Chapter 6
Supply Chain Performance Factors in the Manufacturing Industry

6.1 Overview

As in any other type of industries, performance in manufacturing companies is evaluated to improve the supply chain, either from the inside out or vice versa through the participation of all supply chain actors. The purpose of performance evaluation is to clearly and systematically improve the production system while simultaneously building good customer relationships. These goals can be attained through agility in deliveries and flexibility in the use of resources in order to address customer needs, yet both agility and flexibility are not easy to reach. Certainly, modern supply chains operate in challenging environments where a great number of factors affect performance results. Six of these factors are economic or business forces that can be listed as follows (Coyle et al. 2013):

- Customer demand
- Globalization
- Information technologies
- Competition
- Government regulations
- Environment

Globalization has promoted a geopolitical and economic environment characterized by an internal competition where companies seek to minimize their global networks. This is manifested through both political and economic threats (Coyle et al. 2013). Consequently, most companies care about their operational strategies in order to survive in such a competitive market environment, and in this sense, they tend to wonder the following as regards their business:

– Where should we offer our products?
– Where should we manufacture our products?
– Where should we commercialize our products?
– Where should we storage our products?
– How should we transport our products?

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Another challenge to supply chain management is product life cycle. Product life cycles are getting shorter over time as a result of rapid product obsolescence, rapid product development and innovation, increasing government support in manufacturing and commercial activities, terrorist acts, natural disasters, borderless organizational structures, and global competition. Similarly, current customer demands have set the greatest challenges to supply chains, since modern customers are more educated and informed and thus have greater decision-making power. In other words, today, there is no customer loyalty per se due to the great amount of products that are always available and the ability of end users to compare similar goods anytime anywhere before making a purchase. In this sense, accelerated technological progresses have contributed to this matter.

All the aforementioned factors have significant effects on the supply chain (Roldán 2006) as well as on the way companies operate in order to remain competitive. Some of these effects include:

- Customers demand a better service and more purchasing alternatives.
- Customers demand low prices.
- Products can be shipped to and from anywhere in the world.
- Information technologies facilitate decision making in order to improve timing and increase reliability.
- Environmental awareness and regulations put pressure on companies to reduce waste and reuse materials and consequently demand changes in supply chain design and operation.
- Competition has exponentially increased thanks to technological progresses, information availability, business design creativity, and globalization.

All these changes place companies at a crossroads. They must be able to orient their business strategies toward the globalization of processes and consequently develop a new way of being and remaining competitive. In such difficult situations, supply chain performance evaluation has gained importance, not only because products are expected to be timely delivered, but also because they must have the highest possible value added. In the pursuit of competitiveness, companies measure their outcomes at every stage of the supply chain to compare their performance with that of their competitors.

Export-manufacturing companies usually adopt supply chain evaluation approaches from the inside out. They implement lean manufacturing practices to improve their processes and increase product quality; at the same time, they minimize both waste and production costs. As previously mentioned, export-oriented manufacturing companies belong to complex supply networks, as they are intimately linked with parent companies from an operational perspective. Therefore, they are required to constantly evaluate their performance as competitive and high-quality manufacturers. Many of these companies make constant performance improvements thanks to the implementation of industrial engineering concepts and

tools that demand the involvement of all the employees. Undoubtedly, active participation allows organizations to achieve the best long-term benefits.

In the following section, we discuss some works that have studied supply chain performance in the manufacturing industry. It is important to mention that both lean manufacturing tools and work philosophies (e.g., just in time) are widely used in the industrial sector, especially because manufacturing companies belong to large and complex supply networks and are asked to comply with specific levels of production, quality, and customer satisfaction.

6.2 Factors Associated with Performance in the Manufacturing Industry

Modern companies seek to increase production process efficiency through the supply chain, which allows them to minimize costs and increase product quality and agility. Supply chain performance can be evaluated through a series of attributes and controllable variables that minimize risks in production, suppliers, and demand (Bhatnagar and Sohal 2005). Similarly, supply chain performance can be improved by modifying its operational structure, processes, or even business processes in order to meet customer needs and increase profits.

Supply chain has been increasingly studied over time through attributes and/or variables that are analyzed using a broad range of methodologies, from descriptive analyses to fuzzy logic. Some works have focused on the implementation of information technologies to streamline information processing and improve communication and coordination among supply chain actors, whereas others have sought to develop marketing strategies to diminish the bullwhip effect. Globalization has made companies search for and implement novel management tools and strategies to improve their performance and customer satisfaction through greater production flexibility, availability, and information quality. The performance of corporations such as Toyota, Dell, and Walmart relies on the supply chain management practices and technologies they implement (Kim 2006; Kovács and Paganelli 2003).

In the Mexican industry, most of the supply chain-related studies propose new supply chain management techniques. Likewise, international logistics has been considered in order to evaluate supply chain efficiency aspects (e.g., supplier coordination and cooperation, information sharing, import processes, contingency plans) and determine how these aspects influence on performance characteristics, such as synergy among supply chain members, cash flow, complete orders, costs, and lifecycle times (Avelar-Sosa et al. 2015).

Another study evaluated the relationship between absorption, innovation, and responsiveness capabilities with supply chain performance. The study takes into account suppliers, agility, and work resources/method development capabilities, among others (Monge and Guaderrama 2016). On the other hand, Total Productive

Maintenance (TPM) has been used to identify critical supply chain stages that need improvement in order to prevent machine idle times, downtimes, slowdowns, defective products (Alcaráz et al. 2015). Likewise, structural equation models are popular tools for visualizing corporate benefits as a result of total quality management (TQM) practices (Gil et al. 2015), or to understand the effects of green supplier attributes on the environment and their impact on high-quality green products (Fong et al. 2016).

In the manufacturing industry, the procurement process has been examined to determine its impact on supply chain efficiency in terms of inventory levels, deliveries, and customer satisfaction (Alcaraz et al. 2013). Likewise, kaizen has been associated with performance benefits at all its stages, from planning to implementation control (Vento and Alcaraz 2014), and SMED implementation stages have been related to certain industrial benefits, such as shorter setup times, which have an impact not only on production capabilities and order fulfillment, but also on production costs, waste, productivity, and product quality (Díaz-Reza et al. 2016). From a different perspective, works such as that proposed by Avelar-Sosa et al. (2014b) consider external factors such as the environment, services and services-related costs, and infrastructure to value their influence on quality and customer service in the supply chain.

All the reported works highlight operational factors that present certain risks in suppliers and demand. There is a wide range of alternatives to assess the impact of risk factors on supply chain performance. In this sense, we can also notice that there is great number of factors associated with supply chain performance in the manufacturing industry, and most of them are approached from an economic or organizational perspective, or they are studied in such a way as to encourage the modification and adaptation of industrial operations and processes to provide immediate solutions to companies.

Considering the works discussed earlier, there are three aspects to take into account when evaluating a supply chain: (1) the presence and perception of risk, both inside and outside of the supply chain, (2) manufacturing practices, and (3) and environmental factors (i.e., geographic location), which comprise infrastructure, services, government, and market proximity. As Bhatnagar and Sohal (2005) suggest, supply chain performance results depend on both particularities and the environment, which is why competitiveness depends on both operational aspects and the specific characteristics of human resources and the environment where companies operate. In other words, supply chain does not only depend on the organizational structure or on the way this structure is managed. It also depends on the regional aspects that interact with a company's resources in order to achieve the desired business goals.

The modern manufacturing industry is an important element for productivity and economic growth and has crucial implications. The generation of jobs in the manufacturing sector promotes economic development, contributes to a country's gross domestic product (GDP), and increases life quality. In turn, the supply chain of the manufacturing industry improves production system control and promotes adequate collaboration among companies that are supply chain partners. Similarly,

it unifies goals and objectives to create a solid competitive advantage (Zeng and Yen 2017). In countries such as Taiwan, China, Hong Kong, Australia, and the USA, studies on the supply chain are varied; they include literature reviews and evaluation models and propose alternatives such as performance evaluation metrics and the use of technology to improve benefits. In all cases, the ultimate goal is to help companies and supply chains achieve their business objectives through an evaluation of processes, activities, and impact factors, such as supplier capabilities, customer demands, designs, geographic location, timing. Clear examples of successful supply chains are Toyota, Dell, and Walmart, which have steadily improved their management practices and have wisely embraced new technologies.

