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Coordination in humanitarian relief chains: Practices, challenges and opportunities

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ABSTRACT

Humanitarian relief environments engage a large number and variety of actors, each with different missions, interests, capacity, and logistics expertise. While coordination mechanisms within the domain of commercial supply chain management have been well studied, coordination in humanitarian relief chains is still in its infancy. In this study, we review the challenges in coordinating humanitarian relief chains and describe the current and emerging coordination practices in disaster relief. We also examine some widely practiced supply chain coordination mechanisms and evaluate their adaptability to the unique relief environment.

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1. Introduction

Humanitarian relief environments engage international relief organizations, host governments, the military, local and regional relief organizations, and private sector companies, each of which may have different interests, mandates, capacity, and logistics expertise. Typically, no single actor has sufficient resources to respond effectively to a major disaster (Bui et al., 2000). For instance, over 40 countries and 700 non-governmental organizations (NGOs) provided humanitarian assistance following the 2004 Asian Tsunami (Chia, 2007).

Many factors contribute to coordination difficulties in disaster relief, such as the inherently chaotic post-disaster relief environment, the large number and variety of actors involved in disaster relief, and the lack of sufficient resources. Indeed, aid agencies “often fail to make the effort, or simply find it too difficult to collaborate” (Fenton, 2003). As such, there have been few coordination success stories, such that “coordination has continued to be the fundamental weaknesses of the humanitarian action” (Rey, 2001). Despite continuing challenges and previous failed initiatives, coordination is receiving increased attention, due to the increasing scarcity of global resources, accountability concerns, and the potential opportunities provided by advances in global information technologies (Lindenberg and Bryant, 2001, p. 159).

The literature addresses various aspects of relief sector coordination (see Minear, 2002; Kehler, 2004), highlighting the complexities and challenges associated with coordinating huma-

itarian assistance (see Rey, 2001; Stephenson and Schnitzer, 2006). Another group of studies describes coordination efforts observed during previous disaster relief operations and evaluates the factors leading to the success or failure of these efforts (see Moore et al., 2003; Kehler, 2004). There are also non-academic resources, such as practitioner reports, handbooks, training documents, agency websites, and blogs (see Reindorp and Wiles, 2001; ACFID, 2007; IASC, 2007) that describe current practices and emerging initiatives in relief chain coordination. However, the literature lacks studies that broadly and systematically address relief chain coordination.

This study focuses on pre- and post-disaster coordination in relief chains. The criticality of coordination of material and information flows within and across supply chain stakeholders has been widely addressed in the domain of commercial supply chain management (Lee, 2000). A lack of coordination among chain members has been shown to increase inventory costs, lengthen delivery times, and compromise customer service (Simatupang et al., 2002). Since logistics accounts for 80% of relief operations (Van Wassenhove, 2006), relief chain coordination is key to improving relief chain performance.

Given the fundamental differences between supply chains and relief chains (see Beamon, 2004; Van Wassenhove, 2006; Thomas and Kopczak, 2005; Oloruntoba and Gray, 2006; Kovacs and Spens, 2007; Beamon and Balcik, 2008 for detailed discussions of the unique relief chain characteristics), supply chain coordination mechanisms may be neither feasible nor practical for relief chains. Nevertheless, studying supply chain coordination enables us to evaluate the adaptability of conventional supply chain coordination mechanisms to the unique relief environment to evaluate to what extent relief chains can benefit from commercial practices.

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In this study, we take a first step in examining the current and emerging practices in relief chain coordination. We focus on typical coordination mechanisms observed among the actors in the global relief chain before and during the initial response phase of disaster response. Of particular interest are the coordination activities of international relief organizations (such as non-governmental organizations (NGOs), the International Federation of Red Cross and Red Crescent Societies (IFRC), the United Nations (UN) family agencies), and other major actors operating within the global relief chain (such as donors, private sector companies, local governments, militaries, and local relief organizations). Although there are many different types of disasters (e.g., slow-onset disasters, complex emergencies) and response phases (e.g., recovery, development), our primary focus is on sudden-onset disasters caused by natural events. We also broadly review various coordination mechanisms practiced in commercial supply chains that may be applicable to relief chain coordination, and discuss the benefits, costs, resource requirements, and challenges associated with these coordination mechanisms.

The rest of the paper is organized as follows: in Section 2, we provide an overview of coordination in the relief sector. In Section 3, we provide a focused review of the current relief chain coordination efforts. Section 4 reviews relevant supply chain coordination mechanisms. Section 5 provides an evaluation of supply chain coordination mechanisms within the context of the relief environment. Section 6 concludes the paper.

2. Coordination: overview and background

2.1. What is coordination?

In this study, we will use the term *coordination* to describe the relationships and interactions among different actors operating within the relief environment. For clarity, we also employ the phrases *vertical coordination* and *horizontal coordination* to describe these types of relationships in more detail. Vertical coordination refers to the extent to which an organization coordinates with upstream or downstream activities. For example, if a traditional NGO coordinates with a transportation company, this would be an example of vertical coordination. Horizontal coordination refers to the extent to which an organization coordinates with other organizations at the same level within the chain. An example of horizontal coordination would be if one NGO coordinated with a second NGO to provide relief goods and/or services. Finally, we use the time-based terms *strategic* (long-term, planning level), *tactical* (medium-term), and *operational* (day-to-day) to further describe the level of engagement.

Humanitarian organizations frequently use the terms *collaboration* and *coordination* interchangeably (Russell, 2005). Some studies in the supply chain literature differentiate between these terms based on the strength of the relationships among actors involved. In practice, the term *coordination* has varied interpretations within the relief environment. For instance, *coordination* may refer to resource and information sharing, centralized decision-making, conducting joint projects, regional division of tasks, or a cluster-based system in which each cluster represents a different sector area (e.g., food, water and sanitation, and information technology). Despite differences in terminology, the relief community has sought ways to improve aid coordination over the past three decades (Kehler, 2004). The UN and relief agencies have established various committees and offices (such as the Office of the Coordinator for Humanitarian Affairs (OCHA), United Nations Joint Logistics Centre (UNJLC), and the Inter-Agency Standing Committee (IASC)), and deployed various programs (such as Central Emergency Fund (CERF) and Consolidated

Appeals Process (CAP)) to improve coordination within the relief community (see Reindorp, 2002; Kehler, 2004 for more details). The next subsection details the unique polycentric character of the humanitarian relief chain, and why this aspect and others contribute to coordination difficulties.

2.2. Factors affecting coordination in humanitarian relief

Relief actors operate in an environment that does not necessarily encourage coordination (Stephenson, 2005). Indeed, no single individual or group controls a relief operation. In this subsection, we provide a brief review of the characteristics of the relief environment that impact planning and coordination.

2.2.1. Number and diversity of actors

While each of the actors involved in disaster response has the same general goal: to help people and alleviate suffering, their primary motives, missions and operating constraints may differ. Differences in geographical, cultural and organizational policies may create additional barriers (Van Wassenhove, 2006). Even when organizations intend to coordinate, communication challenges may hinder coordination. For instance, coordination between local and foreign organizations may be impeded by language; coordination meetings held in English inadvertently exclude those NGOs without English-speaking staff (Moore et al., 2003).

An important characteristic of the relief environment is that it is unregulated; there is usually no single organization with the authority to cause other actors to engage in a particular coordination activity (Seaman, 1999; Stephenson, 2005). Typically, the governments of the affected countries are responsible for the conduct of disaster relief operations in their countries, and other actors are obliged to abide by the laws of the country in which they are operating. Unfortunately, governments may lack the necessary experience and knowledge required to manage emergencies effectively, especially when the effects of disasters are overwhelming. In situations in which the government is either non-functional or dysfunctional, the roles of relief actors are often unclear (Seaman, 1999).

