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und Wirtschaftsinformatik



Sascha Ruja

Tariff Zone Design and Technology Options in Road Charging

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Wirtschaftsinformatik

herausgegeben von Prof. Dr. Stefan Voß

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Abstract

New developments in road charging policy and advances in electronic toll collection technologies have become an effective measure for raising revenues and managing road traffic demand. In today's practice, different types of technologies such as automatic license plate recognition (ALPR), dedicated short-range communication (DSRC) and global navigation satellite system (GNSS) are used which allow toll chargers to apply various types of road charging design schemes. The literature in road charging design is vast. However, the costs to build, operate and maintain an electronic toll system are usually ignored, although the type of technology has a major implication on the economic appraisal of a charging scheme. Therefore, a total cost of ownership model for electronic toll collection systems is proposed to analyse the cost impact of the main technologies. The results show that there is not a unique technology option for all road charging applications. Economically, the optimal technology choice depends on the length of the road network, the number of road users, and the cost structure of the technology.

Furthermore, a new approach for designing multiple tariff zones is presented that maximizes net revenue (profit) and minimizes traffic demand, while considering the different technologies and their costs. Given that demand is elastic, a mixed integer linear program (MILP) model is applied that allows a closed form of multiple charging zones. To demonstrate the applicability of the model to real world cases, data from the city of San Francisco is taken, using GAMS / CPLEX. Net revenue maximizing requires the zones to focus on trips with the highest possible toll charge, and the smallest possible number of zones should be created in the network. To minimize trips, the zones should focus on as many trips as possible with the highest possible toll charge, designing as many zone and charging points as possible. An initial analysis was conducted to assess the outcome related to changes to the key assumptions. In particular, changes to the zone level and operating cost of a charging system present remarkable trade-offs between the number and location of tariff zones and the objective function value.

Kurzfassung

Neue Entwicklungen in der politischen Ausgestaltung von Straßenbenutzungsgebühren und Fortschritte in der elektronischen Mauterhebung haben sich als wirksame Maßnahme zur Generierung von Einnahmen und Steuerung der Verkehrsnachfrage erwiesen. In der heutigen Praxis werden verschiedene Technologien wie Automatic License Plate Recognition (ALPR), Dedicated Short-Range Communication (DSRC) und Global Navigation Satellite Systems (GNSS) eingesetzt, die es den Mautbehörden ermöglichen verschiedene Arten der Straßenbenutzungsgebühr anzuwenden. Die Literatur für das Bepreisen von Straßenbenutzung ist umfangreich. Die Kosten für Bau, Betrieb und Wartung eines elektronischen Mautsystems werden in der Regel jedoch ignoriert, obwohl die Technologie einen wesentlichen Einfluss auf die wirtschaftliche Bewertung eines Mautsystems hat. Daher wird ein Total Cost of Ownership-Modell für elektronische Mauterhebungssysteme vorgeschlagen, um die Kostenwirkungen der wichtigsten Technologien zu analysieren. Dieses kann auch als Werkzeug für Systemimplementierungen und zur Entscheidungsunterstützung verwendet werden. Die Ergebnisse zeigen, dass es nicht die eine Technologie für alle Mautanwendungen gibt. Wirtschaftlich hängt die optimale Wahl der Technologie von der Länge des Straßennetzes, der Anzahl der Verkehrsteilnehmer und der Kostenstruktur der jeweiligen Technologie ab.

Darüber hinaus wird in dieser Arbeit ein neuer Ansatz zur Gestaltung von Mautzonen vorgestellt. Dieser maximiert den Gewinn oder minimiert die Verkehrsnachfrage unter Berücksichtigung der unterschiedlichen Technologien und ihrer Kosten. Bei elastischer Nachfrage, wird ein MILP-Modell angewendet, das eine optimale Ausgestaltung von multiplen Mautzonen ermöglicht. Um die Anwendbarkeit des Modells unter realen Bedingungen zu demonstrieren, wurden Daten aus San Francisco genommen. Hierfür wurde GAMS / CPLEX verwendet. Hieraus folgt zum einen, dass die Gewinne maximiert werden, wenn die Fahrten mit der höchstmöglichen Mautgebühr bepreist und möglichst wenige Mautzonen geplant werden. Zum anderen sollten die Mautzonen so gestaltet werden, dass die Fahrten mit der höchstmöglichen Mautgebühr bepreist und möglichst viele Zonen erzeugt werden, um die Verkehrsnachfrage zu minimieren. Darüber hinaus wurden wichtige Annahmen variiert und die entsprechenden Ergebnisse analysiert. Das Modell liefert insbesondere bei Änderungen der zulässigen Anzahl von Mautzonen und der Betriebskosten eines Mautsystems interessante Ergebnisse über die Wechselwirkung (trade-off) zwischen der optimalen Anzahl und dem Standort der Mautzonen und der Zielfunktionswerte.

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