

Big Data and Humanitarian Supply Networks

Can Big Data give Voice to the Voiceless?

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Abstract— Billions of US dollars are spent each year in emergency aid to save lives and alleviate the suffering of those affected by disaster. This aid flows through a humanitarian system that consists of governments, different United Nations agencies, the Red Cross movement and myriad non-governmental organizations (NGOs). As scarcer resources, financial crisis and economic inter-dependencies continue to constrain humanitarian relief there is an increasing focus from donors and governments to assess the impact of humanitarian supply networks. Using commercial ('for-profit') supply networks as a benchmark; this paper exposes the counter-intuitive competition dynamic of humanitarian supply networks, which results in an open-loop system unable to calibrate supply with actual need and impact. In that light, the phenomenon of Big Data in the humanitarian field is discussed and an agenda for the 'datafication' of the supply network set out as a means of closing the loop between supply, need and impact.

Keywords—*humanitarian supply networks, supply chain; humanitarian logistics; needs assessment; outcomes; impact; big data; datification*

1 INTRODUCTION

The humanitarian system consists of governments, a number of United Nations agencies, the Red Cross movement and many thousands of non-governmental organizations (NGOs) of varying size from large multi-nationals to the miniscule. It is estimated that over 25 billion US dollars is injected into the humanitarian system each year to answer the urgent needs of the victims of disaster.

Analogous to commercial supply chains, which balance the flow of supply to demand in 'for-profit' sectors, humanitarian supply networks lie at the core of the humanitarian system and attempt to balance the flow of critical goods and services with the desperate needs of the affected. The nature of humanitarian supply networks, however, is such that neither the real needs of the victims nor the actual impact of providing humanitarian aid is truly captured or assessed [43]. Assessment of the needs of the victims is very rarely shaped by input from the victims. The raising of funds and the supply of aid is typically based on estimates, constraints and variety of agendas. The assessment of impact is also extremely rare, not least because impact requires an all-encompassing view of cause and effect and extends beyond the duration of the humanitarian effort.

It is argued here that developments in the phenomenon of Big Data offer considerable opportunities for research to find correlations and patterns that can yield valuable insights into the real needs of disaster victims and the actual impact of relief efforts. This paper provides a brief overview of the humanitarian

system, outlining the definition and types of disasters, and explaining the distinction between humanitarian aid and development aid. It goes on to describe the unique competition dynamic in humanitarian supply networks that distinguishes them from their commercial counterparts. Issues surrounding the victims' needs assessments that form the basis for raising funds are discussed together with the challenges of assessing the impact of delivering aid.

The paper goes on to describe current views of what constitutes Big Data and closes by discussing the research opportunities that exists in the application of Big Data technologies and techniques to assess the needs of humanitarian aid efforts and the impact of delivering humanitarian relief.

2 THE HUMANITARIAN SYSTEM

In considering humanitarian systems in general and humanitarian supply networks in particular, we first consider the definition, occurrence and consequences of disasters and what is meant by humanitarian aid.

2.1 Disasters

The World Health Organisation's Centre for Research on the Epidemiology of Disasters (CRED) maintains a record of all disasters that have occurred since 1900 on its Emergency Events Database (EM-DAT) [12, 18]. To be entered into this database a disaster must meet at least one of the following criteria [15]:

- Ten (10) or more people reported killed.
- Hundred (100) or more people reported affected.
- Declaration of a state of emergency.
- Call for international assistance.

Disasters are also categorised on cause, natural, man-made or hybrid, and speed of onset, slow or rapid [29].

EM-DAT records show that over 18,000 disasters have taken place world-wide since the start of the twentieth century[18]. Predictions are that the scale, frequency and impact of disasters will increase over the coming years, with climate related disasters alone affecting around 375 million people per year by 2015 [26].

In 2011 the EM-DAT statistical review showed that there were 332 natural disasters, more than 30,000 deaths and over 244 million victims during the course of the year, while the economic impact was the highest recorded at over \$366 billion [24]. During the same year Lord Paddy Ashdown chaired a Humanitarian Emergency Response Review on behalf of the United Kingdom government The subsequent report predicted that by 2030, 61% of the world's population, over 5 billion people, will live in urban areas, making it more likely that future disasters will hit urban centres resulting in a significant increase in economic consequence and that stress on the humanitarian system will continue to grow [26].

