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Carbon related taxation policies for road transport: Efficacy of ownership and usage taxes, and the role of public transport and motorist cost perception on policy outcomes

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ABSTRACT

Based on an extensively calibrated and methodologically reprogrammed national transport model, this paper evaluates the impacts of recently adopted carbon related transport taxes in Ireland. We find that the fuel based carbon tax reduces CO_2 emissions by 1.75–3.82%. The higher band of this reduction range depends on users considering only immediate costs when making trip decisions, and the presence of a strong substitution capacity between public and private transport. Carbon related vehicle registration tax (VRT) and motor (annual road) taxation, however, exhibit little impact on carbon emissions alone and principally support a shift in fleet structure toward diesel and more fuel efficient cars. Over the longer term this shift results in a mild increase in NO_x and PM emissions. Overall the study finds that the fuel based carbon tax is better than VRT and motor tax in terms of tax revenue, carbon emission reductions and social welfare, but worse than the latter in terms of household utility and production costs. The greatest CO_2 reductions are achieved through a combined policy package of fuel tax and VRT and motor tax changes. The combined impacts of VRT, motor tax and fuel tax on the reduction of CO_2 emissions is estimated as 4.29% in 2030, and 4.58% if the elasticities of substitution are improved. The positive combined effects of these policies, in terms of social welfare, can be significantly improved by double-dividend effects, where policymakers replace labour taxes with these new environmental taxes.

1. Introduction

Emissions from transport, particularly road transport, are a highly relevant and challenging component of anthropogenic contribution to climate change (EEA (European Environment Agency), 2008). The European Union (EU) has regulated many emission sources through the EU emissions trading scheme, and has more recently introduced targets for the so called 'non-traded' sectors (EU (European Union), 2009). Transport falls under the auspices of this non-traded sector target. Options for not only limiting, but reducing carbon emissions from mobile sources are since coming more to the fore in many national policy agendas.

Ireland has recently introduced two major taxation policy initiatives in an effort to reduce carbon emissions from road transport. The first of these was to base the rates of vehicle registration tax[1] (VRT) and annual motor tax[2] on CO_2 emissions instead of engine sizes. Changes were introduced on a two tier system such that the new taxes only apply to new cars and cars newly registered after the 1st July, 2008—older vehicles remain on the prior 'engine size' based system. These initiatives have been introduced with a view to encouraging the purchase and ownership of low-CO_2 emitting cars. The second taxation policy initiative has been to add a carbon tax into the existing fuel excise tax. The stated objective of this policy is to reduce carbon emissions, specifically by targeting the usage rates of vehicles. This policy was recommended by the Commission on taxation and came into force in the December 2009 budget at a rate of 4.2 cent for petrol and 5 cent for diesel.[3]

This paper evaluates these policy measures out to 2030 using a nationally calibrated transport model. The assessment considers the policies both independently and as packages with a view to quantitatively analysing the outcomes in respect of the following questions.

- What level of CO_2 emission reductions might be achieved in the road transport sector by 2030 for a given policy package?

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[1] A once off charge on new and imported vehicles.

[2] An annual circulation tax for vehicles in use on public roads.

[3] For the purpose of our modelling we assume the policy starts on the 1st of January 2010. Further details of the actual policies and prior systems are presented in three appended tables.

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- Are there trade-offs from these policies with respect to NO_x and PM emissions?
- How will the fleet structure evolve out to 2030 under a given policy package?
- How will tax revenue and welfare be affected under a given policy package?

In answering these questions we also illustrate the sensitivity of results to two important factors in the model calibration:

- Assumption on the considered costs in the trip decision making process.
- Elasticity of substitution (EOS) between private and public transport.

The results present percentage shifts between a given simulation and the basecase scenario for emissions and vehicle stock. Absolute level changes are presented for utility, welfare and tax revenue. The results identify the scale of change over time and flag relevant turning points in the curves to 2030 that may be used to inform further policy decisions in this area.

The paper is structured as follows. In Section 2 we examine the literature on this topic and some of the recent specific work in Ireland. In Section 3 we describe the model used, including details of some important modifications to the system, and we present general information on the calibration efforts and scenario development. Sections 4–6 present results of the given policy packages with respect to emissions, fleet structure and finally tax revenue and welfare. Section 7 concludes with some policy focused suggestions for further enhancement of the emission reduction potential of these new tax initiatives.

