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Performance measurement in humanitarian relief chains

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Abstract

Purpose – The purpose of this paper is to compare performance measurement in the humanitarian relief chain with performance measurement in the commercial supply chain, develop performance metrics for the humanitarian relief chain, and present a framework that can be used as a basis for a performance measurement system in the relief sector.

Design/methodology/approach – The performance measurement analysis is developed through extensions on an existing performance measurement framework. Details regarding relief chain system were obtained through off-site and on-site interviews with relief professionals from World Vision International.

Findings – The paper finds that this work yielded: a comparison of performance measurement in the humanitarian relief chain with performance measurement in the commercial supply chain, new performance metrics for the humanitarian relief chain, and a performance measurement framework for the relief chain.

Research limitations/implications – The paper shows that future work includes performance measurement in community involvement and empowerment, performance measurement in community development, performance measurement in the combined relief and development mission, and understanding the role and impacts of cooperation and coordination in the relief chain.

Practical implications – This paper provides a practical procedure for developing effective performance measurement systems for relief logistics processes.

Originality/value – The paper presents to humanitarian relief professionals a new approach to performance measurement for relief logistics and to researchers in supply chain performance a comparison and contrast between performance measurement for relief and performance measurement in the commercial chain, new performance metrics for the relief chain, and implications for modern, quick-response supply chains.

Keywords Supply chain management, Performance measures

Paper type Research paper

Introduction

The objective of the relief chain is to provide humanitarian assistance in the forms of food, water, medicine, shelter, and supplies to areas affected by large-scale emergencies. The drivers of the global relief chain, relief organizations, fall into three categories: organizations operating under the United Nations' (UN) family (such as the World Food Programme), international organizations (such as the International Federation of Red Cross and Red Crescent Societies, which operate as a federation with country offices that are auxiliary to country governments), and non-governmental organizations (NGOs) (such as World Vision International and CARE) (Byman *et al.*, 2000, p. 59; Thomas and

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Kopczak, 2005). NGOs also maintain country offices, but their offices are not affiliated with country governments (Thomas and Kopczak, 2005). Each type of organization operates under different rules. For example, the UN and NGOs are different entities in law (Seaman, 1999). In this paper, we base our discussions on relief chains operated by NGOs, although there may be commonalities among NGOs and other relief organizations, in terms of their relief chain structures, processes and operations.

NGOs are voluntary associations independent of government control that seek to provide humanitarian assistance according to need (Byman *et al.*, 2000, p. 64). NGOs engage in two broad types of activities:

(1) *Relief activities*: relief for victims of large-scale emergencies. These short-term activities focus on providing goods and services to minimize immediate risks to human health and survival.

(2) *Development activities*: longer-term aid, focusing on community self-sufficiency and sustainability. These activities include establishing permanent and reliable transportation, healthcare, housing, and food.

Some NGOs are concerned with relief, some with development, and some address both areas. In recent years, several of the larger NGOs have begun devoting greater resources to relief activities (Byman *et al.*, 2000, p. 66). In this paper, we focus on the relief activities of NGOs responding to large-scale emergencies caused by quick-onset disasters.

Performance measurement is critical to NGO accountability (Beamon, 2004). Lindenberg and Bryant (2001, p. 209) state: "As resources become tighter, NGOs face new pressures for greater accountability for program impact and quality. Today, contributors, donor agencies, scholars, and relief and development practitioners are all asking: do NGOs practice what they preach? How do we know? How effective are their programs and projects?" The increased frequency and scale of disasters, scarce resources, funding competition, and the need for accountability require more efficient, effective and transparent relief operations. Since logistics is central to relief operations and the most expensive part of any relief operation (Van Wassenhove, 2006), measuring the performance of relief chains has become vital for all organizations involved in disaster management.

Given the stakes and size of the relief industry (the largest relief organizations engage in billions of dollars worth of relief and development activities per year), the study of humanitarian relief chains is an important domain for supply chain management that has received little attention. Moreover, despite its significance, performance measures and measurement systems have not been widely developed and systematically implemented in the relief chain. Various factors make performance measurement a challenging task for NGOs. Some of the difficulties are associated with common complications observed in organizations operating in the nonprofit sector. Indeed, one of the distinctive characteristics of nonprofit organizations is performance criteria ambiguity (O'Neill and Young, 1988). Furthermore, the inherently unique characteristics of the disaster relief environment make relief chain performance measurement even more challenging for NGOs.

Effective performance measurement systems would assist relief chain practitioners in their decisions, help improve the effectiveness and efficiency of relief operations, and demonstrate the performance of the relief chain, thereby increasing the transparency and accountability of disaster response. As indicated by several authors (Beamon,

2004; Thomas and Kopczak, 2005; Davidson, 2006; Van Wassenhove, 2006; Oloruntoba and Gray, 2006; Thomas, 2007), some supply chain concepts share similarities to relief chains and therefore some tools and methods developed for supply chains can be adapted to relief chains. In this study, we adapt an existing performance measurement framework developed for supply chains considering the unique characteristics of relief chains. Our framework could be used as a basis for a performance measurement system in the relief sector.

The rest of the paper is organized as follows. In Section 2, we compare nonprofit and for-profit organizations, and relief chains and commercial supply chains based on their distinctive characteristics that affect performance measurement. In Section 3, we describe an existing performance measurement framework developed for the commercial supply chain, develop performance metrics for the humanitarian relief chain, and present a procedure for developing a performance measurement system for the relief chain. In Section 4, we present an example implementation of the proposed performance measurement framework. Finally, we conclude in Section 5 and discuss future work.

Background and comparison

Relief-oriented NGOs are nonprofit organizations and differ from for-profit organizations in the commercial (private) sector. The general aspects of nonprofit and for-profit organizations are important in characterizing their supply chains. In this section, we will first describe the distinctive features of nonprofit and for-profit organizations. Next, we will focus on relief NGOs and for-profit supply chains, describe their unique characteristics, and identify the fundamental differences that affect the development of a performance measurement framework for the relief chain.

