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Urban Transportation Financing: theory and policy in Ontario

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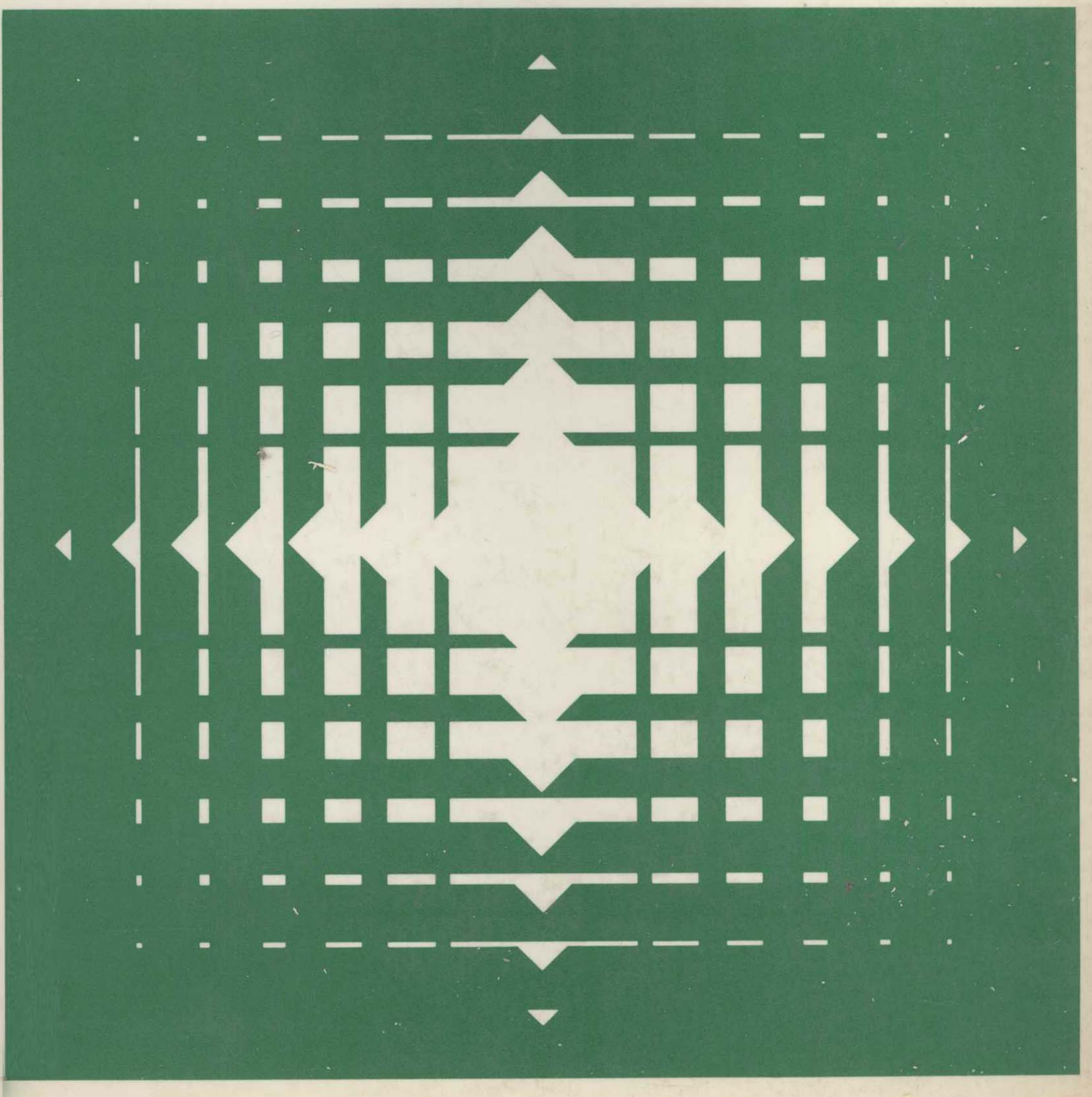

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This report reflects the views of the author and not necessarily those of the Ontario Economic Council or the Ontario government. The Council establishes policy questions to be investigated and commissions research projects, but it does not influence the conclusions or recommendations of authors. The decision to sponsor publication of this study was based on its competence and relevance to public policy and was made with the advice of anonymous referees expert in the area.

