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Managing supply chains in times of crisis: a review of literature and insights

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Abstract

Purpose – The purpose of this paper is to review the literature to describe the current practices and research trends in managing supply chains in crisis. This paper also provides directions for future research in supply chain crisis management.

Design/methodology/approach – Articles published prior to August 2008 are analyzed and classified.

Findings – A unique five-dimensional framework to classify the literature is provided. The study reveals that there has been extensive research done in this area in recent years. Much of the research is focused on proactive approaches to crisis in supply chains. Management during various internal crises such as supplier bankruptcy or loss of key clients is a new, challenging area that requires further investigation.

Research limitations/implications – This paper does not include articles that are not peer-reviewed.

Practical implications – This paper will serve as a guide to supply chain managers who would like to know how crises, disasters, and disruptions in supply chains have been handled in existing academic literature.

Originality/value – To the best of the authors' knowledge, this is the first literature review in the area of managing supply chains during crisis that looks at both SCM and operations research/management science journals. This paper identifies the various methods that have been used to handle crisis situations and provides a framework to classify the literature. Additionally, this paper identifies gaps in the literature that can provide ideas for future research in this area.

Keywords Supply chain management, Disasters, Government policy

Paper type Literature review

1. Introduction

Many operations management principles and methods, such as project management and optimization techniques like linear programming, have their roots in military and government-related activities. Owing to lack of supply alternatives during crisis times, the inventory management principles used in military and government organizations are based on "just in case" philosophies, but supply chains today have moved far from this philosophy. Over the last three decades, the economic emphasis on speed and efficiency has caused members of supply chains to adopt concepts like "just in time," "build to order," and "vendor managed inventories." As a result, supply chains today

The authors would like to thank Drs William Sawaya and Manoj Vanajakumari and the reviewers for their comments that helped to improve this paper.

International Journal of Physical Distribution & Logistics Management
Vol. 39 No. 7, 2009
pp. 535-573

0960-0035
DOI 10.1108/09600030910996251

have become leaner and more profitable since the capital previously locked in inventory is instead available for other profitable activities (Martha and Subbakrishna, 2002). At the same time, supply chains have become more global, resulting in longer lead times. The onset of business trends such as reduction of suppliers, lead time, inventory, and product life cycle, as well as the increased use of outsourcing on long global supply chains, has increased the risks in supply chains, making them more vulnerable to crisis (Norrman and Jansson, 2004). Crises not only affect the flow of goods in the supply chain, but also have a huge impact on its stockholder wealth (Hendricks and Singhal, 2005).

In recent years, there have been several instances of disruptions in the supply chains. Some of them were due to natural disasters, such as the earthquake in Taiwan that affected PC manufactures like Dell and Apple in 1999; hurricane Mitch that destroyed banana plantations, thus affecting supply chains like Dole in 1998; and hurricane Floyd that flooded the Daimler-Chrysler plant in Greenville in 1999. Other disruptions were caused by epidemics, like the outbreak of mad-cow disease that caused a shortage of leather goods in Europe in 2001 and the outbreak of SARS that impacted the IT supply chains in 2003. And some resulted from man-made disasters, like the fire accident at the electronics plant in Albuquerque, New Mexico, which caused $400 million in lost sales at Ericsson; longshoreman strikes at US ports in 2002, which caused an estimated $11 to 22 billion in lost sales; and terrorist actions like 9/11 that crippled transportation networks across the USA. These disruptions have led to a flurry of research activities on how to manage supply chains during times of crisis (Sheffi, 2001; Martha and Subbakrishna, 2002; Monahan *et al.*, 2003; Norrman and Jansson, 2004; Hale and Moberg, 2005).

The present work complements two previous studies by Altay and Green (2006) and Paulsson (2004). Altay and Green (2006) provide an excellent review of the use of operations research (OR) and management science (MS) models for managing supply chains during a disaster. However, they do not include logistics and supply chain management journals, such as *Journal of Business Logistics*, *International Journal of Physical Distribution & Logistics Management (IJPDLM)*, *International Journal of Logistics Management*, and *Supply Chain Management Review*. Moreover, the review by Altay and Green (2006) is almost four years old and does not include any empirical and applied studies in this area. The empirical and applied studies are important as they demonstrate practical quick fixes or solution methodologies that are easy to implement. Paulsson (2004) provides another review of risk management in supply chains. While a few supply chain management journals are included in his study, it is still five-years old (the latest paper in the literature review was published in 2003). Moreover, Paulsson's research is on developing a risk management model, disruption risks in supply chain, for private sector, and it concentrates more on these for-profit supply chains and does not include the research on humanitarian supply chains. Researchers like van Wassenhove (2006) have called for more collaboration between humanitarian and private sector supply chain research. He points out that private sector and humanitarian supply chains have different core competencies. The private sector's core competency lies in efficiently managing its supply chains, while the humanitarian supply chains' competency lies in being agile, adaptable, and better prepared for crisis. Moreover, much more research has been published in recent years following such disasters as the 2001 terrorist attack on the World Trade Center and the 2004 tsunami in the Indian Ocean.

The objectives of this study are to provide a framework for classifying supply chain management literature in crisis management and to identify current and future research directions in this field. In addition, by extending the scope of literature review beyond OR/MS journals, this paper will not only be a resource to academicians but also to practitioners who are looking for best practices in academic literature for managing disruptions in supply chains. This study also includes empirical and applied case studies in supply chain crisis management.

The rest of the paper is organized as follows: Section 2 provides a definition of what constitutes crisis in a supply chain, Section 3 describes how knowledge regarding the state of the art research in managing crisis in supply chains was obtained, Section 4 explains the classification framework, Section 5 classifies the extant literature based on the framework, and Section 6 summarizes the current state of literature and provides insight on areas that need more consideration.

2. Crisis in supply chains

According to Merriam-Webster, crisis is defined as "an unstable or crucial time or state of affairs in which a decisive change is impending; especially: one with the distinct possibility of a highly undesirable outcome." In a supply chain, crisis occurs when one or more supply chain members' activities are interrupted, resulting in a major disruption of the normal flow of goods or services. The magnitude of the effect of a crisis is based on numerous factors and varies with each occurrence.

Although crisis in a supply chain is unpredictable, it may not be unexpected (Coombs, 1999). The process of making proactive decisions to avoid the crisis and reactive decisions in overcoming it is called crisis management. The decisions involved in managing crises caused by natural disasters and man-made disasters are well defined by many government and non-profit organizations, such as the International Federations of Red Cross (IFRC). IFRC classifies an event as a disaster if that event is:

> [. . .] a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources.

IFRC has five main categories of disasters: natural (e.g. droughts), hydro meteorological (e.g. floods), technical (e.g. industrial accidents such as chemical explosions, nuclear explosions, and accidental release of some hazardous material), geological (e.g. earthquakes), and human related (e.g. epidemics and population movement). For further details and definitions on these disaster types, readers are referred to the IFRC web site (www.ifrc.org).

The handbook by the Federal Emergency Management Agency (FEMA), titled *FEMA: Emergency Management Guide for Business and Industry*, provides directions for planning, response and recovery for organizations affected by disasters. Helferich and Cook (2002) provide a comprehensive five-stage disaster management process by adding two more stages, mitigation and detection, to the list proposed by FEMA. They also classify the source of disaster by three dimensions:

(1) cause (intentional, natural, or accidental);

(2) magnitude; and

(3) nature of impact on supply chains.