For-profit versus nonprofit organizations

There is a vast body of literature comparing nonprofit and for-profit organizations from different perspectives (for example, see O'Neill and Young, 1988; Vladeck, 1988; Moore, 2000). We will broadly review the distinctive characteristics of nonprofit and for-profit organizations in terms of their revenue sources, goals, stakeholders, and performance measurement:

(1) *Revenue sources.* Moore (2000) defines the source of revenue as being one of the important differences between nonprofit and for-profit organizations: The defining source of revenue to nonprofit organizations is government funding, charitable donations from individuals and corporations, and in-kind donations (non-monetary contributions such as goods and commodities), whereas the defining source of revenue to for-profit organizations is the revenues earned from the sale of products and services to customers. In other words, for-profit organizations' revenue sources are customers who pay for goods and services for their own benefit; however, nonprofit organizations secure their revenues from people and organizations that expect no economic benefits in return (Moore, 2000; Henderson *et al.*, 2002; Oster *et al.*, 2004, p. 278).

Nonprofits may also raise revenues through fundraising and the sale of goods and services (Oster, 1995, p. 14). However, nonprofits are subject to governmental limitations on how their earned revenues can be used (in part, as a consequence of the tax relief provided to these organizations); any financial

surplus that may result from operations cannot be distributed to those in control, staff, or members (Oster, 1995, p. 4).

(2) *Goals.* The overriding goal for private sector companies is to make profits and provide satisfactory financial returns to shareholder interests (Boland and Fowler, 2000). On the other hand, generating profits is not the goal for nonprofit organizations; rather, each organization strives to achieve its social purpose and mission (Moore, 2000; Baruch and Ramalho, 2006).

As Moore (2000) states: "In public sector enterprises, money is the means to a desired social end. In the private sector, the products and services delivered are the means to the end of making money". Nonprofit organizations also must care about financial well-being, since financial stability is crucial to their missions and survival. However, finances are constraints rather than objectives for nonprofits; that is, although these organizations must monitor their spending and comply with financial budgets, their success cannot be measured by how closely their spending matches their budgeted amounts (Kaplan, 2001). For for-profit organizations, setting the purpose based on shareholder wealth does not mean that the interests of all other stakeholders should be sacrificed for the benefit of shareholders (Moore, 2000).

(3) *Stakeholders.* Stakeholders are defined as "any group or individual who can affect or is affected by the achievement of an organization's objectives" (Freeman, 1984, p. 46). For-profit and nonprofit organizations are distinguishable in terms of their stakeholder characteristics. According to Speckbacher (2003), all business enterprises share the characteristic of having one privileged interest group clearly defined, homogenous with respect to interests; that is, the interests of the owners of a firm guide the firm's policy. On the other hand, nonprofits serve a multitude of constituencies whose goals and needs may be heterogeneous (Speckbacher, 2003). Therefore, financial donors, recipients of services, staff and volunteers are all stakeholders for a nonprofit organization.

Stakeholders for for-profit firms do not consist only of shareholders; for-profit organizations have multiple stakeholders, such as customers, employees, retailers, and suppliers, whose expectations and demands must be considered. Having multiple stakeholders may require tradeoffs to be made; however, meeting the needs of different stakeholders in for-profit companies does not generally conflict with company's long-term goals. After all, shareholder wealth is maximized over the long run by developing customer loyalty and by engaging suppliers and employees in the work of the firm (Moore, 2000). Managing tradeoffs may be more complicated in nonprofit organizations due to the conflicting interests of revenue sources (donors), benefit providers, and recipients.

(4) *Performance measurement.* Given the distinctive characteristics of for-profit and nonprofit organizations, performance metrics and measurement systems for these organizations are unique as well. Although performance measurement can be challenging for any kind of organization, additional challenges exist when measuring the performance of nonprofit organizations, and have been addressed in the literature (Kanter and Summers, 1987; O'Neill and Young, 1988; Letts *et al.*, 1999, pp. 133-136; Sawhill and Williamson, 2001; Brooks, 2002; Poister, 2003, pp. 8-9, 17-21; Speckbacher, 2003; Parhizgari and Gilbert, 2004; Micheli and Kennerly, 2005).

> Many authors suggest that performance measurement in the private sector is more straightforward, since financial metrics are relatively clear and accessible indicators of performance. Profits are measured easily and they are a good test of market-need satisfaction and an organization's ability to operate efficiently (Kanter and Summers, 1987). The challenges identified for performance measurement in the nonprofit sector include the intangibility of the services offered, immeasurability of the missions, unknowable outcomes, and the variety, interests, and standards of stakeholders. Sawhill and Williamson (2001) provide the following example: "Imagine an organization whose mission is to alleviate human suffering. How can you measure such an abstract notion? How can an organization meaningfully assess its direct contribution to such a broadly stated mission? And by whose criteria should success be measured?"
>
> Despite the challenges, performance measurement is critical in the nonprofit sector, due to increasing competition from a proliferating number of agencies, all competing for scarce donor funding and increased demands for accountability of donors, the media, and the public in general (Kaplan, 2001). As a result, many nonprofit managers have adopted the managerial techniques and systems of the for-profit organizations as a way to improve their operations (Oster, 1995, p. 3).