2.2.2. Donor expectations and funding structure

Donors are not obliged to fund any given disaster situation (Seaman, 1999), and if they do, they have an exit option if agencies do not meet the obligations specified in their contracts (Hilhorst, 2002). Therefore, relief organizations seek to justify their existence to those who support them (Kent, 1987, p. 166). In this respect, donors (not aid recipients) are often regarded as the customers of relief organizations (Kent, 1987, p. 166).

Most relief organizations rely almost solely on donor funding, and so cannot initiate a disaster response before funding becomes available (Seaman, 1999). As such, many NGOs arrive at a country to deliver aid only if and when donor funding becomes available. NGOs are also sometimes under pressure to spend the available money in a short period of time (Moore et al., 2003). Donors may even place restrictions on the types of relief activities in which agencies may be involved (Stephenson and Schnitzer, 2006). Such a funding structure is not necessarily conducive to coordination among relief agencies.

2.2.3. Competition for funding and the effects of the media

Relief organizations compete for funding, which may also affect coordination and the humanitarian mission (Kent, 2004). This is especially true during the early stages of the relief response, during which there is intense global attention and funding levels are high (Stephenson and Schnitzer, 2006). For

instance, relief organizations may be reluctant to share information with other organizations if they believe this information gives them a competitive advantage in attracting media and donor attention (Kent, 1987, p. 160; Stephenson, 2005). However, donors are demanding greater accountability, becoming less tolerant of inefficiencies in relief, and therefore strongly encouraging relief organizations to collaborate (Thomas and Kopczak, 2005).

The media is often a critical factor affecting relief operations. Relief organizations seek visibility to potentially attract more resources from major donors and the public (Seaman, 1999). Sometimes, the media can even exert pressure on relief agencies, which may cause agencies to act in ways contrary to what they believe to be appropriate in a given situation (Seaman, 1999).

2.2.4. Unpredictability

There are many sources of unpredictability in disaster relief that may affect coordination efforts. First, by their very nature, the location, timing, and intensity of sudden-onset disasters are typically unknown a priori. Second, the population characteristics and pre-existing regional infrastructure (communications, transportation) in many disaster-prone areas may not be readily available, and the extent of post-disaster infrastructure damage may not be predictable in advance. Finally, the political environment and post-disaster funding levels are unpredictable. Given these uncertainties, it may be challenging to establish coordination mechanisms a priori with the flexibility and efficiency to be effectively implemented in any given disaster situation.

2.2.5. Resource scarcity/oversupply

Matching demand to supply is a particular problem in pre- and post-disaster relief activities. This is due to uncertainties associated with the disasters themselves (location, timing, intensity) and a lack of supporting resources (financial, human, technological, informational), both of which can create coordination difficulties. The relief workforce also commonly contains short-term volunteers or temporary employees, neither of which may possess adequate experience to facilitate coordination activities during a disaster relief operation.

In some cases, there may be insufficient relief supplies and/or logistical resources to meet demand. In the absence of functioning coordination mechanisms, relief organizations may compete for the same scarce resources, which may prove harmful to future coordination efforts. The relief chain may also be challenged by the opposite problem: oversupply. Indeed, the volume of relief supplies and information flowing into a region can be enormous—sometimes in quantities greater than necessary, and sometimes inappropriate and unusable. Unsolicited supplies arriving to a region create difficulties, since they consume staff time, logistical resources, and congest the system (Russell, 2005). For example, approximately one third of the relief containers were still blocked at airport customs five months after the 2004 Asian Tsunami (Van Wassenhove, 2006).

2.2.6. Cost of coordination

Coordination initiatives cost time and money for relief organizations (Salm, 1999; Stephenson, 2005). At the strategic and tactical levels, coordination costs may also include staff salaries and travel costs for coordination meetings held during the pre-disaster period (Minear, 2002, p. 21). In the field (operational level), resource capacities of smaller relief organizations may not allow them to allocate personnel to attend coordination meetings while simultaneously providing relief (Moore et al., 2003).

3. Relief chain coordination

The relief environment affects the structure and operation of relief chains and thereby the type and level of implementable coordination mechanisms. This section focuses on the basic structure and challenges of humanitarian relief chains and the coordination mechanisms currently practiced at different relief chain stages by various relief actors.

3.1. Relief chain structure and characteristics

The operational characteristics of relief chains differ, depending on the type of disaster and the types of relief actors involved. However, the typical flow of supplies in a relief chain driven by international relief organizations is illustrated in Fig. 1. The pre-disaster relief chain includes procurement and stock pre-positioning, while post-disaster operations focus primarily on procurement and transportation.

3.1.1. Supply acquisition/procurement

Relief organizations can procure supplies locally and/or globally. Each option has advantages and disadvantages, in terms of expected logistics costs, lead time and supply availability (Balcik and Beamon, 2008). For example, although local supplies may not be available in the quantity and quality needed, local procurement requires shorter lead times and has lower logistics costs (Balcik and Beamon, 2008). However, strong post-disaster demand and local competition for supplies may inflate local market prices, thereby increasing the unit cost of local supplies. The challenges of global procurement in the post-disaster environment stem primarily from the time-consuming processes involved (e.g., competitive bidding and customs clearance) and transportation capacity requirements for shipping large quantities of bulk supplies. Relief supplies may also be acquired through in-kind (non-financial) donations, which usually become available after a disaster occurs. In-kind donations, particularly if unsolicited, may congest the relief chain, as previously discussed.

3.1.2. Pre-positioning/warehousing

Relief organizations that purchase relief supplies in advance of disasters strategically pre-position those supplies at distribution centers (Balcik and Beamon, 2008). However, due to the uncertainty of disaster occurrences, funding tendencies in the sector, and the costs associated with operating distribution centers, only a few relief organizations use this strategy (Balcik and Beamon, 2008). As shown Fig. 1, relief organizations may hold pre-positioned stock at multiple intermediary levels (i.e., global, regional, in-country). Such intermediary distribution centers may also be established temporarily and used only to support post-disaster relief logistics. Storage facilities at airports and seaports are commonly used for this purpose. However, relief agencies often have difficulty finding secure, affordable, undamaged local warehousing and storage facilities (ACFID, 2007).

3.1.3. Transportation

Transportation is a major component of disaster relief operations. Post-disaster transportation, especially across the “last mile”, can be particularly challenging for relief agencies. The challenge arises from damaged infrastructure, limited transportation resources, and the sheer amounts and bulk of supplies to be transported (Balcik et al., 2008).

Relief agencies do not typically own and operate vehicle fleets in a disaster-affected region. As such, agencies typically rent local vehicles and drivers. However, analogous to local relief supply acquisition, vehicles may be scarce, and the sudden surge of

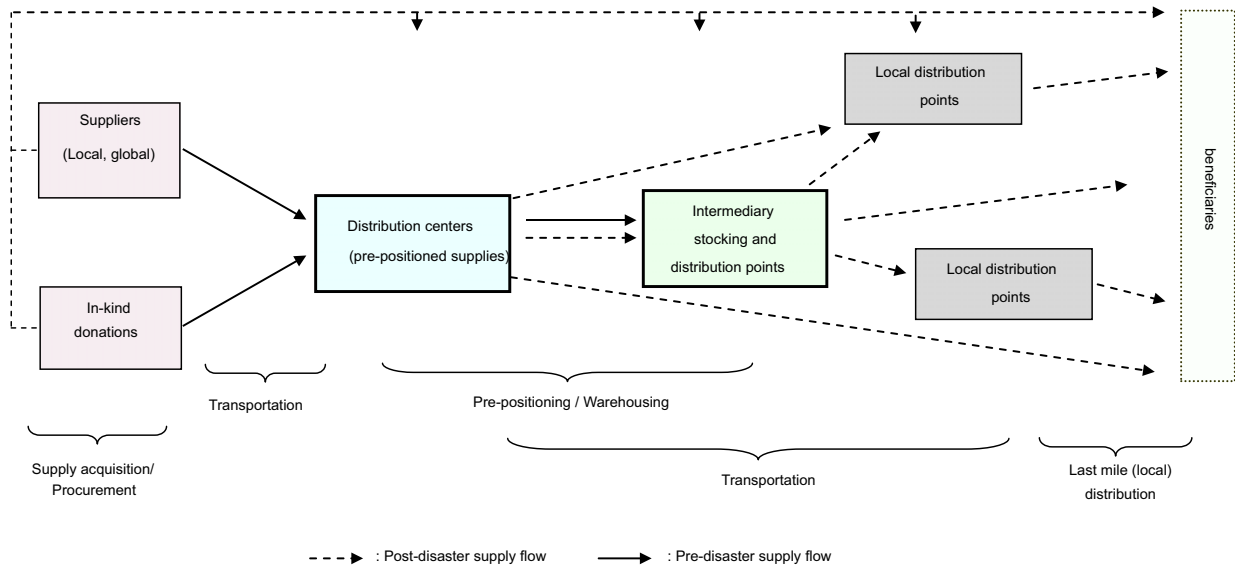


Fig. 1. Relief chain structure.

