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Supply chain resilience for sustainable disaster management

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Introduction

Both natural and man-made disasters are increasing, around the world, in terms of their magnitude, frequency and impact. Damages and losses for the Haiti earthquake and the Pakistan floods of 2010 amount to US \$18.9 billion alone, with another US \$20.4 billion estimated as needing to be spent over the next three years on recovery (Global Facility for Disaster Reduction and Recovery, 2011). Such disasters seriously disrupt the functioning of society, and cause widespread human, material or environmental loss or damage, which is often of such magnitude that the affected areas cannot rely just on their own resources to manage their situations.

The resilience of an organization's supply chain can help reduce the impact of disasters or unforeseen catastrophes by planning for such events, and identifying strategies to enable the supply chain to recover to its original (or better) functional state (Jüttner and Maklan, 2011). As one of the *prerequisites for sustainable development* (Ponomarov and Holcomb, 2009) supply chains can build resilience against risk and vulnerability (the exposure to serious disturbance arising from supply chain risks (Jüttner, 2005)). It is therefore of critical importance to any operation. To date, humanitarian aid (HA) agencies have focused almost exclusively on building their supply chains' capabilities in *immediate post disaster response*, for example, seeking to increase their agility to deliver aid effectively and efficiently. However (as with commercial supply chains) sustainable disaster relief operations and their management involve a continuum of inter-linked activities (Pettit and Beresford, 2005) that consist of *four phases* - preparedness, response, recovery and mitigation - which are all of equal importance, but which each involve different sets of resources and capabilities (Kovács and Spens, 2007). Little is known of the capabilities which HA or other organisations require to meet the specific needs of each stage of a disaster cycle: this paper addresses this lack of attention by exploring the *distinct supply chain capabilities* needed in each *separate phase* of

a disaster cycle to achieve resilience and sustainability both on the part of the organization and in the zone where the disaster has struck.

We extend previous research in three important ways. Firstly, while previous general supply chain management (SCM) research identifies the macro level capabilities associated with supply chain resilience, it generally fails to differentiate between the stages of the process and identify the specific capabilities required for each stage; few empirical studies (with the possible exception of Jüttner and Maklan (2011)) have moved beyond a theoretical exploration of the area, so the research picture is incomplete and specific practitioner guidance lacking. By applying an in depth qualitative case approach and examining each of the four disaster cycle stages, we extend the previous supply chain resilience system level framework provided – mainly by Christopher and Peck (2004) - and add to our understanding of what is needed to build sustainability in a supply network. The systematic exploration of the specific SCM capabilities required to build resilience in each disaster phase allows us to add to theory about resilience in a way which is applicable to both commercial and HA supply chains.

Second, as far as we could ascertain, this paper represents the first attempt to apply the principles of resilience to a HA context, and thus not only responds to the need to identify important supply chain risk management issues from a practitioner perspective (Jüttner, 2005) in an HA supply chain setting, but also surfaces valuable insights from this unique context (Bamberger and Pratt, 2010) for application to commercial practices.

Thirdly, we extend prior HA research by examining SCM practices within a developed country context, which has been largely neglected to date (Olorutoba, 2010). This approach can provide fresh insights, as the complexities of aid responses in developed countries may differ to the challenges of operating in less sophisticated contexts. The resultant insights are potentially invaluable to both HA and commercial practitioners, as HA organisations

operating in developed countries can be expected to be better resourced, and thus more likely to support the adoption and advancement of best practices. As resilience is critical to sustainability, and sustainability is an objective of all organisations, our chosen setting provides a strong opportunity for insights of value to both other aid agencies and commercial managements, regardless of their contexts.

We begin by outlining the current macro-level approach to how organisations prepare for unplanned events so as to identify the general capabilities associated with supply chain resilience. We then present our case study design for identifying the supply chain capabilities required to achieve resilience and reduce vulnerability at *each phase of a disaster cycle*. The following section provides our detailed findings and presents our proposed capabilities framework, and the final part discusses our results in respect of existing theory and identifies implications for management practice and suggestions for future HA and commercial SCM research.

Supply Chain Risk and Resilience

Nobody can identify exactly when or where an earthquake or tsunami will strike (e.g. in Istanbul, Mexico City, California or Haiti) and no amount of preparation can completely protect these places from the possible devastating effects and impacts of such natural disasters (Katoch, 2007). However, regions that are prone to being struck by natural disasters can prepare for particular risks, mitigate their vulnerability and build resilience (Kovács and Spens, 2007) e.g. by developing evacuation plans or training via simulations. Identifying where and when areas are at risk makes it possible to act before disasters occur to reduce the vulnerability (Dilley, 2006) and severity of their impact (Katoch, 2007) and (as far as possible) ensure the continuity of business or aid. Supply chains can lower their vulnerability by adopting a synchronized approach among their network members (Jüttner, 2005).

Supply chain vulnerability can relate to any unplanned and unanticipated event which disrupts the normal flow of goods and materials and so exposes supply network organizations to operational and financial risks (Craighead *et al.*, 2007). In HA terms, disruptions in the aid chain can lead to greater suffering in affected areas. Risks can stem from factors that may be internal or external to the organization and/or the supply chain. Organisations can build their resilience against the potential damage disasters can cause by implementing resilience strategies designed either to restore the system to its pre-disturbed state (or better), or reduce the potential impact of the disturbance by changing the level of risk of an identified threat (Carvalho *et al.*, 2012), so resilience can be seen as a way of overcoming vulnerability (Peck, 2005; Tang, 2006). Supply chain resilience focuses on the whole supply network's capabilities to adapt to deal with the impact of disasters (Jüttner and Maklan, 2011), and will increase as such capabilities are augmented and/or as vulnerabilities decrease (Pettit *et al.*, 2010).

This research follows existing theory in adopting a system-level approach (Jüttner and Maklan, 2011) - suggested by both Christopher and Peck (2004) and by Sheffi and Rice (2005) - as the basis for exploring resilience. The existing conceptualization of a resilient supply chain includes primary capabilities for (1) supply chain (re)engineering, (2) supply chain collaboration, (3) agility and (4) risk awareness. While the model has been criticised as an "*interesting point of view with no theoretical justification*" (Ponomarov and Holcomb, 2009 p. 132), it is generally accepted by both academics and practitioners, suggesting that it provides a strong foundation for further conceptual development.

Supply Chain (Re-)engineering

When a disaster strikes and aid needs peak, it is clearly already too late to try to develop preventative solutions (Tomasini and Van Wassenhove, 2009). Resilience must be built into a supply chain in advance to incorporate readiness to enable efficient and effective responses to

such events (Ponomarov and Holcomb, 2009), and such resilience will require the alignment of all supply network members. Knowledge of the capacity for resilience of the different links in the chain has to be clearly established, including of their coping strategies, local awareness, leadership and institutions, and how existing social structures can contribute to risk reduction efforts, skill, labour, stock and evacuation routes (Haghebaert, 2007).

