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Analysis of Supply Chain Risk Management Strategies: Case Study of Supply Chain Disruptions

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***Abstract*—**Supply Chain Risk Management refers to a set of strategies used by companies to avoid supply chain disruption caused by damage at production facilities, natural disasters, capacity issues, inventory problems, incorrect forecasts, and delays. Many companies use the techniques of the Toyota Production System, which in a way goes against a better management of supply chain risks. This paper studies key events in some multinationals to analyze the trade-off between the best supply chain risk management techniques and management policies designed to create lean enterprises. The result of a good balance of these actions is the reduction of losses, increased customer trust in the company and better preparedness to face the general risks of a supply chain.

***Keywords*—**Supply chain disruptions, supply chain management, supply chain resilience, just-in-time production, lean manufacturing.

I. Introduction

JUST-in-time means making "only what is needed, when it is needed, and in the amount needed." The objective of this concept is to eliminate waste and inconsistencies while improving productivity [1]. Lean Manufacturing is understood as the philosophy of continually reducing waste in all areas and in all forms, which means developing processes that need less human effort, less space, less capital, and less time to make products or services [2]. Supply Chain Risk Management comprises a set of strategies and processes to manage supply chain disruptions, which includes: increasing capacity, acquiring redundant suppliers, increasing inventory and flexibility, and increasing capability. Consequently, Lean Manufacturing and Just-in-time can go in the opposite direction of Supply Chain Risk Management and there exists a trade-off which must be well managed. These three concepts are important because Lean Manufacturing and Just-in-time are common practices that help companies focus on core competencies and reduce cost, whereas supply chain strategies can avoid failures that stretch the supply chain to its breaking point, interruptions on production and distribution, loss of company revenue, and loss of customer credibility. Thus, many companies have started paying attention to supply chain risk management, in addition to the techniques of the Toyota Production System. Nevertheless, there are some challenges involved in supply chain risk management that these organizations have to consider. First, companies need to account for a huge number of physical and non-physical risks. Second, the company must quantify the risks involved with its first-tier and second-tier suppliers. Third, the company has to deal with a larger volume and complexity of data. Finally, there is the need to balance risk control and supply chain efficiency.

What can companies do to avoid supply chain disruptions? First, it is necessary to develop the ability to discover the disruption with a timely responsiveness. Subsequently, they must create methods to recover from the disruption and prevent the supply chain breakdown from impacting their operations and customers. Finally, they must learn from the event and redesign the supply chains, in order to minimize the probability of the event occurring or eliminate the possibility that the problem will occur again.

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II. Literature Review

A. Supply Chain Management

Supply Chain Management refers to a set of strategies used by companies to efficiently integrate the various levels in the supply chain, which includes suppliers, manufacturers, warehouses, distribution centers, and retail outlets. The objective is to ensure that the right product is manufactured and delivered at the right location, at the right quantities, at the right time, and at the right price, in order to minimize cost and improve service levels [3].

Additionally, the definition of Supply Chain Management encompasses the following five basic components:

- Plan: This part is considered strategic because it involves developing strategies to manage the resources that will meet the demand, while also selecting a series of metrics to control the supply chain to improve its efficiency, reduce costs and ensure quality and value to customers.
- Source: Choosing suppliers and establishing prices, delivery and payment procedures, as well as managing the inventory, receiving and verifying shipments, forwarding the information to manufacturing plants, approving supplier payments, and deciding on indicators to monitor and improve the relationship with providers.
- Make: The fabrication section includes all transformations of raw materials into finished goods, which encompasses production, testing, packaging, and preparing for delivery. In this stage, managers usually use the following performance measurements: quality levels, production output and productivity.
- Deliver: The process that deals with the logistics of building a network of warehouses, choosing carriers to transport the products, and deciding on an invoice system to receive payments.

- Return: Providing support to customers who have problems with the delivered products, as well as organizing a system to retrieve defective and excess products back [4].

Furthermore, Supply Chain Management involves planning and managing activities associated with sourcing, procurement, conversion, and logistics, as well as coordinating processes and operations of marketing, sales, product design, finance, and information technology. It also has the function to promote collaboration between partners, such as suppliers, intermediaries, third party service providers, and customers. In short, the proposal is to integrate supply and demand across business functions and companies [5].

Indeed, Supply Chain Management means managing effective and efficient activities, such as product development, sourcing, production, logistics, and information systems in order to maximize customer value and keep the business competitive. Additionally, the basis of this concept is on the idea that the majority of products that reaches a customer represent the cumulative effort of many organizations that are connected through material and information flows. The physical flow refers to the movement of raw materials, intermediate goods, and finished goods between the facilities. The information flow, on the other hand provides a database that enables different partners to coordinate long-term plans and manage goods in numerous supply chain stages [6].

