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Peer coordination and communication following disaster warnings: An experimental framework

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ABSTRACT

The content of official disaster warnings is often lost to peer influence in emergency situations. This is also true in evacuation decisions, where people tend to leave when others leave, leading to miscoordination and congestion. The goal of this paper is to create an experimental framework to study how peer influence mediates the process through which human participants translate disaster warnings into evacuation decisions. The main design objectives are to (1) connect the field of disaster management to behavioral and experimental economics through social dilemmas, (2) establish a baseline treatment of no social interaction to first connect individual characteristics (namely risk preferences) to beliefs and actions, (3) measure the impact of enhancing peer to peer communication on collective evacuation patterns by systematically layering communication treatments upon the baseline treatment. An investigation of whether peer to peer communication can close the gap when official evacuation instructions fail to reach all residents is included as a sample application.

1. Introduction

It has been argued that dissemination of warning information from authorities to the public is not adequate to ensure a timely and orderly response. Those who receive official information do not always respond as expected. For example, the plans for Hurricane Rita called for sequenced evacuation that prioritized areas facing the most danger. However, many from communities under low risk evacuate anyway, creating a situation where "keep[ing] people off the road who don't need to be there" became a critical problem.[1] As a result, some of those who are mandated to leave choose to stay rather than face what they expect to be a difficult and costly evacuation. Studies on evacuation decisions and dynamics reveal that the influence of authorities' instructions is indeed limited: official warnings only alert citizens to danger, but the informational content is often lost to peer influence (Eisenman et al., 2007; Burnside et al., 2007; Nilsson et al., 2009; Bode et al., 2014). Emergency management therefore needs to not only consider the role of vertical (top-down) communication, but also horizontal (peer-to-peer) communication (Comfort et al., 2004; Comfort, 2007).

Seen from the social science lens, the evacuation scenario resembles a social dilemma: acting in one's immediate self-interest is tempting, even though everyone benefits from acting in the long term collective interest. Specifically, it shares many characteristics with the tragedy of the commons, though there are enough important differences to warrant a separate investigation.[2] Deutsch (1958) has found that a brief discussion prior to interaction increased subsequent cooperation in social dilemma; the importance of communication between participants in the dilemma has since then been confirmed in subsequent experimental studies. Balliet et al. (2009) meta-analysis shows that communication affects understanding of the game, expectation of cooperation from others, group identity, and formation of norms. The idea that coordination can be greatly improved if warning systems are supported by self-emergent citizen communication networks (Umihara and Nishikitani, 2013) has produced an influential research agenda for emergency management. Special attention has been placed on mobile technologies – "the next generation" in crisis response tools (Terpstra et al., 2012) – due to their potential for not only rapid one-on-one information transmission but also as a gateway to social media information broadcasts (e.g. Twitter).

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[1] See Evacuation Picked Apart In Houston, Rad Sallee, Houston Chronicle (www.chron.com), 27 Oct. 2005.

[2] Contrast an evacuation problem with overfishing, the classic commons example. The payoff for cooperating (refraining from overfishing) is increased fish stocks, which depends on the number of people who also refrain from doing so, while the payoff of overfishing can be considered independent from others' decision at least in the short term. On the other hand, the payoff from refraining from evacuating (facing the risk of catastrophic loss) can be considered independent from others' decision while the payoff for evacuating is decreasing in the number of people who evacuate.

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However, the condition under which communication leads to positive self-organization in disaster evacuation is unclear. Existing empirical data on evacuation behavior from surveys, simulations, and agent-based models exist but they are not sufficiently fine-grained and are still "lacking systematic, individual-level experimental verification" (Moussaïd et al., 2009, p. 2755).[3] Risk perception has been found to be the most important correlate of evacuation (Smalley, 2013; Burnside, 2006; Burnside et al., 2007; Bateman and Edwards, 2002); beyond that, people are much more likely to follow instructions, or conversely, disregard them, when others do so. Rapid communication capacity can therefore quickly render isolated instances of both compliance and noncompliance (e.g. evacuation of one extremely risk-averse person) into the prevailing norm. In addition, studies have shown that social media broadcast capacity can spread inaccurate information (Thomson et al., 2012) and be used to intentionally create harmful rumors (Castillo et al., 2011). In this situation, enhancing a community's ability to communicate internally may not improve welfare; in fact, peer-to-peer communication may even bring harm through confusion and misinformation. Whether the former or the latter best describes human actions in a disaster setting is a question that needs to be investigated systematically and empirically.

