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## Partner selection in disaster relief: Partnership formation in the presence of incompatible agencies

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## ABSTRACT

From terrorist attacks to tsunamis, natural and man-made disasters have had an increasingly pronounced impact on the world over the last century. While it is important to mitigate the effects of a disaster before it happens, it is also important to prepare an effective and flexible structure to help people, organizations, and governments develop to respond. Marked progress in the literature and in practice has helped humanitarian organizations become more interoperable, and also improved predictive capability for natural and man-made disasters. However, new problems and failures are brought to light with each new bombing, flood, hurricane, earthquake, or tsunami. This paper takes a previously understudied approach to post-disaster partnership selection using game theory. We analyze the dynamics of a sequential partnership selection game where there is a cost for working with an incompatible partner. Using a non-cooperative game structure, we identify some important dynamics that can be leveraged by agencies involved in disaster relief to help improve decision making and increase the impact of resource investments. For example, passing as much of the cost as possible to an incompatible partner, while also attempting to maintain the relationship, proved to be a poor approach to partnership. In this paper we look at how game theory could be used to help agencies make better decisions about whom to work with during the disaster response and recovery phases of a disaster.

### 1. Introduction

Disasters are defined as “events that produce more losses than a community can handle” Lindell et al. [34]. Humanitarian crises also fit the definition of a disaster, and are an extremely important and challenging issue around the globe. The issue addressed in this paper is how to help agencies make better decisions about whom to work with in the wake of a disaster. While it is important to prepare for the impact of a disaster, it is also important to prepare an effective and flexible response structure to help people, organizations, and governments make decisions about how to respond once a disaster has struck. Even when a country or region is extremely well prepared there is always a chance that a disaster could adversely impact people and property. This reality was highlighted by the 2011 triple disaster (earthquake, tsunami, and nuclear) in Japan, one of the most prepared nations in the world Foster [24]. “The government has been praised for its readiness via earthquake/tsunami drills, for the prompt organization of the National Self-Defense Forces, and for its preparedness to send in doctors and volunteers Chavez [12].”

One key challenge to improve disaster relief efforts is that there are

a great number of uncertain or unknown needs. This challenge is further compounded by the presence of incompatible agencies whose stated goals and methods may be different from their actual practices. There are a variety of reasons why a partner might be incompatible, such as different objectives, management styles, or organizational cultures. To our best knowledge, this is a new topic in the literature. In this paper we novelly look at how game theory could be used to help agencies (defined as businesses, government agencies, militaries, and nonprofit organizations) make better decisions about whom to work with during the disaster response and recovery phases of a disaster. Specifically, we look at relief work from the perspective of a decision maker attempting to choose partners in a disaster environment. “Disaster Partners are passionate supporters of the communities where their employees, customers, and colleagues live and work American Red Cross [2].” The model that is defined here focuses on providing a broad perspective of the partnership dynamic. The goal is to provide broader recommendations for the relief community to effectively participate in the agencies’ network in the disaster relief.

The rest of the paper is organized as follows: Section 2 discusses the research motivation and background. Section 3 develops a model of

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partnership behavior using game theory, and gives a general solution for a two-player partnership model. Section 5 concludes.

## 2. Problem motivation and background

An increase in the amount of information broadcast using social media and online news channels has quickly made public any perceived failures in humanitarian relief work. As a result, agencies working in disaster relief have come under scrutiny in the information age due to scandals Duan et al. [21], Sun [49], Carbone [9], new legal guidelines that increase the accessibility of records Cochran [14], and demands from the general public for accountability Macdonald [35]. Positive publicity is very difficult to achieve in humanitarian relief work due to the challenging nature of the situations involved, making it even more important for agencies involved in disaster relief work to maximize the perceived utility achieved from their limited resources (utility represents the motivations of players, and a higher number implies that the outcome is more preferred [44]).

Coordination between different agencies has been shown to increase agency efficacy Stephenson Jr [48], Privett and Erhun [41], Altay and Green [1], Ergun et al. [22], Horney et al. [31]. Agencies responding to disasters should be prepared to interact with other individuals and agencies Gillespie and Perry [25], Drabek [20], Castaneda et al. [10] because partnership may increase operational efficacy by reducing duplicated services and increasing resource utilization. Effective inter-agency cooperation is especially important where governmental oversight and regional management are severely lacking Telford and Cosgrave [50].

