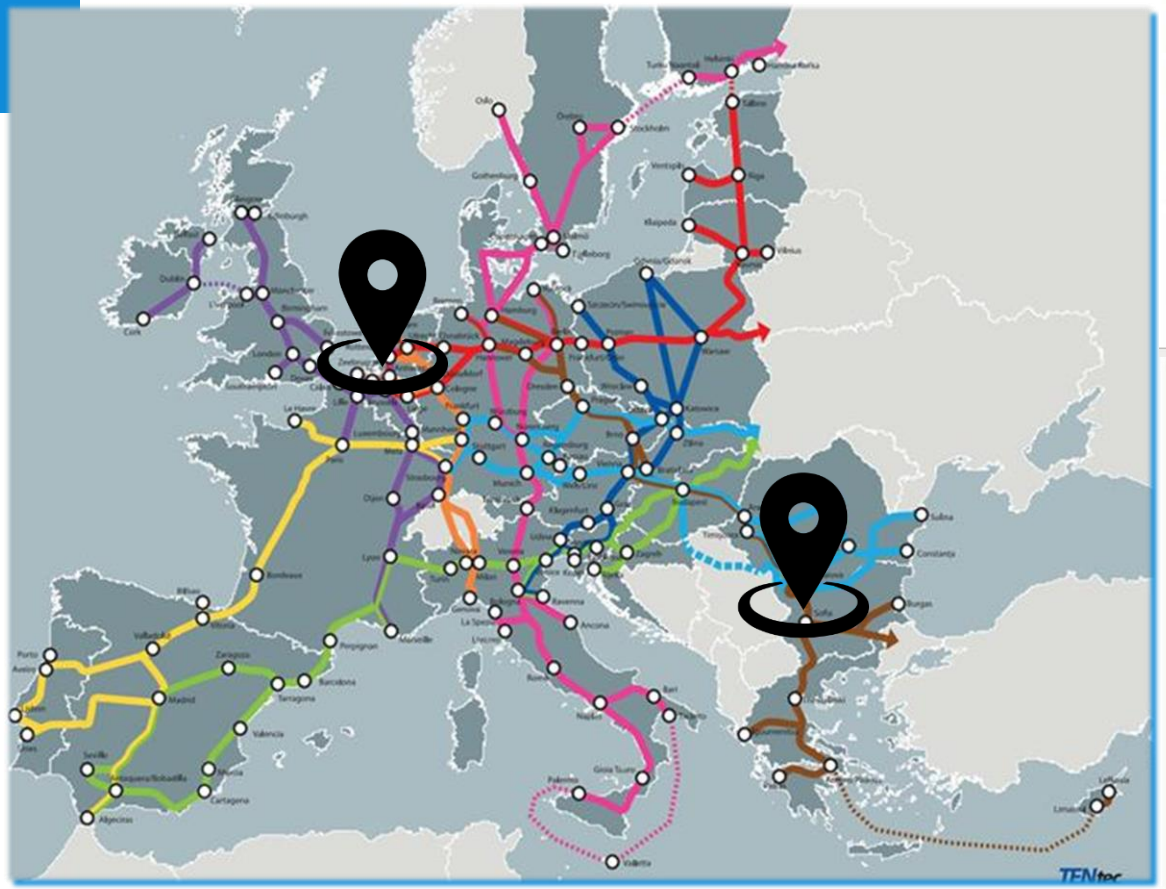


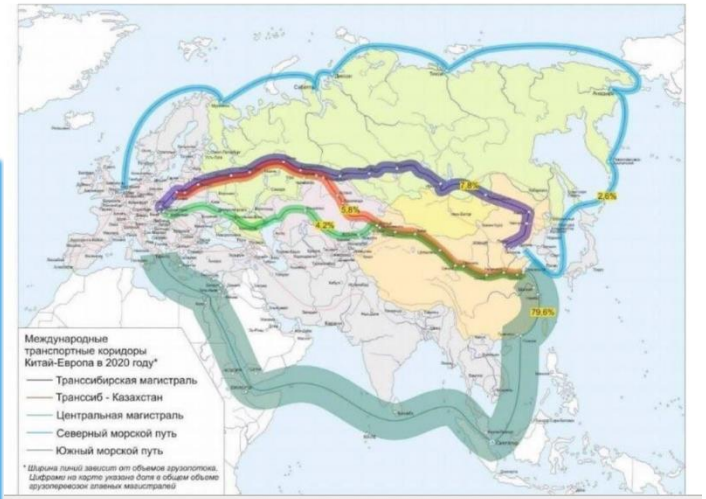
Result: hubs are key for network robustness