B. Supply Chain Risk Management

Supply Chain Risk Management comprises a set of strategies and processes to manage supply chain disruptions. These disruptions can be classified as events such as fires, machine breakdowns, bottlenecks, quality problems, natural disasters, and customs delays, which interrupts the flow of materials and information in the production or distribution. The risk management process includes three components:

- Disruption Discovery: refers to the ability and the speed to discover a disruption. Requires that the company understand the types of risk exposure present in its supply chain, and develop methods to detect when the events are about to occur or have occurred with a timely responsiveness.
- Disruption Recovery: can be defined as the capability to effectively recover from the disruption. Involves creating both proactive and reactive recovery methods; the objective is to prevent that the supply chain breakdown from impacting the operations and customers.
- Supply Chain Redesign: refers to creating supply chain design strategies for higher resilience. In this stage, companies should learn from the event and redesign the supply chains, in order to minimize the probability or eliminate the possibility that the problem will occur again. In addition, it is advisable to develop tools for dynamic management of the supply chain [7].

III. Cases Study

A. Fire at Philips Factory in Albuquerque (2000)

On March 17, 2000, after the storm, lightning struck a power line and the electricity supply was temporarily shut down. Subsequently, a cooling fan stopped working and a fire started in a furnace at the Philips semiconductor factory in Albuquerque. As a result, almost all of the silicon stock was destroyed and the factory was shut down for months for repairs. This plant was responsible for supplying several types of radio frequency chips for Ericsson and Nokia [1], [8], [9].

Three days after the fire, Nokia noticed delays in incoming orders, which led the company to send engineers to evaluate the damage and change the frequency of monitoring at the plant from weekly to daily. After Philips reported a disruption of months, Nokia decided to modify the product design to get the chips from other supplier. However, one type of chip could not be provided from alternative suppliers, and as such, Nokia negotiated with Philips to send the component from its factories in China and the Netherlands [1], [8], [9]. In contrast, Ericsson did not respond in the same way as Nokia. The company took five weeks to realize the gravity of the situation. By that time, the other suppliers were already contracted for Nokia orders. The company lost $400 million in potential sales and suffered a $1.68 billion loss, which led to Ericsson's exit from the cell phone market [1], [8], [9]. In this case, it is evident that two companies' differing levels of responsiveness led to distinct results. After Nokia noticed possible problems with supply chain disruption, the company immediately took action to avoid it. On other hand, Ericsson did not react in the same way as Nokia, and the organization suffered heavy financial losses as a result.

B. Japan Earthquake 2011

On March 11, 2011, a 9.0 magnitude tremor hit northeastern of Japan. The earthquake generated a 10-meter-high tsunami that damaged various locations along the coast, including two nuclear plants in Fukushima. Consequently, thousands of people died and thousands more were injured, the power was shut down and many houses were destroyed [10].

One of many companies affected by the earthquake was Toyota. After the quake disaster, four plants were affected and as a result the production of parts and vehicles was impacted. And, as a result of the business strategy employed by Toyota that focuses on core competencies and cost reductions, the company had adopted a single-source supplier, which in this case led to the interruption of production due to disruptions in the supply chain. In the following months, Toyota declared a 50% decline in production at its Japanese manufacturing facilities, along with severe production cuts in North America and China due to supplying problem [11]. In addition, at that time, it was predicted that the company could suffer a net loss of $12.2 billion in the period of April to June [12]. Fig. 1 (a) reveals the effects of the Japan earthquake on global vehicle production.

Time Frame	Production Location	Production Decline from Jan.-Feb. 2011 Run Rate
April	Output in Japan	-80%
	Japanese automaker output of outside Japan	-15%
	Global output	-13%
May	Output in Japan	-41%
	Japanese automaker output of outside Japan	-33%
	Global output	-16%
June	Output in Japan	-31%
	Japanese automaker output of outside Japan	-21%
	Global output	-11%
July	Output in Japan	-24%
	Japanese automaker output of outside Japan	-12%
	Global output	-7%
August	Output in Japan	-20%
	Japanese automaker output of outside Japan	-4%
	Global output	-3%

Fig. 1 (a) Effects of the Japan earthquake on global vehicle production [13]

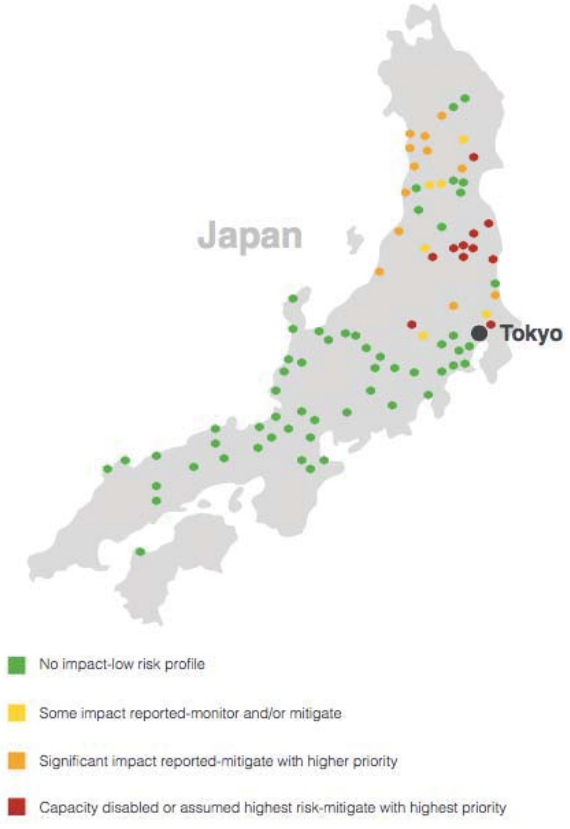

Fig. 1 (b) Map studying the impacts after the disaster [14]

