Managing Disruptions Proactively in the Supply Chain: The Approach in an Auto-Manufacturing Production Line

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Abstract
This paper presents the results of a case study which investigated the approach of an auto-manufacturing’s production line to managing proactively disruptions in their supply chain by using formal processes. Firstly, a supply chain map is presented where the sources of risks are identified and the risk management processes that are currently implemented are described. A critical issue discussed is how managers perceive risk and the level of awareness they have about issues concerning disruptions. Furthermore, the company applies lean practices where it has developed processes to deal effectively and efficiently with daily operational problems, but hasn’t considered dealing formally with supply chain disruptions. Barriers to the development and use of formal processes for disruption management are considered briefly. A key finding is that the company would improve disruption management by developing formal risk management processes. Finally, risk mitigation strategies that could be applied by the company are proposed.

Keywords: Case Study, Proactive, Disruption Management, Supply Chain
1. Introduction

The September 11th terrorist attacks, SARS, the tsunami in South Asia that caused great economic devastation, and the U.S-Canada 2003 blackout which severely affected the logistics of the companies residing in the affected area as well as their customers, are certain kinds of disruptions that increased the awareness of companies in the presence of risks. In order to deal with their daily operations and succeed their strategies under uncertainty, it is also important that organizations have sufficient ability to deal effectively and efficiently with supply chain disruptions. This is because organizations are engaging in longer geographical spread and more complex supply chains, thus increasing the organization’s vulnerability in the presence of different types of disruptions. Disruptions can take many forms, such as natural disasters, economic crises, political instability, and terrorist attacks, and although disruptions are believed to be rare events, they do happen and they are usually quite damaging (table 1).

Table 1: Disruption Examples

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<th>Events</th>
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<td>September 11th terrorist attacks on the World Trade Centre</td>
<td>Thousands of lives lost, and an estimated damage of nearly $80 billion (Grossi and Kunreuther, 2005).</td>
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<td>Fire destroyed Toyota's brake supplier plant in 1997</td>
<td>Stopped Toyota's production lines and was estimated to cost Toyota approximately $40 million per day (Nelson et al., 1998).</td>
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<td>Hurricane Mitch in 1998 that blew throughout Central America damaging banana plantations</td>
<td>Damaged banana plantations resulted in Dole loosing $100 million for the fourth quarter and suffering a 4-percent revenue decline (Joseph and Subbakrishna, 2002).</td>
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Wilson, (2007) defines a disruption as an ‘event that interrupts the material flows in the supply chain, resulting in an abrupt cessation of the movement of goods. It can be caused by a natural disaster, labour dispute, dependence on a single supplier, supplier bankruptcy, terrorism, war, and political instability’. Thus, a disruption is an event that interrupts the smooth flow of raw materials and/or parts and/or finished products in the supply chain,
affecting the satisfaction of the end customer and causes disruption to the operations of the companies affected. All these causes have a negative effect on the supply chain by making unavailable the materials or products when they are needed at different points in the supply chain.

These effects can only be mitigated or prevented if the companies in the supply chain have proactive risk management processes in place, so in the case a disruption materializes it has a zero or minimum effect on the supply chain.

1.1 Alpha Case Study

Alpha (imaginary name) is an automaker company and a subsidiary of the Company (imaginary name). Alpha was chosen because it is a global company, operates in a rapidly changing environment, and faces global competition. Also, it is a well organized company that in the past has dealt with a number of disruptions and its experience would help develop useful approaches to dealing proactively with supply chain disruptions.

During the case study I interviewed three managers; the materials planning and logistics manager, the manufacturing engineer manager, and the purchase manager. I also interviewed the supply chain supervisor, an analyst and a logistics employee. Additionally, observation of the daily operations of the supply chain and logistics team was performed, I had a guided tour through the assembly line and the warehouses, and I was able to inspect company documentation regarding Alpha’s logistic operations.

The objectives of the study were to understand Alpha’s supply chain operations, identify possible sources of disruptions in the supply chain, determine whether Alpha makes use of formal processes to handle these sources, and to consider how these processes might be developed.
2. Alpha Supply Chain Map

Toyota Motor Company has been the originator of the lean approach which has been adopted by a number of automotive firms (Slack et al., 2007). Lean is an approach towards the removal of anomalous and wasteful practices in order to develop faster and more efficient operations which produce better-quality products and services at low cost (Lamming et al., 2000; Slack et al., 2007). Alpha’s production system is also based on the lean philosophy and tries to achieve the elimination of waste in the production process by being cost effective and keeping very limited stocks.

A design of Alpha’s supply chain is presented in order to capture the basic operations and the global supply chain it operates in. The simplicity of Alpha’s network design is not only based on confidentiality issues but also on the need to identify sources of disruptions, low likelihood high impact risks, which are usually not involved in the daily operations but in unexpected and rare circumstances that occur internal and external of the supply network. The supply chain map begins from the first-tier suppliers because Alpha isn’t involved in any form of communication or contracts with its second tier-suppliers. As Fawcett and Magnan (2002) rightly noticed, that few companies are actually engaged in extensive supply chain integration and most companies supply chain practices are with their direct supply chain partners.

Alpha uses with its suppliers a system which monitors what parts are in the plant, in transit (update where the trailer is), and how many pieces to use on a daily basis. Additionally, except from the flow of materials and vehicles through the network from the suppliers to end customers, there are also the information, orders and capital flows moving towards the opposite site. In order to achieve a better understanding of Alpha’s supply network, brief descriptions of the main actors and processes are described.
Suppliers

There are over 300 suppliers in total; Europe: 79%, Turkey: 15%, North America: 5% Africa: 1, and South America: 1. The majority of the suppliers supply more than one carline in the Company and also have more than one manufacturing site.

