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THE UNIVERSITY OF DUBLIN

Centre for Transport Research and Innovation for People

Department of Civil, Structural and Environmental Engineering School of Engineering

Time-Dependent Road Network Design Frameworks with Land Use Consideration: Policy Implications

Dr. W.Y. Szeto, Xiaoqing Jaber & Prof. Margaret O'Mahony

Background

This research was carried out to compare three road network design schemes, namely build-operate-transfer, cost recovery, and cross subsidisation, to illustrate the impact of the implementation of road network improvements on the related parties, especially on landowners, and to show trade-offs between various objectives. As these three schemes are widely applied in many countries, it is important to analyse the impact of these schemes. The proposed frameworks in this research allow the evaluation of the impact of the optimal designs on the related parties including government, landowners, toll road operators, transit operators, and road users. This information can be used to help network planners and profit-makers with decision-making by the elimination of many alternative designs.

- **The build-operate-transfer (BOT) scheme** allows a private company to build a toll road and collect tolls to recover the construction and maintenance cost within a franchised period; and after the franchised period is over, all these toll roads are transferred back to the government. This scheme is very common now in Asia and Europe.
- **The exact cost recovery scheme** uses toll revenue to exactly recover the construction and maintenance cost. The tolling and improvement strategy is to maximise the change in SS. Since the objective of this scheme is to maximise the change in SS, the private sector is not willing to be involved. The builder and operator is thus the government. This scheme can be found in India.
- **The cross subsidization scheme** is similar to the exact cost recovery scheme except that the increase in transit profit is used to subsidise the construction and maintenance cost of the toll road. This scheme is not common and only applicable to the place like Ireland when the transit system is government-owned and can generate a huge profit.

Introduction

- **Current problems in the traditional Transport Network Design Problem (NDP)**
  - focusing on the effect of designs on the transport system alone but not on land use
  - land use-transport interaction tends to be ignored over time
  - the benefit of landowners cannot be evaluated without considering the interaction
- **Goal: design a general time-dependent road network design framework encapsulating the Lowry-type land use consideration**

Model Formulations

- **Profit Maximisation Model (PM model)**

  Max TOP (Profit of A Toll Road Operator)

  subject to: time-dependent Lowry-type constraints and modal-split/assignment constraints, road network design constraints, and financial constraints.
- **Cost Recovery Model (CR model)**

  Max "change in social surplus"

  subject to: the same constraints as in the PM model and the cost recovery condition with TOP=0 and Subsidy =0.
- **Cross-subsidisation Model (CS model)**

  Max "change in social surplus"

  subject to: the same constraints as in the CR model, except Subsidy =0; and the cross-subsidization conditions.

Scheme	*Build-operate-transfer (BOT)*	*Exact cost recovery*	*Cross-subsidisation*
Objective	Maximise Profit	Maximise ΔSS	Maximise ΔSS
Operation method	Use toll revenue to recover the construction and maintenance cost	Use toll revenue to *exactly* recover the construction and maintenance cost	Use the increase in transit profit to recover the construction and maintenance cost
Builder and operator	Private entity	Government	Government

Concluding remarks

- **The proposed time-dependent road network design framework**
  - allow the evaluation of the impact of the design on related parties including landowners
  - help network planners and private firms with decision-making
- **Results show**
  - tradeoffs exist between the objectives of all related parties
  - all schemes lead to unequal changes in landowner profits

Reference: Szeto, W. Y., Xiaoqing Jaber, and M. O'Mahony. (2008) Time-dependent Road Network Design Frameworks with Land Use Consideration: Policy Implications. The 87th Transportation Research Board Conference, National Academies, Washington D.C., January 2008, CD-ROM.

Contact details:

Centre for Transport Research and Innovation for People (TRIP), Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin 2, Ireland

Professor Margaret O'Mahony, Email: margaret.omahony@tcd.ie, Phone: 353 1 896 2084 Fax: 353 1 677 3072