

# *Proactive Product, Supply and Demand Strategies for Constructing Robust Supply Chains*

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## *Abstract*

When major disruptions strike, many supply chains tend to break and take a long time to recover. However, not only can some supply chains continue to function smoothly; they continue to satisfy their customers during and after a major disruption strikes. Some key differentiators of these “robust” supply chains are some specific cost-effective and time-efficient proactive strategies. In this paper, we present various proactive strategies and the associated contingency plans that will enable a supply chain to become more resilient in the face of unpredictable disruptions. We also propose an approach for selecting the most effective proactive strategy. While there are costs for implementing these proactive strategies, they provide additional selling points for acquiring and retaining apprehensive customers.

**Keywords:** Unpredictable Disruptions, Supply Chain Management, Risk Management, Operations Strategies.

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## ***Introduction***

Our world is more uncertain and vulnerable than we think. Over the last 10 years, we witnessed many types of unpredictable disasters including terrorist attacks, wars, earthquakes, economic crises, devaluation of currencies in Asia, SARS, tsunamis, strikes, computer virus attacks, etc. According to two independent studies, one by the Center for Research on the Epidemiology of Disasters ([www.cred.be](http://www.cred.be)) and the other by the world's largest re-insurer Munich Re ([www.munichre.com](http://www.munichre.com)), historical data indicates that the total number of natural and man-made disasters has risen dramatically over the last 10 years. Moreover, Munich Re reported that the average cost of these disasters has increased by a factor of 10 since the 1960s.

When disasters strike, major business disruptions follow. As many supply chain executives strived to improve their financial performance such as Return on Assets<sup>2</sup>, they implemented various supply chain initiatives to increase revenue (e.g., increase product variety, frequent new product introduction), reduce cost (e.g., reduce supply base, Just-in-Time inventory system, vendor managed inventory), and reduce assets (e.g., outsourced manufacturing, information technology, and logistics). These initiatives are powerful and effective in a stable environment. However, these initiatives have created longer and more complex global supply chains, which are more vulnerable to business disruptions in a turbulent world. According to a study conducted by Computer Sciences Corporation in 2004, 60% of the firms reported that their supply chains are vulnerable to disruptions. Examples supply chain vulnerabilities are widespread: Ericsson lost 400 million Euros after their supplier's semiconductor plant caught on fire in 2000; Land Rover laid-off 1400 workers after their supplier became insolvent in 2001; Dole's revenue declined after their banana plantations were destroyed after Hurricane Mitch hit Central America in 1998; and Ford closed 5 plants for several days after all air traffic was suspended after September 11 in 2001. The reader is referred to Chopra and Sodhi (2004), Christopher (2004), Martha and Subbakrishna (2002), and Monahan et al. (2003) for more details.

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<sup>2</sup> Return on Asset (ROA) is equal to Earnings before Interest and Tax (EBIT) divided by total net assets.

As highlighted in Lee (2004), cost efficiency comes with a huge hidden cost should a major disruption occur and one must balance the notion of cost efficiency with agility, adaptability and alignment. To understand the cost associated with different disruptions, let us consider the following examples. First, during the western U.S. port lockout in 2002, the truckers were unable to unload the components from the port and deliver them to the NUMMI plant (a Toyota-GM joint venture) for weeks. Operating under a Just-In-Time environment, NUMMI was forced to close its Fremont plant for a few weeks. The estimated cost of this lockout was 1 billion US dollars per day and President Bush was pressured to intervene. Next, when an earthquake hit Taiwan in 1999, factories responsible for producing more than 50 percent of the worldwide supplies of memory chips, circuit boards, flat-panel displays and other computer components were disrupted for a few weeks. The estimated impact of this earthquake was 5% of the total earnings of all major computer companies such as IBM, Apple, and HP.

Based on anecdotal observations, most supply chains tend to break down during major disruptions and many of them cannot recover after the disruptions. A recent empirical study conducted by Hendricks and Singhal (2003) indicated that supply chain disruptions can have negative long-term stock price effects on the firms and that many firms do not recover quickly from these negative effects. Against all odds, some supply chains tend to be more robust in the sense that they can endure the disruptions without significant problems. More importantly, these robust supply chains continue to satisfy their customers in the midst of the storm. We shall cite three key examples.

First, both Ericsson and Nokia were facing supply shortage of a critical cellular phone component (radio frequency chips) after their key supplier, Philip's Electronics semiconductor plant in New Mexico, caught on fire during March of 2000. Ericsson was slow in reacting to this crisis and lost 400 million Euros in sales. In contrast, Nokia had the foresight to design their mobile phones based on the modular product design concept and to source their chips from multiple suppliers. After learning about Philip's supply disruption, Nokia responded immediately by reconfiguring the design of their basic phones so that the modified phones could accept slightly different chips from other Philip's plants and other suppliers. Consequently, Nokia satisfied customer demand

smoothly and obtained a stronger market position. The reader is referred to Hopkins (2005) for details.