demand may inflate the rental costs of available vehicles. The existing transportation infrastructure within an affected country may be poor even prior to the disaster. The geographical characteristics of a region may also present challenges in accessing affected populations (e.g., the geographically dispersed Indonesian islands and the mountainous terrain of Pakistan). These characteristics may also constrain the use of already-scarce resources. For instance, remote areas may only be reachable by small trucks or helicopters, whereas larger vehicles may only be usable for nearby areas. The disaster relief environment can also be hostile. Therefore, vehicles may need to travel together, as a convoy. Another challenge for relief organizations is in obtaining sufficient information regarding current road conditions. This is because communication and information technologies that would support in-country transportation may not be available. Even the basic needs of responding agencies, such as reliable local maps for general orientation, may not be easily met in the days immediately following a disaster.

Recently, there has been an increasing number of relief practices that lead to a better use of the competencies and expertise of each type of actor along the relief chain. In the next subsection, we give examples of such practices, leading to coordination improvements.

3.2. Coordination mechanisms in the relief chain

A coordination mechanism can be defined as “a set of methods used to manage interdependence between organizations” (Xu and Beamon, 2006). We will use this as a working definition in our discussion and analysis. In this subsection, we will explain how different relief actors interact in the relief chain and describe various coordination mechanisms commonly observed in today’s relief environment.

The types of relief actors engaged in collaborative relationships affect the characteristics of the coordination mechanisms. In Fig. 2, we classify the relationships in the global relief chain based on the types of relief actors involved. Following this classification, we focus on the relief chain coordination mechanisms that involve actors within the international relief community (i.e., UN agencies, NGOs, and the IFRC). First, we focus on coordination efforts among traditional relief providers, and then describe collaborative relationships with private sector companies.

3.2.1. Coordination mechanisms in the relief community

As previously discussed, organizations in the international relief community differ in terms of their mandates, sizes, and expertise. Historically, these organizations have operated separate relief chains responding to global crises, managing their logistics activities (transportation, procurement, warehousing) independently. We now review the coordination efforts: (i) among international relief actors and (ii) among international relief actors and local organizations (local NGOs, the general public, governments, military).

(i) *Among international relief actors*: Most relief chain coordination mechanisms involving international relief actors are horizontal, in that they concern resource sharing and joint decision-making. Most coordination mechanisms also involve a single lead agency (a coordinating body, inter-agency committee, or an umbrella organization) that creates and/or facilitates an environment for horizontal coordination. Since pre-planning (e.g., pre-positioning relief supply inventory) can be expensive, and there are many logistical challenges in disaster relief, relief organizations can often benefit significantly from the support provided by umbrella organizations. In this case, while relief organizations’ autonomy and independence are preserved, the support of the umbrella organization provides a strong incentive for organizations to voluntarily coordinate.

One such umbrella organization that supports inter-agency coordination is the UNJLC, which was formally established in 2002 to handle operational logistics issues in the disaster relief environment and encourage the best use of limited logistics resources (Kaatrud et al., 2003). The UNJLC is mandated by the IASC and hosted by the WFP, which has the largest overall logistical capacity in the relief community (Kaatrud et al., 2003). The UNJLC supports logistics coordination through: (i) gathering, collating and disseminating critical information and data (e.g., infrastructure assessments and updates, transportation availability and capacity, customs issues, maps), (ii) providing information-sharing tools (e.g., websites and mailing lists), (iii) tracking relief supplies and prioritizing cargo movement, and (iv) facilitating the pooling of scarce logistics assets (see UNJLC, 2008; Kaatrud et al., 2003 for more detailed information about the UNJLC).

The UNJLC also supports the logistics cluster, whose global leader is the WFP. The cluster approach is a recent framework, proposed in 2005, that defines nine clusters characterized by

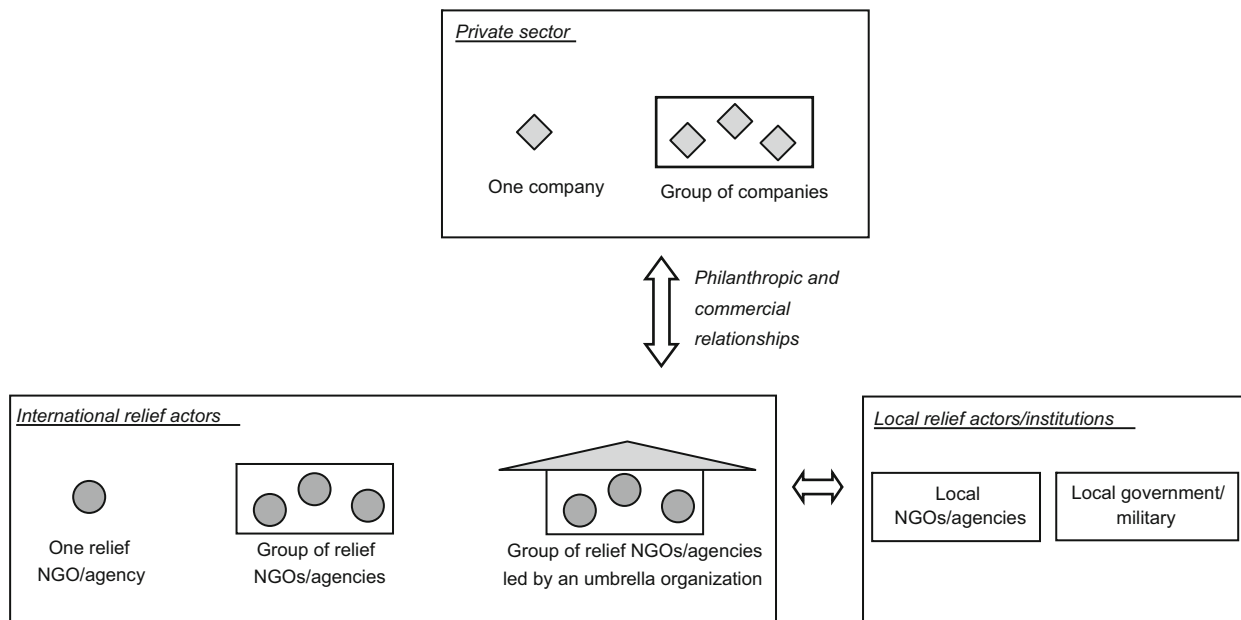


Fig. 2. Relief chain relationships.

different sectors (e.g., health, logistics, emergency telecommunications, nutrition) within the relief community to facilitate division of labor, common standards and guidelines, and enhanced partnerships (Humanitarian Reform, 2008). The cluster approach is not yet widely tested and there are challenges associated with implementing this approach in general (see Stoddard et al., 2007 for a general evaluation). For instance, the cluster approach was applied after the Pakistan earthquake as a pilot program, but failed to ensure effective coordination (Stoddard et al., 2007). The cluster approach was widely criticized as not inclusive, as local NGOs were largely ignored in implementation (Stoddard et al., 2007). Even when local NGOs were invited to cluster meetings, meeting minutes were not translated into the local language (Stoddard et al., 2007).