Though prior research indicates crisis management is actively deployed by government agencies, being prepared to handle crises is also important to companies and businesses. Mitroff (1988) surveyed a broad section of US industries and found that only 38 of the 114 respondents (33 percent) had a crisis management unit within their organization at that time. However, a survey done in 2004 by the American Management Association showed that 61 percent of respondents (174 companies) had a crisis management plan. These statistics show that the importance of crisis management in industries has increased significantly over the past two decades.

3. Research methodology

This study focuses on academic peer-reviewed journals and case publications in supply chain management literature. Apart from using databases such as ProQuest, ABI/Inform, EBSCO, and ScienceDirect, we searched for articles in supply chain management, logistics, management science, and OR journals. We used an expanded set of keywords to search the literature, specifically "crisis," "risks," "disaster," "uncertainty," "emergency," "disruption," and "catastrophe," as well as their extensions, such as "crisis management," "risk management," "disastrous," and "catastrophic."

In 2002, the Council of Logistics Management (now known as Council of Supply Chain Management Professionals) published a report prepared by Helferich and Cook on securing the supply chain. In this report, the authors review a large body of research in practitioner and trade journals along with reports by government funded agencies such as FEMA and the World Health Organization. Those articles are beyond the scope of this research since they are not peer-reviewed. We ask the readers to refer to Helferich and Cook's (2002) report for those publications.

Careful scanning of the resulting literature showed that many articles dealt with operational and local issues that did not amount to supply chain crisis. After eliminating those articles, our search resulted in 118 articles in 48 journals. Even though all authors reviewed the initial search results independently, there is some subjectivity involved in deciding which articles actually cover something that constitutes crisis management in supply chains. For example, a dynamic facility location problem with emergency services like fire companies or inventory optimization studies under supply and demand uncertainties would not qualify as research in crisis management.

Tables I and II list the chosen articles by journal title and country where the first author works in. Of the 118 articles, 63 are from main-stream supply chains and OR journals, and 24 are from peer-reviewed business journals such as *Harvard Business Review*, *MIT Sloan Management Review*, and *Business Horizons*. The *IJPDLM* leads the listing with the most articles published on crisis in supply chain management. These results are in line with Paulsson (2004), but his study did not include as many OR/MS and business journals.

As mentioned previously, Altay and Green's (2006) review studies OR/MS literature exclusively; as a result, six of the top seven journals listed in Table I are not featured in their review. The distribution of the primary author's work-country shows that the USA and Europe lead the pack in discovering new avenues for managing crisis in supply chain management. This trend is also seen in previous studies (Altay and Green, 2006; Paulsson, 2004).

Figure 1 shows the distribution of the crisis management in supply chains literature by year. We can see a steep increase in the number of articles in the last six years,

Journal	No. of articles
IJPDLM	14
Interfaces	11
European Journal of Operational Research	8
Harvard Business Review	8
Supply Chain Management Review	8
MIT Sloan Management Review	7
Journal of Business Logistics	4
Journal of the Operational Research Society	4
Naval Research Logistics	4
Annals of Operations Research	3
Computers & Industrial Engineering	3
International Journal of Production Economics	3
International Journal of Logistics Management	2
Journal of Business Continuity & Emergency Planning	2
Management Science	2
Operations Research	2
Transportation Science	2
Acta Mathematica Scientia	1
Administrative Theory & Praxis	1
American Business Review	1
Business Horizons	1
Business Process Management Journal	1
Computers & Operations Research	1
Computers in Industry	1
Disaster Prevention and Management	1
Expert Systems with Applications	1
Food Policy	1
International Journal of Production Research	1
International Review for Environmental Strategies	1
Journal of Management Studies	1
Journal of Marketing Channels	1
Journal of Risk Research	1
Journal of Services Marketing	1
Journal of Supply Chain Management	1
Leadership & Organization Development Journal	1
Manufacturing and Service Operations Management	1
Oxford Development Studies	1
Physica A: Statistical Mechanics and its Applications	1
Policy Studies Review	1
Production and Operations Management Journal	1
Progress in Development Studies	1
Singapore Management Review	1
Social Marketing Quarterly	1
Southern Business Review	1
The Academy of Management Executive	1
The Business Review	1
The Executive	1
Third World Quarterly	1

Table I.
Articles published – categorized by journal

	No. of articles
Asia	*12*
China	4
India	1
Korea	1
Malaysia	1
Singapore	5
Australia	*2*
Australia	1
New Zealand	1
Europe	*20*
Finland	2
France	1
Germany	3
The Netherlands	1
Sweden	3
Switzerland	1
Turkey	2
UK	7
North America	*83*
Canada	4
USA	79
South America	*1*
Brazil	1
Grand total	118

Note: The country in which first author's workplace is located

Table II.
Articles published – categorized by country

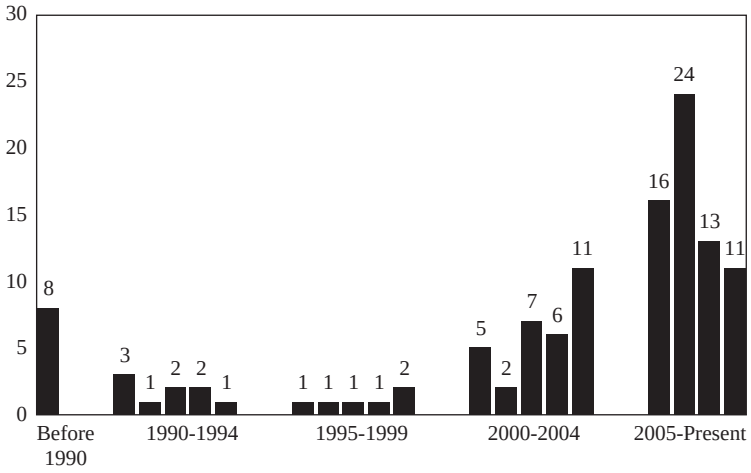

Figure 1.
Articles published by year

especially after events like 9/11, the 2004 Tsunami, and Hurricane Katrina. The last column represents the articles published in the first half of 2008.

4. Classification

The authors develop a unique classification framework for supply chain crisis management literature based on five factors: source, stage, scale, respondent, and the scientific research method employed to address the crisis. The full, detailed classification scheme is shown in Figure 2. Each of these factors and their attributes are explained in detail below.

4.1 Source of crisis

In supply chain literature, the sources of a crisis are commonly referred to as "risks." Paulsson (2007) defines risks that endanger an organization in a schematic way, known as "circle of risks." The circle of risks is divided into two parts. One part represents operational or static risks that exist within the product flow, and the other includes dynamic risks found outside the product flow, such as inflation, new laws, and terrorism. Juttner *et al.* (2002) classify risks in supply chain into three categories: internal, external, and network related. Production, labor, and IT-related incidents are classified as internal risks; political, natural, social, and market risks are classified as external risks; and risks that arise due to interaction between the organizations in the supply chain are classified as network related risks.

