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Exploring the link between the neighborhood typologies, bicycle infrastructure and commuting cycling over time and the potential impact on commuter GHG emissions

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ABSTRACT

This paper investigates the evolution of urban cycling in Montreal, Canada and its link to both built environment indicators and bicycle infrastructure accessibility. The effect of new cycling infrastructure on transport-related greenhouse gas (GHG) emissions is then explored. More specifically, we aim at investigating how commuting cycling modal share has evolved across neighborhood built-environment typologies and over time in Montreal, Canada. For this purpose, automobile and bicycle trip information from origin–destination surveys for the years 1998, 2003 and 2008 are used. Neighborhood typologies are generated from different built environment indicators (population and employment density, land use diversity, etc.). Furthermore, to represent the commuter mode choice (bicycle vs automobile), a standard binary logit and simultaneous equation modeling approach are adopted to represent the mode choice and the household location. Among other things, we observe an important increase in the likelihood to cycle across built environment types and over time in the study region. In particular, urban and urban-suburb neighborhoods have experienced an important growth over the 10 years, going from a modal split of 2.8–5.3% and 1.4–3.0%, respectively. After controlling for other factors, the model regression analysis also confirms the important increase across years as well as the significant differences of bicycle ridership across neighborhoods. A statistically significant association is also found between the index of bicycle infrastructure accessibility and bike mode choice – an increase of 10% in the accessibility index results in a 3.7% increase in the ridership. Based on the estimated models and in combination with a GHG inventory at the trip level, the potential impact of planned cycling infrastructure is explored using a basic scenario. A reduction of close to 2% in GHG emissions is observed for an increase of 7% in the length of the bicycle network. Results show the important benefits of bicycle infrastructure to reduce commuting automobile usage and GHG emissions.

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Introduction

Cycling has been praised for its ability to achieve short to medium utilitarian trips while essentially producing no externalities. In recognition of its many benefits, there has been a shift of focus from motorized travel toward the promotion of cycling in academia and policy circles alike. Several European countries namely Denmark, Germany and the Netherlands have been enjoying cycling booms and consequent benefits (Pucher et al., 1999). Meanwhile in Canada and the USA, cycling has remained a marginal mode of transport, with low modal share in most cities (Pucher and Buehler, 2006). While levels of utilitarian cycling in large North American cities are not comparable to those in Europe, Montreal is generally regarded as one of the North American leaders in urban cycling (Larsen and El-Geneidy, 2011).

In this study, we focus our attention on utilitarian uses of cycling, specifically for home-based work trips (i.e. commute trips). Similar to Wardman et al. (2007) and Caulfield (2014), the commuting market was selected because it represents a significant portion of trips that occur at peak hours when the externalities of private vehicle use are at their highest. Furthermore, the characteristics of commute trips are relatively stable over time, thus, a time-series analysis of mode choice can be executed without the need to consider the more uncertain and complex issues surrounding the generation of new trips (Wardman et al., 2007).

This paper aims to investigate how cycling modal split for commuting has evolved in different neighborhood types and between years in the city of Montreal. More specifically, this paper seeks to explore the effect of neighborhood built-environment typologies and bicycle infrastructure accessibility on commuting bicycle mode choice. Origin–destination (O–D) survey data for the year 1998, 2003 and 2008 are used for this purpose. Generally, built environment indicators that have been found to influence cycling; however, few studies have looked at the temporal evolution and the effect of bicycle infrastructure accessibility indicators. To represent the likelihood of cycling for commuting trips and its link to neighborhood typologies and bicycle infrastructure index, two regression techniques are used: (i) a binary logit model; and (ii) a simultaneous equation model. While the former does not account for residential self-selection bias, the latter does. Once the effects of BE and bicycle infrastructure are obtained, the reduction of greenhouse gas (GHG) emissions resulting from the construction of new cycling infrastructure is explored through simulation.

The paper begins with a literature review of the cycling and built environment literature including the methodologies used in this research. This is followed by the explanation of the data, variables and modeling approaches adopted for the research. Then, the results of each of the different approaches are presented and the effect of new cycling facilities on GHG emissions is estimated through simulation. The paper finishes with the reiteration of the key findings, as well as some avenues for future research.

Literature review

This paper is built upon the vast literature evaluating the effect of the built environment on transportation behavior. The built environment is a catch-all phrase to describe urban locations along a number of dimensions, initially as the 3-Ds (Cervero and Kockelman, 1997) of (population and employment) density, diversity (of land-uses) and design (e.g. road network structure), and later expanded to include destination accessibility (Handy, 1993) and distance to transit, among others. The literature is so extensive that there have been several review papers on the topic, with Ewing and Cervero (2001) and Ewing and Cervero (2010) being the most well-known. This literature has looked at many different aspects of travel behavior including VMT (vehicle miles traveled), number of trips, and mode choice. The most relevant literature for this research considers the effect of the built environment on active transportation, and cycling in particular. Even though the body of literature is quite large, it has typically been focused on active transportation more generally and not explicitly about cycling (e.g. Handy et al. (2002)). The research presented here concerns itself with the literature on the effect of the built environment on cycling mode choice.

As it turns out, there has been a fair bit of recent interest in the factors that influence bicycle mode choice more broadly. Some of that literature, while interesting, focuses on the factors affecting bicycle mode choice, but not on built environment factors (e.g. Wardman et al., 2007; Heinen et al., 2013). The literature of interest here, however, focuses on the effect of the built environment on bicycle use.

Much of this literature (although not all – e.g. Dill and Voros (2007), Stinson and Bhat (2004) and Caulfield (2014)) analyzes the effects of the built environment on cycling with logit models, and other variants of these models (Cervero and Duncan, 2003; Cervero et al., 2009; Moudon et al., 2005; Ortuzar et al., 2000; Parkin et al., 2008; Plaut, 2005; Titze et al., 2008; Wardman et al., 2007; Winters et al., 2010; Pinjari et al., 2007). This analysis is conducted by including built environment variables in logit models of bicycle mode choice and estimating effect sizes based on the coefficients associated with these variables. In more recent studies done by Goodman et al. (2014, 2013), they have looked at the effect of bicycle sharing systems on normalizing the image of cycling (as a safe mode) and also examined how adults use new walking and cycling routes, in London, UK. Aldred and Jungnickel (2014) investigate the role culture can play in transport policy and specially cycling. They show how local cultures in UK shape the experience and understanding of cycling. Sahlqvist et al. (2015) also look at use of new walking and cycling infrastructure in 3 cities in UK.

A complicating issue in the analysis of the effect of the built environment on mode choice, including cycling mode choice, is the phenomenon known as residential self-selection bias. Due to the fact that people who like to cycle are more likely to