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Pricing in Road Transport

A Multi-Disciplinary Perspective

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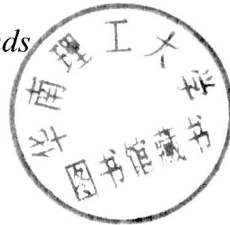
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Pricing in Road Transport

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1. Introduction

Linda Steg, Erik Verhoef, Michiel Bliemer and Bert van Wee

1.1 BACKGROUND

Various developments have put (or kept) road pricing high on the political agenda in most societies. One is the seemingly relentless growth in road transport volumes, causing side-effects such as congestion and pollution, which are among the greatest inconveniences of contemporary urban life. Another is the ongoing improvement in technologies for automated vehicle identification and charging, making sophisticated transport pricing an increasingly attractive option to deal with these side-effects. But also increasing demands on public budgets motivate the search for alternative funding of road infrastructure construction and maintenance.

Most transport analysts would agree that road pricing is a potentially effective instrument for curbing transport and transport-related problems. Likewise, many policy documents, from local authorities, as well as national and international governments, identify road pricing as one of the key cornerstones of contemporary transport policies, and support this by a variety of arguments, ranging from effectiveness and economic efficiency to considerations of fairness and transparency in the financing of infrastructure (the ‘user-pays principle’). But public acceptability often seems to be lagging behind, so that actual implementations, although growing in number, remain scarce. Nevertheless, with the introduction of the London congestion charge in 2003 (see also Chapter 14), and the implementation of charging in Stockholm in the Summer of 2007 (see also Chapter 10), one might hypothesize that urban road pricing is entering a new phase in its history, and will soon spread over Europe and other parts of the world.

Although past research has produced many valuable insights into the workings and possible effects of road-pricing measures, there are still many unanswered questions, involving, *inter alia*, the optimal design of such measures, the (behavioural) effects they may induce among individuals and firms, and questions surrounding the acceptability of road pricing. These and related questions stimulated us to write this book.

1.2 AIM OF THE BOOK

This book aims to provide a multidisciplinary view on the effectiveness and acceptability of pricing in road transport.¹ After a general introduction to road pricing, four topics will be addressed. First, we elaborate on the possible behavioural responses to road pricing. Second, we illustrate how model studies may assist in designing optimal road-pricing policies, given different policy objectives. Third, we describe the acceptability of different types of road-pricing policies by the general public and firms, and indicate how such policies may affect geographical accessibility. Finally, we discuss to what extent road pricing has actually proved to be effective, and indicate the prospects for implementing transport infrastructure pricing in Europe.

1.3 OVERVIEW OF THE CHAPTERS

In Chapter 2, Erik Verhoef provides a basic introduction to the economic theory of road pricing. Introducing concepts and terminology, this chapter serves as a lead-in to the further chapters in this book. Moreover, Verhoef reviews the possible objectives of road pricing, and indicates that the optimal design of road-pricing schemes depends on the objectives set by the relevant authorities. The remainder of the book comprises four parts.

Part I elaborates on the behavioural responses to road pricing. In Chapter 3, David Hensher and Sean Puckett discuss the effects of road pricing on freight transporters and shippers. More specifically, they compare the potential effects of increases in fuel prices (the current main source of charging) and distance-based charges in freight transport. In addition, they examine which of these pricing policies is preferred most by transporters, and why this is so.

As pointed out by Hensher and Puckett, road pricing may especially result in travel-time reliability gains, which in turn have an impact on agents' decision making. Taking this subject further, in Chapter 4, Dirk van Amelsfort, Piet Bovy, Michiel Bliemer and Barry Ubbels indicate how travel-time unreliability may be taken into account in modelling travellers' choice decisions. They discuss different approaches to modelling travel-time unreliability in a discrete choice setting, which may give rise to different values of travel-time reliability, and they argue which value of travel-time unreliability is in their view most plausible. Furthermore, they examine whether it is possible and worthwhile to separate the effects of travel-time reliability on travel-choice behaviour.

Barry Ubbels, Taede Tillema, Erik Verhoef and Bert van Wee analyse the effects of kilometre charging on changes in car use, car ownership and

relocation choices of households in Chapter 5. Some of these changes are more likely to occur in the short term (for example, driving at other times), while others concern long-term changes (for example, changes in car ownership or relocation decisions). The authors elaborate on which types of car trips are most likely to be affected by road pricing, and which types of charges would be most successful in bringing about changes in car use.