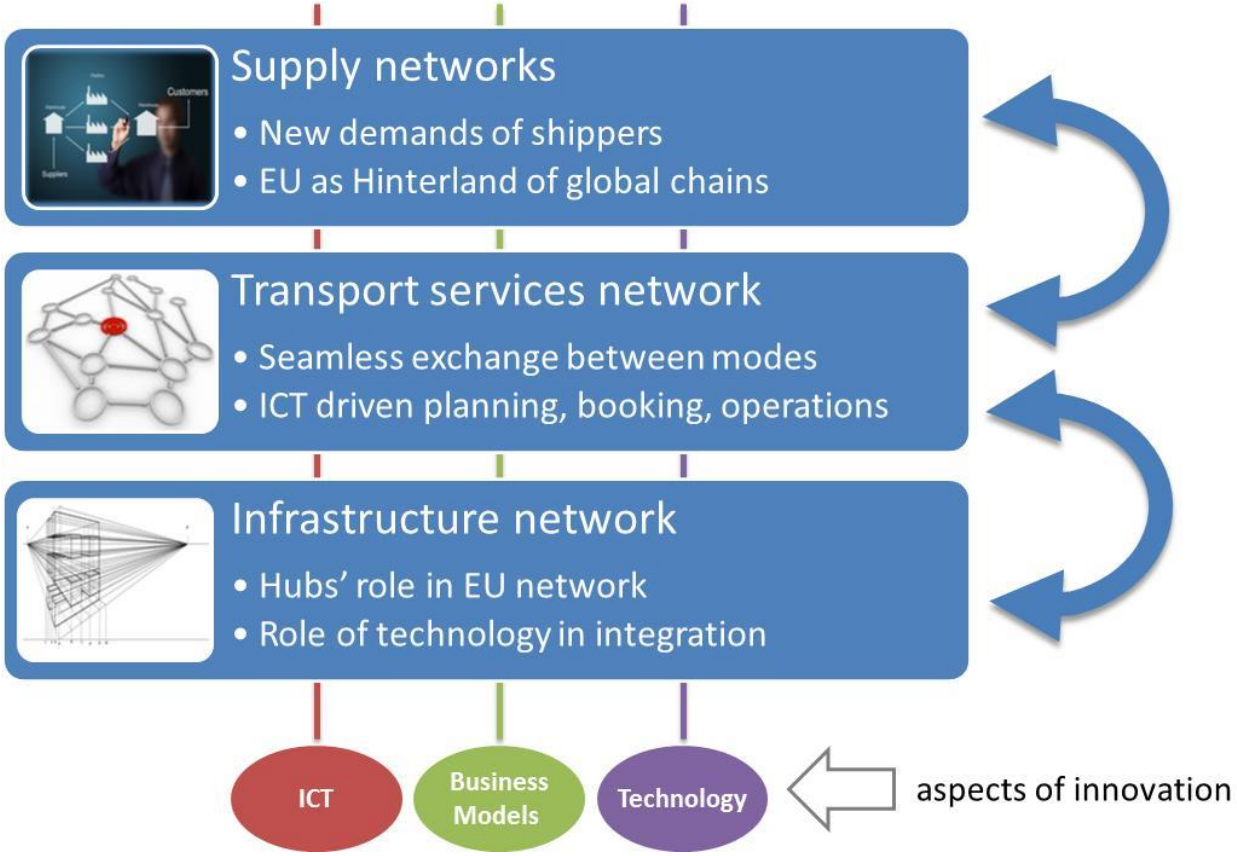
Ro = road; Ra = Rail; Wa = Waterways; T = Terminals

How to advance TEN-T from corridors to a real network?

