

# Pay or not to pay

401.661 Advanced Construction Technology

Oct. 10<sup>th</sup>, 2006

## Moonseo Park

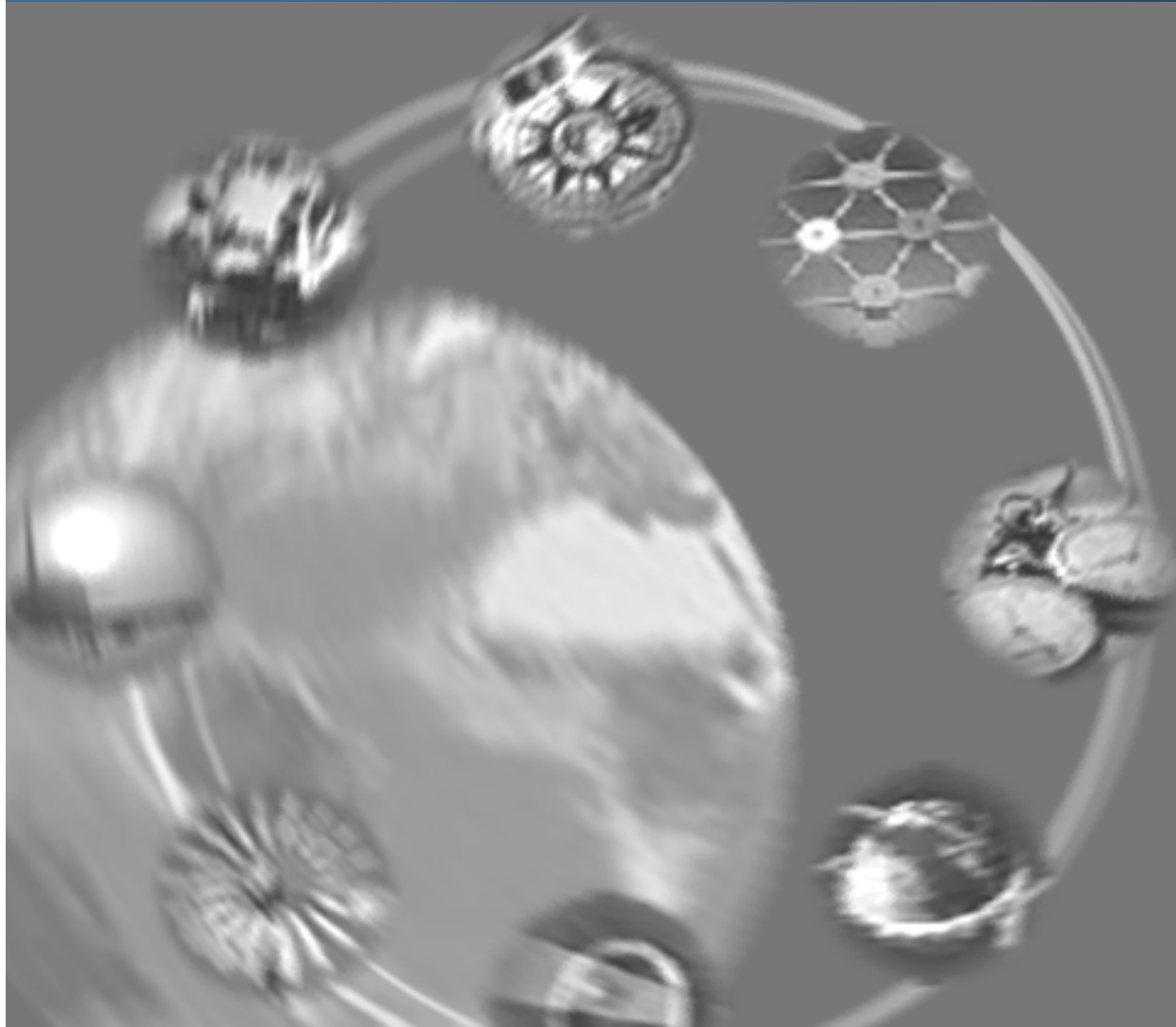
Assistant Professor, PhD

39동 433  
Phone 880-5848, Fax 871-5518  
E-mail: mspark@snu.ac.kr

Department of Architecture  
College of Engineering  
Seoul National University



서울대학교  
건설기술연구실



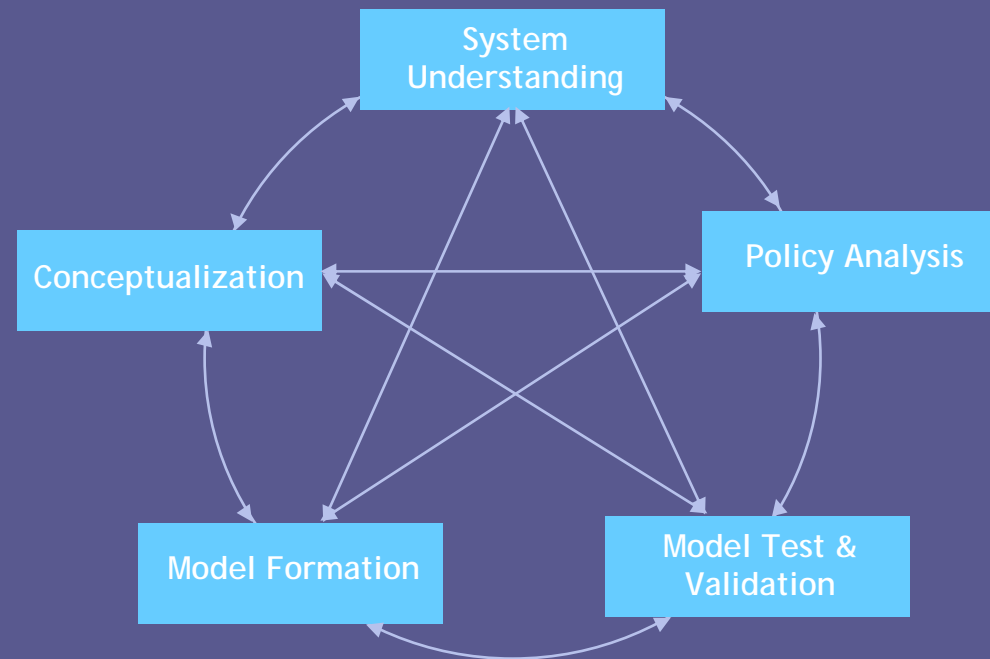
# Lecture Outline

---

- Typical Modeling Method
- Background of the Case Project
- Dynamic Modeling Process

# Modeling Process

- Learning can happen across ALL stages of modeling.
- Involving continuous iterations among the modeling steps.



