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"The Relationship between Lean Management and Resilience"

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Introduction

The first chapter presents Lean Management that aims to achieve the shortest lead time, the highest quality, and the lowest cost. Its development is related to the history of Toyota; in fact, it was created by Kiichiro Toyoda and Taiichi Ohno as an attempt to adapt and improve the mass production system. It is the basis of Toyota's success, allowing it to gain a significant advantage with respect to competitors. Once the Toyota Production System was implemented, Toyota began to export it to suppliers and dealers, creating, in this way, a lean supply chain. To reach the goal, lean companies have to produce or to purchase materials according to customers' requests (Just in Time), the machines used in the process have to be able to distinguish between good and wrong items (Jidoka), and, finally, it is also important to ensure stability. This chapter introduces Lean Management as a pyramid with three interrelated levels; the philosophy is at the top, then there are the five principles, and at the bottom the tools and techniques. Consequently, all three levels need to be present; it is not possible to ignore the philosophy and the five principles focusing only on few tools, but this must be taken as an integrated system. Lean is not limited to a production method but can also be applied to strategy, organizational form, marketing, and accounting.

The second chapter introduces resilience and aims to investigate the capacity of lean companies to overcome threats and adversities. Recent years have been characterized by a substantial increase in terrorist attacks, labour problems, natural disasters, and many other issues with the main result of increasing instability, also underlined by the supply chain volatility index. Therefore, companies have to deal with challenges and adversities; in other words, they have to become resilient. Consequently, companies need to identify the circumstances that signal the arrival of a threat and implement the proper strategies to reduce its impact. At the same time, companies need to be able to adapt and remain competitive during and after an adversity; in fact, resilient entities should be able to achieve the established business objectives. This chapter also introduces the dynamic capabilities that represent the way to overcome challenges. They are then classified into four categories and put in relation with the functions of resilience in order to define the items used to analyse the resilience of lean companies.

The third chapter describes the contribution of workers that is an overlooked aspect of both resilience and Lean Management. The shift of leadership to people who have answers to the current situation and knowledge sharing are two items of resilience where the role of workers is clear; in fact, knowledge sharing requires the willingness of workers to exchange knowledge,

and the other is based on the idea that decisions should be taken by the individuals near the problem because they can decide better and faster (problem solving). This chapter introduces the three types of intelligence useful for solving a problem and the main barriers to the exchange of knowledge. Here, the link between workers and Lean Management, a philosophy based on continuous improvement and teamwork, is also introduced. The last topic presented is the resistance to change.

The fourth chapter presents the case studies of Dell, Nokia, and Toyota that by exploiting the elements seen in the previous chapters have been able to overcome many of the challenges faced in their life. Lean companies have been questioned many times for their resilience; in fact, even if the analysis in the second chapter concluded that lean companies have many of the features needed to be resilient, it does not provide detailed examples as in the case studies of Dell and Toyota. Totally in line with the lean philosophy, Dell has long-term relationships with suppliers based on information sharing, low inventory, and a make-to-order system.

Chapter 1: An introduction to Lean Management

1.1 Introduction

This chapter introduces Lean Management as a system that can change the way the company is managed, and it is applicable to many fields and different types of companies.

After a brief introduction to the history, the chapter presents the goal, the two pillars, and the foundation of the TPS house. Here, the True North for lean thinkers is explained. Clearly, it is only an ideal, but it can provide a guide for the transition of the entire organization.

Lean Management is not only a set of tools and techniques, but, above all, it has a philosophy and five principles. It is not possible to define a company as lean only because it is using some of its tools, but all three levels must be present. In this paragraph, the philosophy of maximizing value and minimizing waste is initially explained with the specification of all the types of waste recognized by Ohno. It also gives an explanation of the five principles that identify the perceived value by the customer, detect and arrange the sequence of activities, define what to produce on the basis of customer requests, and try to continuously improve the efficiency of the overall system (Thangarajoo and Smith, 2015). In the end, a brief overview of the tools and techniques that allow to reach the stability necessary, Just in Time, and Jidoka. Among the main tools, there is also the value stream map that is described in this section, although it is more linked to the second principle.

The chapter ends with the description of four areas beyond production in which it is possible to apply the same ideas as seen previously. This section is about the definition of the value proposition and the arrangement of the value chain that has to be in line with the value offer. It also illuminates how companies should be organized and how marketing should be conducted and clarifies the topic of lean accounting.

1.2 The history of Lean Management

Lean Management (LM) was originally developed as a production system in comparison with craft and mass systems and then expanded far beyond production into marketing, accounting, and many other fields.

It is sometimes called TPS (Toyota Production System) or JIT (Just in Time), but I will use LM because, above all, it is a system for the management of the company. The term lean arrived in

Western countries with the work of MIT financed by the American government at the end of the 20th century.

The history of LM started with Sakichi Toyoda who created a loom that stopped when thread broke, and with his son Kiichiro Toyoda who used the revenues derived from the patent to establish Toyota Motor Company. In the history of Toyota, there is also Taiichi Ohno who used the ideas of Sakichi and Kiichiro to create the TPS.

Toyota grew in a context dominated by mass production, but in some countries, craft production was still dominant. The latter is characterized by the employment of highly skilled workers that produced the item according to the requirement of the clients and using simple tools; usually, the process involved many shops spread throughout the city (Womack et al., 2007). Even if it could grant a customized product, the main problem of the system was the high costs it implied; here, the assumption of a decrease in unit cost with an increase in volume was not valid. The former is instead characterized by narrowly skilled workers and expensive machines. The result is a very low-cost product, but this came at the expense of the variety. The mass system soon expanded around the world and even reached Japan. Here, at the beginning of the twentieth century, American companies satisfied more than 90% of the demand for automobiles. The history changed when the Japanese government decided to protect the industry and finance three companies, such as Toyota, Nissan, and Isuzu (Dave, 2020).

The TPS developed as an attempt by Toyota to adapt and improve the mass production system to the Japanese context characterized by low demand, the desire for lifetime employment, and the presence of many mass producers.

All efforts of Toyota vanished with the arrival of the war when it was forced to support the military effort. After the war, a decrease in sales forced the company to fire a significant share of the employees; this was only possible after the promise to the remaining ones of lifetime employment and seniority-based wages. In exchange, the workers promised to be more flexible and to engage in the active improvement of the company, two pillars of LM. Important is also in the 1950 the arrival of Deming, the father of the PDCA cycle (Plan, Do, Check, and Act), also called Deming cycle (Dave, 2020); this is also the decade of the kanban system.

In 1960 the advantages of the TPS over Western companies were substantial, and Toyota increased the market share for the next 20 years until 1989, when the unbalance with the United States and with the European countries led to the introduction of trade barriers. This did not stop the growth that was achieved instead through direct investments. Usually, they first involved the assembly step and then, gradually, all the others.

An additional advantage arrived when Shingo in 1975 created the SMED (Single Minute Exchange Die) that allowed Toyota to drastically decrease the changeover time (Dave, 2020).

Once TPS was implemented, Toyota began to export it to suppliers and dealers. First-tier suppliers, differently from the situation in Western countries, started to cooperate; this was possible because they were specialized in different parts and then they exported the principles to the second-tier suppliers creating a lean supply chain. The remaining problems regarded dealers that were still relying on inventory and price adjustments and the substantially inexistent relationship between the company, dealers, and buyers; this is the effect of the quite common push system where products were pushed without considering the demand from the customers (Womack et al., 2007). To improve the situation, Toyota set up a network of fully or partially owned dealers and built a long-term relationship with them. These enabled it to become a make-to-order company with the dealers becoming the link between the company and the customers.

