8 Crisis management and SCM

Introduction to chapter 8

Critical events/incidents and crisis-generating factors regarding SCM are acknowledged, while at the same time, respective counter-measures are suggested to effectively address the risks involved. Covid-19 is used as a case study approach in order to better comprehend the effects and their scale of the health crisis on both local and global SCM systems. Supply chain crises have always existed and always will. For the last few decades, low-cost supply and minimal inventory have been the main "weapons" of supply chain management. But in a highly globalized and highly volatile market, where supply chains are immensely dependent on low-cost suppliers, combined with the practice of maintaining minimum stock levels, this is proving ineffective.

Learning objectives

After reading this chapter, you will be able to answer the following questions:

- What are the challenges of supply chains today?
- What is called risk in general and risk in the supply chain in particular?
- What are the stages of risks in the Supply Chain?

Outline

8.1 Challenges involved in modern supply chains

Today's supply chains are global. This is not going to change any time soon because production plants are located far away from their selling points. Moreover, the benefits of acquiring raw materials, semi-finished or finished products from international sources are many, while the search for and expansion into new markets is the main strategic goal of businesses nowadays. According to forecasts by Statista (2020), the market size of international supply chains will reach the exaggerated level of

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$7.1 billion in 2023. On the other hand, specific challenges and risks are being faced today by companies operating or wishing to operate in the international arena.

Research into the challenges of international supply chains confirms the experiences of previous years. The five most important challenges as recorded today are: lack of transparency along the supply chain, required planning over a long time horizon, demand volatility, the existence of multiple channels for purchasing and distributing products, and the instability of circumstances as attested in many parts of the world.

Nearly two in five executives believe transparency is the most significant problem in a global supply chain Statista, 2020; Accenture, 2021). The need for long-term logistics planning by companies participating in an international supply chain network is a major challenge. If this is added to the challenge of fluctuations in customer demand that occur seasonally and over longer periods of time, managing the production and transportation of goods over long distances to meet demand suddenly starts to resemble a Herculean task. The above factors complicate both the volatility of commodity prices and the continuous increases in road, sea and air costs/fares.

An important challenge nowadays is that consumers have the ability to make purchases using multiple channels, which automatically implies the need for multiple distribution channels. According to GEODIS (2020), three in four companies today use four or five modes of transport to meet demand. Traditional retailers and wholesalers are forced to maintain large storage facilities and high levels of inventory near metropolitan centers, while online stores, online markets and drop-shippers have to collaborate with a greater number of logistics service providers. In the last three years, the number of distribution centers has increased by 10% (Bureau of Labor Statistics, 2021).

To all this must be added the significant geopolitical turmoils that take place in various parts of the world, as well as economic and social factors such as natural disasters, wars, currency fluctuations, cultural differences, etc.; such events demand great flexibility on the part of international supply chains with significant investment in modern technological solutions and specialized human resources. Examples of such problems are illustrated in the following section as case studies.

8.2 Case studies of supply chain risks

8.2.1 The Tsunami in Japan

The 2011 earthquake and subsequent tsunami in Japan had devastating effects not only on the country's society but also on the automobile industry's supply chains. Giant companies such as Honda, Toyota, Nissan and Fuji Heavy Industries (manufacturers of Subaru) closed their production plants when their supply chains suffered from severe component shortages. The financial consequences were huge: 75% of Toyota's profits, 81% of Honda's and 49% of Nissan's disappeared in just a few hours (Automotive news, 2011). The factories of these companies around the world – Toyota in China, Europe and North America, for example – stopped production, in some cases for up to three months. Honda cut production at its UK plant by 50% in seven weeks, while three Nissan plants in the USA closed completely. Global car production fell by 3.6 million units in 2011. It was not just Japanese companies that ran into huge problems; from Ford to Volvo and General Motors to Renault, automakers found themselves in deep trouble. Peugeot–Citroën reduced production by 40–70% in most

of its European factories because it did not have enough engine airflow sensors which it imported from Japan. Chrysler stopped receiving dealer orders for vehicles in 10 colors because the paint sources came from Japan (Automotive news, 2011).