Collaboration

SCM is essentially a network theory; so the management of risk must also be examined from a network perspective (Christopher and Peck, 2004). While the vital nature of coordination among network members has been widely addressed in commercial supply chain literature (Lee, 2000), it has been comparatively neglected in the HA context. The fundamental principle of supply chain collaboration is that the exchange of information and application of shared knowledge across the chain can decrease uncertainty (Christopher and Peck, 2004), increase operational effectiveness and efficiency, and enhance customer service – specifically in the case of emergency relief situations, speeding aid delivery times (Balcik *et al.*, 2009). Its support seeing supply chain resilience as a continual process that requires the long-term dedication of all supply chain members (Manuj and Mentzer, 2008) to sharing the risks, costs and rewards involved (Faisal *et al.*, 2006).

Collaboration in supply networks can be vertical or horizontal, and can either be an operational matter - emphasising how it can support supply chain efficiency - or involve strategic knowledge or innovation perspectives, as ways for members to access complementary skills to improve chain performance (Jüttner and Maklan, 2011). While vertical collaboration involves different members at different value chain stages - suppliers, manufacturers, customers, etc.; horizontal collaboration takes place between different organizations working at the same level, usually in partnerships.

Agility

Resilience implies a certain level of flexibility and ability to adapt to both positive and negative environmental influences (Ponomarov and Holcomb, 2009). The driver behind agility is the search for the most appropriate response to change, uncertainty and unpredictability within the business environment (Lin *et al.*, 2006). Flexibility facilitates coordination processes and enables organizations to cope with the high levels of environmental and operating uncertainty that such change brings (Manuj and Mentzer, 2008). The need for flexibility – both in terms of resources and of operational co-ordination - is particularly applicable to HA organizations, as they work in unpredictable and constantly changing environments (Oloruntoba and Grey, 2006; Scholten *et al.*, 2010). Disasters can happen anywhere in the world, at any time, affecting not only local populations, but also local businesses and economies; so matching supply and demand in pre- and post-disaster situations is a critical problem (Balcik *et al.*, 2009) that requires organisational flexibility and agile supply chains.

Risk Awareness

A resilient supply chain demands a supportive management culture, based on clear performance requirements for, and lines of communication between, all network partners (Christopher and Peck, 2004). Supply chain risk awareness enables an organization to monitor and react to dynamic business environments where risk situations depend on external macro forces that cannot be influenced (Faisal *et al.*, 2006). To be risk resilient, organizations need to develop appropriate management policies and actions to assess risk continuously and coordinate the efforts of their supply chain partners (Kleindorfer and Saad, 2005), who must share common understandings and awareness of the risks (Faisal *et al.*, 2006) that could occur within their operations.

In summary, supply chain (re)-engineering, collaboration, agility and risk awareness underpin

a supply network's resilience. Taken separately, these elements are important for good SCM, but we need to understand the specific interplay of the capabilities required at each phase of a disaster cycle if we are to contribute to theoretical justification for current supply chain resilience models, work which has been barely existent to date (Ponomarov and Holcomb, 2009). We also need to address Jüttner and Maklan's (2011) call to systematically explore what additional supply chain capabilities are needed to achieve resilience in different disaster phases. Considering these issues together gives us an excellent opportunity to develop a more complete and theoretically richer understanding of supply chain resilience.

Our inductive case study design allows us to move from a macro approach to investigating supply chain capabilities at each of the different disaster phases, and thus to provide guidance on how operational resilience and sustainability can be achieved. Our research is consistent with recent comments about the usefulness of extreme cases in providing general insights (Bamberger and Pratt, 2010): to date, the only other two studies on supply chain resilience capabilities have involved conceptual hypothesis building (Ponomarov and Holcomb, 2009) and deductive empirical testing of specific capabilities (Jüttner and Maklan, 2011). Our study benefits from a HA setting, where supply chain resilience has so far been unexplored, despite its real importance in maintaining and sustaining operations – even in many cases, life itself.

Methodology

Research Design and Setting

We adopted a single case study design (Eisenhardt, 1989; Eisenhardt and Graebner, 2007) as being particularly suited for developing a holistic and in-depth understanding of a complex, unique and exploratory phenomena in a real-life context (Ellram, 1996; Seuring, 2008; Yin, 2009), allowing questions of why, what and how to be answered to develop a relatively full understanding of the nature and complexity of the complete phenomenon (Voss *et al.*, 2002; Yin, 2009). This approach also supports the call for more methodological triangulation in

SCM studies to achieve greater academic rigour and industrial relevance (Mangan *et al.*, 2004). While qualitative research enables us to ‘open the black box’ of organizational processes (Doz, 2011), it also aligns with our research objective of understanding how disaster management can be made more sustainable through supply chain resilience. Our design considers two units of analysis: the Voluntary Organizations Active in Disaster (VOAD) group in El Paso, Texas and its operations across the four disaster phases in relation to supply chain resilience.

VOAD provides a particularly appropriate research site. It is a national organisation (with 50 members) which coordinates efforts among organizations at both national (US) and State/Territory levels, and was founded specifically to improve supply chain resilience following the inadequate preparations for Hurricane Camille in 1970. The organizations involved have stated aims of reducing potential suffering by increasing supply chain resilience through their commitment to communication, collaboration, cooperation and coordination. They share knowledge and resources to better serve those impacted by each disaster phase, so the organisation offers an excellent setting in which to examine how resilience can be achieved over the four stages. Our in-depth study was based on the local VOAD disaster preparedness group in El Paso, Texas, which was originally formed after unprecedented levels of rainfall in late July/early August 2006 had overflowed all flood-control reservoirs causing major flooding city wide. At least 1500 homes, approximately 20 drainage facilities and 100 roadways were damaged at an estimated cost of approx. US \$200 million (Crowder, 2006).

When the flooding arose, local aid agencies were under enormous pressure to provide aid before the area was declared a federal disaster zone, and the US Federal Emergency Management Agency (FEMA) stepped in to provide critical assistance. Damage and recovery across the county were uneven (Collins, 2010), as there was no system via which the different

government, private and non-for profit sector agencies could coordinate their services or identify resources they needed (from other agencies) to improve their responsiveness. Most community agencies and groups knew very little about how to respond in a disaster, or how to work together to meet urgent client needs, so that some neighbourhoods received a great amount of public and private attention, while other communities struggled with little support. Unnecessary duplication of efforts meant some needs gained adequate attention while others went unmet. Similar experiences are evident in other ill-prepared disaster zones such as the Indian ocean Tsunami 2004 and the Darfur crises 2004/2005 (Jahre and Jensen, 2010).

