BRINGING ORDER OUT OF DISORDER: EXPLORING COMPLEXITY IN RELIEF SUPPLY CHAINS

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ABSTRACT
In today’s world, complexity and uncertainty are the only given factors in the management of global supply chains. International relief chains are influenced by complexity arising from fluctuating demand information and flows, donor funding processes, as well as the challenges of mobilising logistics assets on a global scale and the geographical terrain of the humanitarian theatre. Environmental and supply complexity and uncertainty can have a significant operational and financial impact on both business firms and international relief chains. Therefore, an understanding of the nature and causes of complexity in supply and relief chains is critical to effective supply chain management. This exploratory paper highlights the characteristics of the relief chain, discusses the nature and causes of complexity in both commercial and relief chains, and suggests ways to managing complexity, specifically in relief chains. Attempting to manage complexity in humanitarian supply chains in an unsystematic, piecemeal, and non-strategic manner can result in sub-optimal outcomes, waste of resources, and loss of lives. The proposed strategies can help logistics and supply managers in humanitarian organisations to balance logistics/operational effectiveness and cost-efficiency, as well as provide the optimal level of ‘service’ to all the supply chain members through the identification of strategies for understanding and simplifying supply chain complexity. The contribution of the paper is an inter-disciplinary solution to an important supply chain issue through the incorporation of recommendations from research in various disciplines. The proposed strategies contribute to the relief chains’ ability to promptly deliver relief to disaster sites and the saving of lives.

INTRODUCTION
A large international relief community has developed since the Second World War [1]. It includes multilateral agencies such as the world Food Programme (WFP), and the United Nations High Commission for Refugees (UNHCR) which is supported entirely by private, voluntary contributions, mainly by the wealthier donor governments both in cash and in kind, as well as a wide range of non-governmental organisations (NGOs) both national and international [2]. The delivery of relief aid is influenced by political and military convenience of both donor and recipient countries, media appeal of the disaster, and to the exigencies of the ‘donor industry’. Relief aid delivery often lacks a coordinated plan. NGOs often compete with each other for donations, with donors generally more sympathetic to short-term emergencies than longer-term developmental aid leading to wide divergence in levels of funding [3,4]. However, coordinated supply chains are well-established in the commercial sector, and this paper seeks to highlight the key characteristics of the relief supply chain, the nature and causes of complexity in commercial and relief supply chains, and suggests strategies for managing complexity in supply chains from the relief perspective. The paper applies key assumptions of complexity in commercial supply chain management to determine their suitability for the analysis of complexity in relief supply chains.

The relief chain

The supply chain in Figure 1 describes a multilateral approach through international agencies such as the World Food Programme (WFP), and international non-governmental organisations (NGOs) such as Care International and World Vision. Relief is often given on a bilateral country-to-country basis, and delivered in a number of ways. Unlike most commercial supply chains, the relief supply chain is often unstable. Sometimes, the
supply chain breaks down at the receiving end [3,5,6], but it may also be unstable at its origin because of politicised donations by governments and the competitive nature of fund-raising from private donors, as well as the level of media appeal [7,8,9]. Good practice in commercial supply chain management literature includes some basic assumptions such as: there should be a planned approach, that a longer-term, strategic perspective is adopted, and that it is important to coordinate functions [10, 11,12]. If we attempt to apply such concepts from the ‘commercial model’ to the relief chain, we find many parallels but also important differences. There is evidence of a frequent lack of planning in relief supply chains, resulting in inefficiencies. For example, the overuse of expensive and unsafe air charter, failure to pre-plan stocks, congestion at ports caused by unplanned deliveries [6], delivery of useless or unwanted items to disaster victims and a lack of inter-organisational collaboration for information systems [13,14]. Nevertheless, steps are taken to anticipate events [6,15]. The WFP or the relevant UN agencies, such as UNICEF or UNHCR, usually play a leading role in the mobilisation of relief goods and in primary logistics in large-scale disasters. The WFP, for instance, may be responsible for all food aid logistics up to the extended delivery points (EDPs) at inland destinations close to the affected area with other humanitarian agencies or governments of recipients responsible thereafter [16]. Logistics coordination between NGOs has improved in recent humanitarian operations [17,18] with shared equipment, assets, or resources such as aircraft, trucks, food stocks, forklifts etc., and with some agencies or even individuals designated as having the best local knowledge and contacts.

The longer-term, strategic perspective is not widespread, despite some improved coordination; evidence suggests that the delivery of relief to disaster stricken countries has become less strategic in the past decade [6, 13]. Some authors argue that a better model would be a “relief to development continuum” where there is a transitional stage [3], similar to the changing marketing and logistics strategies required for different stages of the product life cycle [19]. International relief organisations may also be issue-related and therefore exist only temporarily, with each humanitarian effort requiring a totally new supply chain and a project approach [20].

