Journal of Transport Geography 46 (2015) 137–150

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Generalized behavioral framework for choice models of social influence: Behavioral and data concerns in travel behavior

Michael Maness [a,*], Cinzia Cirillo [a], Elenna R. Dugundji [b]

[a] University of Maryland, Department of Civil and Environmental Engineering, 1173 Glenn Martin Hall, College Park, MD 20742, United States
[b] Centrum Wiskunde & Informatica and Universiteit van Amsterdam, Faculty of Economics and Business, Amsterdam School of Economics, Section Mathematical Economics and Mathematics, P.O. Box 16697, 1001 RD Amsterdam, Netherlands

ARTICLE INFO

Article history:
Received 16 May 2013
Revised 11 May 2015
Accepted 1 June 2015
Available online 14 June 2015

Keywords:
Travel demand
Discrete choice
Social interactions
Network effects
Social networks

ABSTRACT

Over the past two decades, transportation has begun a shift from an individual focus to a social focus. Accordingly, discrete choice models have begun to integrate social context into its framework. Social influence, the process of having one's behavior be affected by others, has been one approach to this integration. This paper provides a review and discussion of the incorporation of social influence into discrete choice models with specific application in travel behavior analysis. The discussion begins with a generalized framework to describe choice models of social influence. This framework focuses on the behavioral microfoundations of social influence and choice by separating the social influence mechanism from the source of its influence and by explicitly acknowledging the role of the social network in the model structure. This contrasts with prior work that focused on the measurement of contextual, endogenous, and correlated effects. Then, the state of the art in travel behavior research is reviewed using a taxonomy based on the generalized framework with research performed in sociology, social psychology, and social network analysis. The discussion then shifts to the importance of understanding the motivations for social influence, and the formation and structure of social networks are explored. Additionally, the challenges of collecting data for social influence studies are mentioned and the paper concludes with a look at the challenges in the field and areas for future research.

1. Introduction

Travel is an integral part of peoples' lives which connects their residences and neighborhoods, work and economic opportunities, and geographical points of reference such as school, childcare, shopping, healthcare, and leisure. Increasingly, transportation researchers have become interested in the role of social interactions between people in a given individual's travel behavior (Dugundji et al., 2008, 2011a, 2012). Borrowing from the field of economics (Durlauf and Ioannides, 2010), social interactions are defined as "direct interdependences in preferences, constraints, and beliefs of individuals, which impose a social structure on individual decisions" (p. 452).

Within travel behavior research, the literature on social interactions is becoming relatively well-established. But recently, there has been growing interest in decisions involving social influence.[1] Social influence deals with how an individual's decision making process is altered by others' actions, behavior, attitudes, and beliefs of others (and the individual's perceptions of these). Of particular interest is the analysis of models in which the decisions of others are incorporated into discrete choice models. Since travel may involve different types of social influence from peers, family, neighbors, colleagues, and even society at large, incorporating these social effects into discrete choice models is non-trivial. These models are grounded in theories of individual choice of independent decision makers. Additionally, they are generally estimated on cross-sectional, choice-based data sources which make it difficult to identify social influence effects and their motivations. These motivations are important for understanding long-run behavior and for guiding organizations on appropriate intervention strategies to encourage behavioral change.

* Corresponding author.
E-mail addresses: mmaness@umd.edu (M. Maness), ccirillo@umd.edu (C. Cirillo), e.r.dugundji@gmail.com (E.R. Dugundji).

[1] The more established area of social interactions in travel involves *social cooperation* which deals with active coordination of travel and activities. This generally involves intrahousehold and interhousehold planning and activity scheduling (Arentze and Timmermans, 2008; Van den Berg et al., 2010, 2012; Carrasco and Miller, 2006, 2009; Habib et al., 2008; Habib and Carrasco, 2011).

http://dx.doi.org/10.1016/j.jtrangeo.2015.06.005
0966-6923/

The incorporation of social networks, the types and timing of interactions, and how social networks and interactions interface in spatial dimensions are difficult to model and identify from current data sources. Social influence models use a wide variety of network structures, varying from cliques to sparse networks, and the connections made can be due to similarity in social standing and interests and spatial proximity. Individuals' networks are also bounded by limitations in cognitive effort, time, and space. The spatial dimension of social networks is still an open research field and its use in transport models of social influence has been limited both in its actual application and its simplicity.

