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

- Customized product
- Long lead time (days-weeks)
- Standard product
- Short lead time (< 1 day)

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

Source: Groothedde, 2005
Hybrid supply networks (2)

A) Consolidation center = factory
B) Consolidation center = factory
C) Consolidation center = factory
D) Consolidation center = factory
E) Consolidation center = factory
F) Consolidation center = factory
G) Consolidation center = factory

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
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

Combining road and waterways networks via terminals almost doubles network robustness
How to advance TEN-T from corridors to a real network?
ALICE roadmap for hubs, corridors & synchromodality

Supply networks
- New demands of shippers
- EU as Hinterland of global chains

Transport services network
- Seamless exchange between modes
- ICT driven planning, booking, operations

Infrastructure network
- Hubs’ role in EU network
- Role of technology in integration

aspects of innovation
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

Brains: Apps and Humans

Dynamic data

Sensing

Autonomous Transport Modes

Data space

• Analytics As A Service
• Control Towers
• Situational Awareness (AR/VR)

Cloud/fog computing
• Exchange platforms
• Blockchain
• Smart Contracts
• Data Brokers

Brains: Apps and Humans

Dynamic data

Autonomous Transport Modes
Forwarders’ dis-intermediation headache
## Social value of innovation

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

(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 $\Rightarrow$ intermodal $\Rightarrow$ 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