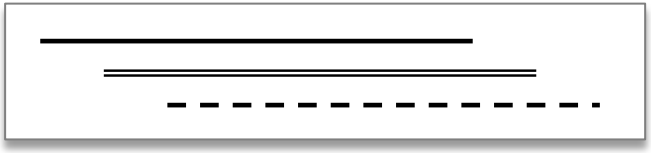


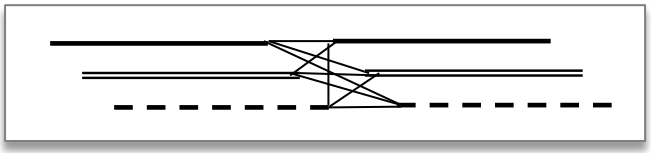


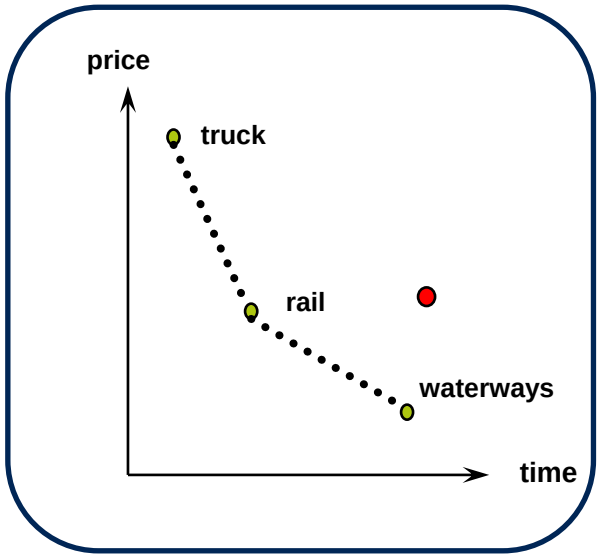
ALICE roadmap for hubs, corridors & synchromodality

