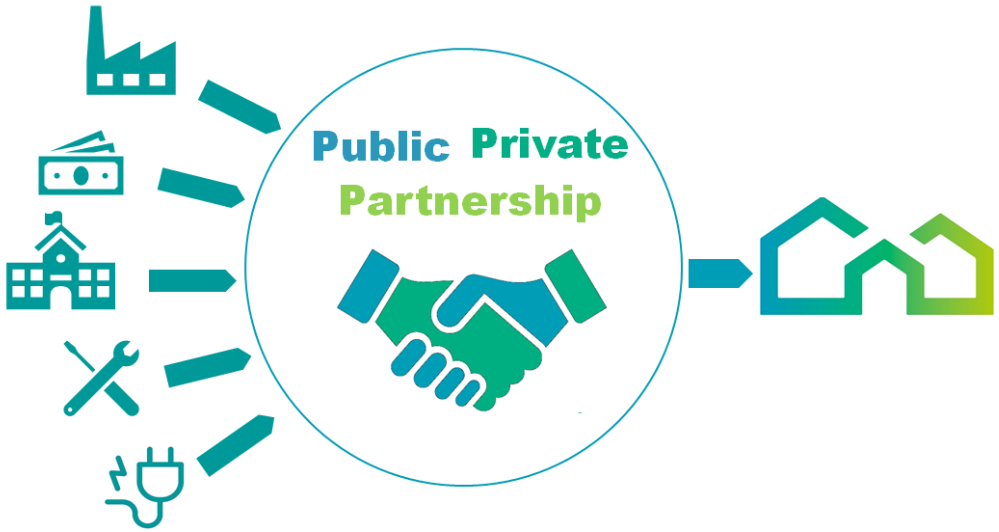
A System Dynamics model for identifying stakeholder coordination strategies for managing PPPs in High-Speed Railway



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Background and Motivation

Shinkansen Key Fact

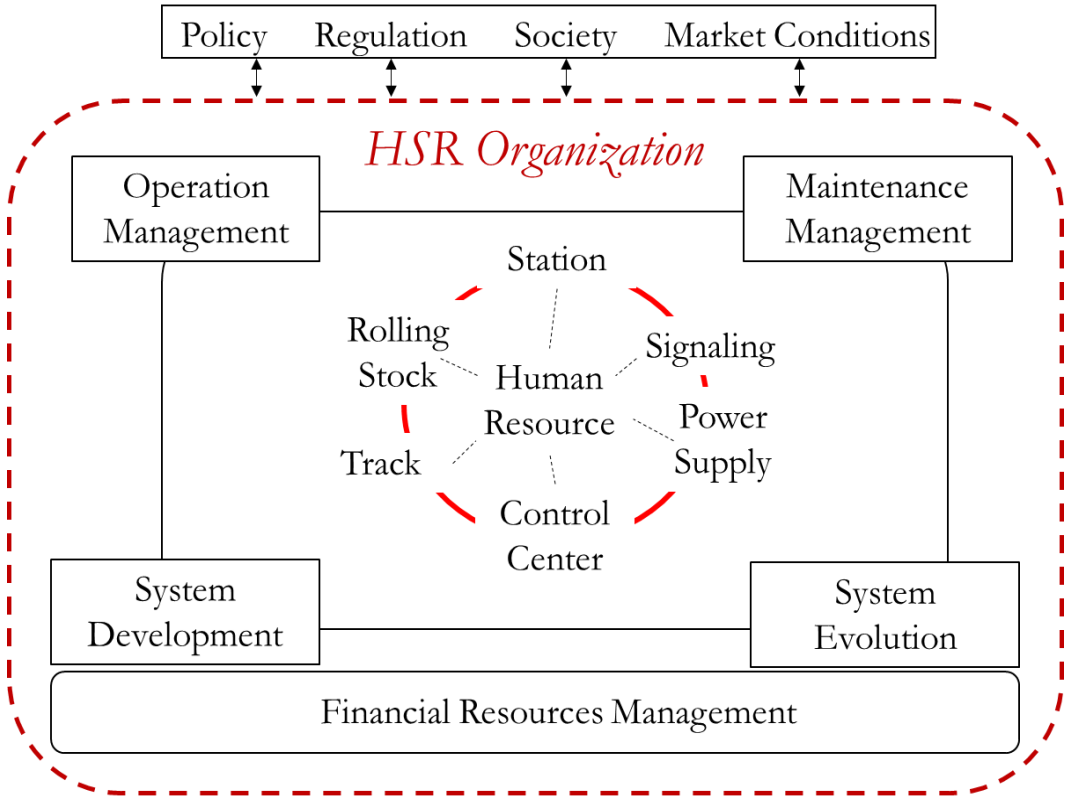
IHRA INTERNATIONAL HIGH-SPEED RAIL ASSOCIATION