Nowadays, companies should achieve greater efficiency at the lowest possible costs and without compromising customer service if they want to remain competitive. As Porter (1985) claims, every competing firm must have a competitive strategy, either implicitly or explicitly; therefore, a correct supply chain evaluation must integrate all supply chain actors at the tactical and operational levels. The elements discussed in this book as performance impact factors have been studied through multiple and varied techniques because they represent performance improvement opportunities. That said, measuring performance requires a process-content context that involves specific supply chain and firm characteristics. In other words, performance measurement takes into account a company's organizational structure and characteristics along with the environment when this company operates (Richard and Wojciech 2011). That is why this book emphasizes on and takes into account externalities to address supply chain performance measurement and evaluation. The following subsections thoroughly review the three key factors to be considered in supply chain evaluation, namely supply chain risk, manufacturing practices, and environmental factors. These elements are the foundation of this book in order to evaluate supply chain performance in the manufacturing industry of Ciudad Juárez.

6.3 Supply Chain Risk

6.3.1 Definition of Risk and Risk Management

Supply chain risk is associated with the logistics activities that manage the flow of materials and information. It emerges as a result of current economic crises, natural disasters, globalization, and dynamic and changing markets and supply chains (Braunscheidel and Suresh 2009; Tang and Tomlin 2008). Risk is present in any supply chain. In every offered product or service, there is a different level of associated risk. As a definition, risk is the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which it outcomes result in the inability of the purchasing company to meet customer demands or cause threats to customer life and safety (Cheng et al. 2012).

To others, supply chain risk is a negative deviation from the expected value of a certain performance (Wagner and Bode 2008), the potential variation of outcomes that influence the decrease of value added (Bogataj and Bogataj 2007), or the likelihood and impact of unexpected macro- and micro-level disruptions or events that adversely influence any part of a supply chain, leading to operational, tactical, or strategic level failures or irregularities (Cheng et al. 2012; Ho et al. 2015).

Supply chain risk sources involve suppliers, customers, and demand alike. Demand risks are caused by unpredictable or misunderstood customer or end-customer demand. Some experts claim that decision makers must consider uncertainties in supply chain planning phases, including demand. Explicitly, it is important to consider potential risks derived from suppliers and manufacturers (Snyder et al. 2006). Supply chain management is seen as an interorganizational collaborative endeavor that relies on qualitative and quantitative risk management methodologies to identify, evaluate, mitigate, and monitor macro- and micro-level events or unexpected disruptions that might adversely affect any part of a supply chain (Cheng et al. 2012; Ho et al. 2015).

Risk is manifested through different types of individual risks that affect supply chain performance (Daniel et al. 2012; Ho et al. 2015). In this sense, supply chain risk sources are usually classified into three groups: environmental risk, organizational or internal risk, and network-related risk. Environmental risks derive from external forces, such as rain, earthquakes, wars, government policies, social trends, and market trends. They comprise any uncertainty caused by the interaction between the supply chain and its physical, social, political, legal, and economic environments (Bogataj and Bogataj 2007). On the other hand, organizational risk comprises risks related to inventories, processes, quality, or management practices; that is, those derived from work- and process-related aspects (Chopra et al. 2007; Jüttner et al. 2003). Also, operational risks arise as a result of new operational events or flow interruptions in the supply chain (Colicchia et al. 2010; Lockamy and McCormack 2010). Also, sometimes it is assumed that operational risks emerge from subcontracting activities, which are also potential sources of network-related risks (Kaya and Özer 2009).

Finally, network-related risks occur from the interactions among supply chain partners and include supplier risks and demand risks. Similarly, network-related hazards involve a whole organization and all the aspects related to its management (Jüttner 2005), including its communication, cooperation, and integration with the other supply chain members. Risk is generally viewed as a source of uncertainty and a series of disruptions occurring in the processes among suppliers and demand (Tang and Musa 2011).

Processes risk results from the perception of uncertainty in the processes due to machine and equipment failures. Demand risk is perhaps the most serious problem, as it emerges from an inaccurate demand forecast (Bhatnagar and Sohal 2005). In general, supply chain risk compromises performance and has adverse effects on inventory costs, delivery lead times, flexibility, responsibility, and reliability. In this book, risk will be viewed as the set of unperformed activities and disruptions that emerge in each supply chain stage and cause adverse effects on supply chain

performance. Risks must never be neglected when evaluating supply chain performance results, as their consideration enables to establish appropriate risk management strategies and criteria. Companies approach supply chain management from different perspectives depending on the type of service or product they offer, yet in all cases, supply chain management strategies aim at increasing performance and therefore flexibility in order to successfully meet customer demands at the lowest possible production costs. In this sense, risk management should be an inherent part of supply chain management. Risk management can be separated into four stages: risk identification, risk assessment, risk treatment, and risk monitoring (Hallikas et al. 2004). Risks cause important economic and productivity losses, yet they are an inherent phenomenon in any system. They reflect on late deliveries, production capabilities, and costs, to name but a few. Overall, they occur as a result of market dynamism, technological progress, an increase of competitors, government policies, or natural disasters, which prevent either raw materials or end products to be delivered on time.

6.3.2 Risk Assessment Methodologies

Risk assessment covers a whole spectrum of methodologies aimed at identifying risk sources and establishing risk mitigation strategies. Common risk assessment methodologies include simulations, descriptive and statistical analyses, Bayesian modeling, linear regression, reverse logic, and conceptual models, to name but a few. Bayesian models have been used for developing a knowledge integration framework for complex network management (Xiangyang and Charu 2007) and for evaluating supply chain reliability (Klimov and Merkuryev 2008). On the other hand, Monte Carlo simulations have proven to be useful in supplier risk assessment (David and Desheng 2011), whereas system dynamics has been utilized to evaluate the bullwhip effect (Disney et al. 2008), assess supply chain terrorism (Bueno-Solano and Cedillo-Campos 2014), and identify the relationship between supply chain risks and performance in terms of costs, quality, and delivery times (Guertler and Spinler 2015).

Fuzzy logic approaches have aimed at evaluating logistics and risk mitigation strategies in the area of product design (Tang et al. 2009), while a linear regression based study has been proposed to estimate supply chain vulnerability (Bogataj and Bogataj 2007). On the other hand, experts have applied stochastic criteria for risk management in global supply chain networks (Goh et al. 2007). Analytic hierarchy process (AHP) has been used for supporting offshoring decision making (Schoenherr et al. 2008), selecting suppliers (Kull and Talluri 2008; Schoenherr et al. 2008), and evaluating supplier risk (Wu et al. 2006). Meanwhile, conceptual frameworks are developed in order to manage volatility-induced risk in the supply chain (Martin and Matthias 2017) and prevent, monitor, and control supply chain

risk (Sarkar 2017). In turn, structural equation models have been developed to assess supplier risk perception from buyers with respect to supplier reliability and joint benefits (Cheng et al. 2012) and to determine the impact of supply chain risk on supply chain flexibility and customer service (Avelar-Sosa et al. 2014a).

Statistical models and simulations have been used to evaluate risk mitigation elements and improve efficiency in manufacturing industries (Talluri et al. 2013), and a P-chart model has been used to evaluate supplier risk management, and consequently, eliminate bottlenecks and minimize costs (Sun et al. 2012). Other works propose theoretical frameworks on supply chain flexibility (Tang and Tomlin 2008), risk in small and medium-sized enterprises (SMEs) (Mohd Nishat et al. 2007), and uncertainty (Jyri et al. 2014). From a different perspective, Bueno-Solano and Cedillo-Campos (2014) propose and analyze a set of terrorism factors that affect supply chain performance, whereas Chad and Bobbitt (2008) and Hoffmann et al. (2013) identify a series of safety impact factors perceived by managers. All these works propose ways of tacking supply chain risk without forgetting that risk itself in inherent in any system. It occurs simply because a supply chain is a group of interrelated companies sharing meaningful flows of materials, information, and money. Any failure or disruption at any supply chain stage affects previous and subsequent stages and directly and indirectly affects performance outcomes.