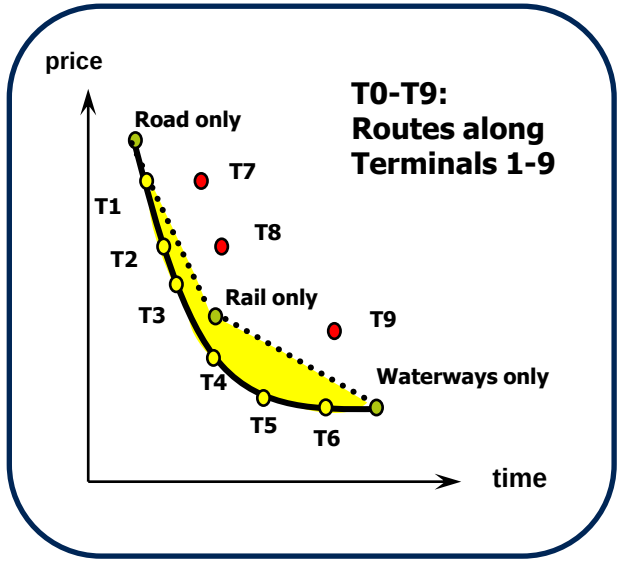


Benefits of synchromodality



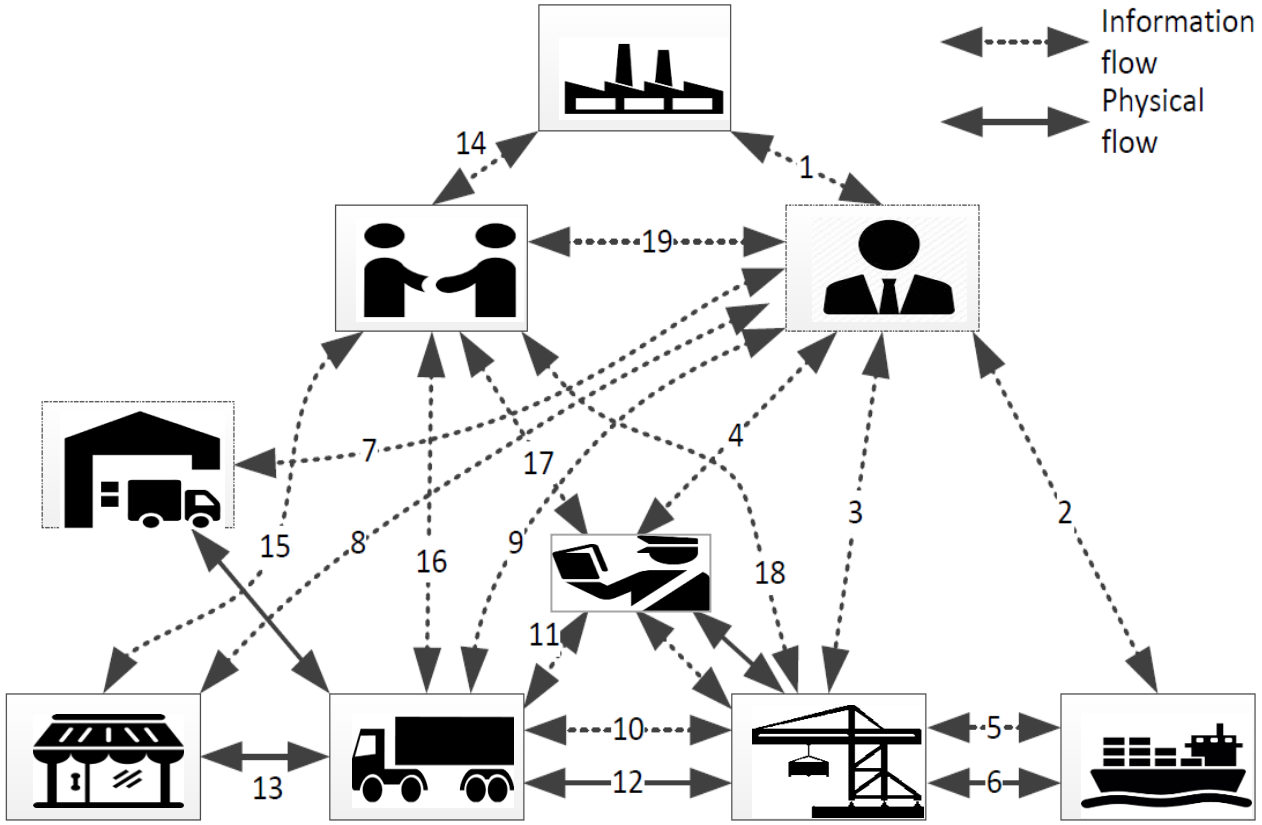






Synchromodality allows differentiation of services to customer classes, by using degrees of freedom in the (combined) deployment of transport modes. This carries opportunities for cost reduction and revenue increase.

