PREDICTING THE UNPREDICTABLE –

DEMAND FORECASTING IN INTERNATIONAL HUMANITARIAN RESPONSE[1]

Everywhere Humanitarian Response and Logistics Services[2] with Daniel Dieckhaus*, Ian Heigh & Natalia Gomez-Tagle Leonard***

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ABSTRACT

Purpose of this paper

Prevailing literature claim that humanitarian logistics unlike its commercial counterpart, is characterized by unpredictable demand making it difficult to estimate demand for goods and services needed for disaster relief operations. The purpose of this paper is to challenge the veracity of such claims by suggesting ways to forecast demand and thereby improving the state of humanitarian logistics.

Design/methodology/approach

A process was designed to collect and record data on 63 disaster cases around the world on logistical needs and response from donors, humanitarian, military and commercial actors. By this systematic capture and institutionalisation of disaster relief logistics experience and knowledge, an annual index of global demand for items and services that can be used to develop forecasts, was designed.

[1]The origins to parts of this work were commissioned by International Federation of Red Cross Red Crescent Societies (IFRC). We are very grateful to IFRC Global Logistics Service for contributing with data and information.

[2]In the text of other papers, this paper is to be referred to as (Everywhere et al. 2011) or (Everywhere, Jahre and Navangul, 2011). The study has been undertaken in *Contribute* – a research concept on disaster relief logistics – and part of this concept is to improve the cooperation between humanitarian logistics research and practice. While academia focuses on individuals' contributions, practice is more oriented towards companies, hence the reference to Everywhere as a company.

Findings

Contrary to prior literature suggesting unpredictable demand as a main problem in disaster relief supply chains, our research demonstrates that traditional methods used in commercial logistics can be applied to forecast demand for the first response phase later to be replaced by real needs information through assessments.

Research limitations/implications

Data collected constitute a representative sample making it possible to draw general conclusions. While every effort was made, variable reliability must be taken into account warranting improvements in reporting, approach and testing in future research.

Practical implications

By challenging the myth of unpredictable demand, the study reshapes the thinking around design and implementation of disaster relief chains and provides the humanitarian community with data and tools to improve preparedness for response, thus increasing efficiency and effectiveness.

What is original/value of paper

Supported by empirical evidence, this paper represents a first endeavour showing that demand is not an inevitable reality one must deal with in managing disaster relief supply chains. This challenges prevailing views in humanitarian logistics literature.

Keywords: disaster relief, quantitative analysis, humanitarian logistics, forecasting.

1. INTRODUCTION AND PURPOSE

In their editorial of a special issue on humanitarian logistics, researchers Tatham and Pettit (2010) conclude that *'…, we sincerely hope that the papers presented….will make a substantial contribution to the challenge of humanitarian logistics…'* However, recent practitioner viewpoints concerning humanitarian logistics research state that:

> *'Most of what's been done seems to me to be case-study type work and conceptual reviews but not a lot of empirical/analytical. Time is a big gap and there doesn't seem to be a strong dialogue between the sector and academia about things that could make a real difference.'* (Blansjaar, Oxfam, in Kovács and Spens, 2011, p.40).

These are strong words, but unfortunately quite representative for experienced practitioners in disaster relief and a sad 'conclusion' considering all the resources and time that have been devoted by researchers and practitioners during the past six years since research 'took off' in 2004 after the Asian Pacific Tsunami. And it is not only practitioners who claim research suffers from empirical insight (Kovács and Spens 2007; Heigh and Jahre, 2010; Oloruntuba, 2010)), in particular in-depth case research and longitudinal studies (Jahre et al. 2010; Kovács and Spens, 2011). Most papers can be characterised as either:

- Purely conceptual based on literature reviews and few empirical studies with practical implications or advice rooted in real problems; or
- Theoretical modelling on problems practitioners don't really recognize*: 'by pretending to solve real problems we are alienating the few remaining practitioners who still read our technical journals.'* (van Wassenhove in Schmenner et al, 2009, p.342); or
- Pure narratives, i.e. stories on previous disasters pointing at problems, characterized by little rigour in the research design and lack of links with conceptual/theoretical frameworks, thus providing limited contributions to theory development or testing.

It is noteworthy that a lot of literature which provides academic views concerning the main challenges and characteristics of disaster relief/humanitarian logistics often focuses on contrasts between humanitarian and commercial logistics, the underlying assumption being that major differences do exist between the two. The purpose of this paper is to challenge such assumptions, which we refer to as 'myths' in this paper. In particular, this paper identifies one often repeated myth in the literature - that of unpredictable demand - and investigates its veracity.

The study was conducted as part of a joint research initiative between academia and practitioners building on systematic capture and institutionalisation of disaster relief logistics experience and knowledge together with research competencies. A tool was developed that will help the humanitarian community to improve practice and provide directions for research that will 'make a difference' by improving the speed of response for delivering items needed into the hands of the people that need it. For example will more frequent smaller disasters where current global tools are far too costly require pre-positioning of stocks, allowing vehicles and ships to deliver relief items at aeroplane speed, but at truck cost. Knowing where to locate such warehouses and what items should be stored where, is necessary to do this in an efficient and effective way and requires information about future needs, thus 'predicting the unpredictable'. In the following the tool that can provide the basis for this is presented. First, section 2 provides an overview of prevailing theoretical views, i.e. 'unproven myths' in the literature, focusing on the belief that demands cannot be predicted. This is followed in section 3 by a description and discussion of the approach and the development of the tool. The fourth and final section presents conclusions and suggestions for further research.

2. CHARACTERISTICS OF DISASTER RELIEF SUPPLY CHAINS AS PRESENTED IN THE LITERATURE

Among the literature reviews published so far within humanitarian logistics, some mainly categorise articles according to their focus in terms of types of disasters or disaster phases (e.g. Altay and Green, 2006; Natarajarathinam et al., 2009). Others list characteristics of relief supply chains to discuss how they differ from their commercial counterparts (e.g. van Wassenhove, 2006; Kovács and Spens, 2007; Balcik and Beamon, 2008). Table 2.1 provides a summary of such papers.

