Journal of Transport Economics and Policy, Volume 42, Part 3, September 2008, pp. 361–366

Toll Competition in Transport Networks

Introduction

Erik T. Verhoef

Address for correspondence: Erik T. Verhoef, Department of Spatial Economics, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands (everhoef@feweb.vu.nl). The author is affiliated to the Tinbergen Institute, Roetersstraat 31, 1018 WB Amsterdam.

Road pricing has received increasing attention over the past decades, both in the academic literature and in transport policy circles. Undoubtedly, this is motivated on the one hand by the increasing need for pricing as an effective instrument to curb growing transport-related problems such as congestion and emissions, and on the other by technical advances that make the implementation of road pricing a realistic policy scenario rather than a primarily academic curiosum. Some recent examples are, of course, schemes as implemented in London and Stockholm.

The actual implementation of road pricing poses new questions to transport economists; that is, the textbook model of road pricing in which a single government controls a single uniform road with identical road users under stationary traffic conditions may be a great educational tool to explain the basic economic insights into the nature of external costs and how Pigouvian charges could optimise these; it is less helpful when facing the task of designing actual road-pricing policies that will have to operate in a reality that is, evidently, much more complex than the stylised world of a simple two-dimensional diagram. This has inspired various scholars to contribute to a rapidly evolving literature on second-best road pricing that has amply demonstrated that such complexities may sometimes drastically affect optimal policy rules and their welfare consequences.

Recent contributions to this literature have addressed a variety of issues, such as network spillovers, heterogeneity of travellers, uncertainty and stochasticity of traffic conditions, restrictions on time-variability of road prices, and imperfections in related markets such as labour markets (Small and Verhoef, 2007, provide a review of this literature). Another issue that has received growing attention, and that will be central in this special issue, concerns the simultaneous presence of multiple regulators in a transport network. Specifically, we will study this in the context of pricing, but also other types of instrument are considered, notably investments and hence, capacity choice.

When networks cross boundaries and cover multiple jurisdictions, different governments are involved, who will be controlling substitute or complementary roads in the same network, pursuing their own objectives. With toll roads, this leads to situations that resemble classic problems of horizontal tax competition. Similarly, instances of vertical competition may arise when different governments put prices on the same vehicle-kilometres, for example, when a local government sets a congestion charge or a parking fee and a national government imposes a fuel tax. Either way, policy competition and coordination problems arise when different governments are concerned with the well-being of different groups, and can set tolls and possibly capacities at specific parts of the network that are not used exclusively by citizens from the regulating jurisdiction.

While it is customary — and convenient — to consider only one single government pursuing one single objective when modelling road pricing, the situation where more public regulators are active in the same network is in fact not so far-fetched. In fact, the situation where one single government controls an isolated network is probably the exception rather than the rule. Most, if not all, congestion-pricing projects to date have been local systems. When increasing numbers of cities within a country introduce such systems, the probability of toll competition on the national network of course increases; but also, plans for national road-pricing schemes are under consideration in an increasing number of countries. Germany already has its scheme for trucks (the so-called 'MAUT'), and plans for nationwide schemes are also under development for, for example, The Netherlands. Tax competition may then easily occur at a higher governmental level, namely between bordering countries — and beyond, when international transport passes multiple borders. Vertical tax competition — such as in the example with national fuel taxes and local parking charges — is, of course, also a very common phenomenon. Whichever form that road toll competition between governments takes, it is highly likely to affect the overall efficiency impacts of road pricing. It is, of

course, important to understand how and to what extent, for example, to design efficient strategies to prevent welfare losses from policy competition and to assess the relative importance of pursuing these strategies. These are important motivations for the economic study of toll competition in transport networks, and hence for the present special issue.

Besides tax competition between governments, toll competition may also occur with private roads, for example when different private road operators are simultaneously active in the same network, but also when there is a combination of private and public toll roads. There may of course also be mixed public–private vertical tax competition even when there are only private roads in a network, for example when the public government can levy fuel taxes on all road users and thus taxes the same base as do the private toll road operators. Given the increasing interest in private road provision, these situations seem far from imaginary.

Furthermore, problems of this type are not restricted to road transport alone. Fare, tax, and capacity competition may also occur in networks for scheduled services, such as rail and aviation, and may then involve multiple parties; for example, governments, nodal operators (airports or stations), link operators (notably in rail), and service providers (airlines and railway companies); in various combinations.

