



## Research article

# What drives public transit organizations in the United States to adapt to extreme weather events?



Qing Miao<sup>a,\*</sup>, Eric W. Welch<sup>b</sup>, Fengxiu Zhang<sup>b</sup>, P.S. Sriraj<sup>c</sup>

<sup>a</sup> Department of Public Policy, Rochester Institute of Technology, 3242 Eastman Hall, 92 Lomb Memorial Drive, Rochester, NY, 14623-5604, USA

<sup>b</sup> Center for Science, Technology and Environmental Policy Studies, Arizona State University, USA

<sup>c</sup> Urban Transportation Center, University of Illinois at Chicago, USA

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## ABSTRACT

Extreme weather events often disrupt the operation of public transit systems, and challenge the capacity of transit agencies to effectively respond to them. In this paper, we draw upon a recent nationwide survey of 273 public transit agencies in metropolitan regions across the United States to understand the factors that influence their scope of adaptation to anticipated climate risks. We find that a transit agency undertakes more adaptation measures when transit officials perceive greater risks and greater adaptive capacity of the agency, or when it experiences more severe extreme weather events. We also show that local institutional environment, in particular, political ideology, affects the scope of transit adaptation activities. Transit agencies that operate in more politically liberal counties tend to engage in more adaptation actions, while the effect of state-level ideology depends on the level of perceived influence from state governments.

## 1. Introduction

Over the past few decades, extreme weather events (e.g. hurricanes, floods, snowstorms, heat waves) have caused massive disruptions and damage. According to the National Oceanic and Atmospheric Administration (NOAA), the US has sustained more than 200 billion-dollar weather and climate disasters since 1980. As more “mega”-disasters become the “new normal” (Tierney, 2014: 238), due in part to climate change (Intergovernmental Panel on Climate Change, 2012), effective adaptation becomes imperative. This need is particularly urgent for government and public organizations that have the responsibility to ensure the safety of citizens. Moreover, public organizations play a critical role in climate adaptation because of the public good nature of many adaptation activities (Tompkins and Eakin, 2012).

A growing body of research has examined organizational adaptation to climate change across various sectors (e.g. Arnell and Delaney, 2006; Tribbia and Moser, 2008; Hoffmann et al., 2009; Brouwer et al., 2013; Li et al., 2017; Curtis et al., 2018; Mitter et al., 2018).<sup>1</sup> Some studies have specifically investigated the drivers of adaptation behavior (e.g. Fankhauser et al., 1999; Grothmann and Patt, 2005; Berkhout, 2012; Arnell and Delaney, 2006; Li et al., 2017). For example, Fankhauser

et al. (1999) suggest that adaptation is determined by the recognition of the need, incentive, and ability to adapt. Grothmann and Patt (2005) develop a socio-cognitive model focusing on the role of risk perception and perceived adaptive capacity. Berkhout (2012) outlines three theoretical approaches – utility-maximizing, behavioral, and institutional – to understand organizational adaptation. While the utility-maximizing approach implies that adaptation is a rational decision based on cost-benefit calculations, the behavioral and institutional approaches place more emphasis on social actors’ cognitions and perceptions, as well as the external institutional environment that influences organizational decision-making.

## 1.1. Aim of the study

In this paper, we focus on public transit and explore the factors that affect adaptive responses by public agencies to extreme weather events as part of the climate change impacts. We consider the case of transit because its operations and physical infrastructure are highly exposed to extreme weather (Koetse and Rietveld, 2009; Neumann et al., 2015; Weiner, 2016), making adaptation highly relevant in this sector (Hodges, 2011). Because public transit agencies tend to face significant

\* Corresponding author.

E-mail addresses: [qxmgl@rit.edu](mailto:qxmgl@rit.edu) (Q. Miao), [EricWelch@asu.edu](mailto:EricWelch@asu.edu) (E.W. Welch), [fzhang59@asu.edu](mailto:fzhang59@asu.edu) (F. Zhang), [sriraj@uic.edu](mailto:sriraj@uic.edu) (P.S. Sriraj).

<sup>1</sup> For a more comprehensive review of the relevant literature, see Berkhout (2012).

political and economic constraints, examining their adaptation behavior provides a valuable perspective to understanding organizational adaptation to ongoing climate change.<sup>2</sup>

Specifically, we ask what factors influence the scope of adaptation strategies implemented by public transit organizations, considering a wide range of actions they can possibly take. Drawing upon the adaptation literature and organizational theory (e.g. Adger et al., 2005; Grothmann and Patt, 2005; Agrawal, 2008; Pelling et al., 2008), we develop a set of hypotheses on the determinants of public organizations' adaptation behavior, including perceived risk, perceived organizational vulnerability and adaptive capacity, and the institutional and political context these organizations are embedded in. We empirically examine these factors through an econometric analysis of the data drawn from a 2016 national survey of 862 public managers in 273 fixed-route public transit agencies in the United States.