Table 2.1: Characteristics of disaster relief supply chains put forward in prior research

Characteristic	Sources
Uncertainty in/ unpredictable demand	van Wassenhove (2006); Beamon and Kotleba (2006); Oloruntuba and Gray (2006); Kovács and Spens (2007; 2010); Balcik and Beamon (2008); Lodree and Taskin (2008); Jahre and Heigh (2008); Day et al. (2009); Tomasini and van Wassenhove (2009); Stapleton et al. (2010); Salmerón and Apte (2010); Mete and Zabinsky (2010); Sheu (2010); Gatignon et al. (2010); Balcik et al. (2010); Rawls and Turnquist (2010); Majewski et al. (2010)
Time more important than cost in the first phase	van Wassenhove (2006); Oloruntoba and Gray (2006); Day et al. (2009); Tomasini and van Wassenhove (2009); Salmerón and Apte (2010); Banomyong and Sopadang (2010)
Lack of resources	Pettit and Beresford (2005); Balcik and Beamon (2008); Jahre and Heigh (2008); Kovács and Spens (2010); Balcik et al. (2010)
Destabilized infrastructure	Long and Wood (1995); Pettit and Beresford (2005); van Wassenhove (2006); Oloruntuba and Gray (2006); Kovács and Spens (2007; 2010); Kovács and Tatham (2010); Balcik et al. (2010); Rawls and Turnquist (2010)
Non-profit: goal is to save lives	Oloruntuba and Gray (2006); Tomasini and van Wassenhove (2009); Kovács and Spens (2010); Kovács and Tatham (2010)
Many stakeholders	Thomas and Kopzack (2005); van Wassenhove (2006); Oloruntuba and Gray (2006); Stapleton et al. (2010); Kovács and Tatham (2010); Balcik et al. (2010)
Uncertainty in supply	van Wassenhove (2006); Oloruntuba and Gray (2006); Kovács and Spens (2007); Stapleton et al. (2010); Balcik et al. (2010); Majewski et al. (2010)
Information flow impediments and weak use of technology	Pettit and Beresford (2005); Thomas and Kopzack (2005); Oloruntuba and Gray (2006); Day et al. (2009); Banomyong and Sopadang (2010); Majewski et al. (2010)
Complexity; lack of control	Pettit and Beresford (2005); van Wassenhove (2006); Kovács and Spens (2007; 2010); Balcik et al. (2010)
Volatile political climate	Long and Wood (1995); van Wassenhove (2006); Balcik et al. (2010)
Donor accountability and transparency	Thomas and Kopzack (2005); van Wassenhove (2006); Jahre and Heigh (2008); Stapleton et al. (2010); Balcik et al. (2010); Majewski et al. (2010)
Lack of institutional learning	Thomas and Kopzack (2005); van Wassenhove (2006); Day et al. (2009); Kovács and Tatham (2010); Oloruntoba (2010)

Many studies put forward uncertainties in/unpredictable demand as the main challenge of disaster relief. However, a deeper review of the literature concerning this specific point reveals that apart from one paper (de Leeuw et al. 2010), the studies do not provide empirical evidence to support this claim. For the most part recent literatures cite previous studies which are not based on real data either. In the article by van Wassenhove (2006), considered seminal in the literature, it is claimed that'…humanitarians are always faced with the unknown. They do not know when, where, what, how much, where from and how many times.' Further, according to Kovács and Spens (2010), 'most natural disasters are unpredictable' (p.224). Lodree and Taskin (2008) say that 'catastrophic events are typically characterised by extremely low probability of occurrence and a significant demand surge for supplies, equipment, and manpower' (p.674). In a similar vein, Balcik et al. (2010) suggest that 'By their very nature, the location, timing, and intensity of sudden-onset disasters are typically unknown a-priori' (p.24). Conclusions that follow are that since one cannot know when or where the next disaster occurs, one cannot predict future demand. de Leeuw et al. (2010), on the other hand, based on real, although limited, data concludes that '…natural disaster occurrence is not that unpredictable as typically understood' (p.171). Makridakis et al. (2009)

discuss how even earthquakes occur with predictable frequencies, even if one cannot predict exact time or location the next will strike (p.799). In the light of the above arguments, this paper investigates as to whether unpredictable demand is indeed an indisputable challenge that confronts disaster relief supply chains.

The extent to which demand *can* be predicted or forecasted is essential for making supply chain decisions. Accuracy in demand forecasting has improved with rapidly developing technology and access to real-time data in the commercial context, and is in fact what drives the whole supply chain (Chopra and Meindl, 2010, p.198). This is probably an important reason for the focus on uncertainty in demand in previous disaster relief literature compared to other characteristics. In terms of providing solutions, papers report on studies undertaken to develop more sophisticated models such as stochastic demand (e.g. Barbarosoglu and Arda, 2004; Salmerón and Apte, 2009; Rawls and Turnqyuist, 2010; Mete and Zabinsky, 2010); Monte Carlo simulation (e.g. Banomyong and Sopadan, 2010); insurance risk management (e.g. Lodree and Taskin, 2008) and dynamic demand planning (e.g. Sheu, 2010). The main focus is development of the models with some testing based on assumptions about demand and/or cases and various scenarios. As put forward in the papers themselves, applications in real situations, however, typically require data on demand, e.g. '[disaster relief demand information] is hard to be approximated using historical data…' and '[there is] lack of previous demand information.' (Sheu, 2010, p. 1-2). Further, '[o]ne limitation of the proposed framework is that complete knowledge of demand distribution associated with the potential extreme event is required' (Lodree and Taskin 2008, p. 683). Hence, a 'catch-22' situation occurs with the studies arguing high demand unpredictability as the main reason for developing more sophisticated models simultaneously as the models require demand data if they are to be used.

3. APPROACH AND DISCUSSION - DEVELOPING THE FORECAST

Section 2 concluded that although demand unpredictability has been put forward by most previous literature as one of the main challenges that plagues the disaster relief sector and makes it different from its commercial counterpart, a deeper review reveals lack of empirical evidence to support this claim. The following section presents how the use of historical data related to disaster relief can provide information to understand and forecast future demand. This study possibly represents the very first substantive attempt to empirically investigate the 'myth' of unpredictable demand. As the investigation reveals and as explained subsequently in this paper, the forecasting models and concepts traditionally used in the commercial logistics can also be applied in the humanitarian context. By studying historical data regarding disasters, their main patterns can be identified in terms of needs and response to project future demand, as indicated by Majewski et al (2011). Section 3.1 gives a brief insight into how the demand estimation currently undertaken in disaster relief practice can be characterised in relation to logistics/SCM models, followed by section 3.2 where our approach is presented.

3.1. Needs assessment vs. demand forecasting

Currently demand is estimated mainly through needs assessments which are often surveys of affected populations or affected areas to understand existing resources and thereby identify what is needed, i.e. the demand. Many problems are associated with implementing these methods:

- There is lack of international consensus on the type and definition of indicators that capture the vital needs (von Schreeb, 2007).

- It is difficult to carry out an accurate assessment in emergency situations and implementation has been slow in spite of initiatives such as SMART[3] and UNDAC[4].
- It is difficult to go from questions and observations of needs to understanding of demand.
- It is challenging to track the rapid and extreme changes in demand common to post-disaster environments, including further disaster events, or the effect of assistance as it is delivered, i.e. keeping track of the supply and how it helps.
- As most donations are based on these inaccurate needs assessments and provided when a disaster occurs they rarely meet real needs.

