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The potential of road pricing schemes to reduce carbon emissions

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A B S T R A C T

Road pricing is a transport measure mainly conceived to fund road management, to regulate the demand for traffic and to reduce the number of private vehicles circulating in urban areas. It can also grant benefits in terms of environmental externalities including the reduction of CO_2 emissions, which has recently become one of the most important elements defining the sustainability of a transport system. However, the carbon potential granted by road charging is rarely assessed economically, thus confirming a sort of secondary role attributed to CO_2 in urban premises. This paper provides an accurate analysis of the relationship between the different forms of road pricing (distance-based, congestion-based and pay-as-you-drive) and their effective role in terms of carbon reduction, which in some contexts is significant, accounting for an overall percentage higher than 10%. Furthermore, practical suggestions to policy makers in terms of implementation of the measure are discussed, highlighting the precautions necessary to include a fair carbon evaluation into an overall effective analysis.

1. Introduction

Recent climate talks attempted to tackle several pressing transport issues including global emissions, related temperature targets and cooperation towards the production of clean energy for alternative vehicles. Despite this breadth of topics and the acknowledged importance of transport within the climate issue (EC, 2009), mobility plans and traffic measures tend to primarily address other issues (Nocera and Cavallaro, 2014, 2016a). Particularly, there is still a relatively limited discussion on the possible role of pricing strategies in reducing greenhouse gas (GHG) emissions.

Road pricing has received a considerable interest in the last 30 years (Newbery, 1990; Yang and Bell, 1997; Small and Yan, 2001; Washbrook et al., 2006; Levinson, 2010; Vonk Noordegraaf et al., 2014). Cutting a very long story short, this measure is primarily aimed at the funding of road management and at the regulation of demand for road traffic. However, literature identifies many other impacts, born directly from transport producers, from the road users and from the community (Sinha and Labi, 2007): some of them can be determined easily while others are expected to emerge in the long term and need some appropriate policy making. The rationale behind road-pricing strategies is straightforward. The marginal cost of a road trip is higher than the direct cost perceived by the driver or the operator as the external costs are partly transferred to other agents. Other users or the community may incur in them, respectively in the forms of congestion and lost time, air and noise pollution or costs of accidents. As a result, decisions about road trips made by individuals are biased since the comparison between costs and benefits does not include all these elements. This leads to a sub-optimal allocation of resources and becomes extremely critical in countries with serious haze problems, in which local government authorities should pay extreme attention to environmental protection. For these reasons, the cost function should correctly consider both congestion and environmental factors, hence counting carbon emissions properly. Their inclusion should be easily identified because of the important role played by transport within climate change issues, even if this may set huge evaluation problems that raise the complexity of the subject (Cavallaro et al., 2013; Nocera et al., 2015a).

This paper investigates the potential role of road pricing in granting a saving of carbon emissions, focussing on the most important GHG, i.e. carbon dioxide (CO_2). Section two presents a classification and a description of the different forms of road charging, including their CO_2

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Table 1
Congestion-based road pricing: impacts on CO_2 emissions.

CONGESTION-BASED ROAD PRICING: IMPACTS ON CO_2 EMISSIONS					
City	**Study type**	**Date**	**Toll**	**CO_2 Reduction**[a]	**Source**
		Year	**€$_{2015}$**	**%**	
Auckland (NZ)	Simulation	2008	4.45	−9.80%	New Zealander Ministry of Transport, 2008
Bedford (UK)[d]	Simulation	2000	0.53	−2.0%	Santos et al., 2000
			1.08	−2.7%	
			2.14	−12.9%	
Cambridge (UK) [d]	Simulation	2000	1.61	−1.4%	Santos et al., 2000
			2.14	−3.2%	
			3.21	−5.7%	
Cambridge (UK)	Simulation	2016	Cars within the cordon: 0.93 Cars crossing the cordon: 6.61	−8.0%	Richardson and Chang-Hee, 2008
Copenhagen (DK)	Ex-post evaluation	2001 – 2003	Peak hours: 10.32 Off-peak hours: 5.16	-(1.0/3.0%)**	Rich and Nielsen, 2008
Edinburgh (UK)	Simulation	2015	1.29	−12.3%	Arifian et al., 2015
Hereford (UK) [d]	Simulation	2000	3.21	−14.2%	Santos et al., 2000
			3.75	−11.6%	
			7.50	−10.4%	
Kingston (UK) [d]	Simulation	2000	5.36	−4.6%	Santos et al., 2000
			6.42	−7.2%	
			7.50	−9.7%	
Leeds (UK)[c]	Simulation	2005	4.98	−2.0% −18.0%	Mitchell et al., 2005
Lincoln (UK) [d]	Simulation	2000	0.53	−4.0%	Santos et al., 2000
			1.08	−2.0%	
			2.14	−2.7%	
London (UK)	Ex-post evaluation	2003	8.29	−19.9%	Beevers and Carslaw, 2004
	Ex-post evaluation	2007	10.47	−16.0% (−1.0%)*	C40 Cities, 2011
	Simulation	2020	Cars, vans and motorcycles: 19.02 Coaches and buses: 151.1	−15.0% (−3.0%)*	Mayor of London, 2014
Milan (IT)	Ex-post evaluation	2012	Residents: 2.05 Non Residents: 5.13	−15.0%	Strompen, 2016
Northampton (UK) [d]	Simulation	2000	6.42	−1.6%	Santos et al., 2000
			7.50	−5.9%	
Norwich (UK) [d]	Simulation	2000	1.08	−2.0%	Santos et al., 2000
			1.61	−3.4%	
San Francisco (USA) [b]	Simulation	2010	2.24	−7.0% (−4.0%)*	San Francisco country transportation authority, 2010
		2010	4.47	−9.0% (−3.0%)*	
		2010	2.24	−16.0% (−5.0%)*	
Singapore (SG)	Ex-post evaluation	1998	-	-	DacandCities, 2014
Stockholm (SE)	Ex-post evaluation	2006	1.23 – 2.46[e]	−13.0% (−5.4%*; −2.7%**)	Hugosson and Sjoberg, 2006
Wellington (NZ)	Simulation	2005	1.28 – 5.10 [e]	−16.0%	Sinclair, 2005
Wien (AT)	Simulation	2012	-	−4.0% (−8.5%)*	Bazzanella et al., 2012
York (UK) [d]	Simulation	2000	1.61	- (2.0/2.6%)	Santos et al., 2000
			3.21	−5.0%	

Notes:
[a] CO_2 reduction refers to the charging area, except for * (CO_2 Emissions are related to the entire city) and ** (CO_2 Emissions are related to the metropolitan area).
[b] Refers to alternative scheme configuration.
[c] Refers to different cordon configurations, with an enlargement of the area in the second case.
[d] CO_2 impact is relate also to elasticity.
[e] The applied toll (included in the range) depends by the time of day.

benefits. Section three describes some of the most relevant experiences at an international level and their implications in terms of carbon reduction. Section four comments on the results of such experiences, discussing the potentiality of this measure and the necessary precautions that policy makers should adopt during the preliminary assessments and the implementation of the measure and concluding with some policy considerations that highlight the role of a correct evaluation of CO_2 emissions.

2. Road pricing and Co_2 emissions

Road pricing is one of the most relevant push measures conceived to shift freight and passengers from less to more sustainable transport systems by adopting financial instruments (e.g. taxes, charges and tolls) or technical and regulatory constraints (e.g. orders and bans). Road pricing belongs to the former group aiming at lowering traffic volumes by raising travel costs. This is expected to reduce private transport, generate revenues, control congestion problems and de-