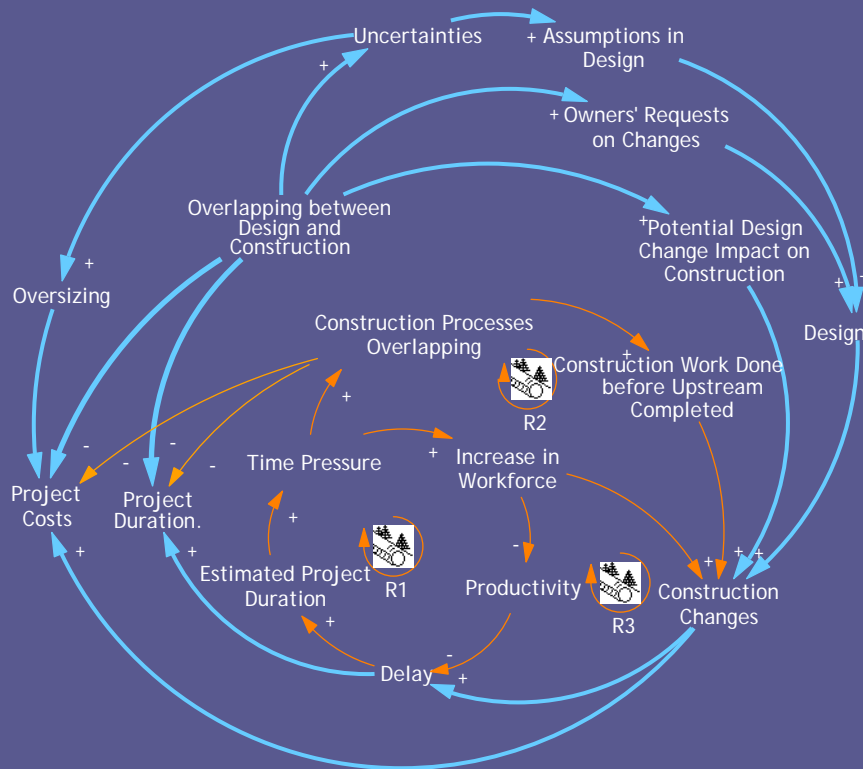
# Modeling Process

---

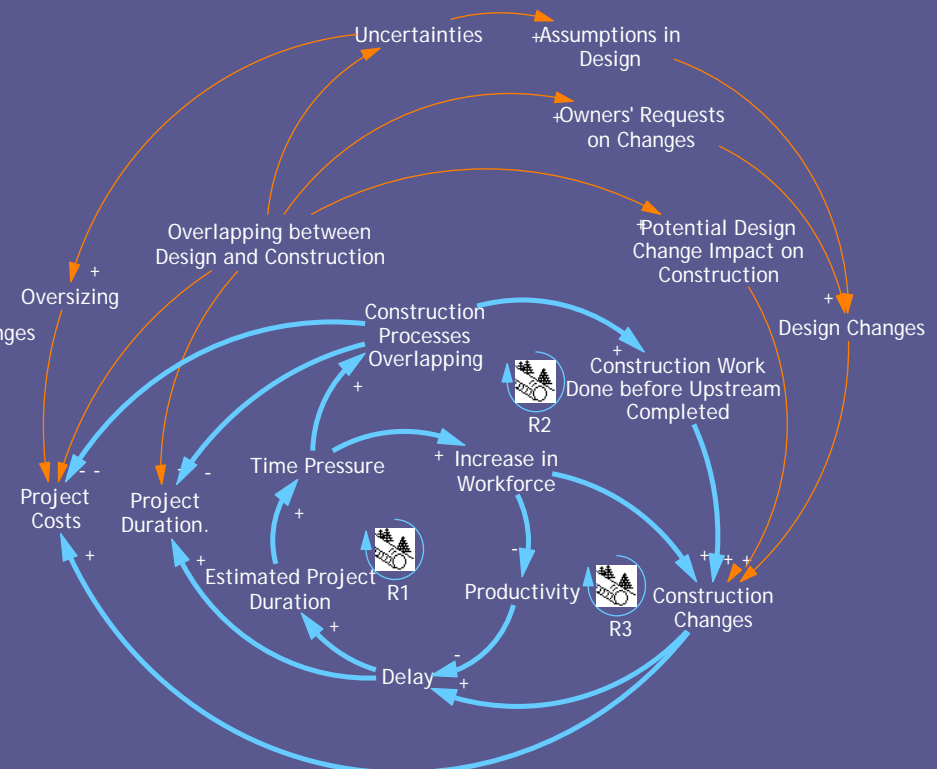
- **System Understanding:** the process of deepening the modeler's understanding of the system with relevant information, usually including **problem statement**, **list of variables**, and **reference modes**
- **Conceptualization:** conceptual model structures are described in the form of a causal loop diagram to show the dynamics of variables involved in the system (also, called **dynamic hypotheses**)

# Modeling Process

## Examples of Causal Loop Diagram



Design-Driven Feedbacks



Construction-Driven Feedbacks

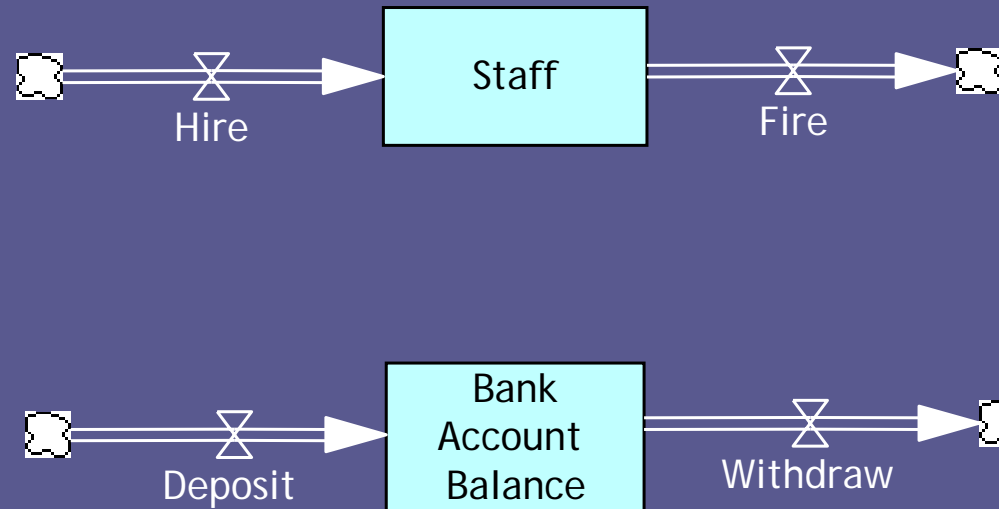
# Modeling Process

- **Model Formation:** having a causal loop constructed, variables in the model structures **come to have quantitative attributes through building mathematical equations** for variables.

This step also includes the identification of **stock and flow** structures, which **characterize the state of the system and generate the information**, upon which decisions and actions are based, by giving the system inertia and memory [Sterman, 2000]