While most of the logistics coordination efforts among agencies (and the support provided by umbrella organizations) in disaster relief address the needs of the post-disaster environment, some coordination mechanisms involve pre-disaster preparation. For instance, the UN Humanitarian Response Depot (UNHRD) network, managed by the WFP, provides logistics support for a wide range of relief organizations that become authorized users by signing a technical agreement with the WFP (UNHRD, 2008). Currently, there are five UNHRDs, strategically located around the world: Europe (Italy), Africa (Ghana), the Middle East (United Arab Emirates), South East Asia (Malaysia), and Latin America (Panama) (UHHRD, 2008). Authorized users pre-position relief supplies at these UNHRDs, where warehousing and inspection are provided free of charge (UHHRD, 2008). By keeping inventory in close proximity to disaster-prone areas, relief organizations can reduce transportation costs. Costs can be reduced further through coordinated shipments and joint procurement procedures. UNHRDs are also used as regional staging areas for in-kind donations at times of crisis (UHHRD, 2008). In this way, a pull-type system can control the flow of goods, rather than pushing all donated supplies to the affected areas, thereby preventing redundancies and blockages that can result from unsolicited supplies.

Through support by various umbrella organizations, relief organizations cooperate in procurement, transportation, and warehousing. Joint procurement is implemented in the pre- and post-disaster environment. Relief organizations that pre-position

supplies at the UNHRD warehouses can procure jointly from the WFP's long-term suppliers (UHHRD, 2008). Joint procurement increases the bargaining power of relief organizations as organizations can purchase larger quantities at lower prices. Also, coordinated procurement practices in the post-disaster environment help reduce the negative effects of agency competition on local supply prices. Pooling scarce transportation resources (e.g., aircraft and trucks) has proven effective in a variety of disaster relief operations. Sharing transportation resources in the field also increases local bargaining power for relief organizations. Coordinating long-haul shipments around the world to the affected regions also yields freight cost reductions and time savings in handling customs procedures. Pre-positioning relief supplies across the relief chain network and sharing warehouse capacity is being increasingly practiced, especially by UN agencies and large NGOs. Shared warehousing also facilitates other joint procurement and transportation practices and improves inventory turnover.

However, the mere existence of a supporting umbrella organization does not guarantee success. For example, the UN's efforts following the 2004 Asian Tsunami failed to ensure a coordinated response in the international relief community in general (see e.g., Volz, 2005; NY Times, 2005). Despite the amount of resources dedicated to coordination, coordination efforts were ineffective. For instance, UN agencies organized large numbers of coordination meetings (up to 72 per week), most of which had no clear purpose (Volz, 2005). Because most NGOs lacked the human resources that would have been required to attend these meetings, and since the meetings were held in English with no translation, most international and local organizations ceased attending (Volz, 2005). The resulting lack of coordination caused shipment delays and a mismatch between the aid provided and what was needed (Volz, 2005).

(ii) *Between international relief actors and local relief actors:* International relief organizations interact with various local relief actors and institutions (e.g., local governments, local NGOs, military). Many factors, including politics, cultural characteristics, and the type and governance structure of relief organizations may affect the level and type of coordination between foreign and local relief actors. Foreign actors are subject to the laws of the countries in which they operate and are bound by the governments'

restrictions and willingness to accept aid. Indeed, governments may refuse humanitarian aid entirely, sometimes even disallowing relief workers entrance into the country.

International and local militaries play important roles in international disaster relief. The military brings much-needed capability and expertise in rapid supply chain deployment (quickly coordinating the flow of large amounts of supplies and personnel). Despite significant differences between the relief community and the military (in terms of their missions, codes of conduct, culture, and operating procedures), which may create occasional tension among these actors, there are also success stories about how they cooperate in logistics (e.g., Mozambique relief efforts in 2000—see Kehler, 2004). While the degree of military cooperation is situation-dependent, the military has historically cooperated horizontally with relief agencies by coordinating airlifts, sharing storage facilities, providing logistics assets (e.g., maritime resources), providing information on infrastructure and security, and setting up communication networks.

In responding to sudden-onset disasters, interactions and coordination activities with local NGOs generally emerge in the post-disaster environment, with the exception of some organizations (e.g., IFRC) that have national affiliates or partner agencies in the aid-receiving countries. The rights and responsibilities of headquarters and members, and the level of central control, affect how these organizations interact with national affiliates (see Lindenberg and Dobel, 1999 for details). While coordinating with local members may yield cost efficiencies, prevent duplication of effort, and improve response time, sometimes these benefits may come at the expense of increased bureaucracy and decreased flexibility. The level of engagement of international NGOs with national NGOs may vary depending on the characteristics of the particular disaster relief situation. However, since local agencies are generally more knowledgeable about the needs of local communities and the characteristics of the region, international actors would benefit from cooperating with local agencies, especially in demand assessment and in “last mile” distribution.

Sometimes, a local agency can provide coordinating functions, acting as an umbrella organization (in ways similar to the UN, as previously described). But just as in the UN case, not all such cases are successful. For example, during the Mozambique floods of 2000, the National Institute for Disaster Management (INGC) was appointed by the government to chair the coordination activities at the provincial and national level (Moore et al., 2003). The INGC was responsible for coordinating and monitoring the activities of NGOs arriving to the region (Moore et al., 2003). However, the government lacked capacity to coordinate the relief activities and some NGOs did not report their presence and activities to the authorities, thereby distributing relief independently (Matsimba, 2003). The lack of coordination resulted in ineffective aid distribution, even leading to situations in which aid recipients were injured or killed in their struggle to obtain food distributed by unregistered relief agencies (Matsimba, 2003; Moore et al., 2003).

3.2.2. Coordination mechanisms involving private sector companies

As shown in Fig. 2, we consider two types of relationships between relief organizations and the private sector. Commercial relationships involve monetary transactions, such as the interactions between relief organizations and suppliers of relief items or transportation companies. Philanthropic relationships occur when private sector companies that support or collaborate with relief organizations in ways that do not include profit making.

(i) *Commercial relationships*: Humanitarian relief is a multi-billion-dollar market for commercial companies (Binder and Witte, 2007). To satisfy the large quantities of goods demanded

during major disasters, relief organizations engage in various commercial relationships, the most common of which are vertical relationships with suppliers and transportation providers.

Due to the preferences of relief agencies for procuring locally and the uncertainties related to disaster occurrences and funding levels, it can often prove difficult to develop strong relationships with suppliers in advance of disasters. Since relief agencies have limited funding, procurement procedures in the relief sector are primarily accomplished through price-based competitive bidding. Therefore, except for large agencies, which may be engaged in long-term relief activities at various locations around the world at any given time, systematic supplier coordination is relatively uncommon in relief. Although such long-term agreements may exist between some suppliers and relief organizations, most relief agencies do not prefer binding pre-disaster commitments for supply purchases, but may instead place simple requirements on held stock. For instance, although the WFP has long-term agreements with some suppliers for procuring non-food items, these agreements do not guarantee maximum nor minimum purchasing amounts, but do contractually bind the supplier to stock extra supplies (WFP, 2004b). As previously described, most agencies obtain transportation resources locally or through in-kind donations. Therefore, interactions with transportation companies generally emerge in the post-disaster environment.

