

Assessing Economic and Environmental Benefits of a Hybrid Approach to Rail Automation

Simulation Model Development and Scenario Analysis Applied to the Swiss Railway System

Graduate



Andre Auf der Maur

Introduction: Automation has become indispensable in today's world. Regarding the rail industry countless technical solutions already exist for the associated problems. However, the economic picture is unclear.

In combination with the environmental aspect, this thesis answers the questions of whether fully automated routes in a hybrid approach (specific routes are fully automated while all others remain manual) can be profitable and on which routes the potential is greatest. In addition, it examines which route related factors have a significant influence on the benefits and whether a hybrid approach can generate added value compared to the traditional approach.

Approach: Based on an existing explanatory model, a railway model is developed which forecasts the characteristics of the automated routes for the year 2050, with the current timetable serving as a boundary condition.

Integrated into a cost-benefit analysis, the strategy related changes (automation and ticket price changes) are monetised. Using a knapsack optimisation, the combined economic and environmental benefit is maximised. With publicly available data and various calculation steps a comprehensive data set is created, which then serves as input for the model. To analyse various possible outcomes, scenarios were created, each of which represents an implementation strategy.

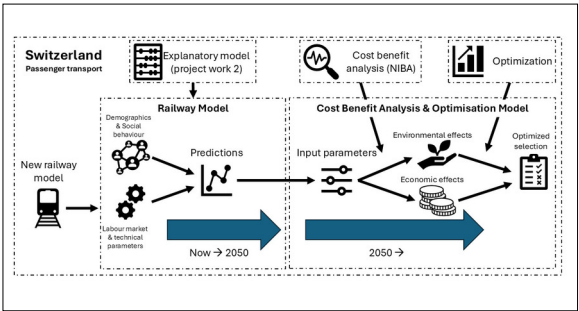
Result: A compact railway model was developed that not only maps route related characteristics but also predicts passenger numbers based on location-related characteristics. Combining the input data required for the railway model with the simulation model provides the basis for quantifying the strategy in monetary terms.

The scenario analysis shows that automation can be implemented with a positive benefit, while suburban railways show the biggest potential. The benefits arise primarily from reduced personnel costs, with the number of daily trips being the most significant factor. In environmental terms, the benefits are relatively small and do not, on their own, justify automation. The isolated effects of automation act as a lever for economic outcomes, while ticket prices act as a lever for environmental outcomes. Larger investment sums are reflected in lower overall cost benefit ratios, and the environmental aspect can be addressed primarily through a pricing strategy.

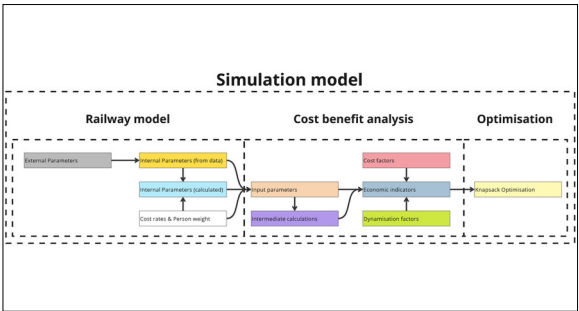
Based on the significant influencing factors of the routes, a formula for the approximate cost benefit ratio is developed. Compared with the traditional strategy, the hybrid approach shows great potential for increasing the benefits of automation, as a

targeted combination of specific routes can generate benefits shortly after implementation. If combined with a specific prioritization of connected routes, fully automated subnetworks within the Swiss network could be created, making it possible to include the benefits of capacity changes.

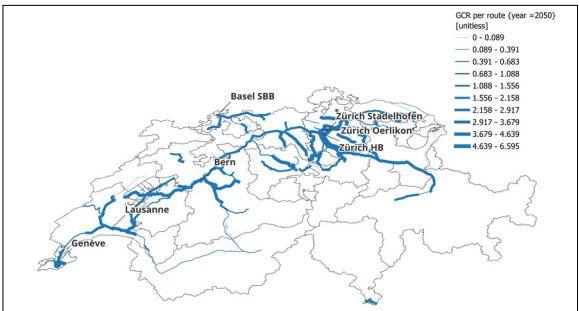
Reference framework with an overview of the methods used
Own presentation



Three-stage approach for comparing economic & environmental changes resulting from automation & ticket pricing strategy
Own presentation



Gain Cost Ratio (GCR) of the baseline scenario (without delay & safety improvements and ticket price variations)
Own presentation



Advisor

Prof. Hanspeter Keel

Co-Examiner

Assoc Prof. Sadat Reza, Singapore

Subject Area

Data Science, Business Engineering, Innovation in Products, Processes and Materials - Business Engineering and Productions, Mechanical Engineering