Risk and Disruptions: New Software Tools

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Abstract

Several large scale disasters have focused the minds of corporate executives and the media on the increasingly important role of supply chain disruptions and their management. Specifically, a lot of attention is centered on the technology to help corporations to effectively manage disruptions. As a result, several companies have developed tools for response planning, tools for event detection, tools for response coordination once a disruption has occurred. These include both in-house tools developed by companies' as well as new offerings in the market place. Publicly available information about in-house tools is limited; therefore this paper focuses primarily on the offerings in the marketplace, adding information about internal tools where available. Together these tools constitute a new category of software products: - supply chain risk management applications.

Introduction

On March 11th, 2011 a 9.0 earthquake struck about 45 miles east of the east coast of Honshu in Japan. The massive earthquake caused a huge tsunami which, in turn caused a nuclear disaster by flooding the nuclear plant in Fukushima. The triple disaster took a terrible human toll on the

Japanese population – more than 15,000 people lost their lives in the disaster with scores more missing, injured and uprooted. This disaster, more than any other in history, put the spotlight on the vulnerability of supply chains to disruptions. It also ushered in efforts by multiple companies to adopt better solutions for assessing supply chain risks and responding effectively to disruptive events.

The Japanese disaster was not, of course, the first large scale supply chain disruption. In his book, Sheffi[i] catalogues multiple other disruptions and corporate responses. Since the book came out, the world has witnessed hurricane Katrina in 2005, the severe financial meltdown in 2008 and subsequent bankruptcies, the swine flu pandemic of 2009, the Eyjafjallajökull eruption and resulting ash cloud in 2010, the revolution in Egypt in 2011, the floods in Australia and Thailand in 2011, and many other events which disrupted manufacturing and transportation links, impacting global supply chain operations.

Supply chain risk and its management have been the subject of increasing amount of academic research in the 21st century. The edited volume "Supply Chain Risks" by Brindley[ii] provides extensive literature review as well as frameworks and approaches. A more recent comprehensive survey of the literature from 2000 through 2007 is offered by Vanany et al[iii](2009). Naturally, the topic of active risk management has been also the subject of corporate attention with the threat and the need to prepare for possible occurrences such as Y2K and the Asian flu.

In this paper we offer an extension of the current framework for classifying risks; review several ongoing efforts to develop software products aiming at supply chain risk management; and describe a case study of implementing one such application at Flextronics, a leading contract manufacturing company.

Risk and Resilience

The Meriam Webster dictionary defines risk as the possibility of a loss. We adopt this definition here in order to clearly distinguish it from the concept of resilience. Resilience is a term rooted in material science – it is the ability of a material to retain its shape following a deformation. In a corporate context it is defined as the ability of an organization to get back to its normal level of production or service (whatever the relevant metric is) following a disruption.

The first step that many organizations take in trying to manage risk and develop resilience is to classify possible future disruptions in order to prioritize the effort require to mitigate and respond to such events. To this end risks are
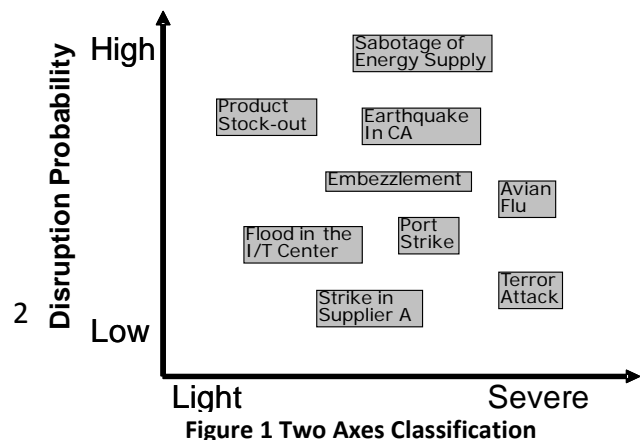

Figure 1 Two Axes Classification

typically classified along two axes. One axis denotes the likelihood of a particular disruption; the other axis denotes the impact (or severity) of this disruption once it hits. Figure 1 shows a simple example of this kind of risk classification. The space in which threats are placed can then be divided into four quadrants, as depicted in Figure 2. Rare, insignificant events (Low-probability, low-consequences (LL) are placed in the lower left-hand quadrant and are not of concern. Events with high probability and low consequences (HL) are also of little concern because data, statistical distributions, and models provide ample warnings and tools to address them.

The events of concern are high-probability, high-impact events (HH) and low-probability, high-impact events (LH). These two should be treated very differently by risk managers.

