Journal of Transport Geography 68 (2018) 130–141

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Urban structural and socioeconomic effects on local, national and international travel patterns and greenhouse gas emissions of young adults

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ARTICLE INFO

Keywords:
Long-distance travel
Greenhouse gas emissions
Travel behavior
Urban structure
Carbon footprint

ABSTRACT

The inverse relationship between urban density and greenhouse gas (GHG) emissions caused by driving is well established. However, at the same time the few existing studies have observed higher levels of long-distance travel and particularly air travel in the same densely built parts of urban regions. This may lead to GHG emissions reduction in local travel offset by the concomitant increase in long-distance travel. With this study we aim to identify the main factors involved in differences in local, national and long-distance travel patterns and the resulting GHG emissions, with a special focus on the role of the different urban zones in the Helsinki Metropolitan Area (HMA) in Finland. We used a softGIS survey to collect data on the personal travel of young adults living in HMA. SoftGIS methodology provides the opportunity to obtain detailed spatial data on participants' residential locations, travel destinations, and destination characteristics such as travel modes, frequencies and trip purposes. Special attention was paid to national and international trips, for which data were collected over 12 months, a period long enough to capture actual travel patterns. GHG emissions were assessed with a wide scope life cycle assessment (LCA) approach, including vehicles and infrastructure, and the results were elaborated with a two-part regression model on participation in travel and amount of GHG emissions. The study found that the residential location was associated with travel emissions on all scales, and independently from major socioeconomic characteristics. Residents of centrally located and densely built urban zones have on average lower emissions from local travel but higher emissions from international travel than residents of car-oriented suburban zones, and the association holds true after controlling for income, education level and household type. Differences in emissions from local travel between most central and most suburban zones were almost completely offset by differences in emissions from international travel. International long-distance trips were a dominant source of travel-related GHG emissions in all urban zones, particularly due to plane flights.

1. Introduction

Energy usage and greenhouse gas (GHG) emissions caused by personal travel in various urban settings have been broadly studied (e.g. Ewing and Cervero, 2010; Newman and Kenworthy, 1999; Mindali et al., 2004; Norman et al., 2006; Chapman, 2007; Brownstone and Golob, 2009; Brand and Preston, 2010; Chester et al., 2013). While the inverse relationship between urban density and GHG emissions caused by road traffic is well established (e.g. Næss, 2012; Ewing and Cervero, 2010; Newman and Kenworthy, 1989, 1999; Mindali et al., 2004; Ala-Mantila et al., 2016), the relationship between urban form and long-distance travel has been much less studied. However, several studies so far have observed higher levels of long-distance travel, and particularly air travel, in big cities and densely built parts of urban regions (Brand and Preston, 2010; Holz-Rau et al., 2014; Ottelin et al., 2014; Reichert et al., 2016). Previous studies have suggested various hypotheses for the reasons behind this relationship. Frändberg and Vilhelmson (2011) attributed the increase in international travel and decrease in car-dependency among Swedish young adults to globalization and flexibilization of lifestyles. Large and globally-connected cities, with good educational and career opportunities, are especially attractive to highly skilled individuals, who not only have resources for travelling but also may be more cosmopolitan in their lifestyles (Reichert and Holz-Rau, 2015; Reichert et al., 2016). Another reason for the higher amount of long-distance travel among big city residents may be better access to airports, as illustrated by Bruderer Enzler (2017). However, these

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https://doi.org/10.1016/j.jtrangeo.2018.02.008
Received 12 October 2016; Received in revised form 23 January 2018; Accepted 20 February 2018

explanations are more likely to apply to urban-rural differences than to differences between various urban zones, which is the focus of this study. Ottelin et al. (2014) and Heinonen et al. (2013a,b) have suggested a monetary-based rebound as another possible explanation that is more closely connected to urban form. Since car ownership and operation are quite expensive, people who do not have these expenses may have higher expenditures on other goods and services, especially holiday travel (see also Lenzen et al., 2004; Ornetzeder et al., 2008; Chitnis et al., 2013; Heinonen et al., 2013a, 2013b). Some researchers have also discussed the compensation hypothesis: the residents of densely populated urban areas may tend to compensate for the lack of open space, green areas, and recreational opportunities by taking longer and more distant holiday or weekend trips (Holden and Norland, 2005; Strandell and Hall, 2015).

The purpose of the study was to closely examine local, national, and international travel patterns of young adults who differ in sociodemographic and life situation characteristics and live in different urban zones of Helsinki Metropolitan Area (HMA). The study extended the research of [citations concealed] about GHG emissions from transport activities of urban dwellers in Finland by enabling more comprehensive data collection on travel purposes, modes and destinations. The previous census data-based studies have suggested substitution between car ownership, local travel and long-distance travel. However, these studies suffered from data gaps, such as short-term reference periods in travel diary surveys and the lack of detailed spatial information on participants and their trips (Ottelin et al., 2014; Holz-Rau et al., 2014; Reichert et al., 2016).