Second, when Indonesia Rupiah devalued for over 50% in 1997<sup>3</sup>, many Indonesian suppliers were unable to pay for the imported components or materials and hence, unable to produce the finished items for their U.S. customers<sup>4</sup>. This sent a shock wave to many U.S. customers who had outsourced their manufacturing operations to Indonesia. In contrast, The Limited and Warner Brothers continued to receive their shipments of clothes and toys from their Indonesian suppliers without noticing any problem during the currency crisis in Indonesia. They were unaffected because they had outsourced their sourcing and production operations to Li and Fung ([www.lifung.com](http://www.lifung.com)), the largest trading company for durable goods such as textiles and toys in Hong Kong. Instead of passing the problems back to their U.S. customers, Li and Fung shifted some production to other suppliers in Asia and provided financial assistance such as line of credit, loans, etc., to those affected suppliers in Indonesia so as to ensure that their U.S. customers would receive their orders as planned. With a supply network of 4,000 suppliers throughout Asia, Li and Fung able to serve their customers in a cost-effective and time-efficient manner. Despite the economic crisis in Asia, this special capability has enabled Li and Fung to earn its reputation in Asia and enjoy continuous growth in sales from 5 billion to 17 billion Hong Kong dollars from 1993 to 1999. The reader is referred to St. George (1998) and McFarlan (2002) for details.

Third, after an earthquake hit Taiwan in 1999, several Taiwanese factories informed Apple and Dell that they were unable to deliver computer components for a few weeks. When Apple faced component shortages for its iBook and G4 computers, Apple

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<sup>3</sup> Indonesia Rupiah opened the year 1997 at 2363 to the US dollars and closed at 5550 against the dollar. However, in July 1997, Indonesia Rupiah was traded at 10,000 against the US dollars.

<sup>4</sup> The currency crisis affected Indonesia in a very serious manner in 1997. For instance, Indonesia's national car manufacturer, Astra, suspended their production because they were unable to pay for imported components. Also, 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. Moreover, 40% of the country's 1500 chemical plants were forced to halt production because of the soaring cost of imported raw materials.

encountered major complaints from customers after they tried to convince their customers to accept a slower version of G4 computers. In contrast, Dell's customers continued to receive Dell computers without even noticing any component shortage problem. Again, instead of alerting their customers regarding shortages of certain components, Dell offered special price incentives to entice their online customers to buy computers that utilized components from other countries. The capability to influence customer choice in a discrete manner enabled Dell to improve its earnings in 1999 by 41% even during a supply crunch (c.f., Martha and Subbakrishna (2002)).

What makes Nokia's, Li and Fung's, and Dell's supply chains efficient and resilient to unpredictable disruptions? Our answer to this question is based on two key observations. First, we have identified three major risk factors (product related, supply related and demand related) that could make supply chains more vulnerable to natural disasters, man-made disasters, and business disruptions (Figure 1). Second, by comparing Nokia, Li and Fung, and Dell with their peer groups, we noticed that each of these companies has developed proactive strategies as countermeasures to mitigate the impact of each of the three risk factors. These two observations seem to suggest the following: Nokia has a "proactive product strategy" that enables them to modify their product configuration quickly; Li and Fung has a "proactive supply strategy" that allows them to ensure continuous supply to their customers; and Dell has a "proactive demand strategy" that enables them to influence customer choice and customer demand in a discrete manner. Moreover, their proactive strategies provide the capability for these three companies to deploy contingency plans efficiently and effectively when facing a disruption.<sup>5</sup>

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<sup>5</sup> To mitigate the impact of various disruptions, Chopra and Sodhi (2004) provided various effective contingency plans such as increase production capacity, increase inventory, increase flexibility, etc. In many instances, these contingency plans can be executed during a disruption only if the firm has committed to a certain proactive strategy prior to the disruption.

| Risk Factor   | Examples  |
|---|---|
| <ul style="list-style-type: none"> <li>Product related factors</li> </ul> | Complex product design architecture, Product variety  |
| <ul style="list-style-type: none"> <li>Supply related factors</li> </ul>  | Just-in-time production system, Reduced supply base, Outsourced global manufacturing, Outsourced global logistics |
| <ul style="list-style-type: none"> <li>Demand related factors</li> </ul>  | Fickle demand, Short product life cycle, Frequent new production introduction, Market competition                 |