# Modeling Process

## Examples of Stock and Flow Structure



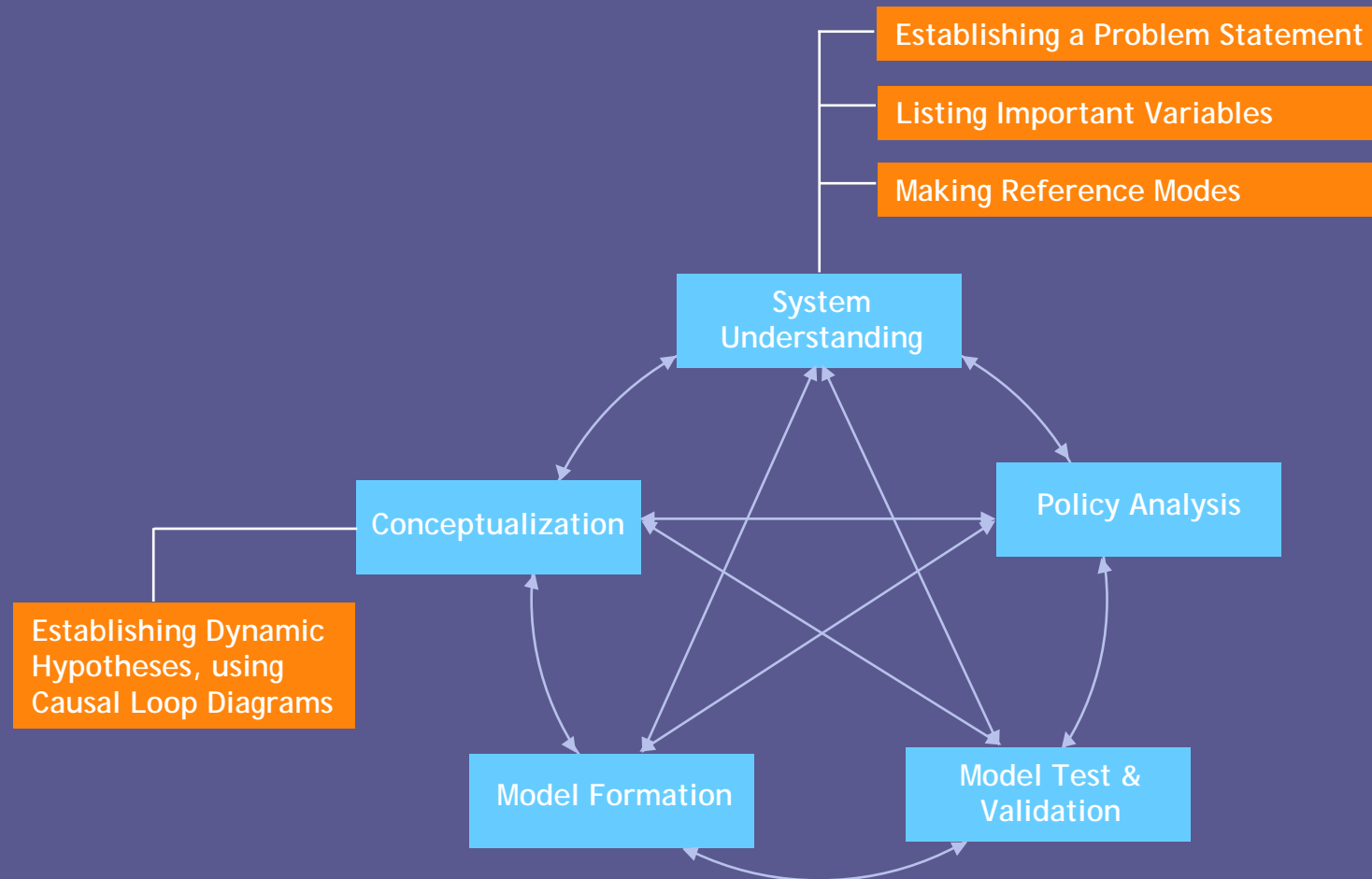
# Modeling Process

---

- **Model Validation:** tested and validated in accordance with the purpose of the modeling
- **Policy Analysis:** the validated model is applied to solving the given problems



# One Typical Modeling Method is ...



# Lecture Outline

---

- ✓ Typical Modeling Method
- Background of the Case Project
- Dynamic Modeling Process

# Background of the Case Project

## Strategic Decisions for Highway Operation

“A construction company has recently completed their highway construction project, which has been awarded with a **BOT** contract” .



“The highway runs from City A to City B in a more direct way than the existing road, and has service facilities for drivers” .

# Background of the Case Project

---

“A discounted cash flow analysis shows some numbers for toll charges that can return their investment within the operation period”.

“However, the top management of the company won't believe the numbers, thinking that **highway operation might not be a simple mathematics**”.

# Background of the Case Project

“According to their experience, drivers choose a drive road depending on **cost-convenience tradeoffs**, having the following two options:”

- A highway with a lot of services and **toll**
- An old road without services

“Because of such a recognition, the top management wants to understand **dynamics caused by drivers’ tendency in choosing a drive road** and to know how to maximize their profits, while keeping an acceptable level of service” .

# Lecture Outline

---

- ✓ Typical Modeling Method
- ✓ Background of the Case Project
- Dynamic Modeling Process

# Problem Statements

---

- Figuring out **the dynamics involved in highway operations** including tradeoffs among toll charges, service level, volume of traffic, and congestion level.
- Finding **an optimal level of toll charges and maintenance costs**, which can maximize their profits, keeping an acceptable level of service.