Most corporate planning activities are focused on HH events. These are events that likely took place in the past or take place on a relatively regular basis. Consequently, such events can be identified and specific preparations can take place. For example, oil companies suffer substantial losses every time a hurricane moves through the

Figure 2 Four Quadrants

Gulf of Mexico. Deep-water platforms have to be buttoned down and evacuated, and platforms are often damaged and have to be repaired at very high cost. However, because hurricanes in the Gulf of Mexico are an annual phenomenon, these companies have well developed processes for dealing with them. Thus, while HH events are likely to require (sometimes expensive) preparations and responses these phenomena should not be of particular concern.

Low-probability, high impact (LH) events, such as the 1986 Chernobyl meltdown, Hurricane Katrina in 2005, the 2010 BP Horizon platform disaster, the 2002 West Coast Port Lockout, the 2011 Japanese tsunami, and similar others, are qualitatively different. These are events that companies, or governments, have not experienced before and consequently, are not prepared for and can therefore have devastating consequences.   For example, in September and October 2011 the worst flooding in Thailand in 50 years shut down over 1,000 factories across six industrial estates and created widespread havoc within the supply chain for the high tech and automotive industries.
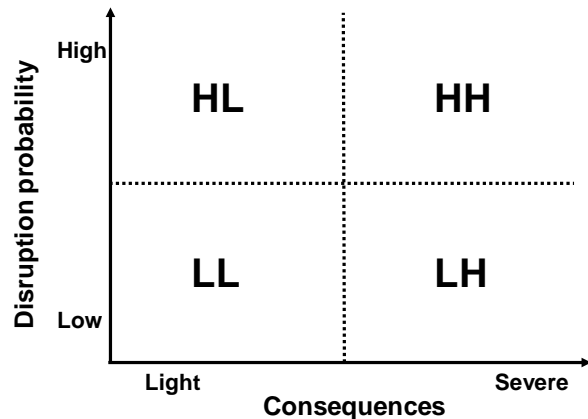
Note that the expected damage (which is the product of probability and consequences) is not a good measure of risk! Frequent small disruptions have little in common with rare, high-impact disruptions, even though their expected values may be similar. The former are dealt with by operations managers in the course of their jobs, while the latter can devastate an enterprise.

Detectability – a Third Risk Dimension

To the two risk classification dimensions depicted in Figures 1 and 2 we introduce an additional one: detectability. It is a well known among professional terrorism experts that the most devastating attack is one where the organization under attack does not know that they are being attacked until it is too late. In corporate parlance, detection is very important because the faster the organization senses the disruption and quantifies the impact, the earlier they execute on recovery. Once detecting the signs of an impending disruption an organization can both try to avoid it, prepare to minimize its effects and bounce back after a hit. Getting to impacted inventory or scarce capacity first can be a source of competitive advantage. Thus, we add the dimension of delectability to the classification scheme, as shown in Figure 3.
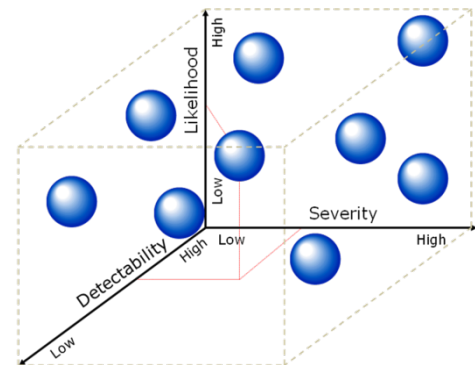

Figure 3 Classification of Threats

Figure 3 depicts an example of a three axis space: Likelihood-Severity-Delectability, where each one of the "balls" in the figure represents a specific risk. Again, the space defined by the three axes can be divided into eight sections, as shown in Figure 4.

When trying to anticipate disruptions, managers should identify all high-probability, high consequences events regardless of their detectability. The detectability of these events is simply one of their characteristics and it impacts the processes put in motion for dealing with them.

This, however, is not the case with low-probability, high consequences events. While such events can be dealt with if they are detectable well in advance, the most dangerous events are LH events with low detectability. These are events that not only the organization is not likely to have experience in the past, but other companies have not experienced it. With such events there will be little warning before the disruption takes place, and even after it occurs,
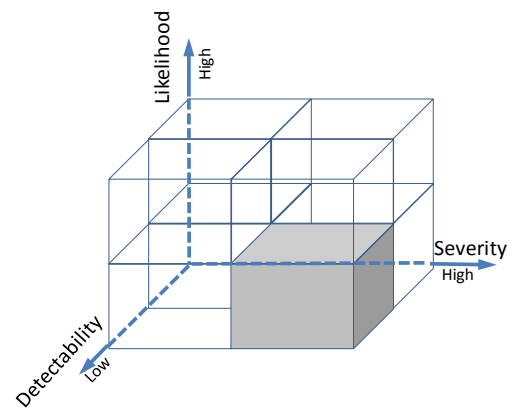

Figure 4 The Danger Region

the fact that it happened and its seriousness, are not immediately apparent. Consequently, corrective actions are not immediately taken, while the disruption propagates, and options for recovery narrow down. For example, more nimble competitors can lock up supplies, suppliers, customers and markets, closing the opportunity for quick recovery.