The importance of coordinated functions
International emergency relief logistics and supply operations frequently require the involvement of several governments and independent NGOs, as well as the use of a number of transport modes [21]. International relief operations may become complex because of administrative and logistical bottlenecks arising from poor infrastructure in the aid-receiving region and the multiplicity of agencies and governments [17], and are often in conflict zones, thus, hindering efficient delivery and distribution of relief cargoes to the needy [17]. Poor coordination may also contribute to complexity both at the disaster site and at donor countries [22,23] because of geographical dispersion, insufficient or inaccurate communication and information flows between the field and the head offices of relief organisations, and between different organisations [24]. Byman et al. [6] provide a comprehensive review of NGO organisational structures, although largely from the perspective of potential collaboration with the US military. They claim that there are too many participants in the field without a clear division of labour, and refer to differences between the focus of NGO headquarters and their field workers, with the former more concerned with relationships with donors than with delivery to aid recipients. All these they claim contribute to complexity in the delivery of relief. The following section highlights the fundamental differences between the commercial supply chain and its relief counterpart.

Commercial versus relief supply chains
Commercial supply chains focus on the final customer as the source of income for the entire chain. However, in relief chains the end user (the recipient or consumer of aid) almost never enters into a commercial transaction and has little control over supplies [25]. He gets what he is given. The end-users of relief supplies are not customers of the supplier, transport-carrier, or donor. Instead, ‘customer service’ and the ‘marketing’ of the relief service may need to target the supplier/donor, who has to be convinced that humanitarian relief action is actually taking place. For example, there may be greater ‘humanitarian visibility’ and media appeal in providing food or medicine before basic logistical equipment such as forklifts, although the latter may be necessary for effective delivery of the former [6]. The end-users of relief are usually, not involved in a commercial transaction, because they are not paying for the relief goods they receive. Similarly, the end-user of relief goods has no complaint mechanism against donor governments or relief NGOs [14,25]. Transactions do, however, take place within relief supply chains, although not necessarily in open markets. For instance, government aid may be tied to making purchases from donor country companies and some commercial suppliers of materials or services may offer reduced rates e.g. ocean shipping companies.

Most supply chain literature refer to organisations as businesses that make profits through serving and satisfying customers, however, relief supply chains are not for profit. Likewise, supply chains have been referred to as a sequence of transactions that may be intra-firm, or inter-firm in a network, relief chains are ad-hoc, and may vary from one disaster to the next, unlike their commercial counterparts that are relatively stable, repetitious and routinised. Emergency relief logistics and supply chains have been described variously as the logistics of an event, or a project [13,26]. Commercial supply chains focus on the final customers as the source of income for the entire supply chain, and as the driver of
innovation, and delivery of value. In contrast to the commercial supply chain, the originating supplier may also be a donor who has to be convinced that humanitarian action is taking place, so that measures of ‘customer service’ needs to be aimed at the supplier/donor, because many times donors are the ‘customers’ to which NGOs (and other agencies) are accountable and have a reporting responsibility [8]. If donors are not satisfied with NGO performance, they will not give any more funds. The following section discusses the nature and causes of complexity, in order for us to understand strategies to simplify and reduce complexity in the relief chain.

