Abstract. Supply chain management theories and the Contingent Theory of Fit are used to develop a framework for improved long-term response to supply chain disruptions caused by catastrophes such as hurricanes, earthquakes, chemical plant explosions, and global terrorist attacks. The four-step process framework includes: the degree to which the organizations interact, the degree of interdependence between organizations, the load on each organization under the duress of the urgent situation, and differences in skill level between each organization.

Introduction and Background. Supply chains play an important strategic role in the role of the world economy. Unfortunately they are also a point of vulnerability in the world economy. They are subject to disruptions with significant consequences to the world economy especially when the disruption comes suddenly, without warning, and with devastation. Due to increases in the numbers and magnitude of supply disruptions, there have been recent calls for research into supply chain security. While risk and risk assessment have been the traditional focus of supply chain disruption research, the focus of this traditional risk assessment has been on designing the supply chain for robustness and assessing the risk and damages of potential disruption. However, the recent losses from categorical disruptions like those seen with hurricanes (e.g. Katrina), earthquakes, chemical plant explosions, and global terrorist attacks provide incentive for improved practices during reconstruction periods from the disruption. Minimizing large costs from these efforts can result in saving not just valuable time and money, but also, potentially lives.

While some devastation can be directly attributed to the disaster, often a significant amount of it comes from poor supply chain coordination during the relief effort following the disruption. A good example of this occurred after Hurricane Katrina: rescuers could not reach stranded victims; supply lines of food, clothing and building materials were cut-off. An inefficient political decision process thwarted the relief efforts of FEMA, Red Cross, and other federally funded agencies.

This paper proposes extending supply chain theories of management and using the Contingency Theory of Fit to provide improved relief to damaged areas, to better organize information coming from those damaged areas, and to facilitate repair efforts of the damaged areas. A framework is provided which takes advantage of supply chain strengths to minimize the damage from the disruption. The framework suggests using information flows that are longer than those for the immediate emergency response to organize the responses of aid. An important part of the framework is that it establishes temporary bypasses of the disruption to minimize the effect of the disruption. The framework is based on supply chain theory, which
indicates that by focusing on management of information linkages and fund flows in addition to managing material flows, sustained competitive advantage can be achieved. The framework also uses additional supply chain theories that have advanced modularization and postponement practices that can enhance flexibility and company survival.

The Contingency Theory of Fit is applied and extended to mitigate consequences of supply disruption. Preparing for and minimizing the residual effect of those disruptions achieve the advantages of this framework. A model is proposed to help predict and help explain the amount of value that that is realized with such a relief framework. The model predicts that an increase in efficiency of a relief effort will be realized when an improved communication structure is followed.

Objective. Develop and test a framework involving organizational interdependence, skill levels, interaction and work load during emergencies. Apply the framework as a tool to guide the decision processes that drive how funding flows, relief material flows, and information flows are handled, and how emergency relief efforts are handled.

Theory. The Contingency Theory of Fit provides a foundation on which to prepare for and to minimize the magnitude of supply chain disruptions. The Contingency Theory of Fit is built on the premise that an outcome is a “fit” or result of the application of multiple factors. Van de Ven and Drazin (1985) argue that factors fit when internal and consistent patterns of a construct, such as organization, context, and structure, establish feasible structural alternatives.

These are contingencies (which could also be called “emergency dependencies”) to the organizational design of the construct. In applicable situations, the theory provides two separate bases for building a communications network for a relief effort during a supply chain disruption.

- First, separate communication contextual factors must be considered for influencing benefits accruing to a relief organizational structure (i.e., organizational structure depends on multiple and separate factors).
- Second, separate communication factors come together to provide contingent alternatives for advancing the relief efforts (Khazanchi, 2005).

Huberman and Hogg (1995) argue that the effectiveness of such a network, particularly when two or more groups are involved (e.g., FEMA and Red Cross), depends on what happens before the relief work begins. A summarized list of such antecedents is as follows:

- Degree to which the organizations interact
- Degree of interdependence between organizations
- Load on each organization under the duress of the urgent situation (i.e., % load and degree of urgency)
- Differences in skill level between each organization.
The proposed framework is intended to provide a functional tool, which can specify how these antecedents affect logistical efforts to improve supply chain response to disruption situations. The framework uses disseminated progress information to improve the degree of interaction between organizations, to enhance the degree interdependence, and to improve skill levels for facilitating flows of information, funds and materials to disrupted situations. By understanding the organizational dynamics of these organizations under increased workload in urgent situations, and by using the tenets of Contingency Theory, better contingency plans can be formed, and the response effectiveness of these organizations can be improved.

**Framework.** The general framework of this paper is depicted in Figure 1 below. The disruption might be a single incident like an explosion in an oil refinery, or it might be one that affects a wider area such as a hurricane, or multiple terrorist acts. The figure is intended to represent a generalization of disruption in the supply chain without detailing any specific type or kind of disruption.

By comparison, Figure 2 represents a traditional supply chain. Two major differences should be noted. The first is that, while information sharing occurs in both scenarios and materials flow in the same direction, the flow of funds, however, is changed. Funds are redirected into
the stricken area. The second major or significant difference is that relief materials and funds may originate from sources outside of traditional sources, so that an additional level of coordination is added.