With an emphasis on behavioral and data issues, this paper aims to provide a behavioral framework for describing choice model approaches for decisions involving social influence. The paper begins with a quick example of how a simple hypothesis can be explained by various social and non-social factors. In Section 3, a generalized behavioral framework for choice models of social influence is introduced. Section 4 describes past research in travel behavior using this framework and describes the shortcomings in current models in the need to understand the motivations behind social influence. Sections 5–7 describe the framework's components of social network, social influence mechanism, and influence sources. Section 5 summarizes recent research on the types, motivations, and tactics of social influence. Section 6 describes the behavioral processes behind social network formation and common structural forms and Section 7 summarizes procedures for gathering social influence and social network data. The paper concludes with a summary and areas for future research.

2. A hypothetical example

To clarify the concept of social influence in modeling, we begin this section with a hypothetical, illustrative example of various sources of influence in travel behavior.

Suppose a researcher studying cycling behavior among students and non-students makes the following observation:

> *College students in the US are more likely to use a bicycle than non-students.*

This simple observation could have various causes. The following are several possible explanations for this observation (observability is in reference to the modeler):

1. College students tend to live on college campuses which often have amenities that are nearby. Therefore, more student trips are within the comfortable range for bike travel compared to non-student trips. Individual-level differences in travel distance and trip time (Dickinson et al., 2003) may explain differences in cycling behavior between students and non-students. These variables are typically observable to modelers [**Observed individual-level effects**].
2. Cycling decisions depend on the choices of others because of social norms and conformity (Dill and Voros, 2007). This can cause a self-perpetuating cycle of low cycling rates in neighborhoods with non-students and high cycling rates in neighborhoods with students. For example, this can lead to a situation whereby once a few people start cycling, a critical mass is reached, and cycling becomes more popular [**Endogenous social influence effects – Conformity**].
3. Preferences for automobiles may be higher among lower income individuals compared to higher income individuals (Parkin et al., 2007). Higher income individuals have higher bicycle ownership and tend to cycle more often than lower income individuals. This may induce students to perceive cycling more favorably, perhaps more favorably than would be expected by income alone due to social norms [**Contextual social influence effects – Compliance**].
4. Environmentally-friendly individuals are more likely to cycle than others (Hunecke et al., 2001). If college campuses expose students to environmentally friendly views more frequently than non-students, this may lead to higher cycling rates among students (Haustein et al., 2009). Here, an institutional environment may cause an increase in student cycling rates [**Correlated environmental effects**].
5. Since cycling is a physical activity, a certain level of physical ability and health is needed to cycle. College students in the US tend to be less obese than non-students (Fowler-Brown et al., 2009) and since obesity correlates with health, this could explain a disparity in cycling rates. Since travel surveys tend to not measure health and ability, this may be an example of an unobservable effect which acts at the individual level [**Correlated individual-level effects**].
6. Schools may create a stronger sense of community than an average community so the strong cohesiveness of the social networks among students may allow quicker, stronger, and self-reinforcing dissemination of cycling behavior (Páez and Whalen, 2010) as compared to the less cohesive networks in communities outside of schools [**Social network structure**].

Each of these possible explanations requires a different policy intervention. For example, explanation #1 suggests that increasing the amenities in less dense areas would increase cycling rates, whereas explanation #2 suggests that investments in encouraging a few people to cycle (e.g. advertising campaign, bicycle loan program) would be more effective. Therefore it is critical to ensure that models correctly differentiate these effects, particularly for policy analysis.

3. Generalized framework for choice models of social influence

Conceptually, Manski (1993, 1995) outlines three different ways in which similarities in group behavior can be explained in a model, namely[2]:

- **Endogenous Social Influence Effects**, "*wherein the propensity of an individual to behave in some way varies with the prevalence of that behavior in the group*";
- **Contextual Social Influence Effects**, "*wherein the propensity of an individual to behave in some way varies with the distribution of exogenous background characteristics in the group*"; and
- **Correlated Individual-level and Correlated Environmental Effects**, "*wherein individuals in the same group tend to behave similarly because they face similar institutional environments [(environmental)] or have similar unobserved individual characteristics [(individual-level)]*".

Endogenous and contextual social influence effects characterize the relevance of group level behavior and group level characteristics respectively for individual behavior. An important distinction between these two specifications however, is that endogenous social influence effects allow for the possibility of direct feedback between individual behavior and group level behavior. Thus, endogenous effects can potentially be reinforcing over the course of time. Contextual social influence effects, while social, are presumed (at least short-term) not to involve direct behavioral

[2] Manski refers to these effects respectively as endogenous, contextual, and correlated effects, but they are renamed here to maintain consistency with the rest of the text.