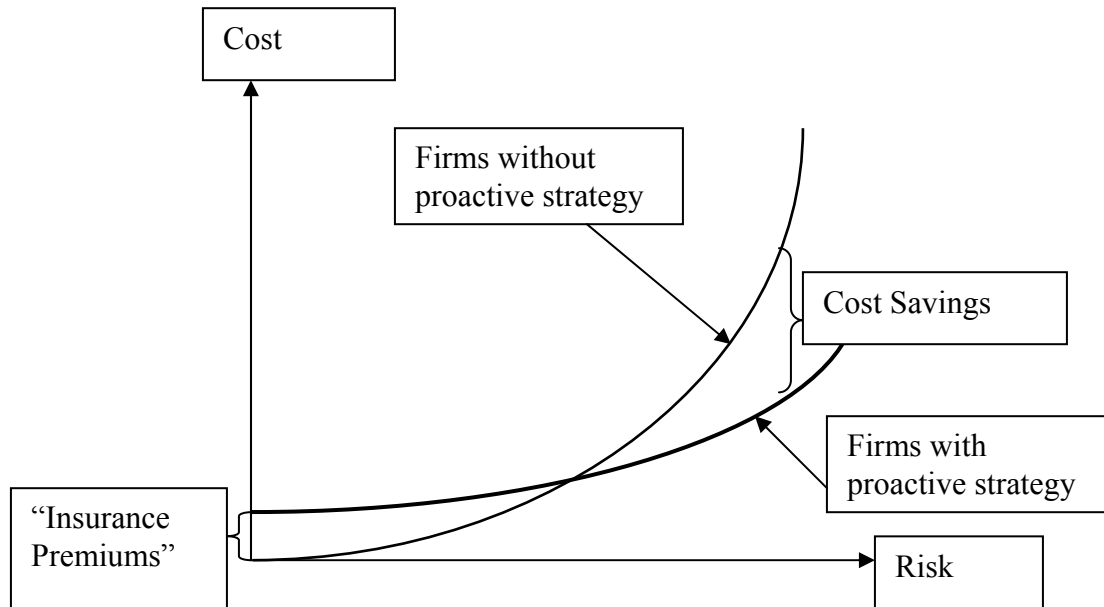
**Figure 1. Key risk factors that make supply chains become more vulnerable.**

While some may express concerns regarding the requisite costs associated with these proactive strategies, others would recognize the additional benefits of these proactive strategies. Specifically, these proactive strategies enhance the competitive position of a firm, especially when other firms’ supply chains are more vulnerable to disruptions. Conceptually speaking, the costs for implementing these proactive strategies can be viewed as “insurance premiums” that will safeguard the supply chains from major disruptions. As we shall see, each proactive strategy offers a set of cost-effective and time-efficient contingency plans for the firm to deploy should a disruption occur. Therefore, these proactive strategies are more cost-effective when the risk<sup>6</sup> associated with a disruption is sufficiently high (Figure 2). Without these proactive (product, supply and demand) strategies, supply chains will be vulnerable to disruptions and supply chains will face many undesirable consequences such as high recovery cost, profit loss, or even

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<sup>6</sup> There are many ways to measure the risk level associated with a disruption. One common measure could be the product of the likelihood of the disruption and the cost implication of the disruption.

deaths.<sup>7</sup>



**Figure 2. Total relevant cost associated with a disruption**

### ***Constructing a Robust Supply Chain***

We propose the follow steps to construct a robust supply chain that is efficient (in terms of cost) and yet resilient to unpredictable disruptions (Figure 3).

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<sup>7</sup> For example, Centers for Disease Control (CDC) estimated that 51,000 people die from influenza infection each year in the United States and about 100 millions of people should take flu shots each year. However, the actual number of people who take the flu shot fluctuates from year to year and the “right version” of the flu vaccine also changes drastically due to constant mutation of the flu virus. In addition to uncertain product identity and uncertain demand, the government agencies put price pressure on the vaccine makers. Consequently, many firms gave up the flu vaccine manufacturing business. In fact, the number of flu vaccine makers for the US market has declined from 12 in the 1970s to 2 in 2004; namely, Chiron and Aventis. Unfortunately, due to bacteria contamination problem at Chiron’s plant in Liverpool, Chiron announced in October 2004 that they would not be able to deliver 48 million doses of vaccine for the U.S. market, which accounts for 50% of the total estimated demand. Facing this supply disruption just before the start of the flu season in 2004, CDC developed a rationing scheme that gave higher priority to those who are in the high-risk groups. This shortage could lead to some unnecessary deaths in the U.S., not to mention about the economic impact on Chiron. The reader is referred to Brown (2004) for details.