While conscious that examining a single organisation limits the generalisability of findings, a single case study can offer convincing results, especially when the situation is deliberately selected to provide certain insights that alternative cases may not reveal (Siggelkow, 2007). Our chosen setting was of particular value as its supply chain network had been relatively recently formed and there was plenty of information available about its evolution and how its capabilities and practices had been established and developed. In addition, the geographically remote location in the far South West of the country places more emphasis on their ability to respond to any disaster independently, highlighting the importance of their supply chain linkages. Much of the disaster response literature assumes that relief is delivered from a developed to a developing country, and assumes that wealthier countries' responses to emergencies will be more efficient (Oloruntoba, 2010). However, the experience of hurricane Katrina in, 2005 or the Japanese earthquake and tsunami of 2011 clearly demonstrate that this does not always hold, and highlights the need for empirically-based research on the effectiveness of disaster relief in a developed country context (Oloruntoba, 2010). We address this deficit by analysing how the collaboration efforts of the El Paso VOAD group led to decreased vulnerability and increased capabilities and supply chain resilience.

Data Collection

To achieve internal triangulation (Voss *et al.*, 2002), we used a range of techniques to collect data: (1) nine interviews with different VOAD member organizations, (2) observation of a 60 min VOAD meeting attended by 15 members, and (3) study of archival sources such as internal reports, memos and strategy documents. We organised individual semi-structured interviews (of approximately 45 minutes) which were recorded and transcribed verbatim, as was the VOAD group meeting (Miles and Huberman, 1994). The interviews with participants followed a standard core (to facilitate data comparison) organised under broadly defined themes, with open-ended questions and probes to encourage detailed responses to uncover material on specific aspects directly relating to disaster events and the VOAD group, as well as a range of general issues relating to the interviewee's organisation: the group's history and size, and descriptions of the specific roles of each supply chain partner's manager. Our original approach was to focus on overall supply chain resilience, but this shifted to embrace the capabilities required within the different disaster phases during the analysis process, reducing the risk of it being biased. We asked respondents to recall examples of disasters that happened in El Paso or the wider region, to describe their organisation's role and the extent of their involvement, and to evaluate the effectiveness of their actions. The VOAD meeting gave us further data on the extent and effectiveness of collaboration between the different organisations. We also reviewed archival sources, such as internal reports, memos, strategy documents and newspaper reports. The interviews were followed by informal discussions which provided additional context for our analysis, but further background information about interviewees has been excluded from this paper as anonymity was a condition of their involvement.

Data Analysis

We tried to balance pure induction with early structure through an analytical approach. We followed a recursive iterative process to relate our data and findings to existing theoretical

frameworks and literature (Eisenhardt and Graebner, 2007). The coding process generated data items ranging in length from a few words up to several paragraphs, and we described the codes and themes using existing terminology and definitions whenever possible (Miles and Huberman, 1994). Where necessary, we followed up our data collection with e-mails and calls to fill in missing details. NVivo9 was used to manage the data analysis process in a systematic and consistent manner, as well as to fragment, reassemble and recode data so as to generate findings progressively.

In analysing the data we first grouped and coded raw data and situations described as parts of emergency actions, referring to Christopher and Peck's (1994) pre-established capabilities (supply chain (re-)engineering, collaboration, agility and risk awareness), with our focus on strategic planning, organization, sustainability and impact. Where we could not group quotes under these capabilities, we developed new second order capability codes. As our primary objective was to understand how disaster management can be made more sustainable through supply chain resilience, these second order codes were then grouped under the four disaster phases: preparedness, immediate response, recovery and mitigation (third order coding) (for further information on the coding trees please see Appendix, Figures 2-5).

Findings

In line with our research objective, we present our findings in relation to the four disaster phases and the evolving supply chain resilience associated with each stage.

Preparedness

Collaboration - Horizontal

Horizontal collaboration was organised via the regular quarterly meetings of the El Paso VOAD group's 28 not-for profit agencies, which ensured communication, collaboration, coordination and cooperation among members. The group is organized into function

committees under 'lead' agencies that coordinate disaster planning activities. The need for horizontal communication across the supply chain network was consistently emphasised, including recognition of the need to embed new members into the network. Participating agencies acknowledged the need to develop better disaster preparedness collaboratively "*including the fire department and the office of emergency response (Functional Manager 1)*", both among organizations, neighbourhoods and families, so people would know what to do in the case of an emergency. They found collaboration important due to the "*remote geographical location (Functional Manager 4* requiring greater self-sufficiency and to address the specific issues thrown up in the flood response. The setting up of horizontal collaborative agreements means such difficulties can be addressed should they arise.

Supply Chain (Re-)engineering

A disaster preparedness plan was created outlining each member's specific role in a disaster (as they themselves defined them), their resources and network activities in case of an emergency, which included the "*set up of supplies in strategic locations (Director 1)*". The group is organized in a way that the full potential of the complementary capabilities and resources of the different collaborative members benefits the disaster relief efforts, avoiding any duplication of effort. "*Our collaboration is geared towards filling individual agencies resource gaps (Director 2).*" Resilience is developed through deliberately choosing members to address all supply chain aspects – i.e., "*chosen to cover specialized disaster response activities such as medical services, mental health, feeding, counselling and immediate response (Director 1)*". In doing so, resources are used in the most effective and efficient way. As a result of the (re-)engineered, supply network inefficiencies can be avoided and eliminated prior to an emergency happening.

Knowledge Management

El Paso VOAD builds knowledge capabilities by arranging training and exercises, and maintaining essential rosters to sustain appropriate levels of readiness for emergencies. Different strategic plans are developed for a range of scenarios, including evacuation, sheltering and outlining who is responsible for what in which situation. *“We always have to make sure we are prepared for anything. We work and practice a lot and we also train by going to other disasters nationally to see how those are run (Functional Manager 2).”* So the different organizations know who is taking on which role and who can provide different resources in a disaster situation: constant learning and knowledge exchange between all participating parties - as well as commercial businesses, institutions and volunteers - is of paramount importance to *“keep skill levels up (Functional Manager 1)”* so as to be prepared.

Immediate Response

Collaboration - Horizontal and Vertical

High levels of horizontal collaboration capabilities are required as part of defining a disaster plan including *“effective leadership, a resource centre and communication hub (external report)”*, and recent smaller disasters have shown that these factors have made collaboration between different VOAD members smoother and better coordinated than it was during the 2006 floods. As lines of communication and the whole resource network become more widely known, disaster victims can be guided in the right direction to get help and duplication of efforts can be avoided. Different agencies’ services in the immediate response phase include *“help with evacuation, Search & Rescue, medical care, road clearance, debris removal, mass sheltering, feeding, communication, pet rescue, counselling / Chaplaincy (Functional Manager 3)”*.