This may explain the claim in the literature about demand unpredictability. A closer look at what the relief sector is attempting reveals that they try to base the set-up, planning and operation on actual demand as in order-based (pull) commercial supply chains. However, the context is characterized by high supply uncertainty (lack of infrastructure and little overview of available supplies), low complexity in terms of a relatively narrow set of standard products (at least for basic relief items as listed in table 3.2) and very high cost of not delivering (lost lives and suffering), which are all characteristics favouring a push-based (forecast) rather than a pull-based approach (Jahre and Heigh, 2008, p.49). Reduced demand uncertainty would make a push-approach fit even better. Hence, if reasonable forecasts could be developed, these would provide information which could be taken into use for quick deployment of supply chains once a disaster occurs and help covering immediate needs while allowing time for actual assessments to be carried out and replacing the forecast as time goes by. *This is the core of the approach presented here.*

3.2. Developing the index that allows forecasting

A research process was designed in order to establish the demand for disaster relief goods, and logistics services for a year's period on a global level. At the outset, the following four questions were posed: What is a disaster? What relief items and services address the basic needs of affected populations? What resources are provided, i.e. response in terms of money, items and logistics activities associated with this? By whom are these resources provided?

Depending on available data, characteristics of products and the expected use of a forecast, models can be qualitative, time series, causal and simulation (Chopra and Meindl, 2010). We use time series because it is assumed that future demand has similarities with historical demand. In this first pilot version a relatively simple model has been developed, basically assuming that the number of affected people in a disaster drives demand varying with type of disaster, region in which is occurs and the time-period of the demand (Emergency; Initial recovery; and Recovery). This can be compared to understanding and identifying customer segments and seasonal demand in commercial models (ibid., p.202). While the needs data is considered equivalent to the demand, the data for response is viewed as the equivalent of sales, which, according to Chopra and Meindl (p. 222), should not be used to forecast demand. This could be even more important in the humanitarian context because past delivery of items does not necessarily indicate demand, as the "customer" beneficiary has no choice in what goods he/she accepts nor does delivery of goods mean that all demand for those goods was satisfied. Moreover, using response data to calculate needs is equivalent to saying that there were no gaps in response, i.e. that the beneficiaries get what they need, which is not

[3]SMART (2002) Standardizing Survey Methodology Conference notes; Improving the Monitoring, Reporting and Evaluation of Humanitarian assistance (http://www.smartindicators.org/workshop)
[4]United Nations Disaster Assessment and Coordination mechanism

necessarily true. Hence, it is the needs data that has been the main basis. However, as it will be explained below, response data is also needed to cover elements of model. To reduce uncertainties aggregated data is used'…. as they tend to have smaller standard deviation of error relative to the mean [compared to disaggregated data]…' (ibid.p.199). Stated differently, when demand is aggregated across several disasters as described in section 3.2, the accuracy of the forecast improves. Hence, we have created an annual index based on a sample of disasters to support the development of a forecast. The degree of demand uncertainty, i.e. deviation from forecast, is normally measured in terms of forecast error (Chopra and Meindl, 2010, p.199). Just as in the commercial sector, it would be impossible to perfectly forecast the occurrences of disasters and the resulting demand on resources (Makridakis et al., 2009). In future model versions, forecasting errors will be calculated by comparing real demand (needs) in specific disasters with the numbers forecasted by the model, to see if more sophisticated models could predict demand with greater accuracy. Further, with more data, seasonality as well as possible trend indexes can be modelled to adjust the index now developed. To summarise:

- Compared to prevailing *practice*, we suggest using a forecast rather than attempting to use actual needs in the first two response phases when real needs data are hard to come by. This could be followed using actual needs in the third phase as data becomes available.
- Compared to prevailing *theory*, we suggest that historical data is available and can be used to develop such forecasts which can be improved with additional and more accurate data.

3.2.1. Sampling, concepts and indicators

To estimate yearly demand, data was collected for 63 specific disasters' needs and response that occurred in the period 2005–2010, the sources constituting official reports, statistics and other available information; i.e. mainly secondary data that was uploaded into the custom-made database. The sample size of 63 yielded a confidence level of 95% with an interval of 11.7% (Bryman and Bell, 2007, p.182 and 194) and was considered sufficient taking available time and human resources into account. In order to sample correctly, the population from which to choose must be defined. A *disaster* is defined as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering" (Vos et al., 2009, p.5, www.emdat.be). Based on the merged records of CRED (2010) on natural disasters and IFRC (2009) data from international appeals and Disaster Management Information System (DMIS[5]) on man-made disasters, an estimated 1,020,145,314 persons were affected by 4067 disasters occurring globally during 2005 – 2010. Of these it was estimated that 605 had international response. Categories were established for 4 main disaster types (drought/famine, flood/hurricane, volcano/earthquake and other) and 5 regions (Africa, Americas, Asia, Europe and Middle-East & North-Africa).

As similar types of disasters generate similar needs but will vary by region and since some disaster types occur much more frequently and some regions are struck much harder than others, stratified sampling was used to get a proportional representation of population i.e. occurrence of specific types in specific regions, e.g. floods in Asia (Bryman and Bell, 2007, p. 187). After delineating the number of cases to be studied per disaster type the specific disasters were selected randomly using an internet tool[6]. Three time periods were defined (1) Emergency phase: first 3 months; (2) Initial recovery phase: 4-6 months; and (3) Recovery phase: 7-12 months. The study categorizes resources into three types: money, relief items, and

[5]https://www-secure.ifrc.org/DMISII/Pages/00_Home/login.aspx
[6]http://www.random.org/

activities required to move the items from point of origin to point of consumption, i.e. the logistics activities required for the set-up and running of the supply chain(s) for a specific disaster[7]. Indicators with quantitative measures for each of these concepts were developed in line with Bryman and Bell (2007, p.158) as shown in table 3.1.

Table 3.1: Concepts, indicators and measures

Concept	Indicators	Measure	Comment
Money	Cash, In-Kind	USD per donation	Money comes in the form of cash or in-kind donations provided to the humanitarian organizations
Items	Food, NFI, shelter, sanitation, other (e.g. medicines)	Volume in m3; Weight in kg ; Cost in USD	Relief items normally provided to cover the basic necessities of affected population. To translate need for items into demand for logistics each item is characterized in terms of volume, weight and procurement cost per unit.
Activities	Freight Forwarding, Customs Clearance, Warehousing, International/ Local Air Transport, International/Local Ground Transport, International Sea Transport, Local Warehousing, Local Sea Transport, Local and International Procurement, Coordination	Cost of activities in USD; per unit (volume or weight) moved/stored, etc...	Activities considered in this study are those needed to assure relief items arrive at the point specified for final distribution to the affected population and include customs clearance, freight forwarding, local warehousing, international warehousing, international air transport, local air transport, international sea transport, local sea transport, international ground transport, local ground transport, technical assistance and coordination. In the model these were grouped into 6 categories. Procurement is defined as % of the value and differs between international and local procurement.