2.2 Humanitarian Aid in Context

Humanitarian aid is focussed on providing a rapid and effective response to an emergency: It sits at the other end of the spectrum to development aid, which is focussed on nurturing and enabling long-term change that should ultimately be driven and cultivated from within a targeted group of beneficiaries.

In response to most major disasters the international humanitarian system moves into action with: (a) Search and rescue initiatives; and (b) emergency relief to address the urgent need for medical care, food, water, sanitation and shelter. As a situation stabilises relief activities move into a transition phase, then

eventually into recovery and last, if appropriate, development, which has the generic aim to “build back better” [51].

Emergency aid programs must deploy rapidly. They are often heavily supported by private donor funding and, from the point of view of these donors, are expected to end when the emergency ends. In contrast, development programs, which are predominantly funded by government and international agencies, take time to plan and implement as their focus is to improve the lives of beneficiaries and their future generations. However, the distinction between humanitarian relief efforts and development aid is not always clear. Debate ensues as some agencies extend the boundaries of their efforts post emergency from relief into recovery and through to development, confusing the assessment of emergency needs and the cost of responding to a disaster [10, 43].

2.3 Humanitarian Funds, Donations and Resources

For large-scale sudden onset disasters the size and complexity of the humanitarian system mobilised to provide aid is immense. As an example, more than 400 international non-governmental organizations (NGOs), as well as numerous smaller initiatives that bypassed the UN registration process, were operating in Indonesia immediately after the 2004 south Asian tsunami [60].

The International Committee of the Red Cross estimate that major disasters can now attract an average of 1000 different organisations. This situation is not surprising considering the United Nations Development Programme gauges the total number of international NGOs to be greater than 37,000 [41]. In addition, the monies and human resources involved are significant. It is estimated that over 210,800 people work within the humanitarian system and that it is funded to the tune of anything from 15 to 25 billion US dollars per year [23, 26, 53]. The huge range in funding estimates indicates the extent to which exact information is not available.

2.4 Humanitarian Supply Networks

At the heart of the international response to a disaster is the humanitarian supply network providing an urgent flow of resources and supplies to meet the (desperate) needs of the survivors. Some researchers posit humanitarian supply networks represent up to eighty percent, over 20 billion US dollars, of the annual cost of humanitarian aid. [59]. It can also be argued the entirety of the response to a disaster is a de facto humanitarian supply network as the system as a whole is focussed on funding, sourcing and delivering relief goods and services [52].

At this juncture it should be noted that supply networks in the humanitarian sector are more commonly referred to as ‘logistics’ by NGOs and humanitarian aid agencies, whereas ‘supply chain’ is a term that is more prevalent in the commercial sector. However, some commentators contend the complexity of the aid response to a humanitarian emergency is not adequately portrayed by the use of ‘supply chain’ or ‘logistics’, and is better described as a ‘supply network’ [52]. That said, even the use of the word ‘network’ gives a semblance of order that often belies reality. Illustrative of the complexity and co-ordination challenges that underpin humanitarian supply networks is the international response to the South Asian tsunami of 2004. The final death toll from this disaster is estimated to be 230,000, with more than 160,000 Indonesians killed within one hour of the initial earthquake, and over one million people displaced [4]. In the aftermath of the disaster the overwhelming presence of large numbers of aid agencies and international armed forces created a co-ordination nightmare and the ensuing flow of aid caused agencies to struggle to sort, store and distribute supplies and dispose of inappropriate items [56].

3 DOES THE NETWORK DO WHAT IT SHOULD DO?

The difficulty experienced by the humanitarian system in responding to the south Asian tsunami, has fuelled the development of thought, theory and practice in humanitarian supply networks in an effort to improve the ability of the humanitarian system to save lives and ease the suffering of the survivors [19]. Some researchers argue that there may be opportunities for the 'not-for-profit' sector to benefit from the experience and practices of the 'for-profit' sector as humanitarian supply networks are believed to be lagging behind their commercial counterparts by about 15 years [37, 53, 57, 59].

While there are undoubtedly opportunities for humanitarian supply networks to benefit from some of the experience, technologies and techniques that have developed over the years in the management of commercial supply chains, it is important to take cognizance of the significant differences between the models however.