1.3 Toyota Production System

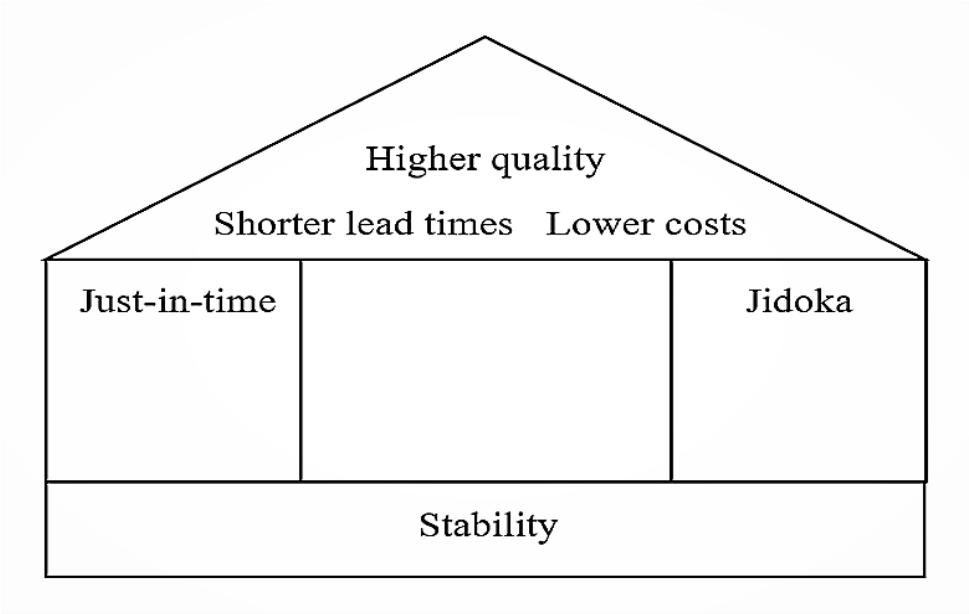

Figure 1: The TPS House

The TPS house is one of the most common representations of this system and it underlines its main elements: the goal, the two pillars, and the necessary foundation (Figure 1).

Goal

The aim of the system is to reach the shortest lead time, the highest quality, and the lowest cost; clearly, this is an ideal, but the main advantage of this refers to the ability to provide guidance to employees, pushing them to continuously improve in order to achieve it. It can be defined as the True North (Furlan, 2018).

The traditional idea is that quality can only come at the expense of cost and time, so there is a trade-off; according to this approach, however, quality does not have a cost, but improving the quality of the process is possible to reduce waste and, consequently, time and cost.

Just in Time

JIT was developed at the beginning as a method to reduce the inventory level and now, can be defined as a philosophy applied to manufacturing that involves several techniques. It can be summarized with the idea of producing or purchasing materials only on the basis of a customer's request and in the quantity and time requested.

The traditional method is called Just in Case and entails producing a good for the inventory just in case the customer demands an urgent order (Javadian Kootanaee et al., 2013).

The development of this philosophy in Japan is not due to fortune but is attributable to the need to conserve scarce resources and to cultural reasons. This thesis is also supported by the fact that the spread of this methodology in the West occurred only with the oil embargo. Among the cultural aspects, that also include the work ethic, to consider, there are the attitude for cleanness, the concern for space, the focus on speed and efficiency, the attention on customers, and the low interest in leisure time (Javadian Kootanaee et al., 2013).

JIT was developed by Kiichiro Toyoda and implemented by Taiichi Ohno, known as the father of JIT. Toyota was the first to implement it, but it gained widespread attention only in 1975.

It has several goals (Javadian Kootanaee et al., 2013):

1. The reduction of waste, time, and effort in the operations.
2. The improvement of the ability of the company to compete with rivals and to survive in the long term.
3. The improvement of the efficiency of operations which allows the organization to achieve greater productivity reducing the related costs.
4. Production of what customers want, exactly satisfying their demand.

The main advantages of JIT refer to the reduction of waste and costs and to the improvement of efficiency, productivity, and quality. It is also associated with the reduction of lead times and the increase of reliability; when reliability increases, it is also possible to reduce safety stocks (Javadian Kootanaee et al., 2013). The willingness and pressure to achieve the advantages that the Japanese companies were reaching led to different approaches to this methodology that created more damage than benefits.

Javadian Kootanaee et al. (2013) suggested that it is necessary to consider three elements in order to achieve these benefits. The first regards people's involvement and the idea is that people's agreement and consensus can only be achieved when they are involved and informed; the result is an easier implementation of JIT. In each organization, there are several groups with different interests, and consequently to create agreement and consensus, the right points need to be touched. With respect to shareholders and owners, it is necessary to underline the long-term advantages, even at the expense of the short-term ones. Work union is equally important because a lack of involvement results in the resistance to change of workers; for this reason, it is important to explain the benefits for the workers and the effect on work practices. With the work union and shareholders, the support of government and management, the latter necessary to initiate the change, is also essential. The second element to take into account is the plant, where kanban, layout, and kaizen are vital. The last aspect regards the systems, defined as the technology that sets the activities for each stage (MRP).

Together with the definition of the JIT, the implementation is equally important; this can be a very tough process involving a lot of time, effort, and uncertainty. Toyota has spent ten years to fully implement it. Given that it involves several techniques and that the simultaneous application of all these is not realizable, it is not possible to define a clear sequence of steps; in any case, there are some guidelines such as the elimination of important bottlenecks, long lead times, unlevelled schedule and long changeover time, and the education of workers about the philosophy and the techniques (Javadian Kootanaee et al., 2013).

Jidoka

The second pillar of the Toyota Production System is called Jidoka and can be translated as autonomation with human intelligence. The idea is that machines should be able to distinguish between good and wrong items and stop immediately when abnormalities occur. Jidoka is useful for JIT because it prevents defects from a process from flowing in the next process; stopping immediately the machine, it is possible to investigate about the root causes of the problem and to improve the quality (Marchwinski, 2003).

Autonomation was first developed by Sakichi Toyoda through the loom that stops when the thread breaks and then applied by Toyota even in the manual line. It relies on different techniques, some of which will be explained in the next paragraph.

Thanks to the autonomation, the operator does not have to continuously watch the machines and can move to other machines; this is called multi-process handling and it is at the basis of the improvement of productivity.

Jidoka is now applied to all the machines of Toyota. It is possible to define two phases; in the first step, the mechanisms necessary to make the machine able to switch off after having finished its tasks are derived and the related outcome is the increase of productivity. Instead, in the second step, the machines are modified to stop in case of abnormalities, improving overall quality (Monden, 2011).

Stability

Stability represents the foundation of the Toyota Production System (TPS), and it is necessary to implement the two pillars and reach the goal. On the other hand, variability is the sign of instability. For having stability, work needs to be standardized, machines, equipment, and the workplace need to be reliable, and kaizen activities are the only way to deviate from standards. When there are no standards, the time necessary to perform a task changes from person to person and over time.

