



Investing in disaster management capabilities versus pre-positioning inventory: A new approach to disaster preparedness



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ABSTRACT

Disaster preparedness has been recognized as a central element in reducing the impact of disasters worldwide. The usual methods of preparedness, such as pre-positioning relief inventory in countries prone to disasters, are problematic because they require high investment in various locations, due to the uncertainty about the timing and location of the next disaster. Investing in disaster management capabilities, such as training staff, pre-negotiating customs agreements with countries prone to disasters, or harmonizing import procedures with local customs clearance procedures, has been recognized as a way to overcome this constraint. By means of system dynamics modeling, we model the delivery process of ready-to-use therapeutic food items during the immediate response phase of a disaster, and we analyze the performance of different preparedness scenarios. We find that pre-positioning inventory produces positive results for the beneficiaries, but at extremely high costs. Investing in disaster management capabilities is an interesting alternative, as it allows lead time reductions of up to 67% (18 days) compared to a scenario without preparedness, at significantly lower costs than pre-positioning inventory. We find that the best performance can be achieved when combining both preparedness strategies, allocating part of the available funding to disaster management capabilities and part to pre-positioning inventory. We analyze 2828 such combined scenarios to identify the best mix of preparedness strategies for different levels of available funding. On the basis of our findings, we provide recommendations for relief organizations on how to allocate their preparedness budget.

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1. Introduction

Natural and man-made disasters strike unpredictably every year, claiming thousands of victims worldwide. Millions of people are affected by the direct consequences of these disasters, and their survival depends on disaster relief assistance provided by governments and international relief organizations. This assistance must be provided within the first hours following the disaster in order to increase the survival rate of the affected populations. The first priorities are locating the victims (e.g., in the case of an earthquake), delivering health care to the injured victims, and providing water, food, and shelter to the survivors. These tasks require complex logistical activities, as the needed supplies are rarely available directly at the location where the disaster struck. These logistical activities, generally referred to as humanitarian logistics, are hampered by several barriers, such as destroyed transport and communication infrastructures, custom clearance procedures, and operational bottlenecks at key access points, such

as airports, harbors, or border crossings. Further, when disasters strike in developing countries, relief organizations may face additional challenges. The local government does not always cooperate with the international relief organizations, security problems impede access to the victims, and a population's extreme poverty increases its vulnerability. The uncertainty of the demand also poses a challenge to relief organizations, as precise data related to the number and location of victims are unavailable in the first hours following a disaster.

In order to speed up disaster relief assistance and increase its effectiveness, and thus reduce the impact of disasters worldwide, academics and practitioners are increasingly calling for the implementation of disaster preparedness (Duran et al., 2011; Gatignon et al., 2010; Jahre et al., 2009; Kovács et al., 2010; Perry, 2007; Van Wassenhove, 2006). This preventive phase of disaster management can be defined as all of the activities that can be performed by the population, the government, and relief organizations before a disaster strikes, with the aim of decreasing its potential devastating effects (Van Wassenhove, 2006). Such preparation efforts and the related uncertainty about the occurrence of unfavorable events are well established in traditional risk management fields (e.g., financial services). However, in the field of humanitarian aid, such proactive risk-hedging actions are considerably hampered,

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since donors traditionally only finance response efforts once a disaster has occurred (Jahre and Heigh, 2008).

The most well-known form of disaster preparation suggested in the literature is the pre-positioning of relief supplies in countries prone to disasters (see Table 1). However, this is problematic, because pre-positioning requires high investment and holding costs at various locations, due to the high levels of uncertainty regarding the timing and location of the next disaster. In addition, product expiry is a major problem, as there is no inventory turnover between crises (Whybark, 2007). For these reasons, rather than pre-positioning supplies, Van Wassenhove (2006) proposed that relief organizations invest in disaster management capabilities (DMC). Investing in DMC can be done, for example, by training staff to be prepared to operate in a new country, developing and disseminating best practices on the basis of past disasters, educating the local population, pre-negotiating agreements with suppliers and governments, harmonizing procedures with local government requirements, or securing cooperation with local governments and NGOs (Table 2 provides a complete list with references). Investing in such capabilities, rather than in

physical pre-positioned assets, has several benefits. First, the DMC developed by an organization can be deployed worldwide, in contrast to pre-positioning supplies that have to be duplicated in various locations. Second, DMC (especially those related to import processes) allow organizations to deliver supplies quickly from a centralized warehouse when a disaster occurs. Third, it costs less to invest in DMC than to pre-position supplies in large quantities in various locations.