Stochastic linear programming has been used for risk management assessment, considering inventory planning, or for demand disruption assessment (Qiang and Nagurney 2012; Radke and Tseng 2012). Likewise, genetic algorithms have been applied to assess multiple sourcing activities under supplier failure risk and quantity discount (Meena and Sarmah 2013), and an approach based on graph theory has managed to calculate supply chain vulnerability through supplier–customer interdependence (Wagner and Neshat 2010).

Finally, Bayesian networks have been implemented to evaluate the impact of supplier and network-related risks on company performance (Lockamy and McCormack 2010). Table 6.1 summarizes these works. As can be observed, studies on supply chain risk mainly focus on risk mitigation, risk management, supplier evaluation, and supply chain flexibility and security.

The literature review shows rising trends in supply chain risk management. As (Bhatnagar and Sohal 2005) point out, business competitiveness is attached to operational risk factors, supply risks factors, and demand risk factors. Many research works have demonstrated the importance of risk assessment in supply chain management by considering risk as an inherent element in all supply chain stages and all supply chains. That said, it is important to identify the different source of risk to find the best ways to assess them and tackle them. In this sense, the following subsection addresses the various sources of demand risks, supplier risks, and production process risk as well as their impact on supply chain performance.

Table 6.1 Risk attributes and risk assessment methodologies

Author	Element	Methodology
Bhatnagar and Sohal (2005)	Location, performance	Linear regression
Wu et al. (2006)	Suppliers	AHP
Faisal-Cury and Menezes (2007)	SMEs risk	Descriptive analysis
Li and Chandra (2007)	Information	Bayesian analysis
Goh et al. (2007)	Global supply chains	Stochastic processes
Wu and Olson (2008)	Suppliers	Monte Carlo simulation
Towill and Disney (2008)	Bullwhip effect	Dynamic of systems
Kara and Kayis (2008)	Bullwhip effect	Dynamic of systems
Schoenherr et al. (2008)	Suppliers	AHP
Klimov and Merkuryev (2008)	Survival	Simulation
Autry and Bobbitt (2008)	Security	Descriptive analysis
Williams et al. (2008)	Security	Descriptive analysis
Tang and Tomlin (2008)	Flexibility	Descriptive analysis
Kull and Talluri (2008)	Suppliers	AHP
Tang et al. (2009)	Risk management	Fuzzy logic
Wagner and Neshat (2010) Lockamy and McCormack (2010)	Risk management Supplier risk	Graph theory Bayesian networks
Cheng et al. (2012) Sun et al. (2012) Qiang and Nagurney (2012) Radke and Tseng (2012) Talluri et al. (2013) Meena and Sarmah (2013)	Risk management Risk management Supply risk Risk management Risk management Risk mitigation Supply risk	Literature review Structural equation modeling P-chart model simulation Stochastic linear programming Stochastic linear programming Statistical methods and simulation Genetic algorithm
Hajmohammad et al. (2014) Avelar-Sosa et al. (2014) Manuj et al. (2014) Ho et al. (2015) Heckmann et al. (2015) Rajesh and Ravi (2015)	Supplier sustainability risk Risk management Risk management Risk management Risk management Risk mitigation	Descriptive analysis Structural equation modeling Simulation Literature review Literature review DEMATEL method
Martin and Matthias (2017)	Risk mitigation	Statistical methods and simulation

Source Prepared by the authors

6.3.3 Types of Supply Chain Risk

There is no unified method to classify supply chain risk. Each research work contributes in its own way to a better understanding of risk sources in supply chain environments, especially because supply chains are varied. Some authors have

proposed to classify supply chain risk into internal risk and external risk (Ch and Himpel 2013; Flynn 2009; Narasimhan and Talluri 2009; Wu and Olson 2009). The former refers to those disruptions that arise inside of companies (risks in processes) and in the supply chain network (supplier and demand risks), whereas the latter comprises external risk factors (e.g., natural disasters, wars, terrorism, and political instability. From a slightly different perspective, supply chain risk has been classified into micro-risk and macro-risk, depending on its impact (Ravindran et al. 2010; Tang 2006). After conducting a literature review on supply chain risk management, Ho et al. (2015) categorized natural disasters, terrorism, political environment, accidents, and wars as macro-risk factors, whereas micro-risk factors comprise demand, manufacturing processes, and suppliers. This book assesses the micro-risk factors discussed by Ho et al. (2015) in their literature review. To summarize this review, we present Table 6.2, which details the types of supply chain risks along with their corresponding factors and elements.

Table 6.2 Supply chain risk types, factors, and elements

Risk type	Risk factor	Element	Authors
Internal	Supply, demand, production or manufacturing, transportation and distribution risk, capacity, operational, logistics, network, infrastructural risk, information risk, financial risk	Procurement delay, material flow, physical plant, inventory, information flow, financial flow, quality, information delays, costs, technology, transparency, behavioral and political, bullwhip effect, flexibility, product obsolescence, demand uncertainty	Samvedi et al. (2013), Hahn and Kuhn (2012), Tang and Musa (2011), Tummala and Schoenherr (2011), Kumar et al. (2010), Tuncel and Alpan (2010), Tang and Tomlin (2008), Wagner and Bode (2008), Manuj and Mentzer (2008), Bogataj and Bogataj (2007), Wu et al. (2006); Tang (2006), Cucchiella and Gastaldi (2006), Chopra and Sodhi (2004), Cavinato (2004)
External	Natural disasters, terrorism, accidents, exchange rate fluctuations, political system, market, competitors, economic crises	Hurricanes, floods, earthquakes, inflation, contagious diseases, employee strikes, consumer prices, index changes, exchange rate fluctuations	Hahn and Kuhn (2012), Kumar et al. (2010), Olson and Wu (2010), Trkman and McCormack (2009), Wagner and Bode (2008), Kull and Talluri (2008), Blackhurst et al. (2008), Wu et al. (2006), Tang (2006), Chopra and Sodhi (2004).

Adapted from Ho et al. (2015)

6.3.3.1 Demand Risks

Synchronizing supply with actual demand in a supply chain is a challenging endeavor. It is a complex task itself, and also, there is always a certain degree of demand uncertainty in the market, which is known as implicit uncertainty. Risk propagates both downward and upward in the supply chain and therefore affects demand. In this sense, demand risks is a set of adverse effects at the downstream partners of a firm (Zsidisin 2003; Wagner and Bode 2008). Likewise, demands risk includes risks associated with turbulent environments and unstable and dynamic customer needs. Unstable demand is generally the biggest challenge for modern companies, as it leads to high inventory levels, low levels of customer service, and unreliable deliveries (Chen and Paulraj 2004). Demand risks is a micro-risk factor (Ho et al. 2015) and is mainly caused by elements such as information distortion, the bullwhip effect, inaccurate demand forecasts, short lifecycles, demand variability, high market competition, and low in-house production.

Risks at the demand stage imposes great challenges, since modern businesses rely on demand-driven production models; that is, just-in-time models that produce only when a customer places an order (customer demand) to satisfy that demand. Demand risks must be visualized through a systematic evaluation of potential risks in the company in order to establish anticipated solutions that prevent greater risks and monetary losses. A categorization of demand risk elements can be consulted in Table 6.3. The first column lists the risk elements reviewed in the literature, the second column includes the works that address these elements, and the third column

Table 6.3 Demand risks elements

Element	Author	Frequency
Demand forecast	Ho et al. (2015), Hahn and Kuhn (2012), Samvedi et al. (2013), Kim (2013)	4
Bullwhip effect	Udenio et al. (2017), Raghunathan et al. (2017), Ho et al. (2015)	3
Demand uncertainty	Ho et al. (2015), Hahn and Kuhn (2012), Samvedi et al. (2013), Bhatnagar and Sohal (2005), Su and Yang (2010)	5
Demand inaccuracy	Ho et al. (2015), Tang and Musa (2011), Kang and Kim (2012)	3
Demand visibility	Ho et al. (2015), Avelar-Sosa et al. (2014), Bhatnagar and Sohal (2005), Su and Yang (2010)	4
Information distortion	Ho et al. (2015), Bhatnagar and Sohal (2005), Su and Yang (2010)	3
Poor communication	Ho et al. (2015), Bhatnagar and Sohal (2005), Su and Yang (2010)	3
Outsourcing	Ho et al. (2015)	1
Order fulfillment errors	Ho et al. (2015)	1

Source Prepared by the authors

lists the frequency of appearance of these elements in the literature. Some aspects of demand risk considered are demand forecast, demand visibility, demand inaccuracy, information distortion in supply chain, and poor communication across members, bullwhip effect, error on fulfillment of orders, etc.