As a result, the focus in managing the risk associated with these events is on operational resilience, rather than planning. In other words, when a disruption affects several supply chain elements, the focus should be on quick identification, assessment of the significance of the disruption and prioritization of the response. This is in contrast with planning activities which are geared to specific high-probability/high consequences disruptions.

A Developing Supply Chain Software category

During 2010-2011, there have been several efforts to develop tools to help companies identify risks and respond to them. These include software companies developing applications, in-house development of supply chain risk management processes and consulting services centered on risk management and resilience. The focus in this paper is on software company offerings.

Examples of in-house company-developed software include applications developed by IBM, Cisco and ATMI. Software companies developing software (and possibly related consulting services) include Razient Inc. of Miami, FL,[iv] Resilinc Inc. of Fremont, CA[v] , MetricStream of Palo Alto, CA[vi] and Impact Factor Inc. of Princeton, NJ.[vii] Several companies providing supply chain event management applications have also geared their offerings to risk management. Such companies include Trade Merit Inc.[viii] CDC Software[ix] Manhattan Associates,[x] and others. In addition, many consulting organizations have developed supply chain risk management practices, assisting companies in assessing the risks and developing prevention and mitigation measures. Examples include Price Waterhouse,[xi] JLT Specialty Limited in the UK,[xii] Marsh Risk Consulting,[xiii] Capitol Risk Concepts Limited,[xiv] LMI[xv] and scores of others.

In this paper we do not look at consulting offers since those are varied and context-dependent. We also do not look at supply chain event management software. These software applications are based on using product movement visibility and comparing it to product movement plans. When a shipment does not hit a milestone – say it is a day late into certain port, an alert is triggered. Such alerts can be very useful for recovery and resiliency but (i) they mostly deal with small events of late or missing individual shipments and not with events that pose large risks and (ii) the alert sent may be too late as it reveals a supply chain failure rather an impending problem. Such applications may have some use in tandem with specialized supply chain risk management applications to identify potential larger problems.

Most of the software applications under development for supply chain risk management try to operate in two time frames: planning and operations. In the planning mode these software applications use the two traditional axes framework likelihood/impact. In the operational mode they do not try to assess the probability or the likelihood of detrimental events; instead the approach is focused on the other two dimensions of the risk framework depicted in Figure 3: detectability and severity. In both modes these applications look at suppliers and the risk to a company from a supplier failure to deliver raw material or parts (as well, of course, as a failure in one or more of the company's facilities). To this end, most of the applications mentioned above are based on the following data sources:

- Supplier information, including:

    o Plant location of the Company plants as well as its suppliers (Tier 1+), and identification of risks inherent to those locations, whether geopolitical or natural disaster.

    o Supplier response to various questionnaires assessing the business continuity capabilities of the supplier. These include suppliers' characteristics, compliance with various government and industry regulations and initiatives, such as the suppliers' risk management processes, their C-TPAT compliance, insurance requirements, achievement of ISO 14000 standard for environmental stewardship, etc.

    o Financial strength assessment of the supplier collected from questionnaires and public sources

- Product information

    o Which part is supplied by what supplier and at what plant are the parts produced

    o Material Requirement Planning-based information and supplier files for each product in order to identify the plants and suppliers responsible for each part and which product it goes into

    o Sensitivity information regarding impact on the company and its customers of disruptions from product deliveries

- Incidents information

    o Historical data about frequency of disruptions of various kind by geography and time of year

    o   Real time potential disruption information. These data are taken from news reports and specialized sources regarding events around the world.

Planning and Operations

As mentioned above, these software tools operate on two dimensions: planning and real time alerts. In the planning mode, the focus is on the development of risk metrics in order to allocate resources for risk mitigation. The focus then is on the high impact/high probability risks – those that belong in the upper right-hand-side quadrant in Figure 1. To this end, the IBM
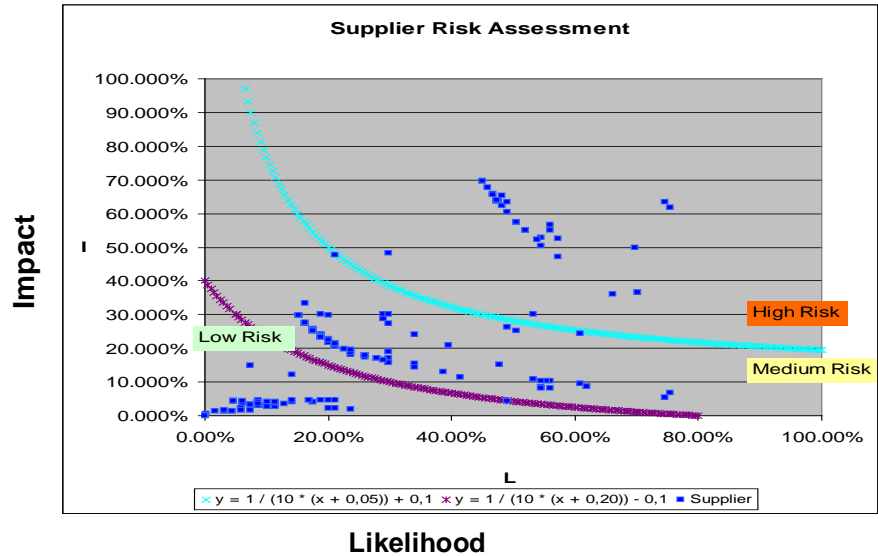
Figure 5 IBM's Classification of Risky Suppliers