An estimation model for needs based on previous work commissioned by IFRC (Heigh and Leonard, 2009) was developed by an experienced disaster relief logistics expert and checked off with the researcher team. This model follows the same logic concerning time periods, indicators and measures of goods and activities as listed in table 3.1 and is based on IFRC procurement systems (IFRC Humanitarian Logistics Software)[8], the Emergency-items catalogue (2009)[9], the Sphere Catalogue[10] and 32 IFRC Operational and Appeal Reports[11].

3.2.2. Data collection

Data were classified into two different sets: static and variable i.e. disaster specific. The static data necessary for the planning of input sheets was collected first and contains information on named actors involved in disaster response, relief items, as well as item and activity specific data. Microsoft Access was used as database software to host all information collected. The disaster specific data collection started 7th October, 2010. Information was gathered over a period of 4 months with a team of four collectors, one for each actor type – donors, humanitarian organisations, military and commercial. A pilot test was run in order for the team to familiarize with data collection, and to test custom made excel workbooks. The results of this pilot were reviewed by the whole researcher team. The process and documents were adjusted according to the review, and used for further data collection. In total 5 iterations were undertaken each lasting one week with compilation, population and revision between each round. Each of the collectors was required to provide three documents: the actual data, the sources of information and the methodology developed for the specific sets of data (Everywhere et al., 2011). Similarly, needs were estimated for each selected disaster during these rounds using the model developed, whereupon data was registered and populated in the

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[7]Note that items included (and according logistics services) are not all encompassing. E.g. are health services and equipment for treatment in clinics not included in the data at this point.
[8]http://wwwdev.ifrc.org/what/disasters/responding/elements/logistics/software.asp, 20th March, 2011
[9]http://procurement.ifrc.org/catalogue/, 20th March, 2011.
[10]http://www.sphereproject.org/, 20th March, 2011.
[11]http://www.ifrc.org/en/publications-and-reports/, 20th March, 2011

same way as the collected response data. The process was finalised by a thorough 'housekeeping', i.e. cross-checking iterations to assure information consistency across all 63 disasters. The key aspects of the datasets are provided in table 3.2.

Table 3.2: Dataset characteristics

Key Aspect	Core data	Needs	Donor response	Humanitarian response	Military response	Commercial response
No. of inputs	63 disasters 15 characteristics = 945 inputs	63 disasters 27 items 3 periods 3 characteristics = 15309 inputs	217 donors 1719 donations =1936 inputs	109 organisations 1196 item responses 5013 activity responses = 6318 inputs	145 military units 205 activity responses = 350 inputs	63 disasters 5 top commercial actors involved 6 different activities 5 regions = 9450 inputs
Main Sources	www.emdat.be ; www.ifrc.org; UN statistics; population services; World Bank; and other.	Due to lack of historical data on needs, an estimation model was developed. Based on affected no. of people, 4 categories of disasters, percentage requiring international assistance, average no. of people per family, distribution over 3 periods , needs for each disaster were estimated.	www.reliefweb.int ; Financial tracking service reports IFRC-situation reports; Internet search using Google for additional data on specific disasters.	www.reliefweb.int; UN Consolidated Appeal Process reports (CAP); Operations reports , Project-reports per agency; Agency web-sites; News articles.	www.reliefweb.int; Country Announcements; OCHA / IFRC Situation Reports; AP/Reuters/Other news websites; US Combatant Command; Regional/Traditional Military Involvement; Internet search using Google	Due to lack of data, an estimation model was developed. Base data for specific company involvement was collected from 4 large humanitarian organisations and combined with company research to establish ranking in the 5 different regions with regards to market shares in the different logistics activities.
Types of data	Unique disaster no., Dates, No. of people affected, Location: region and country, Type of the disaster.	(1) Initial items: jerry can, hygiene & shelter repair kit, kitchen set, mosquito net, tent, tarpaulin, sleeping mat; (2) Food items: cereals, pulses, oil; (3) Local procurement items: baby kit, bed sheets, buckets, food parcel, hurricane lamp, soap, mattress, kerosene stove; (4) Shelter items: prefab house, roofing sheets, timber pack, nails, tarpaulins, local shelter; (5) Cash vouchers.	Donations in cash; In-kind donations; Donations from preparedness funds.	No. of people assisted per agency; Quantity/weight and volume of each item; Logistics activities required.	Quantity/weight and volume of each item; According logistics activities required. (Often handling logistics activities for humanitarian organisations.)	Assume 100% outsourcing by humanitarian organisations to military or commercial. Hence, commercial response is total logistics activity less military activity.

3.2.3. Estimating needs in terms of item volume, weight and value

Needs are directly linked to the people requiring assistance in terms of their need for relief items, shelter, water and medical attention. Based on previous reports and experiences from disasters, the number of people in need is calculated as 33% of affected number of people. Estimated needs then constitute the quantity of the demand from the affected population, i.e. number of families requiring assistance, and the composition of demand, i.e. type and quantity of assistance needed per family, including the logistics activities required for that assistance. The latter was developed based on past response with some examples shown in table 3.3.

Table 3.3 Example of base-data – quantity of items needed per person per disaster

	Drought / Famine				Volcano / Earthquake			
Initial items	**Total**	**period 1**	**period 2**	**period 3**	**Total**	**period 1**	**period 2**	**period 3**
Blanket	2,000	1,200	0,600	0,200	2,946	1,768	0,884	0,295
Kitchen set	1,000	0,600	0,300	0,100	1,000	0,600	0,300	0,100
Cereal	90,000	54,000	27,000	9,000	90,000	54,000	27,000	9,000

The model's "items needed per person per disaster" data was then combined with the static data describing each item in terms of volume, weight and value per unit, as well as the estimated number of persons requiring assistance in each disaster. The resulting data shows the estimated needs of each item in terms of quantity, volume, weight, and value for each disaster. These item data were then aggregated as presented by the snapshot in table 3.4.