The Company has started applying the new supplier program in which it is reducing the number of suppliers for the different components but is increasing its level of cooperation and commitment with these preferred suppliers. Through this program they are also increasing the use of common parts for multiple vehicles. The Company can achieve lower costs, higher quality, improved communication, transparency on costs and volume data, and increasing innovation and teamwork with their preferred suppliers. This is also evident in the Japanese model, where the buyer and the supplier develop a long-term mutual dependency, close communication and interaction between them (Wasti and Liker, 1997).

Quality Standard

The suppliers the Company is dealing with are Company quality certified suppliers and most of them are large global companies. The Company always encourages its suppliers to push all of the quality disciplines back into their tier-two suppliers as well. Most of the suppliers, because when a part is supplied to the Company, they have to fill in a part submission form for the components in order to state they can provide the components, the part is completely production representative, and that it meets all the specifications of the drawing. It may not be exactly the same Company documentation the suppliers are using with their suppliers, provided though that they are using the same processes with their tier-two suppliers.

Single Source

Originally the Company had three to four supplies per part, but now for each part they have one supplier, except from tyres and rear springs where they multiple source. The single source suppliers provide competitive prices, quality assurance, technical innovation, and
higher levels of assembly. By maintaining competition between small numbers of suppliers and helping them to develop, an automaker can ensure that the parts have the desired quality, performance, and price levels (Wasti and Liker, 1997).

**Multiple sources**

Alpha multiple sources tyres from up to six different suppliers. They chose tyres due to the high volume required, to facilitate customer choice, and reduce freight cost if vehicle plants are located in different continents.

Alpha dual sources rear springs because the company they originally sourced from couldn’t meet the capacity, so they divided the required capacity between the original company and another.

**Logistics**

Logistics is the process of strategically managing the procurement, movement and storage of materials, components, finished inventory, and information flows through the firm and its supply chain, in order to maximize current and future profitability through the cost-effective fulfilment of orders (Christopher, 1998). Alpha has outsourced its inbound logistics services to two major logistic provider companies, one mainly for Europe and one for America. The company for Europe is the lead logistics partner for the Company and takes control of the inbound network and tries to manage it efficiently. It also designs the network and then Alpha chooses the carrier (e.g. affordable cost (balance between quality and cost) and makes some changes to it. For the Outbound logistics Alpha is responsible and it uses its own carriers.

**Transportation**

A multi-modal transportation system is operated through the network. The different methods of transportation normally used are: Americas and Africa: ship, Europe and Turkey: train and trucks. Airplane is an alternative method of transportation in case there are delays in receiving the parts and affecting production.
From Europe and Turkey the trucks go to the different Origin Distribution Centres such as Prague, Paris, and Madrid where full load of supply materials to these centres is achieved and then distributed to the scheduled plants. Trains, on the other hand, typically follow different routes from trucks.

An additional two truck transportations are used: Milk Runs and Less Than Truck Load. Milk Runs are used when there are two to three suppliers who are located in the same area and together comprise enough materials to make the full load e.g. one truck that goes gradually to each supplier. Most of the milk runs go to an ODC, but some of them go to a train terminal. On the other hand, with Less than Truck Load, a truck goes to one or possibly more than one supplier and then goes to an ODC. The difference between the two depends on where the suppliers are located.

In America the trucks and trains go to Canada and then loaded on a sea container which usually goes to the nearest U.K port to the plant, but sometimes due to reasons such as heavy traffic, the ship goes first to a neighbour country and then to the U.K port.

**Inventory**

The material inventory as soon as it leaves the supplier’s plant and is on the Company’s truck it is on Alpha’s inventory. When the material is in the plant and is built into a vehicle, the vehicle is still on Alpha’s manufacturing inventory until it is gate released when the vehicle starts its outbound journey when it is on Alpha's sales company inventory. The vehicle then goes to the dealer, and once the dealer buys the vehicle, it is on the dealer’s inventory.

When a supplier forwards the materials, an ISN (in-advance supplier notification) is entered into the system so the system takes into account that the load is on its way because the supplier inputted it into the system saying it has left the supplier and is on route. So, the stock control system shows what is in plant, and what there is in transit.
For each part they keep different stock levels. The stock kept is based on the calculation: average daily use of the part * cost of the part. From the calculation, the lower the number the more stock is kept. Where the stock will be located in the warehouses is governed by the point of fit and the type of part.

The majority of the stock is in the plant (warehouse, market-place), but they also have very few stocks outside the plant. As an example the exhausts are sequenced by a place 20 minutes away from the plant. The need of having parts (e.g. engines) outside the plant is because there isn’t available space in and around the plant so they can’t expand at all. Space is a constraint, so they have to utilize other warehouses.

Production

‘What I have to recognize with this vehicle is that it is a unique animal. If you go into a dealer, to order an Alpha, there are over a thousand different types you could order’.

The time required to build a vehicle is about two days and 90% of all the vehicles they produce are customer orders. Alpha’s production line operates 18 hours from Monday-Thursday and 12 hours on Friday with the potential for extra shifts on Saturdays with a reduced workforce.

There are nearly 4000 parts for the assembly plant. A number of parts are usually supplied by the same supplier, for example, the may supply a type of valve with different configurations. They set they sequence at the beginning of trim, to call the parts from sequence suppliers and they keep that sequence until the vehicle comes of the line, so they can’t take without physical intervention any vehicles outside of the sequence. Sometimes they stop for a quality stop, and if it is serious then they may stop the whole line.

In the assembly line the employees are not as flexible in workstations rotation as Alpha would desire. Although there is labour mobility, it’s not always easy to move employees around different jobs, and there are restrictions such as medical restrictions where
certain employees can do certain operations at a certain height and use certain parts of the body, so Alpha has to make sure that it matches these restrictions to the operations as well.

**Parts**

Significant and non-significant parts are classified in terms of line stoppage, whether it can keep on assembling or not. In the case a significant part is unavailable they have to stop the assembly line because they cannot build the vehicle without it, or live the vehicle in buffer zone. Buffer zone has a certain capacity and it depends on the part e.g. engine on how much capacity will be allocated to it. If it is a part for every vehicle then you have to stop production if it cannot be fitted later on. Engines, instrument panels, and insulations are a critical part and if not available then have to stop production. They can still build the vehicle but is so much repair time which is not worth carrying on. If it is a non significant part they can produce the vehicles and fit it later. When the vehicle finishes although it may fail the end of line tests, they can fit them afterwards. Sometimes and very rarely because it is very expensive they have the dealers fix the problem.

**Dealers**

The dealers are companies that market and sell the vehicles on behalf of Alpha, thus, they are the people faced directly to the customer. They also provide after sales services to the customers such as vehicle repair and warranty services. Ultimately the Company pays for changes needed under warranty. When a vehicle is returned to the dealer to change a component under warranty, that component should be returned back to a central location in the Company, which they would then send back to the manufacturer that would try to identify what caused it (e.g. design issue, manufacturing problem) and actions to improve the manufacturing process. Additionally, the dealers provide the company with important feedback such as customer satisfaction.
Customers

After the vehicle is sold, the after market customer service maintains extra capacity for the parts that are required in the case, for example, of a vehicle breaking down or a part needs to be changed. Trying to achieve and maintain the satisfaction of the customer, the Company operates customer clinics, mainly for their fleet customers, where it listens to the critiques about the current products and how they would like the company to enhance the product. Additionally, it performs benchmarking against the competition, and in conjunction with customer clinics it tries to understand what the needs of its customers are. Then, a feedback is pulled together to establish what the content of the next generation vehicles should actually be.

3. Sources of Disruptions

When a risk materializes and it is threatening to stop the production line, Alpha will try to implement alternative actions (e.g. airfreight) that will help maintain the continuity of production. If the production line stops it will cost Alpha millions of pounds. Sometimes though with disruptions such as fire, strike, flooding and terrorist attack it is very difficult to keep production running. In this case the company must already be implementing plans that will make the company and the supply chain more robust and resilient to supply chain disruptions.

Based on the interviews with Alpha’s personnel the sources of disruptions that Alpha has encountered were identified and listed. These are:

- **Strikes**: they usually have to deal with an industrial action in their supply chain about two-three times a year with some countries being more prone to industrial action than others.

- **Transportation**: rail is not robust due to engineering works in line, network breaks down thus transportation changes needed, traffic, bank holidays (every country different). Also, there are risks of crossing the different countries’ borders until you get to the E.U where
there are tariff free boundaries. However there can still sometimes be problems in the E.U. Furthermore, suppliers that are long way (e.g. exhausts that come from Africa, petrol engines from America) is a risk because sea freight is unpredictable and particularly the transatlantic route because it is so busy and the Alpha is such a small buyer of transatlantic sea freight.

- **Natural Hazards**: bad weather conditions especially in Europe, e.g. bad weather conditions at the North of Spain in February 2007.
- **Supplier Issues**: fire at second – tier supplier, a storm took the roof off a supplier’s press shop so they weren’t able to make any parts. Also, supplier bankruptcy, for example, a hardware supplier is under administration and Alpha is taking parts until they can supply. They buy from a distributor in the U.K which is supplied by America.
- **Production Problems**: equipment breakdowns
- **Stock**: The system sometimes shows on screen that there are e.g. part A has 300 pieces in stock but in fact there are only 50 pieces in stock.

The sources of disruption of most concern to the materials planning and logistics manager are: (1) Supplier did not send the materials, (2) Transportation issues and (3) Industrial action. The supply chain supervisor is most concerned with: (1) Supplier issues, (2) Transportation and (3) Limited stock for assembly line. Supplier issues that result in not sending the part and transportation issues that also relate to not delivering the part have the same ranking in both managers. The managers are familiar with these types of disruptions because they are linked to their daily business, and they are aware of the cost damages they can cause, such as closure of the assembly plant. Additionally, the supply chain supervisor recognizes as a source of disruption the limited stock which is linked to the lean practices Alpha employs. The materials planning and logistics manager though has to justify to seniors why more stock (millions of pounds) is needed when increased levels may not comply with the Company’s lean production system to keep limited stocks. Although additional inventory would decrease
Alpha’s vulnerability to supply chain disruptions, it would also disregard the Company’s lean philosophy which guides the practices in Alpha.

Although at Alpha they have encountered and are aware of sources of disruptions such as strikes, supplier issues, transportations, natural hazards and limited stock, there are also other sources of disruptions that can cause a high impact on their supply chain. The Company may have not considered them because they haven’t come across with such types of disruptions so far. Some plausible potential disruptions based on experience elsewhere are summarised in Appendix 1.

We can see from the examples the interconnectivity between different sources of disruption, and how can the occurrence of one disruption, initiate in parallel another source of disruption. For example, although the closure of all U.S west ports was caused by strikes, the strikes in turn caused transportation limitations for the large vessels that could only use specified ports. Transportation limitations meant goods caught up in transit leaving manufacturing companies unable to produce their products because they were short of the necessary materials. Thus, when developing proactive risk management processes, not only the variety of the different sources of risks need to be identified, but also the interconnectivity of these sources needs to be determined. Sources of disruptions are not static points in a stable environment. They materialize in a dynamic and changing environment which affects the relations between these sources.

4. Managers Risk Perception

The purchase manager, the materials planning and logistics manager, and the manufacturing engineer manager were asked on how they conceptualize risk and disruption, and if they distinguish any substantial difference between the two. Their replies heavily depended on their position and experience at Alpha. Whether the managers concerned are operational supply chain specialists or CEOs with an eye to shareholder value and corporate
governance requirements, research suggests that each will perceive supply chain risk through the subjective lens of their own goals and performance measures (Peck, 2006).