Chapter 6 focuses on effects of road pricing on firms. Taede Tillema, Bert van Wee, Jan Rouwendal and Jos van Ommeren argue that road pricing may affect firms' decisions in various ways: road pricing may affect not only firms' travel behaviour, but also their business and human resource policies. The authors consider the effects of kilometre charging on trip frequency, time of travel and types of trips (for example, business or transport of goods). Moreover, they examine to what extent firms intend to reimburse their employees, which may seriously affect the effectiveness of kilometre charging on commuter trips. Also, they describe to what degree firms consider mitigating (extra) costs due to a kilometre charge by increasing the price of their goods and services, and whether firms plan to relocate if a kilometre charge is implemented.

Part II focuses on the modelling effects of transport pricing. Three chapters discuss ways to design optimal road-pricing policies, given different policy objectives. Chapter 7, by Michael Bell and Muanmas Wichienin, considers the setting of an optimal congestion charge consistent with the commercial decisions to transit operators. The authors argue that the reactions of transit operators on congestion charging should be considered, as these will influence traveller costs, which will in turn affect the optimal congestion charge. They analyse the impact of profit-maximizing transit fare setting on the social surplus under a range of congestion charges, and examine the competitive advantages of tolling for transit operators.

In Chapter 8, Dusica Joksimovic, Michiel Bliemer and Piet Bovy argue that the macroscopic results of road pricing should be understood from their micro foundations, that is, the behaviour of the individual actors. The authors introduce game theory as an appropriate way to do this, and present the results from a series of game-theoretic studies to illustrate their proposition. They show that, in this setting as well, the optimal design of a road-pricing policy (for example, toll level) depends greatly on the main policy objective set.

Chapter 9 focuses on time-varying optimal toll designs. Michiel Bliemer, Dusica Joksimovic and Piet Bovy consider uniform and time-variable tolls during the peak, taking route choice and departure time choice responses of travellers into account. They demonstrate that policy objectives can be optimized by imposing tolls, and that different policy objectives lead to different optimal tolling schemes and toll levels. Thus, this chapter once

more illustrates that the optimal design of road pricing depends on the policy objectives.

Part III focuses on the acceptability of different types of road-pricing policies. The first two chapters discuss the acceptability of road pricing among the general public. In Chapter 10, Tommy Gärling, Cecilia Jakobsson, Peter Loukopoulos and Satoshi Fujii discuss how acceptability judgements may best be derived. Next, they present a theoretical framework to account for determinants of acceptability, and examine to what extent these determinants actually explain public acceptability of the Stockholm congestion charge scheme. They hypothesize that road pricing is more acceptable if individual car users are aware of the problems caused by car use, whether they expect the road-pricing scheme to be effective in reducing these problems, and whether the road-pricing scheme will affect their own car use.

Geertje Schuitema, Barry Ubbels, Linda Steg and Erik Verhoef further investigate the relationship between effectiveness and acceptability of road pricing in Chapter 11. Like Gärling et al., they argue that individual car users will consider two types of effects when evaluating the acceptability of road pricing: effects on the problems resulting from car use (for example, congestion) and effects on their own car use. They contend that the latter will depend on the degree to which a car user can cope with expected cost increases, which will be related to factors like annual kilometrage, income and price level. Next, they examine how acceptability judgements are related to possibilities of evading transport-pricing policies, and the extent to which car users are compensated for negative consequences via revenue allocations.

One way in which car users may benefit from road pricing is increased accessibility. Taede Tillema, Tom de Jong, Bert van Wee and Dirk van Amelsfort determine, in Chapter 12, to what extent various factors may affect changes in accessibility due to road pricing. Among these factors are the value of time, and characteristics of the road-pricing measure (for example, price level). They first assess the effects of a time-differentiated kilometre charge on accessibility in general, and next examine whether accessibility is sensitive to variations in value of time, characteristics of the road-pricing measure, and types of costs and benefits considered by those involved. They argue that various types of costs and benefits should be taken into account when assessing the effects of road pricing on accessibility, and that approaches focusing only on travel-time gains may not provide an accurate picture in this respect.

In Chapter 13, Linda Steg, Taede Tillema, Bert van Wee and Geertje Schuitema discuss the acceptability of road pricing by firms. As in Chapters 10 and 11, they focus on the relationships between the effectiveness and

acceptability of road pricing. They start from the reasonable assumption that, if firms are more likely to suffer from road pricing, kilometre charging will be less acceptable to them, while it will be more acceptable if firms benefit from it. Firms may consider various costs and benefits, such as the expected changes in travel costs and accessibility of firms. The last two effects in particular are considered in this chapter.

Finally, Part IV discusses both the past and the future of road pricing. In Chapter 14, Georgina Santos discusses the London Congestion Charging Scheme. She provides a thorough and critical discussion of the background, design, effects, and costs and benefits of the scheme, and indicates its 'winners' and 'losers'. Furthermore, she elaborates on the possible effects of extending the scheme.