In the following paragraphs, we provide an overview of these elements to highlight their importance in supply risks management and hence in supply chain performance evaluation.

Demand Forecast

Forecasting is a key element in any organization. It sets the grounds for long-term plans, budget planning, and costs management. Marketing departments depend on sales forecasts to quantify their plans for new and existing products, evaluate their sales strategies, and assess promotional impacts that optimize fundamental decision making. Similarly, production staff and operators rely on production forecasts to make regular decisions about the production processes, inventories, and programs and to plan an adequate facility layout (Jacobs and Chase 2005). Finally, forecasting allows capacity planning and therefore ensures that the resources are well managed so that customer demand is met in the right amount, at the right time, and with the right quality (Hahn and Kuhn 2012; Kim 2013; Martínez et al. 2015).

Bullwhip Effect

The bullwhip effect is the phenomenon of demand amplification and distortion in a supply chain. Demand variability increases as it is transmitted along the supply chain links and therefore translates into an increase of uncertainty for decision makers, thereby affecting supply chain activities (Romero et al. 2017). The bullwhip effect was named for the way the amplitude of a whip increases down its length. A small variance in real customer demand can disrupt the regular upstream flow of the supply chain and therefore compromise the flow of information in manufacturers, which are unable to produce what is requested. Similarly, the bullwhip effect refers to a phenomenon where supplier orders have bigger variance than sales to the buyer, and the alteration propagates upstream in an enlarged form (Disney and Towill 2003; Udenio et al. 2017).

Demand Uncertainty and Inaccuracy

Demand inaccuracy can be understood as the degree to which demand is erroneously estimated due to controllable factors associated with supply chain operations. On the other hand, demand uncertainty refers to those disruptions caused by wrong long-term projections of customer demand. The causes of demand uncertainty are exogenous and include environmental and operational conditions,

changes in customer interests, technology development, and the number of competitors a business faces, among others (Bolaños and Correa 2014; Kang and Kim 2012). Both demand uncertainty and inaccuracy can have adverse effects on supply chain performance (Bhatnagar and Sohal 2005; Samvedi et al. 2013; Su and Yang 2010).

Demand Visibility

Supply chain visibility is the ability to share on-time and accurate data on customer demand, amount and location of inventory, transportation costs, and other logistical aspects (Hendricks and Singhal 2003). Therefore, demand visibility is a company's ability to share real time, on-time, and accurate data on product requirements through the use of information technologies and systems. Some authors suggest that in order to mitigate demand risk, it is important to increase supply chain visibility, and even its ability to look ahead. This would increase supply chain planning and efficiency and therefore effectiveness (Yu and Goh 2014).

Poor Communication

Poor communication is a major risk, as it is impossible for supply chain members to interact among them without sharing information and viewing themselves as part of a team, a network. In order to control and manage logistics, production, and financial operations along the whole supply chain, there must be an adequate collaboration, coordination, and cooperation among all supply chain partners. Such a communication approach brings benefits for all.

Outsourcing

Globalization and modern production and business models have made companies rely on outsourcing (i.e., hiring a party outside of a company to produce services and goods that were traditionally performed inside of the company). The risk of this practice mainly lies in the fact that it is impossible to control the whole transformation process inside the company's facilities. Moreover, it is difficult to maintain relationships and a solid coordination with multiple companies.

Order Fulfillment Errors

According to Sucky (2009), order fulfillment errors cause customers to receive the wrong items, and shipping and returns can be difficult and unreliable. In this sense, without an effective order fulfillment organization, it is difficult to successfully satisfy customer demand.

In conclusion, the demand risks elements or attributes discussed in this section can explain how demand risks occurs in the manufacturing industry as a result of the demand-related activities that they perform or fail to perform and their relationships with customers. Considering this review and Table 2.5 presented earlier, we can conclude that demand in the export-oriented manufacturing industry has the following four attributes (Bhatnagar and Sohal 2005; Hendricks and Singhal 2003; Su and Yang 2010):

Product demand

- is often communicated by the customer in advance.
- is transmitted in real time by customers via information systems.
- is visible for both companies and suppliers.
- is frequently stable and does not affect production scheduling.

These attributes can assess the degree of demand risks perceived by manufacturing companies as a result of both their relationships with customers and the demand management practices adopted in the supply chain.

6.3.3.2 Supply Risks

Nowadays, trade environments are complex, and supply networks fluctuate as a result of an increasing number of suppliers. Such phenomena are important supply risk sources. In the past, supply risks was rare and easier to manage, since manufacturing companies produced only within their facilities, generally relied on local suppliers, and sold mostly to local end customers. However, current consumption rates and the increasing complexity of product requirements, from design to distribution, have led to the participation of specialized companies in the production process. Moreover, deliveries now cross borders, and customers of a same product can be found anywhere around the world. Supply networks are lateral and horizontal connections and bidirectional exchanges in the upward and downward flows of a supply chain. Risk in supply networks is the consequence of an increasing pressure on manufacturers to be efficient and effective. Similarly, as a result of globalization, companies now focus on distribution strategies and outsourcing businesses, which have considerably reduced the number of suppliers in a supply network (Bogataj and Bogataj 2007).

To some authors, supply chain risks are defined as an individual perception of the total potential loss associated with the disruption of supply of a particular item purchased from a particular supplier (Ellis et al. 2010). To others,supply chain risks are potential deviations of inbound materials from the moment a purchasing order is placed, and which may result in uncompleted orders. Supply deviations have a consequence on the costs, quality, and delivery of the requested raw materials (Kumar et al. 2010). Moreover, risks are inevitable in the supply chain and emerge from deviations in the inbound materials requested by the manufacturer (Blome and Schoenherr 2011).

A study conducted by Snell (2010) revealed that 90% of companies are threatened by supply risk, whereas 60% of them do not have adequate knowledge about supply risk. On the other hand, Hendricks and Singhal (2003) found that technical failures in suppliers reduce the operating income of firms by 31.28%, whereas another study revealed that at least 40% of supply chain disruptions come from suppliers, namely Tier 2 and Tier 3 suppliers. In this sense, it is important to increase supply chain visibility and integration (LexisNexisGroup 2013). For instance, Toyota, Cisco, and P&G have made significant efforts to identify their suppliers, from Tier 1 to Tier 3 suppliers (Revilla and Sáenz 2014), which is important because we rarely see the relationships that manufacturing companies have with their suppliers.

Some authors have analyzed inbound supply chain risk from individual suppliers (Wu et al. 2006), others have claimed that supply risk assessment must include supplier capacity and responsibility (Chopra and Sodhi 2004, 2014). On the other hand, studies have emphasized on the effects of information on deliveries, demand adjustments, and other aspects requested by customers (Gaudenzi and Borghesi 2006; Su and Yang 2010; Tummala and Schoenherr 2011) or have analyzed the causes of failures in supply deliveries, including uncompleted orders, late deliveries, or poor product quality (Cucchiella and Gastaldi 2006; Chopra and Sodhi 2004; Kull and Talluri 2008; Samvedi et al. 2013). The literature also reports the effects of supplier quality on perceived supply risk (Cucchiella and Gastaldi 2006; Manuj and Mentzer 2008; Ravindran et al. 2010; Tapiero 2007) and the impact of supplier communication on supply chain integration and coordination (Sun et al. 2012; Talluri et al. 2013). Similarly, other studies have analyzed the effects of external factors, transportation systems, and supplier monitoring on supply risk (Manuj and Mentzer 2008; Meena and Sarmah 2013; Wu et al. 2006).