Pre-planning for post-disaster procurement includes identifying a list of candidate suppliers that can provide relief items with the desired specifications. These candidate suppliers are registered into the system and then become eligible to submit bids. One such example is the UN's Global Marketplace, launched in 2004 by 15 UN agencies, where suppliers can become registered, view procurement notices, and obtain information about previously awarded contracts electronically (UNGGM, 2008). Another recent initiative is the Global Fleet Forum, launched jointly by WFP, IFRC, and World Vision International in 2003, whose objective is to promote discussion of common problems in operating vehicle fleets and identify potential collaborative practices to increase operational effectiveness and efficiency (WFP, 2004a; IASC, 2005).

(ii) *Philanthropic relationships*: Private sector companies interact with the global relief chain in ways other than providing commercial supplies. For example, a private-sector company may engage vertically or horizontally, providing monetary or in-kind donations (involving supplies, staff, and/or other resources) to a relief organization. Donation-based relationships are typically short-term, spanning only the disaster relief period. However, private sector companies and relief organizations may also interact through strategic partnerships, in which the private sector company shares its expertise and resources to improve relief chain logistics in a more systematic way. Such partnerships are generally long-term and involve significant resource commitment and joint planning. These interactions may even involve multiple companies joining forces to increase the impact of donations or strategic partnerships (such as the Partnership for Quality Medical Donations, the Business Roundtable, the World Economic Forum, and the Disaster Resource Network; see Thomas and Fritz (2006) for details on these types of alliances).

Although there may be various reasons for the private sector to engage in disaster relief (such as brand image, corporate social responsibility, staff motivation; see Binder and Witte (2007) for a more detailed discussion), here, we use the general term “philanthropic” to refer to all charitable private sector relationships, whether they are based on donations or strategic partnerships. Thomas and Fritz (2006) classify these interactions as philanthropic partnerships and integrative partnerships, which refer to donation-based and strategic partnerships, respectively.

Growing in size and scope, most of the strategic partnerships involving business partners emerged after the 2004 Asian tsunami

relief efforts, during which coordination problems made international headlines (Thomas and Fritz, 2006). Binder and Witte (2007) discuss the key issues related to private sector involvement in relief and provide a list of various initiatives between companies and relief organizations in different areas. In their case studies, Samii and Van Wassenhove (2004) and Tomasini and Van Wassenhove (2004) examine the strategic partnership between WFP and TNT, one of the largest partnerships between a logistics company and a relief agency. Other logistics companies and relief organizations that work as strategic partners include Federal Express and the American Red Cross, DHL and Mercy Corps, and DHL and the IFRC. There are also a number of companies (e.g., Home Depot, Lowe's, Coca-Cola, and Wal-Mart), that routinely make resources available to relief agencies, sometimes through business consortiums.

The majority of logistics partnerships are vertical, supporting transportation and warehousing processes in relief. In transportation, companies provide physical resources, such as trucks, flight charters, and cargo aircraft. The private sector is also sometimes directly involved in long- and short-haul delivery of relief supplies and equipment to the disaster-affected areas. Beyond physical resources, companies may also share their knowledge and expertise in transportation systems management, such as fleet management (support vehicle maintenance and outsourcing decisions), shipment tracking, and delivery route optimization. Partner companies also dedicate their resources and expertise to improve warehousing and handling in disaster relief. For instance, they provide warehouse space for relief items in company-owned global warehouses (e.g., UNHRD warehouses in Ghana and Panama are owned by TNT and UPS, respectively) (UNHRD, 2008). To streamline material flow in the relief chain, company employees help organize the handling (sorting and palletizing), warehousing, and loading of relief supplies at airports. Companies may even provide facilities layout expertise and install warehouse management and inventory tracking systems (UNHRD, 2008).

4. Supply chain coordination mechanisms

Although increasing in number and scope in recent years, coordination mechanisms in the relief chain are still not as developed as in their commercial counterparts. In this section, we focus on coordination mechanisms implemented in commercial supply chains. In particular, we first describe the basic characteristics of coordination mechanisms commonly used to coordinate logistics processes (procurement, warehousing, and transportation) in commercial supply chains and then examine these coordination mechanisms based on their attributes and costs.

4.1. Procurement coordination

A supply chain's efficiency can be improved by effectively coordinating the parties (such as suppliers and manufacturers) involved in the procurement process. Several mechanisms are available to assist in coordinating procurement activities, including various strategic alliances between the supplier and buyer, as well as collaborative procurement arrangements.

4.1.1. Supplier-buyer alliances

Procurement activities can be coordinated between the manufacturer (buyer) and its suppliers through different types of strategic alliances. These alliances include quick response (QR), continuous replenishment (CR), vendor managed inventory (VMI), and consignment VMI (CVMI). The most important aspect of these mechanisms is information sharing, typically by way of electronic

data interchange (EDI), Internet-based private exchanges, bar-coding, or providing the supplier with limited access to the buyer's production planning system (Simchi-Levi et al., 2003, pp. 154–155). This information enables the control of procurement activities to be shared between the buyer and supplier.

The level of information sharing varies with each mechanism, as does the amount of control given to the supplier. In a QR strategy, suppliers receive point-of-sale or point-of-use data from the buyer and use this information to synchronize their production and inventory activities with actual production or sales occurring on the buyer's end. Similarly, in a CR mechanism, the supplier receives data from the buyer; however, the buyer and supplier agree upon delivery intervals and specific inventory levels that the supplier must maintain. Subsequently, it is the supplier's responsibility to use the demand data to meet this schedule. VMI is very much like a CR program, except that in this case the supplier determines for the buyer the appropriate inventory levels of each of their products and the inventory policies to maintain these levels (Simchi-Levi et al. 2003, p. 154). That is, the supplier monitors the buyer's inventory levels and establishes order quantities and the timing of periodic replenishments (Danese, 2006). A CVMI relationship takes VMI a step further such that the supplier owns the goods until they are sold or used by the buyer.

4.1.2. Collaborative procurement

In collaborative (or joint) procurement, multiple buyers work together to gain synergy in their purchasing activities. Collaborative procurement primarily occurs across multiple organizations that are either in the same or related industries. These buyers might have similar supply chain requirements or buy from the same group of suppliers. In some cases, this coordination mechanism can be implemented by competing organizations, particularly when they face a common competitive threat. Collaborative procurement is also implemented by various non-profit sector organizations. For example, members of a group purchasing organization, Voluntary Hospitals of America, aggregate their demand for medical supplies (Keskinocak and Savasneril, 2008). In Great Britain, the non-profit Northern Housing Consortium collectively buys commodities used to build social housing (Clarke, 2007).

Collaborative procurement can be limited to information sharing. For example, buyers may provide detailed procurement information to other buyers by sharing preferred supplier lists. Likewise, buyers can share their experience with others through discussion of best practices. This type of communication can occur informally or more formally through dedicated-purpose online tools. Beyond sharing general procurement information, buyers in closely related industries can also take advantage of joint contracts, which enable multiple buyers to pool their demand while purchasing the same types of items or buying from the same suppliers. This function can be outsourced, as well; buyers can relinquish the responsibility of procurement for an item or category to a third party, which then pools requirements from other organizations (Clarke, 2007).

4.2. Warehousing/inventory coordination

To improve efficiency by coordinating warehousing, material handling and inventory management activities, commercial supply chains typically employ two main mechanisms: the standardization of methods, and outsourcing to third-party logistics providers (3PLs).

4.2.1. Standardization of methods

Warehouses act as consolidation points in supply chains. Depending upon the status of the material when it is received from suppliers and the specific needs of the downstream customer, the warehouse often must prepare the material before it can be stored, tracked, and distributed. One way of reducing this work is through standardization, particularly of material packaging and material coding. The warehouse receives material from the supplier in some type of containerized configuration, such as pallets or cartons. These configurations can be standardized throughout the supply chain; for example, pallet height requirements or case quantities can be predetermined. In addition, for each shipment received, the warehouse requires certain order information, such as item descriptions, quantities, and associated purchase order numbers (Keeney, 1998, p. 257). This information can be standardized throughout the supply chain by requiring all parties to use the same labeling and coding system (Nixon, 1998, pp. 655–656).

