The relevance of the local context for assessing the welfare effect of transport decarbonization policies. A study for 5 Spanish metropolitan areas

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ABSTRACT

The effectiveness and efficiency of policies that try to reduce carbon emissions in the transport sector may depend significantly, at least in the short term, on the availability of options to shift away from diesel and gasoline private cars. This paper uses a detailed model, and a carefully-constructed dataset, to show how a fuel tax reform affects differently Spanish metropolitan areas based on their fleet composition, share of public transport, and urban vs suburban distribution. We find that those areas with the largest share of diesel and with the highest penetration of public transport are able to reduce more their carbon emissions and energy use, at a lower welfare loss. We also find that the reductions obtained are not large, thus requiring additional measures.

1. Introduction

The relationship between transport and sustainability has been long since under the scrutiny of the scientific community (Proost and Van Dender, 2012) and policy makers (European Commission, 2011b), because of its importance and its complexity. On the one hand, transport plays a very relevant role supporting economic development and also leisure; and, on the other hand, its has a substantial impact on the environment, both at the local (Friedrich and Bickel, 2001) and global levels (International Energy Agency, 2009), and also on congestion or accidents.

For example, in Spain (considered in this paper as representative of many developed countries) the impact of the transport sector on climate change is very relevant, contributing to a 30% of the total carbon emissions coming from energy consumption. Mendiluce and Schipper (2011) and Sobrino and Monzón (2014), using a Laspeyres Index decomposition, analyse the causes of the CO_2 emissions in the Spanish transport sector, identifying, along with freight and industrial activity, diesel and private transport as among the main drivers. Both authors propose the introduction of additional fiscal and administrative policies to improve the sustainability of the sector and, particularly, to curb the widespread reliance on private transport which is behind many of these trends.

However, well-meant transport policies may bring unexpected outcomes. As an example, diesel cars, until very recently, have been promoted in Europe with lower taxes Mayeres and Proost (2001), Burguillo-Cuesta et al. (2011), Sobrino and Monzón (2014), Schipper and Fulton (2009) because of their higher efficiency and lower CO_2 emissions. However, this did worsen problems like congestion and local air quality. Mayeres and Proost (2011), for instance, compared the actual, optimal, and efficient taxation for car usage in Belgium, taking into account elements such as congestion charges or fuel taxes. In both cases, they concluded that diesel should be taxed more than gasoline, provided the differences in efficiency and the emission of atmospheric pollutants. The complexity illustrated in this example requires policy makers to tackle all these issues from a wider perspective, but with the required detail. For this reason, a tool able to assess the variety of effects that a fiscal policy applied to the transport sector can yield is not only recommended, but also needed in order to capture and quantify the interactions between demand for mobility, the ways to supply it and its consequences on welfare and the local and global environment, as stressed out in Schäfer et al. (2009).

In the academic literature, the estimation of the impacts on the economy and sustainability of transport policies has relied on adapted energy models. The first models that represented transport as an energy service rather than just a fuel demand were Schäfer and Jacoby (2006) and Loulou and Labriet (2008); yet, only later examples (E3Mlab, 2008; Schäfer and Jacoby, 2006; Proost et al., 2009) increased the complexity in picturing transport and mobility, developing non-linear relationships that describe better demand and supply in the sector. A correct estimation of the impact of transport policies requires taking into account time and location, as well as the diversity of transportation modes available.

A particularly relevant place to look at is metropolitan areas, where many different transport options are possible, and also where most of the population lives. According to the World Bank, the population

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living in urban areas accounts for 54% of the total (World Bank, 2017b), with one fourth of it residing in the metropolitan areas that exceed 1 Million inhabitants (World Bank, 2017a). These areas are the ones in which much of the economic activity is generated, (e.g. representing 80% of global GDP), but also where 60–80% of all energy demand and 75% of all carbon emissions take place (Swilling et al., 2013). This presents a challenge between preserving the environment and keeping welfare levels unaffected. Also, not all metropolitan areas are the same regarding alternative transport modes or demand for mobility. Observing the mobility in 52 European cities, Albalate and Bel (2010) notice the links between city characteristics and urban transportation, including size, location, and socio-economic factors as the drivers of the use and the magnitude of urban transportation. Thus, decarbonization policies affecting the transport sector in different metropolitan areas will probably have different outcomes.

However, we are not aware of any study that looks in detail at how these policies would affect welfare in different metropolitan areas depending on their different configurations. In Spain, for example, these estimations have been done mostly at the national level, e.g. Sobrino and Monzón (2013), who adopted the TREMOVE model (Ceuster and Ivanova, 2007) to estimate the increase of greenhouse gases in the period 2000–2006. Studying only the case of Madrid, Guzman et al. (2014) simulated the introduction of a congestion toll (similar to the congestion charge in London), applying system dynamics techniques to evaluate the effects on social welfare over a 40 years span. But again, their results cannot be compared to those obtained in other places because of different methodologies. Therefore, the first research gap identified in our review is the need to compare, with the same methodology, the effect of a certain transport policy on different metropolitan areas, so that we may understand the different outcomes and the drivers behind them.