The above brief introduction implies that studies into the economics of strategic interactions between operators in transport networks can be classified according to a fair number of relevant dimensions. The *network* considered can allow for parallel links (substitutes), serial links (complements), both (in bigger networks), or none of these (when a single link is considered). The *policy instruments* can include pricing (tolls), capacity choice, both, and in principle other instruments also (for example, convenience, reliability, and so on). The *operators* can be public welfare maximisers, private profit maximisers, and also both types can be present simultaneously in a network. The *number of operators* can be one (for example, when 'competing' with an unpriced link), two (in a duopoly setting), or more than two, where the latter may include the possibility of endogenous entry. The *game-theoretical set-up* could assume Nash behaviour or Stackelberg leadership, could involve single or multiple stages (in particular, when both capacities and tolls are endogenous), and might consider one-shot or repeated games. The *organisation structure of network operators* can involve a simple bi-level structure, as would be relevant for road transport when there are road operators and atomistic users; but it could also have multiple layers when, for example, end-users purchase services from service operators (for example, airlines), who in turn purchase services from nodal or link-based infrastructure operators (for example, airports), who in turn may be under the direct control of public regulators

(as could, in fact, be the service operators). The relevant structure is, of course, related to yet another dimension, namely which *transport mode(s)* are considered, and whether this implies a uni- or multi-modal network. Undoubtedly, one could think of further dimensions of interest, but already this list implies that there is a huge potential for different possible cases of interest to study in this field. No surprise, then, that the contributors to this special issue had little difficulty in identifying relevant and challenging questions for study in their respective papers. Let me give a brief preview of the problems studied, without giving away too much of the various papers' main conclusions.

The first paper by Se-il Mun and Ki-jung Ahn considers road pricing in a serial two-link network, for the various ownership regimes that may arise when both of these links can be untolled, tolled by a private regulator, or tolled by a public regulator. They find that the pricing rules differ substantially from their counterparts as applying on a parallel two-link network, and also study how the initial degree of congestion affects the relative performance of the various regimes.

André de Palma, Robin Lindsey, and Fang Wu, in the second paper, study road pricing on a larger network, with dynamic congestion. They are particularly concerned with the impacts of the following 'attributes' of tolling regimes: the goals of the operator (private profit-maximising behaviour versus public welfare maximisation); the set of links that can be tolled in relation to the network structure (pay-lanes, toll roads, cordons); and the time structure of the tolls (flat tolls, coarse step tolls, and fine step tolls). The paper provides new insights on, for example, the relative performance of different time structures for different sets of links and different ownership structures.

The third paper is by Lei Zhang, David Levinson and Shanjiang Zhu. They consider toll and capacity choices for heterogeneous users by public and private operators in an agent-based setting, in which traditional equilibrium analysis is replaced by an evolutionary modelling approach in which decision makers (both travellers and road operators) adjust their decisions according to prespecified behavioural updating rules. The model provides important insights into how a network may develop over time under the presence of multiple road operators.

A similar dynamic view on endogenous network development is provided in the fourth paper, written by myself.[1] This paper focuses on the endogenous development of a network in terms of links, their capacities,

[1]To avoid any possible conflicts of interest, this paper was handled, in a standard review procedure, by the journal's editor-in-chief. Only after final acceptance in that procedure was it decided to include the paper in this special issue.

and their tolls, under various regimes. One is a free-entry regime for private road operators. The second is a regime in which road concessions are auctioned off. As a benchmark, a third regime is a particular second-best sequence of link additions to the network. Although some structure is imposed on allowable network configurations, the model is constructed such that it allows for both serial and parallel competition between toll roads.

The fifth paper is by Andrew Yuen, Leonardo Basso and Anming Zhang. It is the first of two papers in this special issue to consider the interactions between congestion pricing in a gateway or (air-)port and that on infrastructure in a downstream hinterland. In this paper, an oligopolistic market structure of carriers active in the gateway is considered. This comprises the second layer of the model ('below' the two local governments); the third layer is the price-taking behaviour underlying final demand.

Bruno de Borger, Stef Proost and Kurt van Dender, in the sixth paper, are also concerned with a port–hinterland structure, but they consider the case of two competing ports, each with a monopolistic operator, under the jurisdictions of two different local governments, with region specific infrastructure enabling hinterland transport to a joint final destination. They consider port pricing, and capacity choice for both the port and the hinterland infrastructure. Again, the focus is on interactions between tolls (and now also capacities) between parallel and serial links, and the implied welfare effects.

The seventh and last paper, by Kenneth Button, concerns aviation. His primary interest is the impact of market power of airlines upon the desirability of different types of instrument to cope with airport congestion. The central question addressed is whether insights from the road pricing literature can be directly transferred to the case of congested airports, or whether the market structure and other technical differences between congested road and air traffic may make other economic instruments, notably tradable slots, a more desirable way of coping with congestion than traditional Pigouvian taxes.

The various contributions in this special issue make clear that the modelling of toll and capacity competition between infrastructure operators is a complex task, but rewarding in the sense that the ultimate economic efficiency of the network usually depends strongly on the nature of the operators, the characteristics of the network, and the way in which operators are distributed over the network and, if relevant, how the market is regulated. There are, therefore, no universal answers to questions concerning the most desirable (industrial) organisation of operators over transport networks. Hopefully, the various contributions in this special issue contribute to our understanding of such questions and of

ways to address them using economic theory, at the same time providing inspiration for further study in this field.

Reference

Small, K. A. and E. T. Verhoef (2007): *The Economics of Urban Transportation*, Routledge, London.