In the current study we used a softGIS survey to collect data on local, national and international travel of young adults (25- to 40-year-olds) living in the Helsinki, Espoo, Vantaa and Kauniainen municipalities within the Helsinki Metropolitan Area (HMA). Geographical data on mobility patterns and environmental evaluations were contributed by the respondents themselves through an online questionnaire coupled with an interactive map (Kahila and Kyttä, 2009; Kyttä, 2011; Brown and Kyttä, 2014). SoftGIS methodology has been used previously in mobility-related studies (e.g. Salonen et al., 2014; Haybatollahi et al., 2015). The survey method allowed us to obtain detailed spatial data on participants' residential locations and trip destinations, and helped to avoid some of the caveats of previous mobility studies related to spatial unit aggregation (Kwan, 2012). It also allowed us to ask contextual questions related to the trips, such as their purpose, frequency, and travel mode. Our research covered a 12-month period for national and international trips, which was enough to overcome the shortcomings of some previously used datasets (Ottelin et al., 2014).

The GHG emissions assessment was conducted with the life cycle assessment (LCA) approach, including both direct and indirect emissions. Inclusion of the indirect or upstream emissions, up to the production of the utilized vehicles and construction of the transport infrastructure, is an important feature adding value to this study, since these have been found significant in the context of transport (Chester and Horvath, 2009; Chester et al., 2013), but have been excluded from most of existing studies. Furthermore, the employed GHG emissions factors included both the typical long-lived GHGs (LLGHGs) included in standard LCAs, as well as the short-lived climate forcers (SLCFs) for air travel, which account for an important part of the climate impact of aviation (Lee et al., 2009; Borken-Kleefeld et al., 2013; Peters et al., 2011; Aamaas et al., 2013; Aamaas and Peters, 2017).

1.1. Research goals and questions

In line with the overall purpose of the study, the first specific goal was to compare the GHG emissions related to local, national and international travel by young adults who inhabit different urban zones of the HMA. The second, and the main, goal was to identify the key factors in the differences in travel-related GHG emissions among the studied population. We sought to provide evidence on whether the differences in GHG emissions between inhabitants of the urban zones were solely due to their sociodemographic, economic and life situation characteristics, or there was also a separate effect of urban structural variables. We also discuss how the findings related to the compensation hypothesis, rebound effects, and cosmopolitan lifestyles, all of which have been suggested as potential reasons for such differences in travel behavior, but were not systematically tested in this study.

1.2. Scope of analysis

The study was limited to young adults (25- to 40-year-olds) living within the HMA. The choice of the age group was meant to minimize the effect of life course variables on the analysis, as its members predominantly belonged to an active workforce, were already independent adults, but were still well before retirement age. Furthermore, people of this age have grown up in a globalized world with access to information and communication technologies, which may explain differences in their travel patterns compared to those of older adults. Finally, understanding the travel patterns of younger people is especially relevant for the design of future sustainable built environments. The analysis of national and international travel patterns focused on trips related to leisure and family visits. Business trips were not included, because they normally constitute a relatively small share of long-distance travel, and are influenced by factors other than those affecting leisure trips (Reichert et al., 2016; Bruderer Enzler, 2017). Analysis of local travel included both leisure and work- or study-related travel.

The paper is structured as follows: the next section presents the Research materials and methods, followed by the Results section. The paper ends with a Discussion and conclusions, including Future Research directions.

2. Research materials and methods

2.1. Sampling and data collection

The data were collected using softGIS, a public participation GIS (PPGIS) method that combines online questionnaires with interactive maps (Brown and Kyttä, 2014). In this study, we used softGIS methodology to record travel patterns.

Study participants marked destinations of local, national, and international trips as points marked on an interactive map. Each marked location was accompanied by questions on trip characteristics such as purpose, travel mode or frequency of visits (SI Figs. 1 to 3). The survey also included questions not related to a map, such as background information about respondents and their household, car ownership and characteristics (fuel efficiency and annual mileage), residential location and dwelling characteristics, satisfaction with life domains, pro-environmental behaviors, consumption patterns, and personal attitudes. The questionnaire that we used for this study consisted of 12 thematic pages and was distributed in two language versions: Finnish and English. Only background information and travel patterns were used in this study.

The target population of the survey were all inhabitants of the HMA (consisting of municipalities of Helsinki, Vantaa, Espoo, and Kauniainen) aged from 25 to 40 years. The Population Register Center of Finland provided addresses for a random sample of a target population living in the region. A total of 5000 individuals were contacted by letter in August 2016 and asked to use the Internet to answer the questionnaire. A second round of invitations was sent out later during September of the same year. Altogether 962 respondents replied to the questionnaire. Because of incomplete responses, we limited the sample used in the analyses to 841 respondents (response rate 16.82%).

2.2. Study area and urban zones

HMA is the capital region of Finland and the most populous