Firstly, the purchase manager conceptualizes risks and disruptions as the same, with no basic difference between them. For him, risk is related with supplier issues Alpha usually encounters such as the supplier doesn’t supply the parts, poor management and capacity planning at the supplier’s organization, not having sufficient capacity on their machines, not getting the right return from their machines, not maintaining the tools properly, and machine breakdown in the facility. He attributed these risks to the lean practices companies are trying to achieve by avoiding holding stocks. The risks the purchase manager referred to are operational risks, high likelihood low impact risks, that if not controlled and handled at an early stage, they may develop into a source of disruption and affect the continuity of Alpha’s supply chain. So, the Company needs to work closer with certain suppliers in order to resolve issues that can negatively affect the availability and the quality of the part.

The manufacturing engineer manager due to his position in the assembly plant visualizes risks differently from the purchase manager, but views risks and disruptions as the same category. Risks from his point of view are risks that can arise in the assembly line such as volume loss because Alpha can’t produce, quality risks because the vehicles have to come off line which is extra repair time and extra time for the vehicle on wheels, health and safety risk, and also risks to damaging equipment which leads to risk in volumes. From his examples of what risks are we can conclude that he is also mostly concerned with operational risks than disruptions, and maybe has never considered any disruptions because they haven’t materialized until now inside the assembly plant.

Finally, for the materials planning and logistics manager, risk or disruption is anything that will either stop production or cause Alpha to build vehicles with parts missing. Thus, he is mostly interested of the causes and not the sources of risk. He recognizes that there is a potential of risk in every single supplier they have, in every aspect of the supply chain, from
whatever country it is coming from, however far or near it is. He identified though the risks that can affect the continuity of the assembly line: sea freight which is unpredictable, some suppliers’ performance not satisfying and need to monitor it, long distance thus long lead times and only way to react quickly is by air-freight. What he never considers on this thinking about risk is September 11th, 7/7 in London, flooding on the north of England, tsunami, because as he said he can’t plan for those. If they happen Alpha will find a way around them.

From these three descriptions or risk perception we can conclude that Alpha managers perceive risk and disruption as the same, and the only risks they consider is usually related to the operational risks. For most cases Alpha has already developed contingency plans and capability teams to respond to operational risks because these are risks they come across often and affect their daily business. A big gap ignored though are disruptions which although they are rare events, and they cannot plan for those, in case they materialize the negative impact will be huge for the company and its supply chain.

5. Current Disruption Management Processes

‘Something that the company is good at is fighting fires, if things go wrong they are very good at reacting and fixing it. I would prefer we would get better in our upfront planning’.

This statement underlines the company’s effectiveness in dealing reactively with operational risks, risks that are in their daily activities. But what happens in the case of a disruption materializing that they never handled and is unfamiliar to them. That’s why the manager is stressing the need of upfront planning. Upfront planning will help Alpha develop competencies and familiarize the personnel in handling sources of disruptions proactively.

Alpha is aware of the operational risks accompanying its business, and has in place reactive and contingency plans such as technical assistance to suppliers, cycle checkers, incremental tooling, and vehicle pre-production processes. This cases study’s focus though are supply chain disruptions, and is interested in what processes Alpha employs that help
Alpha be more robust and resilient to disruptions. Strategies that are currently operated by Alpha to manage supply chain risks are summarised in Appendix 2 / Table 2.

We can see from these examples that Alpha has contingency plans in place and is very effective at reacting to operational risks and certain sources of disruptions such as strikes and transport limitations. This is because these are disruptions they have encountered in the past and they have developed response scenarios which they have executed more than once. Other disruptions such as fire at second-tier suppliers and natural hazards affecting suppliers, although unusual, Alpha eventually finds a solution. With the fire at the second-tier supplier Alpha was lucky because the part affected could be supplied by other suppliers, thus the first-tier supplier found easily an alternative supplier. In the case of a disruption with a steel supplier or a supplier of a unique critical component, the situation becomes much more difficult because even if they find an alternative supplier it may not have the capacity for the volume needed by Alpha, and until the supplier builds the necessary capabilities and capacity, Alpha may lose many days of production. Although, at the end of the day Alpha will build the lost number of vehicles the recovery costs will be enormous.

6. Barriers to the development of proactive risk management processes

Alpha needs processes in place that will serve dual purposes; these processes will not only be applied for the daily operations of the company, but also in the rare event of a disruption, these processes will be in place that will help the company react to the disruption resulting in a non or minimum negative impact on the company. Barriers though exist for the development and use of proactive formal processes for disruption management. Firstly, the support from senior management from the Company is required. Every manager is busy with their duties that there isn’t available time to think beyond their activities. Even if they want to initiate a different way of thinking, this way of thinking must be applied to the whole Company, and without the approval of top management this is very difficult to be achieved.
Usually managers although they are aware of the effects of a disruption, because they are rare events, they don’t want to spend resources on mitigating something that may never materialize. As Repenning and Sterman (2001) rightly state, that nobody ever gets credit for fixing problems that never happened. Sheffi (2007) identified as one of the difficulties dealing with the possibility of disruptions, the difficulty in measuring the economic benefits of cost avoidance, because avoided disruptions not show up as revenues, costs, profits, assets, or in any other form on the company’s financial statements. The only thing that shows, is the cost associated with disruption avoidance. Thus, managers are doubtful in investing time and resources in activities that are rare and which can’t be measured precisely in economic terms, and the benefits cannot be shown immediately, except in the event of a disruption.

Rice and Caniato (2003) based on a broad range of responses from the ‘Response to Terrorism’ Study” concluded that most of the companies were reactive, meaning that the actions taken were in response to government regulations and other mandates. Alpha is part of a U.S.A company, and in the States now the companies need to comply with the Sarbanes-Oxley Act 2002. Economic scandals such as Enron and WorldCom induced legal requirements such as the Sarbanes-Oxley Act 2002 in the U.S.A. Sarbanes-Oxley Act requires U.S companies to inform shareholders of their risk profile and their approach to manage risk (Tang, 2006a). Thus, it helps reinforce investment confidence and protect investors by improving the accuracy and reliability of corporate disclosure1. Alpha has started developing business continuity plans which is a requirement from the Sarbanes – Oxley Act. Alpha needs to develop plans in order to respond to situations such as:

- Fire in the paint shop; would they halt production, would they make the bodies and take them to be painted in a different location and then bring them back to the plant for the trim phase?

