Cities 75 (2018) 101–110

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

The influence of the built environment on household vehicle travel by the urban typology in Calgary, Canada

Kwangyul Choi

Haskayne School of Business, Faculty of Environmental Design, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada

ARTICLE INFO

Keywords:
Land use
Vehicle travel
Urban typology
Calgary, Alberta
Monocentric city

ABSTRACT

Most land use and travel studies have addressed the area-wide impact of land use and transportation policies on vehicle travel, yet few studies have examined the varying impact of those policies on vehicle travel in different spatial settings. The aim of this study is to investigate how land use and transportation factors influence household vehicle travel in Calgary according to the city's urban typology, defined by its development form and functions in Calgary's Municipal Development Plan (MDP). This study employed a segmented regression method, also known as a piecewise regression, to examine the impact of various land use and transportation characteristics on household vehicle kilometers of travel (VKT) in four areas of the city including the center city, inner city, established area, and greenfield sector. The main data sources for the study include the 2011 Calgary and Region Travel and Activity Survey (CARTAS) in conjunction with spatial datasets from the City of Calgary. There is no additional benefit of VKT reduction in the center city found by the intensification efforts tested in this study. However, densification and provision of light rail transit (LRT) may be key to reducing household vehicle travel in the established area and greenfield sector of Calgary. The study results also suggest that households tend to drive significantly more as they live further from the center city, where more than half of the city's employment is clustered. This implies the need to have sub-centers across the city.

1. Introduction

Many existing studies have examined the relationship between land use and travel. The common findings suggest that land use strategies (e.g., densification, mixed-use development, street network improvement) and investment in public transit services (e.g., bus rapid transit, light rail transit) can contribute to mitigating many negative impacts of automobile dependency by reducing vehicle travel (Ewing & Cervero, 2010; Zhang, Hong, Nasri, & Shen, 2012). Hence, many local and regional municipalities in North America have implemented various land use and transportation policies to promote compact and mixed-use development and support sustainable modes of transportation.

The City of Calgary has embarked on various land use policies encouraging compact development across the region. As an outcome, Calgary showed an increase in urban density (population + jobs) between 2001 and 2011 (Kriger et al., 2015). Despite these efforts, the city-wide daily mode share by private automobile for all purposes increased slightly from 77% in 2001 to 79% in 2011 (The City of Calgary, 2013a). However, there are substantial discrepancies in the mode share change by location within the city. While the inner areas show relatively dramatic decreases in vehicle travel for the period with frequent uses of public transit and active modes of transportation, the auto mode share in the outer areas either increased or remained the same. The mode shares by private automobile for the center city and inner city dropped by 18% and 5% in 2011, respectively. However, the share of private automobile for the established area slightly increased by 4%, while the share for the greenfield sector was steady in 2011 (The City of Calgary, 2014).

Though most studies have reported the city- or region-wide impact of land use on travel, few studies have examined the link between land use and travel in sub-areas of the study. Thus, the aim of this study is to examine how land use and transportation factors influence household vehicle travel according to the urban typology of Calgary. The outcomes of the study will provide planning practitioners and policy-makers with a better understanding of the impact of land use strategies on automobile use in relation to the level of development intensity and location in the city while considering its particular urban growth pattern.

2. Literature review

Over the last several decades, numerous studies have revealed that changes in urban form are associated with different aspects of travel, including trip length, trip frequency, and mode choice. The existing

E-mail address: kwangyul.choi1@ucalgary.ca.

https://doi.org/10.1016/j.cities.2018.01.006
Received 4 July 2017; Received in revised form 5 January 2018; Accepted 6 January 2018

studies have demonstrated that intensification or modification of land use can lead to changes in one or more aspects of travel and consequently influence travel behavior (Badoe & Miller, 2000; Bento, Cropper, Mobarak, & Vinha, 2005; Boarnet & Crane, 2001; Brownstone & Golob, 2009; Cervero & Kockelman, 1997; Ewing & Cervero, 2001, 2010). For instance, increasing density or mixing different land uses in a given area can reduce trip length by bringing potential destinations closer together (Frank, Greenwald, Kavage, & Devlin, 2011; Kim & Brownstone, 2013; Zhang et al., 2012). In a similar vein, these efforts can influence mode choice by making other means of transportation more attractive than private automobiles (Zhang, 2004). A more interconnected street network, for example, generally leads to shorter distances for travel and provides a number of alternative routes (Khan, Kockelman, & Xiong, 2014). An extensive transit network and bike paths also help to reduce travel times for these modes, particularly when they link higher density destinations (Bailey, Mokhtarian, & Little, 2008). In addition, the design of streets and other facilities as well as the aesthetic qualities of the environment are important in making transit, walking, and cycling more attractive. Policies supporting densification, mixed-use development, transit-oriented development, car-free zones, and streets designed to accommodate users other than vehicles all help to achieve these outcomes (van Wee & Handy, 2016).

With a particular interest in vehicle miles traveled (VMT), many noted scholars have conducted comprehensive reviews of the literature on the relationship between land use and VMT. Most prominently, Ewing and Cervero (2001, 2010) conducted two meta-analyses to quantify the magnitude of the effects of the commonly cited D-variables (i.e., density, diversity, design, distance to transit, and destination accessibility) on VMT. In their earlier study, they found that destination accessibility has the most substantial impact on VMT among D-variables. They also found that the combined effects of several land use factors on vehicle travel could be significant and larger although the individual effects are modest (Ewing & Cervero, 2001). The results from their recent study support their previous findings as well as that transit use is also related to location proximity to transit stops and street network design (Ewing & Cervero, 2010).