software uses several inputs and a curve fitting equation to identify the top right hand side quadrant. The "High Risk" area in the figure is, in fact, the top right-hand-side quadrant in Figure 1. The use of the equation to identify the risky suppliers does not seem to be better than the simple placement of supplier on the impact/likelihood space by a group of experienced managers. Regardless of the use of a set of equations or a simple four quadrant map, what the system provides are the existing risks which the companies should be focusing its mitigation measures on. More importantly, once calibrated, changes in risk profile of suppliers maybe made automatically to the "high risk" category and managers can assess if they are prepared to deal with the disruptions associated with that particular risk.

For real time alerts, companies do not assess disruption probability. Instead, these software tools sound an alarm when a potentially disruptive event has or may have occurred. The software tools allow decision makers to set thresholds for the alerts in order to avoid an avalanche of minor alarms.

To this end, the first functionality included in these tools is a mapping of the various suppliers and their facilities as well as the company's own facilities. The rationale is that many disruptions are geographically limited. This is true for cases when a particular plant is hit with an event, such as fire, sabotage, quality issues or industrial action. Geographical mapping is also useful in alerting companies about events taking place in the vicinity of a supplier's facility. Such events

may include wild fire, political upheaval, violent activities, labor troubles, earthquakes, floods, port/airport closures, bridge collapse, power outage (or brownouts), etc. Even regulatory or legislative actions with potential supply chain impact can be localized geographically.

Using the Data Base

In the planning mode these applications develop risk scores for suppliers and for each of their sites, as well as for the company's own sites. Combining this information with the bill of material information, one can develop risk scores for individual parts and from that for individual products and even individual customers. The risk scoring methodology is proprietary to each application. For example, Impact Factor Inc. offers an example of "Vulnerability Rating" 1 to 10 score with 10 being the most vulnerable and 1 being the least, as shown in Figure 6. As the company seems to focus on financial risks metrics, the scoring is for companies, rather than locations or individual parts.

In the planning domain Razient seems to focus on regulatory compliance management – implying both corporate risk of non compliance by suppliers and possibly, identifying lax processes by suppliers.
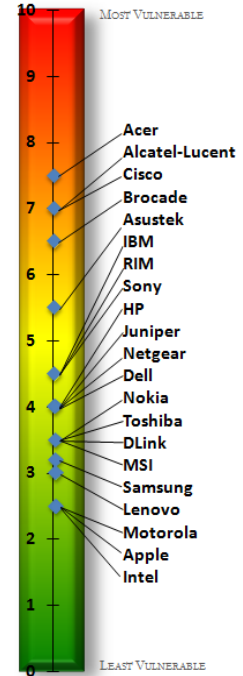

Figure 6 Impact Factor's Example Risk Scores

Resilinc is focused on suppliers' locations and parts availability, thus its software highlights supplier locations with the highest revenue impact on a company, taking into account the financial risk score of the supplier, the location risk of the sites, and their "recovery score," which accounts for the sites' recovery capabilities. The map in Figure 7 is from Resilinc's dashboard showing global supplier locations and representing regional aggregation of sites. Clicking on a pin brings up its risk score as well as other relevant information about the site. IBM's software also delivers supplier risk metrics focusing on the riskiest supplier with mitigation measure prior to any

