Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 24 (2017) 250–258

Transportation Research Procedia

www.elsevier.com/locate/procedia

3rd Conference on Sustainable Urban Mobility, 3rd CSUM 2016, 26 – 27 May 2016, Volos, Greece

Assessment of the marginal social cost due to congestion using the speed flow function

Nikolaos Gavanas[a*] , Anastasios Tsakalidis[b], Magda Pitsiava-Latinopoulou[c]

[a]*Post-doc researcher, Transport Engineering Laboratory, Aristotle University of Thessaloniki,Thessaloniki GR54124, Greece*
[b]*PhD candidate, Transport Engineering Laboratory, Aristotle University of Thessaloniki,Thessaloniki GR54124, Greece*
[c]*Professor, Transport Engineering Laboratory, Aristotle University of Thessaloniki,Thessaloniki GR54124, Greece*

Abstract

An integrated strategy was recently set out in Europe regarding the internalization of external costs from transport, i.e. the costs from the negative externalities to the society generated by the transport users. These externalities refer to impacts on the rest of transport users, such as delays due to congestion, accidents and scarcity of infrastructure, and the society, such as pollution, noise, energy dependency and spatial impacts, as well as to the global impact of greenhouse gas emissions on climate change. The external costs derive from expenditures for traffic control, health services, the loss of quality of life, global warming etc., and, added to the users' private costs, formulate the social cost from transport. The marginal social cost is used as a basis for the efficient pricing of transport services and infrastructure in the context of the internalization of external costs.
The scope of the present paper is the description of a methodological approach for the assessment of the marginal social cost due to congestion along the urban road network. The first part involves an overview of available methodologies for the assessment of costs due to congestion followed by the description of the proposed approach, which takes advantage of the speed-flow functions of representative segments of the categorised urban road network. The main feature of the approach is that it allows for the estimation of the marginal social cost due to congestion using floating car data (FCD) as input. A pilot application in the city of Thessaloniki, Greece and a comparative analysis of the results in relation to the results of recent studies in Europe are presented in the next part. The paper is concluded with the discussion of the prospects and obstacles for the future implementation and enhancement of the methodological approach.

Peer-review under responsibility of the organizing committee of the 3rd CSUM 2016.

Keywords: road transport; congestion; marginal social cost; speed-flow function
* Corresponding author. Tel.: +30-231-099-4160; fax: +30-231-099-5789. E-mail address: n.gavanas@civil.auth.gr

1. Introduction

Congestion remains the most significant challenge for the urban road networks of Europe with an estimated annual cost of approximately $80 \cdot 10^9$ € (European Commission, 2013). The external cost of congestion, i.e. the cost of congestion to the society, derives from its negative impact directly on the mobility conditions, the increase of delays and also on the aspects of safety, emissions, fuel consumption, noise, visual annoyance and the overall quality of life. The European Commission sets as a policy objective the internalisation of the external costs from urban transport and

2352-1465
Peer-review under responsibility of the organizing committee of the 3rd CSUM 2016.
10.1016/j.trpro.2017.05.115

mainly road transport (European Commission, 2007). Thus, the Commission's Action Plan on Urban Mobility (European Commission, 2009) focuses on congestion pricing schemes, such as green zone charging.

The scope of the present paper is the description of a methodological approach for the assessment of the marginal social cost due to congestion along the urban road network. The overall objective is the development of a tool for the assessment of the marginal and total social cost due to congestion in order to support the development and monitoring of congestion pricing schemes. The methodology capitalizes on the development of a set of speed-flow relations for representative roadway segments of the urban road network and the use of Floating Car Data (FCD). Apart from the introductory section which describes the policy background, the scope and the overall objective, the paper comprises the overview of the methodological background, the presentation of the proposed methodology, the pilot application of the methodology and the comparison of results to the findings of a recent Europe-wide study and the conclusive remarks.

Nomenclature

$MPC_{congestion}$	Marginal Private Cost due to congestion
$MSC_{congestion}$	Marginal Social Cost due to congestion
$TSC_{congestion}$	Total Social Cost due to congestion
F.C	Fixed Travel Cost
T.C	Time Cost
V.O.T	Value of Time
L	Travel distance
S	Average hourly speed
F	Average hourly traffic flow
M	Level of mobility
$O.R_{average}$	Average occupancy rate

2. Methodological background

The international literature provides different methodological approaches for the estimation of congestion related social costs. These approaches evolve through the years with the contribution of new tools and technologies and the support of policies for sustainable mobility. Towards the purpose of transferring policy into practice, the marginal social cost of transport is used as a basis for the efficient pricing of transport services and infrastructure in the context of the internalization of external costs. The methodological approaches for the estimation of congestion related marginal social costs often contribute to decision making regarding the feasibility of transport planning and mobility management interventions.

The concept of the marginal social cost is based on the common fact that drivers do not consider the full extent of impacts from the use of a segment's capacity, especially when it comes to external impacts. Thus, after a specific point of balance between the availability of infrastructure and the travel demand, externalities start to occur. The marginal cost for the society corresponds to a higher value than the marginal private cost for the driver at the same level of mobility because the private driver does not consider all elements of transport externalities. The "polluter pays" strategies for the enhancement of sustainability in the road transport system attempt to bridge the gap between the social and private transport costs (Ruta, 2002; De Borger, 1997).

According to the above concept, the methodological approach for the estimation of the marginal congestion cost in the current paper is mainly based on the methodology of Madisson et al. (1996). According to the specific methodology, the Marginal Private Congestion Cost, i.e. the marginal cost for the individual driver due to congestion, is set equal to the average Marginal Social Cost. The average social cost for the individual driver refers to the sum of Fixed Costs of the trip due to fuel consumption, maintenance etc., and the Time Cost due to the trip's duration. The time cost depends on the road users' average Value Of Time, the travel distance and the average speed. The above are described in the following equations: