THE IMPERFECT WORLD: MANAGING SUPPLY CHAIN DISRUPTIONS FROM THEORY TO PRACTICE

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Abstract

It is part of the human experience to observe, at times, the most carefully crafted plans and/or processes crumble under the weight of risk and uncertainty. In the Supply Chain Management (SCM) world this phenomenon manifests itself in the form of interruptions of the flow of raw materials, commodities, finished goods, and information. The capacity of a chain to maintain continuity through and after unforeseen disruptive events is determined by the built-in resilience of its process design and control strategies. In addition, the metrics by which the impact of these disruptions is assessed reflect not only the ability to understand the extent of the damage, but also the capacity of the chain to cope effectively and lead the enterprise to a full recovery. In spite of the rising interest in disruption recovery in the SCM field, there are still excellent opportunities to build bridges between theory and practice. Such opportunities are explored in this working paper as it presents the issue of both measuring and managing the effect of disruptions in a supply chain context from the practitioner stand point. Special attention is given to the Latin American context for which current models for post-disruption recovery and mitigation may require reexamination. The main purpose is to invite researchers in related disciplines to enrich the existing body of knowledge regarding these issues, by taking a closer look at the points hereby presented.

1 Introduction

According to Handfield and Nichols (2002), a supply chain is defined as the set of processes and activities pertaining to the flow and transformation of goods or services from the raw materials stage, through to the point of sale or service (POS) where the end user finally gains access to it. They also add that this definition of supply chain includes the flow of the information needed to carry on those processes.

The problem of effectively managing the supply chain becomes accentuated in the international arena where companies must span their organizational structure and processes across geographical, demographic, and political boundaries. The successful integration, synchronization and management of supply chains in today's global context is a vital matter, as organizations across the world depend on each other for energy, raw materials, food supply, goods and services. The world has "shrunk" as enabling technologies allow companies to manage resources around the globe with unprecedented visibility and high levels of collaboration. In this context, and as outsourcing grows as the practice of choice in today business world, many companies are choosing to set their sourcing sights on developing and emerging markets. Each day, production facilities are being moved from the industrial giants of yesteryear to places where labor costs (and laws), production costs, proximity to raw materials, transfer taxes, and tariffs give a company a chance to remain competitive.

In spite of their often publicized political and social economic conundrums, many Latin American economies have experienced incredible economic growth due to the transformation in the worldview of matching supply and demand in a profitable manner. According to a 2007 report by the World Economic Forum, "over the past three years Latin America has enjoyed its strongest cycle of economic growth in three decades, with average growth rates exceeding 4%." Nevertheless, these benefits are not reaped without a toll. The advantages of this global approach to doing business can be at times blurred by the risks involved.

The aforementioned 2007 World Economic Forum report states that the playing field in this "globalized" business environment is mined with threats, both natural and man-made (Figure 1 displays graphically which are the main risks, while Figure 2 shows their correlation to one another).