1.4 The lean pyramid

Arlbjørn and Freytag (2013) defined Lean as a pyramid made of three interrelated levels; in the first level there is the philosophy, in the second the principles, and in the third the tools. The idea is that, even if the tools have a general purpose and can be applied without considering the principles and the philosophy, a company cannot be defined as lean if it does not go through all the three levels.

1.4.1 Lean philosophy

Lean is above all a philosophy that suggests the idea of enhancing the perceived customer value while minimizing waste. According to Lean, the creation of value should occur with fewer resources: less human effort, less space, and less time. Customer value is very important for every lean thinker; Lean is not only about the reduction of waste, and, for sure, it is not a waste elimination tool, but the guide should always be the customers. They are the only ones able to define value, and even in the elimination of waste, value is very important. In fact, waste can be defined as any activity that does not add value to the customers and, consequently, that should be eliminated. One of the most common errors is to think of Lean as a strategy itself without realizing that a clear strategy is instead required; otherwise, the company will be able to reduce lead times, space, and human effort, but in the end, it will lose customers.

In Japan, waste is translated as muda, but this is not the only problem; in fact, along with muda, there are also muri and mura. They are named the three Ms and are closely related to each other and to three main principles of Western management (R. Schonberger and R. T. Schonberger, 1982).

- Muri can be translated as excess and occurs, for example, when the company places a higher load on machines than recommended, causing breakdowns; the same can occur with employees. Muri is reflected by Western techniques of ordering or purchasing in batches (EOQ and EBQ); the problems with these formulas are that they consider ordering and setting costs as fixed, when instead every company should try to continuously reduce them, and that they do not consider many of the advantages of smaller batches.
- Mura instead can be defined as unevenness, and it happens with uneven work pace or when there are no standards, so a given task is performed differently from person to person and over time, and, consequently, the results are different. The buffer stock, present in many companies, has the function of keeping high productivity in the different work centres even if the previous one is not working, accepting in this way the unevenness. According to LM, the company should instead remove the buffer stock, exposing, in this way, the unevenness in order to identify and correct the causes.
- The well-known waste can instead be translated as muda, and it identifies every wasteful activity that does not add value and therefore needs to be eliminated. It can be divided into type one muda for the activities that cannot be eliminated immediately, and type

two muda, when the activities can be quickly eliminated (Marchwinski and Shook, 2003). It is related to the Western quality sampling performed by the quality department that indirectly accepts the presence of defects (muda). LM proposes instead to eliminate batches, to install one-item flow (without batches, there cannot be sampling), and to give the quality check task to operators.

Clearly, muda, mura, and muri are interrelated; mura can cause muri and muda. Ohno defined seven types of muda that have been analysed by Toyota initially and by the other companies successively to improve the productivity and the profitability:

1. Overproduction refers to producing more than necessary, earlier than necessary, and/or in a different mix of what the customer is asking. It is the most serious form of waste because it creates other forms of waste; in order to produce ahead, the company will need space, energy, raw material, and many other things. It can also occur with services.
2. Inventory refers to the waste produced by having more inventory than necessary. In fact, LM does not mean having zero inventory, but it means synchronizing demand with production; even adopting a Lean approach, you can have inventory. Waste is produced by excess inventory that needs to be moved, requires space, or is outdated.
3. Motion is necessary to add value; there is waste when the value could be added with less motion; it can refer to machine motion, transportation motion, or human motion.
4. Defects refer to scrap and to every product that does not comply with the standards and/or that requires rework or repair.
5. Over-processing occurs when the company does something beyond the customers' requirements or beyond the required level of value added. In the end, it is a matter of carefully defining what is required and not going beyond. An overlooked aspect of this kind of waste is the process itself; there is waste even when the process is not done in the correct or best way possible. The process is defined during the engineering or development stage, and the company must determine the most efficient one.
6. Waiting is not value added, so almost all waiting is waste. It can occur in the production line when a task is slower than another, and so the operator in charge of the next task has to wait; to solve this issue, the company has to design very balanced processes or otherwise the risk is given by downtimes and frustration.
7. Transport occurs when items are moved from one point to another; it adds no value, and hence customers are not willing to pay for this.

Nowadays, managers spend a lot of time in their office, but problems cannot be eliminated from the office also because, without direct observation, it is not possible to have a clear understanding of them. Managers should spend more time in the gemba, the place where value is created (Furlan, 2018). Even if the gemba, many times, is referred to the factory floor, to be precise, it is the place where the activity that the manager is trying to understand is performed.

To identify and eliminate the seven types of waste, it is necessary to look at the gemba with respect to the employees who perform the tasks. Respect for people is necessary, in addition to the fact that it is education and the right thing to do, because improvement cannot occur without the involvement and contribution of employees.

1.4.2 Lean principles

The lean approach, with its focus on improving operational performance and customer satisfaction, is spreading far beyond the automotive and manufacturing sector to hotels, mining, public services, and many others. Surveys report that 50% of UK companies have introduced the lean approach in some parts of their facilities, and the same is true for 75% of American manufacturers. The lean approach is based on the identification of value adding and non-value adding activities and the elimination of the last ones. This is done following five principles that identify the perceived value by the customer, detect and arrange the sequence of activities, define what to produce on the basis of customer requests, and try to continuously improve the efficiency of the overall system (Thangarajoo and Smith, 2015).

Define value

The definition of value is one of the most important principles; it involves carefully looking at the perspective of the customer that is the only one capable of defining value. Even if the value is created by the producer, the focus should be on the customers. The company is therefore forced to identify its customers first and then, to ask them for which features they are willing to pay (Thangarajoo and Smith, 2015). The object of Lean is to maximize customer value, so it is not the company, but the customers that define features, functions, and characteristics.

Traditionally, value is instead defined by the departments of the company; in fact, a first distortion occurs when the product is defined by the finance department through a financial perspective. Here, customers are not the priority, as instead occurs for the needs of shareholders. Even if companies can ignore financials, they may fall prey to another distortion led this time

by the engineering department; the value is defined by engineers that add complexities and characteristics of interest only for experts. Once the product launch fails, they usually justify themselves with the lack of readiness of customers for these innovations. Quite problematic is also the definition of value from distant offices completely overlooking the local needs, as made for a long time by Japanese companies (Womack and Jones, 2003).

Many times, the correct definition is complicated because the existing assets and technology, that firms try to use as efficiently as possible, also enter the equation; the product becomes the result of what the company has already bought with the use of the price lever in case of acceptance problems. A further complication is given by the presence, in the steps from raw materials to final products delivered to buyers, of many different companies that define value differently according to their needs (Womack and Jones, 2003).

In order to arrive at the correct definition of value, companies have to change the way they dialog with customers and with the other companies involved in the value stream; even changing the interaction way, the correct specification of the products can be complicated by the fact that the customers themselves may not be able to define value. Ford said: ”If I had asked people what they wanted, they would have said faster horses.” They also have to put aside the needs of shareholders and engineers, ignore the existing assets and technology, and change the organizational processes and culture accordingly. Once a value definition has been derived, this has to become part of the kaizen cycles, constantly looking for a better definition (Womack and Jones, 2003).

Identify the value streams

The second principle involves the identification of the value stream for each product or product family; Womack and Jones (2003, p. 19) define it as a group of three management tasks common to all the products:

1. Problem solving task

   It refers to the development process which goes from the initial concept to the launch of the product.
2. Information management task

   It focuses on the information that is treated and arranged, flowing from the order taking through the scheduling to the final delivery.
3. Physical transformation task

   Here, the raw materials are acquired and treated by the company, and it has as output the final product.