Wu *et al.* (2006) propose an internal/external factor-based classification for inbound supply risk. The authors follow a similar categorization and divide the sources for crises into two categories: internal and external. The main difference between our research and Wu *et al.* (2006) is the scope. While Wu *et al.* (2006) deal with inbound supply risk from a single company's perspective, the authors consider the overall supply chain, which results in different internal/external factor classification. For instance, Wu *et al.* (2006) consider a problem with a supplier as an external factor,

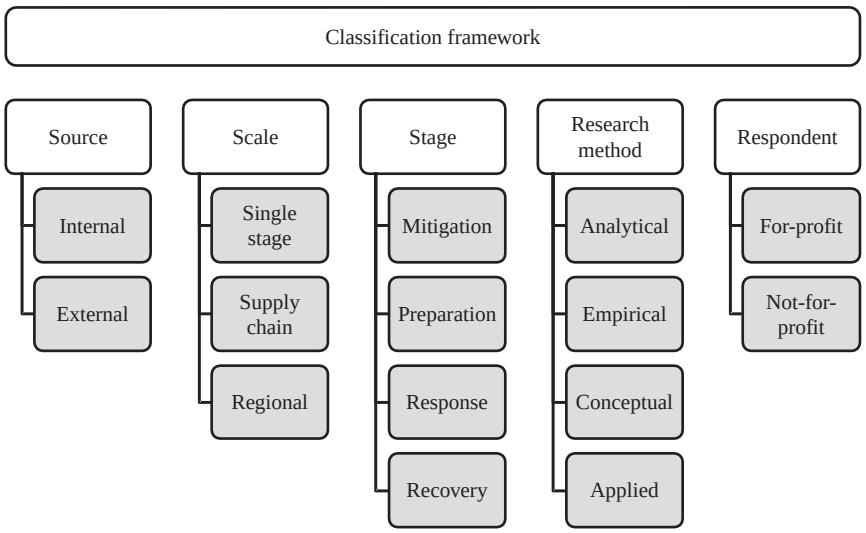

Figure 2.
Classification framework

whereas in our consideration, this could be either an internal factor (e.g. machine breakdown due to the lack of preventive maintenance) or an external factor (e.g. damage at the suppliers' facility due to an earthquake). In the following few paragraphs, the authors provide more details regarding the sources of crises.

Crises that are caused by the supply chain operating environment are classified under external sources. Some examples of external sources are disasters (both man-made and natural), market, economy, and legal/regulatory/political issues together with some other miscellaneous factors such as criminal acts and infrastructure.

The authors consider an event as a disaster based on the IFRC's definition – as discussed in Section 2. External sources such as market and economic factors are very common in today's business climate. Recent increases in the commodity and oil prices in addition to the devaluation of the US dollar have caused several companies to alter their procurement and distribution strategies. If the price of oil reaches $200 a barrel, the cost of shipping a container from Shanghai, China, to Los Angeles, California, would be $15,000, up from $3,000 in the year 2000. The current high gas prices have already caused several establishments to rethink their far-flung supply networks (*USA Today*, 2008). Legal and regulatory crisis occurs when regulators change or impose new laws that affect supply chains negatively. Although political crisis could be a reason for legal and regulatory changes, it has a broader definition. Root (1972) defines political crisis as:

> [. . .] possible occurrence of a political event of any kind (such as war, revolution, coup d'état, expropriation, taxation, devaluation, exchange control and import restrictions) at home or abroad that cause a loss of profit and/or assets in an international business operation.

The authors also consider nationalization as a part of political risk. The final group consists of miscellaneous external factors that affect supply chains, such as criminal acts and infrastructure related factors.

In addition to external sources of crisis, there are many internal sources of crisis that affect supply chains. The internal sources could be employee-related (e.g. worker strike); criminal-related (e.g. fraud, sabotage, and corporate espionage); infrastructure related (e.g. industrial accidents); product related (e.g. recalls); IT related (e.g. computer networks crashing); or finance related (e.g. supplier bankruptcy). Note that some of these internal factors can also be considered as external factors. The authors provide more details on how to differentiate internal and external factors below.

It is clear that finding the true source of a crisis can be very difficult in some cases and may require a judgment call. In addition, for some cases, the source of crisis could be a combination of internal and external factors. While classifying the research, the authors asked the following question to find the source of crisis: "What is the cause of crisis?" Clearly, this question does not consider the place that crisis occurs. So, the objective is identifying the underlying causes for crisis rather than where crisis occurs. For example, the source of crisis for criminal acts can be internal, external, or both. If someone within the supply chain is involved in a criminal act without an external factor's existence, it is an internal source. On the other hand, if the person is not part of the supply chain (e.g. a hacker hacking into the computer system), the source is an external factor. Finally, if the hacker's success was because of a lack of an existing computer security system, then sources are both internal (not having a proper security system) and external (hacker hacking into a computer system).

As a more specific example, let us look at the fire accident at the Ericsson's supplier (Phillips) plant in New Mexico. Though the fire accident was caused by lightening, an external factor, the source of crisis can also be classified as an internal factor. The reason for internal classification is Ericsson's lack of crisis preparation and inability to respond to crisis rapidly. For instance, Nokia was using the same facility for its products; however, immediately after the accident, Nokia tied up spare capacities at the other Phillips' facilities and also renewed some of its products so that chips from other manufacturers could be used (Eglin, 2003). Therefore, the source of crisis is classified as both internal (poor supply chain management) and external (lightening) for this case.

The supply and demand uncertainty, which has been well researched (Tang, 2006) in OR literature is not classified as a source of crisis in our research. Instead, the authors classify based on the source that is causing the supply or demand uncertainty.

4.2 Scale of crisis

The authors define three categories for the scale of a crisis based on its geographical scope. The different categories are single stage (or company), supply chain, and regional. Helferich and Cook (2002) include additional factors, such as duration and frequency of crisis, in their classification. However, as duration and frequency are not available in academic literature, the authors restrict their classification only to the geographical scope of the crisis. The crisis that affects just a single organization or member of the supply chain is classified as having a single stage scale. There are other crises that affect the entire supply chain and some that affect the whole region. The authors classify all these crises that do not limit their effects just to the supply chain as regional crises. Examples of such crises would be earthquakes, hurricanes, and terrorist attacks, in which the effects are felt at a regional (national or global) level, not just within the supply chain. It is clear that almost all natural disasters are large-scale events that affect thousands of people's lives and all supply chains that operate within. Note that the same kind of disasters or events may not result in the same outcomes. For example, a magnitude 7.2 earthquake in Japan in 2008 resulted in 12 deaths, whereas the same magnitude earthquake in Turkey in 1999 caused more than 25,000 casualties. Thus, effect of a crisis can be significantly reduced by planning.

4.3 Stage of crisis management

The authors classify the literature based on the level of crisis management in the supply chain. The four primary stages are mitigation, preparedness, response, and recovery. Although there has been a consensus lately regarding the classification of crisis (disaster) management, there are still many different approaches in terms of classifying activities related to crisis management. Many researchers (Mushkatel and Weschler, 1985; Waugh, 2000; Altay and Green, 2006) accept a four-phase comprehensive approach proposed by the Center for Policy Research for the National Governors' Association (National Governors' Association, 1978). The report proposing this approach coincided with the establishment of FEMA in the USA in 1979. The four-phase approach proposed in the *Emergency Preparedness Project: Final Report* consists of the following stages: mitigation, preparedness, response, and recovery.