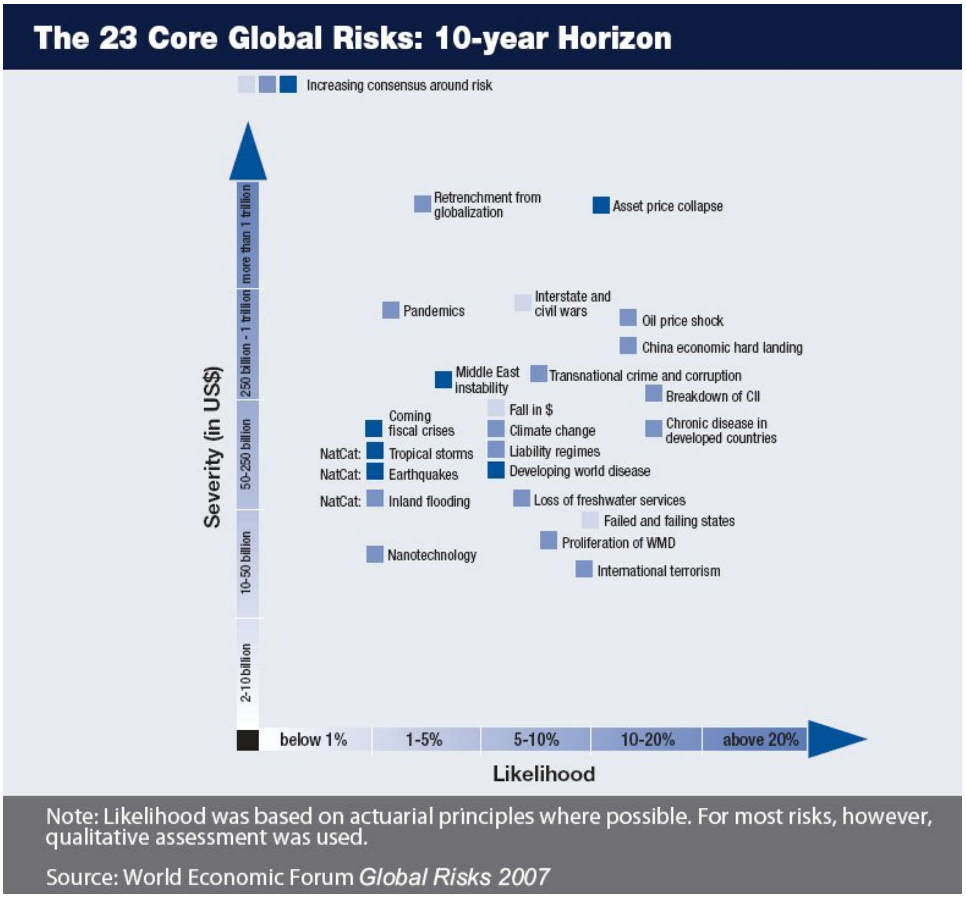

Figure 1. Global Risks
(2007 World Economic Forum *Latin America@Risk* Report)

Whenever one of those risks materializes into a crude reality, a disruption occurs. In the SCM arena, disruptions are defined as unforeseen events that bring to a halt or decelerate the flow throughout the chain. When they arise, a "ripple" effect propagates quickly to other links. The negative impact of the disruption then becomes a function of the ability of the organization to cope with and mitigate the aftermath, and to restore full capability in minimal time. As Latin America continues to breakaway as an economic force to be reckoned, special attention must be placed in making sure that the body of research in SCM addresses the appropriateness of current disruption impact measurement and recovery models to its specific conditions. What are the right objectives? How well do the model assumptions hold? How can the models be more adequately adapted and adopted by Industry? The following pages set out to lay a foundation for future research that can answer these and other related questions.