Organizations that are horizontally collaborating can be involved in vertical collaboration at the same time, helping victims climb the different steps on their way towards recovery (the final point of the supply chain). *“We have other not-for profit organizations that help us [...]*

we could call the other organizations to bring in clothing, shower units [...] (Director 3). Further vertical collaboration takes place between the government, VOAD, trained Community Emergency Response Training (CERT) volunteers and commercial businesses, with which *“memorandums of understanding have been set up [...] to activate more resources (Director 1)”*. Overall, horizontal and vertical collaboration during an emergency helps to get aid to people in every area effectively and efficiently, and again avoiding duplication of effort.

Agility

While having a permanent communication infrastructure for action during disasters is important, it is even more vital that the network and its structure are agile and adaptable to different situations and needs that might occur during any emergency. Even though El Paso has established a disaster plan which outlines roles, processes and procedures for emergency situations, it cannot be relied on to meet any and every eventuality. *“There is no routine, every disaster is different (Functional Manager 1)”*. Agencies need to be able to adapt to changing needs, whether it is due to one of its members (or their resources) being affected (such as the local community shelter warehouses being destroyed) or other unforeseen circumstances. *“We got, maybe 12 hours notice and we were ready. We were ready within 3 hours for what we thought might be 5-7,000 people being evacuated (Functional Manager 1).”* Such agility is also required to assimilate changes in resources, for example to distribute corporate donations of food or of water, or government provision of funds or of volunteers. In sum, flexibility is a key capability in the immediate response phase.

Recovery: Collaboration - Horizontal and Vertical

For the recovery phase, VOAD El Paso has pre-established plans of how families or individuals in different situations can be helped on a long term basis by different member

organizations - e.g. in terms of shelter, counselling, repairs etc. - to make initial response efforts sustainable. *“We have lists of resources that we could provide for them. So we send out referrals for them. These are three different companies that are actually handing out what they need (Functional Manager 3).”* Horizontal and vertical collaboration capabilities are evidenced by long term recovery committees established at the El Paso case. *“We talked to other organizations and said we need to bring people together and we worked with FEMA representatives. So we worked together for about three years (Director 3).”* While some organizations committed to handle basic immediate/short term (one week) needs, others took on the responsibility of providing resources on a long term basis, giving disaster victims furniture, clothing, long term shelter etc. *“They came out to give them anything they need beyond the two to three days (Functional Manager 3).”* All members have full information about the resources held by the different agencies, which are available to all of them as needed so that, while collaborating horizontally to help people in need, they can also refer victims to the other agencies that might have the right, more appropriate or complimentary resources (on a vertical supply chain basis) in order to avoid inefficiencies and effort duplication. Horizontal and vertical collaboration in the recovery phase helps establish a network where resources and complementary skills can be used in the most effective and efficient way.

Mitigation

Collaboration - Vertical

The VOAD partnership goes beyond just preparing for emergencies to focus on reducing the potential vulnerabilities of affected communities via volunteer programmes (such as CERT). *“There are quite a few citizen corps programmes collaborating with the government and community agencies (Volunteer 1).”* CERT programmes were developed to assist communities to take care of themselves in the aftermath of major disasters when first

responders are overwhelmed or are unable to respond because of communication or transportation issues. *“The fire department first responders responded to 300 calls in one day, just to shut off main water lines and power (Functional Manager 3).”* Most emergency situations give residents very little time to react, so it is important to plan ahead of time, be prepared and know what to do at the local community/ neighbourhood level. *“They had a power outage and so they activated themselves, they went through their neighbourhoods and were checking on people. They removed a cardboard that had fallen down for a vehicle. They were monitoring a small fire till the fire department got there (Functional Manager 2)”*. Vertical collaboration between aid agencies, volunteers and local communities can help further reduce vulnerabilities.

Knowledge Management/ Risk Awareness

Enabling citizens to help themselves by building their knowledge about how to respond to disaster situations also builds resilience at the mitigation stage. *“People cannot help unless they are trained (Functional Manager 3)”* –VOAD members concluded that communities need assisting to prepare for disasters, so set up pre-emergency training courses ensure volunteers are ready to step in and help. *“The flooding in 2006 happened very suddenly in the neighbourhoods and many people who were in their homes didn't know what to do (Volunteer 2).”* CERT runs such courses in some 1835 active communities across the US. In El Paso it runs a 20 hour course on fire suppression, fire safety, life search and rescue, (mass) medical operations, evacuation, ‘cribbing’ and some disaster psychology. It teaches participants to check on their neighbourhoods, to go to community shelters, obtain what is required and do whatever is needed to help or to look for senior citizens who might be alone in their homes in an emergency. By the end of the course, participants are certified in disaster and emergency preparedness and thus qualified to help sustain themselves and their families in the event of an emergency. *“CERT people are a lot of help, because they are already trained, so we don't*

have to stop our primary job or tell them what to do, since they already know (Functional Manager 4).” The CERT central system for volunteers helps to mitigate disaster by building and transferring knowledge prior to an emergency, which can then help match resources to needs during the immediate response phase, as well as establishing local self-sufficiency against small scale disasters and therefore promoting sustainability.

Discussion

Resilience plays a critical role in building sustainable supply chains capable of speedy recovery from and readjustment to disaster. Building on previous research that adopted a macro approach to identifying the capabilities required to develop resilience, this study has identified the capabilities built by a dedicated organisation’s supply chain cycle for each specific stage of a disaster, an approach that reflects growing recognition of the need to adopt a more systematic approach to achieving sustainability. Utilising rich data across the disaster cycle from a recently established but well developed HA organisation, we identified the capabilities required to meet the demands of each of the four specific phases in practice.

While our findings have significant implications for broader SCM, our main contribution is to add to the understanding of the specific capabilities required for building resilience into each disaster stage, particularly for HA agencies. While we find support for the previous macro model suggested by Christopher and Peck (2004), our extended framework develops our awareness of the value of the capabilities involved and of how they interact with each other, as well as providing important new insights into the need for collaboration - both vertical and horizontal - before, during and after an emergency. We found that knowledge management and learning can play essential roles in achieving preparedness and mitigation against disasters, new fine grained insights which have particular implications for each disaster phase (see below). While we discuss each phase separately for ease of reference, in reality each phase is part of an ongoing sequence which demands continuous assessment and

reassessment (see Figure 1).