Mitigation is assessing possible sources of crisis and identifying sets of activities to reduce and/or eliminate those sources so that crisis never happens or its impact is reduced. Preparedness is developing a crisis response plan and training all the involved parties so that in the case of a crisis people know their roles and will effectively be able to

deal with it. Mitigation and preparedness are crucially important to eliminate or reduce the damage caused by disasters. These two stages lead to proactive decisions in crisis management. For example, as discussed previously, Japan and Turkey had the same magnitude earthquakes, but while more than 25,000 people lost their lives in Turkey, only 12 people died in Japan. The reason for this enormous difference is Japan's proactiveness. Since Japan is prone to destructive earthquakes, its buildings are specifically reinforced against earthquakes of high magnitudes, whereas Turkey has not taken the same proactive approach to mitigate the effects of earthquakes.

Figure 3 shows the degree to which a crisis can affect an organization with and without a crisis management plan. The bold black line shows the impact the crisis has on an organization that does not have a structured crisis management plan. The dotted line below it shows that the impact is reduced in companies that have a plan.

A good crisis management plan also has a clear plan for responding to crisis. Response constitutes the set of immediate actions taken after a crisis occurs, and it aims to reduce the impact by utilizing the plans created during the preparedness stage. A very effective first response also helps to reduce problems that will be encountered during the recovery stage. Recovery is the final set of activities that deals with crisis in the long run. The objective during the recovery stage is to support all involved parties until they resume their normal operations. These two stages constitute reactive decisions in crisis management.

In addition to the four-stage approach provided in the *Emergency Preparedness Project: Final Report*, there are other four-phase approaches, such as the one proposed by Boin and Hart (2003). The authors use prevention and reconstruction instead of mitigation and recovery. However, there are no significant differences between these two classifications. Helferich and Cook (2002) add an additional stage of detection between proactive and reactive decisions, making their approach a five-stage process. In academic supply chain management literature, detection is rarely referred to as a phase, and hence, the authors choose to employ the four-stage emergency management approach for classifying supply chain crisis management literature.

4.4 Scientific research method used

Next, the authors classify the literature in supply chain crisis management based on the scientific research method used in the paper. The authors consider the following categories: conceptual, analytical, empirical, and applied research. Under the conceptual work,

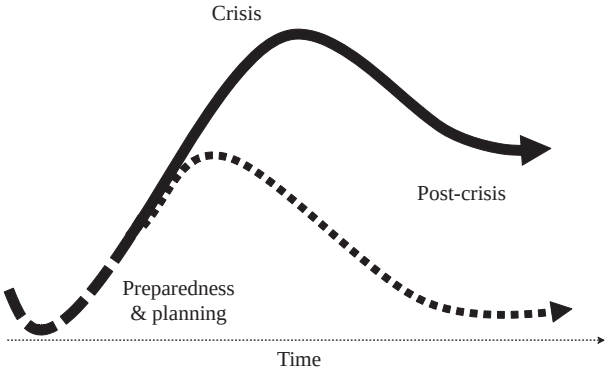

Figure 3.
Effects of crisis management

the authors consider articles that propose a new method, technique, or approach to crisis management. These methods or approaches are not justified with any additional work such as modeling, case study, or empirical research. The authors also classify articles that provide a literature review as conceptual research. Research methods such as simulation and mathematical modeling fall under the analytical research category. Under empirical work, researchers collect data and observations and evaluate the collected information. Case studies, opinions, and interviews are classified under the applied research category.

4.5 Respondent to crisis

The last attribute of classification is based on the parties involved in or responding to the crisis. The authors define two different parties: not-for-profit organizations and for-profit organizations. Not-for-profit organizations include both government entities and non-governmental organizations, such as IFRC. All of the humanitarian supply chain literature falls under the not-for-profit organization category. There are differences between not-for-profit and for-profit organizations' supply chains, and Whybark (2007) points out these differences in procurement, storage and distribution of products in humanitarian and enterprise (for-profit) supply chains.

5. Analysis and discussions

In the surveyed literature, there is more research that has been done for crisis caused by external sources. More than 60 percent of the articles surveyed deal exclusively with crisis caused by sources external to the supply chain. The most common ones are the natural and man-made disasters. For example, Hale and Moberg (2005) discuss different types of disasters (e.g. terrorist attacks, natural disasters, and regional power outages) and propose a model to select a number of locations to store critical emergency resources. Similarly, Sheffi (2001) also looks at terrorist attacks (i.e. 9/11) and then discusses the supply chain management under increased uncertainty. The author suggests that companies need to cooperate with the government and create surplus capacity to be able to cope with such situations in the future. Researchers like Barbarosoglu *et al.* (2002) and Kovacs and Spens (2007) focus on humanitarian logistics activities during incidents of natural disasters. Barbarosoglu *et al.* (2002) propose a model to efficiently deploy helicopters to the disastrous area during relief operations, while the study by Kovacs and Spens (2007) approaches humanitarian relief operations from the conceptual side. The authors suggest that disaster relief logistics should learn from business logistics, and they provide a framework for disaster relief operations.

The research on crises caused by internal sources is considerably less because the authors have not included all the research on risk management in supply chains. The premise behind this is that not all risk results in a crisis, disaster, or disruption in the supply chain. For example, Parlar (1997) talks about inventory optimization under supply interruptions. This clearly falls under the category of risk management but not crisis management in supply chains. On the other hand, work by Weiss and Rosenthal (1992) is considered as crisis management since the authors consider strikes (i.e. a strike at the source of supply, a strike by the shipping firm, or a strike at the demand point) as the cause for disruption. A detailed breakdown of cause of crisis under each category is listed in Table AI in the Appendix.

As illustrated in Table III, most of the researchers look either at a crisis that affects a supply chain or one that affects a region. Based on data collected, 48 out of 118

Category	Count	Percentage
I. Based on source of crisis		
External	74	63
Internal	20	17
Internal/external	24	20
II. Based on scale of crisis		
Supply chain	48	41
Regional	48	41
Single stage	16	14
Supply chain/regional	3	3
All	2	2
Single stage/supply chain	1	1
III. Based on stage of crisis		
Preparedness	27	23
Mitigation	20	17
Mitigation/preparedness	19	16
Response	18	15
All	11	9
Response/recovery	6	5
Preparedness/response	6	5
Recovery	5	4
Preparedness/response/recovery	3	3
Mitigation/response	2	2
Mitigation/preparedness/response	1	1
IV. Based on scientific research method of crisis		
Analytical	45	38
Conceptual	36	31
Applied	26	22
Empirical	11	9
V. Based on respondent to crisis		
For-profit	75	64
Not-for-profit	43	36

Table III.
Summary statistics of supply chain crisis management literature based on proposed classification framework

(41 percent) of the reviewed articles consider a supply chain, and 48 articles (40 percent) cover a crisis related to a region. The authors classify any crisis that has its effect beyond the supply chain as regional. This category of research includes articles related to both regional problems, such as Perry (2007), and global problems, such as Lui *et al.* (1999).

Table III shows that many researchers look at a single entity (e.g. a company) and evaluate disasters from this single entity's perspective. Yang *et al.* (2005) consider a production problem where a single manufacturing plant tries to recover after a disruption such as market change, machine breakdown, power failure, or worker no-show. The authors propose a mathematical model using dynamic programming. Long and Wood (1995), Smith (2005), Midanek (2003) and Seville *et al.* (2008) are examples of those researchers who consider both supply chain and regional level crisis at the same time.

As is shown in Figure 1, the number of articles dealing with supply chain crisis published in peer-reviewed journals has tripled since 2004. Initially, the authors see that researchers focused on studying each of these stages (i.e. mitigation, preparedness, response, and recovery) individually. For example, Hershey (1975), one of the early articles in the area of disaster management, only considers planning (preparedness).