In humanitarian supply networks speed and cost are key drivers, not profitability and market share [45]. Humanitarian supply networks do not compete for consumer demand (i.e. the urgent needs of the affected victims) as demand outstrips supply and those affected are not in a position to 'shop around' for alternatives [8]. For humanitarian supply, however, heated competition exists upstream where agencies and NGOs vie for funding [31, 43, 50]. Additionally, the multitude of actors and lack of cohesion within the humanitarian system makes driving efficiency, agility and transparency difficult objectives to attain [40, 60]. Finally, and most importantly, for humanitarian supply networks actual demand (i.e. the needs of the affected), the effective satisfaction of that demand and the subsequent impact of the relief intervention cannot be accurately and definitively measured or assessed [43, 50, 52].

The ultimate success of commercial supply chains can be assessed by their impact on the bottom line. Therefore, performance targets can be financial and operational rather than impact related. Commercial supply chains can therefore be considered closed loop, in that there is a clear and unequivocal connection between expected demand and actual demand (Fig 1). If the quantity, type and quality of goods and services planned and delivered do not meet the needs or wants of the intended recipients, then revenue, and ultimately the bottom line, suffers. As such, reality is able to calibrate planning and execution.

The ultimate success of humanitarian supply networks can only truly be assessed by the accuracy of the needs assessment and the impact of the relief effort. Unfortunately, data that would enable this is typically subjective, biased, flawed, never captured or difficult to obtain [33, 43, 52]. Needs assessment for humanitarian relief are 'guesstimates' that are:

- Based on the perceptions and experience of field workers who are plagued with difficulties of access and coverage, rather than the input of those directly affected [14, 43, 52];
- Potentially inflated due to varying boundaries between relief and development needs and to counteract the limitations caused by donations that are tied by the donor to specific supply sources [10, 61];
- Prone to distortion because agencies ask for what can be funded rather than what needs to be funded [49];
- Liable to fall short because of insufficient allowances for 'leakage' (e.g., loss of goods in transit) [43].

Similarly, assessing the performance of humanitarian supply networks is fraught with challenges. Aid agencies often assess their performance based on what they can measure (e.g. financials, execution and outputs) rather than outcome and impact, data for which is difficult to obtain [1, 8, 11, 16, 27, 42, 46]. In this context outcome is the benefit derived from the relief effort [52]. Impact extends this further and is defined by the Development Assistance Committee, Organization for Economic Co-operation and Development (DAC/OECD) as:

“Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended” [2].

This definition of impact, marginally modified to include short-term effects can equally be applied to humanitarian relief as follows:

*Positive and negative, primary and secondary, **short-term** and long-term effects produced by a **humanitarian** intervention, directly or indirectly, intended or unintended*

Impact is difficult to assess, however, not least because of the lack of formally collected data and the sparsity of input from the affected, but also because of the transitory existence of humanitarian relief efforts. Humanitarian supply networks deploy rapidly in varying formations and are designed to exist for the duration of the emergency as defined by each aid organization [8, 43]. Therefore impact can emerge over time after the lifespan of the relief effort and is often influenced by other factors such as development programs and political machinations. Additionally, what may intuitively seem an appropriate response to a crisis can actually have no obvious, or unforeseen, impact? For example it would be reasonable to assume that sending food to victims of famine would save lives, but according to de Waal it could not be confirmed that the three million sacks of grain delivered as food aid in Darfur saved any lives because most of the deaths were from health crisis and not starvation [17].

Humanitarian supply networks are more akin to open loop systems in that there is no real-world tightly-coupled feedback between impact and need that will influence the planning and flow of goods and services (Fig 2). Reality is not definitively known (or defined perhaps), therefore cannot calibrate planning and execution. This means that humanitarian supply networks can supply unwanted or useless goods to their beneficiaries without direct impact on the cash coming into the system as the intended recipients have no recourse or readily available mechanism to confirm their needs are being met [39, 43, 52].

At the other end of the network donors are increasingly expecting both performance and impact as differentiators and are not tolerant of duplication of effort and wasted resources [31, 43, 56]. As a result there is now an even greater drive for accountability and transparency to ensure traceability of donor funds and organisations such as the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP) have been established in an attempt to facilitate this [6]. However, Linda Polman, a highly vocal critic of the current humanitarian aid system, believes that NGOs create illusions of transparency through increased paperwork and by making demands of their partners in crisis-ridden countries in order to ensure continued support from donors [40].