Optimization has been widely used in an attempt to improve humanitarian relief efforts prepositioning resources for disaster response work Wardell [52], Salmerón and Apte [45], Coupet et al. [17], Heier Stamm et al. [30]. Similarly, the challenges of achieving sustainable recovery have also been enumerated Smith and Wenger [47], along with a discussion of how to focus on the development of performance goals that help to rebuild a community. Optimization has been studied extensively from a supply-chain perspective for application in humanitarian logistics, and has an increasing presence in the literature Van Wassenhove [51], Blecken and Hellingrath [4], Ergun et al. [23], McLachlin and Larson [37], Cavdur et al. [11]. Unlike Coles and Zhuang [16], where they only propose an approach to support and guide decision makers on how to select and develop relationships to improve resource utilization and project outcomes in emergency environments, this paper develops and examines a model of agency partnership selection in a disaster relief environment while attempting to maximize the efficacy of their responses. This is a new approach that has not been covered in the literature, to the best of our knowledge.

### 2.1. Partner selection decisions

Agencies with partnerships are defined as those that have relationships with other agencies and share resources, information, or operations. Gonçalves [26] defines a framework for understanding how a humanitarian agency could to achieve capability goals (long-term) or relief goals (short-term). Telford and Cosgrave [50] and Kapucu [33] demonstrate the importance of interagency partnerships in humanitarian relief operations to conduct effective humanitarian relief operations. Mitchell [38] emphasizes that it is critical for international agencies to understand their effect on local agencies and the national economy. The importance of understanding the impact of relief operations on the local economy and environment by differentiating between external agencies (those agencies only entering the affected area after the disaster) and internal agencies (those agencies which had a significant presence in the impacted area prior to the disaster) is also emphasized Coles and Zhuang [16]. Johannessen et al. [32] find that partnerships should encourage small entrepreneurs to support the most vulnerable in society. And Binder and Baker [3] explores the relationship between local and

external disaster response efforts focusing on the role of culture. This paper focuses on improving partnership decisions without attempting to define an agency's goals or how agency reliability might be calculated.

As the number of agencies involved in a disaster relief effort increases, the complexity of the network involved increases exponentially. Different objectives, management styles, or organizational cultures of incompatible agencies make the formation of partnerships more difficult. While interagency partnership is an important component of relief, the method of execution often leaves much to be desired Telford and Cosgrave [50]. In the supply chain literature, Bryson et al. [7] and Wishart [53] discuss the importance of having an equal balance of power to maintain a stable and effective relationship. Mitchell [38] highlights the key role that common ideas and objectives play in helping a partnership to be effective. Simo and Bies [46] identify the importance of having effective partnership collaboration and inter-agency coordination when the environment is poorly managed. Measures of efficacy for partnerships have been developed in the supply chain literature Donaldson and O'Toole [19], and could easily be adapted to study the strength of disaster relief relationships. In our previous study, Coles et al. [15] design and execute six experiments to study how agencies make partnership decisions in a disaster environment, and how such decisions would affect operational efficacy. However, how the operational efficacy could be maximized was not modeled and studied. This paper contributes to the literature by examining the implications of working with potentially incompatible partners in a disaster relief operation. To our best knowledge, no study previously has examined the formation of partnerships among incompatible partners in disaster relief domain, especially from a game-theoretic perspective. We focus on the development of links, or partnerships, rather than the whole network in disaster relief context.

### 2.2. Using game theory

Game theory is a well-studied framework used to analyze the interaction of multiple agencies in a variety of circumstances (e.g., competitive, cooperative), and is useful for providing action recommendations to each agency involved Camerer [8]. "Applications of game theory to humanitarian supply chain systems are limited to date but that many components of humanitarian operations can benefit from such study Muggy and Heier Stamm [40]." A perspective on how game theory principles could be incorporated into the decisions made by agencies in disaster relief operations is proposed by Coles and Zhuang [16], but they did not offer a mathematical model as is done in this paper. The interactions among players have been studied. Zhuang et al. [56] present a game-theoretic model to study the interplay between nonprofit organizational disclosures and individual donations. The strategic interactions between a company and a government in disaster environment is studied in Hausken and Zhuang [29]. And a supply chain disruption in a defender-attacker game is modeled in Xu et al. [54]. However, none of them study the formation of partnership.

One important distinction in our discussion of game theory is the difference between cooperative and non-cooperative game theory. Cooperative and non-cooperative game theory can provide very different perspectives on the same problem space. Non-cooperative game theory is more commonly used and widely discussed because there is a greater degree of control in the problem design and it is feasible to explore the actual mechanism of interaction Borg [5], for example, the sequence of moves, and the adaptive strategies for each player. Ergun et al. [22] introduce a cooperative game theory model exploring under which conditions multi-agency coordination could be feasible and desirable. Cooperative game theory looks at the bigger picture of a problem by focusing on outcomes of relationships without regard to the interaction mechanism, allowing any cooperative game to be modeled as a non-cooperative bargaining game. Unlike non-cooperative game, cooperative game does not focus on the interactions among players Harsanyi and Selten [28].

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