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Policy mix to reduce greenhouse gas emissions of commuting: A study for Barcelona, Spain

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ABSTRACT

Commuting or the journey to work makes up an important part of transport. It should therefore be a target of climate policies that aim to reduce greenhouse gas emissions from transport. To design an effective climate-transport policy package, this article constructs a framework consisting of two core aspects of commuting patterns driven by five categories of underlying factors. Policy implications are derived from this. The set of factors and policies are then studied for the Barcelona Metropolitan Region in Spain. We find that it is essential to limit dispersion of the population and provide spatially adequate public transport services. In addition, effects of imperfections in labour and housing markets, and commuter bias in transport preferences towards car use, should be addressed in policy.

Introduction

The transport sector is almost entirely dependent on fossil fuels. It is the second largest sector producing global greenhouse gas (GHG) emissions and the second fastest growing sector of emissions in general, while future projections of emissions look dim (OECD, 2008a). Policies targeting transport externalities, such as energy consumption and emissions, are often subject to rebound effects, notably increased use of vehicles, that reduce their effectiveness (Rajan, 2006; Rietveld, 2006). The policy challenge is to formulate a combination of effective supply- and demand-side policies, technology-oriented solutions and physical planning. There is a clear need for understanding what a complete, effective policy package looks like as substantially reducing GHG emissions from transport is very difficult (Gilbert and Perl, 2010; Hickman and Banister, 2014).

This study will put the spotlight on commuting transport and try to obtain such a policy package on the basis of identified core factors of commuting. Commuting or the journey to work makes up an important part of transport. It should therefore be a target of climate policies that aim to reduce greenhouse gas emissions from transport. Commuting has long been an important target of transport policy and urban planning, because of its regular pattern, its close connection with congestion problems, and its association with people's choices about locations of work and housing (van de Covering and Schwanen, 2006). Where people live influences their overall travel behaviour for extensive periods of time. In this study we use the term "commuting" to denote one-way journeys to job destinations. We concentrate on commuting at a regional scale and consider both intra- and intercity journeys. For the study of GHG emissions from commuting, we will focus on two aspects of commuting patterns and behaviour, namely commuting distance and transport mode choice. We give special attention to car use in view of its disproportional contribution to GHG emissions. In addition, the relationship between commuting distance, commuting time and transport mode is discussed. We find it advantageous to consider this relation since commuting distances, while relevant from a planning perspective, may be overlooked by travellers who may be more sensitive to variations in commuting time costs.

Many studies deal with the question concerning which factors underlie increased commuting distances and car usage. We review planning studies, economic studies, and studies from environmental and social psychology (i.e., behaviour studies). These three perspectives will be offered and from the insights gained we will identify a set of core factors, and then apply this to obtain a policy package for the Barcelona Metropolitan Region (BMR) in Catalonia (Spain). We do not consider here reducing carbon intensity of energy used for commuting since this has been analysed elsewhere (e.g., Chapman, 2007; Ison and Ryley, 2007; T&E, 2006). In 2006, commuting made up 15.8% of the total number of journeys made within the BMR. In contrast to personal-purpose journeys (e.g., for shopping or daily leisure), commuting journeys usually involve

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relatively long distances, much time, and the use of motor vehicles (either public transport or private vehicles) (Miralles-Guasch, 2011). In addition, commuting journeys are more scattered now and, thus, are not easily served by public transportation leading to an increase in the relative share of the use of the private vehicle. Changes in modal split and commuting distance have obvious repercussions in the amount of emissions. Vehicle traffic is the principal source of GHG emissions in Barcelona, being responsible for 30–35% of total emissions for the period 1987–1996; only between 3.8% and 4.2% of the total CO_2 emissions from transportation in Barcelona originates from public transportation, even though this accounts for 55% of the total number of journeys made within the city (Baldasano et al., 1999). All in all, the BMR is a relevant case for studying commuting patterns in relation to GHG emissions and environmental policy. Our contribution to the literature on commuting transport and its use of energy and related emissions is thus threefold: development of a framework based on the extensive literature on commuting and its factors; derivation of an environmental policy package addressing GHG emissions from commuting; and an application of these to Barcelona.