2. Literature

The merit comparison between ownership and usage taxes of transport has been frequently discussed in the literature (De Jong, 1990; Van Dender, 1996; De Borger and Mayeres, 2004; Muthukrishnan, 2010). In an environmental context, transport policy assessment models have been developed to analyse the impacts of the carbon adjustment of these taxes on transport emissions quantitatively. Especially, there are some models that have been used in Europe such as TRENEN (De Borger et al., 1997), EUCARS (Jansen and Denis, 1999), TREMOVE (DG Environment Commission, 2007; Proost and Regemorter, 2009) and the UKTCM (Brand et al., 2012). These models were used to assess the efficiency of various pricing and regulation policies in relation to emission reduction and the internalisation of other externalities. For example, with TRENEN, De Borger et al. (1997) find that fuel taxes are a good mechanism to optimise social welfare. When all taxes on passenger and domestic freight transport equal the marginal external costs, there would be a 4% decrease in total volume of passenger-km and an 18% decrease in freight transport. Jansen and Denis (1999) with EUCARS, indicate that fuel taxes or other usage taxes should be combined with differentiated purchase taxes to achieve greater levels of emission reduction without the losses of social well-being, and they imply that a 26% increase in fuel prices will yield a 10% reduction in CO_2 emissions and a 2.1% reduction in the number of cars. Proost and Regemorter (2009) used TREMOVE 2 to evaluate the impacts of radical changes of taxes on emission reductions. Specifically, they matched the taxes with marginal external costs and found a 12.2% decrease in CO_2 emissions is possible through such a radical reform. It is notable that changes in fuel costs are proportionally lower in the overall mix where the fixed costs of owning a car are included in the trip decision and cost function. Therefore those studies which do not exclude fixed costs in the trip decision analysis may underestimate the effects of an adjustment in immediate costs. This point is revisited later in our analysis.

In other countries outside of Europe, Hayashi et al. (2001) developed a transport model for Japan and their results show that the car usage tax has the most significant effects on reducing CO_2, while ownership taxes principally shift the demand to smaller cars. With an urban transport model of TRESIS, and focusing on Sydney, Hensher (2008) finds that a carbon tax of AUS €0.20 c/kg will lead to a reduction of 2.53% for vehicle kilometres, a reduction of 2.67% for CO_2, and government revenue would increase by 9.34%. He suggests that a carbon tax would be the most attractive option for reducing CO_2 emissions when balancing efficiency, equity and sustainability. There are also some technical transport models such as Mobility Model (Fulton et al., 2009), COPERT (Mellios et al., 2011), MOBILE (U.S. EPA, 2003) and transport network models such as SCENES (SCENES consortium, 2001), VACLAV-VIA model (Shoch, 2000), ASTRA system dynamics model (Martino and Schade, 2000) and the EXPEDITE meta-model (De Jong et al., 2004). The former category mainly focus on the effects of technical progress and the evolution of the vehicle fleet on emissions, and the latter are used to forecast transport demand based on networks. Studies of the impacts of carbon taxes on transport are usually not based on these technical or transport network models.

Besides analyses using a specialised transport model, there are some more general ways to study the quantitative impacts of carbon related transport taxes: (i) Studies on the changes of the historic data that cover the period before and after the new tax policy. (ii) Comparison between countries that apply different tax systems. (iii) Econometric analyses that build up the relationship equation between the dependent variables of emissions, vehicle stock, transport activities and those explanatory variables including taxes. (iv) General equilibrium approaches.

The latter approach, general equilibrium modelling, is a popular means of evaluating the prospective outcomes of environmental policy. However, such studies are often not specifically related to the transport sector alone. For instance, there have been studies of the effects of carbon taxation in Norway (Bruvoll and Larsen, 2004) and in Ireland (Wissema and Dellink, 2006; Callan et al., 2008), which have considered a broader carbon tax for society. Wissema and Dellink (2006) examined the performance of a carbon energy tax for Ireland in contrast with a uniform energy tax using a computable general equilibrium model, and identified energy related CO_2 emissions reductions in response to a carbon energy tax of 10–15 Euros per tonne of carbon emissions. In the application of a general equilibrium model to the transport sector, researchers have principally estimated the effects of vehicle and fuel supply technology progress on outcomes (e.g., Schäfer and Jacoby, 2006).

The remaining methods found in the literature often obtain results without the previously discussed forms of model simulation. In Ireland, with short run historic data, an assessment of the impacts of the new carbon related Irish VRT and motor tax on purchasing trends by Ó Gallachóir et al. (2009) shows how this policy indicates a promising shift in the CO_2 emissions profile of new additions to the national fleet. They point out that without these new environmental taxes, improvement in fuel efficiency of the car fleet may have been offset by the purchasing trends towards larger size cars. Rogan et al. (2011) and Hennessy and Tol (2011) find similar effects and also make note of a sizeable forecast reduction in tax revenue from the evaluated tax changes. The former analysis shows that in the first year of the new taxation system the average specific emissions of new cars fell by 13–145 g/km and it results in a 33% reduction in tax revenue from VRT. The latter estimated that the overall market share of diesels, which are more efficient, will increase from 25% to 58% as a