Table 6.4 above summarizes the main trends in supply risk analysis. As can be observed, the major sources of supply include supplier communication, supply visibility, information sharing, quality control, supplier coordination, and failed deliveries. Based on this summary and the previous discussion, we propose the following six elements or attributes used to assess supply risk in the manufacturing industry.

My suppliers:

- continuously deliver the raw materials on time.
- frequently deliver complete and accurate orders.
- continuously deliver quality materials.
- maintain a frequent communication with our company to reduce failures.
- continuously coordinate their processes with ours.
- use information systems (MRP I, MRP II, SAP).

These attributes can identify the degree of supply risks perceived by manufacturing companies as a result of both their relationship with their suppliers and their supply management practices. It is important to highlight communication as a key

Table 6.4 Supply risks elements

Element	Author	Frequency
Inbound risk	Wu et al. (2006), Manuj and Mentzer (2008), Chopra and Sodhi (2004)	3
Visibility and information sharing	Gaudenzi and Borghesi (2006), Su and Yang (2010), Bhatnagar and Sohal (2005); Tummala and Schoenherr (2011)	4
Delivery failures	Chopra and Sodhi (2004), Cucchiela and Gastaldi (2006), Kull and Talluri (2008), Tummala and Schoenherr (2011), Samvedi et al. (2013)	5
Supplier quality control	Cucchiella and Gastaldi (2006), Tapiero (2007), Blackhurst et al. (2008), Manuj and Mentzer (2008), Lockamy and McCormack (2010), Ravindran et al. (2010)	6
Supplier communication	Sun et al. (2012), Talluri et al. (2013), Su and Yang (2010), Bhatnagar and Sohal (2005), Gaudenzi and Borghesi (2006)	5
Environmental risk	Meena and Sarmah (2013), Bhatnagar and Sohal (2005), Chopra and Sodhi (2004), Manuj and Mentzer (2008)	4

Source Prepared by the authors

ingredient to make any kind of correction on time, either in product requirements or quality. Also, all supply chain members must synchronize their goals and activities with one another to extend their benefits.

6.3.3.3 Production Process Risk

Production risk factors, also known as manufacturing risk factors (Ho et al. 2015), occur in all those operational activities performed by manufacturers. Manufacturing or production risk comprises all those events or adverse situations that occur within companies and affect their internal capacity to produce the desired quality and quantity at the right time (Wu et al. 2006). Production risk affects productivity and is the result of poor reliability in the production process due to failures in procedures, human resources, machines, and support services. In order to assess production risk, we rely on the contributions of Chopra and Sodhi (2004), Tuncel and Alpan (2010), Wagner and Neshat (2010), Tummala and Schoenherr (2011), Su and Yang (2010), and Soin (2004). To mitigate production risk, these works suggest elements such as manufacturing practices, design changes, flexibility, low inventory levels, information transparency, and information technology (IT) platforms. Likewise, they address a series of activities and actions for manufacturing process improvement, such as low machine failure rates, low employee absenteeism levels, and employee motivation.

The elements that this book considers to assess production risks also address the impact of communication and collaboration among supply chain members on risk mitigation and hence on supply chain performance. Information must flow

smoothly and coordinately to prevent production delays and errors, and companies must rely on the necessary support services to mitigate any potential production risks. Production departments must focus on generating and managing product quality, whereas the other departments are responsible for providing the appropriate services that guarantee the company's functions. The listing below presents the attributes used to assess the perception of production risk in the manufacturing industry. These attributes cover logistics, financial, and telecommunications services. A low level of efficiency or availability in any of these attributes causes a greater perception of risk. Therefore, production can be compromised when companies do not know for sure the demand or the transport characteristics, or when they lack the necessary facilities to manufacture their products.

My production processes:

- are highly affected by a lack of logistics services (customs, transportation, warehouses, security, legal advice).
- are highly affected by the low efficiency of financial services (banks, insurance companies, fund administration services).
- are highly affected by a lack of connectivity with target markets.
- are highly affected by the low efficiency of telecommunications services (landlines, television, radio).
- are reliable thanks to stable government policies, both fiscal and commercial policies.
- are efficient thanks to the implementation of lean manufacturing practices.

These attributes can assess the production risk perceived by manufacturing companies as a result of a lack of support services, which are necessary not only for performing internal operations, but also for communicating with external commercial activities and the environment. In this sense, the relationship between external and internal factors should never be underestimated, let alone discarded, in any risk assessment or supply chain performance evaluation. Also, considering fiscal and commercial policies as production risk attributes suggests that governmental intervention can influence a company's ability to manage its supply chain and obtain the desired benefits. This implication will be further analyzed in the third section, when we present a series of models to evaluate the effects of these attributes on supply chain performance.

In conclusion, in supply chain performance, namely supply chain risk, information technologies and financial systems (Chopra and Sodhi 2004), as well as transport systems (Wu et al. 2006) are critical factors. Any disruption in any of these systems can adversely affect supply chain performance. These three aspects give rise to the infrastructure risks suggested by (Ho et al. 2015), who propose valuable contributions to the understanding of risk in demand, supply, and production process.

6.4 Manufacturing Practices

As previously mentioned, the manufacturing industry transforms raw materials or inputs into different consumer products. Manufacturing practices are the best way to optimize production processes, and without them, it would be impossible to transform products, let alone to satisfy customer needs. Manufacturing practices are closely linked to production processes, as they allow companies to produce in an orderly and systematic way through the implementation of certain production tools and philosophies. Commonly, manufacturing practices are associated with the concept of lean manufacturing, developed in Toyota's production system and first introduced by Sakichi Toyoda. In the last 20 years, lean manufacturing practices have managed to reduce production process times by relying on the design of inter-functional equipment, rapid communication through the Internet, and process simplification. In this sense, lean manufacturing also refers to an integrated socio-technical system whose goal is to reduce waste at each stage of the production process in order to obtain more economic benefits and deliver high-quality products (Shah and Ward 2007).

Lean manufacturing has become a miraculous global methodology for process improvement. Companies around the world seek to reproduce the results obtained by Toyota in terms of profits and market penetration via the implementation and management of lean tools. As previously mentioned, lean tools aim at reducing all those activities that do not add any value to the product (i.e., waste) while simultaneously reducing inventory levels. In any lean environment, employees are the key for process improvement and business transformation.

Taiichi Ohno identified six types of waste, also known as muda, in Toyota's production system:

- Over production
- Waiting
- Unnecessary transport
- Excess inventory
- Wasted movement
- Defects

6.4.1 Toyota Production System and Competitiveness Enterprises

The Toyota Production System (TPS) refers to a set of tools and techniques for waste elimination that also optimize processes, improve product quality, and increase system productivity and efficiency. The most commonly implemented manufacturing tools are the 5s program, just in time, Six Sigma, poka-yoke, kanban, and single minute exchange of die (SMED). The continuous improvement of

any production process is possible as long as the work methods are improved and monitored through these tools.

Competitiveness in such a globalized environment reveals the importance of having more efficient operational and administrative processes in order to improve customer service levels, delivery times, product/service quality, and resource utilization (Rodríguez-Méndez et al. 2015). From this perspective, manufacturers around the world strive to gain all the benefits that good lean manufacturing practices guarantee (Liker and Hoseus 2009). In a pursuit of global competitiveness, production managers become increasingly interested in knowing and managing all those factors that, at the country level, impact a business's location, supplier selection, and operational improvement (Schoenherr and Swink 2012). Lean practices have improved the flow of information along the supply chain and have made supply chain members pay close attention to costs, quality, on-time deliveries, and flexibility. Lean practices emerged from a Japanese concept whose purpose is to reduce waste (layout, materials, time, money, workforce, etc.) and improve productivity and product quality.

In order to evaluate the degree of implementation of manufacturing practices in the surveyed manufacturing companies, this book takes into account practices such as total quality management (TQM), just in time (JIT), and total productive maintenance (TPM), and manufacturing technologies such as computer-assisted design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). The following sections provide an overview of each practice in order to contextualize their use in this book and justify their effect on supply chain performance.