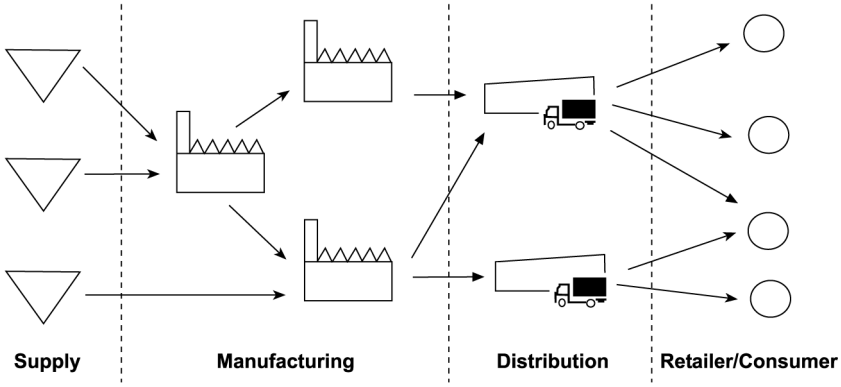
Different types of organizations require different supply chain designs and strategies. An organization's supply chain strategy must be aligned with its business strategy and goals, and tailored to meet the needs of the customers. For instance, a lean supply chain would be appropriate for a sector with a small variety of products, long product life cycles, and predictable and stable demand, since the basis of competition in this case would be cost and quality. However, agile, responsive and flexible supply chains would be appropriate for the sector of innovative (high-technology) products (Fisher, 1997; Lee, 2002). In this respect, the distinctive characteristics of for-profit and nonprofit organizations would affect their supply chain structures and logistics processes. In the next sub-section, we will compare relief chains and supply chains based on their distinctive characteristics that affect performance measurement.

For-profit supply chains versus humanitarian relief chains

The ultimate goal of any supply chain is to deliver the right supplies in the right quantities to the right locations at the right time. Supply chains comprise all activities and processes associated with the flow and transformation of goods from the raw material stage through the end user (Shepherd and Gunter, 2006). Figure 1 illustrates a supply chain with four functional stages (echelons): supply, manufacturing, distribution and consumers.

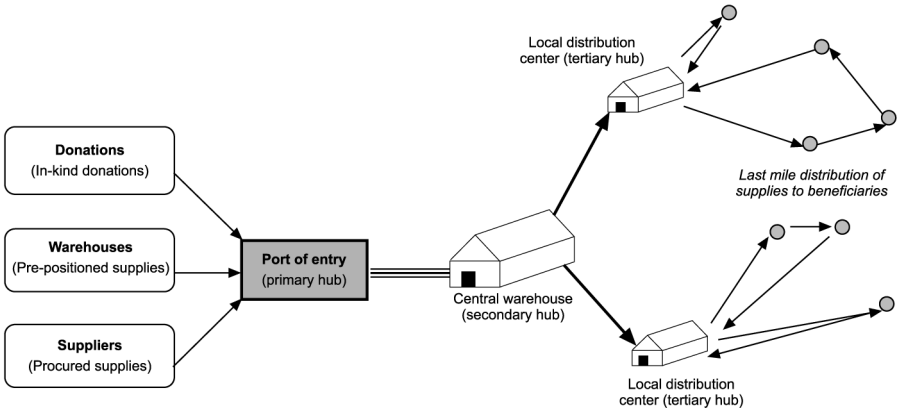
Similar to a commercial supply chain, supplies flow through the relief chain via a series of long haul and short-haul shipments. The flow of relief supplies in a typical relief network is shown in Figure 2.

Supplies flowing through the relief chain primarily consist of pre-positioned stocks in warehouses, supplies procured from the suppliers, and in-kind donations. Supplies are shipped from various worldwide locations to a primary warehouse, which is usually located near a sea- or airport. Next, supplies are shipped to a secondary hub (a large, permanent warehouse typically located in a larger city). At this secondary hub, supplies are stored, sorted and transferred to tertiary hubs (local distribution centers).



Source: Modified from Beamon (1999)

Figure 1.
Supply chain



Source: Modified from the figure in UNDP Disaster Management Training Programme, Logistics module 1st edition (p.18). http://www.undmtp.org/english/logistics/logistics.pdf (Retrieved: April 23, 2007)

Figure 2.
Structure of the relief chain

Finally, local distribution centers deliver relief supplies to beneficiaries. Supplies acquired from local sources may also be stored at secondary and tertiary warehouses, or directly distributed to the beneficiaries.

Once a disaster occurs, a relief organization generally adheres to the following basic process:

- *Assessment.* An individual from the relief organization travels to the site to perform an assessment (usually within the first 24 hours of a crisis) to estimate the supplies required to meet the relief needs of the affected population (Thomas, 2007). This individual then communicates the results of the assessment to an off-site logistician who translates the assessment into supply requirements;

- *Procurement.* A preliminary appeal for donations of cash and relief supplies is often made within 36 hours of the onset of a disaster (Thomas, 2007). If donors respond and the appeal is funded, relief supplies are mobilized. The logistician first attempts to procure the supplies from local sources, and if the relief organization owns a centralized warehouse, the logistician then checks available supplies in those warehouses. Anything that cannot be fulfilled locally or from centralized warehouses is procured from global suppliers through competitive bidding. There can be and are usually multiple suppliers supplying a single relief organization for each relief effort; and
- *Shipping.* Depending on the location of the disaster, the shipping capabilities of the supplier, and the negotiated contract, the goods are shipped to the disaster site.

Although the humanitarian relief chain may share similarities with commercial supply chains, in terms of structure and logistics activities, the relief chain differs on various levels. Given the dynamic demands and risks of operating global supply chains (Lee, 2004; Van Wassenhove, 2006), companies in the private sector may increasingly require the same types of characteristics (agility, adaptability, flexibility) that do humanitarian agencies. Nevertheless, the unpredictable, dynamic and chaotic environment in which relief chains operate is unique. Below, we discuss the distinctive characteristics of the relief environment that affect performance measurement in relief logistics. These characteristics are broadly divided into: strategic goals, demand characteristics, and customer characteristics:

(1) *Strategic goals.* Within the broader objectives of businesses (i.e. whether the company is to seek profit, survival, market share, growth, etc.), Ballou (2004, pp. 35-37) identifies three objectives for a firm's logistics strategy: cost reduction, capital reduction, and service improvement. The cost reduction objective is directed toward minimizing the costs associated with item movement and storage. Capital reduction focuses on minimizing investment in logistics thereby maximizing the return on logistics assets. The service improvement strategy seeks to maximize the value provided to the customer, thereby increasing revenue. In this respect, the strategic objective of a commercial supply chain system can be defined based on the financial returns delivered to shareholders and the value delivered to customers; that is, on producing profit and high quality goods or services corresponding to customer goals and values.