Chapter 15 identifies some prospects for transport infrastructure pricing in Europe. In this chapter, Chris Nash provides an overview of progress on the EU transport-pricing policy. He concludes that actual progress towards more efficiency in transport-pricing has been slow. He provides various reasons for this lack of progress, and indicates how some of these barriers may be overcome.

The final chapter summarizes the main conclusions of the book. On the basis of these, various suggestions for future research are indicated. Furthermore, the main implications for transport policy are described. Overall, the chapters in this book indicate that it should be feasible to implement road-pricing policies that are both effective in reducing transport and traffic problems and acceptable to the public and to firms.

NOTE

1. Many chapters report on research that was carried out in the context of the Dutch NWO/Connekt VEV project on 'A Multidisciplinary Study of Pricing Policies in Transport'; the financial support of NWO is gratefully acknowledged. This applies to all chapters, except Chapters 2, 3, 7, 10, 14 and 15.

2. Road transport pricing: motivation, objectives and design from an economic perspective¹

Erik Verhoef

2.1 INTRODUCTION

Road pricing is gaining increasing attention in transport policy circles. After the first contemporary area-wide applications in, for example, Singapore and Scandinavia, which demonstrate the technical viability and potential effectiveness of pricing measures, more places have been following suit, either by implementing schemes or at least by considering them. The pricing schemes concerned vary from classic toll roads to express lanes, toll cordons, area charging and kilometre charges. Also charge levels, and degrees of toll differentiation, may differ quite significantly between applications. This may reflect differences both in local conditions and in the schemes' objectives, and indicate that (local or national) governments have a wide variety of road-pricing options to choose from, after deciding to implement road pricing in the first place.

This contribution reviews the various possible objectives that may motivate the practical implementation of road-pricing schemes (in Section 2.2), and to discuss (in Section 2.3) how such objectives may affect the design of schemes. These questions are, in the first place, of intrinsic interest, because any government considering the implementation of road pricing will benefit from a careful *ex ante* identification and specification of the scheme's objectives, and an assessment of how to best achieve these through optimizing the design of the measure. But, second, these same questions also allow us to provide an introduction to the remainder of the book, by presenting some of the basic (economic) theory of road pricing and linking this to the practical design of road-pricing schemes. Section 2.4 concludes.

2.2 VARIOUS OBJECTIVES OF ROAD PRICING

The implementation of road pricing in itself does not seem to be a very meaningful final objective to pursue. But it can be an effective and efficient means of pursuing other objectives. A meaningful assessment of various types of road pricing, and a motivated choice between them, can be made only in the light of the (policy) objective(s) to be pursued. It is not true that there could be only one possible objective justifying and motivating the implementation of road pricing. On the contrary, operational road-pricing schemes have varying objectives, and hence sometimes strongly differing designs and, consequently, different effects. This section therefore discusses the possible objectives of road pricing, and the possible tension and inconsistencies between these, in more detail.

It is important to emphasize from the outset that economic science cannot objectively answer the question of what the ‘appropriate’ objectives of (transport) policy, including transport pricing, should be. But economists *can* help to identify how to achieve a given objective in the most efficient way, that is, employing the lowest possible amount of scarce resources.

It is also important to realize that objectives can be defined at various levels of abstraction. For example, the possible objectives of economic policies in general – including policies such as road pricing – could be defined in general as (i) achieving an efficient allocation; (ii) achieving an acceptable income distribution; and (iii) stabilizing unemployment and inflation. In what follows, we shall consider often-mentioned objectives of road pricing defined at a somewhat lower level of abstraction. For example, the first possible objective to be considered – internalizing external costs – in itself could be motivated by a desire to achieve an efficient allocation. And the fifth objective – fairness – is closely related to distributional concerns. We use the lower level of abstraction mainly because it ties in more closely with how road pricing is discussed in policy circles in practice.

2.2.1 Efficiency within Road Transport Markets: Internalizing External Costs

A first important possible objective of road pricing, and the one that probably receives most attention in transport economic texts, is the internalization of external costs. This means charging for unpriced costs that a road user imposes on other individuals, who might include not only fellow road users, but also broader groups such as local residents, the whole world population and even future generations. Doing so would prevent socially excessive consumption of road trips (see below). The four most important