# List of Variables

---

Toll Charges

Highway Capacity

Travel Time

Traffic Volume

Service Quality

Trip Frequency

Road Attractiveness

Degree of Congestion

Time Reduction through Highway

GDP\*

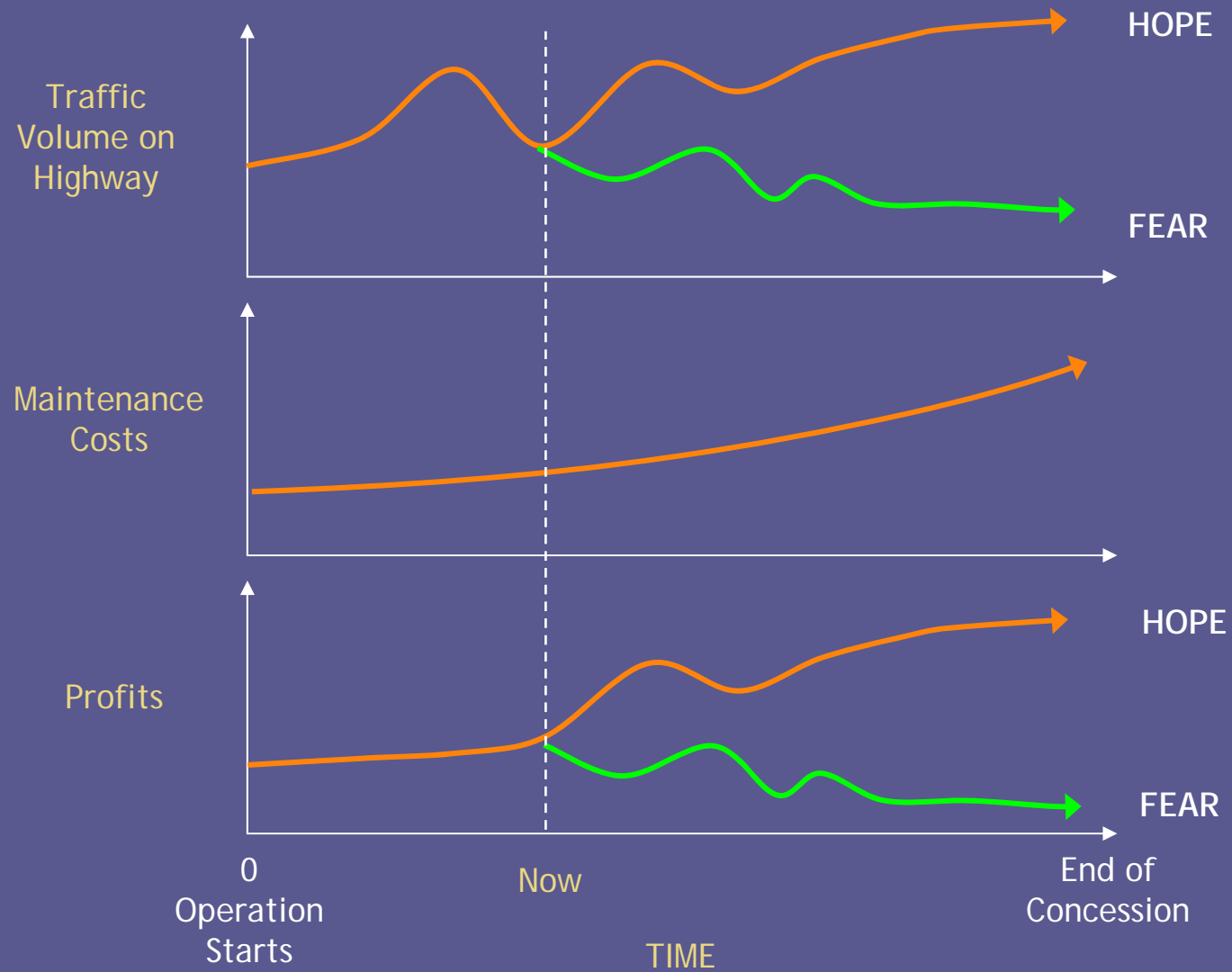
Population\*

Price of Gasoline per Mile\*

\*Exogenous Variables

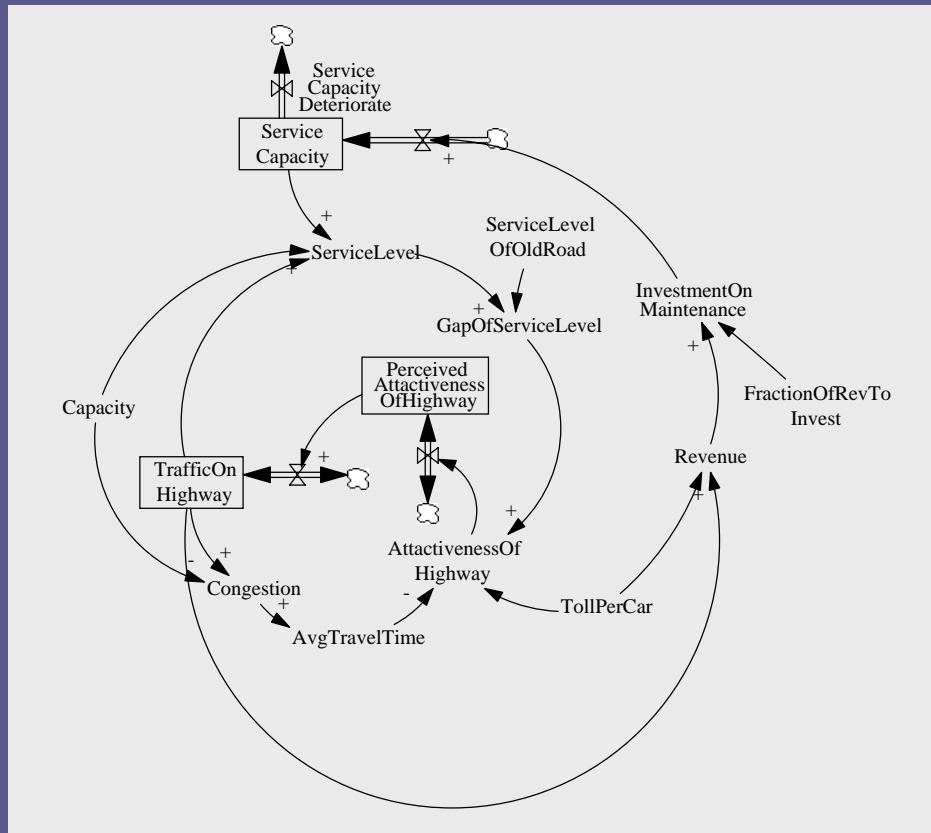


# Reference Mode



# Dynamic Hypotheses

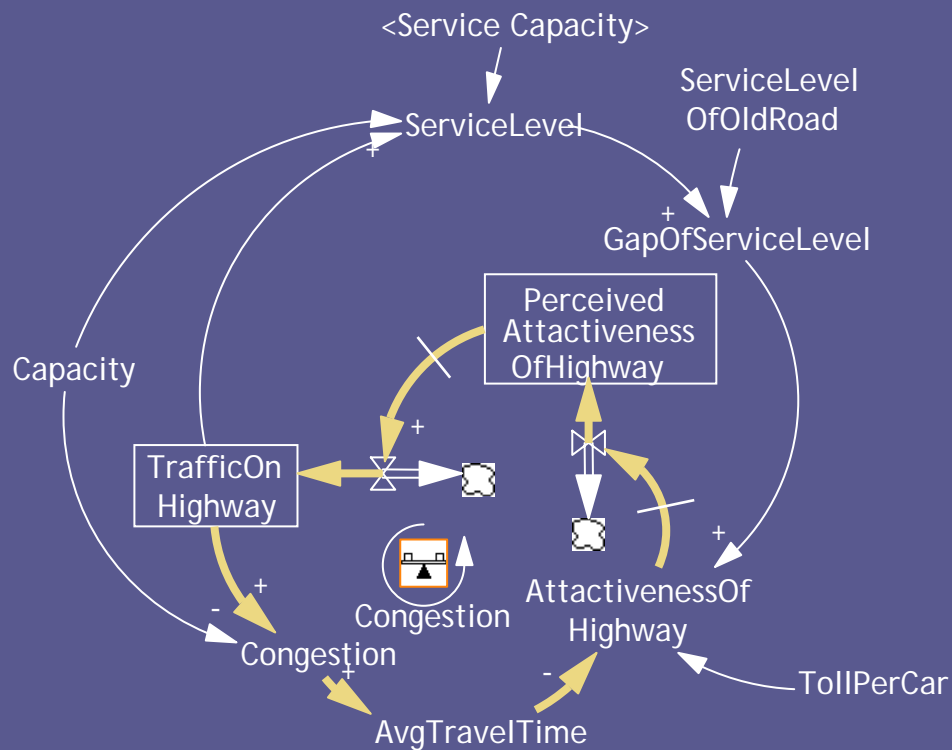
## The Spaghetti



For the first stage of the development, one needs to analyze feedback loops that have the most significant impacts on the system and established dynamic hypotheses of them.