Safety	0 Fatalities for over 55 years
Reliability	Average delay under 1 min incl. delay due to natural disasters
High-speed	6.5h→2h21m, Tokyo⇔Osaka(515.4km)
High-volume	458k passengers/d, 27k passengers/h(6:00-23:00), Tokyo⇔Osaka
High-frequency	17 trains/h

- 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



HSR System

- 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

SD Model Development

1. **Problem Statement :** Simulate the long-term trends (about 30 years) of the number of passengers using the HSR line

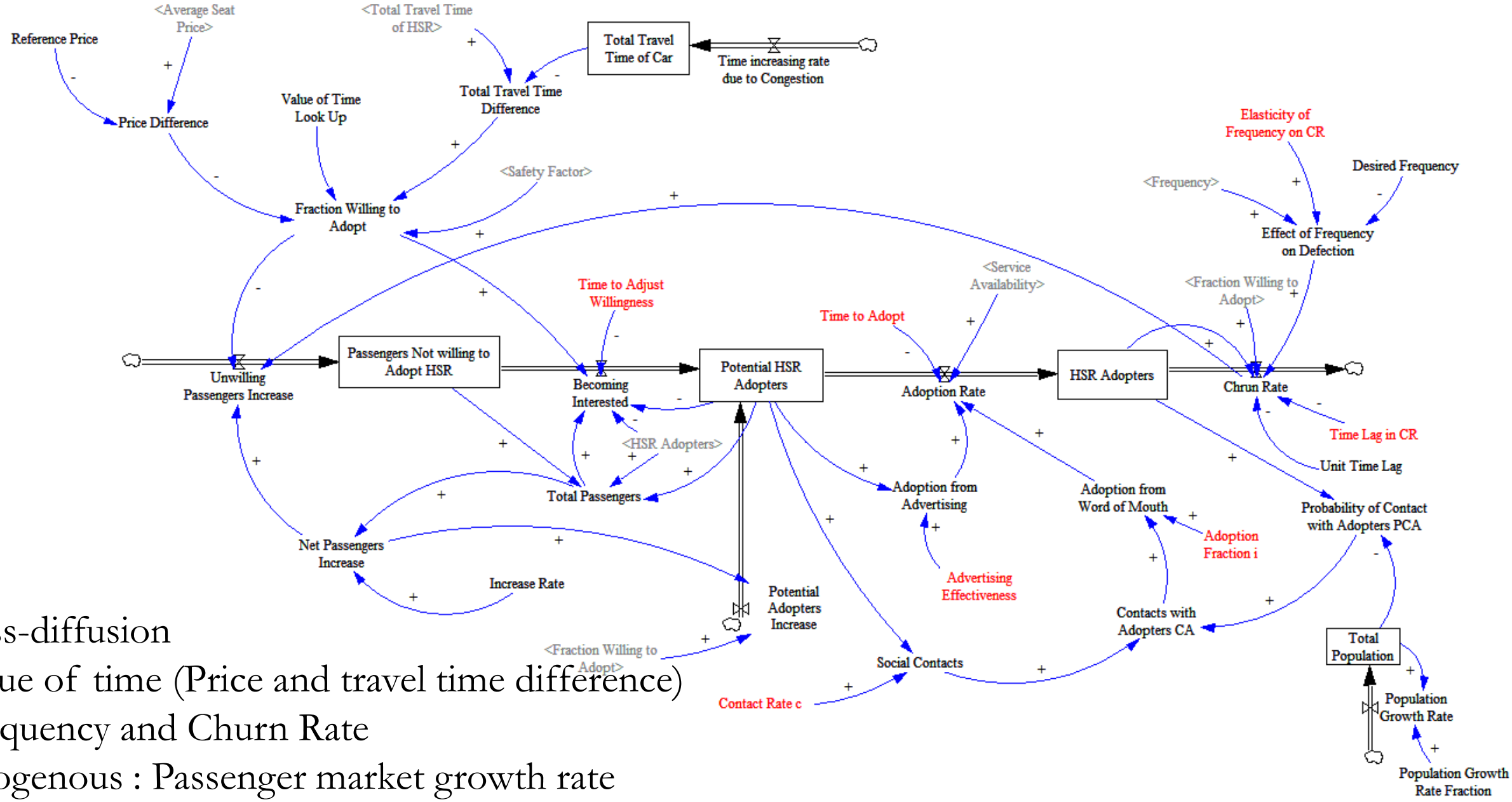
2. **Model Boundary :** Interactions between pricing, seat availability, maintenance, service quality, and their impact on ridership of HSR passengers are modeled endogenously (aspects that a train company can control)