What initially emerged was that a huge number of components, from electronics to paint and engines to gearboxes, came from Japan. The "just-in-time" (JIT) philosophy was heavily criticized as being the driving force behind the success of these Japanese giants. According to this philosophy, companies are pushed to operate without large stocks and instead receive small quantities from suppliers only when required. But in a globalized market that requires large supply chains, the "just-in-time" philosophy which proposes chains that rarely extend over a hundred miles has proved ineffective. Furthermore, the practice of single procurement was also criticized: it makes car-makers vulnerable to disruptions when the supply sources are not working/malfunctioning for whatever reason.

The results of this natural disaster have led almost all companies in the industry to take immediate action without abandoning their basic principles, using "simple" philosophies like JIT and local suppliers. Initially, databases with suppliers' data were designed and developed, which highlighted potential risks and disruptions in the immediate supply and smooth handling of raw materials and semi-finished products, components, etc. The 60/20/20 supply model was also implemented: this splits costs between different suppliers, sharing out the risk. Such a plan must include an alternative supplier, in order to seamlessly convert production to an alternative installation in the event of a breakdown in the main installation, not just for a few weeks after the event, but more or less immediately, as quickly as possible. Thus, in the case of any failure on the part of the main supplier (who provides 60% of the volume), production from the other two sellers can be increased to cope with a small drop in the main supplier. It is believed that building up a surplus in the supply chain could combine the supply chain's resilience with its core principles; in other words, the goal is now: "*Instead of changing our suppliers or our production approaches, what we need to do is to better understand who is supplying whom*." The end result could be a more durable car supply chain, but not at the cost of economies of scale, or abandonment of the principles of JIT and lean manufacturing.

8.2.2 The economic crisis

The economic crisis which rocked almost the entire Western world started around 2006–2008 and continues to this day; it had and still has a huge negative impact on almost all business activities. The trade sector was one of the first economic activities to be affected, given that the phenomenon of a simultaneous and significant reduction in demand for products and services was immediately observed. Among 3PLs (Third Party Logistics), this led to a dramatic reduction in orders, the cancellation of transportation contracts by all means of transport, and a general decline in goods transport and storage volumes; it also stopped a large number of companies operating, and many merged with bigger players in the field. Nevertheless, the logistics services industry has shown a small but positive trend in recent years.

This demonstrates the acceptance of executives' perceptions, by both the companies they work for and the market, that logistics management is one of the most important survival weapons for a company in the event of a "financial tsunami". Businesses today see logistics management as the tool that will reduce their operating costs and

the means to create competitive networks capable of meeting all the great challenges they must face. At first glance, there seems to be a paradoxical relationship between the economic crisis and the logistics industry, as illustrated by the following two examples:

1 While there has been a very large decrease in national transportation during the period 2008 to date, there has actually been a significant increase in international transport, as well as an increase in storage services (packaging, labeling, pricing, order management).
2 Most companies continue to carry out their logistics activities internally while maintaining their own warehouses; at the same time, most management/administration bodies have stated their intention to outsource this work in the coming years.

Regarding the above increases, managers identified the following reasons: improved sales performance, increased sales due to exports, reduced operating expenses, increased sales due to the development of new services and improved performance of the provided services. Correspondingly, the reasons given for the decreases were: sales decreases in the local market, higher interest rates, slight price increases, increases in fuel costs and utility costs (electricity, gas, etc.) and sales decreases due to higher prices.

The following table shows the effect of the economic crisis to supply chain management (Table 8.1).