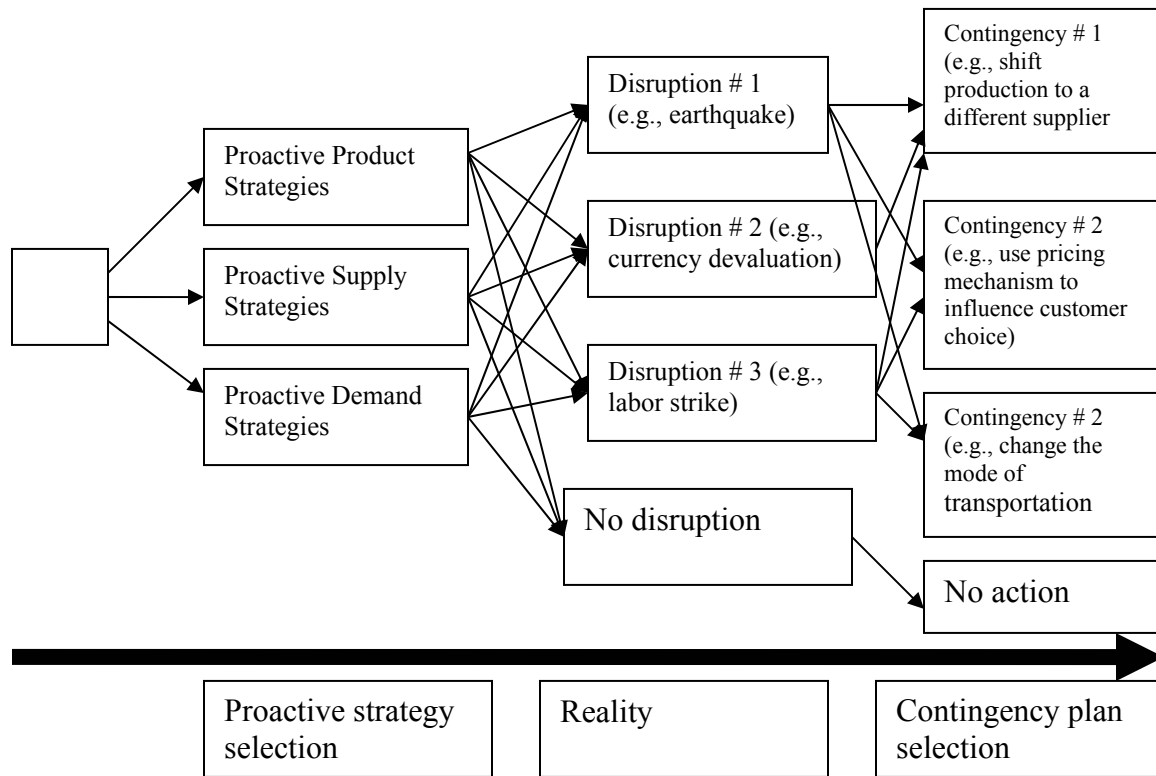
1. Identify Risk. Identify different types of disruptions and estimate the likelihood of these disruptions and their potential impact on the supply chain.<sup>8</sup> For example, September 11 terrorist attack disrupted all air traffic, which put all in-bound or out-bound shipments by air to a complete halt.
2. Identify the weakest link. Identify the weakest link in your supply chain. For instance, the in-bound parts delivery operations is the weakest link at Chrysler because their production will be suspended if their just-in-time in-bound parts deliveries are disrupted.
3. Select a proactive (product, supply, or demand) strategy. Select a proactive strategy that will enable the supply chain to deploy certain contingency plans so as to continue their function smoothly during this disruption. For example, to avoid parts delivery disruptions, Chrysler selected a multi-modal logistics for their in-bound parts delivery operations proactively. This proactive supply strategy enabled Chrysler to use alternative mode of transportation when a particular mode of transportation is disrupted.
4. Execute a contingency plan should a disruption occur. Should a disruption occur, select and execute a contingency plan that will enable the supply chain to continue its function smoothly. For instance, given the proactive strategy selected by Chrysler, they were able to continue to receive their parts from their suppliers by switching the mode of transportation from air to ground immediately after September 11.<sup>9</sup>

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<sup>8</sup> To evaluate supply chain vulnerabilities, Mitroff (2003) suggests a simulation game called “Wheel of Crisis” that generates different types of disruptions randomly. This simulation game is intended to enable a team of senior executives to assess the impact of various disruptions on their supply chain.