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

4. **SFD Development :** Real information on Taiwan High-Speed Railway (THSRC)

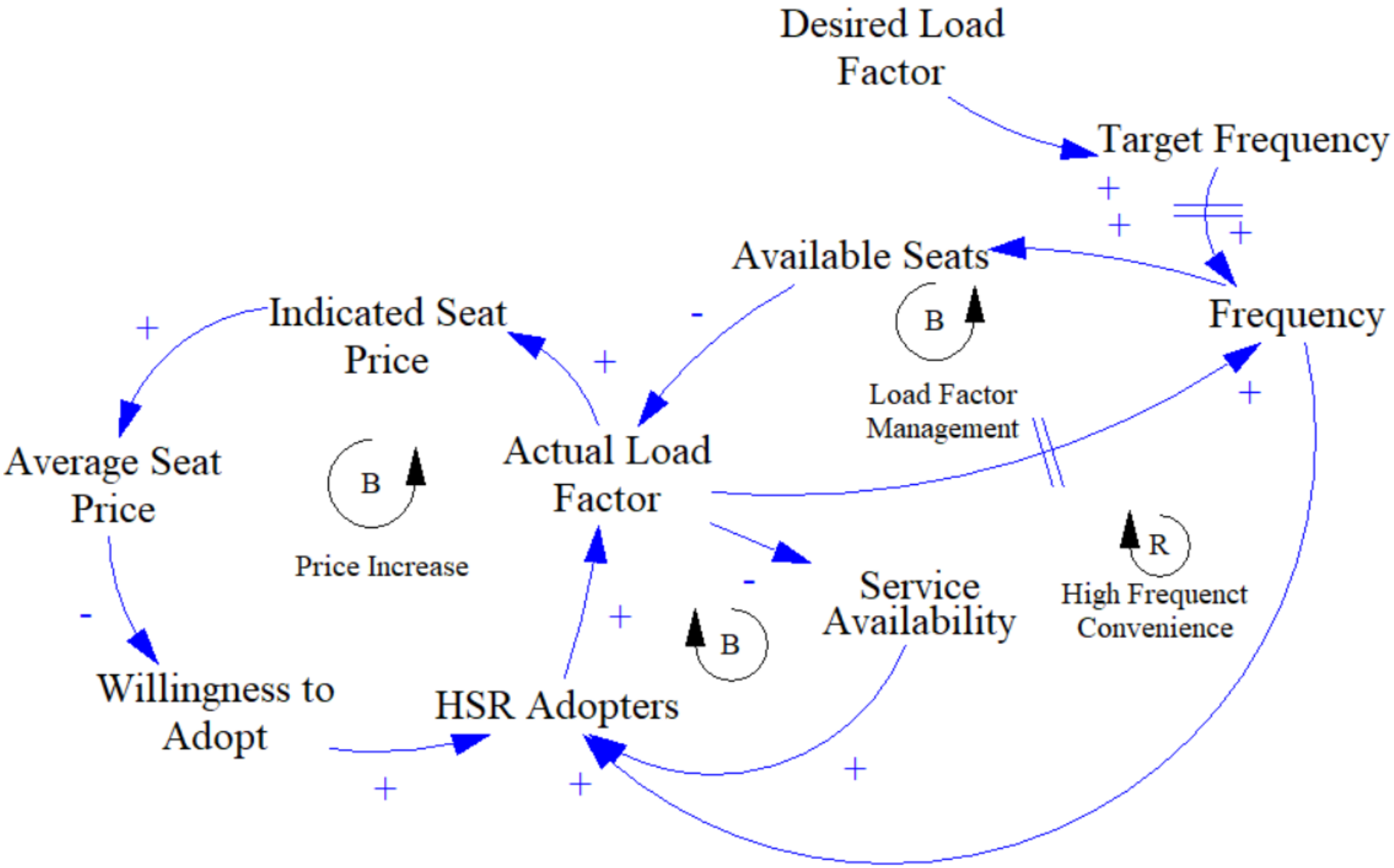
- World's first PPP HSR Project, largest by value so far
- Multiple challenges since then
- Various re-organizations in project governance structure in roles of public and the private partnerships