At the same time, interviews were conducted with company executives who had declared increased profits. The main points on which most executives agreed were as follows:

- Estimating real demand has become a complex process. Executives often believe that it is difficult to predict demand even for their loyal customers. As the main

Table 8.1 Effect of the economic crisis according to the supply chain function

Supply chain function	*Effect*
Procurement	• Seek out the best suppliers (with cost as the main criterion) • Regular monitoring and evaluation • Strict partner selection process
Inventory management	• Inability to obtain reliable demand forecasting • Drastic reduction of stock • Dominance of the 'push' philosophy • Non-maintenance of safety stock levels
Warehousing	• Reduction of orders • Fewer goods per order • Lower profits per order/customer • Increase in the number/frequency of orders
Transportation	• Reduction of order/lot size • Seeking out alternative means of transportation • Planning of network distribution based on demand • Longer waiting time for a full load ("is full capacity a priority?") • Inability to execute two-way routes

reasons for this, many cite the difficulty of finding reliable information about demand and the difficulty of communicating with customers.
- Continuous evaluation of partners is essential, as is monitoring their performance; redefining relationships with third parties is a common practice, which leads many to enter into short-term and flexible contracts that take demand into account.
- Meticulous inventory level control is now conducted based on the premise: "f*rom full-service to a cost efficient service*".
- Logistics service providers are stricter in their choice of customers. This simply means that managers now seek to work with trusted customers who are able to meet their financial obligations, as cash flow problems are now intensified among more and more companies in the industry.
- Finally, warehouse/distribution center staff work longer hours and productivity levels in warehouses decrease, especially during peak times. For this reason, managers are trying to find ways to increase productivity, at the same time as minimize warehouse operating costs.

Businesses are desperately looking for solutions as they try to find a way out. In this context, cost reduction becomes the first strategic choice for overcoming the crisis. Logistics and supply chain management aim to reduce costs while increasing the level of service provided. Therefore, logistics tools are potential, reliable solutions and effective tools for businesses.

8.2.3 The Covid-19 pandemic

With the advent of the year 2020, all national and global economies were hit hard by the coronavirus pandemic. The situation arising from Covid-19 revealed the vulnerabilities of supply chains in most, if not all, economic and industrial sectors. According to a survey by the Institute of Supply Chain (2020), almost 75% of companies reported disruptions in their supply chain in the months of April–September 2020 due to the spread of the virus, while the number was expected to increase in the coming months. The impact of the pandemic was identified in the following logistics system functions:

- In the production and distribution of products, with some countries imposing strict controls on the production and distribution of their products.
- In communications with collaborating companies and other members of the supply chain.
- In the supply of products, especially from countries whose governments had imposed correspondingly strict export restrictions on their products.
- In stock management, creating either: high-speed supply chains, food-supply chains, electronics/electrical goods and general widely-used products, which need continuous resupplying; or: low-speed product chains such as clothing, furniture, cars, etc. whose demand was significantly reduced. Due to store closure during the pandemic crisis (e.g. the catering and tourism sectors), some sectors showed zero demand for products from the first category of the supply chains.

Businesses have worked much harder throughout this period, following very strict logistics procedures with staff working work remotely, while managers were called to

analyze their weaknesses in order to better prepare for other unpredictable but essentially inevitable future crises. The impact of the pandemic has strengthened the view that in the coming years, smaller and simpler supply chains will be needed, with a reduced number of participating companies and staff, but with greater flexibility and adaptability.

It is also apparent that companies need to look for better ways to work with other members of their supply chain in order to deal with order cancellations/changes, and the general problems involved in fulfilling orders. Companies must redefine their supply chain by rigorously evaluating their existing suppliers and adding new ones that bear fewer risks. Their priorities in investment initiatives are likely to change; the processes of adopting technological infrastructure and automation solutions with high transparency levels are likely to be accelerated. Businesses are always looking for solutions to organize their activities digitally so that they are better able to identify potential supply chain problems and mitigate their impact.

The main goal of supply chains in the near future will be to create vertical-expanding supply chains which will lead to an increase in the number of suppliers per level in the chain. This is believed to be the key to reducing costs and capital items/expenditure, with faster distribution of products in the markets. However, companies must possess the appropriate technological solutions that can provide all its members with a common concept of the supply chain; otherwise, complexity increases, visibility decreases and control are reduced. One of the positive effects of the Covid-19 pandemic was the large increase in online ordering; this showed up the difficult role that logistics companies were called upon to play in order to meet high demand.