Similar studies to ours are found for large metropolitan areas, such as New York and London (Hickman et al., 2009, 2010, 2013; Sperling and Gordon, 2009). Hickman et al. (2013) mainly focus on reducing emissions from transport by investing in planning of, and infrastructure for, public transport in London and Oxfordshire metropolitan regions. Here we adopt a broader perspective, including a larger set of commuting determinants (factors) which allows us to derive a wider palette of policy options. Hickman et al. (2009, 2010) have a similar scope to ours, but focus on backcasting techniques, scenario-building and transport and carbon simulation models. Our study can be seen as complementary to these studies in that it aims to identify the full set of commuting factors (for the BMR). It should further be noted that the earlier studies do not deal specifically with commuting as we do, but instead address transport in general, including all personal journeys, freight transport and aviation.

The remainder of this article is structured as follows. Section 'Commuting distance and transport mode: three perspectives' contains a literature review of the factors underlying commuting, and presents three distinct perspectives that offer a basis for policy design in the case study later on. Section 'Policy mix to reduce GHG emissions due to commuting' discusses general elements of a policy package for reducing GHG emissions of commuting. Section 'Application to the Barcelona Metropolitan Region (BMR)' presents the case study of the BMR. Section 'Conclusions' concludes.

Commuting distance and transport mode: three perspectives

In subsequent subsections we identify the major factors underlying commuting based on a review of the literature. These factors include built environment (BE), transportation factors (TF), market factors (MF), socioeconomic factors (SE) and behavioural factors (BF). They are summarised in Table 1, while their relationship with the core factors of GHG emissions from commuting are depicted in Fig. 1. It should be noted that these factors are not independent but some of their components may affect or correlate with those in others. In addition, a sixth factor "policy and regulation" can influence all of the factors. Together, the factors provide a framework to design a policy package to reduce GHG emissions from commuting (Section 'Policy mix to reduce GHG emissions due to commuting').

Table 1 combines the many suggestions found in the broad literature on commuting, which is reviewed in subsequent sub-sections. The table can thus be seen to provide a close to complete picture of all the factors that determine commuting. In view of the broadness and completeness of the framework, it is impossible to offer a fully quantified analysis approach as many factors defy quantification. As a result, we are forced to use a qualitative approach of analysis.

Commuting distance versus time

Commuting distance and time are related through speed. Improvements in private vehicles and public transport have allowed commuters to travel longer distances at higher speeds within the same time (Metz, 2004). Information about commuting distance is especially relevant from a planning perspective, while commuting time and time perception are more relevant to the individual and thus to understand their choices regarding commuting distances and transport modes. Average commuting times for many metropolitan areas have been rather constant over time, known as the "commuting time paradox" (van Ommeren and Rietveld, 2005). This has led to the idea that an upper bound to commuting time may exist, that is, a time threshold below which workers are indifferent to commuting distances (Rouwendal, 2004). This threshold is suggested to be about one hour for total daily travel. The results of Rouwendal and Meijer, (2001) indicate that commuters may change their residence when commuting time exceeds one hour. An explanation for this one-hour budget time is competition between various uses of time during the day (Metz, 2004; Mokhtarian and Salomon, 2001). To compare, the

Table 1
Factors underlying commuting patterns.

Built environment (BE)	Transportation factors (TF)	Market factors (MF)	Socioeconomic factors (SE)	Behavioural factors (BF)
• Urban density (i.e., employment and residential densities) • Diversity of land uses (balance of jobs and houses) • Design of street and transport networks • Design attributes of the neighbourhood • Destination accessibility • Regional accessibility • Urban form • Distance or access to public transport (including infrastructure)	• Average travel time, reliability and punctuality (travel time variability), • Uncertainty about occurrence of unpredictable events (e.g., vehicle breakdown, accidents) • Level of service of public transport • Parking opportunities • Congestion (peak and off-peak periods)	• Labour market imperfections (search and moving costs, imperfect information about job offers and uncompensated commuting costs) • Housing market imperfections (search and transaction costs, regional/local price differentials) • Transport market imperfections (transport price and the cost of commuting affect both distance and mode)	• Age • Gender • Income • Level of education • Professional category • Occupational status • Household structure (dual-career, children)	• Self-selection bias • Activity patterns and lifestyle • Past behaviour and habits • Norms • Status seeking behaviour • Emotions