Environmental implications of congestion pricing schemes: a case study of Toronto

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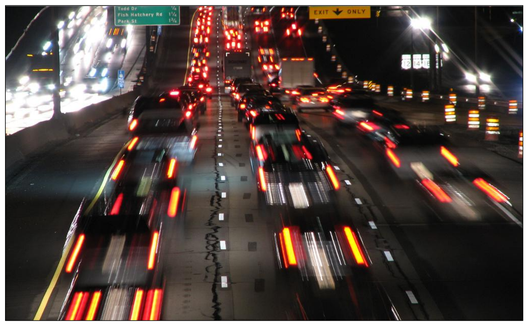
Overview of Research

Area-based tolls are simulated for the city of Toronto with special emphasis placed on the implications of congestion and increasing environmental impacts. The main conclusion is that with an optimal toll the number of trips decreases with increasing environmental costs, but that economic welfare actually increases.

Introduction

According to a Statistics Canada study, personal vehicle use accounted for approximately 63% of total household emissions in 2005. In addition, a study conducted by Transport Canada determined that greenhouse gas emissions from Canadian road networks produced indirect social costs equal to $3.68 billion in 2000. Despite numerous externalities arising from congestion, there are few mechanisms in place to encourage individuals to alter their behavior and reduce driving. Further, existing fuel taxes and road pricing mechanisms are not effective for controlling congestion – it is estimated that only 385km of Canadian roads are tolled. Within this context, it is crucial to implement road pricing mechanisms that reflect the true costs of congestion.



Implementing more efficient and effective road pricing in Canada would help alleviate traffic-related externalities, such as air pollution and congestion, and would also act as a new source of revenue to fund roadway infrastructure.

User-Fee Charges on Roads

A user charge on roads that reflects marginal social costs would make road use more economically efficient. Operationalizing the concept of the marginal social cost of roads – a notion that refers to the idea that each additional vehicle-trip undertaken should include all costs, including external costs, that it imposes on society – involves *internalizing* road transport externalities, so that the private costs of driving equal the social costs of driving.

This project aims to evaluate the prospects of area-based tolls for the City of Toronto. The results suggest that road pricing could be used to address congestion relief, and act as a user-paid source of funds for roadway infrastructure.

Methodology

A static model is adapted from Lindsey's (2007) paper titled, "Prospects for Urban Road Pricing in Canada". The model assumes that vehicle trips are made from a single origin to a single destination with one person per vehicle.

Model

The welfare maximizing toll in equilibrium is calculated according to the following equation:

$$\tau = \Gamma d + (MCPF - 1)(b + \Gamma \mathrm{d})\mathrm{D}^{-1}(a - c) + (b + \Gamma d)\mathrm{D}^{-1}e$$

The social surplus including toll revenues is calculated from the following equation:

$$W = aN - \frac{bN^2}{2} - (c + \Gamma dN + e)N + (MCPF - 1) * \tau N$$

For the City of Toronto, the following table presents key parameters for the optimal toll model:

Table 1: Key Parameters for City of Toronto	
Value of Travel Time	$31.447/hr
Driving Distance	12km
Space mean speed	33.3km/h
Operating and maintenance cost	$0.081/km
Variable component of vehicle capital cost	$0.039/km
Parking cost	$5
Schedule delay cost	$2
Time structure of toll	1
Elasticity of demand	0.5
Revenue Generation	1
Proportional increase in travel time due to congestion	0.25
Equilibrium Number of Trips	386, 400

Results

The following three tables present core results along with sensitivity analysis obtained from the model:

Fig.1: Relationship between Optimal Toll and Environmental Cost

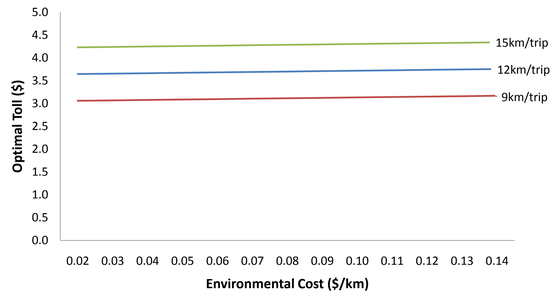


Fig.2: Relationship between the Number of Trips and Environmental Cost when Optimal Toll is Imposed

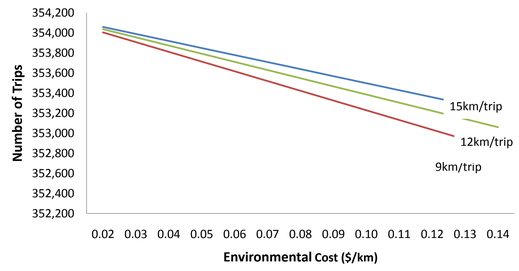
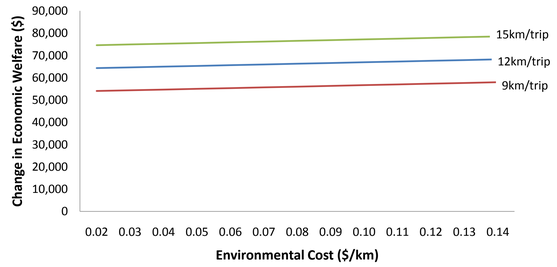


Fig.3: The Change in Economic Welfare versus Environmental Cost when Optimal Toll is Imposed



Sensitivity analysis was conducted around distance travelled per trip. The above figures examine three scenarios, assuming trip distances equal to 9km, 12km and 15km.

The main findings are:

- Figure 1 demonstrates that the optimal toll increases as environmental costs increase;
- Figure 2 illustrates that the number of trips decreases as environmental costs increase; and,
- Figure 3 shows that economic welfare increases as environmental costs increase when the optimal toll is imposed. This implies that even though Torontonians are taking fewer car trips their overall economic welfare increases due to a reduction in negative externalities.

Several limitations of the results should be mentioned:

- First, data to calibrate the model for the City of Toronto are challenging to find. Values from several other cities were often used as proxies.
- Second, the model is not spatial and disregards spillover effects of the cordon toll on the rest of the untolled network.
- Finally, the model assumes that travelers' behavior is identical except for their reservation price to drive.

Policy Implications

Since road related-revenues do not cover the total costs of roads, the remainder is paid for by general tax revenues. The high subsidization of roads has caused an artificially high demand for roadway infrastructure and excess vehicle use, leading to economically inefficient outcomes which are overall detrimental to society in terms of congestion and pollution. An increase in road related revenues will allow governments to cover a greater proportion of the cost of roads through direct taxation, and will free up general tax revenues currently being spent on roads to be used for other priorities.

Regardless of whether fuel taxes or road pricing mechanisms are employed, determining how revenues will be used from the pricing mechanism is crucial in shaping behaviours. If revenues are used efficiently to reduce other taxes or to provide additional beneficial services, they may be able to offer significant net benefits. For example, a portion of revenues could be used to justify spending on improving travel options. On the other hand, using revenues wastefully can reduce prospective economic welfare gains.

Conclusion

Overall, it is evident that congestion and pollution externalities generate a high cost for Toronto. An optimal toll yields to an overall welfare increase even as the number of trips decreases. User charges enable the internalization of externalities, ultimately making residents of Toronto better off by alleviating the unintended costs of congestion and vehicle-related air pollution.

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City of Toronto

Facts on Toronto:

- Average commute time is 33 minutes
- Average commute distance is 12km

Barriers to Implementation:

- Resistance from the petroleum, vehicle and transportation industries, and car users
- May require tolling currently untolled highways

thestar.com 65% of Torontonians say no to road tolls; 72% want bike lanes

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