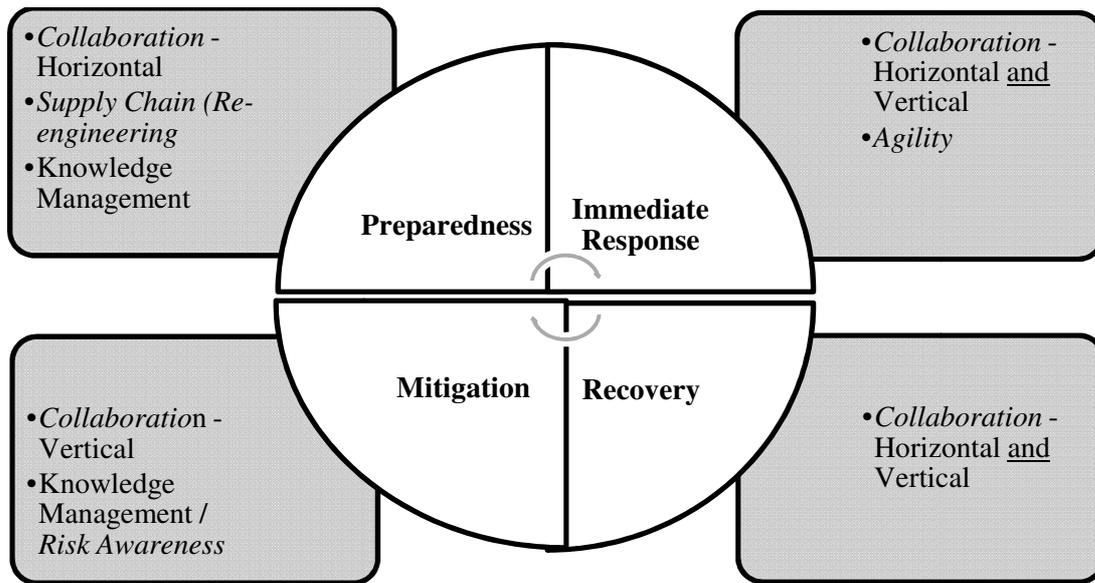


Figure 1 An emerging framework of sustainable humanitarian action
(Capabilities in italics align with those in Christopher and Peck's (2004) resilient supply chain framework)

Preparedness (Horizontal Collaboration, Supply Chain (Re-)engineering and Knowledge Management)

The continuous learning and knowledge management capabilities in building supply chain resilience that we identify - which have been overlooked by the literature to date - are essential to maintain resilience in today's turbulent external environment, where change seems to be the only constant. New knowledge creation and innovations stem from new combinations of existing knowledge and other resources (Kogut and Zander, 1992). Our data suggests that such new combinations are stimulated by the entry of new members into the value chain (in our case, during the preparedness phase). Knowledge is also enhanced proactively, by learning from experience, training and education, and scenario planning and practice runs. In all these cases, changes in the knowledge base trigger adjustments in preparation plans, resources and group dynamics which keep overall resilience levels up: so being prepared for a disaster can mean restructuring the supply chain network, including pooling and/or pre-positioning relief elements (Tomasini and Van Wassenhove, 2009). Since such elements might be physical resources, capabilities or knowledge, and pre-positioning

might be physical, or organisational – such as where along the supply chain they are held, or where they might be needed – such restructurings may need to be repeated several times.

Consideration of knowledge management capabilities reinforces the importance of developing and maintaining strong horizontal collaboration, which our findings suggest is essential to exploit the strength and complimentary resources of members during emergency relief operations, while avoiding duplication of their efforts. Resource and capability plans can be created, underpinned by formal agreements and memoranda of understanding that express supply partners' commitment to ongoing mutual support and resource sharing across the network. Our data suggests that established communication infrastructures and resource co-ordination are also essential to facilitate collaboration. They must be established around existing knowledge in the pre-disaster preparedness phase, and should include e.g. establishing strategic locations for shared stock, so that aid can be distributed everywhere within a certain timescale. The better the preparations are arranged, the more effective and efficient the response phase will be (Van Wassenhove, 2006).

Immediate Response (Horizontal and Vertical Collaboration and Agility)

At the onset of a disaster information is usually very limited (Tomasini and Van Wassenhove, 2009), so trade-offs between speed, cost and accuracy regarding the deployment of different resources may have to be made (Maon *et al.*, 2009). The ability of different organizations to work together well and collaborate to develop a collective strategy often determines the success or failure of the disaster response (Chandes and Paché, 2010), as a single actor will rarely have sufficient resources to respond effectively on their own. Our data indicates that, when combined with a pre-established disaster plan, horizontal collaboration makes the immediate response phase run more smoothly and use resources more effectively and efficiently and without duplication of effort, as members understand both their own and each others' roles.

We also identify the role of other vertical network members - commercial businesses, institutions and the local communities/ground staff - in increasing resilience. Commercial organizations may offer in kind services and resources, institutions may provide funds or locally trained volunteers/staff and the supply network needs to be flexible enough to incorporate changes in resources (human, physical and organizational). Pre-established disaster plans need to be sufficiently agile to incorporate any possible change in situations as they develop. Every disaster has its own unique characteristics - while our findings show the benefits of building agility, contingencies also need to be incorporated to cope with situations where a supply chain member is directly affected or an unanticipated scenario develops. Matching supply and demand in pre- and post-disaster situations is a specific problem (Balcik *et al.*, 2009) that demands great organisational flexibility and supply chain agility.

Recovery (Horizontal and Vertical Collaboration)

Our findings show that, during the recovery phase of the disaster, many organizations that collaborated beforehand on the horizontal level simultaneously become vertical collaborators, accessing each other's complimentary skills (such as, for example, when some excel in providing immediate aid and others in helping with shelter or medical support on a longer term basis). However, full information about existing and new network resources from all HA institutions and commercial businesses must be available to all involved if this open collaboration is to be supported, and pre-established lines of communication are need to ensure constant exchange of knowledge of new industry resources.

Mitigation (Vertical Collaboration and Knowledge Management)

Building sustainable supply chains requires developing local self-sufficiency through the transfer of technology, knowledge and expertise (Alexander, 2006). Our data suggest that resilience planning needs to involve local communities (or, in commercial terms, every

worker in the business) at every level. This suggests a bottom up approach (Haghebaert, 2007) is required, so that risk reduction activities at an international level involve integrating disaster response processes and resources developed at regional, national and local disaster response planning levels (Katoch, 2007). All supply chain elements must be aware of the different possible disasters that can affect the lives/business in their area/region, whether it is a flood, a terrorist attack or a flu pandemic. Unless proper attention is given to reducing the vulnerability factors that can lead to such events in the first place, or to increasing the community's ability to deal with them, sustainable results are unlikely to be achieved (Tomasini and Van Wassenhove, 2009).