8.3 Conceptual approach of crisis management in supply chains

A variety of definitions of "risk" exist in the literature. A general definition defines risk as "*the threat that something may happen to disrupt or even stop normal and planned activities*" (Waters, 2011). Similarly, supply chain risk is defined as the potential occurrence of an event or failure that impedes the free and uninterrupted flow of material and information, from suppliers to the end-user, causing disruptions in a supply chain (Tang and Musa, 2011). The consequences of risk can be identified either in a single company or member(s) of a supply chain, or they may focus on the performance of the supply chain as a whole, which can be affected by the escalation of results across the chain (Wagner and Bode, 2008). The impacts of unforeseen events may adversely affect part or all of a supply chain and may lead to operational, tactical or strategic problems.

At this point, a distinction must be made between the concepts of 'uncertainty' and 'risk'. Risk has some quantifiable measure of future events, while uncertainty does not. Uncertainty suggests that unexpected events can happen: we can report events that may happen in the future, but we do not know what will actually happen or what the probability of something happening is. Both concepts refer to a lack of knowledge about the future – and the events that may or may not occur – but they do not necessarily state whether the events are harmful or not.

The conceptual approach to risk in the supply chain also includes the definition of sources of risk in supply chains, the risks themselves, and the consequences (effects) of risks:

- *Sources of risk* are environmental, intra-business or inter-business (i.e. supply chain level) variables that cannot be predicted with certainty, and which affect the performance and success of a supply chain (Lessard, 2013).
- *Risks* are events, i.e. specific realizations of these uncertainties, e.g. a fire in a distribution center, a terrorist act, etc.
- *Effects/consequences of risk* are the (potential) impact of the realization of these risks on the value(s) of a company's operation(s), such as cost, safety, reputation, response time, etc. as well as other economic, social and environmental impacts (Lessard, 2013).

8.3.1 Sources of risk for supply chains

According to Lessard (2013), "*sources of risk are variables whose future values are not known with certainty, due to a lack of information about the underlying process, or because they are the result of unpredictable social, economic or political interactions, or both.*"

Supply chains are currently exposed to various risks arising from a number of issues:

- *Political and social unrest:* In Europe and the Western world in general, Brexit has had a negative impact on trade in commercial transactions and exchange rates, creating instability and disruption among markets and supply chains, especially within the European area. In the USA, 72% of sportswear and footwear imported to the country in 2013 were produced in high-risk countries with poor working conditions. In 2019, Mexico faced a shortage of staple foods, such as corn flour and wheat flour, when teachers from the National Committee for Labor Education blocked the railway lines to protest their labor demands. This has hampered the distribution of supplies to various industries, including hydrocarbons and grains such as corn, a staple of the Mexican diet.
- *Conflict wars:* In recent years, the creation and maintenance of war zones have created huge problems in the physical distribution of goods, especially in countries serving global markets where the terminals for ships, aircraft, trains, etc. are located, and also in areas where fuel is extracted.
- *Economic instability:* Economic instability is another threat to world trade. For example, the bankruptcy of one of South Korea's largest shipping companies (Hanjin Shipping) led to a dramatic reduction in the strength and capacity of the global shipping supply chain.
- *Changes (increases) in customs duties:* Japan has imposed strict export controls on South Korea for chemicals such as hydrogen fluoride, photodilators and fluorinated polyimide, which are necessary for the production of new-age cellphones and semiconductors. During the Trump era, the former US President decided to place tariffs on products coming from the EU, Canada, Mexico and China, imposing high import duties on all goods (e.g. 10–25% tax rate on steel and aluminum imported into the US). In response to these attacks, the Chinese government reacted by imposing tariffs on American products, etc. Until the decision was revoked, it had forced companies to redesign their supply chains.
- *Rising fuel prices:* Between 2014 and 2016, crude oil prices increased by 60%. This rise had serious consequences for areas that supplied low-value products and

materials. In general, rising fuel prices play an important role in global supply chains, affecting transportation more than storage and inventory management.