However, this trend has changed, and the authors now observe an increase in research focusing on studying a combination of these stages.

Only two articles dealing with all stages were published before 2004, while nine have been published since 2004. The number of articles published have more than doubled. This depicts the shift from research focusing on individual stages of planning to the planning for all stages of the crisis simultaneously. For example, Herzog (2007) proposes a theoretical framework-based approach to deal with natural disasters. The author suggests that there is a "management" stage between planning (preparedness) and response and uses public administration theory in disaster management.

The authors also see more research on proactive stages like preparation and mitigation rather than on response and recovery. This reinforces the findings by Billa *et al.* (2006) and Wright *et al.* (2006). There is not much research done in examining recovery of a supply chain from a crisis. This needs to be looked into, as the recovery stage details the plans for getting back to normal operations. Three years after Hurricane Katrina, life has not returned to normal in New Orleans, Louisiana. This shows how recovery from a disaster is challenging, even with support from local and national organizations. Therefore, more analysis and research that concentrates on recovery planning is needed.

There has been limited empirical study done examining how supply chain managers plan to handle crises (Spillan and Crandall, 2002), how they have handled crises in the past (Gorton *et al.*, 2006), or how a crisis affects a community (Spillan and Crandall, 2002), but there has been a lot of analytical research done using OR/MS techniques. There are also many applied research articles describing various crises scenarios. However, further research on developing scales for the level of crisis management, robustness of supply chains, and supply chain resilience are required.

The literature on crisis management for not-for-profit organizations is almost half as much as the literature on crisis management for for-profit organizations. Non-profit organization supply chains generally deal with disasters, and the majority of the literature deals only with analytical models. There is a need for more case studies and empirical research in crisis management for not-for-profit supply chains.

Most of the research that has been analyzed looks at supply chain management from a perspective of a single member. A more comprehensive study on a granular level supply chain planning for crisis is the need of the hour. Though complex, a study that can provide insight on how a crisis affects an entire region, the supply chain(s) in the region, and each entity in the supply chain is a feasible one. The study should prescribe scenarios/actions/tasks that will help each member of the region to handle adverse situations.

Many of the models and solutions developed in the literature are very specific to the crisis situation, like location of disaster recovery centers, power restoration and scheduling of vehicles such as helicopters (Dekle *et al.*, 2005; Sarker *et al.*, 1996; Barbarosoglu *et al.*, 2002). On the other hand, only a few tools and strategies that help in preparing and evaluating the crisis management capability of a company have been developed in the supply chain literature. Table IV provides the list and summary of some of these articles.

Based on the review, the authors see that most of the research done has been on managing crises that arise from sources external to the supply chain, especially natural disasters. It will be very useful for researchers to look at supply chain management during crises that arise from internal sources to the supply chain (e.g. executive fraud, corporate espionage, etc.). The authors also see that the majority of the research looks at crises affecting a region or just a single supply chain. Research examining how the

Authors	Supply chain studied	Practical implications of the study
Faisal *et al.* (2006)	Small and midsized companies in India	Proposes an interpretive structural modeling-based framework to develop hierarchy of variables that would help to mitigate risks in manufacturing supply chains
Svensson (2000)	Automotive industry (Volvo), furniture industry, retail industry and industry of pre-manufactured houses	Develops and tests a framework for analyzing the vulnerability of supply chains especially on the inbound logistic flow to manufacturers. The vulnerability analyzed has two dimensions – categories of disturbance and sources of disturbance
Kumar and Stecke (2008)	General industries	Provides mitigation strategies for the various causes of crisis in the supply chain
Norrman and Jansson (2004)	Ericsson	Provides details of the supply chain risk assessment framework, risk management evaluation tool and management program developed at Ericsson following the "Albuquerque accident"
Roberto *et al.* (2006)	NASA	Provides a simple questionnaire that can be used to understand whether an organization spends too much of its time reacting to emergencies or has built a capability for detecting and responding to threats
van der Vorst and Beulens (2002)	Food supply chain	Provides a valuable tool that can be used in supply chain redesign projects. The tool indicates potential and effective redesign strategies when a specific source of uncertainty is encountered in a supply chain
Wu *et al.* (2006)	US PC manufacturer	Presents a new risk classification scheme and its implementation architecture. The scheme is implemented at a US PC manufacturer

Table IV.
Summary of practical implications of supply chain crisis management literature

effect of a macro crisis at several levels can be reduced is needed. Another significant observation is that several researchers have looked at how to prepare for a crisis, but not many have looked at how to plan for recovery of a supply chain or how to return it to its normal mode of operation following a crisis. As van Wassenhove (2006) points out, there is a need for more research in the areas of non-profit organizations and humanitarian organizations. There are many examples of how crises in supply chains have been managed, but specific details through case studies are not available. It will be beneficial for academicians and practitioners to have access to that knowledge.

6. Conclusion

The number of occurrences of disastrous situations has been increasing over the years; therefore, there is a great need for researchers and practitioners worldwide to plan ahead for such situations. This paper has drawn on literature that uses math models on how to solve problems, survey results on how a situation was handled, real-world case studies, and expert opinions on facing and dealing with crises. The authors see that many researchers have concentrated on handling natural and man-made disasters. This has been spurred due to the recent tsunamis, hurricanes, pandemic disease threats, and terrorist attacks around the world. Research that can help managers and practitioners to

solve crises that arise internally within the supply chain needs more attention. Supply chain professionals are looking for tools to manage supply chains during situations such as bad acquisitions, supplier bankruptcy, worker strike, etc. Given the state-of-the-art of research in the field of managing supply chains during crisis, there are many research areas that needs further investigation, such as recovery planning and scales for crisis management. The authors hope this literature review provides the future researchers with a head start in conducting their studies in supply chain crisis management.

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(The Appendix table follows overleaf.)

Appendix

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
1	*Acta Mathematica Scientia*	Disruption management for supply chain coordination with exponential demand function	Chongchao *et al.* (2006)	External	Market	Supply chain	Response	Analytical	China, Australia and USA
2	*Administrative Theory & Praxis*	A model of natural disaster administration: naming and framing theory and reality	Herzog (2007)	External	Natural disaster	Regional	All	Conceptual	USA
3	*American Business Review*	Impact of the Asian economic crisis on US joint ventures	Chan and Timsawat (2000)	External	Economic	Regional	Response/ recovery	Applied	USA
4	*Annals of Operations Research*	A hypercube queueing model embedded into a genetic algorithm for ambulance deployment on highways	Iannoni *et al.* (2008)	External	Man-made disaster	Supply chain	Response	Analytical	Brazil and USA
5	*Annals of Operations Research*	Computerized support systems for emergency decision making	Jianshe *et al.* (1994)	Internal/ external	General	Supply chain	Response	Analytical	China
6	*Annals of Operations Research*	Emergency logistics planning in natural disasters	Ozdamar *et al.* (2004)	External	Man-made/ natural disaster	Regional	Response	Analytical	Singapore and Turkey
7	*Business Horizons*	The management of organizational crises	Ford (1981)	Internal/ external	General	Single stage	Mitigation/ response	Conceptual	USA