Table 3.4: Example of estimated needs per disaster - aggregated

Disaster no.	Type	Area	Families assisted	Volume (cm3)	Weight (kg)	Purchase Cost (USD)
2005-0640	Storm	Americas	5 940	42 669	12 518 687	7 996 429
2006-0373	Volcano	Americas	19 800	199 581	60 431 686	48 551 970
2007-0261	Flood	Africa	37 314	268 040	78 640 302	50 232 234
2009-0632	Cold	Mongolia	50 761	205 074	13 576 869	21 381 848
2010-0252	Floods	Europe	984	7 069	2 073 929	1 324 742

The third step to reach the annual index was to aggregate multiple disasters by region/disaster. Because the 63 chosen cases were taken from a total of 605 cases over 6 years, in order to develop a model index, it was necessary to calculate how representative the chosen cases were compared to the total to come up with a multiplier (i.e. percentage: selected disaster population/total population). The index uses the multiplier as factor in order to extrapolate the results to the rest of the 605 cases. Furthermore, because the cases occurred over 6 years' period, it was necessary to establish the one-year average by dividing by a factor of 6. The result was a one-year index of needs for each region/disaster combination, with specific relief item information, as well as the aggregated. This is shown in table 3.5.

Table 3.5: Example of estimated needs per year for specific items for floods in Africa

Items	Units	Weight(Kg)	Volume(m3)	Cost of goods(USD)	Number of families needing assistance in 1 year
Blanket	365 705	585 129	4 388	1 828 527	133 156
Kitchen Set	137 023	712 521	2 466	3 836 651	133 156
Cereal	11 984 012	11 984 012	23 129	11 984 012	133 156
Total		287 203 998	517 825	209 383 785 07	133 156

3.2.4. Estimating response in terms of item volume, weight and value

The data from 63 cases studied were organized in terms of disaster type, region, actors providing money and items. The information was recorded in three time periods 1-3 months, 4-6 months, and 7-12 months. The same multipliers were used to extrapolate the results from cases studied to the 605 cases. As in the needs module, the results were then divided by a factor of 6 to establish the One year average.

3.2.5. Estimating needs and response of logistics services - volumes and costs

The logistics activities taken into consideration were those logistical services performed to deliver the relief items. From a comprehensive list the key logistics services (listed in table 3.1) were selected according to the advice of experts and experienced practitioners from the commercial, military and humanitarian sector. Commercial experts provided estimates for the cost of each service per region. As done in several organisations procurement cost was calculated based on a percentage of cost of goods. For proprietary reasons, these estimates cannot be disclosed.

Since no model existed to determine the logistics services for moving the *needed* items, formulas were developed based on the *response* data for relief items and logistics activities. The logistics activities response module was designed to establish the One Year Index based on all information available. Data collected on each of the 63 disasters revealed the services employed by each humanitarian or military actor for each disaster response item in a response, while core static data provided both the total quantity of services required (kg or m3 per item multiplied by quantity of item) and the cost of each service (USD per m3 or kg multiplied by quantity of service). The result was a comprehensive module that takes into consideration the relief items weight, volume and cost in a similar way that a commercial company would use past costs knowledge as the basis for future estimates. In the first round of aggregation to determine needs, each actor's logistics activities were consolidated to calculate the total (m3, kg, or USD) for each activity of the actor in each disaster/region combination over the 63 disasters studied. As with the response items, it was necessary to use the previously determined multipliers in order to relate the data to the larger 605-disaster set. After dividing these totals by 6 to account for the six-year (2005-2010) period analysed, a series of one-year indexes were produced showing total response activities per actor in each disaster/region combination. A snapshot example is found in table 3.6.

Table 3.6: Selection of activities for responding to floods in Africa by selected organisations

Actor	Activity	Families Assisted	Kg	m3	Cost of Activity USD
American Red Cross	Customs Clearance	90 991	1 719 687	3 036	9 971
American Red Cross	Local transport - Land	90 991	1 719 687	3 036	355 896
Norwegian Church Aid	Customs Clearance	10 339	3 488	59	191
Norwegian Church Aid	Intl transport - Sea	6 931	2 125	43	1 249
Norwegian Church Aid	Local Warehousing	10 854	11 220	67	20 493

3.2.6 Estimating families assisted

A separate module was developed to determine families assisted based on recorded numbers. The same process as the needs, response and logistics services was used. The results from 63 researched cases were first aggregated into a table that was manipulated to determine families assisted by region, and type of disaster. Because these data represented the actual response, a correlation was done between families assisted in the cases studied, and the 605 cases. Finally the results were divided by 6 to get the one year average.

3.2.7 One Year Index Summary

The One Year Index Summary is the consolidated result of 6 modules containing 3 response phases, 4 disaster types, 5 regions, 6 key logistics services, 27 relief goods, 109 humanitarian organisations, 145 military forces, 217 donors, 605 disaster cases, within a 6 years period. Combined they give a comprehensive tool that offers an overview of disaster needs, response, and gaps. Figure 3.1 gives an illustrative summary of the process undertaken .