The ultimate goal of the relief chain is to save lives and reduce human suffering, given financial constraints. Unlike the private sector with its sharp focus on a single bottom line, NGOs have two major bottom lines: mission effectiveness and financial sustainability (Moore, 2000; Lindenberg and Bryant, 2001, p. 218). Therefore, the logistics strategy of an NGO must support high-value service provided to the recipients at low logistics costs. Although customer service and cost are common considerations for both the supply chain and the relief chain, the differences between the two sectors bring different dimensions to these common objectives. For instance, the pressure of time in the relief chain is not a question of money but a difference between life and death (Van Wassenhove, 2006).

Two of the most important characteristics that distinguish the relief chain from the supply chain are related to stakeholders and funding constraints. The

number of stakeholders in a relief operation, the complex relations that evolve around them, and their different and possibly conflicting interests and demands lead to challenges in setting and prioritizing goals in relief logistics. Although the main responsibility of NGOs is perceived to be toward the beneficiaries, they also face donor pressure in resource allocation. Donors tend to fund NGOs for specific missions or activities according to their own agendas and may not consistently contribute to infrastructure. This bestows more implicit importance on operational activities (e.g. specific relief efforts) than on building organizational infrastructure. Therefore, NGOs are encouraged to focus on operational disaster relief activities rather than disaster preparedness that will reduce expenses or make relief more effective over the long-term (Thomas, 2007). For instance, although access to timely and accurate information is vital for relief organizations before (for assessing vulnerabilities and capacities), during (for demands assessment, monitoring and tracking relief supplies), and after a relief operation (for reporting results, assessing performance, and building capacity), information systems are not well-established in the relief chain. Also related to funding constraints, strategic, tactical, and operational techniques used for inventory control and distribution in the relief chain are often ad hoc and ineffective. By contrast, commercial organizations typically earmark financial resources for both strategic and operational activities in much less restrictive environments. In this way, financial constraints are not imposed by external forces if a company wants to invest in infrastructure that will improve their supply chain. For instance, many commercial firms have recognized information technology as a competitive advantage in managing their supply chains. Therefore, modern information systems have been increasingly used in the for-profit sector, and reliable, rapid and consistent information is comparatively widely available. Moreover, logistics and supply chain management techniques are typically well-defined, utilizing advanced technology.

(2) *Demand characteristics and order fulfillment for quick-onset emergencies.* While the demands in a relief chain are supplies and people, the demands in a commercial chain are products and services. The larger difference between the two, however, is the demand pattern. For unanticipated, quick-onset emergencies, demand in the relief chain is generated from random events that are unpredictable in terms of timing, location, type, and size. The required set of supplies may vary greatly by situation depending on factors such as the type and the impact of the disaster, demographics, and social and economic conditions of the area. In these cases, demand requirements must be estimated after they are needed, based on an assessment of disaster characteristics. The commercial warehouse operating within a commercial supply chain experiences comparatively stable, predictable external demand patterns, often from fixed locations in set quantities, and typically places orders in regular intervals from a set of fixed (and often certified) suppliers.

The order fulfillment process for the relief chain responding to a quick-onset emergency is also unique, due to the following factors:

- *Lead times*. In unanticipated, quick-onset emergencies, there is usually zero lead time (no warning) between the time a demand occurs (disaster strikes) and the time the supplies are needed. In the commercial domain, customers

typically accept a lead time of several days to one week (or longer, for some customized products) between the time they place an order and their shipment arrives.

- *Reliability of the transportation system.* Demand location uncertainty in the relief chain makes it difficult to establish reliable transportation routes. Transportation unreliability is also affected by political instability, in-country infrastructure, and topography. In commercial distribution, most distribution channels are available, established, reliable, and static. Moreover, unlike in relief systems, the commercial system is likely able to establish sufficient prior transportation capacity to meet customer demand.
- *Pricing.* Once a disaster occurs, demand for supplies increases dramatically, and suppliers will often raise their prices in response. Price gouging in humanitarian relief is exacerbated by the fact that NGOs request bids on supplies from the suppliers every time they respond to a disaster, and may grant the final contract to different suppliers each time. Depending on the location of the disaster, supplier locations, and the suppliers' own in-house transportation capabilities, the NGO can also use different transportation methods and shippers. For most non-commodity-based commercial industries, pricing is relatively static over a reasonable time horizon.

(3) *Customer characteristics*. The customer definition and characteristics are critical to performance measurement as they have an impact on all customer-service-based performance metrics. For the commercial distributor, the customers are the individuals or organizations receiving the products. The customers in the relief chain are the aid recipients. It is important to note here that donors play such a large role in the humanitarian relief sector that the vast majority of NGOs currently regard donors (not aid recipients) as customers. From this perspective, the NGOs manage a service chain, providing the service (for donors) of delivering aid-to-aid recipients. Since our research objective is to study the humanitarian logistics function from an operational standpoint, we must view aid recipients as the customers of the relief mission (NGOs manage a relief chain, providing people, supplies, and services to aid recipients) and the donors as analogous to a commercial board of directors. This conceptual model acknowledges the importance of donors (an important stakeholder to whom NGOs are held accountable) while allowing us to concentrate on relief chain operations (the logistical processes that enable us to provide relief efficiently and effectively).

The differences between commercial supply chain customers and relief chain customers (aid recipients) are significant. Unlike in the commercial chain, the aid recipient does not have the luxury of market choice for supply (relief supplies, in this case). Thus, the aid recipient operates in an unregulated monopoly, where the stakes associated with supplies are often life or death. Moreover, there is no formal contract between NGOs and recipients with agreed-upon standards, so recipients may not have effective mechanisms for representation and often lack recourse to appeal if their expectations are not met (Hilhorst, 2002). In most commercial supply chains, a customer is free to analyze the market and decide to purchase a product based on such factors as quality,

price, availability, and service. With few exceptions (e.g. healthcare and security applications), the stakes in the commercial supply chain are generally lost commerce, increased costs and customer dissatisfaction.