Model Structure – HSR Adopters

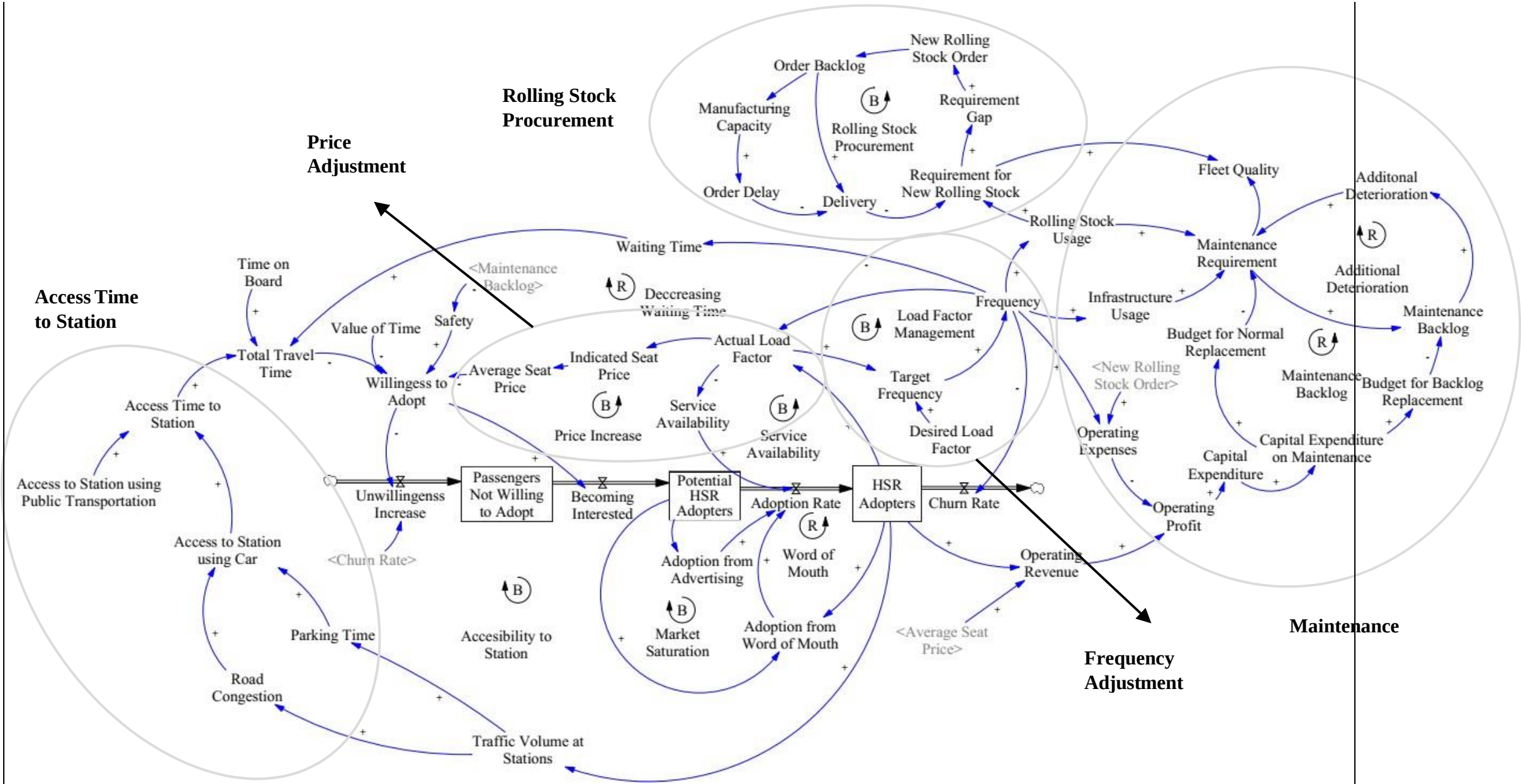


- Bass-diffusion
- Value of time (Price and travel time difference)
- Frequency and Churn Rate
- Exogenous : Passenger market growth rate