Physical vs information flows

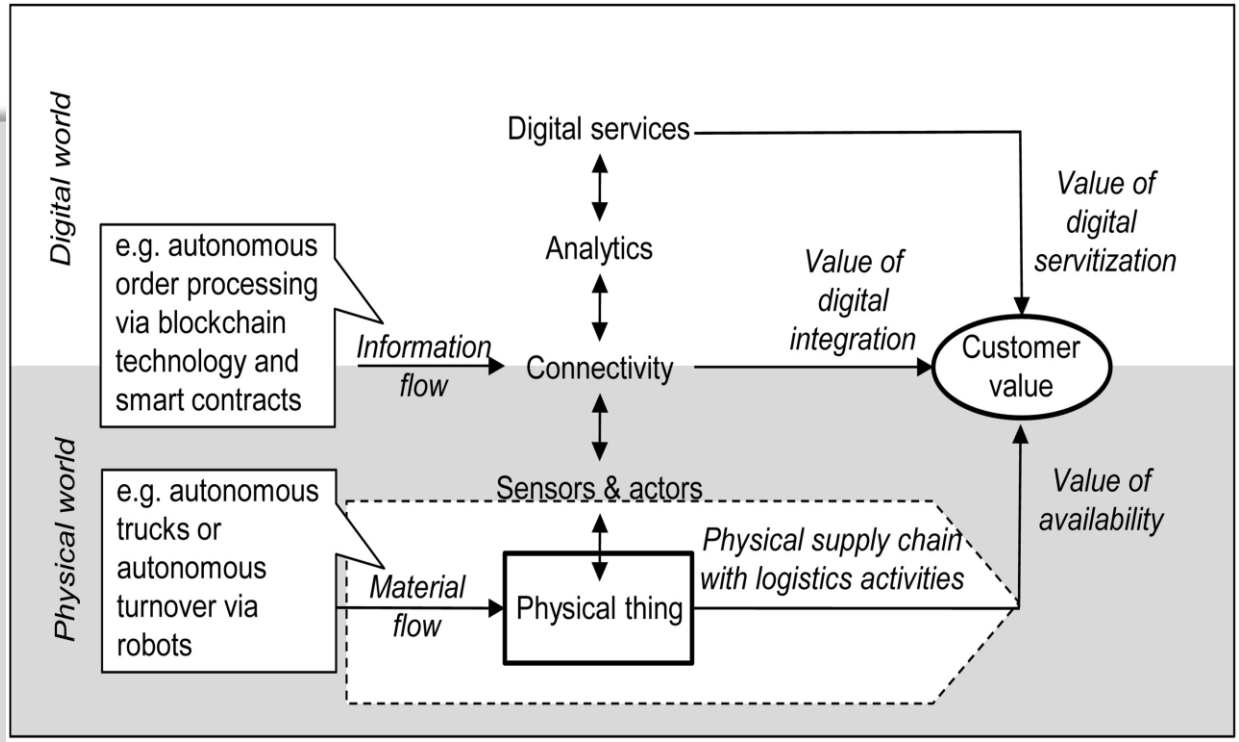


(after: MSc thesis Anton Delawari, TUD)