Preface

In writing this study I have benefited from the use of unpublished data provided by R. Allen Harvey of the Canadian Transit Association, Juri Pill of the Toronto Transit Commission, Gordon Arblaster of the London Transit Commission, and Gerry McMillan of the Ontario Ministry of Transportation and Communications. At the same time, I have concluded that the public would benefit from publication by the Ministry of Transportation and Communications of much more complete data on the province's transit subsidy programs, since much information about what is done with the tax-payers' dollars is not readily available.

I have also received valuable comments from the participants in two seminars held at the Ontario Economic Council and from Richard Arnott, Donald Dewees, George Fallis, David Gillen, Stephen Glaister, Herbert Mohring, Richard Puccini, and Enid Slack. Of course it should not be assumed that any of these people agree with my analysis or conclusions.

This study deals almost exclusively with urban transportation pricing and subsidy policies. Readers who are also interested in other urban transportation issues, such as modal choice behaviour, regulatory policies, and evaluation of investment decisions, may wish to read my textbook on *Urban Transportation Economics* (Toronto: Butterworths, 1979).

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URBAN TRANSPORTATION FINANCING: THEORY AND POLICY IN ONTARIO

1
Introduction

OVERVIEW

This economic analysis of urban transportation financing in Ontario has a double purpose. First, since few of the urban transportation policy-makers in Ontario are trained in economics, it tries to demonstrate the importance and usefulness of evaluating the economic merits of policy alternatives. Second, it attempts to determine whether existing policies waste resources or lead to undesirable transfers of income between different groups of people. When existing policies are found to be deficient, it suggests improvements in the ways people are charged for the use of roads and public transit and in the ways governments subsidize transit.

Resources are being wasted, for example, because use of urban roads is substantially underpriced during periods of peak demand. Furthermore, while there are sound economic justifications for substantial public transit subsidies, the allocation of subsidies by the Ontario provincial government on the basis of capital expenditures can be expected to waste resources. It is also concluded that maximization of ridership is not an appropriate objective for public transit systems because it is likely to lead to fare and service policies which waste resources.

On a number of other questions the information available was not sufficient to evaluate policy. For example, there was not enough evidence to determine whether the recent introduction of monthly transit passes in a number of urban areas in Ontario has wasted resources or not. Similarly, the merits of introducing in Ontario automated transit fare collection or honour fare systems of the type used in some West European cities could not be assessed. Nevertheless, the criteria of resource waste in these cases have been explained in light of the type of economic analysis needed in the future formulation of transportation policy.

OUTLINE OF THE STUDY

This study provides an economic analysis of the major issues involved in three areas of urban transportation financing policy: road pricing, transit fares, and transit subsidies. Rather than devoting equal resources to original research on each of the three topics, it was decided to concentrate on evaluation of transit subsidy programs and, secondarily, on transit fare policies. Extensive research has already been done on the economics of road pricing, while the literature on transit subsidies is quite meagre, and significant gaps exist in the literature on transit fare policies (such as on fare collection costs and monthly passes). Road pricing thus occupies only a single chapter (Chapter 2), whereas transit fare policies occupy two (Chapters 3 and 4), and transit subsidy policies occupy six (Chapters 5 to 10).

The reader must first be aware of the existing underpricing of road use in order to understand the issues involved in transit financing. The analysis of transit fares then makes the point that economically efficient transit fares will not raise enough revenue to finance an efficient level of transit services. This leads finally to the discussion of transit subsidies, which bridge the gap between transit revenues and costs.

Chapter 2 summarizes what economists have written about road user charges, including pollution and congestion charges. The discussion of this important topic has been deliberately kept brief because comprehensive road pricing was felt unlikely to win political acceptance in any urban area in Ontario in the foreseeable future regardless of its economic merits. Nevertheless, this question has important implications for a number of other policy issues such as the pricing of parking, gasoline, and public transit.

