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Emissions cap-and-trade approaches for managing urban road mobility

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Abstract

This paper develops a methodology to analyse the impact of emission taxes for private vehicles for controlling and reducing atmospheric pollution. The main feature of the proposed approach is the integration of emissions from individual emitters (private vehicles) in Emissions Trading Markets designed for macro-emitters. The presented approach consists of two hierarchical levels. At upper level the emissions trading for macro-emitters (cities or consortium of cities) is considered. In this work three emission trading schemes are proposed and studied: i) Fixed emission rights per city, ii) Auction market for the emissions, which tries to reach the environmental objectives at the minimum cost, and iii) Emissions cap-and-trade scheme. These trades allow the system to provide an efficient scheme in a cost-efficiency sense and equity among regulated cities. At lower level the behaviour of the users of the traffic network is modelled for each city. A multi-user equilibrium model with elastic demand and pollution taxes estimates the emissions produced. The lower level represents the emissions market for private vehicles in which the emission taxes paid per user depend on travelled kilometres and the type of the vehicle. The price for each ton of (greenhouse gas) emissions is fixed in the Emissions Trading Market. The three schemes have been solved with a fixed point approach and a numerical study has been carried out to motivate pros and cons of the above schemes.

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Keywords: : Emissions markets; Cap-and-trade schemes; Combined equilibrium models with elastic demand;

1. Introduction

Currently exists an international purchasing and selling market regulated by Kyoto Protocol in which the rights on contaminant emissions produced by countries are traded. The main objective of this Protocol is to reduce the polluting emissions, therefore, is important to reduce the emissions produced by transport because is an area in which they are still growing.

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Since the implementation of the Kyoto protocol on December 11th, 1997, industrialized countries have had to reduce/stop their greenhouse gas emissions in order to meet the international commitments set in the Kyoto Protocol Reference Manual (2008). To meet the Kyoto protocol objectives, a number of policies have emerged as the EU Emissions Trading System (EU ETS), also known as the European Union Emissions Trading Scheme, which is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. EU ETS was the first large emissions trading scheme in the world, and remains the biggest. It regulates the CO_2 emissions from approximately 12,000 installations across the EU, including power generators, mineral oil refineries, airlines and other heavy industrial sectors.

EU ETS scheme is run on a 'cap-and-trade' basis. Emissions from each installation covered by the EU ETS are capped each year. An installation that emits less than its allocation can sell the excess EUAs or 'bank' them for future use. Conversely, any installation emitting more than its allocation must purchase additional EUAs, or other eligible instruments, from the market. Those installations who fail to surrender enough allowances are required to pay an excess emissions penalty and remain obligated to purchase the extra allowances they require. This scheme exploits differing Marginal Abatement Cost Curves (MACs) in the productive sectors to achieve the goal of reducing the emissions and the economic costs.

Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second greenhouse gas emitting sector after energy. Furthermore, transport is one of the few sectors where emissions are still growing (see Chapman (2007)). Road transport alone contributes about one-fifth of the EU's total emissions of CO_2, the main greenhouse gas. The EU has policies to reduce emissions from a range of modes of transport, such as including aviation in the EU Emissions Trading System (EU ETS) and CO_2 emissions objectives for new cars and vans.

Five generic policy instruments could be employed for carbon pricing, carbon taxes, cap-and-trade, emission reduction credits, clean energy standards, and fossil fuel subsidy reduction (see Aldy & Stavins (2012)). The approaches mainly used in transportation are *tradable mobility credits* and *market-based solutions*. *Tradable mobility credits* consider a competition between individual drivers who negotiate their credits. The advantage of this approach is its applicability because it considers only one city (see Yang H. & Wang X. (2011) and Nie, Y.M. (2012)). This work is focused on a *market-based solution* approach. The main differences with tradable mobility credits are that the competition is established between cities and all users pay with respect to each individual emissions. The disadvantage of this approach is the necessity of negotiation between cities, but it guarantees an efficient minimization of emissions, meeting the environmental objectives.

This paper proposes various cap-and-trade approaches for the inclusion of road traffic in the Emission Trading Markets. The main challenge is that the users of private vehicles are micro-emitters but the markets are designed primarily for large companies (regulated sources). One way to overcome this difficulty would be that certain public entities (Central Authority *i*, CA*i*) were responsible for the emissions in certain regional area *i* such as a city or a consortium of cities, managing their participation. The CAs should participate in emissions market directly and should be involved in the impact of their emission taxes when using private transport (either for commercial or personal use) to reduce/finance the acquisition of rights of emissions. In this process a key element is that each CA should know the MAC of its area in order to properly manage the purchase/sale of emission rights. This paper follows the model proposed by Almodóvar et al. (2011) to represent the MAC of an area which allow to estimate the emissions produced by each micro-emitter in a city, depending on the equilibrium price per ton, the user type (defined by a vehicle class and social-economic characteristics) and the congestion level of the traffic network managed by the CA*i*.

This paper is structured as follows: Section 2 describes the market designs for the emission trading, Section 3 proposes a solution method and Section 4 shows the computational tests performed to illustrate the proposed methodology on a synthetic network (Nguyen & Dupuis, 1984). Finally, Section 5 summarizes the main contributions of this paper.