Analysis of telecommuting behavior and impacts on travel demand and the environment

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ABSTRACT

The discussion of whether, and to what extent, telecommuting can curb congestion in urban areas has spanned more than three decades. This study develops an integrated framework to provide the empirical evidence of the potential impacts of home-based telecommuting on travel behavior, network congestion, and air quality. In the first step, we estimate a telecommuting adoption model using a zero-inflated hierarchical ordered probit model to determine the factors associated with workers' propensity to adopt telecommuting. Second, we implement the estimated model in the POLARIS activity-based framework to simulate the potential changes in workers' activity-travel patterns and network congestion. Third, the MOVES mobile source emission simulator and Autonomie vehicle energy simulator are used to estimate the potential changes in vehicular emissions and fuel use in the network as a result of this policy. Different policy adoption scenarios are then tested in the proposed integrated platform. We found that compared to the current baseline situation where almost 12% of workers in Chicago region have flexible working time schedule, in the case when 50% of workers have flexible working time, telecommuting can reduce total daily vehicle miles traveled (VMT) and vehicle hours traveled (VHT) up to 0.69% and 2.09%, respectively. Considering the same comparison settings, this policy has the potential to reduce greenhouse gas and particulate matter emissions by up to 0.71% and 1.14%, respectively. In summary, our results endorse the fact that telecommuting policy has the potential to reduce network congestion and vehicular emissions specifically during rush hours.

1. Introduction

The transportation sector as the fastest growing energy end-use industry accounts for 27% of total U.S. greenhouse gas (GHG) emissions, making it the second largest contributor of U.S. GHG emissions (USEPA, 2016). Similarly, this sector accounts for more than 20% of total CO\textsubscript{2} emissions in the European Union countries (Eurostat, 2016). These rates are even more distinguishable in the countries where personal travel and goods movement are heavily relied on fossil fuels (Shaheen and Lipman, 2007). These trends along with the severe impacts of traffic-related air pollution on climate change and public health drive the need for effective congestion and pollution mitigation strategies.

The emergence of advanced mobility technologies such as alternative fuel vehicles (including electric and hydrogen vehicles) and
hybrid vehicles can help to increase the fuel efficiency and reduce traffic-related emissions. While promising, these technologies have not yet reached their full potential and cannot yield substantial emission reductions in the short term (Amigholy et al., 2017; Miralinaghi et al., 2017; Nichols et al., 2015). Mobility management strategies, on the other hand, have the potential to reduce travel demand and thereby traffic-related emissions in relatively short time horizons. Some examples of these policies are promoting the ridership of public transport, encouraging the use of shared mobility services (car-sharing, ride-sourcing, and bike-sharing), congestion pricing, and telecommuting.

Prior research has shown that among these policies, telecommuting imposes lower costs to the users and takes a shorter time to be implemented (Choo et al., 2005; Kim, 2017; Zhu and Mason, 2014). Telecommuters partially or entirely replace their out-of-home work activities by working at home or at locations close to home. In general, telecommuting offers more flexibility to workers by relaxing the temporal and spatial work-related constraints.

This policy has several potential benefits for both employers and employees. Firstly, it can improve telecommuters’ family-work balance by providing more time for taking care of family members (Hilbrecht et al., 2008; Mokhtarian et al., 2004). Further, since telecommuters can travel during working hours on telecommuting days, they can plan more efficient activity-travel arrangements (Pendyala et al., 1991). In addition, previous research has shown that this policy can increase the employees’ morale and productivity which significantly reduces organization costs in the long run (Bernardino, 2017). The increased productivity may be associated with multiple factors. In addition to the saved commuting time, it has been observed that telecommuters spend more time on work activities than they would in the workplace (Grawitch and Barber, 2010). Further, the flexible work schedule allows them to work during the hours when they are actually more productive, rather than the regular work hours (Kirk and Belovics, 2006).

On the other hand, since telecommuters have more flexibility to allocate time to various in-home or out-of-home activities during their working hours, they may decide to conduct additional trips and activities. This flexibility also opens up the opportunity of making more joint activities with other family members, such as leisure and recreational activities (Asgari et al., 2016; Golshani et al., 2018). Some studies have found empirical evidence of this travel-inducing effect, called rebound effect (see, for example, Koenig et al., 1996; Nilles, 1991; Zhu and Mason, 2014). In sum, the potential impacts of telecommuting are still debatable and empirical evidence on whether, and to what extent, telecommuting can improve traffic network congestion and traffic-induced emissions remains inconclusive.

Previous studies on telecommuting can be broadly categorized into two main streams. The first stream focuses on workers’ telecommuting adoption behavior and aims to identify the factors associated with their propensity to adopt this policy. Some examples of this research direction include Alexander et al. (2010), Drucker and Khattak (2000), Manering and Mokhtarian (1995), Mokhtarian and Salomon (1997), Sener and Bhat (2011), and Singh et al. (2013). The second group, on the other hand, investigates the potential consequences of this policy. Some examples of this research line which explore the impacts of telecommuting on travel-related decisions (e.g., mode choice and departure time choice) and network congestion measures (e.g., trip counts in the network and VMT) include Asgari and Jin (2017), Choo et al. (2005), Helminen and Ristimäki (2007), Lachapelle et al. (2017), Pendyala et al. (1991), and Zhu and Mason (2014). A detailed review of these studies can be found in “Literature review” section.

The current study brings together the two research areas by presenting a comprehensive telecommuting analysis which first, investigates workers’ telecommuting adoption behavior and second, evaluate the consequences of this policy on travel behavior, network congestion, and air quality. The contribution of this study to the literature is threefold. First, we develop a home-based telecommuting participation and frequency model. In doing so, a zero-inflated hierarchical ordered probit model is set up and estimated using a revealed choice data obtained from the CMAP Travel Tracker Survey (CMAP, 2008). The rationale for adopting this method lies in the excessive number of non-telecommuters in the dataset, which is expected because many workers either do not have the option of telecommuting or they prefer not to telecommute even when it is a feasible option for them (Singh et al., 2013).

Second, we implement the estimated model in the POLARIS activity-based framework (Auld et al., 2016a) to simulate the potential impacts on workers’ activity-travel behavior and network congestion. Activity-based models can provide more realistic and policy-sensitive simulation environments for assessing the potential effects of travel demand management (TDM) policies in general and telecommuting in specific. However, despite their great capability in simulating individuals’ activity-travel behavior, studies that have focused on telecommuting and its implications for travel and the environment are still scarce. Third, the US DOE’s Autonomie vehicle energy simulator and the US EPA’s MOVES mobile source emission model are used to estimate potential changes in vehicular fuel use and emissions in the network as a result of telecommuting. The results of this study can shed light on understanding the true effects of this policy and offers a practical approach for testing potential effects of such TDM strategies.

The remainder of this article is structured as follows: In the next section, we briefly review the related studies on telecommuting behavior and integrated travel demand-emission frameworks. Then, descriptive analysis of the data used in this study is presented. In Section 4, we describe the structure of the telecommuting participation and frequency model, along with detailed estimation results and interpretation of model parameters. Section 5 elaborates on the integrated simulation platform, implementation of the estimated model, and simulation results. The paper concludes with a summary of the major findings and recommendations for future studies.

2. Literature review

2.1. Telecommuting behavior and implications

Telecommuting can entirely reshape workers’ daily activity schedules. Therefore, to obtain an accurate representation of their activity planning and scheduling behavior, it is of great importance to account for their propensity to adopt telecommuting. Several studies have attempted to address this issue over the past few decades (see, for example, Drucker and Khattak, 2000; Mokhtarian and
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