Chapters 3 and 4 provide an economic analysis of urban transit fare policies. Chapter 3 deals with the following topics: (i) efficient fare policies based on marginal social cost pricing principles, including peak / off-peak fare differentials, fares based on distance, and charging for transfers; (ii) fare policies which are efficient when the use of automobiles is priced below marginal social cost; (iii) fare policies which are efficient when the transit system is subject to a deficit constraint; (iv) the welfare gain from efficient fare policies; and (v) the economic costs of alternative methods of fare collection. Chapter 4 then deals with (vi) monthly transit passes; (vii) income distributional effects of transit fare alternatives; and (viii) a comparison of ridership maximization and economic efficiency as objectives for urban transit systems.

The remainder of the monograph is devoted to an economic analysis of urban transit subsidies. Chapter 5 explains and evaluates four arguments for subsidizing public transit in order to increase the efficiency of resource allocation, on the grounds that marginal cost is below average cost for public transit because of increasing returns to scale; private automobile trips are priced below their marginal social cost; there are external benefits associated with the form of urban development promoted by the existence of high-quality, low-fare public transit; and the knowledge gained from research and demonstration projects in urban public transit is a public good which benefits many urban areas. We also examine the justification for transit subsidies based on income distributional effects, how the level of subsidies should vary among cities of different sizes, and how the burden of subsidies should be allocated between local, provincial, and federal governments.

Chapter 6 describes the various federal, provincial, and municipal transit subsidy programs which have operated in Ontario during the past two decades, including capital and operating subsidies for subway, streetcar, and bus systems, the GO Transit commuter rail / bus system, and demonstration projects such as dial-a-bus. The chapter also includes a brief summary of subsidies available in other provinces and elsewhere.

Chapters 7 to 10 evaluate the effects of transit subsidies in Ontario on resource allocation and income distribution.

Chapter 7 surveys the many different consequences of transit subsidies, from the effects on fares and services, through the effects on capital intensity, labour contracts, and technical efficiency, to the effects on income distribution. It also looks at how provincial subsidy policies influence municipal government subsidies.

Chapters 8 to 10 focus on the effects of subsidies on fares, service, and ridership. Chapter 8 analyses the results of alternative transit subsidy formulas by means of an explicit theoretical model of a transit system under alternative assumptions about the objectives of the transit firm.

By contrast to the analysis in Chapter 8, which is entirely theoretical, Chapters 9 and 10 are empirical studies of the effects of transit subsidies on fares, service, and ridership using two different sets of data. Chapter 9 uses data from nine urban areas in Ontario for 1950-78 to make a graphical analysis of the effects of subsidies. Chapter 10 uses data from London, Ontario, to make a statistical analysis with an explicit econometric model.

Chapter 11 presents the conclusions of the study and recommendations for urban transportation pricing and subsidy policies in Ontario.

2
Road pricing policies

Although a system of comprehensive road pricing in which road users are charged for the congestion and pollution costs imposed by their trips is unlikely to be established in the near future in any urban area in Ontario, there are two reasons that anyone interested in urban transportation problems should be familiar with the question. First, some simple measures to charge for the use of roads through parking or gasoline taxes might become feasible, particularly if more people understand their justification. Second, an understanding of the optimal road user charges allows one to appreciate the consequences of *not* collecting such charges. One cannot analyse urban transit fare policies or evaluate the case for urban transit subsidies without understanding the complications that arise because of the failure to charge for road use on the basis of marginal social cost.

EFFICIENT URBAN ROAD USER CHARGES[1]

If the government wishes to achieve an efficient allocation of resources (including efficient use of existing urban roads and urban land), road user charges should be set so that road users pay the marginal social costs of their trips. The marginal social cost of a trip is the value of the other goods and services (including leisure) that are given up by all members of society because that trip is produced.[2] If road users pay the marginal social costs of their trips, they will take

1 For a more detailed discussion of this topic, see Frankena (1979, chap. 4).

2 The marginal social cost of a trip on an existing urban road normally consists of the travel time and the vehicle operating costs of the person making the trip, the congestion and pollution costs imposed on others, and the wear and tear of the road.