4.2.2. Warehousing through a third party

Companies can utilize the warehousing and inventory management expertise of a 3PL to improve supply chain performance. 3PLs can typically perform a wide variety of warehousing functions for their clients. Basic functions include receiving, storage, inventory control, picking and packing, labeling and order fulfillment. Special additional functions can include cross-docking, customs brokerage, kitting, and possibly even assembly (Coyle et al., 2008, p. 125).

A 3PL that provides warehousing functions will consolidate the storage, handling and management of the inventory of multiple customers. Therefore, the inherent efficiencies of this consolidation must be balanced with the needs to meet each individual customer's strategic goals. To do this effectively, the 3PL must maintain very close relationships with its customers. In particular, it is necessary for the client to provide the 3PL with demand information through EDI or Internet-based exchanges, bar-coding and scanning, or the client's production planning system. Sharing this data allows the 3PL to become a strategic partner in the client's supply chain and enables the 3PL to serve its customers successfully.

4.3. Transportation coordination

Improved transportation coordination improves the overall success of the supply chain since transportation accounts for a significant percentage of supply chain costs and plays a critical role in meeting customers' expectations (on-time deliveries, short lead times). Coordination is often accomplished through outsourcing transportation to a 3PL, but the shippers can also coordinate directly with their customers and the carriers without an intermediary. This choice depends on the scale of the shipper's operation and its ability and desire to keep the logistic functions in-house.

If the shipper is operating on a small scale, or if it already has in-house competency in logistical coordination, it can choose to work directly with its carrier(s) and customer(s). At a minimum, the shipper must coordinate with the carrier to schedule pick-ups. However, a more collaborative relationship can be developed in which the shipper shares planning and forecasted demand details with the carrier (Feng and Yuan, 2007). The carrier can then translate these details into a shipping forecast (Feng and Yuan, 2007). The shipper may also choose to collaborate directly with other shippers. In this case, multiple shippers share forecast and planned shipping volume data in order to consolidate shipments and reduce transportation costs.

Alternatively, the shipper can take advantage of the expertise of a 3PL for its transportation needs. In many cases, a 3PL that

manages transportation for other companies will own its own fleet. In this way, the shipper is able to control shipping schedules and freight consolidation directly. Otherwise, the 3PL will typically have close relationships with transportation companies and will work with them to coordinate the consolidation and shipment of multiple customers' freight.

Data exchange among the shipper, the carrier (or the 3PL), and the customer is essential to these types of coordination mechanisms. This information includes forecasted demand details and anticipated shipping schedules from the shipper. In return, the carrier or 3PL provides information on shipping options, availability, and tracking. Historically, this information had been sent through phone calls, faxes or emails. However, it can now be sent and received more efficiently through EDI, the Internet, bar codes/scanning, or access to the shipper's production planning software. Additionally, carriers and 3PLs typically have their own Internet-based software for providing tracking information to shippers and their customers.

4.4. Collaboration via a systems-based 3PL (4PL)

As discussed in previous subsections, 3PLs offer a means for supply chain members to outsource specific functions, such as warehousing and transportation, to an intermediary with expertise in that particular function. However, with increased supply chain globalization, customers are looking for players that can manage virtually all aspects of their supply chain, which has led to the concept of a fourth-party logistics provider (4PL). A 4PL is a type of general contractor who manages other 3PL warehouses, carriers, customs brokers, and other members of the supply chain (Chopra and Meindl, 2007, pp. 426–427). Using the services of a 4PL, the client is not only able to outsource logistics functions, but it also relinquishes all responsibility for managing the outsourcing function itself. Some 4PLs are purely systems-based; that is, they do not actually own any logistics assets but manage the assets and services of others (Chopra and Meindl, 2007, p. 427). One example of a 4PL is the consulting firm Accenture. By contrast, many asset-owning 3PLs have begun offering integrated logistics solutions, wherein they perform some functions themselves and outsource the remainder (Chopra and Meindl, 2007, p. 427). United Parcel Service, Inc. (UPS) has done this with its UPS Supply Chain Solutions division (<http://www.ups-scs.com/>). This group offers total supply chain management, including the transportation services of UPS (<http://www.ups-scs.com/>). Also, companies whose core business is not logistics but who have significant logistics expertise have begun offering 4PL services to other companies. For example, Caterpillar Logistics Services, Inc., a division of Caterpillar Inc., not only provides supply chain solutions within Caterpillar, but also uses its logistics expertise to serve as a consultant and 4PL to other firms in other industries, such as automotive and aerospace manufacturers (<http://logistics.cat.com/>).

Outsourcing logistical coordination to 4PLs provides many of the same benefits to clients as 3PLs, and presents similar challenges. With 4PLs, however, these tradeoffs are magnified. By relinquishing complete control of all logistics functions to a 4PL, the client can focus more completely on its core competencies; however, being far removed from all logistics functions takes almost all control away from the client, including control over operations and the protection of sensitive data.

4.5. Coordination mechanism characteristics: attributes and costs

Given the variety of coordination mechanisms, it may be challenging for organizations to select the most appropriate mechanism(s) for their systems and operations. Xu and Beamon

(2006) provide a general framework for selecting coordination mechanisms based on critical attributes and costs. In this subsection, we use that framework to examine the characteristics of the supply chain coordination mechanisms discussed in the previous subsections.

Xu and Beamon (2006) use four categories of attributes to characterize a coordination mechanism: resource sharing structure, level of control, risk and reward sharing, and decision style. Resources (e.g., information) can be shared at different levels among supply chain members: operational (e.g., point-of-sale data), tactical (e.g., production plans), and strategic (e.g., capital investment plans). The level of control involved with each mechanism can be high (involving strict rules and monitoring) or low (little to no monitoring and control). The risk and reward sharing structure of a coordination mechanism can be described as fair or unfair. The coordination mechanism is fair if the benefits received by a company are commensurate with the risks undertaken, whereas in an unfair mechanism one company assumes less risk while enjoying greater benefits than do other partner companies. Finally, in a mechanism exhibiting a centralized decision style, one firm has primary control, while each firm makes autonomous decisions in a decentralized decision style.

Xu and Beamon (2006) associate three types of costs for each coordination mechanism: coordination cost, opportunistic risk cost, and operational risk cost. Coordination costs are direct costs associated with physical flow and coordination management. Opportunistic risk costs result from reduced/lost bargaining power or resource control. Operational risk costs are associated with unsatisfactory partner performance, such as shirking responsibilities or a refusal to adapt to changing environments.

The attributes of a particular coordination mechanism affect the costs associated with coordination (Xu and Beamon, 2006). For example, a high level of resource sharing would result in reduced coordination costs; however, the greater interdependence of the parties would also result in increased operational risk costs. Table 1 provides the relative costs associated with coordination

mechanism attributes. In Table 2, we list the attributes of the previously described supply chain coordination mechanisms. Given the attributes and potential costs associated with coordination mechanisms, supply chain members can determine which mechanism is most appropriate for their situation.

In Table 2, most mechanisms have either an operational or tactical resource-sharing structure. The three mechanisms that exhibit a strategic level of resource sharing are those in which a supply chain member has decided to outsource a significant portion of its logistical operations to a third party (3PL or 4PL). The coordination costs for these three mechanisms are low, whereas the opportunistic risk cost and operational risk cost is high. This is intuitive, since outsourcing logistics functions should reduce costs through consolidation and third-party expertise. However, the partner that outsources the functions incurs high operational risk cost because it depends completely upon the third party to perform well. This partner also experiences high opportunistic cost risk because once it delegates the management of its logistics functions to a single 3PL or 4PL, it loses bargaining power in that it is no longer readily able to switch partners or demand services; it is now entrenched in the partnership.