The end result of this process is an interrelated set of activities (the value stream) that go through many companies, and that can be classified into value adding or non-value adding activities with the aim of eliminating the activities that do not add value. With the elimination of waste, the company can reduce production costs and increase efficiency, improving its competitiveness against competitors (Thangarajoo and Smith, 2015). The advantage of this principle is that it forces the company to compete against itself in the elimination of wasteful activities, setting an absolute standard that is better than persistently looking at competitors.

The value stream should also push the company to reflect about its organization and to cooperate with all the firms involved in order to get better results (Womack and Jones, 2003).

Flow

After identifying the value stream, the three tasks seen before are made to flow; the problem is that the flow is difficult to see, especially for beginners. Historically, activities have been grouped by type within departments and performed in batches with the idea of using the most efficient production method. The error lies in the link between efficiency and the high utilization rate that this method is able to grant; a high utilization rate per se does not imply producing more, but a better performance can instead be reached through flow. It was implemented for the first time by Henry Ford but required high volumes; Taiichi Ohno instead understood the importance of applying flow to small batch production. To introduce the principle of flow in the organization, it is necessary to remove the boundaries of functions, careers, and jobs and to modify the existing work practices and tools (Womack and Jones, 2003).

Companies usually organize the problem solving task in batches in a process that starts with the marketing department and then moves to the engineering, prototyping, and tooling department. Here, every new project has to wait in the queue of each department before moving on, and therefore the completion requires a lot of time that is critical for the competitiveness of the company (Womack and Jones, 2003).

Instead, in the LM approach, the development process is managed by product teams containing all the relevant skills, and their members come from the scheduling, marketing, tooling, engineering, and sales departments (Womack and Jones, 2003). All teams follow the same approach so that the times can be measured and the process improved. The result is a substantial reduction in development time and an increase in hit rate. This has been one of the most important advantages that Toyota has been able to gain over Western countries.

The same is true for the information management task where, as mentioned above, the marketing and scheduling are part of each product team. In this way, the marketing campaign can be organized early in the process, and the sales are done taking into account the production system. The synchronization is attained through the takt time (Womack and Jones, 2003).

Even in the physical transformation process, activities are organized into departments and carried out in batches with the effect of producing a large amount of waste. To diminish this, Taiichi Ohno has developed the JIT principle that arises as an inventory reduction method. It requires, for working effectively, the presence of smaller machines, low changeover time, heijunka, a kanban system, and a proper layout; Small machines are easier to maintain, move, and set up (Womack and Jones, 2003).

When everything is taken into account, with the introduction of flow, a company can easily cut the space, inventory, and human effort by half, but businesses need to move from the EOQ/EBQ logic to one-piece flow (Womack and Jones, 2003). Even if there are many times in which the implementation of one-piece flow is not possible, there are also situations in which the companies work in batches with no reason. Another problem is given by the recent trend of outsourcing some steps of the production; when supplies take one month to arrive, clearly one-piece flow is not possible. Many times, the high logistic costs and inventory more than offset the advantages with the result that it is usually better to search suppliers close to the customers, like in the case of Toyota whose suppliers are able to deliver every 40 minutes. This is not a one-piece flow, but it is a good approximation.

Pull production

Once the flow principle has been implemented, it is important to be sure of producing what the customers want; for this reason, the pull principle plays a crucial role. It is about producing what customers want and when they want.

The opposite logic is called push, and it reflects the old-fashioned production style based on forecasts, MRP, and MPS. To understand the old logic, its main elements need to be defined. MPS derives volume and timing decisions about the final product using information on customer orders and forecasts and is one of the main inputs of MRP. This has as inputs the MPS, the inventory data, and the bill of materials and computes the number and the time in which the parts are required (Slack and Brandon-Jones, 2019, p. 508). Here, the production steps are not linked to each other, but are more isolated islands (Figure 2). The problem is that the forecasts do not reflect reality, and the consequences affect the size of the inventory, the amount of idle time, and the extent of the queues. Inventory has important consequences

because it is responsible for part of the variability in the marketplace; as Womack and Jones (2003, p. 88) wrote, half of the decline in the normal business cycle is due to the use of inventory by producers, and half of the increase is due to the building of inventory.

The opposite principle is called pull, and it requires to start the production only when customers ask for a specific product without relying on forecasts and MRP (Figure 3). To work effectively, all the steps in production need to be well connected and made to flow. The implementation of flow is the perfect ground for the pull principle, which for sure requires a short lead time. An example is given by McDonald that uses a pull system in all its restaurants implemented through a supermarket containing all main burgers; the number of burgers in each line depends on the production lead time.

Even if forecasts are not used for day-to-day operations, they are still relevant with capacity planning and, precisely, to decide the size of the plants. Another practice historically used is that of promotions that requires the production to inventory of large amounts of parts because it is never possible to forecast the exact requests. In the end, given that forecasts are not precise, what remains is waste that creates even more waste (Womack and Jones, 2003).

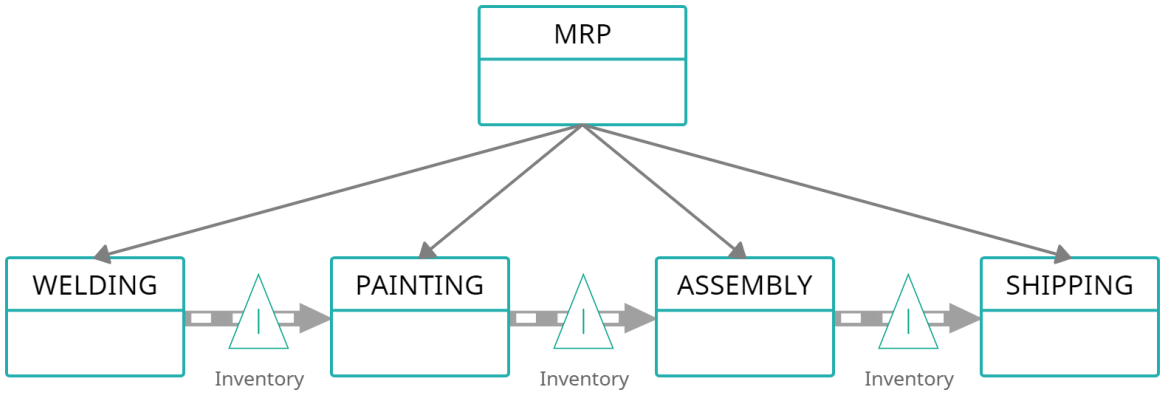

Figure 2: Push system

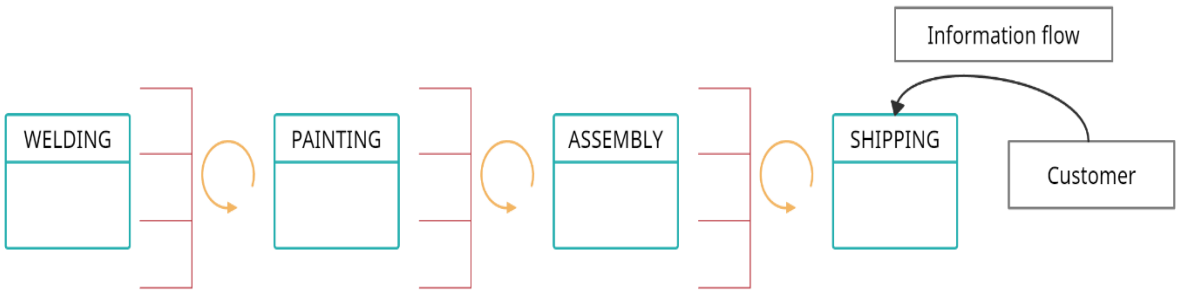

Figure 3: Pull system

Perfection

The full potential of Lean cannot be achieved without the fifth principle according to which improvement is an endless process that never stops. It is not possible to do the actions right the first time, because a further improvement can always be reached. The idea is that companies should continuously try to reduce waste and, at the same time, space, effort, and inventory (Womack and Jones, 2003). The principle of perfection is an ideal, and therefore, lean thinkers strive to get closer to it.