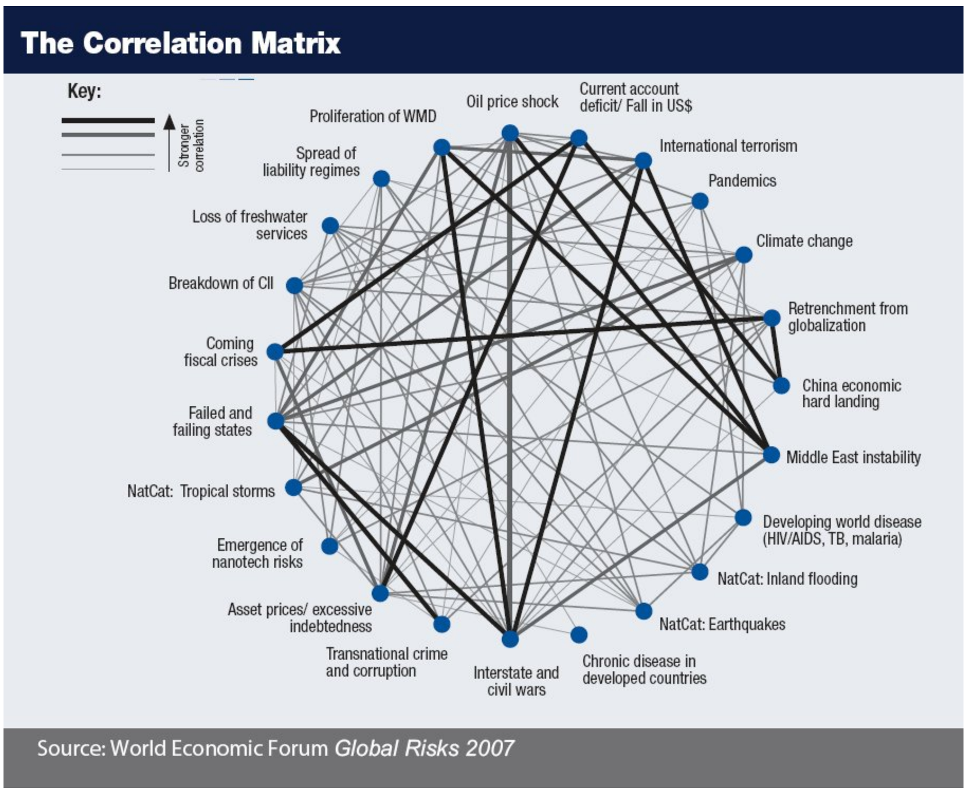

Figure 2. Global Risks Correlation Matrix
(2007 World Economic Forum *Latin America@Risk* Report)

2 Understanding the Threats

The starting point of any disruption management initiative is to understand the vulnerabilities along the entire chain. Risk assessment in SCM is a well researched topic with many techniques to quantifiably obtain a measurement or index of the hazards throughout the extended chain (Wu et al., 2006). However, March and Sharpira (1987) claim, as a result of a study, that senior decision makers are quite insensitive to risk estimates. The same study warns that managers do not trust, understand, or use such approximations. A similar result is obtained by Fischhoff et al. (1981). It is necessary to address the reasons for this, in order to empower practitioners to take advantage of these methods. Therefore, this opens a series of questions:

- How to build a risk assessment business process blueprint that is best suited for a specific business environment?
- Whose responsibility should such process be?
- What are world-class best practices in risk assessment? How should companies benchmark?

These questions seem basic, yet in practice the answer is not found as easily as it might be expected. Without addressing these, it is in vain to go on a disruption management "spree" trying to sell models and strategies to management.

2.1 Threat Classification

Another issue, which is also important, deals with the variety of disruption threats that are faced by supply chain organizations. Not all disruptions are created equal, therefore neither should be any approach used to either measure their impact, or manage a recovery effort. Based on this notion, a simple approach to review supply chain disruption models can be defined using a two-dimensional graph with two axes. The vertical axis represents the severity of the disruption, while the horizontal axis accounts for the frequency (please refer to Figure 3). This two factors act in tandem to frame the potential impact of any disruptive event. For instance, frequent events with severe consequences require different contingencies than those that are less repeated or less serious. The following is a description of each quadrant with some illustrative examples.