After the disaster, Toyota did not have any mitigation plans. The company suffered a net and a production loss. Through simulation analysis of the impact of the disaster, as in Fig. 1 (b), Toyota could choose its supplier to minimize the chance of another disruption. Another plan would be to not depend on a single supplier; otherwise, in the case of a disruption there is no alternative supply source. Finally, in this case various cities had no electricity supply, so another alternative would be adopting standardized parts and global suppliers to minimize the effects of region-wide disruptions.

C. Samarco 2015

Samarco is a mining company which produces iron ore, and is a joint venture controlled by Vale and BHP Billiton. On November 5, 2015, after a disruption at the Fundão, dam located in Mariana (MG), which belongs to Samarco, 35 million cubic meters of mud was dumped into the environment. After some hours, the residue reached the Doce River, which supplies water and sustains economic activities, such as agriculture and fishing in the surrounding areas. A few days later, the material reached 663 kilometers of river in the neighboring state of Espirito Santo, burying 207 of 251 buildings in the Bento Rodrigues district, leaving 600 families homeless, killing 17 people and leaving thousands of families along the river without access to the economic resources received from fishing. [15]

The environmental impact of the accident is estimated at 150,000 hectares of vegetation destroyed, 11 tons of dead fish, and 80 kilometers of mud deposited in the coast of Linhares (ES). In December 2015, tests were conducted on the water and the researchers found 20 times more iron, 10 times more aluminum, and five times more chromium and manganese than normal, which unbalances and changes the ecosystem. [16], [17].

The environmental impact has led to economic consequences; farmers reported a loss of US$ 7 million due to the damage to 195 properties, which were formerly used for pastures, sugar cane plantations, grains, and horticulture [18]. Besides that, 80 Espirito Santo state producers who were using the river water to irrigate cultures of coffee, corn, tomato, and banana have been affected. One agriculturist declared a loss of 21,000 tomato plants, a financial loss of around US$56,000. Another challenge faced by farmers is the loss of customer´s trust, as there is the fear that regional products are contaminated [19]. Another sector affected was the mining. Samarco has the capacity to produce 30 million tons of iron per year, which represents 2% of global supply. The company halted production and it absence from the market affected the price of iron ore, which came close to $50 a ton, which is 7.5% above the current level [20].

With regard to the consequences for Samarco, aside from severely damaging the image of the company, the organization was ordered to pay R$250 million in fines by IBAMA (Brazilian Institute of Environment), with R$20 billion requested by the Brazilian government for the purpose of creating a reconstruction fund, and R$1 billion in legal agreements to restore the environmental and social damage [21]. In cases like this, companies can develop plans and strategies to avoid such accidents happening again; for instance, monitoring any signals failures using sensors to identify pressures or deformities, as well as conducting regular

inspections to identify cracks, infiltration and vegetation growth [22].

IV. Conclusion

According to the Supply Chain Resilience Report 2015, 74% of companies experienced at least one event of supply chain disruption. This number shows how frequent these problems are in the day-to-day operations of most organizations. Therefore, the importance of this concept is preventing supply chain breakdowns from affecting operations and customers. In addition, it is important to limit the impact on the company with regard to the issues such as loss of productivity, customer complaints, increased cost of working, loss of revenues, impaired service outcomes, stakeholder concern, damaged brand reputation, delayed product release, delayed cash flows, loss of regular customers, product recall, and fall in share prices [23].

What can companies do to avoid supply chain disruptions? First, it is necessary to develop the ability to discover the disruption with a timely responsiveness. Subsequently, they must create methods to recover from the disruption and prevent supply chain breakdown from impacting their operations and customers. Finally, they must learn from the event and redesign the supply chains, in order to minimize the probability or eliminate the possibility that the problem will occur again. Some examples of mitigation approaches used by organizations to avoid supply chain disruptions include: increasing capacity, acquiring redundant suppliers, increasing responsiveness, increasing inventory and flexibility, aggregating demand, and increasing capability [24].

Finally, it is worth mentioning the importance of the balance between the practices of Lean Manufacturing/Just-in-time and Supply Chain Risk Management, as one concept will help eliminate waste and inconsistencies while improving productivity, while the other will avoid failures, interruptions on production and distribution, loss of company revenue, and damaged credibility with customers. Accordingly, one limitation of this article and possible future work includes the possibility of studying the balance of Lean Manufacturing, Just-in-time and Supply Chain Risk Management practices in other study cases with quantitative data.

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