Perfection has traditionally been pursued through breakthrough improvement, which refers to the process of making one big improvement and then keeping everything the same for a long time. Lean instead is based on the notion of kaizen that is frequently translated as continuous improvement, but it also has another side given by the respect for people (primarily referred to employees). These are very complementary in the sense that it is not possible to pursue the first without the second. The consequence is that in finding new ways to reduce waste, the company has not to fire people, otherwise it will lose their trust and contribution.

When Toyota discovers that an activity can be performed with two fewer employees, its next step is not to fire the worst ones. Toyota instead gives a different assignment to the best ones that are more flexible, and it focuses on better training the remaining; the goal is to maximize their potential installing a long-term relationship with them. Respect for people is also given by team-based problem solving, job enrichment (with maintenance and setup tasks), job rotation, and multi-skilling. Without this, employees will not contribute to the suggestion of improvements, and the continuous improvement process will never start.

In the suggestions, there are two main rules to respect; according to the first, employees have to follow the PDCA process, which will be treated in the next section. The second rule says that the suggestions need to be cheap, this means that they should not involve new machines or employees.

Improvements arise from problems; hence, every problem is an opportunity that needs to be caught. There are usually many problems initially and these can cause some difficulties for the company that can be easily solved using a prioritization system.

Once there is a problem, the next step is to identify the root causes that can be related to employees, machines, materials, or methods (Slack and Brandon-Jones, 2019, pp. 571-573). Different techniques are available to investigate the root cause of a problem, such as the 5 Whys. Five is just a number; the aim is to arrive at the root cause without considering the number of whys. The idea is that after each Why, the company identifies a cause, and the process continues

until the goal is reached. In reality, this process can be very difficult; for this reason, a problem prioritization method is needed.

1.4.3 Tools and techniques

In the third level of the pyramid, there are the tools and techniques. To define an organization as Lean, all three levels are necessary. It is not possible to ignore the philosophy and the five principles focusing only on few tools, but this must be taken as an integrated system (Arlbjørn and Freytag, 2013). In this section, the main tools and techniques will be presented (Table 1).

	Tools and techniques
Identify the value streams	Value Stream Mapping
Stability	Standardize work 5S TPM Kaizen: • PDCA • Six sigma • 3A • Suggestion system
Just in Time	Layout SMED Kanban Heijunka
Jidoka	Poka Yoke Andon

Table 1: Main tools and techniques

Value stream mapping

It helps the company eliminate waste and improves its efficiency, analysing both production and information flow.

- Production process
  This is also called the physical transformation process because raw materials are transformed into final products.
- Information process
  It includes all the steps from the order taking activity to the delivery of the product.

Current state map

It is a qualitative tool that describes the company system through predefined icons, the main ones are shown in Figure 4. The basic unit here is the process indicated with the proper box; the next process starts where the material flow stops. The company also has to collect some data for each process (cycle time, changeover time, available working time per shift, EPE, and number of operators required); the EPE (every product every) defines the batch size. Together with the material flow, the information flow is equally important and is indicated by a narrow line. To have a measure of throughput efficiency, every map must contain a timeline that states the lead time for each process and inventory. To find the lead time for the inventory, the company has to make the division between the inventory and the daily customer requirements. Summing together all the lead times, the company gets the production lead time that can be compared with the processing time (Rother and Shook, 1999).

Once the whole set of activities (the value stream) for each product family has been defined, it is possible to identify three types of activity (Thangarajoo and Smith, 2015).

- Value added activities
  They can be defined as the total effort to transform an input into an output for which the customer is willing to pay.
- Necessary non-value added activities
  They are due to the presence of regulatory or legal requirements or technological constraints.
- Unnecessary non-value added activities
  Wasteful activities that must be eliminated.

The current state map is very useful because it shows the flow and causes of waste which will be the target of the future state map.

Future state map

In the future state map, all waste should be eliminated, and all processes should be closely linked; this is where the company wants to arrive (Rother and Shook, 1999). Once eliminated all the unnecessary non-value added activities, the next target should be the necessary non-value added ones. Initially, it is not possible to modify the process technology, the plant location, and the product design; therefore, they should be taken as granted.

After drawing the future state map, the company has to think about implementation. The first step, since it is not possible to implement the map all at once, is to separate it into segments and then to define a yearly implementation plan. The plan specifies, for each segment, objectives, measurable goals, when and how much time it will take to reach them, the person in charge, and the reviewer. This can also be used as a means to evaluate the performance (Rother and Shook, 1999).

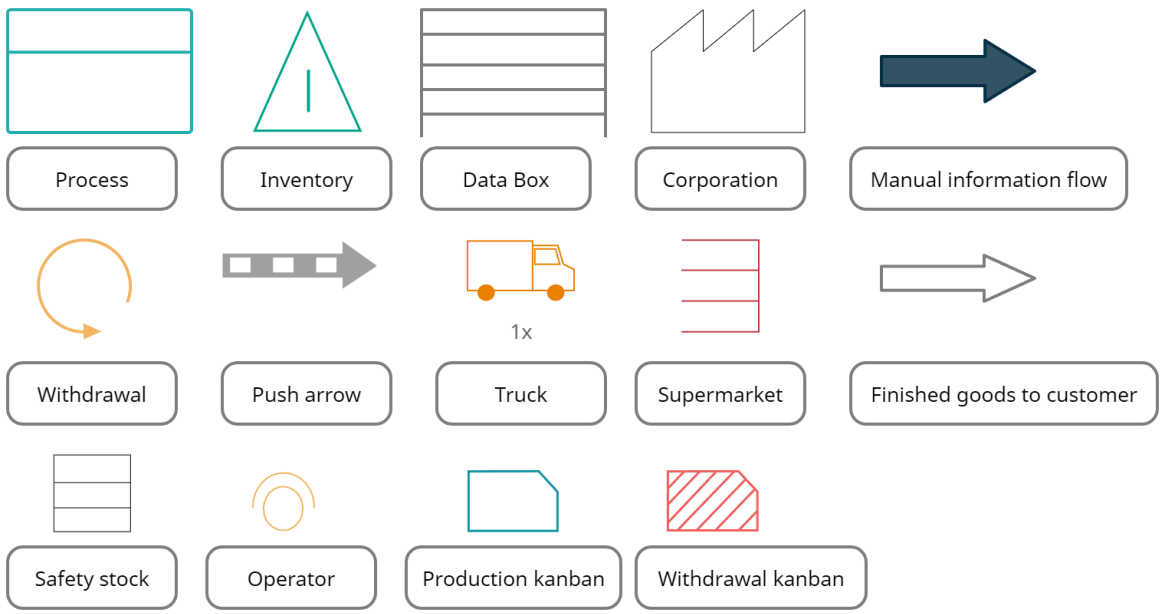

Figure 4: Icons of value stream map

Source: Adapted from Rother and Shook (1999, p. 121)

Standardized work

Standards can be defined as the agreement on the best-known method to perform the work of a given operator considering the available tools, equipment, material, and people. Standards are fixed by nature and the only way to deviate from them is through kaizen activities; in establishing them, the company has to take into account the takt time that gives the production pace needed to meet the customer demand, the accurate sequence of tasks which the operator has to follow, and the required inventory necessary for the operation to flow smoothly. Standards can also be used as a starting point for improvements, to train employees, and to ensure safety, efficiency, and quality; they are created using different tables, charts, and sheets (Marchwinski and Shook, 2003).