Performance measurement

There is a vast and diverse body of literature on performance measurement. Review studies in performance measurement research particularly addressing the corporate sector include Neely *et al.* (1995), Folan and Browne (2005), and Neely (2005). Neely *et al.* (1995) define a performance measure as a metric used to quantify the effectiveness and efficiency of an action. Effectiveness is defined as the extent which customer requirements are met, while the efficiency is the measure of how economically the resources are utilized when providing a given level of effectiveness. Neely *et al.* (1995) examine performance measurement on three levels: individual performance metrics, sets of performance metrics (the performance measurement system) and the relationship between the performance measurement system and its environment. Performance measurement frameworks and systems are often used interchangeably in the literature. Rouse and Putterill (2003) clarify this by stating that performance measurement frameworks assist in performance measurement system development by clarifying boundaries, specifying dimensions and providing initial intuition into relationships among the dimensions. That is, performance measurement frameworks are not systems, but they form a basis for developing performance measurement systems.

Folan and Browne (2005) classify performance measurement frameworks as structural frameworks (i.e. frameworks specifying a typology for performance measure management;, e.g. Balanced Scorecard by Kaplan and Norton (1992)) and procedural frameworks (i.e. a step-by-step process for developing performance metrics from strategy;, e.g. Wisner and Fawcett (1991) and Medori and Steeple (2000)), which are usually developed in isolation and combined in performance measurement systems. Neely *et al.* (1995) note that different measurement frameworks have been developed; however, a generally applicable systematic approach to performance measurement has not been developed. According to Beamon (1999), the difficulty in creating a general approach is that the different types of systems require specific measurement system characteristics.

Although there is an increasing interest in performance measurement of nonprofit organizations, fewer attempts have been made to provide these organizations with a performance measurement framework (Micheli and Kennerly, 2005). Some examples are as follows: Buckmaster (1999) develops a performance measurement framework with a focus on measuring program outcomes for nonprofit organizations. Kaplan (2001) describes an implementation of the Balanced Scorecard approach to several nonprofit organizations. Sawhill and Williamson (2001) develop a performance measurement framework for a nonprofit organization (The Nature Conservancy). The proposed performance measurement framework assesses organizational performance in three areas: impact, activity, and capacity. Henderson *et al.* (2002) reports on an international child care agency's experience in developing a performance measurement system based on outcome and output-type metrics. Sowa *et al.* (2004) present a measurement framework to assess organizational performance for nonprofits. The authors' model captures two dimensions of effectiveness: management effectiveness and program effectiveness. Zimmermann and Stevens (2006) provide an exploratory study that gives examples of performance measurement used in nonprofit organizations.

Supply chain performance measurement

Schmitz and Platts (2004) and Folan and Browne (2005) classify performance measurement as intra- and inter-organizational and note that inter-organizational performance management (e.g. supply chain performance measurement) is relatively neglected but a growing area in the literature. Beamon (1998, 1999) provides a literature review of performance metrics used in supply chains. Beamon (1999) observes that performance measurement in commercial supply chains focuses primarily on cost and customer responsiveness. However, many types of costs are not quantifiable, and many other types of metrics are not easily or appropriately converted into costs. Based on system complexity, the author argues that a performance measurement system (rather than a single metric) is required in order to meet the characteristics of effective performance measurement. Beamon (1999) develops the following three-part framework for performance measurement consisting of resource metrics, output metrics, and flexibility metrics:

(1) *Resource performance metrics* measure the level of resources used to meet the system's objectives. Resources are generally measured in terms of the minimum requirements (quantity) or a composite efficiency metric (resource utilization), and are explicitly tied to flexibility and (usually) output. Examples of resource performance metrics include the number of person-hours required for an activity, inventory holding costs, and heating and air conditioning costs.

(2) *Output performance metrics* measure the effectiveness with which supply chains are able to supply. Ideally, output performance metrics correspond to an organization's strategic goals and to its customers' goals and values. Examples of output metrics include sales (dollars or units), percent on-time deliveries, customer responsiveness, manufacturing lead time, number of back-orders or stock-outs per cycle, quality, and the quantity of final product produced.

(3) *Flexibility metrics*, as applied to supply chain analysis, describe the range of possible operating conditions that are profitably achievable by the chain. Examples of flexibility metrics include the number of automobiles that a plant can profitably produce in six hours and the shortest delivery lead time that the distribution center can profitably achieve.

Several studies use this framework to select performance metrics in supply chain modeling, such as Persson and Olhager (2002) and Angerhofer and Angelides (2006). There are other performance measurement frameworks in the literature developed for the supply chain or its specific components, such as transport logistics (e.g. Chow *et al.*, 1994; Lai *et al.*, 2002) and supplier performance (e.g. Schmitz and Platts, 2004). The proposed frameworks are mostly structural; a procedural (process-based) framework is developed by Chan and Qi (2003). For a detailed literature review of performance metrics and frameworks for commercial supply chains, the interested reader is referred to a recent review paper by Shepherd and Gunter (2006).

Relief chain performance measurement

Poister (2003) explains why performance measurement is vital in the nonprofit sector: "Effective performance measurement systems can help nonprofit managers make better decisions, improve performance, and provide accountability. Moreover, when they are designed and implemented effectively, performance measures provide feedback on

agency performance, and motivate managers and employees to work harder and smarter to improve performance. They can also help allocate resources more effectively, evaluate the efficacy of alternative approaches, and gain greater control over operations, even while allowing increased flexibility at the operating level".