Figure 7 Resilinc Supplier Locations Map

incident. Since it is mainly aimed at planning applications, the IBM software application is run twice a year to estimate the risk profile of the supply chain.
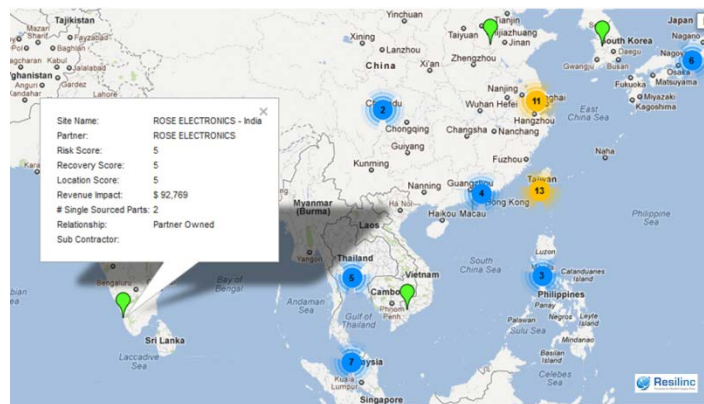
A similar approach was taken by SAP in their Value Accelerator product. Components at risk, by product, can be displayed, as shown in Figure 8, in order to get management's attention to the riskiest part of the business.
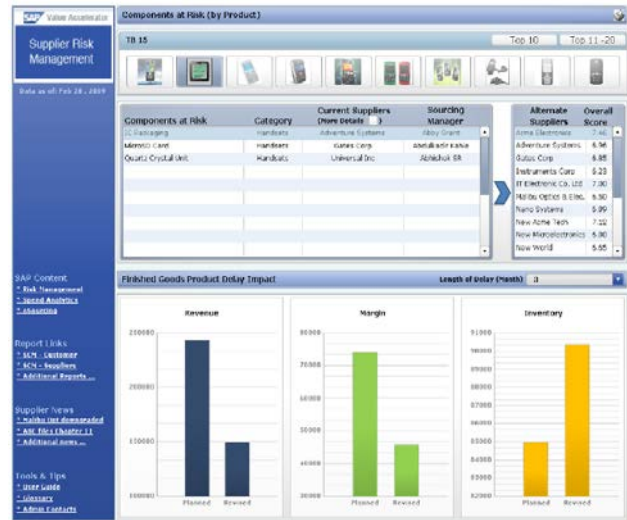

Figure 8 SAP Components at Risk Display

The other use of supply chain risk management applications is for alert systems in real time. The basic methodology here is to impose events on the geographical location reveals which locations are in danger from specific events. The alert system includes thresholds which can be based on the risk score associated with the plant, supplier, or part involved using the risk metrics developed earlier. At this point, however, the risk should not account for the likelihood of an event. At this point an event has already taken place and the software role is to highlight the danger. Figure 9 depicts a real time events display taken from the Razient web site. A similar map, superimposing the supply network nodes within the radius of a disruptive event is shown in Figure 10, which is taken from Gartner's case study of Cisco's risk management software.[xvi]

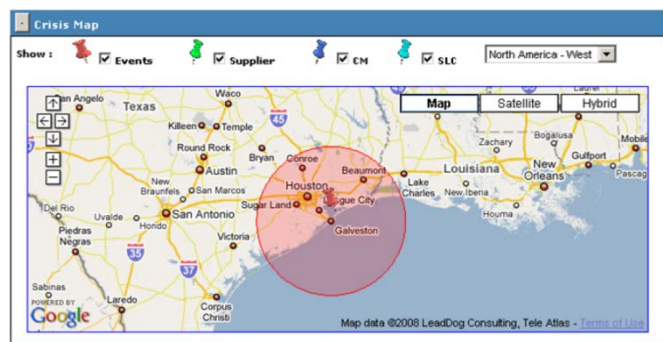**Figure 9 Razient Real Time Event Display**

Figure 10 Cisco Network Nodes within Impact Area

A Warning and Preparation - Supplier Bankruptcy Example

A leading high technology company in California ("Company") started developing its own software for resilience in the middle 2000s and the benefits of these efforts were significant.

The case study below demonstrates its success with identifying a problem early and avoiding customer impact. The case involved the bankruptcy of a critical supplier.

The software application which Company developed internally to alert it to impending risks started showing Spansion as an "at risk" supplier in August 2008. Spansion is a supplier of advanced NOR flash memory chips which allows true random access and therefore direct code execution. These chips are used in wireless modems, cellular handsets, handheld computers, GPS receivers and personal information management devices. The alert regarding Spansion was caused, in part, because parts from Spansion were used across the highest revenue products throughout the range of Company products. The analysis prompted the supply chain team of Company to conduct a focused analysis which identified over 50 single-sourced parts supplied by Spansion. Fearing a bankruptcy and loss of parts the Company supply chain team started working to mitigate the potential problem. The first line of defense was to identify alternate suppliers. Indeed, another supplier – Numonyx – had the capability to supply several of the parts at risk and the Company team immediately qualified this alternate source.

However a fifth of the Numonyx parts were not pin-to-pin compatible with the parts from Spansion. Finding no other alternate suppliers and due to the high revenue impact of the products in question, Company launched an expensive redesign effort for the board under considerations to have a dual footprint so that it had the circuits in place to support both Spansion and Numonyx parts.