- Process capacity sheet
  It is useful to compute the capacity of a set of machines, and it indicates, for each machine, the manual work time, the machine cycle times, and the tool change time.
- Standardized work combination table
  It allows to compare the takt time with the work content for each operator because it records the machine time, the manual work time, and the walk time that summed together give the work content.
- Standardized work chart
  It shows the three elements, previously seen, that each company has to take into account in establishing standards, and, for this reason, it is important for kaizen activities, after which it is immediately updated.
- The work standards sheet
  It is a summary of many documents that allows the company to realize the product as thought by engineers, and it ensures the product quality.
- Job instruction sheet
  It is relevant for training because it indicates all the steps of the job.

5S

5S has been developed to maintain the stability necessary to reach the goal and for the two pillars of the TPS house. Its application is not limited to the production line, but it is useful in the warehouse, in the office, and in all places where cleanliness is important. Waste cannot be seen with dirt and disarray; therefore, 5S is incredibly important. The first step of the implementation process is always training the employee about its components and benefits, because otherwise they will try to resist changes; once implemented, the company will get a clean and effective workplace that will result in a reduction of lead time and production costs, in an increase of the safety, and in higher quality relationships (Monden, 2011; Filip and Marascu-Klein, 2015). This tool is made up of five elements:

1. Sorting (Seiri)

   It means dividing necessary tools from unnecessary ones. It refers to searching tools in all the possible places like tables or above or below a machine and to the verification of the number of times they are used and of the reasons.
2. Set in order (Seiton)

   It refers to the arrangement of the tools so that they can be easily found. The idea is to place the tools that are important and used frequently close to the workstation, instead putting the unnecessary and rarely used tools elsewhere; their closeness depends on their importance (Filip and Marascu-Klein, 2015).
3. Shine (Seiso)

   It means keeping the workplace, machines, tools, and equipment clean and tidy. Cleanness can reduce machine problems and extend their life, and it is a necessary precondition for having high quality products.
4. Standardization (Seiketsu)

   Standards are necessary to maintain the results achieved above and to reduce their variability.
5. Sustain (Shitsuke)

   It refers to the development of commitment and pride in maintaining standards. Once the standards have been defined, the most difficult part is to respect them. Without discipline, the risk is the return to the conditions prior to the implementation of the 5S method.

Total productive maintenance (TPM)

In a very globalized world where countries compete against each other, good maintenance practices can give an important advantage. Historically, companies relied on reactive maintenance "responding" only in the event of performance failure or significant performance decrease. Even if a reactive strategy can decrease the costs of keeping the equipment working, in the end it will result in higher overall maintenance costs. Waiting for problems and then reacting can be very dangerous; in today's ultra-competitive world where the focus is on improving efficiency by cutting costs, this approach is no longer possible (Jain at el., 2014).

TPM has been developed in Japan by a Toyota Motor Company supplier with the aim of reaching the ideal goals of "zero defects, zero accidents, and zero breakdowns" (Jain at el., 2014). It has several direct and indirect advantages, such as increasing customer satisfaction, product quality, and equipment efficiency, the development of a better and healthier working environment, and the reduction of costs and complaints. Like so many changes that involve the entire organization, it cannot start without the top management support; in fact, it is cross functionals and requires the contribution of all employees at all levels that are trained on maintenance skills and on the new approach. As frequently occurs in lean organizations, they work in teams that bring together people from different worlds (maintenance, production, and engineering), making the exchanges of experiences, knowledge, and information easier (Jain at el., 2014).

Teams are used for maintenance prevention practices where the design of the product and equipment is optimized to make maintenance easier. It, as the entire organization, has to improve over time; this is the function of maintainability improvement teams (Swanson, 2001).

Kaizen

Kaizen, as written above, means continuous improvement, but respecting people; they are the heart of lean organizations and necessary for their survival. Many times, companies rely on consultants for the introduction of Lean, but once they leave the company, it returns to the previous system. This occurs because they fail to install a kaizen mentality; to have continuous improvement, people need to be motivated. This creates the perfect environment for Lean to take root in depth and for continuous improvement to occur.

Motivation cannot be created teaching tools and techniques, but instead employees need to receive a challenging problem with only few hints, pushing them, in this way, to think creatively. Given the difficulty of the challenge, it can happen that they fail; if this occurs,

leaders have not to underline the failure, but they should thank their employees for their efforts; only in this way, the next time they will be available to try again (Monden, 2011).

Kaizen is a broad category that includes many techniques that are in some way interrelated:

- PDCA cycle

  The evolution of the PDCA cycle starts with Shewhart and his cycle, used to describe the steps in mass production. Initially, it was a straight line; this is a refinement made by him of the starting idea that can be translated for the scientific method in the three steps of defining hypothesis, executing an experiment, and verifying the hypothesis. In any case, the meaning of the inspection stage is to use the sales figures, and so the data from the customers, to arrive at a new specification. This has been subsequently formalized by Deming who added the fourth step (research) with the idea of using the complaints of customers to arrive at a new and improved design and restart the cycle. When the Deming cycle arrived in Japan in 1950, this has soon been used to elaborate the PDCA cycle (Moen and Norman, 2010). It is the way in which Japanese companies introduce a new improvement with a scientific approach. The sense is that when the company identifies a problem, it should gather data to understand the possible causes and a possible solution to it. In the next steps, the firm should implement the solution in a small part of the production line (Do) to see whether the solution is effectively able to improve the performance (Check). If the test has been successful, the company should then define a new standard that prevents the problem from occurring again; otherwise, it should use the acquired knowledge to restart the cycle.