The analysis of the efficiency of marginal social cost pricing for road use applied in this chapter rests on three assumptions. First, collection of road user charges is costless.

only those trips for which their willingness to pay is at least as much as the amount that all affected parties would be willing to accept as compensation for giving up all the goods and services forgone when scarce resources are allocated to the production of road trips. In this case, the allocation of resources will be efficient. By contrast, if road users pay less than the marginal social costs of their trips, they will take some trips which they value at less than the marginal social cost. In this case, the allocation of resources will be inefficient.

The marginal *social* cost of an extra road vehicle trip on an existing road consists of five elements: (i) the value of the travel time of the people in the vehicle making the extra trip; (ii) the operating costs of the vehicle making the extra trip; (iii) the marginal *congestion* costs imposed on other road users because the extra vehicle trip increases the density of traffic on the road and hence increases travel times, vehicle operating costs, and the risk of accidents for other road users due to congestion; (iv) the marginal *pollution* costs imposed on others because the extra vehicle trip increases air and noise pollution damage; and (v) the marginal *road maintenance* costs imposed on the government because the extra vehicle trip increases wear and tear of the road and increases requirements for road administration, police, and court services.

In the absence of road user charges, the marginal *private* cost of using an urban road includes only the first two of the preceding five elements.[3] Consequently, the marginal private cost of vehicle trips would be less than the marginal

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Second, there are no distortions in related sectors of the economy which interfere with the efficient allocation of resources, e.g. other goods and services such as urban transit rides are priced at marginal social cost. Third, there are no costs involved in raising revenues to finance the road system in the event that the revenues from road user charges are not adequate for this purpose.

3 The marginal *private* cost of a trip is the cost of the trip which is actually borne by the person who takes the trip. In the absence of road user charges, the person who takes a trip bears the cost of his own travel time and vehicle operating expenses but does not bear the congestion and pollution damage or the maintenance costs imposed on others by the trip. The congestion and pollution damage and the maintenance costs are the marginal *external* costs of a trip. The marginal private cost and the marginal external costs add up to the marginal social cost of a trip.

There are two reasons that the marginal private costs of vehicle operation may understate the corresponding category of marginal social costs. First, automobile insurance premiums in Ontario typically do not depend on current automobile use, except to the extent that they depend on whether an automobile is used in an urban area, whether it is used for work trips, and whether it is driven more than 10000 miles per year. Second, in recent years gasoline has been priced below its marginal social cost as a result of federal government policy.

social cost in circumstances in which an additional vehicle trip increases congestion, pollution damage, or wear and tear of roads. As a result, some people would take road trips which they value at less than the marginal social cost, and road use would be inefficiently high. In addition, the level of pollution damage per vehicle trip would be inefficiently high.[4]

In these circumstances the government could reduce road use to an efficient level, and also reduce the level of pollution per vehicle trip to an efficient level, by imposing appropriate road use and pollution charges. These charges per vehicle trip would be equal to the sum of the three marginal external costs imposed by an extra vehicle trip, that is, the marginal congestion costs, the marginal pollution costs, and the marginal road maintenance costs. Imposition of these user charges would raise the marginal private cost per vehicle trip to the level of the marginal social cost.

The manner in which these charges might be applied will be discussed further below. But first we will consider how they are calculated.

MODEL OF ROAD CONGESTION CHARGES

For the sake of simplicity, we will assume in this example that road users do not impose pollution damage or wear and tear on the road. Because of this assumption, the only marginal external cost of road vehicle trips is the marginal congestion cost imposed on other road users.

