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Commuters' behavior towards upgraded bus services in Greater Beirut: Implications for greenhouse gas emissions, social welfare and transport policy

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ABSTRACT

Climate change is one of the most critical environmental challenges faced in the world today. The transportation sector alone contributes to 22% of carbon emissions, of which 80% are contributed by road transportation. In this paper we investigate the potential private car greenhouse gas (GHG) emissions reduction and social welfare gains resulting from upgrading the bus service in the Greater Beirut Area. To this end, a stated preference (SP) survey on mode switching from private car to bus was conducted in this area and analyzed by means of a mixed logit model. We then used the model outputs to simulate aggregate switching behavior in the study area and the attendant welfare and environmental gains and private car GHG emissions reductions under various alternative scenarios of bus service upgrade. We recommend a bundle of realistic bus service improvements in the short term that will result in a reasonable shift to buses and measurable reduction in private car emissions. We argue that such improvements will need to be comprehensive in scope and include both improvements in bus level of service attributes (access/egress time, headway, in-vehicle travel time, and number of transfers) and the provision of amenities, including air-conditioning and Wi-Fi. Moreover, such a service needs to be cheaply priced to achieve reasonably high levels of switching behavior. With a comprehensively overhauled bus service, one would expect that bus ridership would increase for commuting purposes at first, and once the habit for it is formed, for travel purposes other than commuting, hence dramatically broadening the scope of private car GHG emissions reduction. This said, this study demonstrates the limits of focused sectorial policies in targeting and reducing private car GHG emissions, and highlights the need for combining behavioral interventions with other measures, most notably technological innovations, in order for the contribution of this sector to GHG emissions mitigation to be sizable.

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1. Introduction

1.1. Climate change and the transportation sector

Climate change is one of the most critical environmental challenges faced in the world today, with significant threats to ecosystems, food security, water resources, and economic stability overall. Atmospheric carbon dioxide (CO_2) concentrations have increased from approximately 280 parts per million (ppm) in the pre-industrial age to an estimated level of 430 ppm (IPCC, 2007), and could reach between 540 and 970 parts per million over the next century (Nakicenovic and Swart, 2000). Over the past half century, most of the observed warming has been caused by human activities ranging from the production and consumption of fossil fuels to the expansion of the agricultural sector and the changing land use.

The transportation sector alone contributes to 22% of carbon emissions globally (IEA, 2012). Due to its intensive use of fossil fuels which leads to the emission of greenhouse gases (GHG's), the transportation sector is considered a main driver of global warming. Within the transportation sector, road transportation is responsible for over 80% of carbon emissions (WRI, 2012) and accounts for 81% of total energy used. As the popularity of the motor car is no longer confined in the developed world, this could have huge implications on ongoing efforts towards containment of GHG emissions.

1.2. Sustainable transportation and behavior change

Substantial research has been conducted on sustainable transportation as high oil prices and rising travel demand have bolstered the need for efficiency improvements (IEA, 2013; Schwanen et al., 2011). Studies have focused on the impacts of technological change and the adoption of hybrid or electric cars, the impacts of new car or bike sharing schemes, improved bus services and amenities, and behavior change. Behavior change mainly involves the shift from private cars to more sustainable forms of transportation such as public transportation. It could also involve adopting eco-driving, such as the use of clean-fuel vehicles, carpooling, and more efficient driving that reduces fuel consumption (Barkenbus, 2010). An important behavioral change would be required to promote a modal shift to public transportation and the attendant significant reductions in emissions (Chapman, 2007; Hensher, 2008; Waterson et al., 2003).

A number of soft behavioral interventions (such as the provision of free public transportation tickets) have been tested and found to result in some shifts towards sustainable behavior or more favorable attitudes towards public transportation (e.g. Abou-Zeid and Ben-Akiva, 2012; Fujii and Kitamura, 2003; Matthies et al., 2006; Thøgersen, 2009) and significant impacts on the reduction of GHG emissions (Bin and Dowlatabadi, 2005; Pershing, 2000; Younger et al., 2008). Several studies have also shown that increasing people's environmental awareness by providing them with information related to their car emissions and the latter's impact on their health and the environment might induce them to change their behavior and choice of transportation mode (Gaker et al., 2011; Graham et al., 2011). In fact, when people keep track of their activities and undesired behaviors such as high emission transportation modes and driving methods, those tend to decrease (Jariyasunant et al., 2015), at least in the short term.

Despite the growing importance behavioral change has received in the transportation literature, there still exists substantial research that emphasizes the use of technology, infrastructure, and economic instruments as mitigation measures rather than the behavioral change of travelers through awareness campaigns and social marketing. Yet, it is not possible to completely separate technological and behavioral change. When exposed to new technologies, people's behaviors are often reconfigured and it is quite difficult to predict in which direction they will move (Schwanen et al., 2011). Therefore, to achieve a significant reduction in GHG emissions from transportation, behavioral change induced by targeted policies and public transport improvements is essential as technological innovation alone does not suffice (see also El-Fadel and Bou-Zeid, 1999).

1.3. Objectives, contribution, and organization

This paper studies the potential reduction of private car emissions and social welfare gains resulting from improved bus services in Greater Beirut, Lebanon. In this developing country, the car ownership rate is extremely high, public transportation is perceived to be unreliable and of low quality, and vehicular emissions are a major contributor to air pollution whereby the concentration of pollutants in the air exceeds by far air quality standards (Baalbaki et al., 2013; Borgie et al., 2014; Chaaban et al., 2001; Daher et al., 2013; Waked et al., 2012). A higher degree of public transport adoption in Lebanon would lead to improved air quality alongside other benefits. For example, at average bus occupancy, bus transit in the US generates about 33% less CO_2 per passenger mile compared to single occupancy vehicles, and the savings increase with higher bus occupancy (Hodges, 2010). Generally, cities with higher modal shares of public transport and non-motorized modes have less CO_2 emissions per capita (UITP, undated), and consequently, cities where investments are made in bus rapid transit and bike or walk infrastructure may witness reductions in emissions (Kost, 2004; Wright and Fulton, 2005). To explore the potential consumer and environmental benefits for Greater Beirut commuters and citizens at large, a disaggregate mixed logit model of mode switching from private car to bus is developed based on stated preference data. The model is then used to forecast aggregate switching behavior in the Greater Beirut Area and the resulting welfare and environmental impacts under various alternative scenarios of bus service improvements.