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
8	*Business Process Management Journal*	Supply chain risk mitigation: modeling the enablers	Faisal *et al.* (2006)	Internal/ external	General	Supply chain	Mitigation	Analytical	India
9	*Computers & Operations Research*	Real-time supply chain control via multi-agent adjustable autonomy	Lau *et al.* (2008)	External	Man-made disaster	Supply chain	Response	Applied	Singapore
10	*Computers & Industrial Engineering*	A food distribution model for famine relief	Hwang (1999)	External	Man-made/ natural disaster	Regional	Response	Analytical	Korea
11	*Computers & Industrial Engineering*	Artificial neural network based predictive method for flood disaster	Wei *et al.* (2002)	External	Natural disaster	Regional	Mitigation	Analytical	China and Taiwan
12	*Computers & Industrial Engineering*	Power restoration in emergency situations	Sarker *et al.* (1996)	External	Natural disaster	Regional	Response	Analytical	USA
13	*Computers in Industry*	A model for inbound supply risk analysis	Wu *et al.* (2006)	Internal/ external	General	Supply chain	Mitigation/ response	Analytical	USA
14	*Disaster Prevention and Management*	Comprehensive planning and the role of SDSS in flood disaster management in Malaysia	Billa *et al.* (2006)	External	Natural disaster	Regional	Response	Analytical	Malaysia
15	*European Journal of Operational Research*	A dynamic logistics coordination model for evacuation and support in disaster response activities	Yi and Ozdamar (2007)	External	Man-made/ natural disaster	Regional	Response	Analytical	Singapore and Turkey

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
16	*European Journal of Operational Research*	A stochastic model for risk management in global supply chain networks	Goh *et al.* (2007)	Internal/ external	General	Supply chain	Mitigation	Analytical	Singapore
17	*European Journal of Operational Research*	An interactive approach for hierarchical analysis of helicopter logistics in disaster relief operations	Barbarosoglu *et al.* (2002)	External	General	Regional	Response	Analytical	Turkey
18	*European Journal of Operational Research*	Optimal ordering policies when anticipating a disruption in supply or demand	Weiss and Rosenthal (1992)	Internal	Employee related	Supply chain	Preparedness	Analytical	USA
19	*European Journal of Operational Research*	OR/MS research in disaster operations management	Altay and Green (2006)	External	Man-made/ natural disaster	All	All	Conceptual	USA
20	*European Journal of Operational Research*	Supply chain disruption management and evolutionarily stable strategies of retailers in the quantity-setting duopoly situation with homogeneous goods	Xiao and Yu (2006)	Internal/ external	Product Related	Supply chain	Recovery	Analytical	China and USA

(*continued*)

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
21	*European Journal of Operational Research*	The risk of second-tier supplier failures in serial supply chains: implications for order policies and distributor autonomy	Kull and Closs (2008)	Internal/ external	Product related	Supply chain	Mitigation	Analytical	USA
22	*European Journal of Operational Research*	Using formal MS/OR modeling to support disaster recovery planning	Bryson *et al.* (2002)	External	Man-made/ natural disaster	Regional	Recovery	Analytical	USA
23	*Expert Systems with Applications*	Feature selection to diagnose a business crisis by using a real GA-based support vector machine: an empirical study	Chen and Hsiao (2008)	Internal	Finance related	Single stage	Preparedness	Analytical	USA
24	*Food Policy*	Overcoming supply chain failure in the agri-food sector: a case study from Moldova	Gorton *et al.* (2006)	Internal	Employee related	Supply chain	Response	Empirical	UK and Moldova
25	*Harvard Business Review*	Disaster Relief, Inc.	Thomas and Fritz (2006)	External	Natural disaster	Regional	Response/ recovery	Applied	USA
26	*Harvard Business Review*	Doing business in a dangerous world	Morse (2002)	External	Political	Supply chain	Mitigation/ preparedness	Applied	USA
27	*Harvard Business Review*	Facing ambiguous threats	Roberto *et al.* (2006)	Internal	Human related	Single stage	Mitigation/ preparedness	Applied	USA
28	*Harvard Business Review*	How multinationals analyse political risk	Rummel and Heenan (1978)	External	Political	Supply chain	Mitigation	Empirical	USA
29	*Harvard Business Review*	Managing risk in an unstable world	Bremmer (2005)	External	Political	Supply chain	Mitigation	Applied	USA
30	*Harvard Business Review*	Planning for the unthinkable	Hershey (1975)	Internal	Human related	Single stage	Mitigation/ preparedness	Applied	USA

(*continued*)

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Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
31	*Harvard Business Review*	Thinking ahead – planning for the next energy emergency	Lindsay (1981)	External	Economic	Regional	Preparedness	Applied	USA
32	*Harvard Business Review*	What's the plan?	Clarke and Morse (2004)	External	General	Regional	Preparedness	Applied	USA
33	*Interfaces*	A Florida county locates disaster recovery centers	Dekle *et al.* (2005)	External	Man-made/ natural disaster	Regional	Mitigation/ preparedness	Analytical	USA
34	*Interfaces*	A planning heuristic for military airlift	Rappoport *et al.* (1992)	External	Man-made/ natural disaster	Regional	Preparedness/ response	Analytical	USA
35	*Interfaces*	A solution to post crash debt entanglements in Kuwait's al-Manakh Stock Market	Elimam *et al.* (1997)	External	Regulatory	Regional	Recovery	Analytical	USA
36	*Interfaces*	A survey of operations research models and applications in homeland security	Wright *et al.* (2006)	External	Man-made/ natural disaster	Regional	ALL	Conceptual	USA
37	*Interfaces*	Designing the response to an anthrax attack	Whitworth (2006)	External	Man-made disaster	Regional	Preparedness	Analytical	USA
38	*Interfaces*	Global optimization of emergency evacuation assignments	Han *et al.* (2006)	External	Man-made/ natural disaster	Regional	Response	Analytical	USA

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
39	*Interfaces*	Large-scale dispensing for emergency response to bioterrorism and infectious-disease outbreak	Lee *et al.* (2006)	External	Man-made disaster	Regional	Preparedness/ response	Analytical	USA
40	*Interfaces*	Montgomery county's public health service uses operations research to plan emergency mass dispensing and vaccination clinics	Aaby *et al.* (2006)	External	Man-made/ natural disaster	Regional	Preparedness	Analytical	USA
41	*Interfaces*	Responding to bioterrorist smallpox in San Antonio	Miller *et al.* (2006)	External	Man-made disaster	Regional	Preparedness	Analytical	USA
42	*Interfaces*	Responding to emergencies: lessons learned and the need for analysis	Larson *et al.* (2006)	External	Man-made/ natural disaster	Supply chain/ regional	Preparedness/ response	Conceptual	USA
43	*Interfaces*	The *EXXON Valdez*: an assessment of crisis prevention and management systems	Harrald *et al.* (1990)	Internal	Infrastructure related	Supply chain	Preparedness	Conceptual	USA

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
44	*International Journal of Logistics Management*	Inventory management support systems for emergency humanitarian relief operations in South Sudan	Beamon and Kotleba (2006)	Internal/ external	General	Regional	Response	Analytical	USA
45	*International Journal of Logistics Management*	Supply chain management under the threat of international terrorism	Sheffi (2001)	External	Man-made disaster	Supply chain	Mitigation/ preparedness	Applied	USA
46	*International Journal of Physical Distribution & Logistics Management*	A conceptual framework for the analysis of vulnerability in supply chains	Svensson (2000)	Internal	General	Supply chain	Preparedness	Empirical	Sweden
47	*International Journal of Physical Distribution & Logistics Management*	Drivers of supply chain vulnerability an integrated framework	Peck (2005)	External	General	Supply chain	Preparedness	Applied	UK
48	*International Journal of Physical Distribution & Logistics Management*	Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident	Norrman and Jansson (2004)	Internal/ external	Product related	Supply chain	Preparedness	Applied	Sweden