1  http://thecaq.aicpa.org/Resources/Sarbanes+Oxley/
• Failure of the vehicle scheduling system which controls 90% of the plant; would they be able to work through it manually?

• The information systems network goes down and information is not accessible from the suppliers; could employees be sent home and be able to work from a laptop and on the phone?

Each area in the plant requires developing a business continuity plan. Alpha has not completed this yet but they are in the process of doing it. Business continuity is related to predicting things that may go wrong and taking planned and rehearsed steps to protect the business and hence the stakeholders’ interests. It is about co-ordinating and incorporating all the planning processes across departments and presenting a confident image to the outside world (Reeves, 1999). Thus, a risk management culture has started developing in the plant, which can be the basis for the development of proactive risk management processes, thus moving from the phase of just having contingency plans in place in the case of a disruption. Additionally, they can then expand their proactive risk management culture to their supply chain partners, because mutual benefits can achieved, such as decreased operations costs, information sharing and better relationships.

7. Developing formal risk management processes

‘While we are busy by sorting out all these things that don’t need to happen, but one serious shortage that happens underneath all of this comes pass and gets to the line and all of a sudden they are running out of a part, and the reason they didn’t spot it is because they are busy messing around with all the noise in the system’.

Alpha is a company that has developed contingency plans for operational risks but has ignored disruptions because they are low likelihood high impact events. Thus, they are events that are not present in their every day activities, and also Alpha employees believe due to the global presence and powerful company they are part of, if a disruption materializes they will
find a way to handle it. From a manager’s statement above we derive the conclusion that although they are efficient in handling operational risks and busy with ‘fighting fires’, they may ignore a major risk that may have the most significant impact on their assembly line. This highlights the importance that Alpha must not only take a reactive approach to each risk materializing, but the need to have proactive risk management processes in place that will help them not only identify the risks in their supply chain but also build into the system capabilities and strategies that will make Alpha resilient in the presence of disruptions.

The only barrier standing between companies and a disruption in its supply chain is luck, which eventually it runs out (Rice and Caniato, 2003). This demonstrates the volatile environment an organization and its supply chain operate in, and that the possibility of a disruption affecting the supply chain is always present. Rice and Caniato (2003) underline the need of supply networks to have comprehensive security processes and procedures prepared, and to be resilient enough to recover from any kinds of disruptions. They highlight the need of placing proactive processes in place that will help the company recover quickly after the event of a disruption by being resilient. In materials sciences resilience is the ability of a material to return to its original shape after a deformation that does not exceed its elastic limit (Sheffi, 2007; Rice and Caniato, 2003). In business terms resilience accepts that it is not possible to avoid, control, or eliminate all risks and it focuses on the ability of the system to return to is original or move to a new, more desired state after being disturbed, i.e. its ability to absorb or mitigate the impact of the disturbance (Peck, 2006; Christopher and Peck, 2004). Additionally, resilience measures the ability and the speed of an organization at which it can return to the usual performance level after a high impact/ low probability disruption (Sheffi, 2007). The more resilient the company is the fastest it will recover from a disruption in its supply chain. Sheffi and Rice (2005) propose that if companies desire to be resilient they require building flexibility into each of five essential supply chain elements: the supplier, conversion process, distribution channels, control systems and underlying corporate culture.
Thus, resilience is a process that involves not only the company but also its suppliers and the processes used in the supply chain, and a proactive risk management culture is essential for the resilience of a supply chain network.

Christopher and Peck (2004) identified the need for formalized procedures for supply chain risk management within and between organizations. This is because practitioners feel uneasy when they have to determine the scope and variety of potential risks. As a result, the majority of them were not in a position to readily identify appropriate tools and techniques suitable for managing potential risks. This was also evident with Alpha; managers and employees were very relaxed in discussing about issues concerning their job, but when the discussion was about how they conceptualize risks and disruptions they felt uneasy, and needed some time to think before answering the questions. When they answered, most answers evolved around concepts and techniques related to operational risks and not disruptions.

Taking into consideration these facts a process framework can be developed that will facilitate Alpha take effective measures and make efficient decisions to handle proactively disruptions along its supply chain while minimising cost. Although frameworks are available in risk management they only analyse the business activities of a company and not its relation and activities with its supply chain partners. Due to global competition though, companies are no longer seen individually but part of a supply chain with an objective to satisfy its end customers, at a minimum cost, and remain competitive. Although, risk management frameworks are mostly used for individual companies, recently they have started been expanded considering also supply chain partners. Thus, the current company risk management framework will be readjusted to incorporate the supply chain.

The risk management approach tries to establish a common language between the interacting entities that facilitates internal and external communications and supports resource allocation through prioritization of risk (Deloach, 2000). It’s a formal process that helps the
decision makers in identifying vulnerabilities, triggers for these vulnerabilities, likelihood of occurrence, identifying potential losses, understanding the likelihood of potential losses, and assigning importance to these losses, and mitigation and risk transfer activities (Kleindorfer and Saad, 2005; Giunipero and Eltantawy, 2004). Dell, Toyota, and Motorola are certain companies that stand out at identifying risks in their supply chains, and at creating powerful mitigation strategies that neutralize potentially negative effects (Chopra and Sodhi, 2004). The formal risk management process will help the company first develop a proactive disruption management culture in the company, making personnel familiar with what risk and disruptions are, and then with the cooperation of the different departments and supply chain partners, identify the sources of disruptions, assess them using a cost/benefit analysis, and then ranking and prioritizing them in order to develop the appropriate risk mitigation strategies.