But for a small portion of the parts the redesign option was too expensive and consequently Company placed a "lifetime buy" from Spansion for three years worth of supply for those parts, costing millions of dollars.

The benefit of all the efforts that went into the mitigation became evident when Spansion declared bankruptcy in January of 2009. The combination of alternate supplier, board redesign and extra inventory meant that Company could continue to serve its customers with no disruption.

Flextronics Case Study: Crisis Response

Headquartered in Singapore, Flextronics is a Fortune Global 500 contract manufacturer and distributor servicing major original equipment manufacturers (OEMs). It operates in 30 countries around the globe and works with thousands of suppliers worldwide to source hundreds of thousands of parts globally.

The Flextronics Milpitas site manufactures Integrated Network Solutions (networking and communication, enterprise and home connectivity, server and storage, power and Global Services). These are highly complex products requiring tens of thousands of parts shipped from all over the globe.

The Milpitas site procurement and supply chain team is the conduit between Flextronics' OEM customers and their suppliers. The customers make sourcing decisions specifying the suppliers whose parts get designed into the product. Decisions about second sourcing and splitting business between suppliers are also generally made by customers. However, it is the Flextronics team which interacts with suppliers on a daily basis, schedules and places orders, receives shipments, schedules product builds etc. Some of the smaller customers have skeleton staff for supply chain, and are heavily dependent on Flextronics for their supply chain management experience and capabilities.

When a disruption occurs, it is Flextronics that has to react and recover as well as provide customers early visibility to potential impact. Since many customers are dependent on Flextronics for ongoing supplier interactions, the procurement and supply chain team quickly gets inundated with customer inquiries. Additionally, a supply chain disruption can cause a major financial impact to Flextronics Milpitas. High fixed costs and operational commitments mean continuing cash burn while revenues are reduced or delayed. An IBM study shows that a company like Flextronics, which has high fixed costs, loses twice as much in a 10 day disruption compared to some of its customers, who have relatively lower fixed costs[xvii]

The Japanese Tsunami

In the aftermath of the March 11 Japan earthquake, tsunami and subsequent power outages, many Japanese suppliers were disrupted and components went on allocation for a period of time. In the first few weeks, the Flextronics Milpitas supply chain and procurement organization found itself reacting to information trickling in from the impacted suppliers. It took several weeks to gauge the full scale of the disruption, identify all suppliers in the impacted zone and contact them to get more information. Furthermore, while most suppliers posted high level status updates about factories being impacted, Flextronics had no visibility to which parts actually came from each factory. In some cases, Flextronics purchased hundreds of parts from a supplier and it was impossible to assess which of them were built in the impacted factories.

Flextronics' OEM customers, however, expected regular and detailed updates regarding suppliers who were impacted, parts which were going on allocation or experiencing extended lead times and resulting product delivery delays. The supply chain team members found themselves spending many hours working with information in different Excel files, connecting

impacted suppliers to parts, parts to inventory and shortages, to products and "build" plans etc., just to be able to provide information to their customers. At the same time the team had to identify, qualify and line up alternate sources of supply. Additionally, the team found that many of the parts were purchased from distributors or manufacturers' representatives. Therefore, contact information for the actual manufacturer was often outdated and sometimes just unavailable; further complicating and delaying the transmittal of accurate information to the OEM customers.

During this time, Flextronics was trying out the Resilinc software solution. The database underlying this application maps suppliers' footprint and part origin information, and connects this type of supplier information with products and revenue. The company also delivers a repository of manufacturer emergency contact information for quick access during a crisis. Collaborative information sharing capabilities further enabled internal information exchange, group based updates and file sharing.

Flextronics piloted the Resilinc solution in the Japanese crisis response. Even though the supply chain had not been mapped yet, the availability of a central information repository connecting parts to suppliers and products was useful by itself. This experience led to a focused effort to proactively collect the data needed for dealing with the next disaster, including mapping all suppliers' plant locations, identify parts which were built at different sites and collect information about alternate sites and recovery times.