6.4.1.1 Quality

Quality in products or services is a profit criterion promoted by companies among suppliers in an attempt to gain a competitive advantage (Galloway et al. 2012). To achieve the desired quality, total quality management relies on statistical process control tools, quality circle, Six Sigma, diagrams, and graph analysis. Statistical process control (SPC) is a method that employs statistical methods to monitor processes and identify common causes of variation, whereas quality circles refer to a group of workers who to the same or similar work and meet regularly to analyze and solve work-related problems. Six Sigma comprises a set of techniques and tools for recognizing the causes of common variation in a process. It measures the probability of defects per million parts. Total quality management (TQM) is a lean manufacturing tool for organizational management that focuses on quality in order to improve customer satisfaction (Amasaka 2014). TQM is used to integrate commercial operations and create products or services with the highest possible quality. To be successful in the future, global traders must develop excellent quality management systems that can impress consumers and continuously generate high-quality products and services for the twenty-first century (Amasaka 2008).

6.4.1.2 Just in Time (JIT)

Just in time is a production philosophy initially developed for Japanese companies after the Second World War. The goal is to attain a competitive strategy, reduce production lifecycles, increase flexibility and product quality, and minimize costs. The basic principle of this philosophy is that materials are received only when they are needed in the production process, thereby reducing inventory costs. Just in time is also viewed as a production approach that emphasizes on the importance of continuous improvement at each supply chain stage from inter- and intra-organizational perspectives (Olhager and Prajogo 2012; Shah and Ward 2007). JIT seeks to increase customer satisfaction and is a key tool for operational and financial performance. Companies that implement JIT are able to respond to customer needs, promote perfect production activities, have high-quality products, make on-time deliveries, and minimize costs (Amasaka 2008).

JIT can be applicable in a broad range of industries and is a strong motivation to evaluate the performance of manufacturing industries in this book. Additionally, this philosophy integrates supply chain functions of marketing, distribution, customer service, sales, and production in controlled processes that eliminate waste, simply processes, reduce setup times, control the flow of materials, and emphasize on maintenance as a way to improve supply chain management. A just-in-time system tries to maintain a stable flow of materials by requesting only what is needed when it is needed (Galloway et al. 2012; Schoenherr and Swink 2012). Just in time is one of the pillars of lean manufacturing and is essential for improving business performance, through delivery times, for example (Danese et al. 2012).

6.4.1.3 Maintenance

The goal of any maintenance system is to prevent machine stoppages and keep the equipment in optimal conditions. Its main characteristics are the elimination of pollution sources, equipment cleaning and inspection, cleaning standards, maintenance training, and work environment control and management. Maintenance programs are usually approached from a Total Productive Maintenance (TPM) philosophy throughout the life of the production equipment. TPM engages operators to improve equipment effectiveness with an emphasis on proactive and preventive maintenance. Its main goal is the rapid improvement of production processes to reduce failures and the integration of machine and equipment with operators (Konecny and Thun 2011).

A TPM program is a comprehensive improvement program that emerged from TQM's concept of zero defects and aims at managing equipment performance (Seth and Tripathi 2005). The goal of any TPM program is to maximize production system reliability by maximizing machine and equipment effectiveness. In their work, McKone et al. (2001) analyzed the relationship between TPM and business performance using adjusted production as a mediating variable. The results indicated that TPM has a positive impact on costs, quality, and delivery times.

Also, because maintenance programs are supported by TQM, before implementing a lean production approach, both TPM and TQM must be implemented together, not apart.

Speed should be another attribute of maintenance programs. The implementation of TPM allows companies to reduce setup times, thereby generating more benefits. In this sense, single minute exchange of die (SMED) is another important tool (Chiarini 2014). It was developed by Shingo (Shingo and Dillon 1989) as a proposal for eliminating bottlenecks at car body-molding presses at Toyota. In the past, these machines did not work at their full capacity; thus, companies could not obtain the desired benefits. As Ulutas (2011) claims, nowadays, SMED is one important lean tool for reducing waste in the production process, since it is efficient in reducing exchange times in machines (Díaz-Reza et al. 2016).

TQM, JIT, and TPM strive to maintain a continuous improvement and increase organizational performance (Cua et al. 2006). By combining these techniques, companies can develop an integral and solid set of manufacturing practices that improve business performance. For this reason, many manufacturers focus on a simultaneous implementation of these programs in order to attain a synergistic effect. Many studies on TQM, JIT, and TPM explore improvement programs and their relationship with performance (Agus and Hassan 2011; Danese et al. 2012; Digalwar et al. 2015; Seth and Tripathi 2005; Teeravaraprug et al. 2011; Topalović 2015).

6.4.1.4 Advanced Manufacturing Systems

Gunasekaran (1999) discusses the need for manufacturing companies to be flexible and adapt to changes in market conditions through flexible manufacturing. Similarly, the author argues that in order to plan and manage their operations, firms should rely on effective support systems, such as material requirements planning (MRP), computer-aided design (CAD), computer-aided engineering (CAE), and enterprise resource planning (ERP). These technologies, when combined, reduce product design time and increase agility. Moreover, using the computer as a way to manufacture and train operators increases their potential. Unfortunately, traditional and less developed manufacturing industries tend to pay little attention to the power of advanced manufacturing systems and information technology.

Production processes can be classified according to the degree of automation and sophistication of control systems. The classification ranges from manual production to the use of computer-integrated manufacturing. In general, we refer to flexible manufacturing system as a production system made up of machines and subsystems linked by a common transportation and control system, with the ability to perform multiple tasks without changing the equipment in the system, thereby allowing for flexibility (Vallejo 2011). We will not discuss flexible manufacturing systems in detail, since this book considers the application of any of the following systems in the manufacturing industry as lean tools.

Flexible manufacturing systems are classified in five:

- Numerical Control Machine (NCM): It has its own numerical control and includes a feeding system and an automatic tool change.
- Transfer: It comprises a set of machines with a transportation system and a sequence of activities. It generally uses programmable logic controllers (PLC).
- Flexible manufacturing cell: comprises a few computerized numerical control machines for the exchange of machinery parts, as well as a central computer that coordinates activities, storage, and transport.
- Flexible production lines: an arrangement of machines or flexible cells that are interrelated thanks to a transportation system, which includes inspection. Flexible production lines use computers for production control and monitoring.
- Fully automated company: They have a series of flexible manufacturing lines and robot-automated warehouses. Everything is computer managed, including the planning of production, sales, and orders, among others.

To conclude this section, it is important to highlight that the goal of any manufacturing practice and its implementation should be to improve the production system through productivity and customer satisfaction. This book only considers four manufacturing practices to not distort the scope of our research, and because we believe they are the basic tools for an internal management of production processed and product quality.

This section discusses four manufacturing practices, selected from a literature review because of their relevancy as supply chain performance impact factors (Alcaráz et al. 2015; Amasaka 2014; Danese et al. 2012; Díaz-Reza et al. 2016; Digalwar et al. 2015; Teeravaraprug et al. 2011). Below, we list the attributes of these manufacturing practices, which will be used in subsequent chapters to assess the degree of implementation of such practices.

Total Quality Management (TQM)

- the company continuously implements statistical process control.
- the company frequently performs quality audits.
- the company frequently implements Six Sigma in processes.

Just-in-Time (JIT) System

- the company implements the just-in-time philosophy in all manufacturing processes.
- the company continuously seeks to minimize inventory levels.

Maintenance

- the company relies on preventive and predictive maintenance programs.
- the performance of preventive and predictive maintenance programs is effective.
- changes in processes are effective and efficient.

Advanced Manufacturing Systems

- the company makes effective use of computer-aided design (CAD), computer-aided engineering software (CAE), and computer-aided manufacturing software.
- the company uses flexible manufacturing systems.
- the company maintains communication with all its supply chain members through information systems.

6.5 Regional Aspects of the Supply Chain

6.5.1 Overview

The role of business location on performance is a topic of great interest. The location models so far proposed in supply chain contexts have had fruitful and fascinating applications (Melo et al. 2009). Multiple studies have attempted to explain the impact of business location on trade conditions, new production systems, technology development, manufacturing capabilities, and global networks (Cedillo-Campos and Sánchez-Ramírez 2013; Krumm and Strotmann 2013). Aspects such as land cost, taxes, infrastructure, urbanization levels, traffic, export tariffs, industrial concentration, employment levels, and the degree of tertiarization (managed about thirty parts) have all been taken into account to analyze industrial growth (Bhatnagar and Sohal 2005; Cirtita and Glaser-Segura 2012).