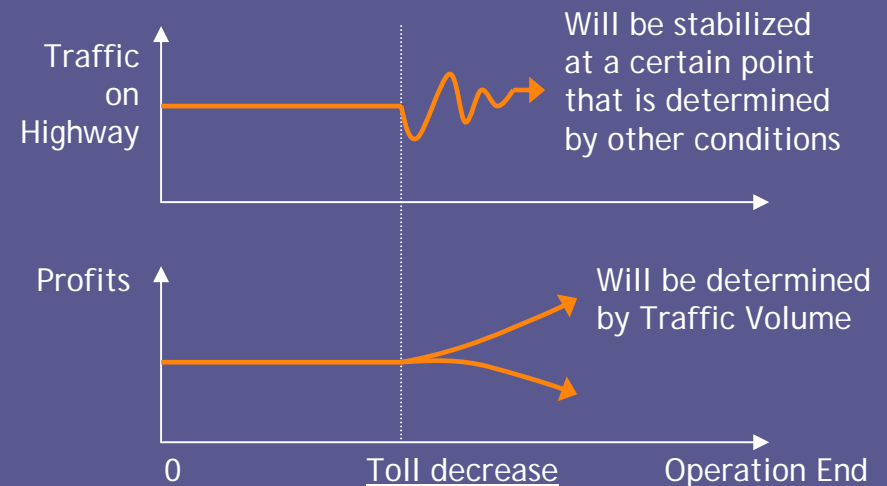
# Congestion

## Congestion Balancing Loop



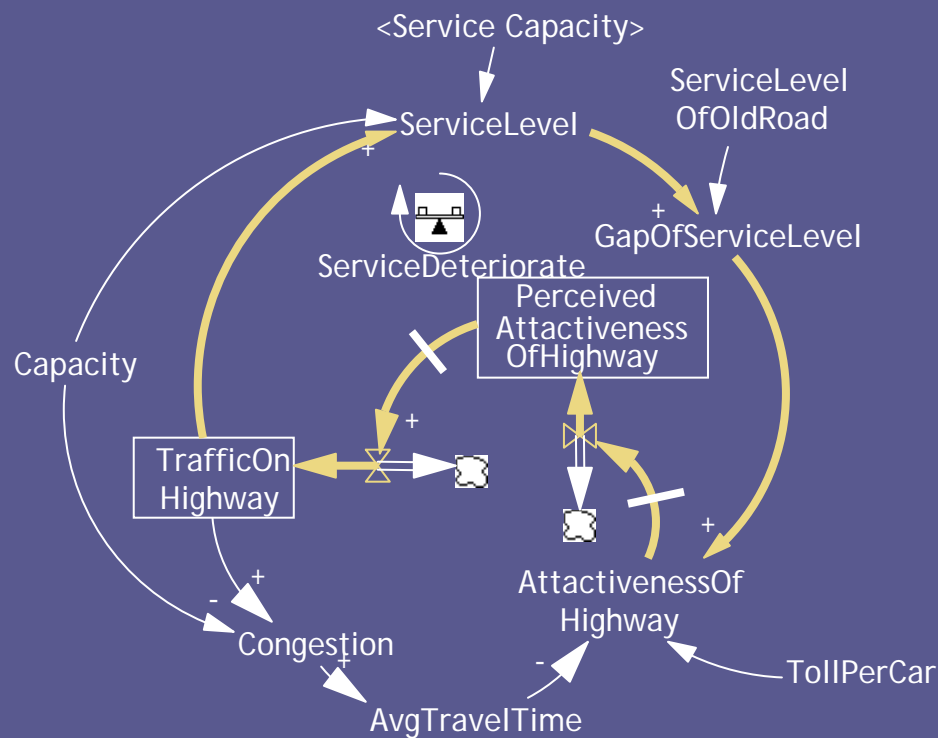
If toll decreases, traffic goes up, congestion becomes more, and drivers have a higher average travel time. That affects negatively on the Attractiveness of Highway with the consequent reduction in traffic.

The following hypotheses on the system's behaviors are established when toll is decreased.



# Service

## Service Balancing Loop



The attractiveness of the Highway with respect to the service level depends on both the service on highway and in the alternative route. **As an increase in traffic deteriorate the Highway's service level and in turn its attractiveness.**

The same hypotheses on the system's behaviors as Congestion Loop are established when toll is decreased.