- *Economic recession:* It is well known that most buyers and suppliers in global supply chains are heavily dependent on banks to provide them with working capital to finance their production, stocks and transportation–distribution activities. The impacts of recessions on global supply chains are not just economic. Many companies that are based on overseas supply sources experienced severe disruptions in their ability to acquire materials and products. The reduction of orders in developed countries spread rapidly through global supply chains, resulting in severe production cuts at multiple levels of the supply chain. In some cases, suppliers failed due to a lack of financial capacity to survive the dramatic drop in orders.
- *Urbanization of populations and creation of megacities:* The number of megacities around the world is increasing. More than 40 megacities are expected by 2030, compared to 18 at the beginning of the century, especially in Asian countries. The creation of these huge urban centers will create a series of challenges in the supply chain: delays in the execution of orders due to traffic jams and high population density, a rise in the need to implement pro-environmental practices, and greater storage requirements for products at multiple distribution centers are some of the problems envisioned.
- *Population growth:* According to research, by the year 2050 the total population on Earth will reach 9,000,000,000 people. Satisfaction of supply for mass consumption will deplete fuel reserves. It will create the need for large supply chains that will transport large quantities of supplies to demand points by sea. At the same time, it will create ports and terminals capable of handling a large number of containers.
- *Aging of the population:* An important demographic element is the increase in the percentage of people aged over 60. This percentage is constantly rising; by the year 2050, it is expected to reach 22% (a percentage corresponding to 2 billion people). Aging of the population is estimated to affect global supply chains with increased door-to-door deliveries to customers, a large dispersion of demand points and possible staffing problems among logistics companies, such as 3PLs, courier services, etc.
- *Immigration:* The world is experiencing the biggest migration crisis since World War II, where hundreds of thousands of people are being displaced from their homes, and searching for a safe haven under the threat of danger. This is a challenge for many European countries as they are not ready to accept huge numbers of refugees. Furthermore, due to the economic and political instability affecting many regions of the world, many young people in search of work opportunities aspire to emigrate to the developing countries of the Western world. As previously mentioned, Europe's population is aging; thus, immigration in these countries can be a key factor in mobilizing the workforce, driving growth and increasing demand and investment as more people need housing and other services. In order to achieve these advantages, European countries as well as the USA, Canada, etc. could offer programs to attract skilled workers and train them in logistics and supply chain positions.
- *Pandemics (health crises):* As discussed earlier, pandemics reveal the vulnerabilities of supply chains in most economic and industrial sectors. Most of the

problems lie in the lack of market resupply due to restrictions imposed by national governments on the suppliers operating in them. During the Covid-19 pandemic, for example, some retailers procured more than half their stock from China, according to Statista for 2020. Another Statista study found that 44% of retailers expect delays and 40% expect stock shortages due to supply chain disruptions related to the pandemic.

- *Climate change:* By 2040, companies operating in cutting-edge technologies such as the semiconductor industry which is needed for electronics, computers, smartphones, etc. will be located in Korea, Japan, Taiwan and other nodes in the western Pacific region. The increased occurrence of hurricanes in recent decades (which according to many researchers is due to climate change) can disrupt their supply networks and the corresponding supply chains in general.
- *Environmental legislation:* As mentioned earlier, interest has been focused on the effects of the environment on supply chain logistics systems in recent years in the context of the circular economy; at the same time, many Eurozone countries have adopted a strict regulatory framework for the implementation of environmentally-friendly "green" practices. For example, Switzerland has adopted the transport of containers by train instead of by truck. The Netherlands has reduced the maximum speed of trucks from 120 to 100 km/h in order to reduce carbon dioxide emissions. Many countries in South Asia, e.g. China, Indonesia, and Taiwan, have implemented strict control measures in production units as well as in the circulation of freight transport and distribution.
- *Information and communication system failures – Cyber-attacks:* In 2017, Ukraine's government information systems were affected by malware (worm). The effects were enormous; it is believed to have disrupted the smooth operation of ports, factories and offices in about 60 countries. The dramatic development of information systems and the ability to access central computer systems have allowed hackers and terrorists to attack the information systems of multinational corporations that support global supply chains. More specifically, similar IT systems and technologies find a wide variety of applications in supply chain management, such as market and order management activities, management of customer/supplier relationships, monitoring and forecasting of demand and inventory management, cash flow management, etc. Companies that are members of a supply chain need to create new levels of cooperation with businesses that specialize in security issues.
- *Globalization:* When a company's materials, factories and customers are widely spread all over the world, it is at the mercy of global events such as natural disasters, port and border closures and geopolitical landscape changes. In short, globalization is the accelerator of all the above sources of risk. Globalization of markets generally increases the complexity, competition, information gathering and the need to achieve transparency across chains, as well as giving rise to a host of legal issues.