<sup>9</sup> Chrysler selected a proactive supply strategy with a third party logistics provider, which would allow Chrysler to switch the mode of transportation from air to ground immediately. This proactive strategy enabled Chrysler to get the parts from their suppliers such as TRW via ground transportation instead of air transportation immediately after September 11. In contrast, Ford did not establish such proactive supply strategy. As such, Ford was unable to switch the mode of delivery after September 11, due to a surge in





**Figure 3. Proactive Strategy and Contingency Plan Selection Process.**

By observing the “tree” structure of the decision process as depicted in Figure 3, we can employ the traditional decision tree analysis for selecting an effective and efficient proactive strategy. Specifically, one can first assign the probability of each potential disruption and the relevant costs (supply chain recovery cost associated with each disruption and the implementation costs of each proactive strategy and its corresponding contingency plan). Then we can compute the expected relevant costs associated with each proactive strategy. By comparing these expected relevant costs, we can select the optimal proactive strategy that yields the lowest expected relevant cost. We recognize that these calculations will not always be straightforward. When it is difficult to assign the likelihood of the occurrence of certain disruptions, one can either perform sensitivity analysis on the likelihood of the occurrence or one can utilize the “min-max” criterion to

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demand for ground transportation. Facing part delivery problems, Ford closed 5 of the U.S. plants for weeks and reduced its production volume by 13% in the fourth quarter of 2001 (c.f., Hicks (2002)).

select the optimal proactive strategy. The reader is referred to Denardo (2002) for a detailed explanation about different decision analysis techniques.

***Proactive Strategies for Constructing a Robust Supply Chain***

We now present three types of proactive strategies that serve as countermeasures for those three risk factors displayed in Figure 1. Essentially, each of the three proactive strategies aims to enable a firm to deploy a contingency plan so as to ensure smooth operations when a disruption hits. As displayed in Figure 4, the proactive product strategy enhances the flexibility for a firm to change product configuration quickly; the proactive supply strategy offers different mechanisms for a firm to stabilize the supply operations quickly; and the proactive demand strategy provides various approaches for a firm to change the customer demand quickly in an unobtrusive manner.

| <b><i>Category</i></b>       | <b><i>Key Proactive Strategies</i></b>  | <b><i>Key Benefits</i></b>  |
|------------------------------|---|---|
| Proactive Product Strategies | <ul style="list-style-type: none"> <li>• Postponement</li> <li>• Silent product rollover</li> </ul>   | <ul style="list-style-type: none"> <li>• Increase product flexibility</li> <li>• Increase product substitutability</li> </ul>   |
| Proactive Supply Strategies  | <ul style="list-style-type: none"> <li>• Strategic Stock</li> <li>• Flexible Supply Base</li> <li>• Make-and-Buy</li> <li>• Economic Supply Incentives</li> <li>• Flexible Logistics</li> </ul> | <ul style="list-style-type: none"> <li>• Increase supply flexibility (in terms of changes in location, volume and technology)</li> <li>• Increase delivery flexibility</li> </ul> |
| Proactive Demand Strategies  | <ul style="list-style-type: none"> <li>• Pricing and Promotion</li> <li>• Assortment Planning</li> </ul>  | <ul style="list-style-type: none"> <li>• Increase demand flexibility (in terms of volume and product choice)</li> </ul>   |

***Figure 4. Proactive strategies for constructing robust supply chains.***

## ***Proactive Product Strategies***

There are two major proactive product strategies: postponement and silent product rollover strategies.

Postponement. Postponement strategy utilizes product or process design concept, such as standardization, commonality, modular design, and operations reversal, to delay the point of product differentiation. This strategy enables a firm to first produce a generic product based on the total aggregate demand of all products, and then customize the generic product later on. The postponement strategy has been proven to be a cost-effective mass customization tool at Xilinx, Hewlett Packard, and Benetton.<sup>10</sup> In the context of disruption recovery, the Postponement strategy offers a cost-effective and time-efficient contingency plan that allows a supply chain to reconfigure the product quickly in the event of supply disruption. For example, when Philip's informed Nokia that they were unable to deliver certain parts after Philip's plant was shut down after the fire, the Postponement strategy enabled Nokia to deploy a contingency plan by reconfiguring their generic cell phone quickly so that the reconfigured generic phone could accept a slightly different component from other suppliers in the U.S. and Japan. This product flexibility enabled Nokia to recover from a serious disruption without any significant problem.