Therefore, in this paper we propose a model able to compare these issues in different metropolitan areas in Spain. We simulate the impacts of a tax reform for liquid fuels on five Spanish metropolitan areas, and estimate changes in welfare, environmental impacts, and transport modes for each of them, then contrasting the different results obtained with their particular characteristics, and hence providing clues for adapting transport policies to these characteristics.

The reform of fuel taxes has already drawn the attention of many institutions. Here we follow the proposal of Labandeira (2011) who, following the lines included in European Commission (2010) and European Commission (2011a), updates a previous work in Labandeira and López Nicolás (2002) and analyses a tax proposal that would involve a broader energy tax reform, thus including both transport fuels, electricity, and heating. The reform proposes the substitution of the current fiscal structure with one directly linked to the energy and the CO_2 content of the fuel. Along with other implications, this would reduce the current difference that exists between gasoline and diesel, as proposed in Mayeres and Proost (2001). Furthermore, it could help alternative fuel sources, such as biodiesel and ethanol, to be more competitive with traditional fossil fuels.

Previous works have estimated the effects of the reform on tax revenues from private transportation in Labandeira (2011) and on energy consumption and CO_2 emissions in Danesin and Linares (2015). Both papers analyse the outcome at the national level using previous econometric results, finding positive effects of its implementation on economic, energy and carbon emissions. On the one hand, Labandeira finds that the tax reform would provide an additional 12,000 million Euros in fiscal revenues from the energy sector, with the transport sector representing an important share of the increase. On the other hand, Danesin and Linares show that the reform could lead in the long run to an overall reduction of energy consumption in transport of up to 480 million GJ, while cutting CO_2 emissions by 29 million tons.

However, both assessments cited come short in that they do not include all the elements that characterise transport, in particular in a metropolitan context. The interaction between private and public

modes, as well as their availability, can deeply affect the results and should be taken into account when evaluating the impact of such a proposal. This is the second research gap that we have identified, and the reason why we were so keen at including in our model different transport modes, and the elasticity of substitution between them, calibrated for the current situation.

By comparing the outcomes of the same fuel tax policy applied to different metropolitan areas and including in our model the possibility to change modes of transport, we can identify the factors that drive the outcome of the policy, and the extent to which this policy may be effective or not, depending on the local context.

Section 2 presents the model developed, while Section 3 describes the significant challenges regarding data, and how they have been overcome. Section 4 shows the results, and Section 5 offers some conclusions.

2. The model

The model we developed is a partial equilibrium model fitted to a metropolitan area, where consumers choose how to allocate resources for using transport services, while, on the supply side, transport providers decide the quantities, given the available technology and associated cost function. Finally, a (central) government affects the market prices through taxation. For each resulting equilibrium we calculate welfare (including external costs), as well as CO_2 emissions and energy consumption, and total tax revenues, as can be seen in the diagram in Fig. 1.

The model used here takes inspiration from other well-established models such as TRENEN (Proost and Van Dender, 2001) and TREMOVE (Ceuster and Ivanova, 2007). While the second is designed to model with a high level of detail a whole region or nation, and introduces the dynamic dimension of the transport system, the first is a static partial equilibrium model aiming to optimise welfare in local areas, such as cities or small regions. We therefore follow the structure of TRENEN, and we adopt from it the utility and cost function design, as well as the use of the Marginal Utility of Income (MUOI, hereafter) to monetarize the utility and so construct the welfare function.

However, the model presented here differs from the previously presented models. The lack of data and the scope of the study led us to the construction of an apropos configuration. The objective of the model is to evaluate how policies affecting transport have an effect on local transport systems and the associated welfare. For this, we use a comparative static approach. We also had to drop some characteristics, given e.g. the difficulty to gather information about travelling time in metropolitan areas. Hence, a congestion function is not included, thus allowing for an easier description of time-dependent patterns.

Specifically, the maximization problem of the consumer is as follows (equation (1)), where x_l is the transport mode consumption and x_{NT} is the non-transport good consumption:
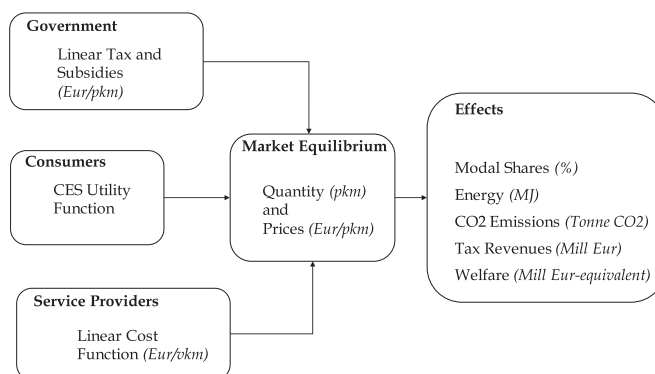

Fig. 1. Modular representation of the model.