Travel behavior is also influenced by several other factors, particularly residential location choice. For several decades, scholars have struggled with the issue of residential self-selection, by which individuals or households may choose their place to live based on their travel preference (Bhat & Guo, 2007; Brownstone, 2008; Cao, Mokhtarian, & Handy, 2009; Handy, Cao, & Mokhtarian, 2006; Mokhtarian & Cao, 2008). Thus, controlling for self-selection effects has been a critical part of proving the directionality and causality between land use and travel for several decades. Many studies have dealt with this issue through methodological improvement or attitude surveys because of the difficulty of a pure experimental research design in which the subjects of study are randomly assigned to either treatment or control groups. With a rich set of socio-demographic information, land use and travel variables can be jointly modeled. However, the results are inconclusive. Some studies used instrumental variables to control self-selection biases and found no significant relationship between density and VMT (Boarnet & Sarmiento, 1998). In contrast, other studies have found a significant link between land use and travel after controlling for the self-selection effects, even if the magnitude of the impact is marginal (Bhat & Guo, 2007; Vance & Hedel, 2007). Brownstone and Golob (2009) used a system of structural equations to control for self-selection biases and found a small but significant relationship between density, VMT, and transportation fuel use. Another large body of literature addresses the self-selection issue through attitude surveys that measure respondents' preference regarding the built environment and travel. These studies found that individual attitudes explain most of the variation in travel patterns (Bagley & Mokhtarian, 2002; Kitamura, Mokhtarian, & Laidet, 1997; Schwanen & Mokhtarian, 2007; Van Acker, Mokhtarian, & Witlox, 2014).

Growth patterns of a given area also affect residents' travel behavior (Ewing, 1997; Gordon & Richardson, 1997). There has been a debate on this relationship with very distinct perspectives. On the one hand, polycentric structures (i.e., deconcentrated structure with many subcenters across the region) cause residents to travel a relatively shorter distance for work trips in particular (Gordon & Richardson, 1997). On the other hand, Ewing (1997), who had a negative view on the decentralization, argued that suburban residents tend to travel much longer than those living in the central cities. However, this polarized view of the relationship between urban structure and travel has been alleviated by empirical evidence (Næss, 2011, 2012; Schwanen, Dieleman, & Dijst, 2001). Studies by Næss suggest that the location of sub-centers as well as the main city center influence traveling distance by private automobile (Næss, 2011, 2012). Schwanen et al. (2001) provided additional empirical evidence by studying the Dutch cities with different urban systems. Their findings suggest that decentralization can encourage driving but reduce distance traveled (Schwanen et al., 2001).

Although most studies have paid more attention to the area-wide effects of land use on travel, a few recent studies have found that the impact of land use strategies on travel may not be identical across a given area (Choi & Zhang, 2016, 2017; Hong, 2017). Hong (2017) used quadratic regressions to examine the non-linear influence of population and employment density on automobile use. He found that the effect of density on vehicle travel becomes insignificant as population density reaches a certain level. Choi and Zhang (2016) applied piecewise regressions to analyze the effects of diverse built environment factors on household VMT and compared four sub-groups by population density level. They also found discrepancies in the magnitude and significance of the effectiveness of land use factors on VMT. Although land use strategies are an effective tool to reduce regional vehicle travel, they found variations in the effects of land use factors on household VMT across the population density sub-groups. Their recent study focused on the impact of land use factors on vehicle travel in mixed-use districts in Austin, Texas, suggesting that densification effort no longer operate in terms of VMT reduction in high-density areas (Choi & Zhang, 2017).

Thus, this study will fill the gap in the literature by examining the impact of land use and transportation factors on vehicle travel by Calgary's urban typology, which corresponds to the growth pattern of the city.

3. Study methods

3.1. Calgary, Alberta

Since the Alberta oil industry boomed in the 1970s, Calgary has grown at an unprecedented rate. As of 2016, the city had a population of 1,239,220 and a metropolitan population of 1,392,609, making it the largest city in the province of Alberta, the third-largest municipality and fourth-largest census metropolitan area (CMA) in Canada (Statistics Canada, 2016). Geographically, the province of Alberta is bounded by the provinces of British Columbia to the west, Saskatchewan to the east, the Northwest Territories to the North, and the U.S. state of Montana to the south. Fig. 1 shows the geographical description of the study area.

As the city's population increased, the city expanded its boundary by annexing surrounding areas. Consuming a significant amount of greenfield areas, the city has grown outward in the last two decades. Currently, most of these annexed lands have been developed for residential purposes to accommodate the city's increasing population as well as for public facilities and services. The city reserves lands at the edge of town for future development. The city boundary presented in Figs. 1 and 2 is its area as of 2007.

As seen in Fig. 1, Calgary consists of 1380 traffic zones (TZs) with an average size of $0.61\,km^2$ (min = $0.002\,km^2$, max = $11.50\,km^2$, SD = 0.67) within the city boundary. Each TZ shares common attributes with other TZs across the city. Based on the similarities of land