The nature and causes of complexity
Today’s global environment is characterised by complexity, volatility and uncertainty [27,28]. The intricate web of organisational and trans-organisational processes is a source of supply complexity, and the unexpected rapid onset disaster also contributes to demand variability. In humanitarian relief chains for rapid onset disasters like tsunamis and earthquakes, the sheer number of organisations involved in the respond contributes to complexity. For example, the coordination host and donor governments, municipal authorities, a large number of local and international non-governmental organisations (NGOs), transport companies, local churches, partner organisations and so forth all add to the complexity and increases response time in aid of victims. Complexity is an unnecessary cost of doing business as it creates inefficiencies, reduces productivity, and increases costs [29]. It also decreases an organisations ability to respond quickly to customers. Complexity makes it more difficult for customers, suppliers and other supply network/value chain members to do business with the organisation. At the operational level, managers and employees’ work becomes overly complex, intricate and challenging [28,30]. In commercial supply chains, complexity comes in many different forms, it occurs at various stages of the business model and the supply process, however, complexity refers to things: ‘unduly intricate’, ‘not easily understood, used or analysed’ [28]. In business terminology, the word complex is often used to describe products, services, systems, markets, and organisations as regards the difficulty of tackling the task at hand. It is often associated with unnecessary time wasting, as well as increased risk, which may result for example, from over-reactions, unnecessary interventions, second-guessing, distrust and distorted information throughout a supply chain [27,31,32]. In inventory management the well known “bull whip effect” which describes rising fluctuations of order/demand patterns from the retailer through the wholesaler and up the manufacturer and supplier is an example of such complexity within the supply chain, and it leads to higher costs and inefficiencies, as well as poorer service to the customer [33,34]. Complexity is used to describe something that has more steps, content, processes, or requirements than necessary [29]. It appears to grow over time and hampers organisational performance [35]. Similarly, in the relief supply chain, the various processes for an international relief response include, host governments formally requesting assistance, the United Nations (UN) and NGOs launching an appeal for disaster funding and goods-in-kind, mobilisation of relief professionals like doctors, nutritionists, epidemiologists and search and rescue professionals and so forth. Also there has to be a needs assessment of what the victims of the disaster require (e.g. food, blankets, medicines) and what responding international relief organisations require to make and sustain an effective response (e.g., rebuilding of roads, air traffic control and other logistics infrastructure). In commercial supply chains complexity may arise from government regulations, for example, the mandatory and voluntary security regimes in place post 9/11 at the port of loading such as container security initiative (CSI), at sea and en-route as well as the maritime / seaport interface, for example customs inspections and verification of cargoes [36]. In the relief chain, assuming all donor country/upstream activities such as fund raising, packing, loading and forwarding are completed, the relief cargoes still have to undergo the usual customs procedures although in a somewhat expedited rate. At the port of discharge, the same procedures are repeated. In addition, the nature of the supply process itself contributes to complexity, for example, is the product to be delivered critical to operations? Is it to be delivered just in time (JIT)? Is it to be delivered straight up to the disaster sites? In a sector where suppliers are few and specialised and most relief goods not purchased in open markets, any delays or failures in the part of suppliers will cause delays in the relief supply chain. The nature of the sourcing system is a potential source of complexity. For example, is it a singular transaction or a continuing relationship? In an on-going supply relationship, uncertainty and complexity is reduced because buyer and supplier know each other well. In a one-off big item purchase, the procurement process is more complex as the buyer and seller may not have had a previous commercial relationship, therefore, there is a need for stringent prior research and pre-selection processes before a decision is made, of course, this further contributes to time pressure. The rating and qualification of prospective suppliers may be complex as information from formal and informal sources is processed in order to choose the best supplier to meet all the requirements of the purchasing organisation. In international sourcing, there may be currency complexities and monetary differences, as well as psychic distance and language differences between the purchasing NGO and the suppliers. Issues of the number and network of suppliers, supplier turnover, supplier dispersion and location may increase the level of supply complexity. With up to half of a typical supplier's costs contained in its supply base, the ability of the lower tier suppliers to meet requirements such as just-in-time delivery is a critical factor for a cost-effective and agile relief chain capability [28,29]. Distorted or truncated information can
increase costs in the form of ‘just-in-case’ inventories, premium air freight and unplanned procurements, thus adding to supply complexity [30]. The nature and density of the network, for example the management of transport mode selection, as well as carrier choice, number of logistics and marketing intermediaries, and number of ports of entry are other sources of complexity in supply chain planning for disaster response. For example, a typical large international NGO may receive relief goods from scores of suppliers in 20 countries, and have to manage a large number of forwarders, customs brokers, insurance companies, ports of loading and discharge, export agencies and inland carriers, as well as a combination of several dozen combinations of origin and destination [36]. It may also have to coordinate with the militaries of host and donor countries in distributing relief to the victims of a disaster. The product itself has consequences for the management of supply chains: its damage potential, its dimensions, packaging, storage or transport, as well as from its inherent physical nature, is a source of complexity. The nature of the commercial supply chain member organisation, its organisational structure (e.g., centralised or decentralised), and historical nature of its growth influences complexity. For example, merged and acquired organisations have unique problems of organisational structure, as well as computer systems which may not be compatible and do not communicate with each other hence resulting in manual data re-entry. Another factor is an organisational culture that fosters functional silo mentality, for example, sister divisions and strategic business units (SBUs) in the same organisation that do not cooperate with each other. Finally, organisational complexity often means job security for some persons, who spend their energy doing well what should not be done at all.

**Strategies in managing complexity**

The inability of international humanitarian organisations to make particular relief items available when needed is critical for many suffering people. Although international relief chains are clearly unpredictable, turbulent, and require flexibility, the ability to thrive and prosper in an environment of constant and unpredictable change requires responsiveness and a mastery of turbulence [37]. In addition, relief chains require developing an organisation-wide capability that embraces organisational structures, information systems, logistics processes, and mindsets [38], in order to reduce complexity in the relief chain. Several strategies for managing complexity in relief chains are discussed below.