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
49	*International Journal of Physical Distribution & Logistics Management*	Humanitarian logistics in disaster relief operations	Kovacs and Spens (2007)	External	General	Regional	Preparedness/ response	Applied	Finland
50	*International Journal of Physical Distribution & Logistics Management*	Identifying sources of uncertainty to generate supply chain redesign strategies	van der Vorst and Beulens (2002)	External	Man-made/ natural disaster	Supply chain	Mitigation/ preparedness	Empirical	The Netherlands
51	*International Journal of Physical Distribution & Logistics Management*	Improving supply chain disaster Preparedness: a decision process for secure site location	Hale and Moberg (2005)	External	General	Supply chain	Mitigation/ preparedness	Analytical	USA
52	*International Journal of Physical Distribution & Logistics Management*	Key areas, causes and contingency planning of corporate vulnerability in supply chains: a qualitative approach	Svensson (2004)	Internal	Employee related	Supply chain	Preparedness	Empirical	Sweden
53	*International Journal of Physical Distribution & Logistics Management*	Mitigating supply chain risk through improved confidence	Christopher and Lee (2004)	Internal/ external	General	Supply chain	Mitigation	Applied	UK and USA
54	*International Journal of Physical Distribution & Logistics Management*	Natural disaster management planning: a study of logistics managers responding to the tsunami	Perry (2007)	External	Natural disaster	Regional	Preparedness/ response/ recovery	Applied	Australia

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
55	*International Journal of Physical Distribution & Logistics Management*	On the sensitivity of configure-to-order supply chains for personal computers after component market disruptions	Papadakis (2003)	External	Natural disaster	Supply chain	Mitigation/ preparedness	Empirical	USA
56	*International Journal of Physical Distribution & Logistics Management*	Risky business expanding the discussion on risk and the extended enterprise	Spekman and Davis (2004)	Internal/ external	General	Supply chain	Mitigation/ preparedness	Conceptual	USA
57	*International Journal of Physical Distribution & Logistics Management*	Securing the upstream supply chain a risk management approach	Giunipero and Eltantawy (2004)	External	Man-made/ natural disaster	Supply chain	Mitigation/ preparedness	Conceptual	USA
58	*International Journal of Physical Distribution & Logistics Management*	Supply chain logistics risks From the back room to the board room	Cavinato (2004)	Internal/ external	General	Supply chain	Preparedness	Conceptual	USA
59	*International Journal of Physical Distribution & Logistics Management*	Supply chain risk in an uncertain global supply chain environment	Barry (2004)	External	General	Supply chain	Preparedness	Conceptual	USA
60	*International Journal of Production Economics*	Coordination of supply chain after demand disruptions when retailers compete	Xiao *et al.* (2007)	External	Market	Supply chain	Mitigation	Analytical	USA, Hong Kong

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
61	*International Journal of Production Economics*	Issues in managing disaster relief inventories	Whybark (2007)	External	Natural, political, economic	Regional	Preparedness/ response/ recovery	Applied	USA
62	*International Journal of Production Economics*	Perspectives in supply chain risk management	Tang (2006)	External	General	Supply chain	Mitigation	Applied	USA
63	*International Journal of Production Research*	An empirically derived agenda of critical research issues for managing supply chain disruptions	Blackhurst *et al.* (2005)	External	General	Supply chain	All	Empirical	USA
64	*International Review for Environmental Strategies*	The challenges of Tsunami disaster response planning and management	Tolentino (2007)	External	Natural disaster	Regional	Mitigation/ preparedness/ response	Conceptual	Germany
65	*Journal of Business Continuity & Emergency Planning*	Organisational resilience: researching the reality of New Zealand organizations	Seville *et al.* (2008)	Internal/ external	General	Single stage/ supply chain	Response/ recovery	Conceptual	New Zealand
66	*Journal of Business Continuity & Emergency Planning*	The case for regional post-natural disaster preparation	Claringbull (2008)	External	Natural disaster	Regional	All	Conceptual	Canada
67	*Journal of Business Logistics*	An empirical examination of supply chain performance along several dimensions of risk	Wagner and Bode (2008)	Internal/ external	General	Supply chain	Mitigation/ preparedness	Empirical	Germany and Switzerland

(*continued*)

Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
68	*Journal of Business Logistics*	Global supply chain risk management	Manuj and Mentzer (2008)	Internal/ external	General	Supply chain	All	Conceptual	USA
69	*Journal of Business Logistics*	Life without trucks the impact of a temporary disruption of road freight transport on a national economy	Mckinnon (2006)	External	Natural disaster	Regional	Mitigation/ preparedness	Conceptual	UK
70	*Journal of Business Logistics*	The logistics of famine relief	Long and Wood (1995)	External	Natural disaster	Supply chain/ regional	Response	Conceptual	USA
71	*Journal of Management Studies*	Understanding industrial crises	Shrivastava *et al.* (1988)	Internal	IT related	Single stage	Preparedness/ response	Applied	USA and Canada
72	*Journal of Marketing Channels*	Sources of supply chain disruptions, factors that breed vulnerability, and mitigating strategies	Kumar and Stecke (2008)	Internal/ external	Man-made/ natural disaster	Regional	Mitigation	Applied	USA
73	*Journal of Risk Research*	Emerging issues for Natech disaster risk management in Europe	Cruz *et al.* (2006)	External	Man-made/ natural disaster	Regional	Preparedness	Conceptual	USA, The Netherlands, Italy, Spain
74	*Journal of Services Marketing*	Business (not) as usual: crisis management, service recovery and the vulnerability of organizations	Smith (2005)	Internal/ external	General	All	All	Conceptual	UK

(*continued*)

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
75	*Journal of Supply Chain Management*	Unraveling the food supply chain strategic insights from China and the 2007 recalls	Roth *et al.* (2008)	Internal/ external	Political	Regional	All	Conceptual	USA
76	*Journal of the Operational Research Society*	A multi-objective heuristic approach for the casualty collection points location problem	Drezner *et al.* (2006)	External	Man-made/ natural disaster	Regional	Preparedness	Analytical	USA
77	*Journal of the Operational Research Society*	A two-stage stochastic programming framework for transportation planning in disaster response	Barbarosoglu and Arda (2004)	External	Man-made/ natural disaster	Regional	Response/ recovery	Analytical	Turkey
78	*Journal of the Operational Research Society*	An insurance risk management framework for disaster relief and supply chain disruption inventory planning	Lodree and Taskin (2008)	External	Man-made/ natural disaster	Regional	Mitigation/ preparedness	Analytical	USA
79	*Journal of the Operational Research Society*	Humanitarian aid logistics: supply chain management in high gear	van Wassenhove (2006)	External	Natural disaster	Regional	All	Conceptual	France
80	*Leadership & Organization Development Journal*	Crisis management: prevention, diagnosis and intervention	Kash and Darling (1998)	External	General	Supply chain	All	Conceptual	USA