This paper intends to fill two gaps. First, it aims to provide a simple experimental framework to study how individuals translate official evacuation instructions into action when they are isolated from social influence. By including elicitation of individual characteristics (i.e. risk preference) and beliefs about disaster probabilities and others' evacuations behavior, this framework can be used by researchers to trace the baseline process through which official instructions drive individual behavior. Second, it provides a way to systematically embed the individual in an increasingly complex social setting, revealing how local mechanisms shape collective patterns of behavior. In this experiment, each potential source of social influence (observation of nearby peers' behavior, 1 on 1 conversations, and broadcasted messages) is introduced as a separate experimental treatment that can be layered on top of each other. This allows researchers to isolate the impact of policy that utilizes social influence as a tool to improve evacuation outcomes, such as the enhancement of peer to peer communication capacity.

The approach in this paper links these questions to research in behavioral and experimental economics. Behavioral economics integrate psychological insights with a sharp focus on institution (as represented by information and incentives) in understanding human behavior. Experimental economics tests models of behavior by putting humans in strictly controlled experimental environments that replicate the basic information and incentives structure of the institution of interest. Due to its focus on replicability and micro-level causal mechanisms, this experimental approach may feel especially stark for researchers that are used to richer data from naturally occurring sources. However, its simplicity and self-contained nature allows subjects to participate in multiple rounds of the interaction of interest, generating data on the long run evolution of behavior. This is extremely valuable in studying behavior in response to disaster warning, where long run empirical data on the evolution of coordination and communication in a community under the threat of disaster may be very difficult and expensive to collect.[4] Through a multi-round experiment we may find that a certain kind of communication technology (i.e. broadcast) does not perform very well at first at improving evacuation responses, but then becomes very effective in the long run (i.e. as the pool of people who use broadcast technology shrinks and only the most effective leaders remains).[5] Researchers can then investigate if these experimental findings can be confirmed in more complex field experiments or site-specific studies before using it to inform policymaking.

In the next section (Section 2), I will provide a brief and necessarily incomplete review of the wide range of related literature. In Section 3, I will describe the information and incentives structure in the disaster scenario that motivates the experimental framework. I will also discuss the role of individual characteristics (i.e. risk preferences) on the decisions to evacuate. Section 4.1 provides the basic experimental framework of evacuation decision without communication; sample computer screens are provided. Briefly, participants in the experiment are assigned to two districts that may be affected by an impending disaster. Evacuation costs increases in the number of evacuees, but is the only way to avoid suffering catastrophic losses in case of disaster. After observing private signals on disaster probabilities, an official aided by a computer system announces which of the districts has to evacuate. Participants then decide whether to evacuate. Section 4.2 discusses several extensions (Observation, Communication—1:1 and/or Broadcast, and Partial) that can be used to understand the conditions under which peer communication would improve evacuation coordination. Section 5 provides an example of how this framework can be used to investigate policy questions: whether peer to peer communication can close the gap when official evacuation instructions do not reach all residents.

2. A brief overview of literature and methods

Actual decision making in evacuations can be difficult to study since disasters happen rarely and real time data on interaction, communication, and movement is difficult to collect. Researchers have dealt with this challenge through two approaches: surveying individuals who lived in areas that were under evacuation orders due to an impending disaster, and studying actual evacuation decisions through scenarios simulated in real life or in computer games.

Surveys on evacuation are usually conducted with affected individuals during some period after the disaster by face-to-face interview or random direct dialing (RDD). The focus of these interviews includes: risk perception, information from media, local authority, and peers (Lindell et al., 2005); past evacuation decisions ("crying wolf"); evacuation obstacles such as transport (Eisenman et al., 2007); pets (Heath et al., 2001); and property, socioeconomic status, race and gender (Smalley, 2013; Burnside, 2006). Risk perception has been found to be the most important correlate of evacuation (Smalley, 2013; Burnside, 2006; Burnside et al., 2007; Bateman and Edwards, 2002) while the influences of other factors have so far been inconclusive.[6] These studies have consistently found that social influence matters (Eisenman et al., 2007; Burnside et al., 2007). For example, Lindell et al. (2005) finds that those affected by Hurricane Lili trusted information coming from peers most, followed by local authorities, and, finally, news reports.

[3] Findings from the standard commons problem, though useful, cannot be directly extrapolated to the evacuation setting due to important differences.

[4] Controlling for confounds such as changes in local government, evolution of communication technology, types of disaster, and the changing demographic of an area in this type of data is also challenging.

[5] For example, the ability to broadcast may get a community fully informed and energized to work together in overcoming the first threat of disaster, but may be used instead to protest and agitate as false alarms happen and past evacuation costs accumulate over time. On the other hand, we might find that the ability to broadcast causes a great deal of confusion the first time it is introduced but becomes effective over time as trusted community leaders emerge.

[6] For example, Smalley (2013) found that African Americans are less likely to evacuate while Burnside (2006) did not find this to be the case. Similarly, while Benight et al. (2004) and Burnside (2006), and Burnside et al. (2007) found that having evacuated in the past when catastrophe did not happen (crying wolf) does not affect likelihood of evacuation in the future, Smalley (2013) finds that it does.

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