8. Risk mitigation strategies

Finally, risk mitigation strategies are proposed that will help Alpha become more resilient to disruptions. The experience Alpha has had with disruptions can also be used as a guide in developing the appropriate strategies. The risk mitigation strategies developed need to strategically fit the company, and adapt to the special requirements of Alpha. Thus, Alpha must be aware of the sources of disruptions it is mostly interested with, and then develop strategies that comply with Alpha’s operations and the Company’s lean philosophy. A key issue here is which risk mitigation strategies are worth investing in. This can be decided by performing a cost benefit analysis. For determining though effectively which sources of disruptions Alpha should mitigate and decide if the benefits are attractive enough, the steps of the risk management process framework must be applied and followed. What is best to be applied must be decided after implementing the proactive risk management framework.
Following in table 2 risk mitigation strategies which Alpha can apply are proposed, and the related benefits are presented. Every strategy has its drawbacks also, but this paper displays only the benefits in order to demonstrate how Alpha can benefit from each strategy.

Table 2: Possible additional Risk Mitigation Strategies

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<th>RISK MITIGATION STRATEGIES</th>
<th>BENEFITS</th>
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| **Flexible Sourcing Strategies** (Joseph and Subbakrishna, 2002; Lee and Wolfe, 2003; Rice and Caniato, 2003; Christopher and Peck, 2004; Chopra and Sodhi, 2004; Tang 2006a) | ▪ Flexibility (e.g. contracts)  
▪ Necessary back-up  
▪ Avoid disabled sites and trade lanes  
▪ Continuous supply of materials  
▪ Spread Risk across two companies and two locations  
▪ Shift Production elsewhere |
| Multiple supply sources for the same component, Local supply source, Multiple supply sources with the appropriate manufacturing capacities, Supplier with more than one manufacturing site to supply materials. e.g. Alpha can source a significant part from two suppliers: one providing fixed supply volume, and the other offering flexible volumes in predetermined min and max limits. |  |

| **Supply Chain Visibility** (Christopher and Lee, 2001; Lee and Wolfe, 2003; Christopher and Lee, 2004; Christopher and Peck, 2004; Tang 2006b) |  |
| Accessing and sharing information upon close collaboration in the supply network from upstream to downstream suppliers, with no barriers to vision\(^2\). Types of supply chain visibility are: vendor managed inventory, electronic data interchange, collaborative forecasting, and comprehensive tracking and monitoring. e.g. Alpha can enhance its information sharing network by sharing information with their second and third tier suppliers, thus having better visibility of the supply chain processes and been aware of any shortfalls. | ▪ Coordination, better visibility, agility and effective response  
▪ Real time information  
▪ Reduce inventories  
▪ Increase customer service  
▪ Reduced production/ logistics/ transportation cost  
▪ Enables reroute goods, revise production plans, redeploy production resources, and adjust capacities |

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| **Flexible Transportation** (Chopra and Sodhi, 2004; Tang 2006a) | ▪ Prevent supply chain operations stopping  
▪ Flexible logistics strategy  
▪ Switch carriers quickly  
▪ Low-cost global deliveries  
▪ Promote competitive bidding |
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<tr>
<td>Multi modal, multi carrier and multiple routes transportation. e.g. Although Alpha is very efficient in flexible transportation, it should also reserve extra capacity in carriers’ agreements, in order to be able to change automatically from one mode of transportation to another.</td>
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| **Postponement Strategy** (Sheffi, 2001; Lee and Wolfe, 2003; Tang 2006a; Tang 2006b) | ▪ Meet demand  
▪ Cost-effective and time-efficient  
▪ Reconfigure the product quickly |
| Delay the point of product differentiation. e.g. This will be possible for Alpha after the assembly line process will be simplified in order to offer the customer packs. Currently, due to the huge variety of products produced postponement strategy cannot be applied. | |
| **Stockpiling** (Gilbert and Gips, 2000) | ▪ Quick Response  |
| Maintain extra inventory of critical parts. e.g. Stockpile the significant parts that are sole sourced. | |
| **Economic Supply Incentives** (Tang, 2006a; Chopra and Sodhi, 2004) | ▪ Economies of scale  
▪ Suppliers develop needed competency  
▪ Back-up and Quantity flexibility contracts with suppliers |
| Cultivate additional suppliers when additional suppliers are unavailable. e.g. Induce suppliers to manufacture a part which is monopolized by a certain supplier. | |
| **Standardization** (Sheffi, 2007) | ▪ Shift production from one disrupted facility to an alternative  
▪ Flexibility, interchange-ability  
▪ Move personnel around, work across plants  
▪ Same part for different products |
| Standard factories, platforms, equipment, standard components, and standard processes. e.g. This can be achieved across the Company’s manufacturing plants so they can shift workforce and production across plants. | |
9. Conclusions

Alpha has developed effective reactive processes for dealing with operational risks, but at the same time has overlooked supply chain disruptions that may have a large negative impact on its operations. This is evident by the manager’s responses that perceived and conceptualized operational risks and disruptions as the same, and thus the tools and techniques they proposed for disruptions management are those employed in the presence of operational risks. From their answers though on the contingency plans they apply at Alpha, some of the techniques could also be implemented formally for the proactive risk management process.

Alpha is part of a global supply network which makes it vulnerable to a variety of disruption sources, such as strikes, natural hazards and economic crises. This vulnerability also increases by the lean approach Alpha adopts, which although it facilitates in building better quality products, at lower prices and satisfying the end customer, simultaneously it reduces the safety net between Alpha and disruptions. Alpha by having no redundancy in place such as alternative suppliers, extra stock and reserved extra supplier capacity decreases its resilience to low likelihood high impact risks, which may cause the closure of the assembly line in very short notice. The stopping of the assembly line though, is something that they try to avoid at Alpha, due to the high costs incurred. On the other hand keeping surpluses in not only very costly for Alpha, but it also doesn’t comply with the lean philosophy applied at Alpha.