The Thailand Floods

In July 2011, Thailand began to experience heavy flooding in the northern agricultural provinces. Over the next three months, the floods would worsen until waters reached the low lying basin with Bangkok at the mouth[xviii] – an area that is home to thousands of manufacturers across a wide range of industries.[xix] Almost half of the country's land area would be flooded, as shown in Figure 11.
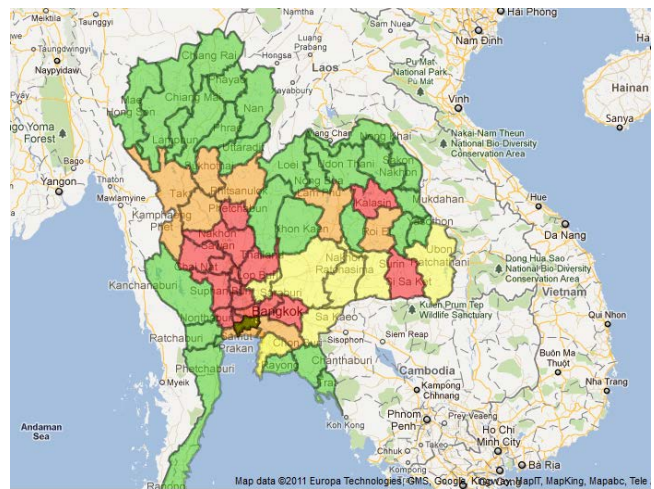

Figure 11 Thailand Area Impacted

This time, the Flextronics Milpitas team was better informed. On October 8th floodwaters breached the barriers protecting the Rojana Industrial Park. On October 9th, Resilinc's tool sent an event notification to the key users at Flextronics, shown in Figure 12, about the developments in Thailand. Among others, one of the suppliers listed on the first October 9th

notification was Western Digital, which would experience massive factory inundation and extended disruptions.

The notification identified not only suppliers in the impact zone, but also the many of the parts built there and the products that were potentially disrupted.

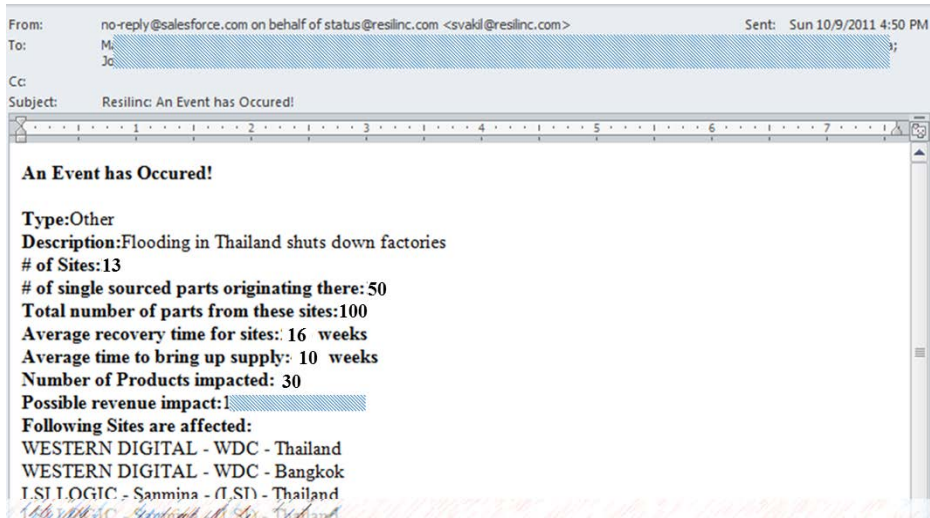Flextronics began to engage with the suppliers in the

Figure 12 An Alert Message

impacted zone starting Monday October 10th. As the situation in Thailand worsened, water started flooding Bangkok and the industrial parks in Ayuthaya and Pathumthani, home to several suppliers, was impacted. The team now created a "Supplier and Part Tracker". By Friday October 15th, the list had grown to almost 20 suppliers potentially in the impact zone and by October 21, there were over 30 suppliers on the tracker, as shown in Figure 13.
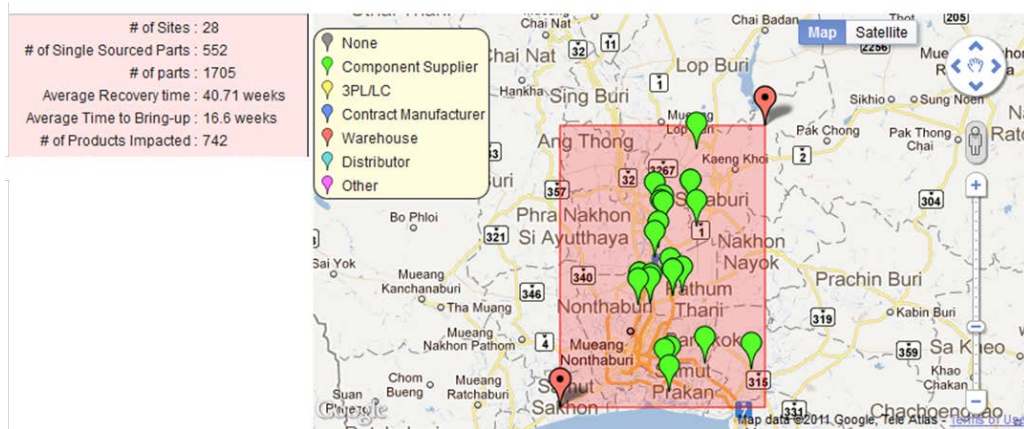