Promise of digitalization

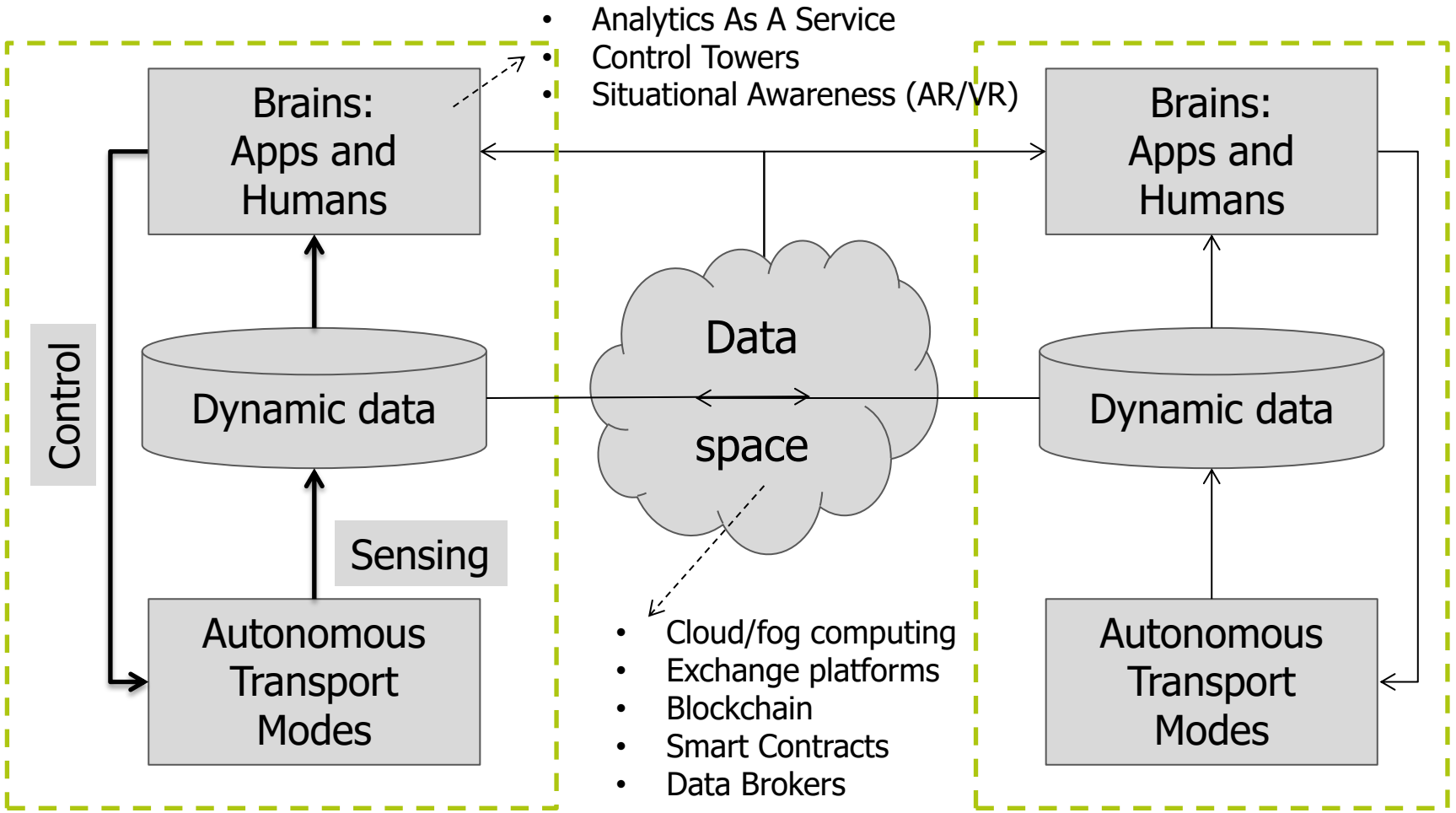
10 mini-revolutions…

1. Computing Power
2. Size of Computers
3. Automation
4. Ubiquity
5. Artificial Intelligence
6. Collaborative Computing
7. Digitalization of Admin
8. Data Availability
9. Data Governance
10. Distributed systems