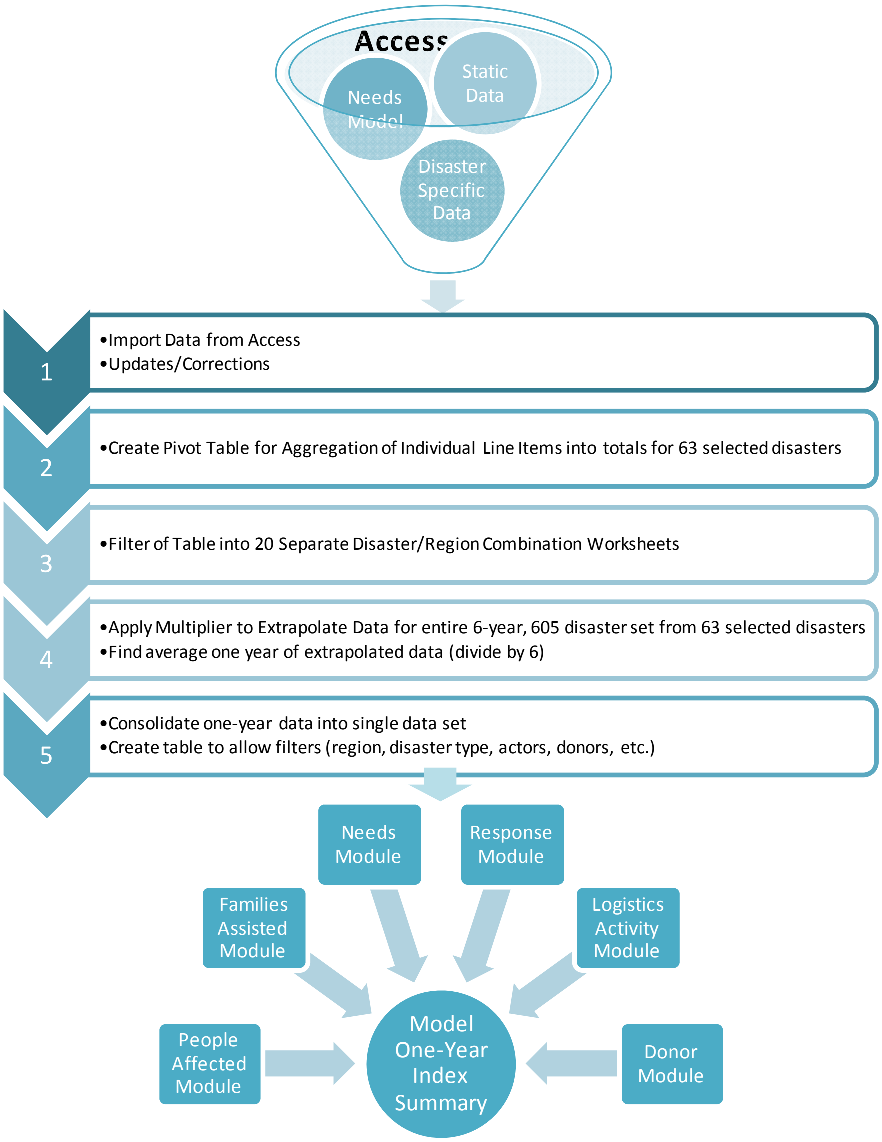

Figure 3.1: The index development process

The One Year Index Summary provides series of reports of consolidated information about needs and response on relief items, logistical services, and funding. Various queries can be used to sort the data such as per response phase, disaster type, region, and agency in kilos, cubic metres and costs.

3.2.8 Assuring quality in the data

The study is based on a quantitative research strategy using a cross-sectional design with collection of secondary data from a number of different sources. This approach was chosen for a number of reasons. Most previous research is based on single case studies with mainly qualitative data which cannot be used for developing generic tools and solutions. There is a need for quantification in terms of a large number of 'cases' and numeric data collected. Use of secondary data gave advantages in terms of the time and cost involved and provided, with some adjustments, standardised and thus comparable data from one case to another (Bryman and Bell, 2007, p. 328). Typically secondary databases provide data of high quality with opportunities for longitudinal, cross-cultural and sub-group analyses. Mitigating strategies for possible limitations (ibid. p.334) are presented in table 3.7.

Table 3.7: Securing validity and reliability (adapted from Bryman and Bell, 2007)

Quality measure		Mitigation strategy used
Limitations with secondary data	Lack of familiarity with data	Used disaster relief experts who are familiar with humanitarian, commercial and military data.
	Lack of control over data quality	Checked data collection procedures with each of the main sources used. Assumed that organisations receiving donations have to report their activities in annual reports as they need to make their work publicly available in order to continue receiving support.
	Absence of key variables	Developed estimation models for missing data sets.
Reliability	Stability: is the measure stable over time?	The measures applied use basic and well-known logistics/SCM theory and concepts, e.g. measuring logistics activity in terms of volume, weight and cost. Other measures used stem from secondary data used for a number of years in disaster relief. One weakness is that as this is a rapidly developing sector in terms of standardisation, the definitions and measures may change over time.
	Inter-observer consistency: is the measure consistent between observers?	The team constituting seven researchers have continuously discussed to obtain consensus on indicators and measures. Methodology has been tested by having more than one researcher on a dataset, e.g. donor-data.
Validity	Face validity: does the measure reflect the concept in question?	Used disaster relief expert who has planned and coordinated response for major organisations in most major disasters during the past 10 years to develop the needs estimation model. Tested the measures and the concepts with humanitarian organisations and other practitioners and researchers.
	Measurement validity	Cross-referencing data for different organisations by using various sources. However, there may be inconsistencies in the reporting that are difficult to detect.
	External validity: can results be generalized?	Systematic sampling procedure and use of random selection in accordance with statistics theory is described in detail.
	Ecological validity: are results applicable to everyday, natural settings?	Systematic use of expert practitioners to secure data. And database logic is consistent with reality of disaster relief logistics.
Replicability	Make it possible for others to repeat the study	The main idea is to establish a process that allows the collection and updating of the database in following years to improve on quality and reliability of results that allow others to use it. The data collection procedures, sampling method and other aspects of the research approach and methodology have been documented more thoroughly by Everywhere et al. (2011) than in this research paper.

Sampling procedures, sources, developments of indicators and measures and mitigation strategies to secure reliable and valid data assure that results from the data collection in the sample can be generalised to the whole population and be the basis for establishing a baseline, i.e. an average year of logistics needs and response in disaster relief operations. Whilst there are limitations in terms of uncertainties in the data collected and the assumptions used in the estimation models because of lack of information on real needs and commercial response data, great efforts have been made to secure a solid and scientific methodology.

As with other forecasting models, once the baseline has been established reliability and validity can be improved upon in future developments. Similar to most quantitative approaches also this one suffers from simplification of real life. Accordingly, a next step in our research is to do case studies of specific disasters for the purpose of (1) Testing the model in terms of how it predicts needs and response for specific types of disasters in specific regions and by this be able to develop models for trends/seasonality indexes and also taking forecasting errors into account based on different types of uncertainties (Makridakis et al. 2009, p.811); (2) Developing data registration procedures on needs and response so that they can easily be submitted for population in the model; and (3) Understanding more details with regards to the dynamics of supply and demand and the relationship between design and operation of disaster relief supply chains in terms of mapping supply chains and understanding how actors cooperate. The model will in the immediate future also be tested with practitioners for its applicability to support their contingency planning for the coming ‘high’ season of disasters in the fall.

4. CONCLUSIONS, IMPLICATIONS AND FURTHER RESEARCH

The main purpose of this paper was to challenge and investigate the claim that unpredictable demand is one of the important characteristic of humanitarian logistics which differentiates it from its commercial counterpart. In order to do this, previous literature was analysed to identify mainstream trends. This was held up against the model developed by demonstrating its assumptions and the type of information provided through the analysis of the data collected. It seems that the prevailing argument regarding lack of knowledge of demand, rests on the missing systematic use of knowledge and experience.

Contribute - the research project within which this tool was developed - is rooted in the belief that the humanitarian sector needs research that can be taken into use to solve real problems: *'why make up problems when the world around us is full of fascinating and crucially important problems that beg for some elementary insight'* (van Wassenhove in Schmenner et al., 2009, p.342). We hope that we have demonstrated the importance of real data applied to real problems. Due to lack of, or inaccurate needs assessments in the immediate phase of a response, supply chains are generally set up based on guesstimates by logisticians who use their previous experiences from other disasters regarding what people would normally need. The effectiveness and efficiency of this supply chain then depends almost solely on the competencies and experience of the individual logistician in charge and will vary from one response to the other and between organisations. So far, this has led to lack of systematic use of historical data and accumulated previous experiences and little success in efforts made to coordinate the response avoiding overlaps and covering gaps. Hence, in terms of implications for practice, the research provides the basis for decision support tools that can be used by major stakeholders in disaster preparedness and response including:

- Longer-term planning in terms of prepositioning of regional stocks (e.g. how much is needed per item to secure supply in response to annual needs for specific regions)
- Longer-term planning in terms of framework agreements with suppliers
- Longer-term planning in terms of capacity needed: goods, services, funding
- Planning for training and recruitment
- Short-term planning in terms of deployment of supply chains once a disaster occurs – organisations should be able search the data and extract information on average needs given a specific type of disaster in a specific region.