Silent Product Rollover. Under the silent product rollover strategy, new products are "leaked" slowly into the market without any formal announcement. As such, customers are not fully aware of the unique feature of each specific product and they are more likely to choose the products that are available instead of those products that are out of stock or

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<sup>10</sup> Recently, Xilinx, the leading innovator of programmable logic chips, revealed their postponement strategy that enables their customers to use software to fully configure the function of their chips (c.f., Brown et al. (2000)). Next, in order to produce 500,000 different configurations of workstations at HP in an effective manner, HP utilized the postponement strategy by mass producing a generic version of the workstation in a make-to-stock manner. This enabled HP to respond to customer order quickly by inserting certain product specific components into these generic workstations (c.f., Feitzinger and Lee (1997)). Finally, by re-sequencing the dyeing and knitting process at Benetton, Benetton was able to postpone the color specification of the sweater by knitting the undyed sweaters first and then dye the sweaters into different colors after receiving customer orders (c.f., Heskett and Signorelli (1989)). For technical evaluation of different postponement strategies, the reader is referred to Lee (1996), Lee and Tang (1997), Lee and Tang (1998) and Swaminathan and Tayur (1999) for details.

being phased out. To a certain extent, all products are essentially “substitutable” at Swatch and Zara, which is very desirable especially when there is a supply or demand disruption. For instance, as Swatch produces each watch model only once, Swatch utilizes the silent product rollover strategy to launch new watches so that their customers would view all available Swatch watches as collectibles (c.f., Billington et al. (1998) and Moon (2003)). Utilizing the same approach as Swatch, Zara launches their new fashion collection quietly. Since Zara does not usually repeat the production run for the same design of clothes, many Zara’s fashion conscious customers purchase the clothes available at their stores right away (c.f., Ghemawat (2003)).<sup>11</sup>

### ***Proactive Supply Strategies***

To ensure that a supply chain continues to function smoothly during a supply disruption, there are at least five different proactive supply strategies to consider:

Strategic Stock. In the “pre-JIT” era, one may consider carrying additional “just in case” safety stock inventories of certain critical components to ensure that the supply chain can continue to function smoothly when facing a disruption in supply. However, as product life cycle shortens and as product variety increases, the inventory holding and obsolescence costs of these additional safety stock inventories could be exorbitant. Instead of carrying more safety stocks, a firm may consider storing some inventories at certain “strategic” locations (warehouse, logistics hubs, distribution centers) to be shared by multiple supply chain partners (retailers, repair centers, etc.). For instance, Toyota and Sears keeps certain inventories of cars and appliances at certain locations so that all retailers in the nearby region share these inventories. These shared inventories at strategic locations will allow a firm to deploy these strategic stocks quickly to the affected area when a disruption occurs.

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<sup>11</sup> Since Swatch and Zara produce each particular design only once, their production process and their product design have to be flexible so that they can switch from producing one product to the next without incurring significant setup time or set up cost.

Flexible Supply Base. Although sourcing from a single supplier will enable a firm to reduce cost (lower supply management cost, lower unit cost due to quantity discount, etc.), it makes the supply chain more vulnerable. In many instances, a supply chain is more resilient with a flexible supply base with similar capabilities in different countries. For example, Li and Fung's 4000-supplier network offers Li and Fung great flexibility to shift production among suppliers in different countries quickly when a disruption occurs at a particular country; namely, currency exchange rate fluctuation, natural disaster, political instability, or labor strike.

Make-and-Buy. When facing potential supply disruptions, a supply chain is more robust if certain products are produced in house while other products are outsourced to other suppliers. For instance, HP used to make a fraction of their DeskJet printers at their Singapore factory and outsource the remaining portion of their production to a contract manufacturer in Malaysia (c.f., Lee and Tang (1996)). In addition, both Brooks Brothers and Zara produce their fashion items at their in-house factories and outsource other basic items to their suppliers in China (c.f., Ghemawat (2003)). This make-and-buy strategy offers flexibilities that allow firms to shift production quickly should a supply disruption occurs.

Economic Supply Incentives. In many instances, the buyer does not have the luxury to shift production among different suppliers because of the very limited number of suppliers available in the market. To gain the flexibility of shifting production among suppliers, the buyer can provide certain economic incentives to cultivate additional suppliers. For example, due to the uncertainties of producing a specific flu vaccine formula in any given year, uncertain market demand, and price pressure from the US government, many flu vaccine makers including Wyeth Pharmaceuticals have left the market. The decline of the number of flu vaccine makers has put many Americans at risk. In October 2004, Chiron, one of the remaining two vaccine makers for the US market, was suspended due to bacteria contamination at Chiron's Liverpool plant. Facing a shortage of 48 million flu shots from Chiron, the U.S. government could initially offer flu shots only to those who belonged to certain high-risk groups (c.f., Brown (2004)). To avoid this kind of fiasco in the future, the U.S. government could consider offering

certain economic incentives to entice more suppliers to re-enter the flu vaccine market. For instance, the government could share some financial risks with the suppliers by committing a certain quantity of flu vaccine in advance at a certain price and buy back the unsold stocks at the end of the flu season at a lower price.<sup>12</sup> With more potential suppliers, the U.S. government would have the flexibility to change their orders from different suppliers quickly when facing disruptions. Let us consider another example. When Intercon Japan became more concerned about their key supplier's "monopoly" mindset, they offered economic incentives to entice a new supplier, Nagoya Steel, to develop a new steel process technology for producing different types of cable connectors. To make Nagoya Steel become more competitive, these incentives included a minimum order quantity, technical advice about the new steel process technology, and information about the market demand for this new process technology. By establishing additional suppliers that utilized different process technologies, Intercon Japan was able to shift production among suppliers when a particular process is disrupted (c.f., Mishina (1991) and Tang (1999)).<sup>13</sup>