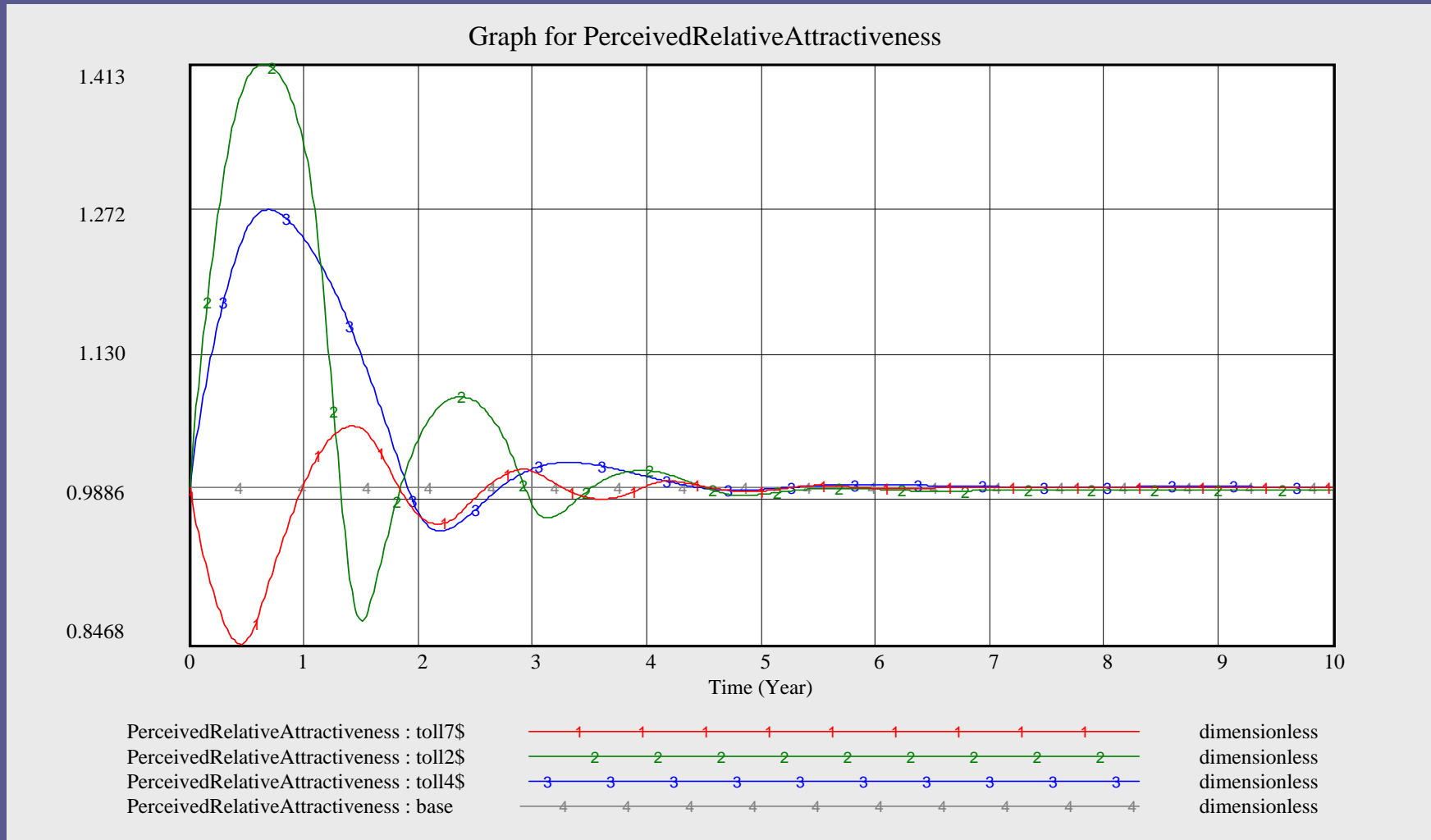


# Model Formation



# Model Analysis

## Toll Impact

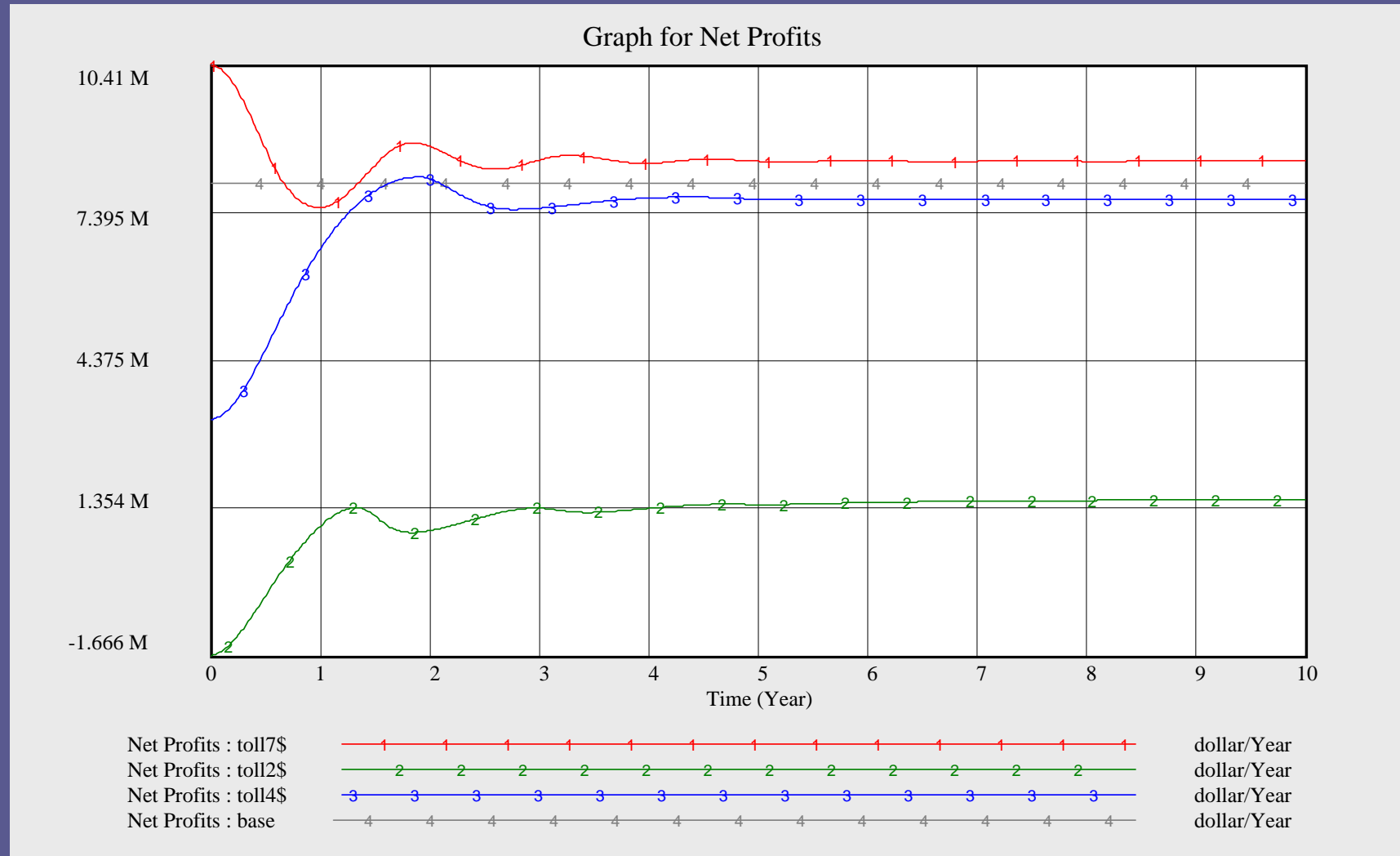






# Model Analysis

## Toll Impact

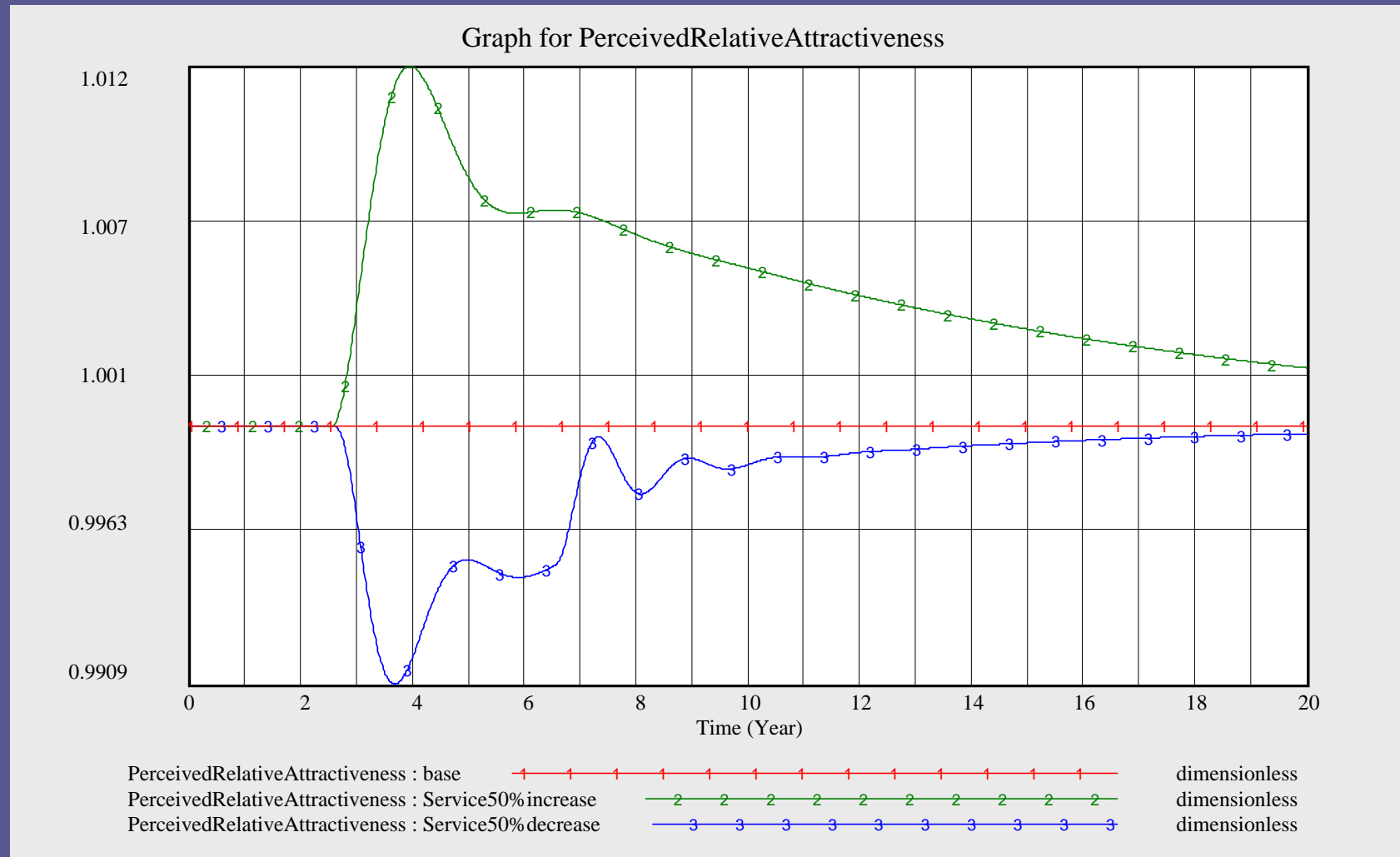


# Policy Implications

- While the relative attractiveness always becomes stabilized at the initial equilibrium point, the traffic volume becomes stabilized at the point where there are no more changes in the attractiveness.
- Net profit from the highway operation may not be proportional either to toll amount or to traffic volume.