8.3.2 Risks

Generally speaking, risks may be classified in the following way:

- Internal risks, which concern the company's logistics system (or that of the supply chain). Examples of such risks are the availability (or not) of staff for the facilities,

risks associated with production support, accidents, breakdowns, equipment failures, human error, etc.

- External risks, which threaten the entire supply chain. These include problems related to logistics service providers, distribution risks, inadequate warehouse facilities, stock shortages, supplier reliability, demand volatility, payment uncertainties, customer ordering problems and supplier-related ordering issues, etc.
- External risks, i.e., risks coming from the external environment (of the markets). Examples of such risks are natural disasters, environmental disasters (floods, hurricanes, tornadoes, bad weather, etc.), or man-made natural disasters (such as terrorist attacks, war, conflict, crime, breakdown of a nuclear energy system, etc.). These also include strict legislation and restrictions, economic crises (such as exchange rates, strikes, fluctuations in market prices, etc.), political instability, damage to electronic infrastructure and information systems, social inequality, etc.

8.3.3 Impact/consequences of risks

As mentioned above, risk effects (as identified in the previous section) comprise the impact of their emergence/appearance in supply chain logistics systems. Table 8.2 is based on the work of Chopra and Sodhi (2012), presenting the effects of risks on the main functions of Logistics Management, and suggesting general ways of dealing with them.

8.4 Crisis management in supply chain

According to SCRLC (2013), "*Logistics risk management is the systematic process of identifying, evaluating and mitigating disruptions in a logistics network, with the aim of reducing their negative impact on performance*". Similarly, Ho et al. (2015) define it as an "*inter-company collaborative effort that uses quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected microeconomic and macroeconomic events or conditions that may adversely affect any part of the supply chain*". Fan and Stevenson (2018) define risk management in the supply chain as "*the identification, assessment, processing and monitoring of supply chain risks, by applying tools, techniques and strategies within the company, with the external coordination and cooperation of other members of the supply chain, in order to reduce their impact and ensure continuity and profitability*".

According to the above definitions, Risk Management in the Supply Chain includes four main stages, as shown in Figure 8.1.

8.4.1 Recognition/identification of risks

This step involves identifying the various sources of risk. The risks associated with modern supply chains have been identified and analyzed in previous sections. A very good presentation and evaluation of these risks were made by Simchi-Levi, Kyratzoglou and Vassiliadis (2013), where the following risk sources emerged, in descending order of importance: fluctuation of prices for raw material, fluctuations in the exchange rate, market changes, fluctuations in energy/fuel prices, environmental disasters, shortage of raw materials, rising labor costs, geopolitical instability, bankruptcy of suppliers/partners, technology changes, information system failures,

Table 8.2 Dangers and ways of dealing with them, depending on the logistics function

Functional/ operational area	*Risks*	*Ways of dealing with risks*
Supplies	• Bankruptcy/financial problems of suppliers • Supply delays • Lack of transparency along the supply chain. This happens because most companies have no vision beyond the first tier of their supply chain. • Dependence on one supply source, or a small supply base (e.g. supply from the source of a primary component or raw material). • Exhaustive use of existing supply sources • Lack of flexibility of supply sources • Low performance of supply sources • Low capacity/response of alternative suppliers • Financial risks such as exchange rate risks, etc. • Use of specific and/or finite sources by the whole industry • Long-term versus short-term contracts	• Increasing the supply base and searching for alternative sources • Increasing the number of local and neighboring suppliers • Commitment of suppliers with strict contracts and clauses • Continuous evaluation of suppliers • Surplus supply for products with high sales volumes, and concentration of surplus supply with a few flexible suppliers for products with low sales volumes • Increasing cooperation between supply chain members • Use of information systems and technologies that allow the creation of collaborative networks