Performance metrics and measurement systems have not been developed and systematically implemented in the relief sector. However, NGOs are becoming increasingly aware of the significance and urgency of performance measurement, particularly due to increasing competition in the sector for scarce resources and increasingly high demands from donors and the public to improve visibility and accountability. Nevertheless, the inherent and unique characteristics of the disaster relief environment bring significant challenges to selecting appropriate performance metrics and developing measurement systems. Particularly due to the difficulties associated with measuring program outcomes and impacts in humanitarian relief, NGOs tend to measure performance focusing on inputs rather than outputs. This is common in the nonprofit sector. As observed by Kaplan (2001) and Henderson *et al.* (2002), nonprofits are accustomed to reporting input metrics such as the financial (e.g. donations, expenditures, and operating expense rations) and non-financial (e.g. hours spent) resources dedicated to specific programs. Similarly, high-performance relief programs are also commonly associated with inputs, more specifically donations, which lead to providing more aid to beneficiaries. However, as emphasized by Kanter and Summers (1987), although the success of nonprofits relies, in part, on resource attraction, the performance criteria for resource allocation might be unrelated to the criteria for resource attraction. Increasing revenues or donations does not necessarily increase the quality of services nor the capacity of the organization to deliver (Letts *et al.*, 1999). Financial considerations can play an enabling or constraining role but will rarely be the primary objective, and success for nonprofits should be measured by how effectively and efficiently they meet the needs of their constituencies (Kaplan, 2001).

Owing to the central role of logistics in relief operations, the effectiveness and efficiency of the relief chain are important indicators of relief performance. However, the area of relief chain performance measurement of relief chains has not attracted much attention in the literature. In a recent study, Davidson (2006) develops a performance measurement framework for relief logistics for the International Federation of Red Cross and Red Crescent Societies and describes an application of the framework to actual relief operations. The proposed framework relies upon four performance metrics, namely appeal coverage, donation-to-delivery time, financial efficiency, and assessment accuracy.

Next, we apply the existing performance measurement framework developed for commercial supply chains by Beamon (1999) to performance measurement in humanitarian relief chains.

Performance metrics for the relief chain. The basic questions regarding humanitarian logistics performance measurement are the same as for commercial supply chain systems:

(1) How best to measure (what metrics are most appropriate)?

(2) What are the relationships between the performance metrics and the information and material flow decision variables?

(3) How are multiple individual metrics integrated into a unified measurement system?

Beamon's (1999) three-part performance measurement framework consisting of resource metrics, output metrics, and flexibility metrics is applicable to humanitarian relief chains, as each type is critical to the overall performance success of the relief chain. Table I broadly compares the basic goals and purposes for each type of metric for supply chains and humanitarian relief chains.

Next, we develop resource, output, and flexibility metrics for humanitarian relief chains and explain the purpose of each metric type in detail:

(1) *Resource performance metrics.* Resource performance metrics indicate the level of efficiency in the relief chain, and are important to the relief system since:

- they enable relief organizations to more accurately estimate funding requirements for various missions or activities;
- they can be used to demonstrate efficiency performance to potential donors ("we can do more with less"); and
- organizations tend to act in response to performance systems and having resource performance metrics in place indicates a philosophy of organizational efficiency, which leads to more people helped per dollar spent.

Cost is the predominant resource metric in traditional commercial supply chains. These costs may include the total cost of resources used, overhead costs, the total cost of distribution (including transportation and handling cost), and inventory costs (the investment value of held inventory or costs associated with obsolete inventory, including spoilage). For the humanitarian relief chain, there are three dominating costs: the cost of supplies, distribution costs, and inventory holding costs:

(1) *Cost of supplies:* Unpredictable demand patterns increase the complexity of relief organization-supplier relationships, making them more difficult to foster than in the relatively stable demand environment of the commercial chain

Performance metric type	Goal	Supply chain purpose	Relief chain purpose
Resources	High level of efficiency	Efficient resource management is critical to profitability	If an organization utilizes its resources poorly, donors may discontinue funding.
Output	High level of effectiveness	Without acceptable output, customers will turn to other supply chains	Poor output performance leads to increased deaths and suffering
Flexibility	Ability to respond to a changing environment	In an uncertain environment, supply chains must be able to respond to change and have the ability to change	High variability and inherent uncertainties related to disaster characteristics and emergency relief environment require high levels of flexibility performance

Table I.
Goals and purposes of the performance metric types

Source: adapted from Beamon (1999)

("send shipments every Monday"). Also related to demand uncertainty, supply procurement options generally cannot be evaluated before a disaster occurs. Therefore, it may be difficult or impossible to control the cost of supplies. However, this pattern is slowly changing in the relief community, as more and more relief organizations are entering into long-term contracts with suppliers. Such contracts enable relief organizations to control emergency supply costs and are designed to ensure the supplier will have certain quantities of certain items available when needed by the relief organization. By measuring the cost of supplies, one could analyze the cost effects of these types of contracts and distribution strategies (e.g. pre-positioning (holding inventory) versus post-disaster procurement (direct shipment from suppliers)).

(2) *Distribution costs:* Relief organizations often need to transport massive amounts of materials in a very short amount of time. However, the nature of the demand in humanitarian relief chains makes relationships with transportation companies more difficult to develop. Varied disaster locations lead to varied transportation modes (truck, train, airplane, etc.). Complexity may be increased by local tariffs and taxes for incoming goods. Furthermore, since disasters occur in different locations that are often remote, it may be necessary to use local distribution companies for the "last mile" delivery of goods. By measuring the different components of distribution cost, relief organizations can identify specific potential areas for cost reductions.

(3) *Inventory holding costs:* Unlike supply and distribution costs, not all humanitarian relief chains will have substantial inventory costs. This is because only some relief organizations maintain and operate their own supply warehouses. There are many types of inventory costs, including: inventory investment, inventory obsolescence (and spoilage), order/setup costs, and holding (carrying) costs. Inventory control for supply warehouses in the relief chain is challenging due to the high variations in lead times, demands, and demand locations. The specific types of inventory costs to measure depend on the type of items being held. For example, if the relief chain stores many perishable items, then the costs associated with spoilage should be measured.