With the use of the tool, it is possible to deploy appropriate quantity and type of prepositioned goods to meet the immediate needs in the aftermath of a disaster, while also allowing time for needs assessment to be carried out and a local plan of action to be prepared. This is a significant improvement over the current ad hoc method of assessing needs immediately post –disaster, which results in slow initial deliver. Through their participation in *Contribute* IFRC Global Logistics Service has used the tool in their LOG2015 - the IFRC's strategic logistics plan - to adjust and finalize the size and location of pre-positioned relief items, assets and expertise. They will also use it as a forecasting model for individual disaster responses.

When it comes to theoretical contributions, this paper, supported by substantial empirical evidence, possibly represents the very first endeavour that challenges the prevailing view in literature that unpredictability in demand is an inevitable reality that one has to deal with while managing disaster relief supply chains. And it does so by adopting a methodology which captures and institutionalizes disaster relief logistics experience and knowledge in a creative manner. The study takes information as provided in Majewski et al. (2010) and translates it into numbers on logistics demand and supply. It has a similar approach to that reported by de Leeuw et al. (2010), but provides a much more comprehensive and systematic approach on global annual needs for a large number of basic relief items with according logistics activities. The information can be used to design and plan all three types of supply chains as conceptualised by Jahre and Heigh (2008). It provides means to avoid 'ad hoc' nature of response by making it possible to use well-known tools and techniques from commercial logistics (Tatham and Pettit, 2010).

The needs estimation part of the methodology is based on assumptions about the number of people requiring assistance relative to people affected and how needs vary by time period and with type of disaster and location. We see this as a first attempt of developing a theory of needs in disaster relief[12]. Refinement of this theory, i.e. the model's concepts, key variables and relationships between them, will be undertaken, for example by testing how well the model projects the needs through collecting and analysing data on specific disasters and then comparing with the projections. Furthermore, already developed sophisticated forecasting models in need of data (e.g. Sheu, 2010) could make use of the work reported on here. Hence, the annual index provides a baseline on which further model development can be undertaken for the purpose of refining and building variations of the forecasting model including trends and seasonal-indexes. The response data collected constitutes a representative sample of disasters making it possible to draw general conclusions. While every effort was made to obtain good data, variable reliability must be taken into account warranting improvements in reporting, the approach and testing of the data collected. Further research will test the results for diversions from the 'averages' as estimated and calculated with use of the tool. There is also need for collecting more real data from primary sources, i.e. the actors themselves, to check against the secondary data available. Hence, improvements in the data collection process which will be undertaken in the years to come, will strengthen data validity and reliability. The vision is to have organisations and other actors involved voluntarily submitting their data once a disaster occurs because they see the value of the tool.

In conclusion, we suggest a move away from the present order/pull-based to a forecast/push-based approach for the immediate response to improve efficiency and effectiveness. To avoid large buffer inventories - a common solution in push-based systems – this must be combined with the use of information to replace excessive costs of stocks (e.g. Christopher, 2010). As pointed out in section 3.1 this is in line with theory developed for commercial sector. More research into this move from a system of pull to push/pull combinations and possible differentiation between the approaches depending on the context, would be interesting. Finally, this paper has focused on one 'myth' which has developed and is being repeatedly claimed without much empirical evidence. Further research can address other claims put forward on characteristics of disaster relief supply chains as identified in section 2 to see if they can be substantiated or should be similarly challenged.

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[12]See Daft, 1985 for discussion of theory as explanation of meaning of variables and their relationships.

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REFERENCES

Altay, N. and Green III, W.G. (2006) “OR/MS research in disaster operations management”, *European Journal of Operational Research*, Vol. 175, pp.475-493.

Balcik, B., Beamon, B.M., Krejci, C., Muramatsu, K.M. and Ramirez, M. (2010) “Coordination in humanitarian relief chains: Practices, challenges and opportunities”, *International Journal of Production Economics,* Vol. 126, pp.22-34.

Banomyong, R. and Sopadang, A. (2010) “Using Monte Carlo simulation to refine emergency logistics response models: a case study”, *International Journal of Physical Distribution and Logistics Management,* Vol. 40, No. 8/9, pp. 709-721.

Barbarosoğlu, G. and Arda, Y. (2004) “A two-stage stochastic programming framework for transportation planning in disaster response”, *Journal of the Operational Research Society*, Vol. 55 No. 1, pp. 43-53

Beamon, B.M. and Kotleba, S.A. (2006) “Inventory modelling for complex emergencies in humanitarian relief operations, *International Journal of Logistics: Research and Applications*, Vol.9, No.1, pp.1-18

Bryman, A. and Bell, E. (2007) *Business research methods*, Oxford University Press

Chopra, S. and Meindl, P. (2010) Supply Chain Management – Strategy, planning and operation, Pearson, US

Christopher, M. (2010) Logistics and Supply Chain Management, Financial Times/Prentice Hall, 4th edition, UK.

CRED 2010; www.emdat.be EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium)

Daft, R.L. (1985) Why I recommended that your manuscript be rejected and what you can do about it. In L.L. Cummings and P.J. Frost, eds., *Publishing in the Organizational Sciences*.

Day, J.M., Junglas, I. and Silva, L. (2009) “Information Flow Impediments in Disaster Relief Supply Chains”, *Journal of the Association for Information Systems*, Vol.10, No. 8, pp.637-660

De Leeuw, S. Kopzack, L.R. and Blansjaar, M. (2010) “What really matters in Locating Shared Humanitarian Stockpiles: Evidence from the WASH Cluster”, in L.M. Camarinha-Matos et al. (Eds.) PRO-VE 2010, IFIP AICT 336, pp.166-172.

De Ville de Goyet (2006) “Evaluation of adequacy, appropriateness and effectiveness of needs assessments in the international decision making process to assist people affected by the tsunami”, Tsunami Evaluation Coalition (TEC).

Everywhere, BI and WW (2011) Contribute Baseline developed by Everywhere Humanitarian Response and Logistics Services with Daniel Dieckhaus, Ian Heigh and Natalia Gomez-Tagle Leonard; BI Norwegian Business School with Marianne Jahre, Jannicke Jensen, Kaustubh Anil Navangul and Amund Leinaas Olafsen; and Wilh.Wilhelmsen ASA and Wallenius Wilhelmsen with Pål Berg Lande and Bjørn Rud, Contribute Report (1) 2011. Unpublished Report 15th April, BI Norwegian Business School.