Our findings indicate that mitigating risks and reducing vulnerabilities requires the vertical collaboration between organizations and the beneficiaries/local staff to be constantly updated through training and education. CERT is one example of a local initiative that trains and prepares local communities - but also local business staff - to handle potential disasters, and our data shows such efforts yields better communication and customer service and more effective and efficient operation by enabling every supply chain organization to focus fully on their own strengths. In the event of an emergency, trained participants will know how to react, give first aid, be able to help their neighbours, and provide assistance in the form of local information and work during the operation, and thus limit and prevent further impact.

Managerial Implications

Awareness of specific capabilities at each phase allows management to direct resources and plan for building the capabilities required. It is important that managers are aware that the capabilities required to support supply chain resilience vary across the different disaster phases, which will affect their planning and resource allocation. In particular, while the need to invest in knowledge management to build sustainable supply chains has not previously been recognised, our findings clearly suggest that extending risk awareness and building new

skills to prepare for disasters is critical to maintaining supply chain. Previously overlooked subtleties in collaboration have implications for how network members communicate at different stages, reinforcing the need for managers to be aware of the importance of continuous commitment to communication.

The insights formed in the El Paso community can be shared with other communities and successful strategies can be replicated. El Paso learned from a disaster, implemented a long-term strategic planning group and now provides training to its local communities, and these efforts proved their success last winter during extremely unusual low temperatures when trained volunteers showed up to help in the neighbourhoods so that the fire department and other agencies could concentrate on what they could do best, helping eliminate duplications of effort.

While we have looked at resilience and vulnerability reduction in a developed country setting, the emerging principles of the contribution resilience can make to sustainability can be used on a field level in any country. Establishing information about the network of resources available prior to the event can help aid agencies, institutions and commercial businesses in disaster prone regions when an emergency strikes. Involving local communities/staff in strategic planning and establishing a disaster supply chain plan, training and educating the local community in first aid or fire drills, setting up networks and infrastructures in advance creates *knowledge* prior to the event that can reduce vulnerability if an emergency occurs. CERT is an example of the kind of general preparedness programme that, if adapted to specific cultural and geographical circumstances and risks, could reduce the vulnerability of local communities in any disaster-prone region.

Many aid agencies specialize in disaster management, so it can be taken as a given that one of their great strengths is that they know what to do in emergencies; and there is great potential for commercial businesses to learn from their practices and specifically about the knowledge

management capabilities needed for resilience. While many companies have developed plans for an actual disaster (e.g., fire evacuation routes), recovery and mitigation activities involving all members of commercial supply networks are rare. But their managers, too, need to be more aware of how to manage knowledge so as to plan for, mitigate, or recover from, disasters if they are to reduce their networks' vulnerability to the risks of financial impacts and operational breakdowns and so achieve overall business sustainability.

Future Research

This paper reports the findings for research into just one VOAD group in the United States but, as it is a central US government initiative supported by a pool of available information, we believe other VOAD groups operate on a similar basis. As with any single case study research, further work is needed to establish the transferability of our findings to different organisational contexts and industries, and replicating our study in developing country or commercial contexts – both in relation to knowledge management and supply chain resilience - would clearly expand our insights.

Conclusion

This paper identifies the capabilities needed at each phase as a disaster strikes to achieve a resilient supply chain network which can reduce vulnerabilities and sustain operations. Our extended framework combines key concepts from disaster management and supply chain resilience to show how adopting a strategic and synchronized approach can alleviate the effects of any given disaster on supply chain members, from first supplier down to the eventual victims (or, in commercial contexts, customers).

Our results show that local level involvement in combination with knowledge management and collaboration across the whole network are essential to reduce long-term vulnerability. The advancement and application of policies, strategies and practices to minimize

vulnerabilities and disaster impact through prevention, preparedness and mitigation (Humanitarian Policy Group, 2007) can lead to sustainability and reduce risks to vulnerable people and businesses. However, two underlying lessons can also be drawn: that disaster response on its own does not address the underlying causes and risks behind crises (Katoch, 2007); and that knowledge and learning should not be seen as simply being supplied from a rich country to a poor (or from one business to another), but as an iterative process of collaboration and knowledge sharing between all supply chain members.