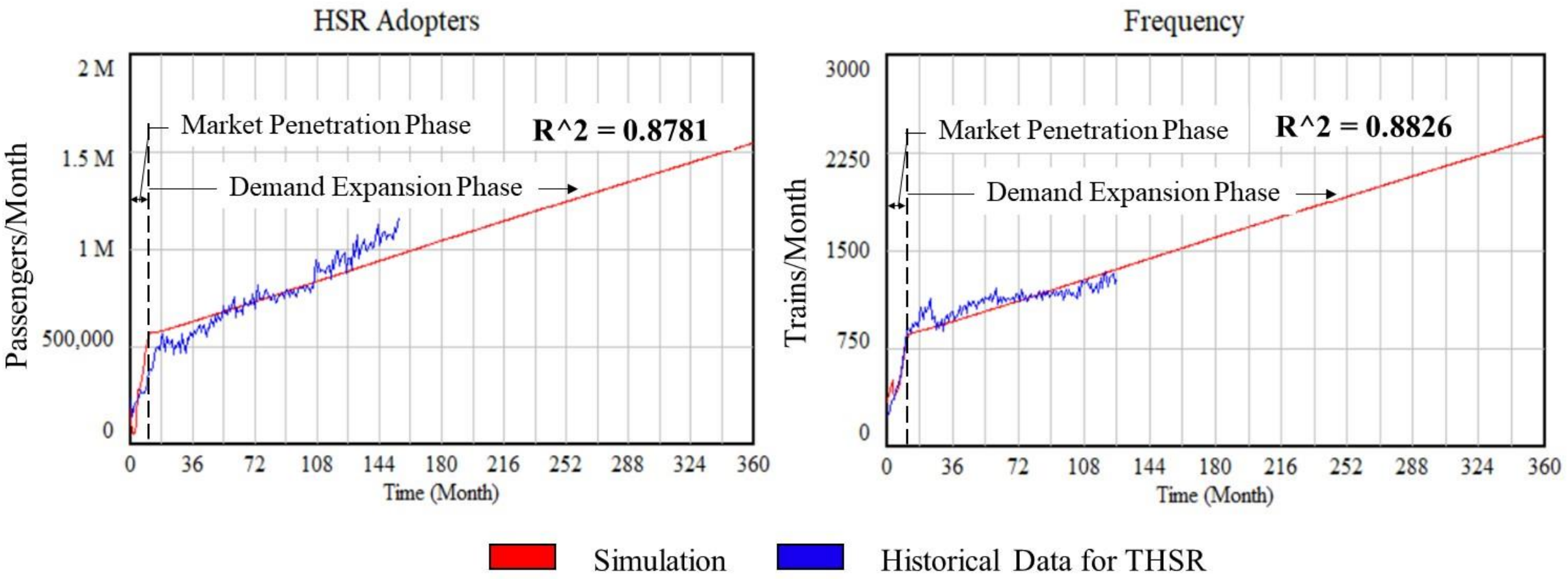
Model Structure – Ridership Management



Model Structure – Integrated CLD

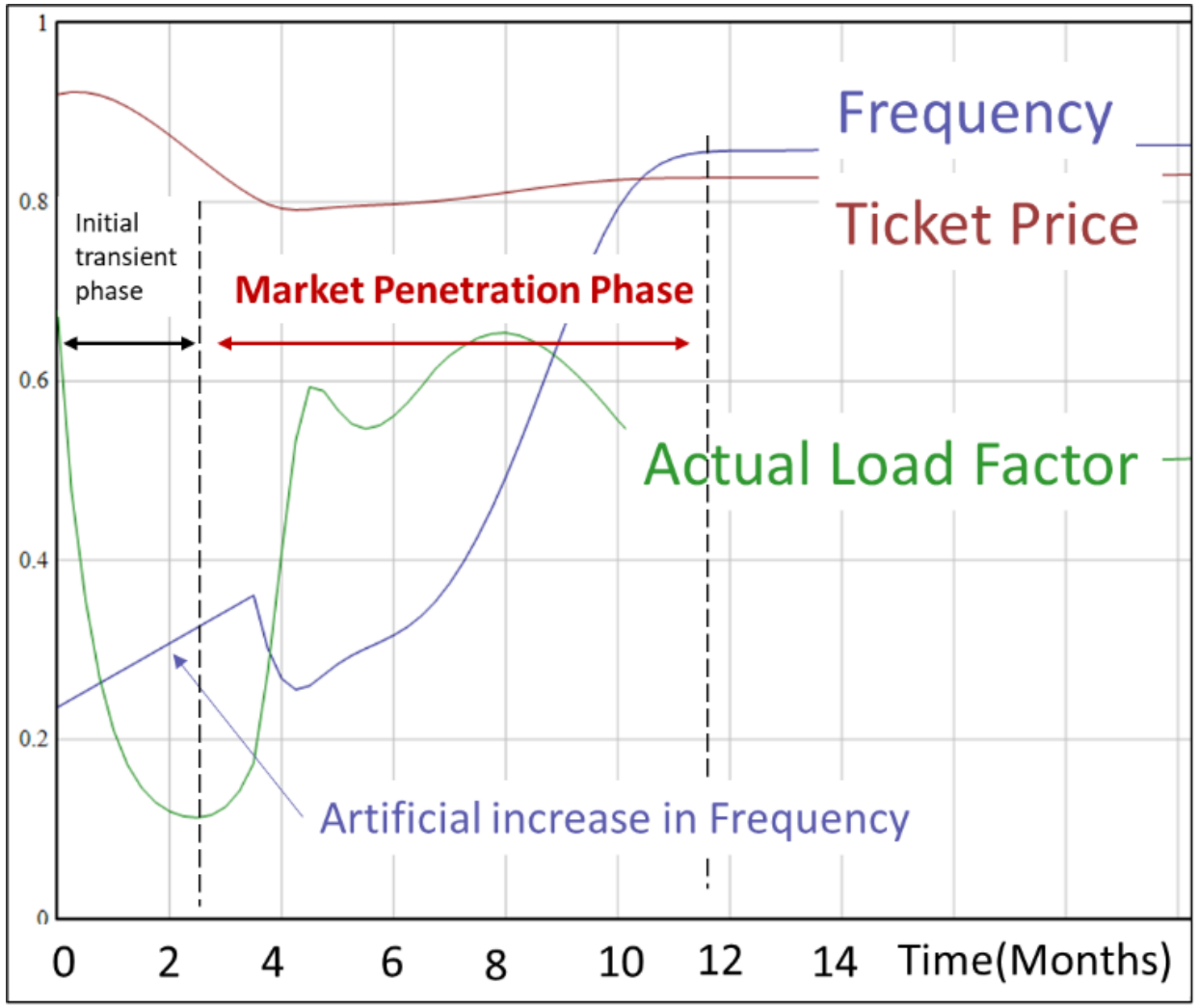


Model simulation and Calibration



Model captures the non-linear trends in HSR adoption

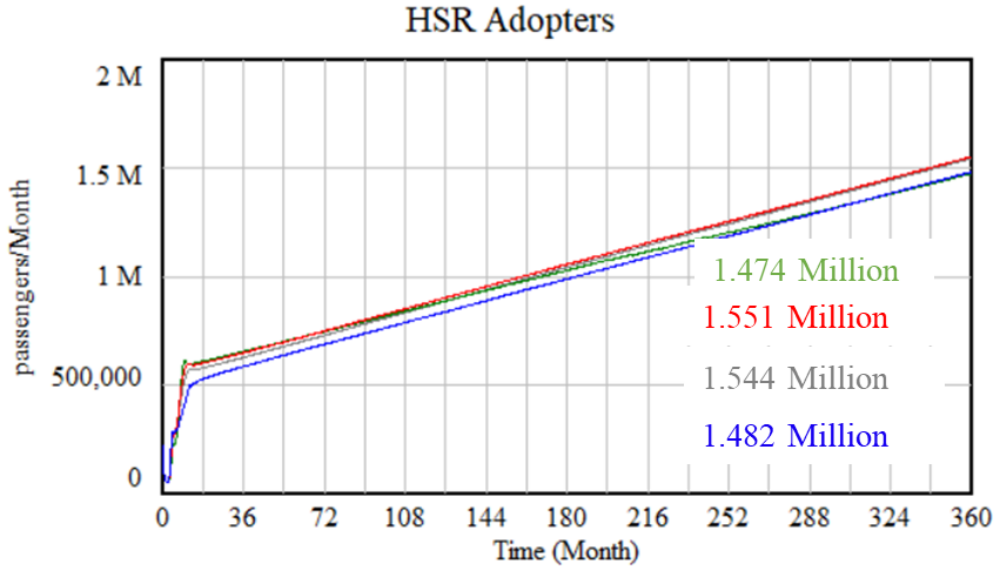
Base Case Simulation