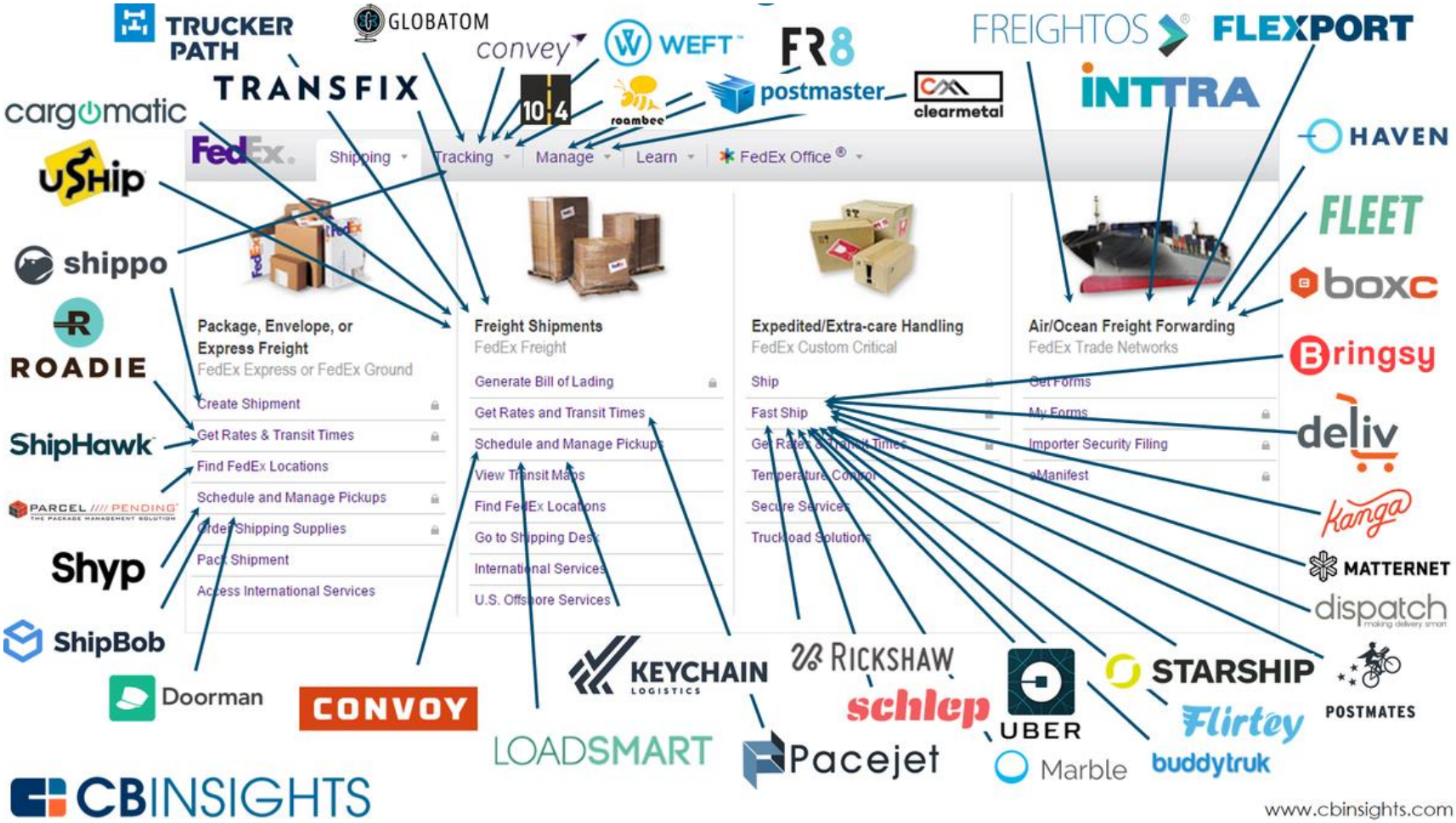


…how do these find application in multimodal transport?

Transport modes-in-the-loop



Forwarders' dis-intermediation headache



Social value of innovation

(bn USD, by 2025)	new business value	logistics cost reduction	emission and congestion
Data analytics	600	--	--
Control Towers	210	--	--
Trade Facilitation	170	600	-55
Crowdsourcing	310	800	180
Autonomous Transport	--	50	--
Shared Warehousing	--	500	70
Total	1290	1950	195

(WEF, 2016)