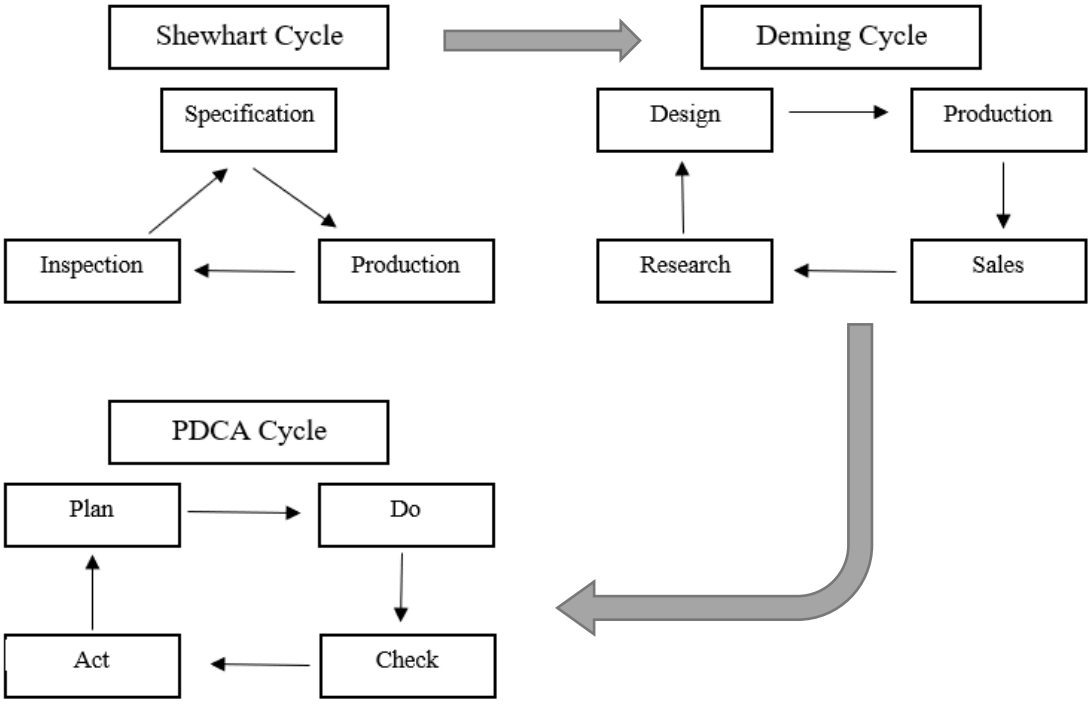

Figure 5: History of the PDCA Cycle

Source: Adapted from Moen and Norman (2010)

- Suggestion system

Benefits			
	High		
	Low		✕
		Low	High
			Effort

Table 2: Evaluation of the suggestion

Many companies start to implement a suggestion system, like a box, for the ideas that come from the employees, and then they execute the best ones. This system requires a team that analyses and gives an explanation (this takes a long time) for all the ideas otherwise, learning is not possible. Clearly, the worst ideals are those characterized by low benefits and high effort, and they should be avoided.

- Six sigma

This methodology promotes the continuous improvement of processes and products that focus on the needs of customers. It has the ideal of zero defects which is the lighthouse for the users of this method. Six sigma formally means 3.4 defects produced by the

process if there were one million opportunities to do so (Slack and Brandon-Jones, 2019); it arises from the necessity of organizations to continuously review processes to avoid the risk of deterioration over time (Snee, 2010). It has been developed at Motorola to improve the manufacturing processes and then has been extended to non-manufacturing processes. They have been defined as the main weakness in the quality system and are the place where the best opportunities can be found. Six sigma has been successively improved by GE, and then it has become famous all over the world. The main results of improving process performance are the increase in customer satisfaction and financial performance.

Motorola also created a six-step implementation process which has been successively refined with the development of the DMAIC process. In the first step, the company defines the problem of the product or of the process (Define), then it has to measure whether the problem is really worth (Measure). Once a valuable problem is identified, the company should make and test hypotheses on the root causes of the problem (Analyses) and find ways to solve the problem. The possible solutions to the issue should be tested, and the best ones implemented (Improve). In the last step, the revised process is controlled, and, if necessary, one of the previous steps may be repeated (Control). This process is very similar to the PDCA cycle, with which it is clearly interrelated (Slack and Brandon-Jones, 2019).

One of the main difficulties in implementation is the resistance to change from employees that can be won through training. Another way to solve this issue is to reach quick wins by setting short-term objectives. Companies should always remember that these are only tools, and continuous improvement cannot occur without first changing the company culture (Snee, 2010).

- A3

  A3 is a problem solving tool that promotes continuous improvement. It is the way the PDCA process is documented and has the typical A3 size. It is very useful because it allows to understand the reasoning applied to a problem and the solutions considered with the respective results. Many times, companies using the PDCA process have not been able to achieve the same results as Toyota because they were not considering the importance of a tool flexible enough to represent each problem in one sheet and its capabilities to promote learning (Schwagerman and Ulmer, 2013).

  As shown in Figure 6, the plan part occupies half of the sheet because of its importance; in fact, better results can be achieved through a good plan. It includes a background section that should be aligned with the target audience and all the information necessary

to understand the magnitude of the problem. The current and future situation, in the latter the sources of waste should be eliminated, are better summarized through the value stream map; with the future situation, the company is able to identify the existing gap. The last section of the plan part lists the root causes of a problem using the method of the 5 Whys. In the do part, the company analyses the possible countermeasures to close the existing gap; to create accountability, and to reach better results, it also signals the person responsible of each countermeasure and the due date. The check part is useful because many times people implement the solution without checking whether this allows them to get the desired future. The act part contains possible further modifications (Schwagerman and Ulmer, 2013).

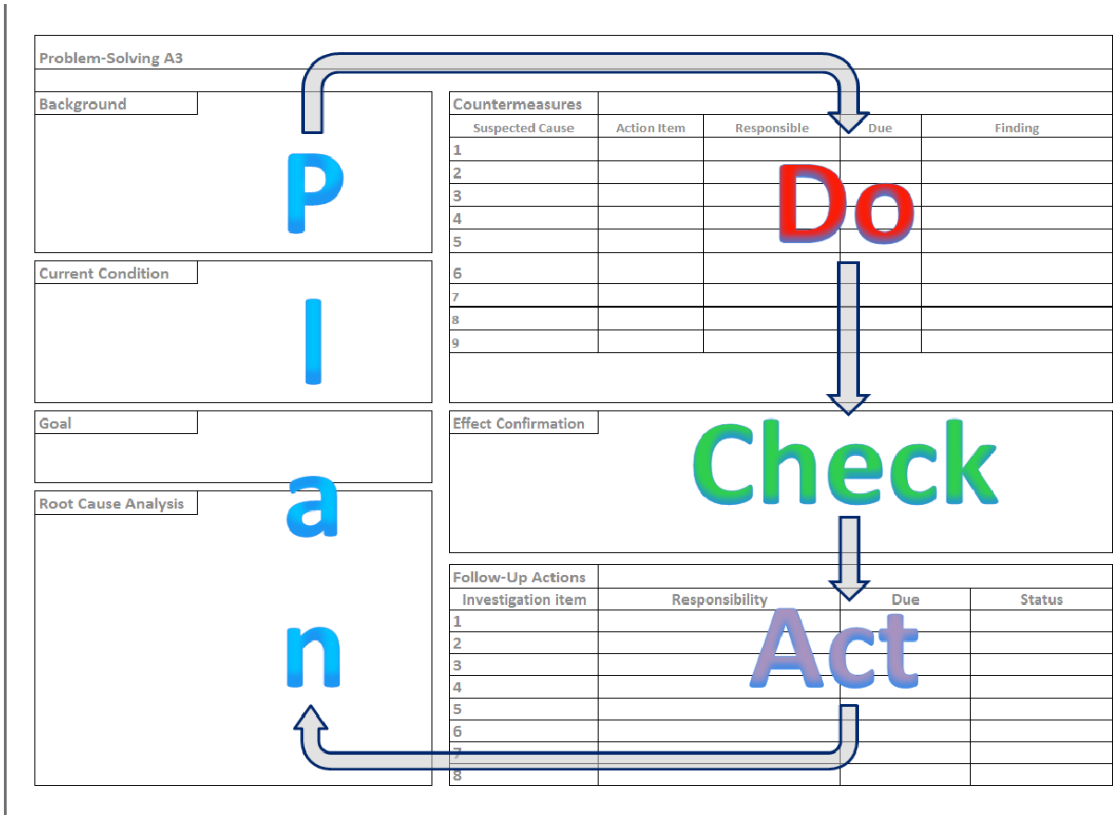

Figure 6: A3

Source: Schwagerman and Ulmer (2013)