Inventory/ warehousing (Storage)	• Uncertainty of supply and demand
	• Inaccurate forecasts due to long order satisfaction times, seasonality, product variety, short life cycles, or small customer base
	• Bullwhip phenomenon - acceleration of information distortion due to promotional activities, incentives, lack of chain visibility and oversupply in times of shortage
	• Inventory risks which depend on three factors: product price, rate of depreciation and uncertainty of supply and demand; risks also increase as the range and number of products increases
		• Increase of storage capacity and storage spaces
		• Decentralization of stock for products with a predictable demand and low volume
		• Concentration of stock for products with opposite features
		• Reduction in the range/variety of stocks.
		• Increased collaboration between supply chain members, especially for demand estimation/forecasting
		• There are three tried and tested approaches that are appropriate for mitigating this risk:
		  • inventory pooling
		  • product design based on common components design, and
		  • postponement or delay of the last production stage until all orders have been collected (gray products)

(*Continued*)

Table 8.2 (Continued)

Functional/ operational area	*Risks*	*Ways of dealing with risks*
	• Collapse of information infrastructure • Verticalization of the system, or extensive system networking • Product devaluation rate • Inventory maintenance costs	• Maintaining surplus stock for high value or short life cycle products can incur unseen costs; however, the strategy can work beneficially for low–value commodities that have low depreciation rates • Insuring stored goods • Outsourcing - use of public warehouses
Transportation/ distribution	• Postponements, delays and cancelations due to natural disasters, wars, terrorist acts, problems with existing infrastructure, etc. • General interruption/disruption of transportation of products from one point to another, which can occur at all stages of the supply chain • Excessive handling due to border crossings or changes in means of transport	• Utilization of direct customer/consumer communication channels • Acceleration of customs clearance • Changes in mode of transport and predetermined air/rail capacity, in accordance with the current traffic reports • Insurance of goods in motion • Modification of supply chain design • Outsourcing–use of public transport
Customer service	• Customer crowding • Consumer purchasing power	• Digitization of supply chain management, which improves the speed, accuracy and flexibility of supply risk management

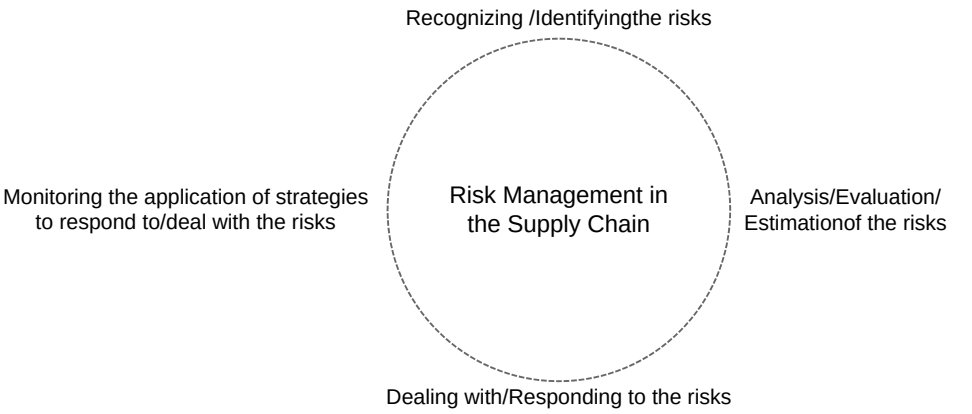

Figure 8.1 Stages of risk management in the Supply Chain.

telecommunication failures, and cyber-attacks. Many companies systematically record and keep in print form, and more commonly in electronic form, the relevant sources of risk related to the operation of their supply chain, in specific registration systems.