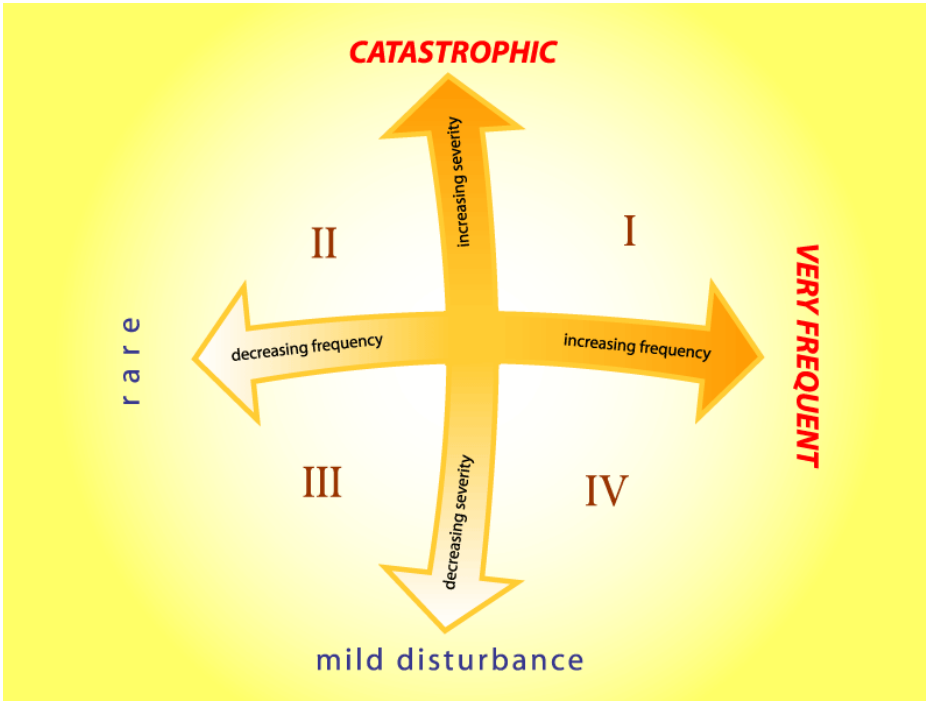

Figure 3. Severity vs. Frequency Disruption Quadrants

2.1.1 The I Quadrant

The I Quadrant (Q1) includes events of high frequency and severe negative outcomes. For instance, a production facility located in a guerilla-controlled area; or underground oil pipelines in earthquake-prone regions are two scenarios that could potentially result in serious recurrent interruptions of inbound or outbound flows (type Q1 disruptions).

The most common and effective approach taken to manage this type of event is avoidance. In general terms, companies tend not to operate where the probability of a Q1 event (P[Q1]) approaches 1. The likelihood and seriousness of the resulting damages are more than most companies are willing to risk. For example, MaCollough (2003) narrates that in 1903 the US Congress indeed strongly considered building an inter-oceanic waterway through Nicaragua, as opposed to Panama. The conditions seemed favorable until it was noted that the frequency of seismic and volcanic activity was very high. The final determination was, implicitly, that P[Q1] ≈ 1 for the Nicaraguan proposal, and that is why there is a Panama Canal today.

Consideration for this type of disruption is usually done in multi-objective facility location models, where risk minimization objectives seek to eliminate completely the likelihood of Q1 type events.

2.1.2 The II Quadrant

The II Quadrant (Q2) represents those events that range from the infrequent to the sporadic (or unimaginable), but have very severe negative outcomes. Examples of Q2 disruption could be a terrorist attack on the Panama Canal, or a nationwide port workers indefinite strike. Regardless of the severity of Q2 disruptions, Mitroff and Alpasan (2003) claim that only 5%-25% of the world's top 500 companies are prepared to handle crises or disruptions. This might be due to an underestimation of the probability of Q2 event (P[Q2]).

Estimating P[Q2] might prove difficult because the number of observations is insufficient to approximate its probability distribution function, thus requiring for most of the risk assessment to be done qualitatively. The issue then lies on the difference between *perceived* vs *real* risk. Lopes (1992) discusses that people tend to assume their perception of the risk to be the actual probability of its occurrence. If they think "that never happens here," they will assume implicitly that P[Q2] = 0, and therefore not prepare themselves, or the organization they manage.

In addition, there are other biases that affect the level of preparation for a disruptive event; most of which are well documented in the decision theory literature:

- *Unrealistic Optimistic Bias*: The notion that adverse events are more likely to happen to others than to oneself (Weinstein, 1980; Lehman and Taylor, 1988).
- *Outcome Expectancy*: In this context, this refers to the belief that no matter what contingencies are put in place, nothing would suffice to overcome the aftermath of a realized risk (Lopes, 1992).
- *External locus of control*: When serious crises occur they are the results of forces we cannot control or fight against (Duval and Mulilis, 1999).
- *Transfer of Responsibility*: The idea that someone else is going to help (Lopes, 1992). For instance, the government subsidizing an Industry sector that was hard-hit by a natural disaster or a terrorist attack.

These biases, combined with the lack of frequency of Q2 events, keep supply chain decision makers from having solid mitigation and recovery plans for this type of disruptions.

2.1.3 The III Quadrant

The III Quadrant (Q3) is the collection of low frequency, low impact disruptive events. An example could be landslides at Gaillard Cut in the Panama Canal; a rather infrequent event that causes minor interruptions to the operation of this important resource.

Estimation of the probability of type Q3 disruption (P[Q3]) has the same level of difficulty as that of P[Q2], given that in most cases it begs qualitative rather than actuarial analysis. Their (relatively) low impact on the chain makes the cost of mitigation a deciding factor on the level of contingency used to manage the risk. A “firefighter” approach is most commonly taken to deal with this type of events, given that investing in redundancies or adding flexibility to the chain might cost more than the financial impact of the disruption.