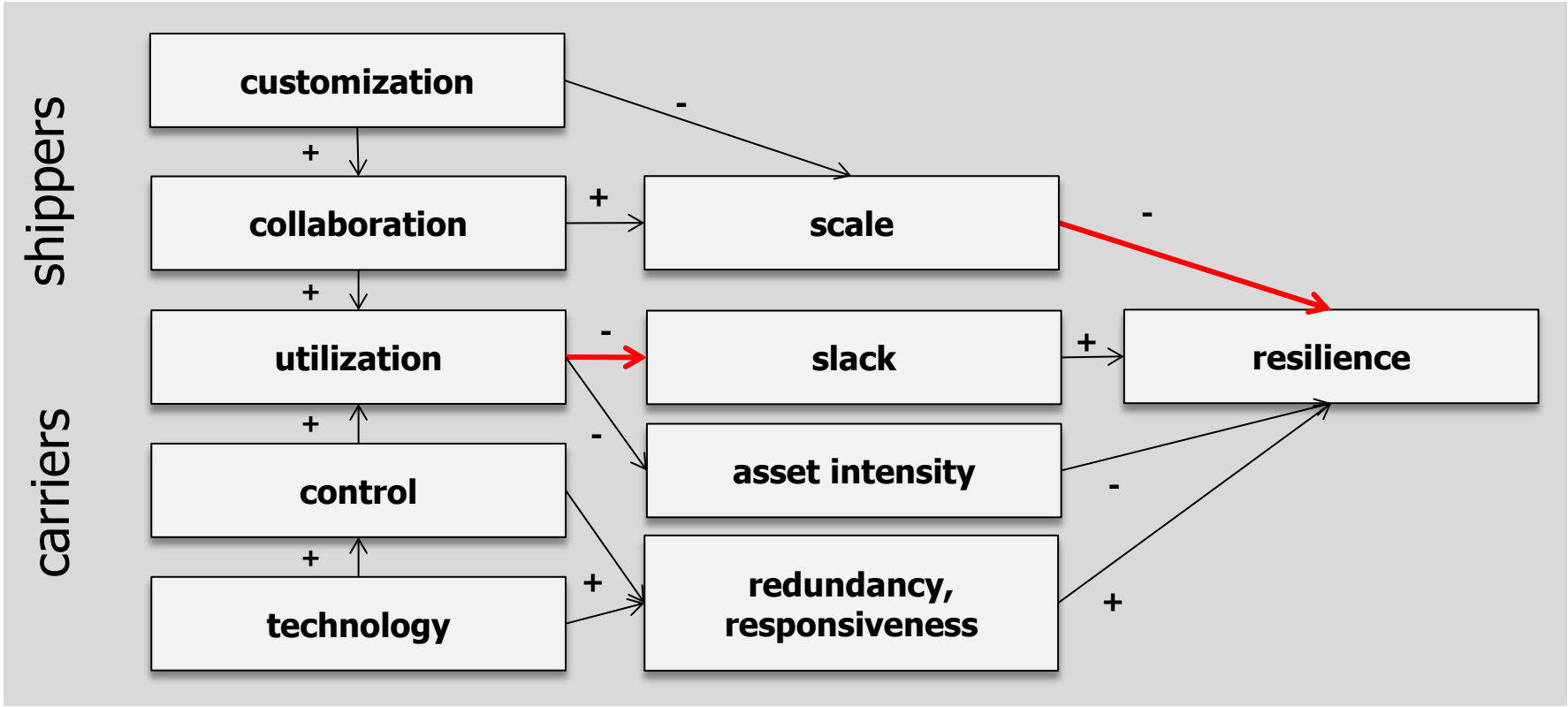
- Focus of impact: collaboration & control
- External cost reduction is limited
- Distributive effects?

PS Impact evaluation disclaimer

- Definition of innovations is often partial or ambiguous
- Propagation of innovations is unknown/uncertain
- Impact combined with redesign of business processes
- Innovations often deployed together in one big bang

Innovation impacts on resilience

- Critical links: higher utilization results in less slack in the system (higher failure probability) and higher scale (stronger failure impact).
- There are many links that could mitigate this risk, but balance is unclear



Conclusions

- Main service innovation: mass-individualised logistics services
- Supporting innovations involve
  - Network integration and synchronisation
  - Transport technologies
  - ICT applications

- Network integration:
  - Potential mostly across modes
  - Multimodal ➔ intermodal ➔ synchromodal
- Transport technologies
  - Integration challenge to achieve efficiency impact
  - Automation & propulsion may affect resilience
- ICT
  - Reduces interaction costs and allows operational control
  - Accelerator for above innovations

- Overall: many claims for impacts of innovation, but no evidence for eventual balance of efficiency vs. resilience improvement