Our paper intends to evaluate the effects of investing in DMC through system dynamics modeling. We model the delivery process of ready-to-use therapeutic food (RUTF) items during the immediate response phase of a disaster. We chose these items because of their growing strategic importance in relief aid. Indeed, in 2007, the UN World Health Organization (WHO) announced a “shift from hospital-based to community-based treatment for severe acute malnutrition with RUTF” (UNICEF, 2009, p. 4). Due to these recommendations, as well as the high effectiveness of RUTF treatments (Tectonidis, 2006), the demand for such items sharply increased, posing numerous challenges for relief supply chains.

Table 1
Types of physical preparedness activities.

Investment in...	Preparedness activities
Inventory	<ul style="list-style-type: none"> Pre-positioning relief supplies in disaster-prone countries (Adivar and Mert, 2010; Altay and Green, 2006; Altay et al., 2009; Balcik and Beamon, 2008; Duran et al., 2011; Görmez et al., 2011; Hale and Moberg, 2005; Jahre and Heigh, 2008; Jahre et al., 2009; Kovács and Spens, 2009, 2011; Mete and Zabinsky, 2010; Oloruntoba and Gray, 2006; Pettit and Beresford, 2005; Rawls and Turnquist, 2010; Taskin and Lodree, 2011; Tomasini and Van Wassenhove, 2009; Van Wassenhove, 2006)
Infrastructure	<ul style="list-style-type: none"> Communication equipment and information technology needed for disaster response (Pettit and Beresford, 2005) Building tsunami-proof housing in protected locations (Perry, 2007) Building earthquake-resistant infrastructure (Natarajarithinam et al., 2009) Building pre-disaster infrastructure, such as distribution centers, road networks, hospitals, emergency power plants (Kovács and Spens, 2009)

Table 2
Types of intangible preparedness activities.
Based on Van Wassenhove (2006).

investment in...	Preparedness activities
Human resources	<ul style="list-style-type: none"> Training staff (Altay and Green, 2006; Perry, 2007; Pettit and Beresford, 2005; Van Wassenhove, 2006) Hiring disaster mitigation and preparedness specialists (Benson et al., 2001) Hiring and training local staff to respond to disasters (Van Wassenhove, 2006)
Knowledge management	<ul style="list-style-type: none"> Learning from previous disaster response experiences and developing best practices (Charles and Luras, 2011; Van Wassenhove, 2006) and “preparedness templates” for different types of disasters (Day et al., 2012) Early warning systems (Oloruntoba, 2010; Van Wassenhove, 2006) Decision-making models and tools (Adivar and Mert, 2010; Balcik and Beamon, 2008; Banomyong and Sopadang, 2010; Day et al., 2009; Görmez et al., 2011; Mete and Zabinsky, 2010; Nolz et al., 2010; Özdamar, 2011; Rawls and Turnquist, 2010; Taskin and Lodree, 2010; Tovia, 2007; Ukkusuri and Yushimoto, 2008) Disaster damage (e.g., earthquake) scenarios (Barbarosoglu and Arda, 2004)
Process management	<ul style="list-style-type: none"> Pre-negotiating agreements with suppliers and logistics providers (Altay et al., 2009; Duran et al., 2011; Kovács and Spens, 2007; Van Wassenhove, 2006) Preparing organizational structures, response plans within relief organizations, and arrangements with other organizations (Altay and Green, 2006; Görmez et al., 2011; Jahre et al., 2009; Oloruntoba, 2010; Pettit and Beresford, 2005)
Resources	<ul style="list-style-type: none"> Preparing financial resources for quick disaster response (Van Wassenhove, 2006) Postponing and pooling resources (Jahre and Heigh, 2008; Kovács and Tatham, 2009; Tomasini and Van Wassenhove, 2009)
Community	<ul style="list-style-type: none"> Educating vulnerable communities to recognize specific pre-disaster events and to respond appropriately (Banomyong et al., 2009; Benson et al., 2001; Kovács and Spens, 2009; Oloruntoba, 2010; Perry, 2007; Van Wassenhove, 2006) Assessing economic and physical vulnerabilities of populations in disaster planning (Perry, 2007) Cooperating with local governments, military, humanitarian organizations, and businesses in order to establish framework agreements or permanent networks of actors (Jahre et al., 2009; Van Wassenhove, 2006) Negotiating customs agreements with local governments (Kovács and Tatham, 2009) Disaster planning by local governments and NGOs, in collaboration with local communities (Adivar and Mert, 2010; Perry, 2007)

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