Fig. 1. Commercial Supply Chains – created from the Supply Chain Council’s Supply Chain Operations Reference Model [44, 47]



Fig. 2. Humanitarian Supply Networks – created from the Fritz Institute’s Relief Supply Chain Model [20, 54]

It is therefore crucial that the humanitarian system find innovative solutions to give good account for the donations and billions of dollars of funds received from public coffers and through the generosity of private donors. As things stand, without diverting significant resource from the relief effort, it is nigh impossible to obtain credible answers to key questions such as:

- Did the money and effort do what it was intended to do?
- Are there unforeseen or unintended, direct or indirect consequences to the relief intervention?
- Did it make the difference the donors expected it to make?
- Did it make the difference the aid agencies and NGOs intended it to make?
- Most importantly, did it make the difference the beneficiaries needed it to make?

To answer any of these questions would require the ability to more effectively assess what was needed by disaster victims, what was delivered to them and, most importantly a ‘big picture’ view of the impact achieved. This in turn would need input from those that survive both the disaster and the relief effort that followed, namely the victims, who are effectively **voiceless** in the efforts to save them [5, 43, 52, 55].

4 CAN BIG DATA GIVE VOICE TO THE VOICELESS?

Internet and mobile technologies are rapidly moving towards global coverage and giving rise to previously inconceivable voice and data connectivity across developed and developing nations, which in turn is helping to fuel the phenomenon known as Big Data [3, 34, 36].

It is difficult to obtain a standard definition of Big Data, so much so that even a group of 150 delegates at the 2013 meeting of the Organization for Economic Co-operation struggled to define it [13]. That said, industry commentators increasingly see big data in terms of the following ‘Vs’.

- **Volume** – the sheer volume of data crossing the internet each second exceeds that of the entire internet two decades ago, In 2012 an estimated 2.5 exabytes (one billion gigabytes) of data was created per day and this volume is expected to increase exponentially at a rate of hundred percent every 40 months [35, 58].
- **Velocity** – the creation of real-time data, the use of real-time analytics and managing the temporal relationships between data created and updated at different speeds [35, 48, 58].
- **Variety** – data now extends beyond the ordered and structured confines of conventional databases. Big Data can include posts to social networks, GPS signals, messages, images, audios,

videos and even data collected from objects, such as sensors, meters, early warning systems, navigators and satellites as well as machine logs [22, 35, 48, 58].

- Veracity – while Big Data accommodates messy unstructured data, decisions made and actions taken are dependent on the credibility and trustworthiness of the data on which they are based [28].
- Value – can be created through increased transparency, new insights, elicited discovery, exposed variability, segmentation, improved performance, innovation and improved or reduced human decision-making [34]. Extracting this value is enabled by new and rapidly evolving technologies and techniques designed to exploit the promise offered by Big Data [21, 30, 34]. In the context of humanitarian supply networks, the value of Big Data is its potential to yield answers to the previously unanswerable questions of assessing the need for and impact of humanitarian aid and giving voice to the voiceless beneficiaries of this aid.

Data that was in the past proprietarily held behind the secure walls of government departments, international agencies and NGOs is being prised open and a multitude of datasets are being made accessible for analysis and scrutiny [25, 38]. Additionally, the growth of connectivity and the increased priority and importance placed on maintaining that connectivity in the aftermath of disasters is generating real-time pulsing streams of data across humanitarian supply networks [36]. Open access to hitherto unavailable proprietary data can be combined with other data types that are generated as a result of the increasing growth and density of digital connectivity. These data types include:

- ‘Exhaust’ data created as a by-product of digital services;
- On-line data, e.g. social media, internet activity, web content, news feeds;
- Data from objects, e.g. satellites, machine logs, sensors;
- Actively supplied data, e.g. citizen reporting and crowdsourcing;

This combination can drive the ‘datafication’ of humanitarian supply networks and help close the loop between real need and actual impact. Datafication being an information technology driven sense-making process that distills actionable knowledge from an ocean of data [32]. However, datafication of humanitarian supply networks is not without significant issues and challenges, for example:

- Volume – data that could hold relevance to the needs from and the impact of humanitarian supply networks is truly vast and could include anything from any number of sources. For example, satellite data, geographic data, crime and conflict data, municipality data, economic data, health and mortality data, social network data, citizen reporting data, weather data, sensor data, global position data, shipping and transportation data, warehouse data, missing person data, mortality data, health and disease data, medical equipment and supplies data, and radio-frequency identification data. This list is by no means exhaustive yet even with this morass of data, issues of opaqueness across flows in the supply network may arise from the lack of access to crucial data from aid agencies reluctant to share with ‘competitors’.
- Velocity – for humanitarian supply networks current and predictive patterns and correlations from real-time data, and the associated corrective and pre-emptive action, quite literally holds the possibility of saving more lives and alleviating more suffering. Considering the scale, complexity and formation of each rapidly established and transitory humanitarian supply network can be unique however; so, the approach to finding corollary and patterns in the ensuing data sets must be tailored accordingly and deployed equally as rapidly.
- Variety – in the context of humanitarian supply networks, variety is not just about the plethora of data types that may be available for analysis. Data sources, participants, durations, temporal-relationships between data sets will also vary for each disaster based on numerous possible

factors such as disaster type, scale of impact, geographic location, developed or developing country, weather conditions, economic conditions, time of year, local and international politics, and the level of internal or international conflict.

- Veracity – the speed at which humanitarian supply networks must be deployed and the varying scale, complexity and formation of each network, requires considerable diligence in establishing and ensuring the veracity of data sets. In listening to the voice of the affected, there exists the risk of also listening to the voice of those hoping to exploit and mislead.
- Value –. datifying humanitarian supply networks can make transparent what was previously opaque, providing actionable knowledge of need (demand) and impact. It can help close the open loop such that supply can be calibrated to satisfy real need and deliver the desired impact. However, the value of actionable knowledge is only truly realized if the action is taken. For humanitarian supply networks the multitude of participants and their interplay carries with it the risk that those empowered to take action either do not engage in a dialogue with the Big Data patterns that manifest or do not harvest the value the correlations promise to yield.

Additionally, the complexity and scale of the inter-relationships between the myriad humanitarian actors provides considerable challenges to accrediting impact to a specific group or actor [43].

Nevertheless, whilst acknowledging these issues and challenges, compelling opportunities for research exist in finding correlations and patterns that are untethered by preconceived notions or theories [7, 9] . Research questions abound exploiting Big Data analytics to develop insights into the impact of the combined humanitarian response to a disaster and give voice to the voiceless victims. For example, the possibility of finding patterns and correlations across:

- Relief funds, violence, disease, mortality - real-time and/or trends across dimensions such as time, scale, disaster type OR
- Food aid, refugee movements, cross-border conflict and human trafficking - real-time and/or trends across dimensions such as time, scale, agency participation, continent, region OR
- Cash aid, internal conflict and economic recovery - real-time and/or trends across dimensions such as time, scale, disaster type, agency participation, continent, region OR
- Relief funds, cash aid, goods wasted or surplus, mortality and health recovery - real-time and/or variations across dimensions such as time, scale, disaster type, agency participation, continent, region

5 CONCLUSION

Billions of dollars are spent each year in humanitarian aid, which is delivered to the victims of disaster through the supply networks of myriad humanitarian agencies and organisations. Unlike their commercial counterparts humanitarian supply networks are rapidly established and temporary, lasting only the lifespan of the relief effort. Additionally, actors in humanitarian supply networks compete for funding and not for market demand, as the flow of money is de-coupled from the flow of goods and services. In other words, those that provide the money do not receive the goods or services it pays for and do not necessarily know how, or how effectively, it is spent. This is problematic as there is no systemic feedback loop that ensures the planning and execution of supply is calibrated to the actual needs of the victims. A situation further exacerbated by the inability to ascertain the accuracy of needs assessment that formed the basis of the aid delivered or the impact of the humanitarian response.

With predictions of increasing scale, frequency and severity of disasters in coming years, stress on the humanitarian system will only grow [26]. While growing pressure from donors demanding increased

transparency and good account of the funds donated, will require the humanitarian system to implement innovative solutions to assess the accuracy and impact of their relief efforts [27].

This paper argues the growth of the Big Data phenomenon with its characteristics of volume, velocity, variety, veracity, while not without challenge, offers considerable opportunities to extract great value in the assessment of humanitarian supply networks. As such, compelling opportunities for research exist in finding correlations and patterns in the swelling ocean of data generated through ever-increasing digital connectivity and thereby give voice to the voiceless victims of disaster

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