2.1.4 The IV Quadrant

The IV Quadrant (Q4) encapsulates those events that have low impact on the chain, yet happen with a high level of frequency. An example of this could be transportation delays due to heavy precipitation during the rainy season in Central America, or border crossing delays due to organizational inefficiencies.

These events tend to be very predictable. The most serious concern regarding Q4 disruption is that a *Normalization Bias* (see Mileti and O'Brien, 1992) can occur; so that the disruption becomes accepted as the "status quo" and little or no contingency is prepared to mitigate it. In practice, the most common way of dealing with Q4 events is through building up safety stock levels (or adding additional servers in a service chain scenario).

If left unchecked this type of disruption over time might destroy customer service satisfaction levels, due to consistently failing to deliver on target, no matter how small the immediate perceived impact.

2.2 Utilizing the quadrant-based classification in practice

The key in using the classification in section 2.1 is that each organization needs to define how to measure disruption impact and what "severe" means to them. The same applies to frequency. Again some important questions that arise are:

- With limited budget for "non-value adding" activities, how should priorities be assigned to deal with potential threats? How should investment in risk analysis be justified? Which quadrant is more critical?

- How do proposed models address the mental biases of the decision makers?

3 Managing Disruptions

Section 2 dealt with a classification scheme to lay the foundation for disruption risk assessment and perceptions. This section aims at addressing four factors that are relevant in order to understand supply chain disruption management gaps between theory and practice: the use of multiple suppliers, effective use of supply chain metrics, disruption discovery, and finally some thoughts on disruption management as it relates to the prominence of the traditional trade in Latin America.

3.1 Multiple Suppliers

It is well documented in the literature that multiple sourcing options are a good way to quell the negative impacts of a disruption. As found in Sheffi (2001), redundancy in the supply base is one of the best lines of defense against inbound flow anomalies. However, depending on the nature and location of the disruption, basic supplier selection models do not hold under certain conditions.

To illustrate this point, consider a model to select suppliers for a specific good or service. Assume the problem is modeled as a facility location model where multiple suppliers must be selected among a pool of N potential candidates, each with a probability q of suffering a disruption (of any type). The task then becomes to find the optimal number of suppliers (and their demand area assignments) that minimizes cost and some function of risk (based on q). For the inputs, most models assume demand to be deterministic and uniformly distributed in the area to be served by the supplier. Many of these models assume then that the cost function is primarily unimodal distance-based and also deterministic. In addition, fixed costs of doing business with a given supplier are assumed to be known. Assume this situation is placed in a sample scenario where trading partners and demand centers are located across different Latin American locations, how would the following questions be answered?:

- Given the variability of border conditions, political climate, and climatic variability how could q be best approximated?
- Tang (2006) does an extensive review of risk management models applied to supply chain, and the obtained results point that nearly all models assume that the demand or the supply process is stationary. Then, how to build disruption management models for non-stationary, non-uniform demand?
- The cost function needs to consider much more than Manhattan distances. How do you incorporate exchange rate fluctuations, tariffs and incoterms variation, and multimodal shipping options in a model to find the optimal supplier base?
- Redundancy allows a supply chain to be more resilient, but how to know where it is needed, or where it is not?

3.2 Effective Goal Setting

Supply Chain *key performance indicators* (KPIs) are financial or non-financial metrics used to reflect the success of the business in achieving its SCM goals. KPIs help define measures that can be linked to the effectiveness of the disruption management strategies, since they are comprised of measurable results and related metrics to attain the results. There is an extensive body of research about how to optimize many aspects of the supply chain: fill rate, processing time, resource utilization, direct costs, to name a few. However, pursuing "optimal" solutions for each factor individually does not necessarily guarantee a significant impact in the company's ability to meet its corporate goals. How to establish priorities among these metrics during a disruption crisis? In the same context, how do we model and optimize for conflicting objectives? Research in this area, must include a high-level approach which defines the metrics and the processes to execute the metrics, as well as any tools that may be created to facilitate their tracking. Also addressed is the frequency of measurement and the timing or schedule of the measurement during the disruption period. This is the utmost importance, because it is the only quantifiable way to know that the models and strategies are delivering on the expected results.