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Appendix

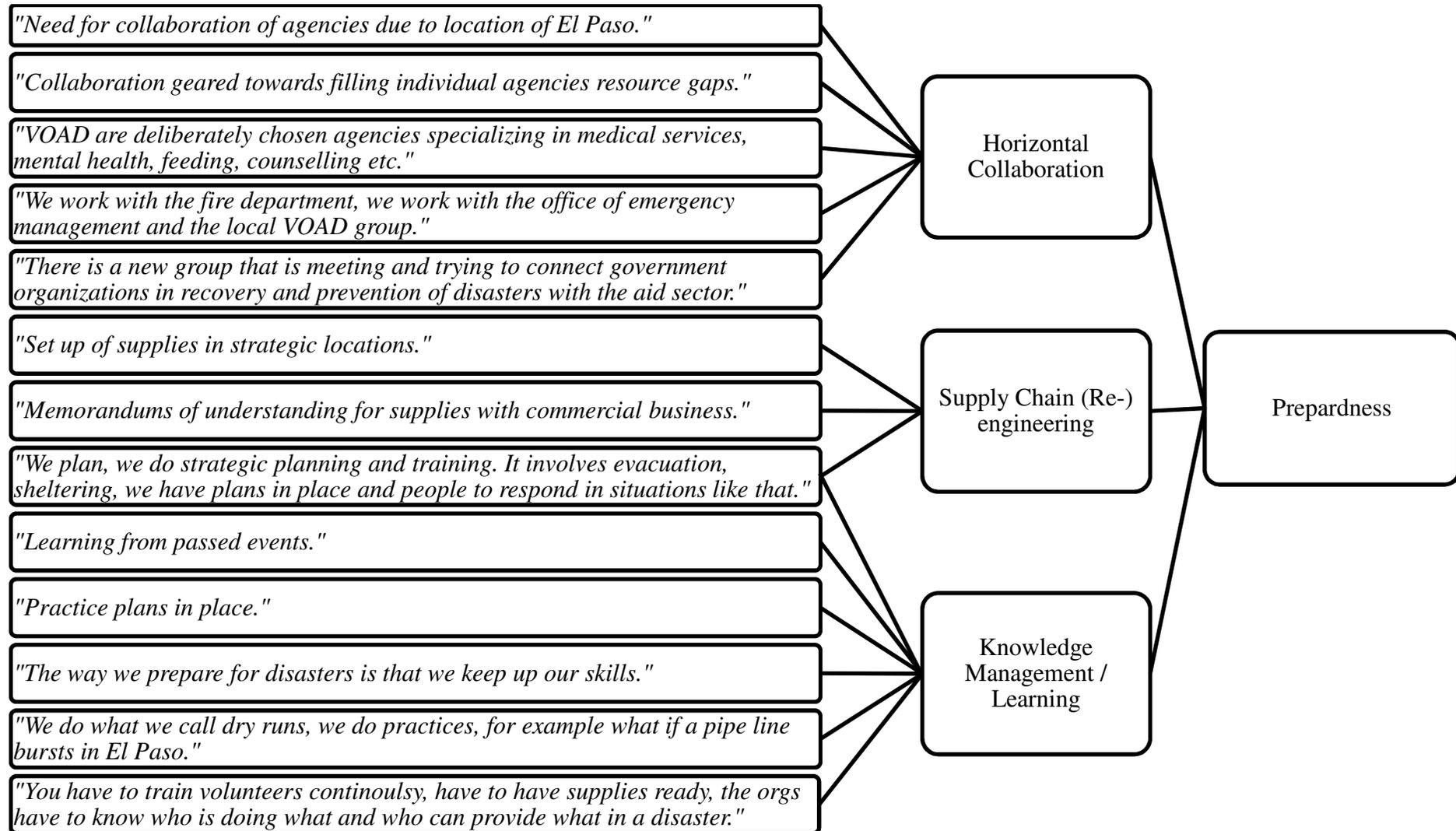


Figure 2 Coding Tree Part I

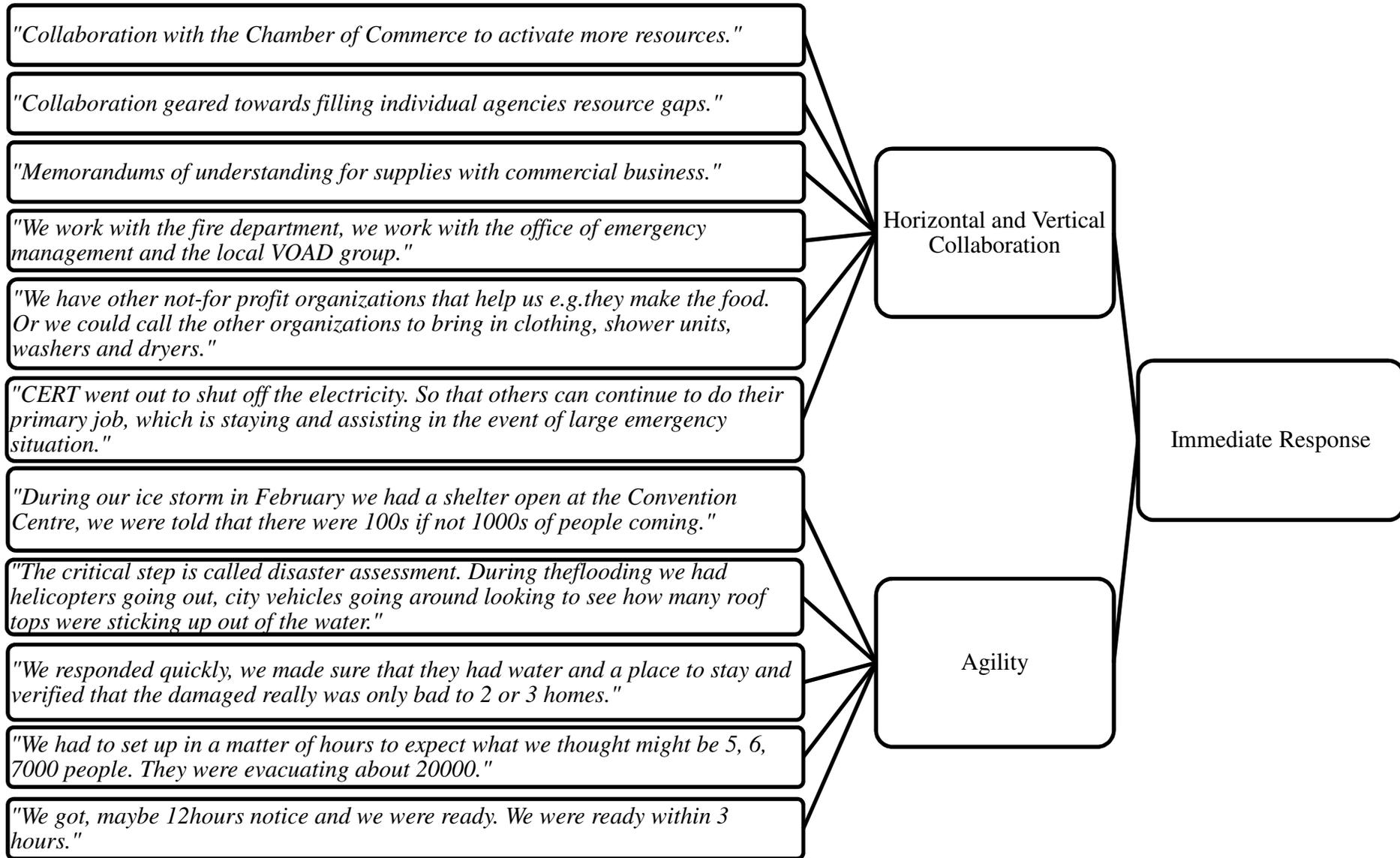