**Funding**

As stated earlier, the ‘customer’ to be satisfied in the relief chain is in effect the donor. Therefore, the management of complexity in the context of relief chains must begin by addressing the unstable nature of funding at its source [39], and the donor funding process. For example, in practice, institutions such as charities are regularly required to raise large amounts of money at very short notice to provide emergency assistance. Concern by donor governments for certain aid to be used for specific relief operations in particular countries drives relief organisations to focus on short term direct relief and distribution, rather than longer term investment in logistics systems and supply processes. Therefore, the donors should be made aware of how crucial an efficient funding process is to the management of complexity within the relief chain and steps taken to develop a streamlined, user friendly, centralised funding mechanism to reside with the United Nations (UN). This centralised pot of funds must not be skewed towards political, security, or media interests of powerful donors, but is solely focussed on need. Consequently, the authors propose a large, common pool of emergency response fund, subscribed to by each donor country every three months. For example, based on gross domestic product (GDP), 7-10% of GDP should be levied on each donor country annually, so that the common pot of funds kept filled for any humanitarian emergency, so that donor governments cannot ‘cherry-pick’ which disaster they like. To make this proposal worthwhile, a specific universal measure of humanitarian need should be developed which is objective and will not lead to donors picking and choosing only the ‘disasters’ that serve their interests or to any other ambiguity as to the required urgency, or, otherwise of any disaster that occurs. This universal measure of humanitarian need will serve as a unified trigger mechanism for immediate release of funds, hence, prompt relief action and prompt setting up of the relief chain from donors, through NGOs and host governments to the victims. Although it may prove difficult to convince donors of the desirability of the routines and procedures necessary for longer-term supply chain efficiency and but which have low media impact, as well as the donors’ rights to choose where they want to put their money.

**Standardisation and transaction time**

As earlier stated, supply complexity has a negative implication for transaction costs, risks, responsiveness, and innovation within each organisation and the entire relief supply chain. A look at the hierarchy and flow of relief goods and services from source (suppliers/donors) through to final consumption and use by victims, one will find areas of the supply chain where opportunities exist to reduce complexity. For example, the relief goods being purchased and the creation of product/service specifications may be simplified with regard to a reduction in the number of transactions, the delivery of the product, as well as the supply relationships. In addition, a reduction in the number of suppliers will contribute to the management of complexity. Likewise, standardising the product/service specifications will result in fewer specifications for what are basically similar items like blankets, cooking utensils, medicines, food, tents, and so forth, continual pruning of weak, low volume, low demand items. Similarly, the cost of transactions, i.e., time spent by buyers such as
international NGOs and donor governments compared to the value obtained from using the particular type of transaction may need to be analysed with a view to having fewer transactions. Likewise, the establishment of direct links between the aid recipients and the suppliers may positively contribute to a reduction in complexity. This strategy has been used in the retail industry for many years. For instance in the well known vendor managed inventory strategy where the vendor/supplier manages the inventory on behalf of the retailer, thereby freeing the wholesaler to concentrate on higher value activities. Thus, suppliers may be asked to manage inventories at disaster sites, freeing up NGOs to focus on distribution. The use of general blanket agreements in supplier contracts is another strategy for reducing complexity and reducing transaction costs.

**Metrics**
Most organisations do not use metrics that track complexity. Supply chain leaders focus more rigorously on product and component rationalization, and use metrics such as the number of configurations offered and the number of component parts more effectively than others, however, appropriate supply chain metrics must be developed to measure complexity.

**SUMMARY AND CONCLUSION**
The paper provides an exploratory, but useful structure within which to understand the generation of uncertainty and complexity within a supply chain. The important implications for management are: sudden changes (in demand) can occur unexpectedly due to unforeseen and uncontrollable circumstances. A chaotic rise in demand can occur, generated by the system i.e. the ‘bull whip effect’ and not necessarily as the result of external events. In addition, longer-term planning is very difficult, and if longer-term plans are made the plans need to be reviewed on a regular basis to accommodate perturbations as they arise in the relief chain. The relief chain should be treated and planned as a complete system, i.e., a holistic approach is mandatory as small changes made to optimise one echelon of the supply chain can result in massive changes in other parts of the supply chain. It is also necessary to focus on the aid recipients as the reason for the existence of the relief chain. Demand information should be communicated as far upstream to donors (and associated funding processes) as possible for demand information accuracy to trigger the correct amount of funding for relief.
REFERENCES


