Addressing Equity Issues Associated with Roadway Pricing

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Outline

- Introduction
- Traffic Equilibrium
- Bicriterion Traffic Equilibrium
- Equity Issues
- Potential Mitigation Strategies

Introduction

Congestion Pricing

- Roadway pricing is a congestion mitigation strategy that involves charging travelers for using selected links in a network.

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- Tolls may be collected within a city or on freeways and can be static or time-dependent.

Introduction

Congestion Pricing

New York State Thruway

Singapore ERP System

London Cordon Pricing

Introduction

Congestion Pricing

- How to measure the impact of tolls?
- How to set the right amount of tolls?
- Are there any equity issues that arise due to congestion pricing?

Traffic Equilibrium

User equilibrium

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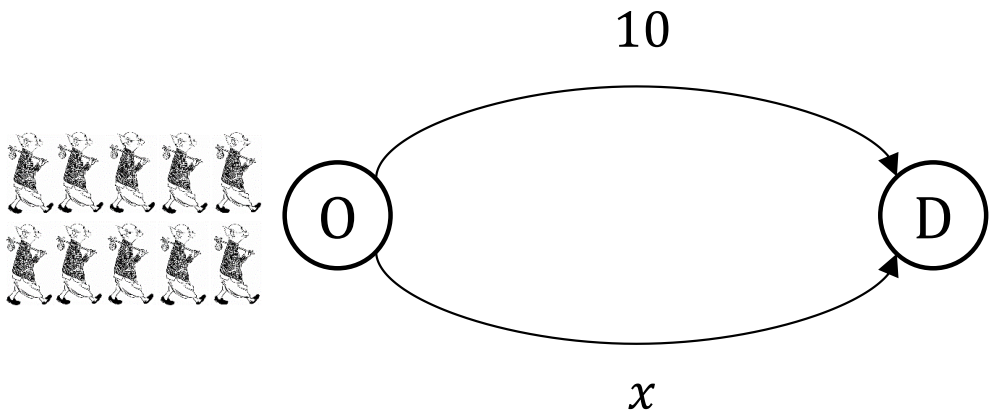

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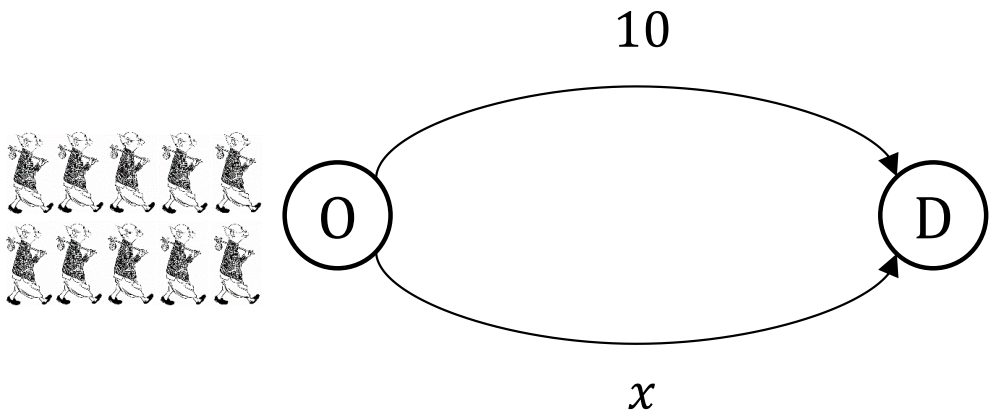

Total travel time of all users $= 10(10) = 100$

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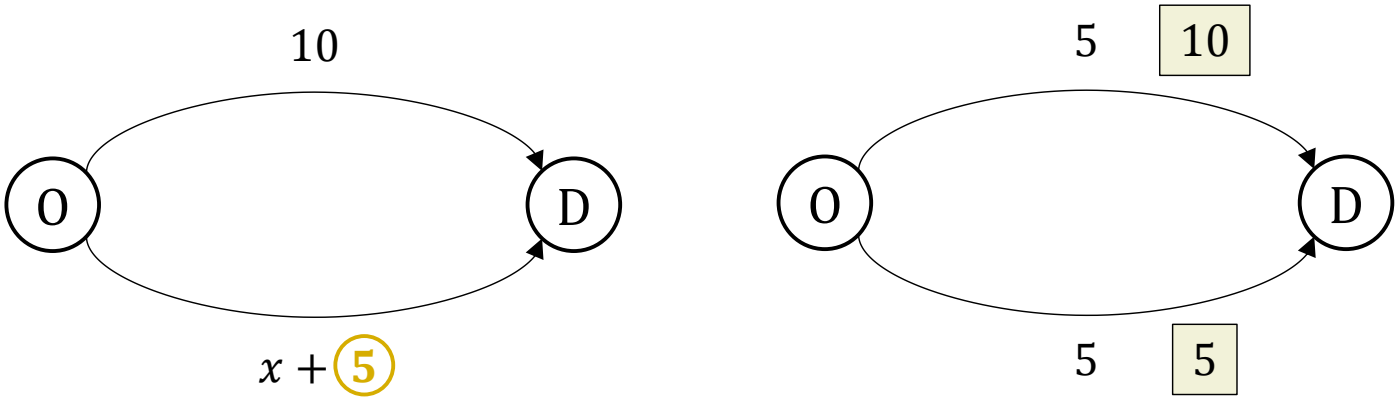