The level of control for each coordination mechanism is also presented in Table 2. Accordingly, the three mechanisms that involve transportation and warehousing outsourcing require a low level of monitoring and control because the 3PL or 4PL is entrusted with performing all assigned logistical functions, typically with little interference from the partners. In this case, the coordination costs are low, because few resources are required to perform monitoring and control functions. However, this benefit comes with a high level of risk because operations are not being closely monitored. In contrast, supplier-buyer procurement alliances require a high level of control. Therefore, coordination costs are relatively high, but opportunistic risk costs are lower because less trust is involved in the coordination.

As presented in Table 2, the risk and reward sharing structure for several coordination mechanisms is unfair; that is, the buyer

Table 1
Relative supply chain costs associated with coordination mechanism attributes.

Attribute	Level	Coordination cost	Opportunistic risk cost	Operational risk cost
Resource sharing structure	Operational	Medium	Medium	Medium
	Tactical	Medium	High	Medium
	Strategic	Low	High	High
Level of control	Low	Low	High	High
	High	High	Low	Low
Risk/Reward sharing	Fair	Medium	Medium	Medium
	Unfair	High	High/low	High/low
Decision style	Centralized	Low	High	High
	Decentralized	High	Low	Low

Adapted from: Xu and Beamon (2006).

Table 2
Attributes of supply chain coordination mechanisms.

Coordination mechanism	Resource sharing structure	Level of control	Risk/reward sharing	Decision style
Quick response (QR)	Operational	High	Unfair	Centralized
Continuous replenishment (CR)	Operational	High	Unfair	Centralized
Vendor managed inventory (VMI)	Tactical	High	Fair	Decentralized
Consignment VMI	Tactical	High	Unfair	Decentralized
Collaborative procurement	Tactical	Low	Fair	Decentralized
Warehouse standardization	Operational	High	Unfair	Centralized
Third-party warehousing	Strategic	Low	Fair	Decentralized
Transportation: shipper collaboration	Strategic	Low	Fair	Decentralized
4PL	Strategic	Low	Fair	Decentralized

assumes less risk and cost than the supplier, but takes a greater share of the benefits. Particularly in consignment VMI, the supplier does not require the buyer to pay upon delivery; instead, the buyer pays the supplier as it uses the items. This scheme of delayed payment benefits the buyer through cash flows and reduced inventory costs, but the advantages to the supplier are not as obvious (Simchi-Levi et al., 2003, p. 156). In a similarly unfair situation, a buyer can reduce its warehousing costs by requiring standardized packaging from suppliers, which benefits the buyer but may increase costs for the supplier without any significant returns.

For the three strategic coordination mechanisms, the decisions are decentralized; that is, the operations and decisions of the third party and its partners are relatively autonomous. Since negotiation and communication are required between the partners, the coordination costs of these mechanisms are high. However, because the firms are working together to make strategic decisions, rather than having one party in control, the opportunistic costs and risk costs are low (Xu and Beamon, 2006). A warehousing coordination mechanism based on method standardization exhibits a centralized decision style if one supply chain member has unilateral control over the chosen standards.

In addition to coordination-related costs, the characteristics of the operating environment must also be considered when choosing appropriate coordination mechanisms for supply chains. More specifically, organizations should evaluate coordination mechanisms based on the level of interdependence among supply chain members, demand and supply uncertainty in the particular market, and information technology requirements (Xu and Beamon, 2006).

5. Analysis and discussion

In this section, we analyze the supply chain coordination mechanisms described in the previous section within the context of relief chains. More specifically, if a particular coordination mechanism is currently observed in the relief chain, we discuss its similarities to and differences from the commercial supply chain practices, based on coordination attributes and implied costs. For mechanisms currently unobserved in relief, we discuss the challenges and costs associated with their potential implementation, and their adaptability to the relief environment.

The analysis in this section focuses on our previously defined classes of coordination mechanisms (procurement, warehousing, and transportation). Coordination mechanisms (whether or not

currently observed) within these classes are examined on the bases of: i) our previously defined supply chain costs (coordination, opportunistic risk, and operational risk), which are now interpreted for the relief chain, ii) NGO technological requirements, iii) conducivity to the relief environment, and iv) potential for implementation. A summary of this analysis is provided in Table 3.

5.1. Procurement coordination mechanisms

There are some limited recent initiatives that implement collaborative procurement or use third parties to streamline the procurement process. However, coordination mechanisms based on supplier–buyer alliances are fairly uncommon in relief, as described in Section 3.2.2. Procurement coordination is challenging in the relief sector, particularly due to uncertainties related to sudden-onset disasters, characteristics of donor funding, specific procurement procedures of relief organizations, and limited information technology availability to support implementation.

Although some relief organizations enter into long-term agreements with suppliers, these agreements generally do not have terms that give authorization to the suppliers in the ordering process, as required by QR, CR, VMI, and CVMI. Relief organizations control purchasing decisions through the competitive bidding process, within which suppliers are not explicitly encouraged to synchronize their production schedules and inventory levels according to the needs of relief organizations. Although relief organizations may share information with candidate suppliers about previous offers and contract terms, the risk of holding additional inventory is high for the supplier, since there is no commitment implied in the bidding process on the part of the relief organization. The coordination cost of the current system for relief organizations is high, since competitive bidding consumes valuable time, human and technological resources.

QR, CR, VMI, and CVMI are not currently observed in the relief chain. If implemented, the coordination cost of such mechanisms would likely be lower than the coordination cost of the existing system for participating NGOs since, with appropriate technology, relatively minimal effort would be required on the part of NGOs to manage and maintain data access to suppliers. However, the opportunistic risk cost to the relief organization would be relatively high, due to the potential foregone savings of finding less expensive procurement options. Similarly, the operational risk cost would also be high, since NGOs would then be dependent on the performance of the contracted suppliers. The technological requirements for NGOs would be substantial to support such

Table 3
Attributes, costs, and applicability of potential relief chain coordination mechanisms.

Coordination mechanism	Currently observed?	Coordination cost	Opportunistic risk cost	Operational risk cost	NGO technological requirements	Conducive to relief environment?	Potential for implementation
QR, CR, VMI, CVMI	No	Low	High	High	High	No	Higher for large NGOs, but low overall
Collaborative procurement	Yes	Low, especially if supported by an umbrella organization	Low	Low when no contracts; high in competitive environment	Low	Yes	High (currently observed)
Warehouse standardization	No	High	Varies	High	Medium	Yes	Low
Third-party warehousing (umbrella org)	Yes	Low	Low	Low	Low	Yes	High (currently observed)
Third-party warehousing (private sector partner)	Yes	Medium	Medium	Varies	Low	Yes	High (currently observed)
Transportation:							
Shipper collaboration	No	High	Varies	High	Medium	No	Low
4PL	No	High	High	High	Medium	No	Low

systems, requiring electronic item tracking. Perhaps the most difficult barrier to implementation of these traditional procurement coordination mechanisms in the relief chain is the nature of the relief environment itself. A supplier would be reluctant, at best, to guarantee performance given the characteristically lumpy, uncertain demands arising from variable worldwide destinations. The risk to suppliers is even greater in CVMI since, in this case, the supplier would bear all inventory holding costs.

The potential for implementation would likely be higher for large NGOs. Large NGOs respond to a greater number of disasters, leading to larger, smoother (risk-pooled) demand patterns overall, which would ease some of the forecasting difficulty for the supplier. Larger NGOs also have more technological and human resources, both of which would be beneficial in establishing and managing electronic data tracking and exchange systems. The potential for implementation for smaller NGOs is likely extremely low, for reasons described above.