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Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
81	*Management Science*	On the value of mitigation and contingency strategies for managing supply chain disruption risks	Tomlin (2006)	Internal/ external	General	Single stage	Preparedness	Analytical	USA
82	*Management Science*	Simulating the response of a small open politico-economic system to international crises: the case of Switzerland	Luterbacher *et al.* (1987)	External	Political	Regional	Response	Analytical	Switzerland
83	*Manufacturing and Service Operations Management*	Competition and diversification effects in supply chains with supplier default risk	Babich *et al.* (2007)	Internal	Product related	Supply chain	Mitigation	Analytical	USA
84	*MIT Sloan Management Review*	A supply chain view of the resilient enterprise	Sheffi and Rice (2005)	External	General	Supply chain	Preparedness	Applied	USA
85	*MIT Sloan Management Review*	Crisis management: cutting through the confusion	Mitroff (1988)	Internal	General	Single stage	Preparedness	Applied	USA
86	*MIT Sloan Management Review*	Information failures and organizational disasters	Choo (2005)	Internal	IT related	Single stage	Preparedness	Conceptual	Canada
87	*MIT Sloan Management Review*	Managing risk to avoid supply chain breakdown	Chopra and Sodhi (2004)	Internal/ external	General	Supply chain	Mitigation	Applied	USA

(*continued*)

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
88	*MIT Sloan Management Review*	Strategies for preventing a knowledge-loss crisis	Parise *et al.* (2006)	Internal	Human related	Single stage	Preparedness	Applied	USA
89	*MIT Sloan Management Review*	Understanding and managing complexity risk	Bonabeau (2007)	Internal	Infrastructure related	Single stage	Preparedness/ response	Applied	USA
90	*MIT Sloan Management Review*	When crisis crosses borders	Midanek (2003)	External	Market	Supply chain	Recovery	Conceptual	USA
91	*Naval Research Logistics*	Designing safety space in a supply chain to handle system-wide disruptions	Mudrageda and Murphy (2007)	External	Natural disaster	Supply chain	Preparedness	Analytical	USA
92	*Naval Research Logistics*	Disruption management in production planning	Yang *et al.* (2005)	Internal	General	Single stage	Response/ recovery	Analytical	USA
93	*Naval Research Logistics*	Optimizing disaster relief: real-time operational and tactical decision support	Brown and Vassiliou (1993)	External	Natural disaster	Regional	Response/ recovery	Analytical	USA and Greece
94	*Naval Research Logistics*	The importance of decoupling recurrent and disruption risks in a supply chain	Chopra *et al.* (2007)	Internal/ external	Product related	Supply chain	Mitigation	Analytical	USA and India
95	*Operations Research*	Assessing risks through the determination of rare event probabilities	Sampson and Smith (1982)	External	Man-made disaster	Regional	Mitigation/ preparedness	Analytical	USA

(*continued*)

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Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
96	*Operations Research*	Multiple objective analysis of input-output models for emergency management	Kananen *et al.* (1990)	External	Economic	Regional	Mitigation/ preparedness	Analytical	Finland
97	*Oxford Development Studies*	Complex emergencies versus natural disasters: an analytical comparison of causes and effects	Albala-Bertrand (2000a)	Internal/ external	Natural/ political disaster	Regional	All	Conceptual	UK
98	*Physica A: Statistical Mechanics and its Applications*	Assessing interaction networks with applications to catastrophe dynamics and disaster management	Helbing and Kühnert (2003)	External	Natural disaster	Regional	Preparedness	Analytical	Germany
99	*Policy Studies Review*	Local government's problem with disaster management: a literature review and structural analysis	Wolensky and Wolensky (1990)	External	General	Regional	Preparedness/ response/ recovery	Analytical	USA
100	*Production and Operations Management Journal*	Managing disruption risks in supply chains	Kleindorfer and Saad (2005)	External	Man-made/ natural disaster	Supply chain	Mitigation/ preparedness	Empirical	USA
101	*Progress in Development Studies*	Disaster relief efforts: an update	Paul (2006)	External	Natural disaster	Regional	Response	Applied	USA
102	*Singapore Management Review*	Corporate strategic responses to the Asian financial crises	Lui *et al.* (1999)	External	Economic	Regional	Response	Conceptual	Singapore

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Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
103	*Social Marketing Quarterly*	Warning signals, wind speeds and what next: a pilot project for disaster preparedness among residents of central Vietnam's lagoons	Ramaprasad (2005)	External	Natural disaster	Regional	Mitigation	Conceptual	USA
104	*Southern Business Review*	Crisis planning in the nonprofit sector: should we plan for something bad if it may not occur?	Spillan and Crandall (2002)	External	General	Single stage	Preparedness	Empirical	USA
105	*Supply Chain Management Review*	18 ways to guard against disruption	Elkins *et al.* (2005)	Internal/ external	General	Supply chain	Mitigation/ preparedness	Conceptual	USA
106	*Supply Chain Management Review*	A framework for protecting your supply chain	Closs *et al.* (2008)	External	Man-made disaster	Supply chain	Mitigation	Conceptual	USA
107	*Supply Chain Management Review*	How to avoid the 6 risk management pitfalls	Swaminathan and Tomlin (2007)	Internal	Employee related	Supply chain	Mitigation	Conceptual	USA
108	*Supply Chain Management Review*	Lessons from the Gulf: Gus Pagonis	Williams (2003)	External	Man-made disaster	Supply chain	Mitigation	Conceptual	USA
109	*Supply Chain Management Review*	Risk-adjusted supply chain management	Hauser (2003)	External	Man-made/ natural disaster	Supply chain	Mitigation/ preparedness	Conceptual	USA
110	*Supply Chain Management Review*	Strategies for managing supply chain risk	Hillman (2006)	Internal/ external	General	Supply chain	Mitigation/ preparedness	Empirical	USA
111	*Supply Chain Management Review*	Stronger protection needed	Tohamy (2005)	External	Man-made disaster	Supply chain/ regional	Mitigation	Conceptual	USA

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Table AI.

S. no	Journal	Title	Author (year)	Source of crisis	Type	Scale	Stage	Research method	Place
112	*Supply Chain Management Review*	Targeting a just-in-case supply chain for the inevitable next disaster	Martha and Subbakrishna (2002)	External	Man-made/ natural disaster	Supply chain	Preparedness	Conceptual	USA
113	*The Academy of Management Executive*	Effective crisis management	Mitroff *et al.* (1987)	Internal	General	Single stage	Preparedness	Conceptual	USA
114	*The Business Review*	Changes in Korean governance since the Asian financial crisis	Lee and Mccalman (2007)	External	Economic	Regional	Recovery	Applied	Canada and USA
115	*The Executive*	From crisis prone to crisis prepared: a framework for crisis management	Pearson and Mitroff (1993)	Internal	General	Single stage	Preparedness	Conceptual	USA
116	*Third World Quarterly*	Responses to complex humanitarian emergencies and natural disasters: an analytical comparison	Albala-Bertrand (2000b)	External	Natural/ political disaster	Regional	Response	Conceptual	UK
117	*Transportation Science*	An expeditious risk assessment of the highway transportation of flammable liquids in bulk	Glickman (1991)	Internal	Infrastructure related	Single stage	Mitigation	Analytical	USA
118	*Transportation Science*	Catastrophe avoidance models for hazardous materials route planning	Erkut and Ingolfsson (2000)	Internal	Infrastructure related	Single stage	Mitigation	Analytical	Canada

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