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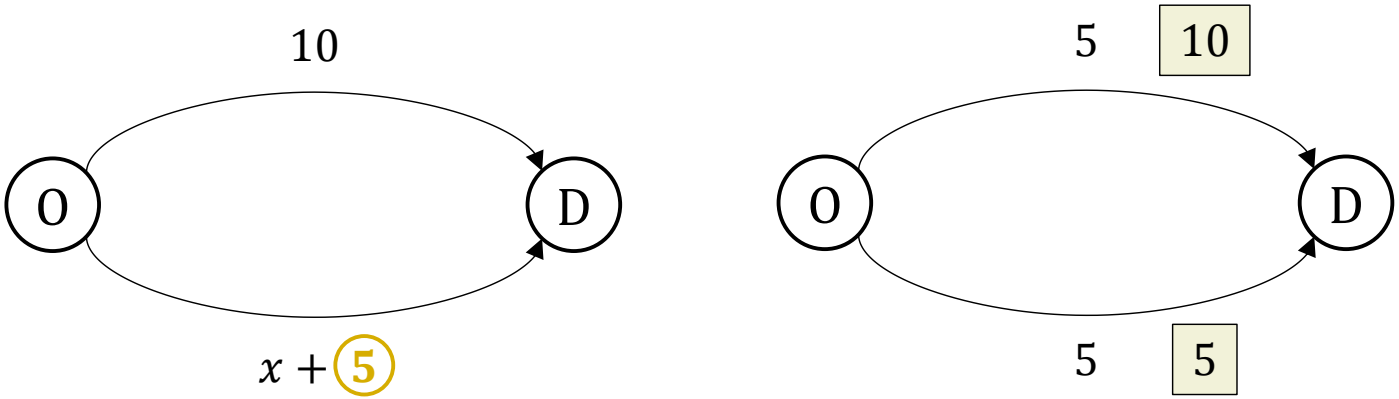
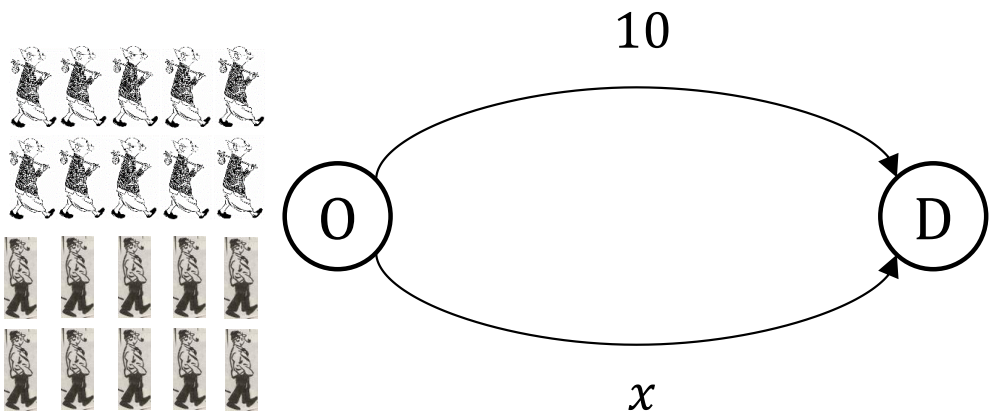