Gatignon, A., van Wassenhove, L.N. and Charles, A. (2010) “The Yogyakarta earthquake: Humanitarian relief through IFRC’s decentralized supply chain”, *International Journal of Production Economics*, Vol.126, pp.102-110.

Heigh, I. and Jahre, M. (2010) “Humanitarian Supply Chains”, editorial, *Supply Chain Forum: An International Journal*, Vol.11, No.3, pp.2-3

Heigh, I. and Leonard, N. T-G. (2009) “Federation Logistics of the Future”. Geneva: IFRC. Unpublished report.

http://procurement.ifrc.org/catalogue/ Emergency Item Catalogue

http://www.emdat.be EM-DAT: The OFDA/CRED International Disaster Database, Université Catholique de Louvain, Brussels (Belgium)

http://www.random.org/ Random.Org-True Random Number Service

http://www.sphereproject.org/ Sphere, Humanitarian Charter and Minimum Standards in Disaster Response.

http://wwwdev.ifrc.org/what/disasters/responding/elements/logistics/software.asp International Federation of Red Cross and Red Crescent Societies(IFRC)- Disasters-Prepa

https://www-secure.ifrc.org/DMISII/Pages/00_Home/login.aspx, Disaster Management Information System

IFRC (2009); http://www.ifrc.org

Jahre, M. and Heigh, I. (2008) “Does the Current Constraints in Funding Promote Failure In Humanitarian Supply Chains?”, *Supply Chain Forum: An International Journal*. Vol. 9, No. 2, 44-54.

Jahre, M. and Jensen, L-M. (2010) "Coordination In Humanitarian Logistics Through Clusters", *International Journal of Physical Distribution and Logistics Management,* Vol. 40, No. 8/9, pp. 657-674.

Jahre, M., Jensen, L-M. and Listou, T. (2009) "Theory development in Humanitarian Logistics - A Framework and Three Cases", *Management Research News*, Vol.32, No. 11, pp. 1008-1023.

Jahre, M., Dumoulin, L., Greenhalgh, L.B., Hudspeth, C., Limlim, P. and Spindler, A. (2010) "Improving Health Systems in Developing Countries by Reducing the Complexity of Drug Supply Chains", Proceedings, RIRL, Bordeaux 2010

Kovács, G. and Spens, K. M. (2007) "Humanitarian Logistics in Disaster Relief Operations". *International Journal of Physical Distribution and Logistics Management*, Vol. 37, pp. 99-114.

Kovács, G. and Spens, K. M. (2010) "Knowledge sharing in relief supply chains". *International J. Networking and Virtual Organisations,* Vol.7, Nos. 2/3, pp. 222-239

Kovács, G. and Spens, K. M. (2011) "Trends and developments in humanitarian logistics – a gap analysis", *International Journal of Physical Distribution and Logistics Management*, Vol. 41, No.1, pp. 32-45.

Kovács, G. and Tatham, P. (2009) "Responding to disruptions in the supply network – from dormant to action". *Journal of Business Logistics*, Vol. 30, No.2, pp. 215-29.

Lodree Jr., E.J and Taskin, S. (2008) "An insurance risk management framework for disaster relief and supply chain disruption inventory planning", *Journal of Operational Research Society*, Vol.59, pp.674-684.

Long, D.C. and Wood, D.F. (1995) "The logistics in famine relief", *Journal of Business Logistics*, Vol.16, No.1, pp.213-229.

Majewski, B., Navangul, K.A. and Heigh, I. (2010) "A Peek into the Future of Humanitarian Logistics: Forewarned is Forearmed", *Supply Chain Forum: An International Journal*, Vol. 11, No.3, pp. 4-20.

Makridakis, S., Hogerth, R.M. and Gaba, A. (2009) Forecasting and uncertainty in the economic and business world, *International Journal of Forecasting*, Vol.25, pp. 794-812.

Natarajarathinam, M., Capar, I. and Narayanan, A. (2009) "Managing supply chains in time of crisis: a review of literature and insights", *International Journal of Physical Distribution and Logistics Management*, Vol. 39, No.7, pp. 535-573.

Oloruntoba, R. (2010) "The analysis of Cyclone Larry emergency relief chain: Some key success factors", *International Journal of Production Economics*, 126, pp. 85-101.

Oloruntoba, R. and Gray, R. (2006) "Humanitarian aid: an agile supply chain?", *Supply Chain Management: An International Journal*, Vol. 11, No.2, pp.115-20.

Pettit, S. and Beresford, A. (2005) "Emergency relief logistics: an evaluation of military, non-military and composite response models", *International Journal of Logistics: Research and Applications*, Vol. 8, No.4, pp. 313-331.

Rawls, C.G. and Turnquist, M.A. (2010) "Pre-positioning of emergency supplies for disaster response", *Transportation Research Part B*, Vol.44, pp.521-534.

Richey Jr., R. G. (2009) "The supply chain crisis and disaster pyramid: A theoretical framework for understanding preparedness and recovery", *International Journal of Physical Distribution & Logistics Management*, Vol. 39, No.7, pp. 619-628.

Salmerón, J. and Apte, A. (2010) "Stochastic Optimization for Natural Disaster Asset Prepositioning", *Production and Operations Management*, Vol.19, No.5, pp.561-574

Schmenner, R.W, van Wassenhove, L., Ketokivi, M., Heyl, J. and Lusch, R.F. (2009) "Too much theory, not enough understanding", *Journal of Operations Management*, Vol. 27, pp. 339–343

Stapleton, O., van Wassenhove, L.N. and Tomasini, R.M., (2010) "The challenges of Matching Private Sector Donations to Humanitarian Needs and the Role of Brokers", *Supply Chain Forum: An International Journal*, Vol. 11, No.3, pp. 42-54.

Tatham, P. and Pettit, S. J. (2010) "Transforming humanitarian logistics: the journey to supply network management", *International Journal of Physical Distribution and Logistics Management,* Vol. 40 Issue 8/9, pp. 609-622.

Thomas, A. and Kopczak, L. (2005) "From logistics to supply chain management. The path forward in the humanitarian sector", http://www.fritzinstitute.org, accessed Jan 11, 2007.

Tomasini, R.M. and van Wassenhove, L.N. (2009) "From preparedness to partnerships: case study research on humanitarian logistics", *International Transactions in Operational Research*, Vol.16, pp.549-559.

Van Wassenhove, L.N. (2006) "Humanitarian aid logistics: supply chain management in high gear", *The Journal of Operations Research Society*, Vol. 57, No.7, pp.475-89.

Von Schreeb, J. (2007) "Needs assessment for international humanitarian health assistance in disasters", Thesis for doctoral degree (PhD.) Karolinska Institutet, Department of Public Health Sciences, Stockholm; p.33.