Figure 13 Supplier Sites in the Impact Region

Due to the large number of factories impacted, (over 1,000), it was assumed that even factories outside the flooded zone would be impacted since they likely sourced from suppliers in the disrupted zone. To account for this, Flextronics placed parts built at factories which were not yet flooded on a "Component Watch List". From the full list of parts, the software highlighted parts which were (i) single sourced, (ii) did not have sufficient inventory to cover short term demand and (iii) feeding high revenue products. This allowed Flextronics to narrow down the

list parts to which they had to pay particular attention from almost 2,000 impacted parts to 100. Figure 14 deoits the parts in various risk categories.

The team began to contact the suppliers requesting updates and regular communications about sites and parts impacted. By October 15th, little to no information was forthcoming from these suppliers publicly or in response to inquiries. However, the Flextronics Milpitas team was able to notify key customers about the suppliers in the impact zone, parts originating in Thailand and expected timelines for supply chain stabilization because of the mapping efforts undertaken before the flooding.

Focused Response: Identify Red parts in days

- ■ Dual Sourced. Contact Alternate
- ■ On hand covers 3 month demand
- ■ Low Potential Revenue Impact (SS & <Inventory)
- ■ High Potential impact (SS & <Inventory)

Figure 14 Focusing the Attention

In retrospect, while having access to information about supplier names was valuable, the main benefits came from the ability to connect all the dots; from supplier name to part numbers, part numbers to inventory and demand positions, from that to specific products and customers. Prioritization by revenue impact was critical to ensure the highest impacting parts were addressed first. Using this information, the team was in a position to have targeted conversations with suppliers and customers about the ~100 parts which were on the "high risk" list. The team then identified recovery strategies such as placing risk buys, qualifying alternate sources or adjusting build schedules and allocating available inventory to the higher priority products.

The speed with which they were able to organize, react and respond and begin collaborating with customers during the Thailand event was greatly enhanced by the investment in tools and processes. They did not experience the "scrambling for information", manual compilation of reports and extensive and extended overtime from people that had been a key problem with the Japan event. They also avoided revenue and margin loss from this event. As an intangible, the ability of the team to be well informed and in control greatly enhanced their credibility and bolstered customer confidence and satisfaction.

Conclusions

The "new normal" in the 21st century is a global, multi-tiered and lean supply chain. Recent studies by the Business Continuity Institute,[xx] Zurich,[xxi] and A. T. Kearney[xxii], all show that almost 80% of companies are vulnerable to a major supply chain disruption. To answer this challenge, a new crop of software tool is under development, creating a new category of supply chain software applications. These models are aimed at helping businesses identify both high probability, high-consequences potential disruptions that the business should focus on
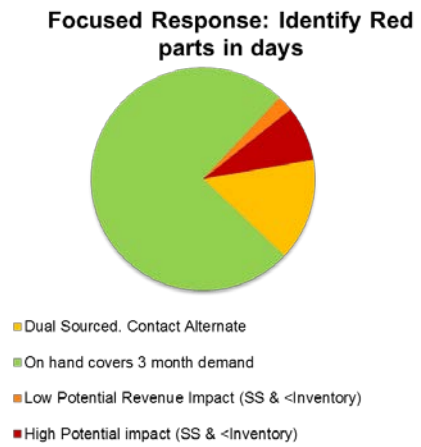
preparing for, and "unknown unknowns," or "black swans" – low probability high consequences disruptions that are impossible to foresee.

These software products help businesses make specific plans for mitigations and recovery from high probability, high impact disruptions. They also help businesses prepare for unexpected low probability disruptions by providing supply chain managers with timely access to relevant and actionable information. In both cases the software should be coupled with clearly defined processes, including roles and responsibilities. This combination of technology, people and process allow companies to identify a problem early and prioritize the response regardless of the nature of the disruption. The software products organize and prioritize the information, pointing decision makers to areas (suppliers, parts, customers) that require immediate and focused attention. By clearly defining triggers for activating a crisis response team, putting in place thresholds for emergency budgets for the CRT and conducting training and crisis drills periodically, companies can mitigate the effects of most disruptions.

The software applications reviewed here, as well as those developed by various companies for their internal needs, constitutes a new category of software products. As these applications grow in popularity and acquire more customers, their utility will increase and the process of mapping and data collection will become more efficient. The reason is that most suppliers serve multiple customers and thus the software vendors can get the data once, feeding multiple companies. The data acquisition and maintenance cost for such software applications is expected to continuously decline over time. Additionally, a comprehensive mapping and analytics solution used effectively for risk mitigation can reduce premium on contingent business insurance (CBI) policies, which might fund part of the investment in the software and the data collection and maintenance.

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