Flexible Logistics. In supply chain management, logistics could be the Achilles' heel that can make a supply chain snap. As such, one should consider adding more logistics flexibility in a proactive manner. Here are three basic approaches for doing so:

- Multi-modal logistics. To prevent the supply chain operations coming to a halt when disruptions occur in the ocean, in the air, on the road, etc., some

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<sup>12</sup> The issues of "risk sharing" and "revenue sharing" has been studied by Narayanan and Raman (2004) in the context of aligning the incentives among supply chain partners so that the entire supply chain can focus on the performance of the entire supply chain.

<sup>13</sup> With a flexible supply base, many firms can enter different supply contracts such as backup supply contracts, quantity flexibility contracts, etc., with their suppliers. For instance, in a backup contract, the buyer is committed to a certain order quantity with the supplier ahead of time. The supplier delivers a pre-specified fraction of this committed quantity before the start of the selling season and reserves the capacity for producing and delivering the remaining units (i.e., the backup units). After observing early demand, the buyer can order up to the backup units by paying the original purchase cost and receive quick delivery. However, the buyer will pay a penalty cost for any of the backup units it does not buy (c.f., Eppen and Iyer (1997)). In a quantity flexibility contract, the buyer is committed to a certain quantity ahead of time, but the buyer has the flexibility to adjust this quantity upward or downward up to a certain amount at certain specified time frame (c.f., Tsay and Lovejoy (1999)).

companies utilize a flexible logistics strategy that relies on multiple modes of transportation. For example, Seven-Eleven Japan urges its logistics partner to diversify its mode of transportation that includes trucks, motorcycles, bicycles, ships, and helicopters. This flexible logistics strategy has won the hearts of many Japanese when Seven-Eleven Japan used 125 motorcycles and 7 helicopters to make rush deliveries of 64,000 rice balls to earthquake victims in Kobe shortly after the earthquake that destroyed many roads in the late 80s (c.f., Lee (2004)).<sup>14</sup>

- Multi-carrier logistics. To ensure continuous flow of materials in case of political disruptions (landing rights, labor strikes, etc.), various air cargo companies such as Aeroméxico Cargo, KLM Cargo, Delta Air Logistics, Air France Cargo, CSA Czech Airline Cargo, Korean Air Cargo, etc., have formed an alliance called SkyTeam Cargo that will enable them to switch carriers quickly in the event of political disruptions. Moreover, this alliance enables SkyTeam Cargo to provide low cost global deliveries in 500 destinations in 110 countries.<sup>15</sup>
- Multi-route logistics. To avoid a complete shut down, various companies are contemplating multi-route logistics so as to ensure smooth material flows along the supply chains in the U.S. For example, due to long delays at the west coast ports and heavy traffic jams along various west coast freeways, some east coast companies are developing multi-route logistics that encourages shippers to develop new routes in addition to the traditional route; namely, ocean freight from Asia to west coast and then rail transportation from the west coast to the east

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<sup>14</sup> Due to the terrain and the road condition in various forests throughout Thailand, many companies have proactively used small trucks and elephants to transport goods and raw materials through the thick forest. This proactive strategy has enabled the Thai government to deploy many well-trained elephants quickly to help out the rescue and recovery efforts in the tsunami devastated areas (Phuket and Phang Nga) immediately in late December of 2004.

<sup>15</sup> Along the same vein, a group of global freight forwarders launched the World Freight Alliance in 2004 that will provide shippers maximum flexibility to switch carriers quickly should a disruption occurs. The reader is referred to Harrington (2004) for details.

coast. Specifically, after the west coast ports were shut down for 2 weeks in 2002, some shippers are considering shipping various manufacturing goods from Asia to East Coast ports via Panama Canal. With this flexible logistics strategy, the supply chain can continue its operations in case a disruption happens at various ports.