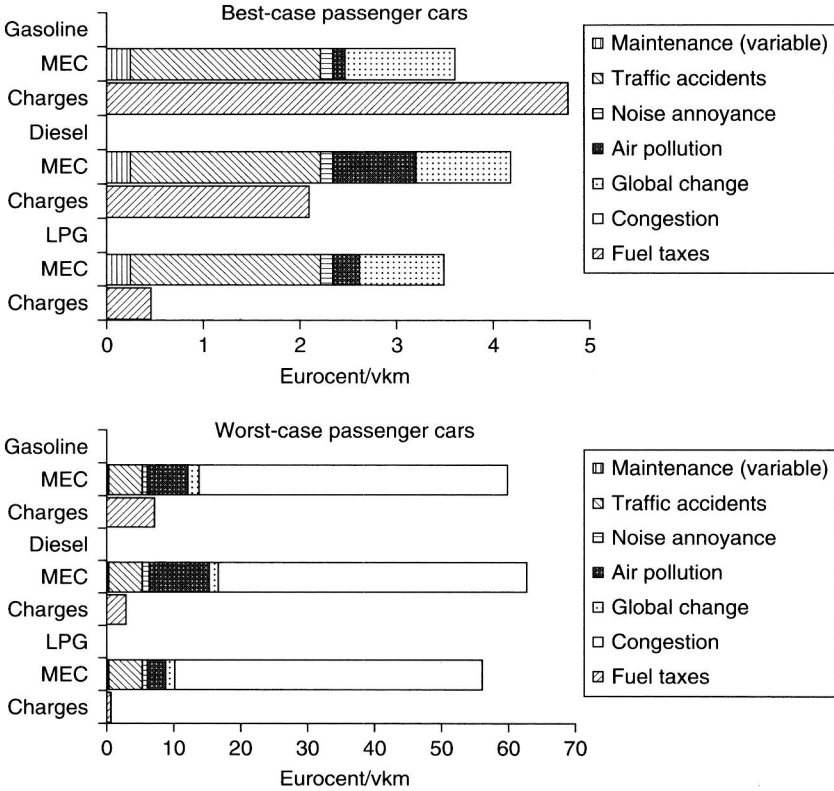
external cost categories associated with the use of automobiles are: (i) travel-time losses through congestion; (ii) accident risks; (iii) noise annoyance; and (iv) emissions. Apart from these, there are kilometrage-independent external costs, which may, for example, result from the ownership of vehicles (externalities such as parking congestion, environmental effects from the production or scrapping of vehicles) or from the existence of infrastructure (externalities such as severance of communities or ecosystems) (see also Verhoef, 1996). These last externalities would, strictly speaking, not provide a strong motivation for road pricing when the objective is internalization of external costs, simply because the relation with the *use* of the road is only indirect or even non-existent.

When internalization is the objective, what are called the ‘marginal external costs’ are the relevant external cost measure: the reduction in external costs that would be achieved when removing one ‘unit’ of traffic (for example, a vehicle, or a vehicle-kilometre). Such marginal external costs may differ strongly by market segment, for example, over time, place, vehicle type and so on. Conventional economic theory dictates that optimal road prices should be equal to these marginal external costs for all users, at all times and at all places; see, however, Section 2.2.2 for some qualifications. This equality is typically not realized, even when, on average, it does appear to apply, as CE (2004) finds for gasoline vehicles in the Netherlands. Differences between charges and marginal external costs for specific segments can then still be significant, as shown in Figure 2.1 which is taken from the same study.

The marginal external costs of road transport thus encompass various cost categories, which in turn correspond with various other possible objectives of road pricing. For example, the internalization of external congestion costs is a specific, economically efficient implementation of the possible objective of ‘curbing traffic congestion’, just as the internalization of environmental externalities is an implementation of the objective of ‘reducing emissions’. The consideration of all four external cost categories in setting road prices may then be taken to imply the simultaneous consideration of four objectives (that is, curbing congestion, accidents, noise and emissions), where the implied ‘target’ for each objective is made dependent on the levels of all marginal external cost components.

The objective of external cost internalization is consistent with the maximization of the ‘social surplus’ on the market under consideration. This social surplus is the most current measure for social welfare in applied economic research. It is defined as the difference between social benefits and social costs.

Why do road prices equal to marginal external costs maximize social surplus? A graphical illustration is given in Figure 2.2 for the case of congestion only (that is, ignoring other externalities), and for the short run (that



Note: 'Best case' concerns a new vehicle (2002) outside the peak period and outside built-up areas. 'Worst case' concerns an older vehicle (1993) in the peak period and inside built-up areas.

Source: CE (2004).

Figure 2.1 Marginal external costs versus variable (fuel) taxes for two representative vehicle-kilometres in the Netherlands (2004)

is, treating road capacity as fixed). It repeats textbook expositions, as can be found in, among others, Button (1993) and Small and Verhoef (2007).

When the number of road users N increases in Figure 2.2, speed will fall and average user cost c will rise because travel times rise. The marginal cost mc exceeds the average cost c because every additional user, besides incurring the average cost c , causes time losses and hence extra costs for all other users. These give the marginal external cost, me_c . The inverse demand