Although cost is the predominant resource metric in commercial supply chains, other metrics may be relevant, such as personnel requirements and equipment (or other resource) utilizations. Possible relief chain metrics include the number of relief workers employed per aid recipient, the number of "value added" hours (the number of direct hours spent on dispensing aid per total number of labor hours), and the total dollars spent per aid recipient.

(2) *Output performance metrics.* Output performance metrics are an important component of any humanitarian relief chain measurement system since:

- they directly measure characteristics of supply (in this case, the amount of aid provided), which is the primary purpose of any supply chain; and
- they can be used to demonstrate supply effectiveness to potential donors ("we can provide aid to this many people").

Output performance metrics for the humanitarian relief chain can be categorized as those associated with response time and the number of items supplied/supply availability:

- *Response time:* In a commercial supply chain, time is an important dimension of output performance. Key time-based output performance metrics in the commercial supply chain are on-time deliveries (average lateness of orders, average earliness of orders, and percent on-time deliveries) and customer response time (time between an order and its corresponding delivery). In humanitarian relief chains, time is also critical. Specifically, response time is perhaps the most critical measure of performance. Many factors can contribute to relief chain response time, including relief organization assessment, procurement and delivery strategies, supplier location, transportation choice, topology, safety, infrastructure, and politics.

Each emergency is unique, based a number of factors, such as location, regional temperature, number of people affected, and the nature of the emergency. However, there are certain items that are especially critical and needed immediately at the earliest stages of all emergencies (e.g. jerry cans, tarps, tents, blankets, hygiene kits). We will call these items Tier 1 supplies. There are other supplies that are less critical (Tier 2 supplies), and can be safely supplied during later stages. Therefore, response time metrics and targets must consider supply type criticalities. For instance, metrics such as minimum and average response time must be differentiated for Tier 1 and Tier 2 supplies:

- *Number of items supplied and supply availability:* One of the basic output performance metrics in commercial supply chains is the number of items produced. There are many variants of this basic metric, such as the number of units produced per time period, of each type of product, sold in each region of the country/world, etc. In the humanitarian relief chain, analogous performance metrics are the number (or amount) of disaster supplies delivered to aid recipients, of each type, in each region, etc.

A distinctive concern related to relief supply distribution is equity. That is, in addition to the total amount of supply delivered to recipients, equitable and fair supply distribution is an indicator of effectiveness for the relief chain. Therefore, the amount of supplies (of each type) delivered *per* recipient (or *per group* of recipients, such as children) over the relief horizon can also be used as an output performance metric in the relief chain.

For a commercial distributor, output performance metrics also include fill rate (e.g. target fill rate achievement, and average item fill rate) and metrics of item availability (e.g. stock-out probability, number of backorders, number of stock-out, average backorder level). Each of these types of metrics may be used for permanent warehouses in the relief chain.

(3) *Flexibility performance metrics.* Slack (1991) identifies two types of flexibility: range flexibility and response flexibility. Range flexibility describes to what extent the operation can be changed. Response flexibility describes the ease (in terms of cost, time, or both) with which the operation can change or be changed. Slack (1991) also identifies four types of system flexibility (for commercial systems), as shown in Table II. Each of these types of flexibility can be measured in terms of range and response.

In a commercial supply chain, flexibility can measure a system's ability to accommodate volume and schedule fluctuations from suppliers, manufacturers, and customers. Flexibility metrics are distinctly different from resource and output metrics. Slack (1983) indicates that flexibility measures *potential* behavior, whereas other operational objectives are actually demonstrated by the system's *operating* behavior. In this way, flexibility does not have to be demonstrated by the system in order to exist.

Flexibility is especially critical to the relief chain, for two reasons:

(1) The stakes of reliable supply (human life and human health).

(2) The greater demand uncertainties (location, type, and volumes).

A relief chain may be currently utilizing its resources efficiently, but flexibility measures the relief chain's:

(1) *Ability to respond to different magnitudes of disasters ("volume flexibility")*:
   - *Volume flexibility:* Volume flexibility for the relief chain measures an organization's ability to respond to different magnitudes (or severity) of disasters. We will define the critical time period for relief (i.e. the time during which the greatest number of lives is lost) as Tc. We will base the severity of a disaster on the total number of persons affected, and define the volume flexibility as the number of Tier 1 supplies (individual units) an organization can provide during the time period Tc. This measure of volume flexibility measures both dimensions of flexibility: range (amount) and response (time).

(2) *Time to respond to disasters ("delivery flexibility")*:
   - *Delivery flexibility:* The time required for a relief chain to respond to a disaster is defined as delivery flexibility. For this type of metric, we will define a response as the arrival of supplies to the disaster site. Therefore, delivery flexibility for the relief chain will be defined as the time as the minimum response time, which is the elapsed time between the onset of the disaster and the arrival time of the organization's first supplies to the disaster site.

(3) *Ability to provide different types of items ("mix flexibility")*:
   - *Mix flexibility:* Over the course of a relief effort, there is a large number of different types of items that are required and shipped to the affected area, including tarps, blankets, jerry cans, high-energy biscuits, ready-to-eat meals, a variety of medicines, hygiene kits, kitchen sets, tents, and clothing. Mix flexibility for the relief chain measures the number of different types of items that the relief chain can provide during a particular time period. Although mix flexibility can be defined across any time frame and for any subset of items, mix flexibility is most relevant for Tier 2 items (there is a small number of critical item types in Tier 1). Thus, the time period over which mix flexibility is defined varies based on item type and an individual organization's delivery time performance goals.

Flexibility type	Definition
Volume flexibility	The ability to change the output level of products produced
Delivery flexibility	The ability to change planned delivery dates
Mix flexibility	The ability to change the variety of products produced
New product flexibility	The ability to introduce and produce new products

Source: adapted from Slack (1991)

Table II.
System flexibility types

Putting it all together: applying the framework to the relief chain. Table III summarizes the performance metrics we have introduced in this paper in the three performance framework categories of resource, output, and flexibility.

