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# Scenario Development by Mental Model Mapping

## Exploring Challenges and Innovations for a Sustainable Freight Transport System in Switzerland

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## Introduction

In the context of the joint project "future environmental performance of Swiss freight system: impacts on rail cargo competitiveness" between the Learning Lab – Future transport systems of ETH Zürich and SBB Cargo, different scenarios for the decarbonization of Swiss freight transport are analyzed. The idea is to investigate the strategic decision areas and solution pathways in the future freight transport system, and the challenges and opportunities associated with them. Different stakeholders have different mental models, or the thought processes for understanding the whole system, the relationship between different parts, and the impact of changes or specific behaviors (Forrester, 1971).

For mapping the mental model of stakeholders, a participatory approach is used to analyze how different expert opinions could be converged towards specific topics and solutions.

## Methodology

A multi-method approach was used for scenario development. A total of 33 expert interviews were conducted to gather ideas and opinions of different stakeholders. A set of analytical tools, complemented the data gathering process (figure 1) in order to do a content analysis of interview manuscripts and transform them into "dynamic hypotheses", i.e. the main stories behind our scenarios. These hypotheses are also inputs for System Dynamics modeling (Dehdarian, 2017), which is at the center of a subsequent complementary research.


*Figure 1. A multi-method approach for scenario development*

## Scenario Development

The interview transcripts were compiled by a version of "the Grounded theory" method. It extracts quotes from interviews and summarizes them into open codes. Each code expresses the main message of the quote. The open codes are classified into higher order codes, called as sub-categories and categories, as the main theme of the selected quote and the specific solution or subject respectively (figure 2).

| code | Quotation | Open Coding | Category | sub-category |
|---|---|---|---|---|
| 1 | If you look at how the congestion developed in Switzerland – I think it doubled in the last ten years – you can't deliver the quality needed by retailers on road transport and in rail transport we can guarantee punctuality of 10 to 15 minutes. | increased congestion on road in recent years as a trend leading to decreased punctuality | rail advantage | congestion |
| 2 | I think the quality and the bundling effect are two main aspects besides the night time ban | quality of service, bundling effect and night ban as the important contributing factors | rail advantage | mass transport |
| 3 | they should find some drivers doing transport at night, supply chain from the retailer should be changed because you may arrive at 2 AM and no one is there; so it is not that easy but that could be for me a bigger potential challenge and threat for rail freight | difficulty of changing night ban for the supply chain of road transport companies and their customers | rail advantage | night ban |

*Figure 1. A multi-method approach for scenario development*

Each open codes is translated into "an impact", where a factor influences another factor. The general idea is that the main message of an open code, can be translated into at least two different factors, while one factor is influencing another one. Based on network terminology, the influencer factor is called the "source", while the other is called the "target", and a network of concepts emerges.

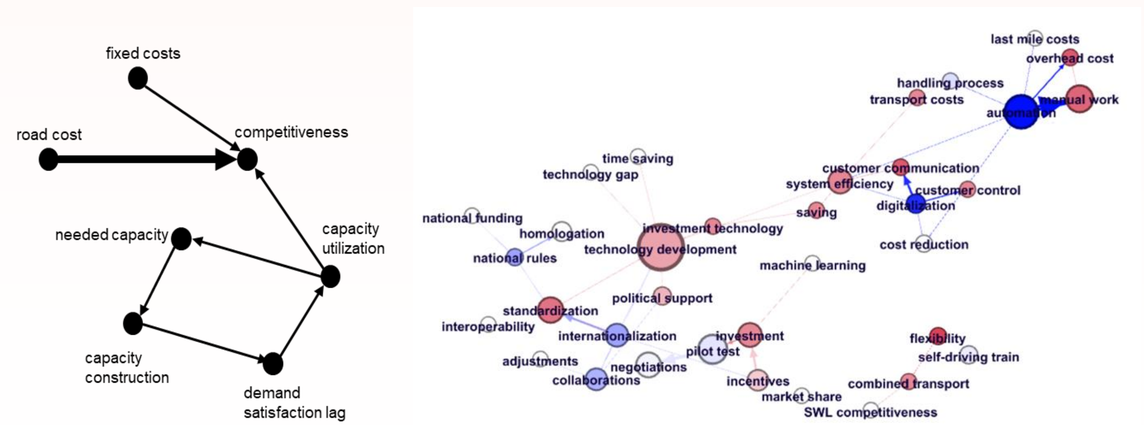


*Figure 3. Left: an example of impact analysis, where link thickness shows the number of times each impact is mentioned. Right: an example of emerging networks of concepts*

## Results

By summarizing open codes and categories (figure 2), a total number of eight main themes emerge, which can be classified into two groups for rail (SBB Cargo) and road freight experts:

*Table 1. A multi-method approach for scenario development*

| Road freight experts | Rail freight experts |
|---|---|
| Road freight electrification | Restructuring the rail freight network |
| Collaborative road logistics | Political support for rail freight system |
| Rail/road complementarities | Threats of rapid market change |
| Exogenous technological developments | Urban logistics |

Constructing the network of concepts (figure 3) helps us to calculate two measures for nodes (concepts): eigenvector centrality (node size), as a measure of connectedness and the importance of connections (Bonacic, 2007), and activity (node colors), as the value of outgoing degree divided by ingoing degree. These measures are used by a method called Vester's Sensitivity model (Ninck et al., 2014) for concept analysis for each of the eight themes. Figure 4 is an example of identifying the critical factors, indicators and influencers.

