A System Dynamics model for identifying stakeholder coordination strategies for managing PPPs in High-Speed Railway

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Background and Motivation

➢ PPPs are essential for HSR, but policymakers need strategies to suitably manage them

➢ Conventionally, the private HSR operating and maintaining organizations are seen as “inert” agents, and not “active” agents

➢ However, the same needs to be challenged

➢ An in-depth understanding of the functioning and competitive strategies for HSR operators is an essential topic of study

➢ Such an understanding of private operators' strategies can guide policymakers their roles to maximize the outcome of the PPP projects
Objectives

➢ Identify strategies for private HSR operators to improve their ridership and profitability.
➢ Identify roles that public agencies can play in enabling these strategies

For ridership improvement, HSR operators can typically play with
✓ Pricing
✓ Frequency
✓ Service Improvement

The study develops a novel integrated SD Model for simulating such strategies

➢ Hidema, 2017 – Taiwan, Frequency, and Ticket Price, but maintenance, finance not considered
➢ Doi, 2016 – Japan, maintenance, and finance, but ridership exogenous
1. **Problem Statement**: Simulate the long-term trends (about 30 years) of the number of passengers using the HSR line

2. **Model Boundary**: Interactions between pricing, seat availability, maintenance, service quality, and their impact on ridership of HSR passengers are modeled endogenously (aspects that a train company can control)

3. **CLD Development**: Doi, 2016; Hidema, 2017; and literature review

4. **SFD Development**: Real information on Taiwan High-Speed Railway (THSRC)
   - World’s first PPP HSR Project, largest by value so far
   - Multiple challenges since then
   - Various re-organizations in project governance structure in roles of public and the private partnerships
- Bass-diffusion
- Value of time (Price and travel time difference)
- Frequency and Churn Rate
- Exogenous: Passenger market growth rate
Model Structure – Integrated CLD

- Rolling Stock Procurement
- Price Adjustment
- Access Time to Station
- Maintenance

- Frequency Adjustment
- New Rolling Stock Order
- Manufacturing Capacity
- Order Delay
- Delivery
- Requirement
- Requirement for New Rolling Stock
- Order Backlog

- Fleet Quality
- Infrastructure Usage
- Budget for Normal Replacement
- Maintenance Backlog
- Additional Deterioration
- Capital Expenditure on Maintenance
- Operating Profit
- Operating Expenses

- Unwillingness Increase
- Average Seat Price
- HSR Adopters
- Adoption Rate
- Word of Mouth
- Operating Revenue

- Passengers Not Willing to Adopt
- Becoming Interested
- Potential HSR Adopters
- Adoption from Advertising
- Adoption from Word of Mouth

- Maintenance Backlog
- Budget for Backlog Replacement
- Additional Deterioration
- Maintenance Backlog

- Total Travel Time
- Value of Time
- Safety
- Accessibility to Station
- Parking Time
- Road Congestion
- Access to Station using Car
- Access to Station using Public Transportation

- Willingness to Adopt
- Indicated Seat Price
- Service Availability
- Service Availability
- Load Factor Management
- Target Frequency

- Decreasing Waiting Time
- Waiting Time
- Decreasing Waiting Time
- Price Increase
- Service Availability

- Operating Revenue
- Access to Station using Public Transportation
- Access to Station using Car
- Parking Time
- Road Congestion

- Traffic Volume at Stations
- Market Saturation
- Adoption from Word of Mouth
- Adoption from Advertising
- Becoming Interested
- Potential HSR Adopters
- HSR Adopters

- Churn Rate
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Model simulation and Calibration

Model captures the non-linear trends in HSR adoption
Base Case Simulation

A close look to the Market Penetration Phase in the Base Case

- Price Increase and Load Factor Management are the dominant loops.
- If actual LF < Desired LF, Seat Price is reduced. Frequency is reduced.
- **Initial Transient Phase**: Artificial increase in Frequency is needed. If not (Actual LF < Desired LF)
- **Market Penetration Phase**: Once the Actual LF > Desired LF. Price starts increasing, and frequency starts increasing. The model oscillates around the desired LF
- Price Increase loop: Dominant till penetration phase
- Frequency Fluctuation: Active throughout
Policy Simulation – Desired Load Factor

- LF is a significant variable. In PPP project, government may also put a bound on minimum frequency of the trains.

- A lower LF is expected to improve ridership.

- However, as per the model: Too High (70%) or Too Low (60% or below) LF is not good.

- For a high LF, the strength of the market penetration phase is weakened. Affecting the long-term ridership.

- For low LF, the price level at which the penetration phase settles is at a higher level, affecting the long-term ridership.
Policy Simulation – Desired Load Factor

Benefits of a low DF in the Market Penetration phase and a high DF in demand expansion phase
### Strategies for PPP management for HSRs

<table>
<thead>
<tr>
<th>Phase</th>
<th>Market Penetration Phase</th>
<th>Demand Expansion Phase</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>High-Frequency, Lower prices</td>
<td>Prices can be increased along with high frequency</td>
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<tr>
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<td>Frequent changes in the price and frequency is necessary</td>
<td>Less frequent changes. Difference in strategy compared to Market Penetration Phase</td>
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1. Public agencies should allow a rather liberal policy in Market Penetration Phase

2. Different types of policy for different phases

3. Requirements for minimum frequency should be carefully evaluated
Novel SD model, linking pricing, frequency, maintenance and other strategies along with financial implications

Full simulation model is developed and calibrated with the actual data from Taiwan HSR

Success of market penetration phase decides the long-term success. Rapid changes in Low Price and High Frequency is necessary. Both public and the private parties shall support the same across different phases

Future model exploration. Stakeholder engagement.
References


References