To identify risks in their supply chains, companies focus on specific functional areas of their logistics system: supplies - number and location of suppliers, customer service – locations of points of sale, number and quantities of shipments, transportation/ distribution – modes of transport, routes and cooperating companies involved in the supply chain (e.g. 3PLs).

8.4.2 Risk analysislevaluationlassessment

This stage includes the probability of a risk materializing, and its impact, which can be measured qualitatively and quantitatively (both methods are often used in combination). Qualitative assessment can be done by describing the risk, its impact (the operational logistics areas that are affected), as well as its relationships with other risks. Quantitative assessment is based on historical data and usually includes mathematical calculations which usually require a greater entrepreneurial and less technical background from the executives who evaluate them. Many companies work with consultants and experts to make these calculations. Some of the methods that can be applied are listed below:

- Ranking the severity of and focussing on the most important risks, with the application of Pareto's 20/80 rule, i.e., 20% of the risks cause 80% of the consequences.
- Calculation of the expected value of the risk, which can also be applied to the severity ranking: for each risk, the probability of its occurrence is assessed and its impact is calculated (usually in some kind of value). For example, a shortage of raw materials, where the probability of occurrence is 5% and the impact of the shortage is valued at €20,000, could have an expected risk value of €1,000. By calculating the value of the expected risk, risks can be prioritized, enabling management to focus on the most important one.
- Failure modes and effects analysis (FMEA), which can be used to detect potential failures. It proposes a systematic examination of each component of a system in order to identify, analyze and document the possible forms that failure can take within a system, and the consequences of each failure in the system.
- Total Quality Management (TQM) tools and charts, such as cause-effect diagrams (herringbone charts, scenario (what if) analysis), control (check-list) analysis, etc.
- Other decision support tools, such as risk tables, risk charts, risk records, computer simulation (to test different variables and quantify the risks), probability and impact tables (to examine different risks and assess their relative significance), decision matrices and Expected Monetary Value (EMV).
- The "Probability-Impact" table, one of the most widely-used risk assessment tools, because it provides a simple, effective, explanatory approach to risk analysis.
- The use of a heat map, which allows executives to easily see the likelihood and potential consequences of different risks, as shown in Figure 8.2.

Probability	Highly likely	Medium	Important	Critical	Critical	Critical
	Most likely	Medium	Important	Important	Critical	Critical
	Likely	Medium	Medium	Important	Important	Critical
	Unlikely	Minor	Medium	Medium	Important	Important
	Rare	Minor	Minor	Medium	Medium	Important
		Insignificant	Of minor importance	Medium	Great	Critical
	Impact					

Figure 8.2 Heat map tool.

8.4.3 Risk management

At this stage, the appropriate way to respond/react/deal with potential risks is chosen. Waters (2011) suggests the following range of risk responses: ignoring or accepting risks, reducing the likelihood of their occurrence, reducing or limiting their consequences, shifting responsibility elsewhere, sharing or diverting them, developing contingency plans and adapting to a new environment.

Chen, Sohal and Prajogo (2016) distinguish three perspectives on mitigating supply risks:

- Developing strong mitigation strategies to counter a risk;
- Ignoring the risk, reducing the likelihood of it happening, reducing its impact, transferring risk to another level or member of the supply chain, adapting to the risk, crisis planning and implementation, etc.; and
- Planning/designing appropriate response methods for dealing with the risk.

8.4.4 Monitoring risk management strategies

The last stage concerns the continuous monitoring and updating of the responses devised to mitigate risks, or dealing with them as proposed in the previous stage. The aim here is to evaluate the application of the selected procedures. This is accomplished through periodic reviews, tests and reports arising from previous incidents, applied measures and drills/exercises, with controls in place to ensure conformity to and effectiveness of the program; establishing, implementing and maintaining monitoring procedures; the continuous recognition of opportunities for improvement; and finally, taking the necessary corrective measures which are believed to positively affect the supply chain.