A good transport infrastructure for all modes of transport is a key to competitiveness and therefore has an impact on decisions related to a business's location. Quantitative factors in location analysis usually include: perception of land costs, energy, transport infrastructure, business services, workforce, and telecommunications (Arent and Steinbrecher 2010). A strategic supply chain design anticipates the problem of quantity, location, and capabilities for manufacturing, assembly, and distribution, which affect the flow of materials, inventory levels, and the mode of transport to be selected (Melo et al. 2009).

For their location, companies also take into account what other countries have to offer (e.g., production capabilities and development and research opportunities) and the very specific characteristics of each firm (technological competence, workforce, size, and organizational structure) (Nachum and Wymbs 2005). Infrastructure quality, workforce, and regional growth are also crucial (Farrell et al. 2004), whereas the accessibility of the location and the incentives might be less decisive. Some studies conclude that global manufacturing networks depend on what other countries offer them as potential locations for their businesses (e.g., infrastructure and human resources) than on costs (taxes and transportation costs).

Business location has become a strategic decision in modern supply chain environments. This decision involves the irreversible allocation of capital and often

has as a crucial impact on key supply chain performance measures. Administrators must appropriately evaluate the potential of a given location in terms of its impact on operational performance. Such evaluation must be performed without underestimating potential risk sources in production processes, demand, and supply (Bhatnagar and Sohal 2005) and by taking into account both qualitative and quantitative aspects that can eventually explain the level of performance attained. To Ferdows (1997) locating a business abroad just to take advantage of preferential tariffs, cheap workforce, subventions, and cheap logistics costs is not enough, since companies do not take advantage of the potential of their processes. Companies should use their businesses settled abroad to approach local customers and suppliers and attract qualified human resources, all this in order to contribute to the company's performance.

Studies that explore the impact of location decision have tried to explain the impact of global trade conditions, new production systems, and new technologies. Likewise, scientists and experts have proposed strategic planning models and have emphasized on the fact that a global logistics network must reflect transportation costs, labor costs, infrastructure, the overall business's environment, proximity to other markets and suppliers, taxes, and strategic alliances (Schmidt and Wilhelm 2000). Other models have associated production, location, and distribution decisions with exchange rates and tariff rates (Bhutta et al. 2003) or studied the impact of foreign investment on five variables: population, wages, GDP, economic stability, and cultural attributes (Sethi et al. 2003). Similarly, the literature reports the study of location decisions in the automotive industry with respect to a country's competitive advantage. The model in question found a significant relationship between a country's level of competitiveness and the success of a company established in it.

Among those research works that discuss Porter's competitiveness model, some have demonstrated that, with a few modifications, the model can be used for strategic location planning, which is interesting because the model could adapted to a given region, depending on that region's competitiveness indicators. From a different perspective, researchers have developed statistical models to demonstrate that product differentiation is a key element to location decisions. That is, proximity and differentiation are associated with the type of industry and the type of product to be developed (Nachum and Wymbs 2005).

Table 6.5 lists some of the research works that explore location decisions and business location as such. As can be observed, these works mainly employ mathematical modeling and optimization models for location decision, considering infrastructure and incentives (Farrell et al. 2004), production and distribution channels (Bhutta et al. 2003), or even product design, product differentiation, and organizational structure (Nachum and Wymbs 2005). Similarly, other works focus on strategic planning for business location (Lee and Wilhelm 2010; Moon 2005; Schmidt and Wilhelm 2000), and other researchers have conducted multiple literature reviews to identify the most common location decision problems (Farahani et al. 2012).

Table 6.5 Regional attributes reported in the literature

Author	Attribute (element)	Approach
Schmidt and Wilhelm (2000)	Strategic planning	Descriptive analysis
Sethi et al. (2003)	Foreign investment	Linear regression
Bhutta et al. (2003)	Location, production, distribution	Mathematic
Farrell et al. (2004)	Location, infrastructure, incentives	Mathematic
Nachum and Wymbs (2005)	Product differentiation	Statistic
Bhatnagar and Sohal (2005)	Location, competitiveness	Linear Regression
Moon (2005)	Strategic location selection	Descriptive analysis
Kim and Kim (2005)	Localization, automotive sector	Linear regression
Bogataj and Bogataj (2007)	Location	Linear programming
Melo et al. (2009)	Location	Operation research
Lee et al. (2009)	Location, supply chain management	Descriptive analysis
Lee and Wilhelm (2010)	Location, strategic planning	Literature review
Bogataj et al. (2011)	Location, global supply chain	Mathematic
Farahani et al. (2012)	Location	Literature review
Krumm and Strotmann (2013)	Location, regional factors	Linear regression

Source Avelar-Sosa et al. (2014)

The methodologies on which these works rely are varied, yet most of them are qualitative or quantitative analyses. This trend presents an area of opportunity, since as Bhatnagar and Sohal (2005) argue, "it is impossible to ignore qualitative aspects in performance measurement." In this sense, in any location decision, firms must consider qualitative elements and their impact on supply chain through location factors of a given region, city, or country. Under this premise, regional aspects are key to obtain short-term benefits. In this book, we consider the aforementioned works to identify the influence of regional factors on companies.

Even though there are many methodologies for studying business location, the use of structural equation modeling is relatively scarce. The studies identified in the literature analyze location decision factors by considering both the company's own characteristics and externalities of the environment to be chosen. In order to explore the impact of these externalities on company performance, this book takes into account seven external attributes found in the literature—regional infrastructure, costs, services, government, market proximity, and workforce.

6.5.1.1 Regional Infrastructure

Infrastructure is the set of facilities, services, and goods provided by the government for companies to work effectively. Infrastructure does not only comprise transport and telecommunications but also all legal and public activities. A poor infrastructure implies external trade costs for supply chain actors. Also, infrastructure refers

to the availability of transportation and telecommunications services, which improve and streamline business operations, or even to those services offered locally with respect to those of other regions. The role of infrastructure was first addressed by classical economics literature, where authors defended the importance of making substantial investments in infrastructure before investing in anything else.

Whether infrastructure has a positive or negative impact is an empirical, and therefore crucial, question for all countries in light of the economic development that is sought nowadays. The study of infrastructure began in the USA in the 1970s, when experts wondered whether productivity stagnation was due to a decrease of infrastructure investment. Eventually, it became important to analyze institutional quality and characteristics in order to identify their importance in and influence on cost effectiveness, thereby proposing a new explanation to the relationship between infrastructure and economic growth (Calderón and Servén 2004; Shi et al. 2017).

To evaluate the infrastructure of a place, Shi and Huang (2014) first suggest knowing about the different types of infrastructure, which include: electricity, roads, railways, and telecommunications, measured in physical units. Then, to the authors, it is important to understand that investing in infrastructure implies long-term planning and offers durability. The study promises long-term effects using a vector error correction model. Finally, Shi and Huang (2014) argue that there should be an optimal interaction between infrastructure capital and private capital, both domestic and foreign. This interaction can be found in an analysis that considers the production function.

Country-specific studies focus on different types of infrastructure. For instance, Röller and Waverman (2001) analyzed the telecommunications infrastructure in 21 OCDE countries, while Duggal et al. (2007) evaluated the United States' technology infrastructure, and (Gonzalez-Navarro and Quintana-Domeque 2010) studied Mexico's road infrastructure and pavement. All these infrastructure aspects are a part of a logistical integration and are key to the productive integration of companies. Without a proper and efficient interconnection between infrastructure networks and services, it is impossible to generate value chains and create overall productivity. The role of the transportation industry in modern trade environments is unquestionable. It is generally agreed that a solid and high-quality transport infrastructure promotes sustainable growth and significantly contributes to closing inequality gaps (Perrotti and Sánchez 2011). The lack of an appropriate transport infrastructure and efficient provision of its services are obstacles to social development policies, sustainable economic growth, and territorial integration (Rozas and Sánchez 2004). In this sense, the role of a region's infrastructure must be oriented toward productivity development, both in the present and in the future. In parallel, political, human, and social policies must be implemented to support this development.