In order for Alpha to be resilient with cost effective approaches in the presence of disruptions, firstly a disruption management culture needs to be developed in the Company having the support of top management. Secondly, this culture must be transmitted to their supply chain partners with whom they will jointly develop risk mitigation plans. Finally, for the successful implementation of risk mitigations strategies, a proactive risk management framework needs to be applied where the sources of disruptions will be identified and cost
effective actions will be applied. Alpha when choosing risk mitigation strategies has to be certain that the strategies chosen strategically fit Alpha and its supply chain.

References


• Hicks, M. (2002), *When Supply Chain Snaps*, *eWeek*, 18 February.


Appendix 1: Examples of supply chain disruptions

- **Operational Risks**: equipment breakdown, delays, security breach, inadequate inventory. If these are not controlled in-house at an early stage they may have a high negative influence on the company and then consequently on the supply chain.

- **Supplier**: bankruptcy, capacity constraints, quality, production technological changes, product design changes, contracts, sole sourcing. In 1978 a major expressway was closed blocking off a single-source supplier of Toyota, affecting in this way Toyota’s production (Tang, 1999).

- **Supply Variations**: Inaccurate supply planning resulted in an inventory shortage of “hot” footwear models for Nike which affected sales during 2001. The amount was $100 million of target (Norman and Jansson, 2004).

- **Accidents** (e.g. fire): In February 1997, after a fire destroyed the plant of Toyota’s brake manufacturer in Japan (Aisin Seiki), Toyota had to stop the production lines. Toyota was forced to shut down 18 plants for almost two weeks due to lack of parts. The cost to Toyota was $195 million and estimated sales loss was 70,000 vehicles ($325 million) (Mortimer, 2001). Toyota’s reliance on just-in-time inventory systems, left Toyota with no spare parts on hand to enable continued production, thus the only option was to stop producing cars until parts could be procured from other suppliers (Tang, 1999).

- **Strikes and Labour disputes**: In September 2002, acrimonious contract negotiations between the International Longshore and Warehouse Union (ILWU) and the Pacific Maritime Association (PMA) resulted in the union applying a work slowdown at all West Coast ports in the U.S. As a result, PMA replied by locking the ports for 10 days, ending the lockout on October 8th, when President George Bush by invoking the Taft-Hartley Act of 1947, forced open the ports and push the parties back to negotiations. As a result, the lockout stopped the large flow of containers through the 29 West Coast ports, which are responsible for $320 billion in imports and exports each year. The huge ocean-going
freight vessels serving the West Coast had no alternative but to wait off the coast. This was because Canadian and Mexican ports were unable to handle these massive container ships, and there were too big to pass through the Panama Canal to the East Coast. Thus, the ships placed a growing inventory of materials and products to be handled (Sheffi, 2007).

- **Transportation Limitations:** New United Motor Manufacturing Inc. (NUMMI), a joint venture between Toyota and GM, uses just in time inventory, thus it is vulnerable to lengthy disruptions with a large risk of stopping production very quickly. NUMMI, just before the 2002 lockout on all West Coast ports in the U.S, although it had pulled more parts than usual, after four days in the lockout resulted in the Fremont, California plant been shut down and idling 5,500 workers. Seven days into the lockout and uncertain with what was going to happen, NUMMI chartered several Boeings 747s to bring parts from Japan, increasing the cost of every car produced with air-freight parts by $300 to $600. As a result, although NUMMI was able to increase its output and make up for the lost production caused by the delays, its costs increased considerably during that period, due to the expensive airfreight, added storage and handling costs, and substantial worker overtime (Sheffi, 2007).

- **Terrorist Attacks:** The September 11 terrorist attacks caused the closure of the U.S airports, and enhanced security at U.S ports and at the Canadian and Mexican borders, therefore significantly slowing down the transportation of parts and products. One company affected by these measures was Ford which was unable to switch the transport mode of delivery, due to an increased demand for ground transportation. As a result of part delivery problems, Ford closed five of the U.S plants for weeks and reduced its production volume by 13% in the fourth quarter of 2001 (Hicks 2002).

- **Natural Hazards:** hurricane Katrina in August 2005, the Kobe earthquake in Japan in 1995, and hurricane Andrew in 1992
- **Computer Virus Attacks**: The well known ‘Love Bug’ computer virus, a fast-spreading infection, which in 2002 caused billions of dollars in estimated damages, shut down e-mails among others at the Pentagon, NASA and Ford (Chopra and Sodhi, 2004).

- **Economic Crises**: The currency crisis of the Indonesian Rupiah in 1997 had a big effect on Indonesia. As an example, Indonesia’s national car manufacturer, Astra, postponed production because they were unable to pay for imported parts. Additionally, 60% of Jakarta’s public transport system was suspended because of the soaring price of the spare parts needed to repair the city’s buses (Tang, 2006b).

- **Political and Legal Instability**: One of Edrich’s clients obtains valves for car airbags from Indonesia. Although the Indonesian source is cheaper that sources in Eastern Europe it suffers more risk of political unrest. This became evident, during the 1998 riots in Indonesia, when vandals set fire to the plant. (Gilbert and Gips, 2000).

- **Diseases**: In February 19th 2001, food and mouth disease (FMD) was detected in 28 pigs and seven months were needed to contain the disease, with a total cost to the agricultural sector that approached £2.4 billion and with an impact on the U.K national economy which was estimated at £4 billion³. British leather production decreased by 50 percent because millions of potentially infected cattle were slaughtered. This affected the flow of raw material to leather suppliers who in their turn provided material to manufacturers such as Nike (shoes), Louis Vuitton (handbags), and Jaguar (car seats). These manufacturers were forced to look for alternative sources of leather supply. Thus, the U.K. leather producers lost many of their customers and were unable to recover to pre-FMD sales levels (Sheffi, 2007).