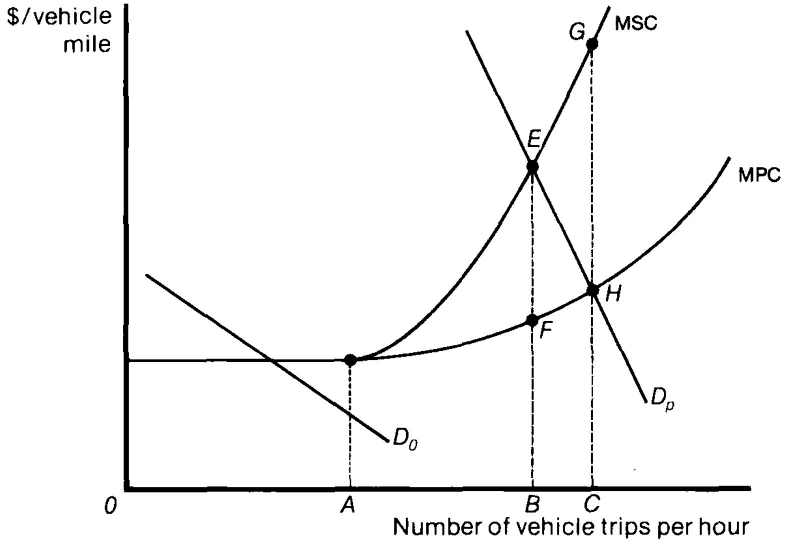
Suppose that the relationship between the marginal private cost (including time and vehicle operating costs) of travel per vehicle mile and the number of vehicle trips per hour on an existing road is given by the curve labelled MPC in Figure 1.[5] In this case there is no congestion, and hence MPC is horizontal, as long as the number of vehicle trips per hour is less than *OA*, but congestion begins, and hence MPC slopes up, when the number of vehicle trips exceeds *OA*. Since there is no congestion if the number of vehicle trips per hour is less than *OA*, in this range an extra vehicle trip does not impose any marginal congestion costs on other road users. Consequently, the marginal social cost (MSC) per vehicle mile is identical to the marginal private cost, i.e. the MSC and MPC curves coincide.

However, when the number of vehicle trips per hour exceeds *OA*, an extra vehicle trip imposes marginal congestion costs on other road users. Consequently, the MSC curve lies above the MPC curve. The vertical distance between

4 Unless emissions were restricted to the efficient level by regulatory policies.

5 It is implicit in this relationship that all vehicles have the same value of travel time per hour. Appendix A deals with a model in which there are two income groups with different values of travel time.

Figure 1
Model of a congested road



the MSC and MPC curves at each level of vehicle flow measures the marginal congestion costs per vehicle mile imposed on all other road users combined by an extra vehicle trip. The distance between the MSC and MPC curves increases as the number of vehicle trips per hour increases, reflecting the fact that as the road becomes more congested the marginal congestion cost imposed by an extra vehicle trip increases. Figure 1 makes it clear that at any level of road use the marginal social cost per vehicle-mile of an extra vehicle trip consists of the marginal private cost per vehicle mile borne by the vehicle that makes the trip plus the marginal congestion cost imposed on other road users.

We can now use Figure 1 to demonstrate the nature of the inefficiency which will result if the government does not charge for the use of congested roads. Suppose that during periods of peak demand the demand curve for vehicle trips per hour is represented by D_p in Figure 1. The equilibrium number of vehicle trips would be *OC*, where D_p and MPC intersect. This is an equilibrium because at the trip level *OC* the marginal private cost per vehicle mile is equal to the price per vehicle mile at which people would take *OC* trips.

The level of road use at *OC* is inefficient, because a number of people would be taking trips they value at less than marginal social cost. For example, when *OC* trips are being taken, one of the road users values a trip at only *CH* dollars per vehicle mile, but the marginal social cost of the last trip produced would be *CG* dollars per vehicle mile. Thus, production of the trip for the person who values it at only *CH* dollars per vehicle mile involves a net waste of resources of *HG* dollars per vehicle mile.

In fact, the efficient number of vehicle trips would be *OB*, where D_p and MSC intersect. When *OB* trips are being produced and are taken by the people who are willing to pay the most for them, only those people who are willing to pay the marginal social cost of an extra vehicle trip (*BE* dollars per vehicle mile) would be taking trips.