Figure 3 Coding Tree Part II

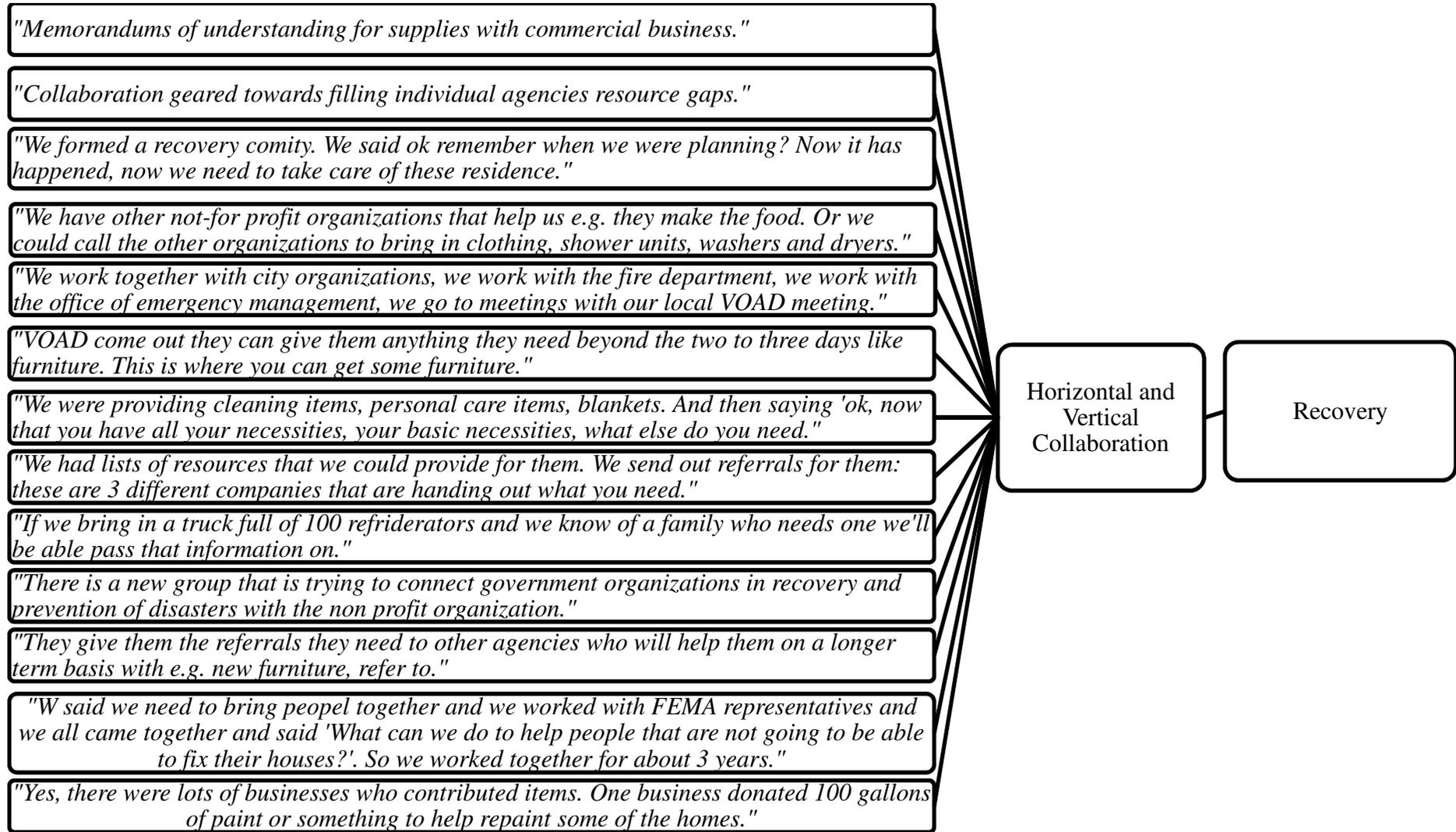


Figure 4 Coding Tree Part III

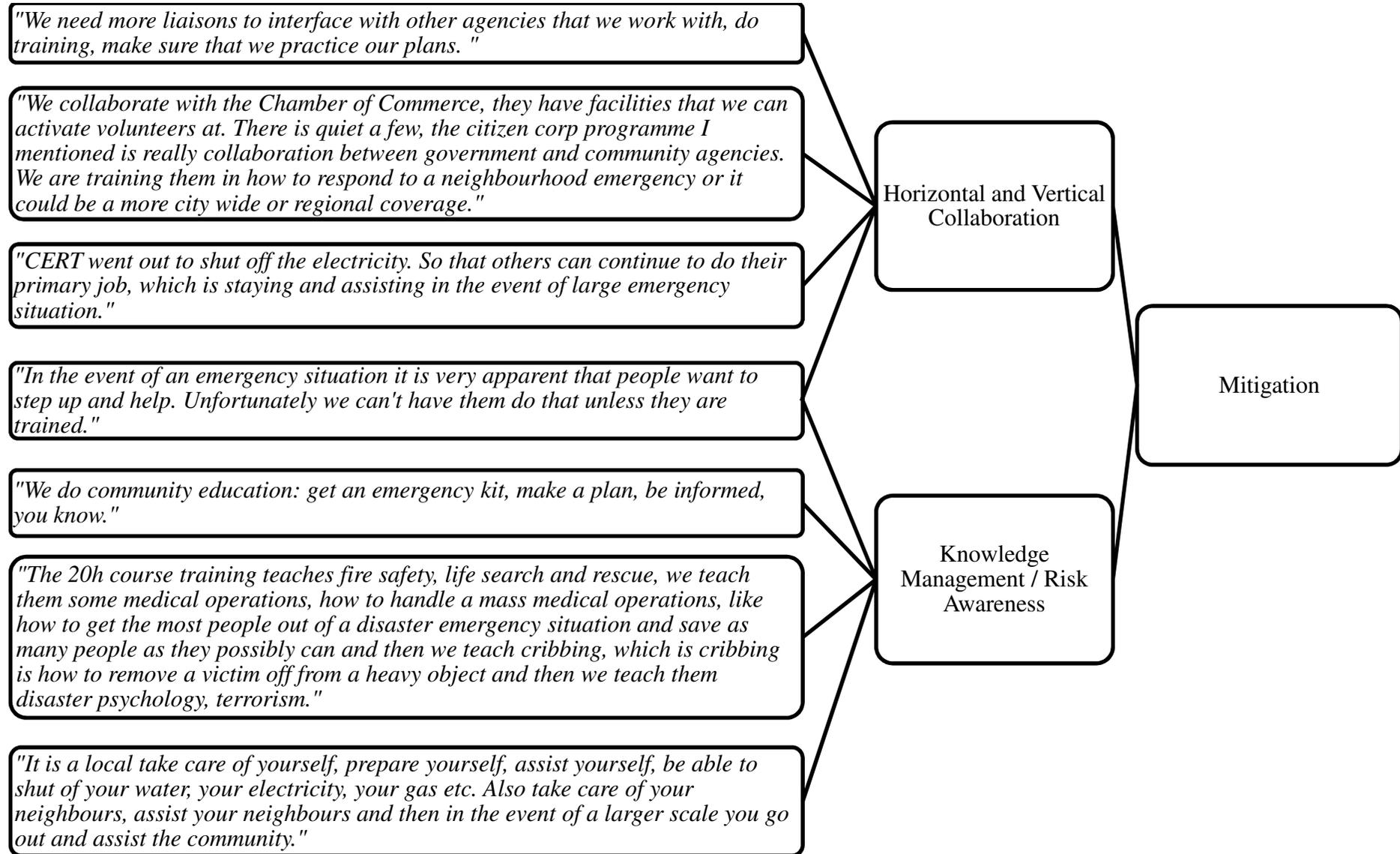


Figure 5 Coding Tree Part IV