### Table 2: Alpha’s Supply Chain Risk Management Strategies

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<tr>
<th>Strategy</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Unions</strong></td>
<td>They work closely with labour unions to develop agreements and governance plans through a collective bargaining process.</td>
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<td><strong>Warehouses</strong></td>
<td>If a warehouse catches on fire, or it is destroyed partly by a storm or flooding they would find an alternative warehouse straight away. Alpha can hire a warehouse or stock in the ODC. They haven’t got in place prearranged agreements, but believe to its location there are several available warehouses that they could hire. If it is a warehouse that’s run by another company then it’s up to them to address that. So, the people who store the exhaust for them are another company, so they have to find another location to store the exhausts and Alpha would have to fly some extra stock in, and try together to salvage what they could from the wreckage.</td>
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<tr>
<td><strong>Standardization</strong></td>
<td>A process they are currently working on is to reduce the complexity of the parts by putting standard features for a lot of the parts, or across all the vehicle lines of the Company. Also, they are trying to develop customer packs, so the customer may choose the comfort pack which may have five or six different characteristics in it although the customer may have four options on the vehicle.</td>
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<tr>
<td><strong>Common Parts</strong></td>
<td>They have common parts with other plants in the Company, such as switches and steering wheels. If a disruption affects a few automakers in the Company, the decision is made centrally to which automaker to allocate the resources. The decision is usually based on which vehicle line makes the most profit.</td>
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<td><strong>Reserved Capacity</strong></td>
<td>They expect their suppliers to have 10% above what their normal requirement is, and that is 10%, mainly for their after market demand. So, whatever they agree to have installed for the Company they expect them to have an extra 10%, and the Company pays for any tooling that is required to accommodate the extra 10% which is fixed price for the components in series production.</td>
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<tr>
<td><strong>Employees Flexibility</strong></td>
<td>If there are employees absent or extra capacity is required at a certain workstation, they have to find someone else from another area. They have a</td>
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10% absence cover so they can cover the jobs, and they also have group leaders that can do all the jobs in their team.

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<tr>
<th>Suppliers</th>
<th>Alternative Suppliers</th>
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<td>There is a list of alternative suppliers they can refer to in the case a supplier becomes idle. This list is not for each individual component, but for a particular commodity such as discs and shock absorbers. There are other suppliers in the commodity strategy, so the information would be given to one of the other suppliers.</td>
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<th>Global Suppliers</th>
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<td>If a supplier had a fire, maybe the business would move to one of its other manufacturing facilities. Global suppliers have manufacturing facilities throughout the world, and in order to protect themselves from such instances, they try to install the same type of machines in all of their manufacturing facilities, so they have the flexibility to move their equipment from one plant to another.</td>
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<th>Demerit Points</th>
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<td>Usually suppliers notify if they don’t send the agreed parts. If they don’t notify, Alpha issues them demerit points which are built into a scoring model affecting them negatively, which may terminate their contract if the score is high. Also, if the supplier is late they expedite transport which is paid by the supplier. If the supplier doesn’t agree to pay for the transport then legal actions are taken.</td>
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<th>Bankruptcy</th>
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<td>The level of assistance the Company provides to suppliers depends on who the supplier is, how willing they are to help the suppliers recover, and how long will it take the Company to find another supplier.</td>
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<th>Transportation</th>
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<td>Bad weather conditions were present at the North of Spain in February 2007. In order to deal with it a monitoring situation every 2 hours was set up, dealing with each material as a case by case. When the network breaks down the logistics team finds an alternative and then asks the materials planning and logistics manager for the cost approval. Depending on the cost required for the alternative route the decision goes up hierarchically. The maximum airfreight the materials planning and logistics manager had to pay for was a six digit number. If it is the supplier fault then the supplier</td>
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usually pays for the airfreight.

In the case where changes in the network or changes due to time constraints have to be made, they usually use the following possible solutions:

- Special Truck
- Airfreight:
  1. Normal airfreight with a company that has a scheduled flight every day from different airports.
  2. Air Charter (hire a plane) to go solely to an airport next to Alpha Plant, only if it will stop the production line.
  3. Hand Carrier, e.g. screws

The communication is good through the network and if there will be a disruption they can be notified by transportation networks and emails. In the possibility of a strike the unions have to notify a few days before.

### Stock

The same type of vehicle is assembled in two plants; at Alpha plant and beta plant. Thus, in the occasion that beta requires a part that is in stock in the Alpha plant, and Alpha plant has enough stock for its production, then beta has to buy the stock from Alpha. For example, a supplier in France had a quality issue that lasted for 12 days. Alpha plant used all the bad stock and they used it because they only found about it too late so they decided to catch the problem at the dealers. Alpha plant’s transit time is two days from the French supplier, and beta’s transit time is 9 or 10 days. The entire stock beta had, was bad stock, so they asked Alpha plant if they could send them 500 parts. Alpha having enough stock at the plant and knowing there was stock on the way, it decided to provide them the 500 parts. So an employee placed the parts in a bag and travelled by plane to go to beta plant.

In the occasion they are notified that transportation will be affected impacting on production then stock will be built and if it is threatening to stop production then higher levels of stock will be kept. For example, if there is a major rail strike in France all the Portuguese and Spanish materials come up through France by train, then all the Portuguese and Spanish vendors will put an extra stock for an extra two days float to protect Alpha against that.

*Pilfered parts:* They have a special secure place where they keep their
pilfered parts, parts that they know that can be stolen usually from their employees. There is a list of parts that are considered pilfered such as radio, phone, and gear and are counted once a month instead of the audit requirement which is once a quarter.

| Insurance          | The company is self-insured; they have a very high deductible that runs into well in excess of 7 figures. They have a legally binding agreement that declares in specific events they will insure themselves. There are parts of the business that they insure outside, but for the bulk of their business they self-insure. All the stock that is in the supply chain is covered by self insurance, so in the contract with the carriers it’s made clear that they are a self insured Company. |