However, all NGOs could potentially (and some currently do) benefit from collaborative procurement. As previously discussed, relief organizations increasingly engage in collaborative procurement in various ways and on many different levels. For instance, relief agencies that pre-position stock at jointly owned/operated warehouses enjoy the benefits of joint procurement. At the field level, organizations increasingly engage in joint procurement, especially if supported by an umbrella organization, which can serve to mitigate the challenges associated with the local procurement process. Often, supplier-related information is shared in the relief system through various offline and online catalogs, and also through word-of-mouth during field-level coordination meetings, leading to relatively low coordination costs and relatively low technological requirements at the operational level. Since these collaborative practices do not typically involve contracts, the operational risk cost would also be relatively low. However, for relief organizations that employ competitive bidding or perceive information sharing about suppliers as a threat to their competitiveness, the opportunistic risk cost would be high.

5.2. Warehousing coordination mechanisms

As previously discussed, few relief organizations can afford the expense related to operating warehouses and stocking relief supplies in advance of disasters. A majority of supplies are acquired after the disaster occurs and may be stored temporarily at various distribution points along the relief chain. Particularly due to general limitations in relief sector technology availability, supply tracking is generally unsophisticated, with many operations still controlled manually. Unsolicited in-kind donations of relief supplies pose further challenges to warehouse processes.

The coordination cost of initiating and maintaining the standardization of relief supply packaging and labeling would be enormous. The vast number of suppliers and simply the presence of in-kind donations would require substantial effort to reach any level of reasonable supplier compliance. Considering purchased supplies only (not in-kind donations), if the standardization is not industry-wide, this could potentially create a high opportunistic risk cost by allowing non-participating NGOs to obtain supplies more cheaply (assuming that suppliers would only be willing to comply to the standard for a premium). The operational risk cost would also be high, since the success of the standardization relies heavily on precise supplier compliance. The NGO technological requirements to implement standardization would be medium, requiring a barcoding system and a database of product standards. Because of the vast numbers of suppliers and the existence of in-kind donations, standardization is not conducive to the relief environment, and therefore has low implementation potential.

From the relief chain management standpoint, in some cases, it may be more beneficial for NGOs to refuse in-kind donations (and some do).

Similar to third-party procurement, umbrella organizations and private sector partners can be classified as third parties providing warehousing services to relief organizations. Because relationships with umbrella organizations generally do not involve formal contracts, when third-party warehousing operations are supported by umbrella organizations, the coordination cost and opportunistic risk cost would be low. The operational risk cost would also be relatively low, since the umbrella organization generally would provide limited warehousing services (perhaps limited to leased space only), with little risk of poor performance. If the third party is a private sector partner, then the coordination cost would likely be somewhat higher, since some resources would be required by the NGO to manage the coordination. The opportunistic risk cost would be medium, since this relationship would likely involve a contract and therefore could pose a possibility that less expensive warehousing support could be secured from another firm; depending on the level of services provided, there could also be a risk of losing control over potentially sensitive data. The operational risk cost would vary, depending on the level of warehousing services provided. If the level of services provided is considerable, so is the risk of poor performance. If the level of service is minimal, then just as in the case of the umbrella organization, the risk of poor performance is also minimal.

5.3. Transportation coordination mechanisms

Similar to coordination mechanisms in relief procurement, coordination mechanisms in relief transportation face a number of unique challenges. In both cases, these challenges stem from the difficulties introduced by lumpy, uncertain demand and highly variable global shipping destinations.

Shipper collaboration is not currently observed in the relief chain. The coordination cost would be relatively high to manage such a collaboration. The opportunistic cost depends on the depth of the relationship. If the NGO shares demand details, then the opportunistic cost could be high, due to the loss of control over potentially sensitive data; if the relationship extends only to the carrier scheduling pick-ups, then the opportunistic cost would be low. The operational risk cost would be high, since an NGO would be highly dependent on shipper performance. The technological requirements would be medium for the NGO (electronic demand data transmission and basic two-way electronic communication capability). The demand patterns experienced in the relief chain would make shipper scheduling (and therefore shipper collaboration, which relies heavily on scheduling) difficult. As such, shipper collaboration is not generally conducive to the relief environment, and has a low potential for implementation.

The use of 4PLs are also not currently observed in the relief chain. The coordination cost for a 4PL would be high in the ever-changing relief environment. The opportunistic risk cost would be high (loss of control over the entire logistics process, including sensitive data) as would the operational risk cost (strong dependence on 4PL performance). The NGO technological requirements for such a collaboration would be medium, requiring electronic data communication for tracking, but most would be handled by the 4PL. Just as with coordination mechanisms in relief procurement, because of the demand patterns and transportation network characteristics of the relief chain, 4PLs would likely be reluctant to commit to a performance standard. "Last mile" transportation might be uniquely challenging in the disaster relief environment. While some relief organizations coordinate

across the “last mile” by sharing vehicles and consolidating shipments, the existing relief environment creates challenges for developing and managing these relationships in a systematic way. Therefore, the 4PLs are not particularly conducive to the relief environment, and therefore their potential for implementation is limited.

5.4. Summary and discussion of relief chain coordination mechanisms

Examining the coordination mechanisms considered, not surprisingly, the mechanisms with the greatest potential for implementation are those that are currently practiced. Such mechanisms (collaborative procurement and third-party warehousing) are distinguished by having low associated costs, low technological requirements, and being conducive to the relief environment. Consequently, these coordination mechanisms should be the easiest to implement. The practical focus for improving the success of these coordination mechanisms would be to improve their level of participation and management effectiveness.

The coordination mechanisms with low potential for implementation (warehouse standardization, (transportation) shipper collaboration, and 4PLs) create a need for establishing new types of relationships and contracts that allow for more flexible, or incentive-based terms, rather than rigid, output-based terms. New relationships would include metrics that reflect relative risks and benefits, and enable parties to equitably share those risks and benefits, particularly in the cases of shipper collaboration and 4PLs. From practice, there seems to be strength in consortium or group-based coordination initiatives. Such initiatives increase marketplace bargaining power and address the aforementioned shared risks and benefits across participants. For example, to more effectively manage demand uncertainty and inventory forecasting, groups of (especially smaller) relief agencies can pool their risk to smooth forecasts. Such NGO groups would likely have enough combined volume and resources to attract and create a similar consortium of “certified suppliers” that would agree to standardized labeling and packaging (warehouse standardization), or “certified shippers” (shipper collaboration). Such coordination activities would likely still require flexible, innovative relationships and contracts, and might be best managed by a 4PL that would act as an umbrella organization, managing the aforementioned logistics needs of the collection of NGOs and suppliers. As experienced in the supply chain, if properly implemented, coordination could yield significant performance advantages. While comparable coordination mechanisms in the relief sector may require additional effort and creativity, coordination in the relief chain can reduce costs, improve performance, and ultimately save lives.

6. Conclusions

Achieving coordination in the relief sector is acknowledged as critical to the dual and intertwined relief goals of saving lives and using limited resources efficiently. However, there are challenges in the relief sector that hinder coordination efforts. This paper provided an overview of coordination in the relief sector and explored the coordination issues associated with the relief chain and logistics operations.

Examining various coordination mechanisms practiced in the relief chains, we observed that the joint logistics activities of relief organizations are increasing, especially with the support of umbrella organizations. Partnerships between private sector companies and relief organizations are also becoming increasingly

common. These initiatives not only consider post-disaster relief activities, but also focus on more strategic pre-disaster coordination, such as joint warehouses. Increasing collaboration among relief organizations is also supporting the development of other coordination mechanisms along the relief chain. For instance, initiatives for joint procurement support coordinated transportation. While these current and emerging practices are promising to improving disaster relief coordination, challenges remain in achieving an integrated global relief chain. Addressing these challenges, both in practice and research, is critical for improving disaster relief operations.

There are opportunities to expand and enhance coordination mechanisms that are currently in use to maximize their benefits. Sophisticated coordination mechanisms, such as those seen in commercial supply chain management that are not currently observed in the relief chain, require further inquiry to develop new and innovative ways to define relationships and contracts in ways that support the relief mission, while fairly distributing risks and benefits to all participants.

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