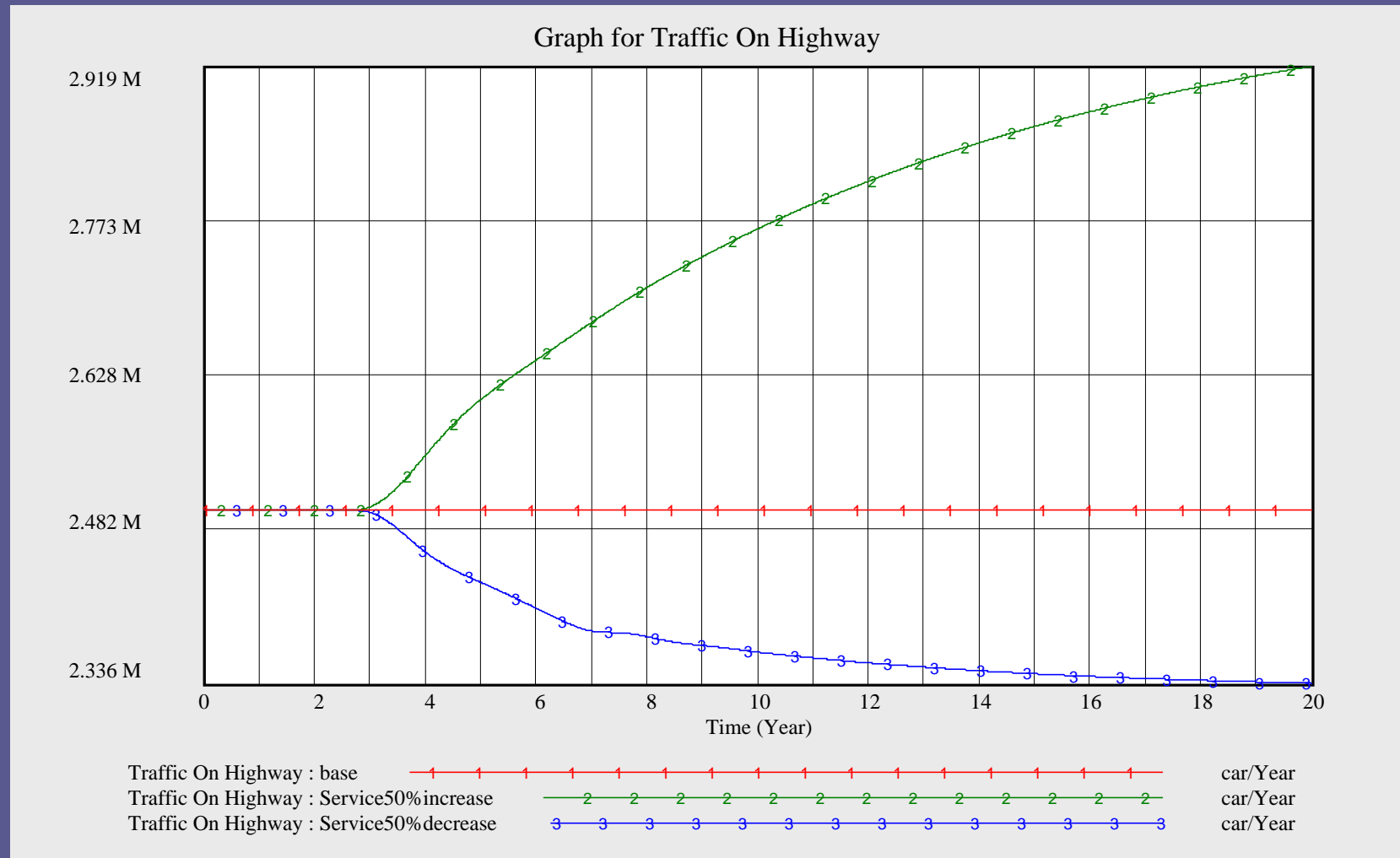
# Model Analysis

## Investment on Service



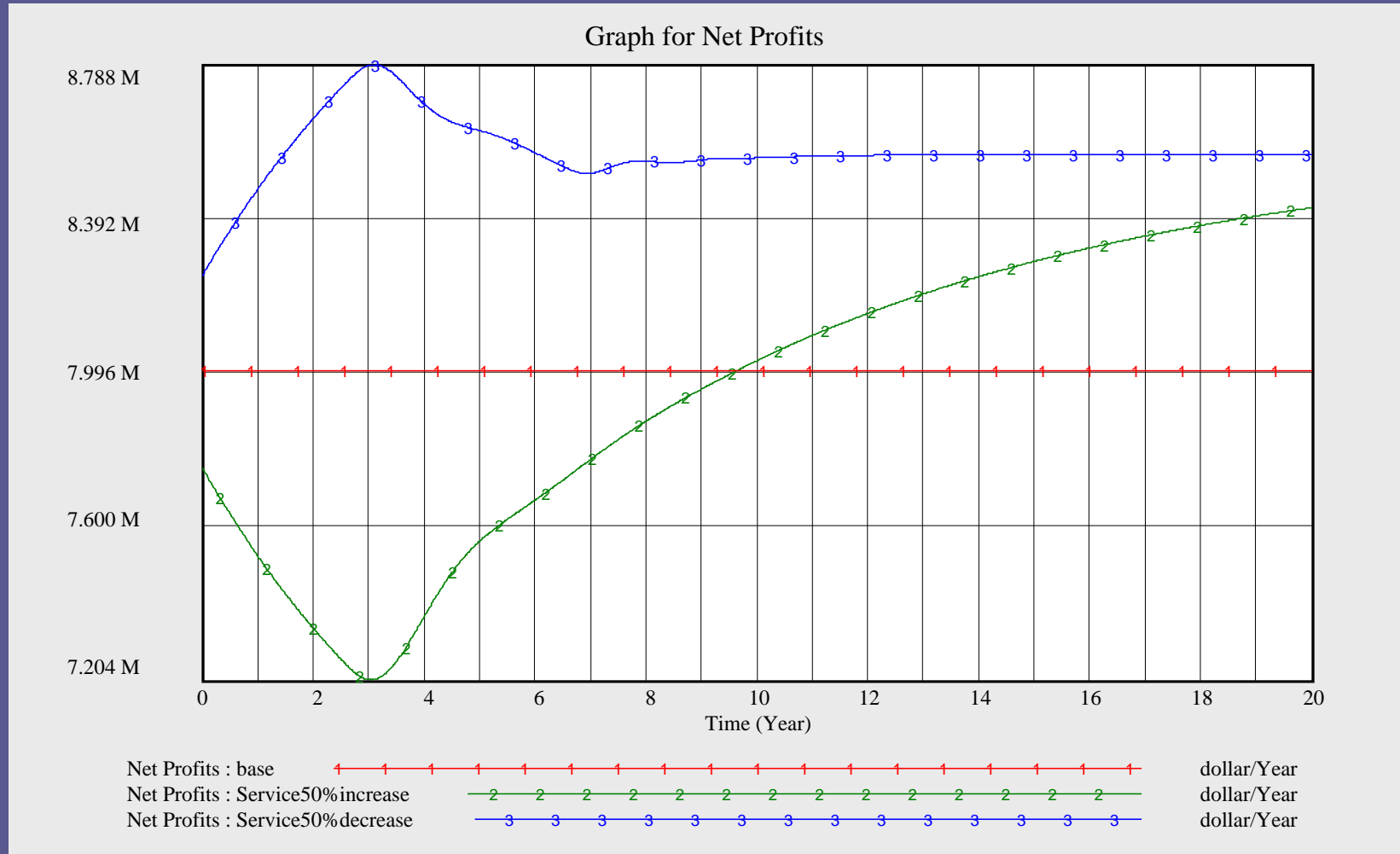
# Model Analysis

## Investment on Service



# Model Analysis

## Investment on Service

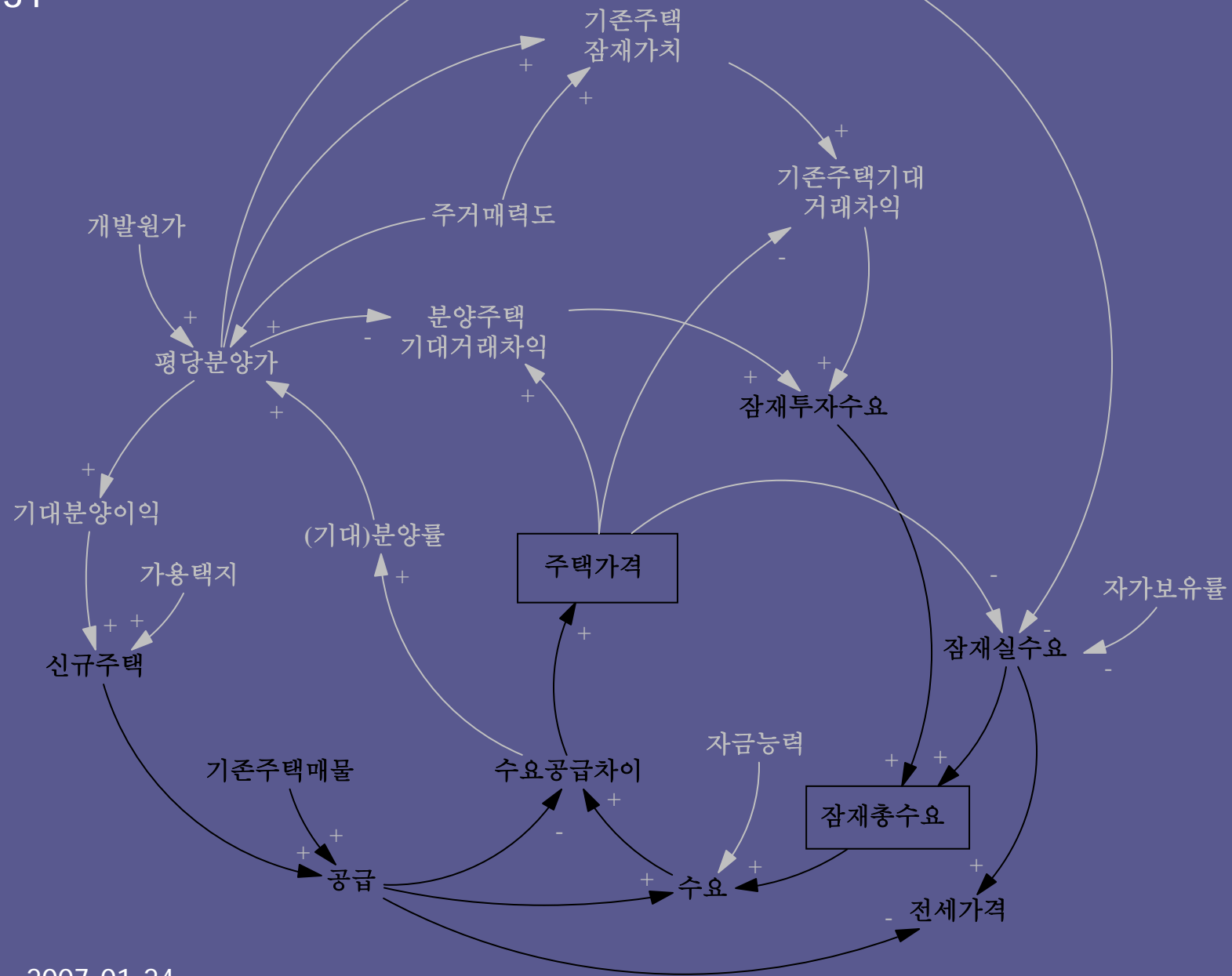


# Policy Implications

- Investment on the service capacity can increase traffic volume and lowers annual net profits.
- However, the system also becomes stabilized, which implies that the long run, we can get almost same annual net profits regardless of the investment amount on service.

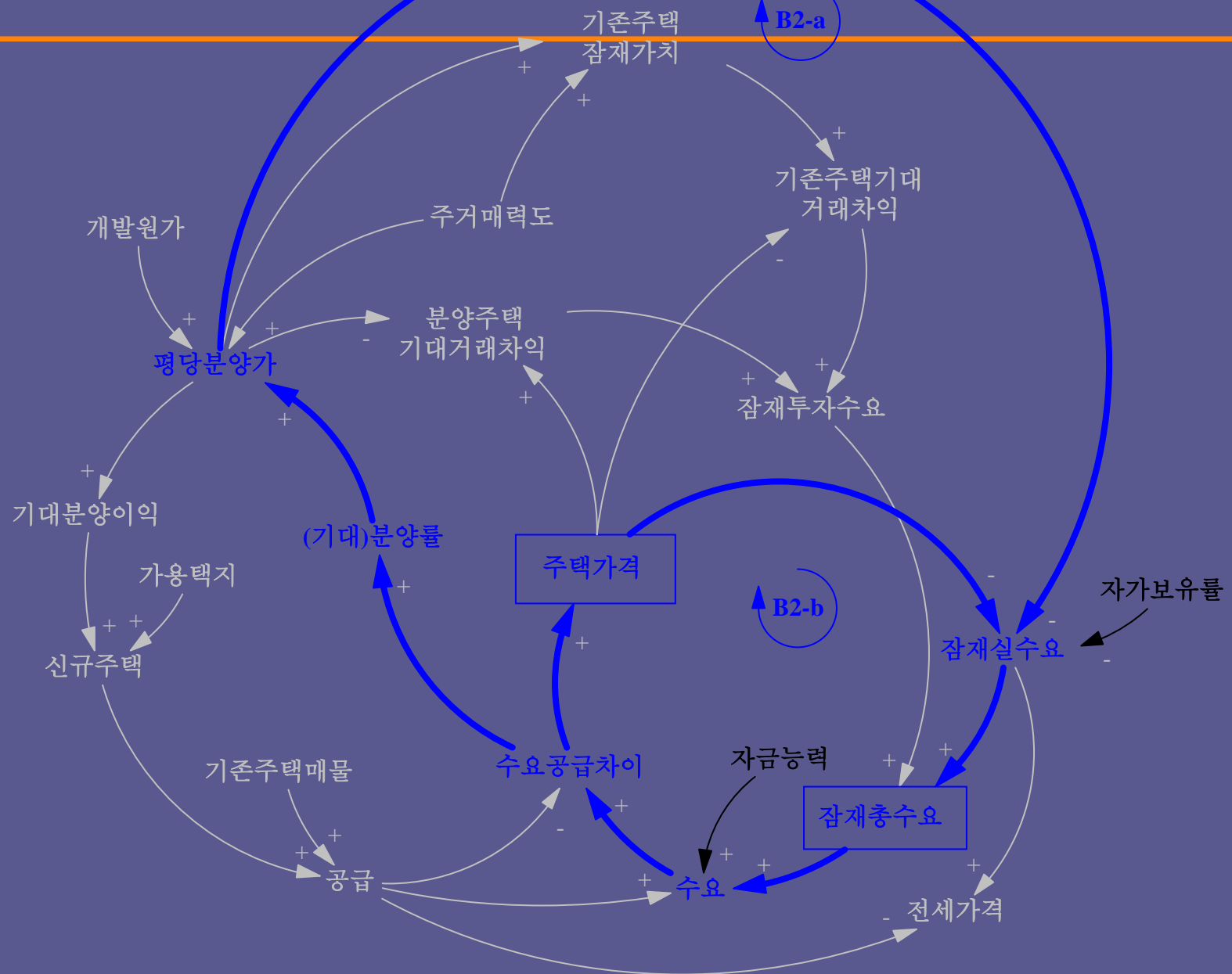
# Policy Recommendations

- Set initial toll price a little bit higher than that of equilibrium case (say 7\$ per car)
- Set the investment amount on service lower than that of equilibrium case (say 50% decrease)
- Invest on marketing for the initial period of operation (say the first 1.5 years)













# References

- Avraham Shtub, Jonathan F. Bard, Shlomo Globerson, "Project management : engineering, technology, and implementation", Englewood Cliffs, NJ, Prentice Hall, 1994
- Frederick E. Gould, Nancy Joyce, Chapter 8, "Construction project management", Upper Saddle River, NJ, Prentice Hall, 1999
- James M. Lyneis \*, Kenneth G. Cooper, Sharon A. Els, "Strategic management of complex projects: a case study using system dynamics", System Dynamics Review, Vol. 17, No. 3, 2001
- Christopher M. Gordon, "Choosing appropriate construction contracting method", J. of Construction Engineering & Management, Vol. 120, No. 1, 1994
- Feniosky Pena-Mora, Jim Lyneis, "Project control and management", MIT 1.432J Lecture Material, 1998
- Barrie, D.S., and Paulson, B.C., "Professional Construction Management", McGraw Hill, 1992
- Halpin, D.W., "Financial and Cost concepts for construction management", John Wiley & Sons, 1995
- Yehiel Rosenfeld, "Project Management", MIT 1.401J Course Material, 2000
- Sarah Slaughter, "Innovation in construction", MIT 1.420 Course Material, 1999
- Chan, Albert P. C.; Ho, Danny C. K.; Tam, C. M, "Design and Build Project Success Factors: Multivariate Analysis", J. of Construction Engineering & Management, Vol. 127, Issue 2, 2001