Total travel time of all users $= 5(10) + 5(5) = 75$

Bicriterion Traffic Equilibrium

User equilibrium

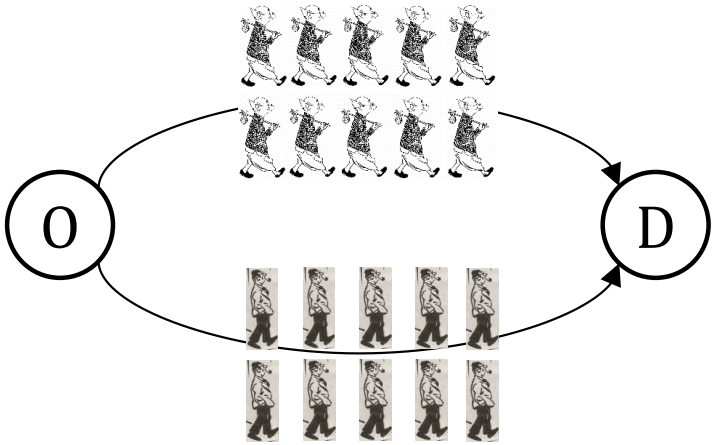
Now suppose there are 10 additional travelers with VOT 2 ₹/ min. Both groups must be on minimum generalized cost paths according to the equilibrium principle.



Bicriterion Traffic Equilibrium

User equilibrium

The equilibrium solution looks as shown below



There are 10 travelers on each link and hence the travel time is 10 min.

Bicriterion Traffic Equilibrium

System Optimum

We now introduce marginal tolls which equal $\bar{\alpha} x t'(x)$, where $\bar{\alpha}$ represents average VOT of users on a link and x and $t'(x)$ represent the volume of travelers and the derivative of the link delay function.

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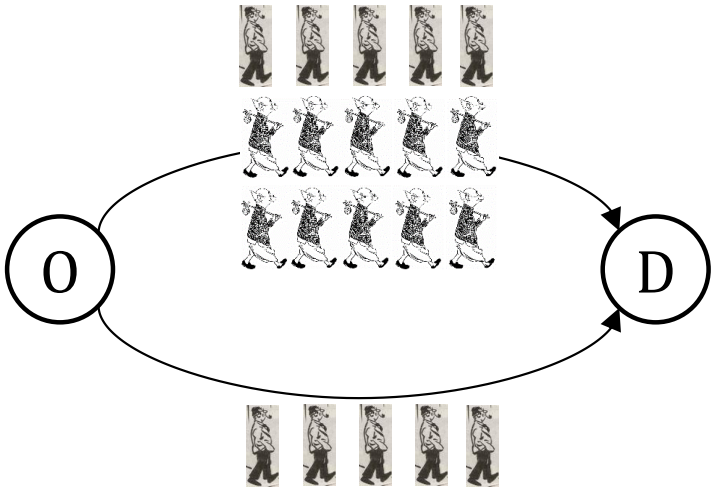

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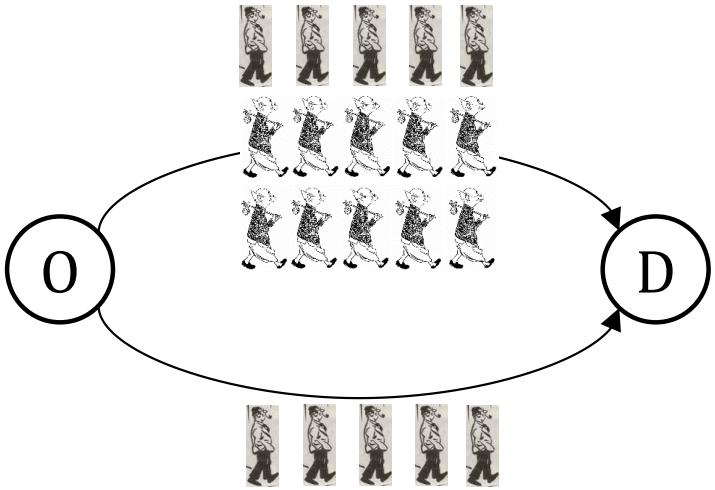

The SO solution shifts 5 travelers with VOT 2 ₹/min to the top path. Note that the travel times on the top and bottom paths are 10 and 5 min and the their tolls are ₹0 and ₹10.

In both examples, travelers paid what they got, i.e., those who paid more experience lesser travel times. The tolls however were not designed to promise better travel times but optimized efficiency.

Equity Issues

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Where's the inequity issue?

- There may not be paths which are toll free forcing everyone to pay.
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- In the second example, travelers with VOT 1 ₹/min are priced out.

These issues can be easily addressed by second pricing and minimum revenue models.

Equity Issues

Evidence and Hypothesis

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Can we model this mathematically to test the hypothesis? How can we minimize inequity if it exists?

Potential Mitigation Strategies

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However, the way we **redistribute revenues** is critical to an equitable congestion pricing framework.

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Each of these strategies must be explicitly modeled to understand who benefits from such projects and how much toll revenue is generated by them using a before vs after equilibrium analysis.

Potential Mitigation Strategies

Other recent solutions

- Targeted incentives
- Credit based congestion pricing schemes

Thank You!

Questions?