### ***Proactive Demand Strategies***

The proactive product and supply strategies presented earlier are intended to enable a firm to deploy contingency plans quickly to restore supply capability when a disruption strikes. We now present proactive demand strategies that will enable a firm to influence customer demand by deploying certain contingency plans discretely. These proactive demand strategies allow a firm to manipulate customer demand so that the resulting demand can be met by the disrupted supply in a cost-effective and time-efficient manner. There are at least 2 proactive demand strategies for manipulating customer demands.

Dynamic Pricing and Promotion. Brick and mortar retailers can always provide price incentives to influence customer's product choice. For instance, when the supply of a particular product is disrupted, a retailer can use pricing mechanism to entice customer to choose products that are widely available. In the context of e-commerce, savvy on-line retailers can utilize the profile of each on-line customer such as past click sequence, past purchasing history, etc., to develop a personalized pricing and promotion strategy so as to influence each customer's product choice. When disruption hits, this dynamic pricing and promotion capability enables on-line retailers to manipulate customer's product choice and hence customer demand discretely. For example, when Dell was facing supply disruptions from their Taiwanese suppliers after an earthquake in 1999, Dell immediately deployed a contingency plan by offering special "low cost upgrade" options to customers if they choose similar computers with components from other suppliers. This dynamic pricing and promotion strategy enables Dell to satisfy their customers during a supply crisis (c.f., Martha and Subbarkrishna (2002)).



Assortment Planning. In addition to pricing and promotion strategies, brick and mortar retailers can use assortment planning (the set of products on display, the location of each product on the shelves, and the number of facing for each product) to influence consumer product choice and customer demand. A study conducted by Chong, Ho and Tang (2001) at 5 supermarkets in the U.S. found that the store manager can manipulate customer's product choice and customer's demand by reconfiguring the set of products on display, the location of each product on the shelves and the number of facing for each product. Their findings suggested that one can utilize assortment planning to entice customers to purchase products that are widely available when certain products are facing supply disruptions.

### ***Additional Opportunities***

Although proactive strategies enable companies to deploy the corresponding contingency plans when disruption occurs, supply chains can become more robust if they can reduce their exposure to risk in the first place. While it is difficult to reduce the likelihood of most unpredictable disruptions, there are several ways to reduce the impact of disruption on the supply chain operations so that these supply chains are less vulnerable. Here are some examples:

Supply Alliance Network. In addition to having the buyers to develop flexible supply base, suppliers (contract manufacturers, airlines cargo companies, trucking companies, logistics providers) can proactively form a strategic alliance with other suppliers in different countries. These alliances can serve as a "safety net" for each member, who will receive help from other members if a disruption strikes. Therefore, the alliance concept reduces the risk exposure of the supply chain and the risk sharing idea would enable the suppliers to continue delivering goods or services to their customers during a crisis.

Shorter Supply Chains. A supply chain is less responsive and hence more vulnerable to disruption when there are too many partners. To reduce the risk exposure, one can shorten a supply chain by having some partners expand their services so that the number

of supply chain partners is reduced. For instance, to reduce the number of supply chain partners, various companies now offer extended services to their customers. We offer two examples. First, in addition to expand various logistics operations, UPS offers banking services and handles letters of credit for customers in order to shorten the replenishment lead time; i.e., the time between the order is placed and the time the order is received by the buyer. Next, to shorten the time to clear customs at the US ports, more than 500 companies have joined the C-TPAT (Customs-Trade Partnership Against Terrorism) certification program in late 2002 so that they can be more competitive by shortening the time to clear customs at the US.<sup>16</sup>

Clearly, in order to execute various proactive strategies and the corresponding contingency plans in the most cost-effective and time-efficient manner, the entire supply chain needs to be integrated. To integrate Dell's and Seven-Eleven Japan's supply chains in a virtual manner, communication, coordination and collaboration (across different functions within a firm and across different firms along the supply chain), and supply chain visibility (information about customer demand, inventory tracking system, etc.) are the key ingredients. These key ingredients enabled Dell and Seven-Eleven to manage the entire supply chain process (product development, product production planning and distribution, pricing and promotion, after sales service, etc.) as a single entity even though their supply chains are comprised of many external supply chain partners (c.f., Magretta (2001) and Lee (2004)). To make a supply chain more resilient to various unpredictable disruptions, it is critical to develop various proactive strategies and contingency plans and it is essential to develop an integrated supply chain.

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<sup>16</sup> To protect the nation's security, US Customs now inspect 4-5% of the containers arriving at the west coast ports. This heightened inspection has caused additional delays at the west coast ports by 6.5 days on average. As a way to clear custom quickly at the ports, US Customs launched a certification program called the Customs-Trade Partnership Against Terrorism (C-TPAT) program in April 2002. To entice companies to comply with the best security practices certified companies are allowed to clear custom at the port faster than those who are not certified. The reader is referred to McGuire (2002) for details.

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