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Early birds, night owls, and tireless/recurring itinerants: An exploratory analysis of extreme transit behaviors in Beijing, China

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ABSTRACT

This paper seeks to understand extreme public transit riders in Beijing using both traditional household surveys and emerging new data sources such as Smart Card Data (SCD). We focus on four types of extreme transit behaviors: public transit riders who (1) travel significantly earlier than average riders ('early birds'); (2) ride in unusual late hours ('night owls'); (3) commute in excessively long distance ('tireless itinerants'); and (4) make significantly more trips per day ('recurring itinerants'). SCD are used to identify the spatiotemporal patterns of these four extreme transit behaviors. In addition, household surveys are employed to supplement the socioeconomic background and tentatively profile extreme travelers. While the research findings are useful to guide urban governance and planning in Beijing, our methodology and procedures can be extended to understand travel patterns elsewhere.

1. Introduction

Extreme conditions often capture our attention and point to important underlying mechanism; we have learned a great deal about our cities by examining the extremes, such as the emergence and dynamics of the most dominant city of a nation, the most depressed city of a region, as well as the most popular gateway city among immigrants. In the past decade or so, against the backdrops of the global financial crisis, increased numbers of the unemployed, self-employed and part-time workers, the rise of telecommuters as well as the relocation of low-paying jobs, extreme commuters have received increasing academic and public attention in recent years. As extreme commuting accounts for an increased portion of daily residential trips, recent analysis starts to look into travelers making unusually long, early, late, and/or frequent trips, which have discretely explored or described by Barr, Fraszczyk, and Mulley (2010); Gregor (2013); Jones (2012); Landsman (2013); Marion and Horner (2007); Moss and Qing (2012); Rapino and Fields (2013); U.S. Census (2005).

As scholarly work on extreme travelers has been largely developed based on North American and European cities, we are interested in extending the framework to understand extreme trips in China. We will examine extreme travel behaviors in public transit, as Chinese cities have historically relied on public transit, and the Chinese government has sought public transit as a major remedy for congestions, pollution, and other issues caused by the rising car ownership.

To date, extreme traveler analyses have mostly used traditional data such as travel diaries and household surveys. More recently, emerging big data sources such as transit smart card data have been utilized to investigate the phenomenon. Transit smart card data record rich information about individual trips (e.g., origin, destination, and time length) and thus could be a useful supplementary data source for understanding travel behaviors. For example, since the 1990s, the use of smart cards has become prevalent in a large number of Chinese cities, partly owing to the development of the Internet and the advancement of mobile communication technologies (Blythe, 2004). Furthermore, Intelligent Transportation Systems (ITS) that incorporate smartcard-automated fare systems had been in place in over 100 Chinese cities as of 2007 (Zhou & Long, 2014). The combination of these conventional and emerging data

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sources could offer new opportunities to deepen our understandings of cities and related routine activities such as traveling and commuting (Batty, 2012; Liu et al., 2015).

While most literature on extreme travelers focuses on excessively long trips, we extend the definition of extreme travelers into four types with the context of Chinese society. The other three types of extreme travelers are public transit riders (1) who make significantly more trips ('recurring itinerants'), (2) travel significantly earlier than average riders (the 'early birds') during weekdays, and (3) ride in unusual late hours (the 'night owls') during weekdays. More specifically, we seek to identify these extreme travelers in Beijing, characterize their spatiotemporal trajectories, profile their socioeconomic backgrounds, and propose necessary policy implications on the phenomenon.

Extreme transit behavior is becoming more prevalent in China and moving to the center of government agendas (Long & Thill, 2015). Without a solid understanding of extreme transit patterns, government programs could easily result in misinformed interventions and policy failures. Therefore, this study seeks to explore the spatiotemporal trajectories of extreme travelers based on refined definitions of 'extreme transit behavior', using Beijing as a case study. Our analysis would leverage the power of emerging public transit data and seek to answer: (1) Are there large number of extreme travelers? (2) Where do these extreme travelers live and work? (3) What are their socioeconomic characters? In addition, our analysis will also tentatively address concerns about the causes of extreme transit behavior.

The remainder of this article is organized in five main sections. First, we relate our analysis to the ongoing debate on the causes and consequences of extreme transit behavior. Second, we detail our data sources, which include both smart card data and conventional household travel surveys. Third, we provide working definitions of extreme transit behavior and describe our empirical framework, which is a modification of the methodology detailed in Long and Thill (2015). Fourth, we summarize key findings based on our exploratory analyses. We conclude with a discussion of empirical contributions and avenues for future research.