6.5.1.2 Regional Costs

Production costs are those incurred by the company in order to produce goods or services; they include raw material costs, labor costs, service costs, and indirect costs. Raw material costs refer to the value of the raw materials used in the production process, whereas labor costs is the sum of all wages paid to employees. On the other hand, service costs are those incurred from employing independent contractors to perform tasks that are necessary for production. Finally, indirect costs are expenses that are not directly associated with the production (Rincón and Fernando 2016). Logistics service costs can adversely affect the economic benefits of supply chains. They refer to those incurred by companies and organizations in order to guarantee a given level of service to both customers and suppliers. They include supply expenses, distribution costs, transportation costs, inventory costs, storage costs, supply-related costs, order processing costs, and general and administrative (G&A) expenses. G&A expenses represent the necessary costs to maintain a company's daily operations and administer the business. They include rent, utilities, water supply services, electricity supply services, and security and surveillance services, among others (Estrada Mejía et al. 2010).

6.5.1.3 Services

Services and their quality have a close relationship with infrastructure, since they are a part of it. Services connect supply chain actors both physically and virtually in a landscape of global production and trade. Because of their characteristics and the infrastructure, services promote territorial, social, and economic connection and have the potential to improve connectivity, minimize transportation costs, and improve the logistics chain in general, thereby improving competitiveness and trade activities. Likewise, services facilitate social development by integrating and connecting regions and allowing people to connect with their environment. Services are important for production and life quality improvement (Rozas and Sánchez 2004).

6.5.1.4 Government

Government support is one of the driving forces of change and shapes the economic and political landscape of any country or region (Coyle et al. 2013). Governments establish policies, regulations, and tariffs that undoubtedly impact businesses and supply chains. For instance, regulations are established in transport, communications, and financial institutions. Moreover, they are the pillars of infrastructure in many organizations. Similarly, transportation costs minimization policies are only effective if regional political actions strive to provide the region with the necessary human capital in order to improve the business environment and thus encourage capital investment and skills concentration (Sánchez-Reaza 2010).

Government support is a key ingredient when the business demands market updating and globalization. To gain access to global markets, business environments should attract new companies or connect existing ones with global production chains (Woodward 2009). Public policies for trade and industrialization promote economic growth in any country or region that includes aspects of equity, efficiency, and coordination. In this sense, vertical coordination across government levels is not only desirable but also indispensable (Sánchez-Reaza 2010).

6.5.1.5 Quality of Life

The concept of quality of life emerged in the USA after the Second World War to refer to the people's perception on their life and financial security. The notion expanded after the 1970s when social scientists collected data on people's socio-economic and educational levels and living standards, which were often low (Bognar 2005). The concept of quality of life originated to distinguish relevant results in healthcare research (Urzúa and Caqueo-Urízar 2012) and demands an objective evaluation of a person's health, physical environment, income, housing, and other observables and quantifiable indicators (O'Boyle 1994). A general definition of quality of life would be living well and with the hope of living even better, according to the principles of personal dignity, solidarity, distribution of goods and wealth, work, and adherence to good values (Brugarolas 2017). Based on this definition, we consider quality of life as those aspects that a region has to offer for people to do their jobs in acceptable conditions and have a dignified life.

6.5.1.6 Proximity

Physical proximity among upstream and downstream companies facilitates information sharing and promotes a continuous exchange of ideas and innovation. In his study about systemic competitiveness, Porter suggests what he calls the mesolevel, which refers to the level of competitiveness generated through policies that encourage the development of specific structures and support for leading national companies. The mesolevel considers competitiveness at a regional and national scale. Because companies do not compete individually, but rather as supply chains, market proximity is a competitive strategy for maintaining a good relationship with suppliers of knowledge and technology. Market proximity generates benefits through three fundamental conducts: availability of qualified workforce, knowledge diffusion, and availability of intermediary goods. Also, market proximity reduces the price of the final product as a result of low transportation costs (Spiekermann et al. 2011). Geographical proximity promotes face-to-face contact between firms and facilitates interpersonal communication among supply chain members, thereby increasing reliability and trust (Ganesan et al. 2005).

6.5.1.7 Workforce

This factor comprises all the characteristic of people living in a specific region. Human resources' characteristics greatly vary across regions and therefore have an impact on the operational performance of manufacturing companies. Through the quantity, quality, or availability of educational institutions, companies hire different degrees of qualified workforce. Human resources must be capable of performing their jobs in the company thanks to their education, abilities, training, and personal skills.

The aforementioned six aspects can assess the regional factors that have an impact on supply chain behavior and benefits. These elements were selected for this book after a careful review of the literature (Bhatnagar and Sohal 2005; Su and Yang 2010). These six aspects, through their corresponding attributes, can help explain how manufacturing companies perceive the environments where they operate. The attributes of each regional factor can be listed as follows:

Regional Infrastructure

- The available land, energy, transportation system, and telecommunication systems facilitate the company's economic development.
- If compared with other regions, the quality of telecommunications and the transport infrastructure allow the company to run properly.
- Internet availability and quality improve the operations of the company.
- Services in the industrial parks give the company operational competitiveness.

Regional Costs

- Land and infrastructure costs make the company more competitive.
- Labor costs make the company's operations competitive.
- Telecommunications costs do not interfere with the company's competitive strategy.
- Public service costs do not exceed estimations.
- Private services costs (banks, transport companies, legal and accounting offices) are low.

Services

- Services availability and information technologies allow the company to operate properly.
- Services quality allows for the continuous improvement of operations.

Government

- The support granted by the city council facilitates the operations.
- The support granted by the state's government facilitates the operations.
- The support granted by the federal government facilitates the operations.
- Protection protocols for foreign investment are adequate.
- Administrative efficiency and transparency facilitate operations.

Quality of Life

- The quality of life in the region is favorable.
- The availability and quality of education in the region are adequate and sufficient.
- The availability and quality of healthcare services are sufficient.
- The region's environment benefits personal growth and development.

Proximity

- Supplier availability and proximity is adequate and reliable.
- Competition in the region promotes innovation in the company.
- Market proximity increases the company's competitiveness levels.

Workforce

- The level of education and skills of the people match those required by the company.
- Availability of engineers, executives, and operators is enough for the company to run properly.
- The experience and competence of the people allow companies to attain their short-term goals and policies.

These attributes will allow us, in further chapters, to assess the perception of the sample on the regional aspects that characterize the environment of the surveyed companies and to determine which of them a key to competitiveness and profits are. Similarly, these attributes will help us identify what kind of support the government actually offers manufacturing companies and the perception of the sample on the impact of this support on supply chain performance and benefits.

Finally, to conclude this chapter, it is important to keep in mind that a wide range of risk factors, regional factors, and manufacturing practices can be associated with supply chain performance and hence competitiveness. The assessment methodologies for these impact factors are also varied. This book addresses supply chain performance impact factors as suggested by (Bhatnagar and Sohal 2005) along with the characteristics of the surveyed industrial environment to explore their influence on supply chain performance.

Manufacturing companies compete with each other to gain the desired competitiveness and have become important links of global production chains. Since global market exigencies are more challenging over time, it is important to assess a firm's internal and external activities, because supply chains comprise a wide range of companies, from suppliers to financial companies, to transportation companies, to name but a few. This level of complexity can compromise an appropriate supply chain management approach. We believe that it is impossible to be competitive when controlling only a business's internal aspects, since physical elements, such as regional infrastructure and location, also have an impact on the performance and competitiveness of a supply chain. For Mexican manufacturing companies, there is a particular external impact factor: the country's proximity to the USA.

In order to know whether companies are appropriately managing their supply chains and actually gain the expected benefits, we need to take into account the activities they perform jointly in the three factors: risks factors, regional factors, and manufacturing practices. The attributes of these factors, which are briefly listed in this chapter, will be further explained in subsequent sections in terms of their structure and their role as supply chain performance indicators.

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