Figure 2: Traditional Supply Chain Scenario

The disrupted supply chain framework involves a 4-step process through which resources are directed, tracked, and monitored assuring proper distribution to the areas of need. Four corollaries of supply chain management, with the Contingency Theory of Fit, provide the basis for the framework and the process:

- Collaborative information sharing
- Directing of material flows
- Flow of funding
- Rebuilding the disrupted supply chain

Basis for the Framework

- **Collaborative information sharing.** Collaborative information sharing leads to collaborative relief efforts. Collaborative information sharing is not, for example, for the purposes of censorship from news reporters, etc. Instead, it enables data collection and warehousing for effective information mining. One of the elements of a disruption, and one that terrorist cells, for example, rely on, is the prolonged confusion that results from the chaos of a disruption. Information flows originate from various sources – from sources like news agencies, individuals calling for help, or from even outside public forums reporting hearsay. Organizing the information and sorting fact from fiction in order to properly direct resources is a proposed fundamental first step.

- **Materials management techniques to control and direct the flow of materials into the disrupted scene.** One of the hallmarks of disrupted scenes is the misplaced emergency relief supplies and lost products due to chaotic shipping practices of getting relief supplies into the affected areas. Materials management best practices can help
Materials management practices including the use of technology to facilitate improved capability. The resulting information can be transmitted to centralized information centers for eventual verification that targeted people in need of the supplies have received those materials.

- **Flow of funding.** Funding is similar to the flow of materials. Relief funding, much like relief supplies, originates from many different sources (federal, state and local governments, relief agencies like Red Cross or FEMA, public donations, religious organizations, etc.) The flow of funding is decentralized and, like material flows, would be counterproductive to handle through a centralized system. However, centralization of the information about the funding, including funds available and who is in need of the funding, is more efficiently handled through collaborative efforts. Too often, funds are lost, appropriations duplicated, or funds are misdirected especially when separate organizations do not understand what the other is doing.

- **Rebuilding the disrupted supply chain** by utilizing operational strategies of supply chain management. The rebuilding plan should include establishing temporary bypasses while original structures are rebuilt. The rebuild of any disrupted establishment may take a significant period of time. A temporary bypass, however, must be established quickly and efficiently. Temporary bypasses deliver several advantages. It relieves performance pressures from the original supply chain players. It focuses attention of victims on positive rebuilding mentalities instead of dwelling on plighted scenarios, and it functionally keeps the supply chain operating.

**Expected Results** from application of the framework. By taking advantage of operational skill sets developed in supply chain management theory to organize relief efforts, coordinate information and funding, mitigate the damage, and efficiently operationalize the system of repair. In this way confusion and inefficiency should be minimized.

**Field Testing.** To determine the final details for application of the framework, field tests will be conducted on each of the four process steps. The field testing will involve the key inter-organizational attributes of organizational interdependence, skill level, interaction, and workload during emergencies. Outcome of this field testing will provide a basis for improved supply chain processes to serve disrupted areas for all relief agencies and organizations. Decision processes will be outlined that drive the key outcomes of how funding flows, relief material flows, and information flows during emergency relief efforts.

**Discussion.** The proposal of this paper is essentially to take advantage of the operational skills sets developed in supply chain management theory to organize relief efforts, coordinate information and funding, mitigate the damage, and efficiently operationalize the system of repair. This paper is not intended to affect or offer suggestions of immediate emergency response efforts. However, cases have shown that often after immediate emergency response efforts have dissipated, confusion and inefficiencies have resulted incapacitating affected areas for months and years (Papadakis and Ziemba, 2001). In the case of potential terrorist activity, this type of confusion from disruption is exactly the result that terrorist cells are attempting to achieve (Kleindorfer and Van Wassenhove, 2004). It is during this time frame that operations and supply chain theory together with readily available technology can be applied to organize relief efforts mitigating longer lasting damages.
The Contingency Theory of Fit is built on the premise that an outcome is fit when patterns of a construct such as organization, context, and structure establish feasible alternatives for responding to the disruption. Under such a premise, the theory provides a basis for building a collaborative communications network. A mathematical algorithm can be used to predict and explain the amount of value that is added through the resulting organization of such a communication structure.

Overall effectiveness for responding to such a disruption is predicated on various groups coming together to organize relief efforts. The degree of effectiveness for these efforts is bounded by the Nash equilibrium prediction that, at a minimum, all relief agencies will locally maximize their relief efforts. This, as known from previous experiences like those from some hurricane and tsunami relief efforts, may leave relief efforts short of desired outcomes. However, the concept developed in this paper is that the more relief organizations can improve information through collaborative communications efforts, the closer relief efforts will come to achieving global optimization of fast and efficient relief efforts.

**Conclusions.** The strengths of advancing supply chain management practices continue to be shown and developed through management practices, case studies, examples, research, and with theory. Unfortunate cases of actual disruption support the idea that when a response is not organized and efficient, the results can magnify the devastation. Supply chain disruptions, when managed efficiently, mitigate the damage and alleviate the confusion. To do this, focused application of supply chain strategies and practices are a strong ally for managers and executives involved in the response effort.

**References**