The dollar value of the gain in efficiency from restricting the number of trips per hour from *OC* to *OB* would be the area of the triangle *EGH*.[6] The area *EGH* is equal to the marginal social cost of increasing the number of vehicle trips per hour from *OB* to *OC* minus what people would be willing to pay for the *BC* extra trips.

The underlying source of the inefficiency in road use is that in deciding whether to use the road people ignore the marginal congestion costs imposed on others. They compare the value of trips to the cost they bear personally rather than to the marginal social cost.

One way to achieve efficient use of the road would be for the government to impose on all vehicles a congestion charge per vehicle mile equal to the marginal congestion cost, i.e. the vertical distance between MSC and MPC, at the level of road use where D_p and MSC intersect. In the present example, the charge would be *EF* dollars per vehicle mile.

The preceding analysis applies to hours of the day during which there is congestion. Now consider a time, such as the middle of the night, when the demand for trips is so low that the number of vehicle trips per hour is less than *OA* and there is no congestion. Suppose that during such periods the demand is represented by the curve labelled D_o in Figure 1. Since the MSC and MPC curves coincide for low numbers of vehicle trips per hour, the equilibrium number of trips that will be taken (which is determined where D_o and MPC intersect) and the efficient number of trips (where D_o and MSC intersect) are the same. Consequently, if it wishes to achieve an efficient allocation of resources, the government should not impose any road user congestion charge during hours when there is no congestion.

It can be concluded that in this model the charge the government would have to collect in order to achieve efficient use of roads varies with the extent of congestion. It would be relatively high on downtown streets and in the direction

6 This assumes that trips are taken by the people who are willing to pay the most for them and is only an approximation since we should be using an income-compensated demand curve.

of peak flow on urban arterial roads during rush hour, and it would be low or zero on suburban residential streets, on rural roads, and during non-rush hours generally.[7]

ESTIMATES OF EFFICIENT URBAN ROAD USER CHARGES

Congestion charges

Dewees provides estimates of the marginal congestion costs imposed by an additional morning rush-hour automobile trip in each direction on a number of different roads in an area about seven miles from downtown Toronto. The estimates take the existing transportation system as given and consider time costs alone. The marginal congestion costs range from zero to over one dollar per vehicle mile. On average, the marginal congestion costs were 25 cents per vehicle mile for all automobiles combined, 38 cents per vehicle mile for inbound automobiles, and 4 cents per vehicle mile for outbound automobiles.[8] Dewees also estimates that at mid-day the marginal congestion costs averaged 1.4 cents per vehicle mile for inbound automobiles (Dewees 1978).

The preceding figures exceed the efficient congestion charges relevant to time costs alone for the existing transportation facilities in Toronto. This is because the marginal congestion costs calculated by Dewees during peak periods correspond to the distance *HG* (i.e. the marginal congestion costs that would be observed in the absence of congestion tolls) rather than the distance *FE* (i.e. the marginal congestion costs that would be observed if efficient congestion tolls were imposed) in Figure 1.[9]

In a study for expressways in a large U.S. urban area, Keeler and Small (1977) find that, if the level of investment in expressways were efficient, then considering only time costs the efficient congestion charge for private automobiles would be about 0.1 to 0.2 cents per vehicle mile on all expressways at night; 0.3 to 1.2 cents on all expressways between 9 a.m. and 4 p.m.; 2 to 9 cents on rural and suburban expressways in the peak direction at rush hour; and 6 to 34 cents on central city expressways in the peak direction at rush hour.[10]

7 These comments are based on a simple model of road congestion in which there is assumed to be no pollution damage and no wear and tear of roads. In the real world it would sometimes be efficient for the government to impose pollution charges and road maintenance charges on road users even when there is no congestion.

8 Dewees (1979). The value of travel time is assumed to be $3.75 per vehicle-hour.

9 However, the calculations assume no rain or snow, no accidents, and no road repairs, so that they tend to understate average congestion costs.

10 Keeler and Small (1977). The value of travel time is assumed to be between $2.25 and $4.50 per vehicle-hour. Road construction costs are in 1972 dollars.