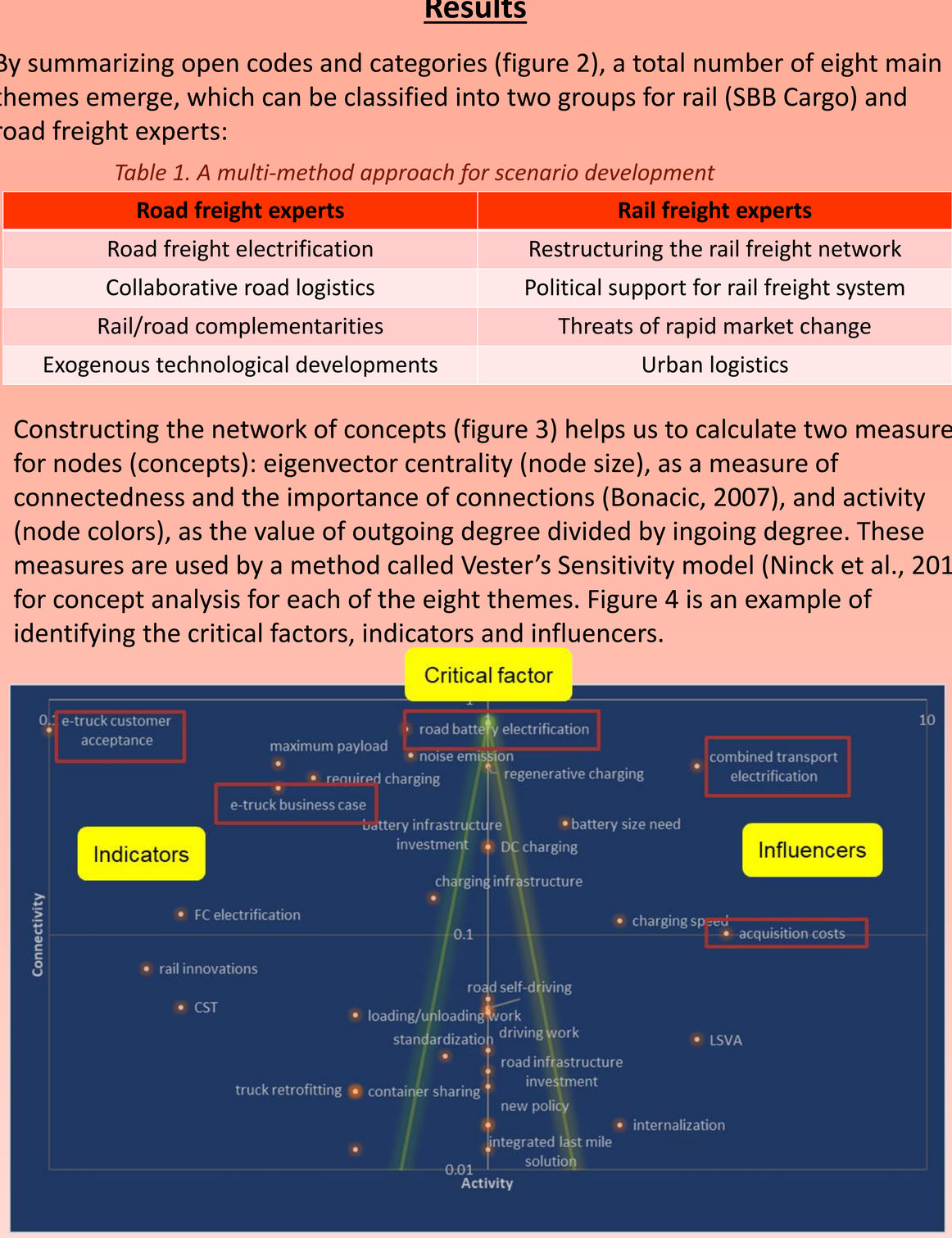


*Figure 4. Results of Vester's sensitivity model for road freight electrification*

In the last step, an analytical tool called "Causal Loop Diagrams (CLD)" is used to summarize the main feedbacks and dynamics of each theme (Sterman, 2001). For instance, figure 5 shows the CLD for road freight electrification, which is focused on the dynamics of road battery electrification, combined transport electrification and purchasing price (acquisition cost).

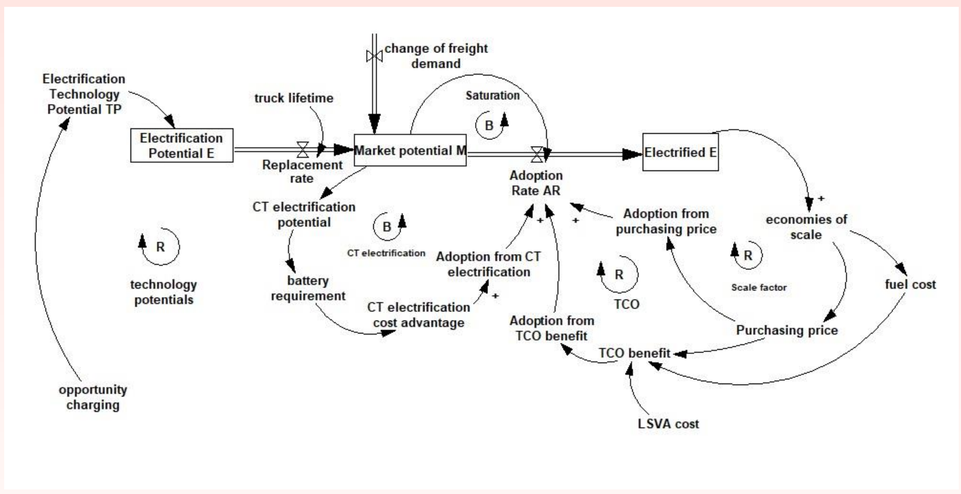


*Figure 5. Causal Loop Diagram for road freight electrification*

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