To measure the relief chain effectively, a performance measurement system (comprised of a number of performance metrics) is needed, rather than a single metric (Beamon, 1999). The first step in developing a performance measurement system for a relief chain is to choose at least one individual metric from each of the three identified types. Selecting metrics from each type enables the study of interactions among the metrics, and can ensure a minimum level of performance in each area. Once we have a candidate list of metrics to include in our measurement system, the next step is to evaluate the measurement system on the basis of the criteria presented in Beamon (1996). These criteria are inclusiveness (measurement of all pertinent aspects), universality (allow for comparison under various operating conditions), measurability (data required is measurable), and consistency (metrics consistent with organization goals). After evaluating the measurement system, the final step is to replace, fine-tune,

Resource	Output	Flexibility
Total cost (of resources used)	Total amount of disaster supplies (delivered to aid recipients)	Number of individual units of Tier 1 supplies that an organization can provide in time period T_c
Overhead costs	Total amount of disaster supplies of each type (delivered to aid recipients)	Minimum response time
Total cost of distribution (including transportation and handling cost)	Total amount of disaster supplies to each region (delivered to aid recipients)	Mix of different types of supplies that the relief chain can provide in a specified time period
Inventory investment (the investment value of held inventory)	Amount of disaster supplies delivered to each recipient	Number of individual units of Tier 1 supplies that an organization can provide in time period T_c
Inventory obsolescence (and spoilage)	Target fill rate achievement	
Order/setup costs	Average item fill rate	
Inventory holding costs	Stock-out probability	
Cost of supplies	Number of backorders	
Number of relief workers employed per aid recipient	Number of stock-outs	
Number of "value added" hours (the number of direct hours spent on dispensing aid per total number of labor hours)	Average backorder level	
Dollars spent per aid recipient	Average response time (average time between occurrence of the disaster and arrival of supplies)	
Donor dollars received per time period	Minimum response time (minimum time between occurrence of the disaster and first arrival of supplies)	

Table III.
Summary of relief chain performance metrics

or add individual metrics to ensure the effectiveness of the measurement system, based on the four criteria.

Performance measurement example: operation lifeline Sudan

The framework presented in this paper is not intended to prescribe specific performance metrics for a particular relief organization or operation. Each system is different, with varied goals, objectives, and operating environments. Rather, this framework is provided as a means of guiding and organizing performance measurement selection for relief organizations. This section presents an example implementation of the proposed performance measurement framework in humanitarian relief.

Operation Lifeline Sudan (OLS) operates out of a United Nations base in the northwest Kenyan town of Lockichoggio, and provides more than a dozen daily airlifts of food, relief supplies, and people (Aboum *et al.*, 2007). Lockichoggio has developed into a logistical hub for the south Sudan relief efforts as many NGOs pre-position relief items in warehouses throughout Lockichoggio. Beamon and Kotleba (2006) describe a project to develop inventory management systems for a World Vision International warehouse operating in Lockichoggio within the OLS framework. The inventory models were based on real-world data collected on-site during the summer of 2004.

In the south Sudan relief effort, the inventory system experiences two types of demand patterns: one type is relatively stable over time, representing the "usual" demand levels associated with the ongoing crisis; the second type is sporadic and unpredictable, representing times of specific unrest and conflict in the region. Beamon and Kotleba (2006) introduced three modeling approaches (a mathematical model, a heuristic model, and a naive approach based on simple rules) to inventory control for this relief system and tested the effects of the inventory models, demand distribution, order stock-out risk, and backorder cost on system performance, specifically on the selected performance metrics.

The authors utilized the performance measurement framework presented here, and selected three performance metrics:

(1) Response time (output).

(2) Annual cost (resource).

(3) Maximum proportion of emergency order cycles (flexibility).

The performance framework facilitated dynamic analysis of these three critical system aspects. As mentioned, a primary goal in relief operations is to minimize the response time (to deliver supplies to the areas as they are needed). Moreover, relief efforts generally operate on limited funds, which increase the importance of efficient (low cost) inventory management systems. For this case study, the inventory management system adapts to demand fluctuations by using emergency (expedited) orders.

This performance measurement system was used in conjunction with simulation modeling and statistical analysis to identify system factors that were critical to overall inventory system performance. The analysis in Beamon and Kotleba (2006) yielded two primary conclusions:

(1) The mathematical model (in addition to prescribing the minimum-cost inventory policy) led to a solution yielding the shortest response time.

(2) Flexibility measurement was observed to be critical.

The results showed that order stock-out risk and demand distribution are significantly important in reducing response time. For annual cost, demand distribution and backorder cost were significant. For flexibility, order stock out risk was significant.

A humanitarian emergency relief operation is a complex and dynamic system, and Beamon and Kotleba (2006) provided a means to analyze the interactions among inventory policies, backorder costs, and probabilistic demand patterns in terms of a system of performance metrics, which were selected through the proposed performance measurement framework.

Summary and conclusions

Performance measurement for the relief chain is critical, in terms of securing donor funding (accountability) and improving the relief mission (saving lives and reducing human suffering). The objectives of this paper were to compare performance measurement in the relief chain to performance measurement in the commercial supply chain, develop performance metrics for the humanitarian relief chain, and to present a performance measurement framework for the relief chain. The proposed performance measurement framework can be used as a basis for a performance measurement system in the relief sector. While this paper identified, developed, and illustrated some new approaches to performance measurement for the relief chain, it has only scratched the surface.

Future work includes performance measurement in community involvement and empowerment, performance measurement in community development, performance measurement in the combined relief and development mission, and understanding the role and impacts of cooperation and coordination in the relief chain. It is important to note that there is much to be learned about high stakes supply chain management for quick response in humanitarian relief that can be applied to commercial supply chain management. E-business and improved information technology have increased the focus on time-based competition for commercial supply chains. As commercial supply chain managers seek to create supply chains that are increasingly agile, the lessons learned from relief chain management will also prove relevant to the commercial sector.

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