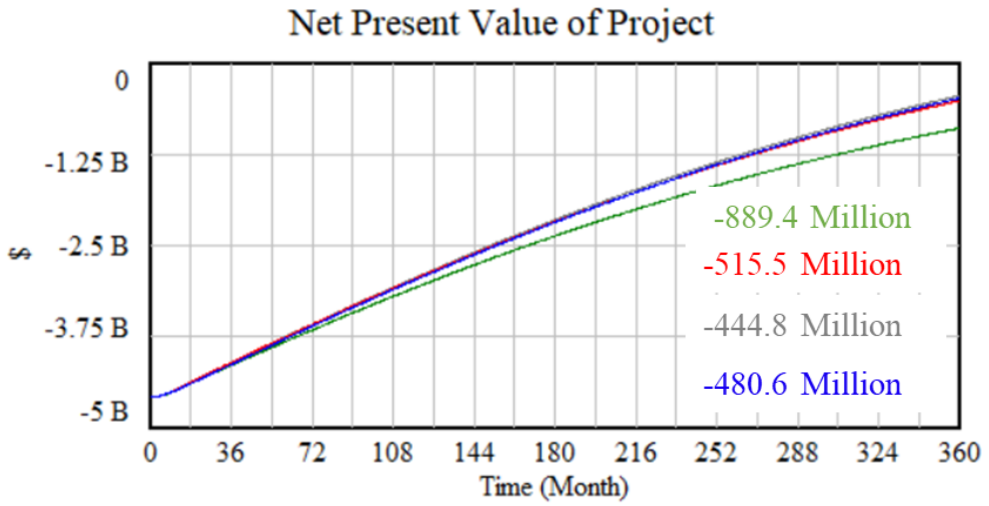


A close look to the Market Penetration Phase in the Base Case

- 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

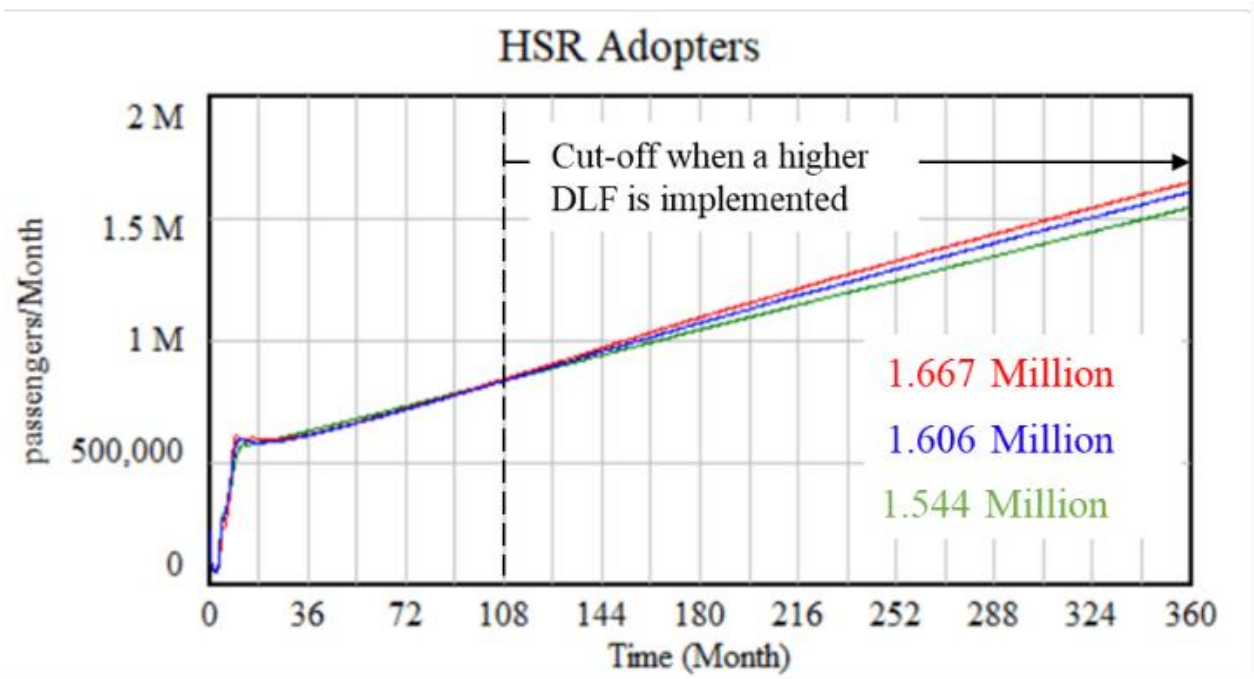


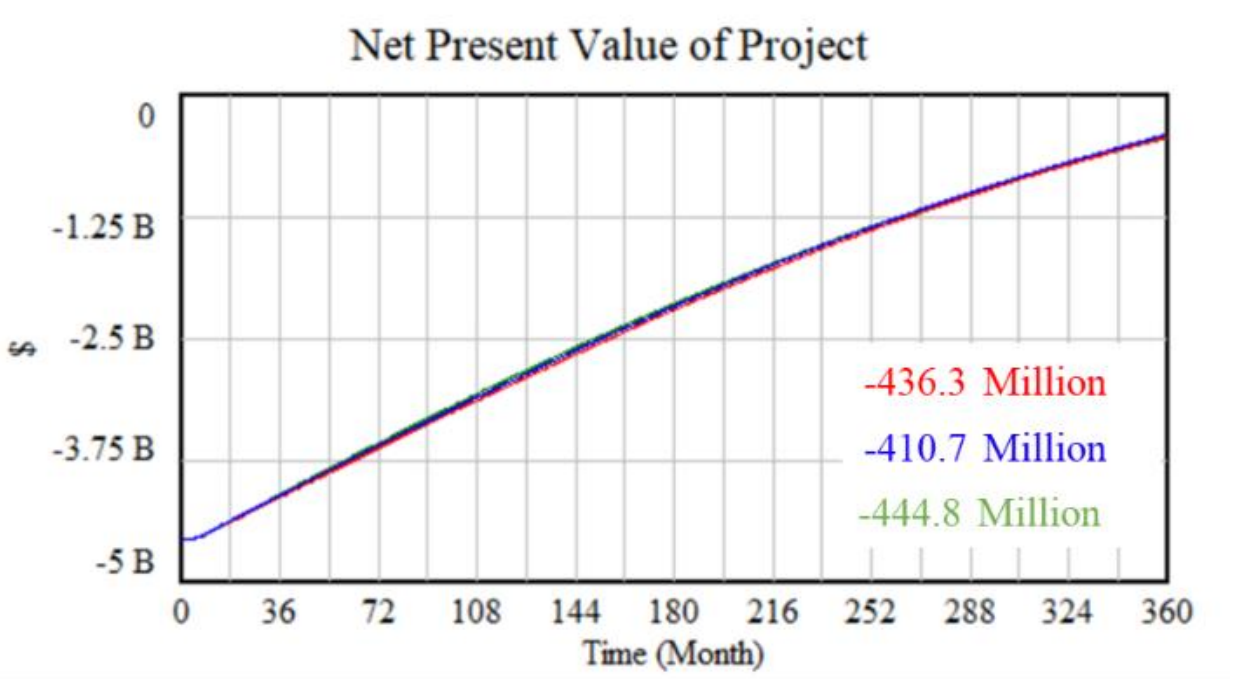


DESIRED LF = 50% DESIRED LF = 60% DESIRED LF = 65% DESIRED LF = 70%

- 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





50 – 70% 60- 70% 65%

Benefits of a low DF in the Market Penetration phase and a high DF in demand expansion phase

Strategies for PPP management for HSRs

Market Penetration Phase	High-Frequency, Lower prices	Frequent changes in the price and frequency is necessary
Demand Expansion Phase	Prices can be increased along with high frequency	Less frequent changes. Difference in strategy compared to Market Penetration Phase

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

Conclusions

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.

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