2. Relevant literature

Passenger trips have long been of interest to transportation planners and modelers. In existing literature, they have been primarily classified according to trip purpose, time of day, day of week, mode, person type, frequency, activity duration, and route choice (Meyer & Miller, 2001). Emerging big data such as smart card data have enabled scholars to examine more types or aspects of passenger trips, over more time horizons and in large sample sizes, as compared to traditional data (Bagchi and White, 2005). Multi-day data of transit riders, for instance, were once difficult to collect if we rely on traditional methods such as surveys or interviews to collect data. But smart card data make it possible. In addition, smart card data can greatly facilitate our studies of activity space, locations and departure time of about 80% of all transit riders (Chu & Chapleau, 2010).

Extra information provided by smart card data enables us to better plan and manage our transit services (Frumin & Zhao, 2012). Utilizing those data, for instance, we can now identify and visualize over 80% of the transit riders' route choices (Tao, Corcoran, Mateo-Babiano, & Rohde, 2014a, Tao, Rohde, & Corcoran, 2014b). Such data also capture a great deal about revealed preference and could thus be useful for evidence-based planning and/or travel demand modeling (Janosikova, Slavik, & Kohani, 2014; Tao et al., 2014a).

Most smart card data, however, are not designed to capture all information about passenger trips, especially socioeconomic information about trip makers and their trip purposes (Pelletier, Morency, & Trépanier, 2011). Extra work is needed to connect smart card data to more information about trip makers. A small but an increased number of scholars have done so. By combing smart card data and socioeconomic information at a fine-grained spatial level, Mohamed, Côme, Baro, and Oukhellou (2014) show how we can detect which social groups (e.g. workers and students) travel, when/why they travel and where they travel to and from. Kusakabe and Asakura (2014) propose and implement a data fusion approach to inferring trip purposes of transit riders. In the same vein, Lee and Hickman (2014) develop heuristic rules and learning algorithms to infer trip purposes of smart card users. Refereed articles similar to the above cited ones, however, as a whole are still small in quantity. They nevertheless have already shown great potential of smart card data. Alone, they may only provide limited information about transit riders. When they are combined with other small data such as household surveys, land use and census, the combined data can allow us to understand transit riders better in theory for every time horizon and to make more informed city-planning and public-policy decisions based on the improved understandings (e.g., see Batty, 2013a).

Despite the progresses mentioned above, little has been done on extreme travelers based on smart card data. Most of the existing work on extreme travelers is by reporters, based on discrete evidences and/or personal stories. Landsman (2013), for instance, identifies several "extreme commuters" in New York, USA, who have a work trip taking 90 min or more each way and cites other sources to show that those commuters are not just a few. Similarly, Gregor (2013) reports several extreme commuters in London, UK and contends that the number of such commuters is growing. Per some reporters, the rise of extreme commuters are composite results of the tough labor market, dual-worker problem and/or personal choices, e.g., better education for children rather than proximity to workplace (e.g.,ones, 2012; Gregor, 2013).

Based on traditional data such as census data, nevertheless, extreme travel has been paid much attention by both governmental agencies and individual scholars. Moss and Qing (2012) argue that work hours, locations and styles have greatly changed due to the rise of modern Internet and Communication Technologies (ICT) and the increasingly globalized economy. These changes contribute to the emergence and growth of "super commuters", who work in the central county of a given metropolitan area, but live beyond the boundaries of that metropolitan area, commuting long distance by air, rail, car, bus, or a combination of modes once or twice per week. Among the top 5 USA counties for super-commuting, each county has 7.3 to 13.2 percent of the workforce that belongs to super commuters. But even before the emergence or growth of super commuters, "extreme commuters" have been profiled and quantified by USA Census (2005), which defines extreme commuters as those workers who travel 90 min or more to work, one-way and collects related data about them. Based on the above, Rapino and Fields (2013) propose three definitions regarding long commuting: (1) Extreme Commuting: Traveling 90 or more minutes to work. (2) Long-distance Commuting: Traveling 50 or more miles to work. (3) Mega Commuting: Traveling 90 or more minutes and 50 or more miles to work. In this study, we assume that human being's tolerance of long travel is similar across countries. Therefore, the above thresholds were used to categorize extreme commuting in Beijing as well.

Why long commuting or extreme travel have been given so much attention and should be given more attention? Existing literature has rarely directly dealt with this. But several streams of literature have provided some clues. The first stream argues that travel time is disutility and long travel time impairs people's access to opportunities that increase their utility (e.g., see Lyons & Urry, 2005 for a good review). Therefore, extreme travelers would have