KPI tools and processes must go beyond the basic "cost" of the disruption, which is usually a function of lost sales/customers. They must give account of the cost of restoring the system to full capability and the time it takes to achieve recovery. Alternate KPIs might include cash-to-cash cycle, fill ratio, and on time delivery before, during, and after the disruption. Further research in this area could shed more light on what KPIs are critical under each of the four disruption scenarios previously described respectively.

3.3 Information Technology and Disruption Discovery

The gap in time between the onset of a disruption and its discovery is critical. It is key for organizations to learn how to leverage existing technologies to minimize that gap, since there are explicit and implicit costs involved in the disruption knowledge delay. For instance, a convoy of containers carrying perishable items reaching a border between two countries, to then realize that the border was closed. In spite of the advances in supply chain visibility, more research is needed to understand the various types of disruptions, to develop methods for their timely detection, in conjunction with criteria to recognize possible trigger events.

3.4 Disruption Management and the Traditional Trade

Modern go-to-market strategies have shifted the focal point from product design and manufacturing to the point-of-sale or point-of-service (POS). In developing and emerging (D&E) economies, such as Latin America, these become interesting because of the prominence of the traditional trade (TT). The TT differs greatly from the modern trade (i.e., large retailers, chain stores) in the level of formality of business transactions, cash payment structures, limited storage capacity, purchasing power of average consumer, and accessibility (in rural or inner city areas). Thus far, the development of supply chain disruption strategies has been, for the most part, driven and tailored to the modern trade. There is the need for a closer look into the complexities of the TT and the development of methodologies that will contribute to a more effective supply chain disruption recovery for this particular type of POS.

4 Conclusions

In today's rapidly changing world, businesses must face the reality that natural and man-made phenomena could divert the course of their organizations at any time. Disruption events can not, and must not, be ignored as strategic plans are laid to maximize the company's performance. This brief discussion from the point of view of a practitioner shows that there remain some interesting questions about how to address disruptive situations, with a particular interest in the Latin American contexts.

A classification system based on severity vs. frequency was used to explain how this helps in adapting the right disruption management solutions to the relevant conditions. Finally some thoughts were shared on four aspects that relate directly to the applicability of disruption models in contingency building in the face of global risks.

The expectation is that these working notes might spark more in-depth analysis and a more structured research agenda can be constructed to follow up on any or all of the questions hereby posed.

References

Duval, T., Mulilis, J., 1999. A Person-Relative-to-Event (PrE) Approach to Negative Threat Appeals and Earthquake Preparedness: A Field Study. Journal of Applied Social Psychology, 29 (3) 495-516.

Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S., Keeney, R., 1981. Acceptable Risk. Cambridge University Press, NewYork

Handfield, R. and Nichols, E., 2002. Supply Chain Redesign. Prentice Hall, New Jersey.

Latin America@Risk Report. 2007. World Economic Forum. Geneva

Lehman, D., Taylor, S., 1988. Date with an Earthquake: Coping with a Probable, Unpredictable Disaster. Personality and Social Psychology Bulletin, 13 (4) 546-555.

Lopes, R., 1992. Public Perception of Disaster Preparedness Presentations Using Disaster Images. The American National Red Cross. Washington, DC.

March, J., Sharpira, Z., 1987. Managerial perspectives on risk and risk taking. Management Science, 33 1404–1418.

McCullough, D., 1977. Path Between The Seas: The Creation of the Panama Canal, 1870-1914. Simon & Schuster, New York.

Mileti, D, O'Brien, P., 1992. Warnings during disaster: Normalizing communicated risk. Social Problems, 39 40-57.

Mitroff, I. and Alpasan, M., 2003. Preparing for Evil. Harvard Business Review, 109-115.

Sheffi, Y., 2001. Supply chain management under the threat of international terrorism. International Journal of Logistics Management, 12 (2) 1-11.

Tang, C., 2006. Perspectives in supply chain risk management. International Journal of Production Economics, 103 451–488.

Weinstein, N., 1988. The precaution adoption process. Health Psychology, 7 355-386.

Wu, T., Blackhurst, J., Chidambaram, V., 2006. A model for inbound supply risk analysis. Computers in Industry, 57 350–365.