Duration of commute travel changes in the aftermath of Hurricane Sandy using accelerated failure time modeling

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A B S T R A C T
This paper used survey data from 397 commuters in the New York City area to determine the transportation-related disruptions and socio-demographic characteristics associated with the duration of home to work commute travel changes after Hurricane Sandy in 2012. The durations examined included those associated with working schedule/location alterations, home-to-work trip delays, telecommuting time, and the alteration of commuting patterns. Accelerated failure time fully parametric duration models, based on the Weibull distribution were used. The models’ significant variables differed. Commuters with higher income or who were highly educated were more likely to prolong the time to return to normal working schedules and increase telecommuting duration. Longer commutes under normal circumstances (based on trip time) prolonged trip delays and the number of days that the commute was changed. Prolonged service recovery periods increased the duration of commute changes and delays, emphasizing the importance of timely transit service restoration. Policies like gas purchase restrictions were found to have trade-offs, since they can prolong the duration of commute changes and create queues at gas stations. Telecommuting can allow commuters to keep their productivity levels high during post-disaster periods.

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1. Introduction

In 2012, Hurricane Sandy disrupted all motorized forms of transportation in the New York City (NYC) area. The transportation service recovery process was extensive and in some areas lasted for weeks. While restoration activities were taking place, transportation agencies and government officials implemented various strategies to make use of available assets, provide transportation connectivity, and manage demand. These strategies included high occupancy vehicle (HOV 3+) restrictions on several major bridges (Bloomberg, 2012b), “even/odd” policies restricting access to gasoline stations by license plate number (Bloomberg, 2012c), modified taxi and other for-hire passenger policies (Bloomberg, 2012a), special agreements with ferry providers, and free parking, bus service, and ferry service to locations in New York (NJ Transit, 2012). While the infrastructure and service adaptations and recovery can be tracked through public announcements (e.g., Kaufman et al., 2012), individual commuter behavior and adaptation are more difficult to capture.

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To capture the changes commuters made and the duration of these changes, a telephone survey of NYC area commuters was conducted. The objective was to use the survey data to estimate duration hazard-based models and determine the parameters that have a statistically significant impact on the duration of commuter behavior changes that occurred in Hurricane Sandy’s aftermath. The starting point for calculating the duration of the events associated with our study is Hurricane Sandy’s landfall. Using accelerated failure time duration modeling, the authors account for the possibility that the likelihood of a commuting behavior change may change over time. After Hurricane Sandy, commuters needed to modify their behavior to adapt to altered transportation availability. As transportation agencies restored infrastructure and service, more choices became available, which may have allowed commuters to return to their normal schedules and commuting choices.

The specific factors examined in this study pertain to the: (1) elapsed time for commuters to return to normal schedules, (2) additional time commuters allocated for their commutes, (3) days commuters spent telecommuting, and (4) elapsed time for commuters to return to normal pre-Sandy patterns of commuting (making the trip), commute mode, commute time, and work location. As such, this paper sheds light on commuting-recovery time by analyzing the relationships between pre-Hurricane Sandy commuting behaviors, socio-demographic attributes, and post-Hurricane Sandy disruptions and the time to return to normal commute patterns.

The remainder of this paper is divided into five sections. Section 2 provides an overview of related literature and presents a series of hypotheses investigated in this work. Section 3 provides a brief overview of the data, Section 4 presents an overview of the modeling approach, and Section 5 discusses the results. The final section provides conclusions.

2. Literature review and hypotheses

Commuters face transportation service disruptions from a variety of sources, including planned reconstruction, natural disasters, infrastructure failures and accidents, and terrorist attacks. For each of these disruptions, commuters must adapt their travel choices, within their abilities and resources, to the infrastructure and services available.

Previous studies indicated that the most commonly observed changes are route and departure time changes, especially for planned efforts such as the nine week reconstruction of I-5 “the Fix” (Mokhtarian et al., 2009), reconstruction of Boston’s Southeast Expressway (Meyer, 1985), and reconstruction of Pittsburgh’s I-376 (Hendrickson et al., 1982). For some unplanned events, such as earthquakes and bridge collapses, the availability of transit options allowed significant (albeit temporary) mode shifts to transit (Ardekani, 1992; Gray et al., 1990), while commuting in other such events showed little decrease in total travel demand and few commuters switching modes (Giuliano and Golob, 1998; Homeburger, 1990; Zhu et al., 2009). Work on travel post terrorist attacks appears similarly mixed. For example, Prager et al. (2011) showed significantly reduced trips on the London Underground following the 2005 bombings that supply factors, such as station closures, could not fully account for, and Rubin et al. (2007) documented changes in travel mode intentions after these bombings. Similarly, Ito and Lee (2005) showed reduced trips in air travel post 9/11, which appears offset in part by highway travel increases (Gigerenzer, 2006). In contrast to these findings, Lopez-Rousseau (2005) found decreases in both train and car travel after the Madrid train bombings in 2004.

Aside from studies pertinent to terrorist attacks, the literature has largely ignored changes in transit use post transport system disruption. Moreover, while a body of work has employed duration modeling and survival analysis to analyze the temporal dimension of everyday commuting behavior such as travel time and congestion duration (Anastasopoulos et al., 2012; Juan et al., 2011; Moore et al., 2013; Zhong et al., 2008; Zhong et al., 2012) and evacuation behavior (Fu and Wilmot, 2006; Hasan et al., 2013), no studies that we are aware of have examined predictors of event duration in the context of transit use after the onset of large-scale disruptive events. We address that gap in this paper by drawing on the covariates identified in duration analyses of non-transit behavior (e.g., gender, income, age, trip length). In particular, we draw on the extant literature to develop eight hypotheses which helped the modeling process by guiding the selection of potential variables.

**Hypothesis 1.** Women are more likely than men to have (a) longer commute alteration durations and (b) lower home to work trip delays.

Gender’s role in travel behavior and disasters is complex but often significant (e.g., Enarson and Morrow, 1997; Fothergill, 1996). Women appear more vulnerable than men during disaster recovery, often due to employment constraints and family care responsibilities (Cutter et al., 2003). We hypothesize that this will increase the number of days on which they alter their commute. In addition, women are more often responsible for re-creating a sense of security for children (Enarson et al., 2007), which may make them more likely than men to cancel commuting trips to be with their children, at least if school is not in session. To further support the first part of the hypothesis, Mokhtarian et al. (2009) found women more likely than men to use vacation days (cancel the work trip) during planned Interstate reconstruction (the "Fix").

Also associated with changing commutes, gender may influence the ability to change modes of transportation. Women on average earn less than men for many reasons, such as differences in education and type of job. About 40% of women do not have a day-shift job and women are more likely to have part time employment (Rosenbloom, 2006). These latter factors may affect the ability to use transit in a post-disaster/disruption scenario where special transit provision may focus on the peak periods. On the other hand, women are more likely to carpool than men for regular travel (Pucher and Renne, 2003) and their social networks may also help them form carpool after a major transportation-disrupting event. Taking all modes together
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