## 2. Conceptual framework and hypotheses

Conceptually, we frame adaptation in the organizational context as *intentional changes made within the system to reduce the anticipated climate change impacts including increased extreme weather events*. Previous research has categorized climate adaptation by the activities of handling risk, strategic directions, or goals (Smithers and Smit, 1997; Berkhout et al., 2006; Arnell and Delaney, 2006). Moser and Ekstrom (2010) classify adaptive responses as (1) short-term coping reactions; (2) middle-range intentional and planned adjustments; and (3) longer-term system transformations. Specifically, short-term coping reactions involve establishing emergency response routines and structures, which focus predominantly on responding to an emergency situation *ex post* at the operational level. In this research, we confine our focus to the middle-range adjustment, which requires understanding of long-term environmental risks, forward thinking, and more proactive approaches to mitigating risks *ex ante* (e.g. through a full range of activities including system planning and asset management). Such adjustments do not involve transforming the entire system but are sensitive to public policies and organizational structures.

To explain the drivers of adaptation in public transit organizations, we employ the behavioral and institutional approaches (Berkhout, 2012) and posit a layered framework (as shown in Fig. 1). At the outermost layer of the framework, extreme weather events represent exogenous shocks that act on organizations, particularly those that must operate complex systems safely and consistently during direct exposure such as transit. These external shocks may raise the risk awareness and test the organization's response capacity, thereby providing a window of opportunity for adaptation. In the next layer, organizations are constrained by the institutional context (e.g. social norms, political ideology) they are situated in. The institutional layer filters and makes sense of extreme weather events in ways that determine an organization's adaptive responses (Berkhout et al., 2006; Weick et al., 2005). In the following paragraphs, we discuss in more detail the factors that influence the scope of adaptation implemented by public organizations.

### 2.1. Risk perceptions

Risk perception has been long recognized as an important component of risk management and governance, particularly pertaining to risks surrounded by uncertainty, complexity, and ambiguity (e.g. Renn, 2008). Risk perception is also conceptualized as a social and mental

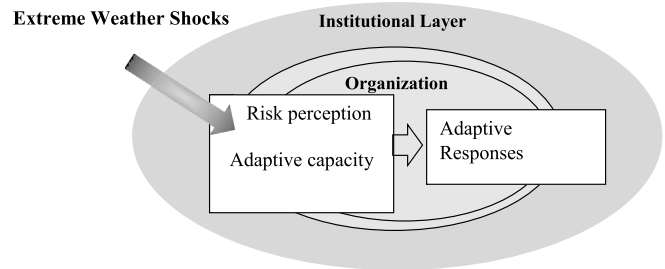


Fig. 1. Conceptual model.

construction, which is bounded by social, political, economic and cultural contexts (Slovic, 1987; Douglas and Wildavsky, 1982; Beck, 2004).<sup>3</sup> Recent climate research suggests that risk perception is a key determinant of individual or organizational adaptation behaviors (Arnell and Delaney, 2006; Moser and Luers, 2008; Hoffmann et al., 2009; Li et al., 2017), because it relates to the problem of severity and the incentive to adapt. Considering its cognitive and subjective nature, risk perception is often treated differently from scientific risk assessment (Beck, 2004) and is influenced by “frequent, unambiguous, and salience evidence from experience” (Berkhout, 2012:95). This also explains why sudden extreme weather events often raise the awareness about climate change risks and provide legitimacy to adaptive responses (Adger et al., 2005; Linnenluecke and Griffiths, 2010; Berrang-Ford et al., 2011; Ray et al., 2017).<sup>4</sup> In this study, we focus on the risk perception of public transit managers and propose:

**Hypothesis 1.** Higher perceived extreme weather risk increases the number of adaptation strategies implemented by a public transit organization.

### 2.2. Perceived vulnerability and adaptive capacity

The degree to which an organization may be affected by an external threat also depends on its vulnerability to the threat (Smit et al., 2000; Arnell and Delaney, 2006). In the climate change context, vulnerability is considered as a function of a system's exposure and sensitivity to climate hazards and its capacity to undertake adaptive actions (Gallopin, 2006; Brooks et al., 2005; Smit and Wandel, 2006). This conceptual approach implies that vulnerability roots in the system's internal structures and properties; for example, a society's vulnerability to climate change could be determined by its socio-economic and political characteristics (e.g. Brooks et al., 2005). In the case of transit, the reliance on physical infrastructure (e.g. busways, rail tracks, subway tunnels) increases the exposure of transit systems to extreme weather. Old and poorly-maintained facilities could further increase the risk of service interruptions or breakdowns. To the extent that organizations are aware of their vulnerability to extreme weather risks, they might be more willing to adapt. Therefore, we propose:

**Hypothesis 2.** Higher awareness of vulnerability to extreme weather increases the number of adaptation actions implemented by a public transit organization.

The adaptation literature (Smit and Wandel, 2006; Brooks et al., 2005; Gallopin 2006) generally suggests that there is substantial variation in the ability of individuals and organizations to undertake adaptation, also called adaptive capacity. Grothmann and Patt (2005)

<sup>2</sup> Two recent studies (Koch and MacArthur, 2013; Dowds and Aultman-Hall, 2015) examined the barriers to climate adaptation in the transit sector. Our study further extends their work by including a nationally representative sample of transit agencies and examining more comprehensively the determinants of their adaptation activities.

<sup>3</sup> For example, Beck (2004) argues that mass media has been playing a critical role in disseminating risk information and shaping the public perceptions of risk over the last half a century.

<sup>4</sup> Recent development in climate science allows attributing certain extreme weather events to climate change and therefore informs climate adaptation efforts (Boran and Heath, 2016).

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