Kanban

It is an information system that allows the company to produce just what is needed and when it is needed. Physically, it is a card containing the name of the preceding and subsequent process, the store address, the bar code, the quantity, and the name of the item. A production and withdrawal kanban system is installed between two processes (Figure 7 shows a simple implementation of a kanban system on the production line). The production kanban indicates the quantity and type of items that the preceding process has to produce; instead, the withdrawal kanban specifies the quantity and type of items that the next process has to withdraw (Monden, 2011, pp. 36-41).

Once the carrier arrives at the store with the withdrawal kanban box, he takes the quantity needed, paying attention to remove and place the production kanban in the receiving box. Each production kanban should be replaced with a withdrawal kanban that will be removed when the operator in the next process will use the first product in the container; then it is placed in its proper box. In the preceding process, the kanban are moved from the receiving box to the production kanban box, paying attention to maintain exactly the same order. According to the kanban instructions, the process starts to produce the needed items that should be followed during the process by the respective kanban. Once the process is terminated, the kanban is placed in the store ready to be withdrawn (Monden, 2011, pp. 41-43).

The kanban system can be extended also to suppliers, this is called supplier kanban and must indicate the receiving door, delivery times, and some other information seen before. In this way, even the supplies are based on what is really needed.

To successfully install a Kanban system, some simple rules must be respected (Monden, 2011, pp. 45-49).

1. The quantity withdrawn has to be in line with the kanban; it is not possible to do more withdrawals than the number of kanban.
2. The preceding process should produce exactly the quantity withdrawn and in the same order.
3. Defective products should not be moved to the subsequent process. When a process discovers that some products are defective, it should stop the line and send these products back to the previous process.
4. Kanban is a measure of the inventory of the parts in the processes, and hence the number should be minimized.

5. The kanban system is flexible enough to adapt to changes in the demand of customers. When the company uses a traditional system and the demand changes, several days will be necessary to adjust the schedule. In a kanban system, schedules are not sent to all processes that instead work on the basis of kanban. Only the assembly process receives instructions that can be revised at the end of the day.

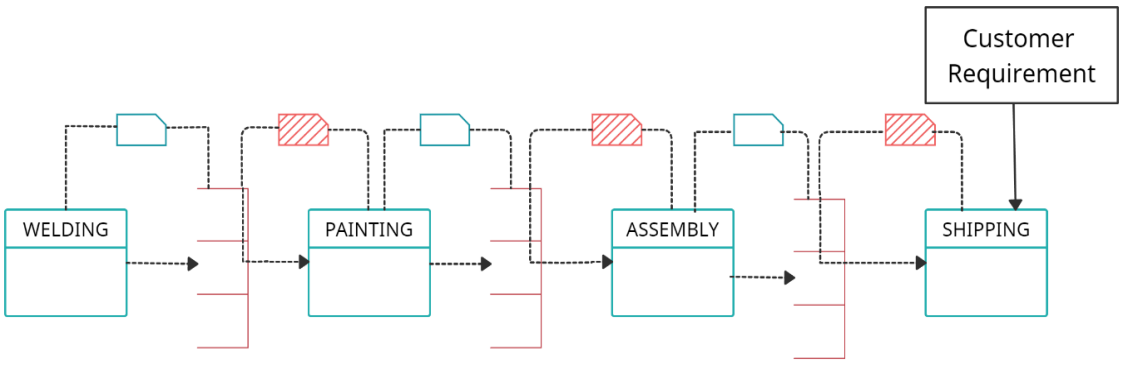

Figure 7: Kanban system

Source: Adapted from Rother and Shook (1999, p. 55)

Heijunka

It refers to the volume and the mix or type of products. With respect to volume, it involves producing on the basis of the average demand keeping a small inventory. In this way, the company keeps the quantity produced constant. Once the volume is defined, the company should take care of the mix; mass production usually relies on the sequential production of large batches of products in the attempt to fully exploit the economies of scale. This system results in a large inventory and very different productive days. A solution can be found increasing the flexibility to the point in which all productive days are equal (Slack and Brandon-Jones, 2019, pp. 532-534).

Single Minute Exchange Die

SMED is about the reduction of the changeover time that is the time necessary to switch process and equipment. It is important to distinguish between internal activities that can be executed only when the machine is off and external activities that can be performed even if the machine is working.

Historically, companies have not paid much attention to the distinction between external and internal activities, performing many activities internally that could be done externally. The division is important because for the external activities, the speed and efficiency are not as

critical as for the internal ones. Furthermore, managers and engineers have never spent much time analysing them.

Usually, companies have grown in the conviction that these operations are quite different from each other and depend on the process and the machine; this is not true because all changeover operations can be divided into four steps. In the first step, operators should bring all the necessary tools and parts and check their effective functioning. Successively, the old parts and tools are replaced with the new ones and then all the necessary measurements and calibrations are executed. In the last step, a small test is performed and, according to the results, the required adjustments are completed (Shingo and Dillon, 2019, p. 27).

In order to reduce the changeover time, there are several steps to follow (Shingo and Dillon, 2019, pp. 29-31).

- Initially, all activities need to be analysed and measured. There are several techniques available, more or less formal, but one of the best is to make a video of the entire operation and show it to operators. This activity can provide quick and immediately applicable insights.
- In the second step, the company should divide all internal from external activities. A check table can be very useful to verify that all the necessary tools are present, but it does not allow employees to verify their correct functioning; this has to be done successively.
- The company should then try to convert, as much as possible, internal activities to external ones. This step can reduce the time by 30% or even 50%.
- The last step is where improvements are made to the elemental activities.

Layout

Companies traditionally instead of cells have used other types of layouts that for different reasons are less efficient. For example, they have assigned to each operator a single machine with the result of a high idle time while the item is processed. This problem can be solved by assigning to the operator more machines of the same type positioned in a triangular, rectangular, or rhombic shape. Even if the productivity of workers increases, the performance in terms of inventory and lead time gets worse. A solution to the inventory problem can come with the creation of isolated islands where multiskilled workers are responsible for different types of machines. The main disadvantages are the inflexibility of this system that does not allow the company to adapt to changes in demand and the difficulty of cooperation among workers. These

issues can be overcome with a linear layout, but the allocation of operations among operators remains difficult (Monden, 2011, pp. 144-149).

Lean thinkers prefer u-shaped cells that minimize the distance walked and promote teamwork. The idea of combining different u-shaped cells in a unique line, as sustained by Monden (2011, p. 149), comes from Toyota and has the advantage of facilitating the allocation of operations among workers when demand changes (Figure 8).

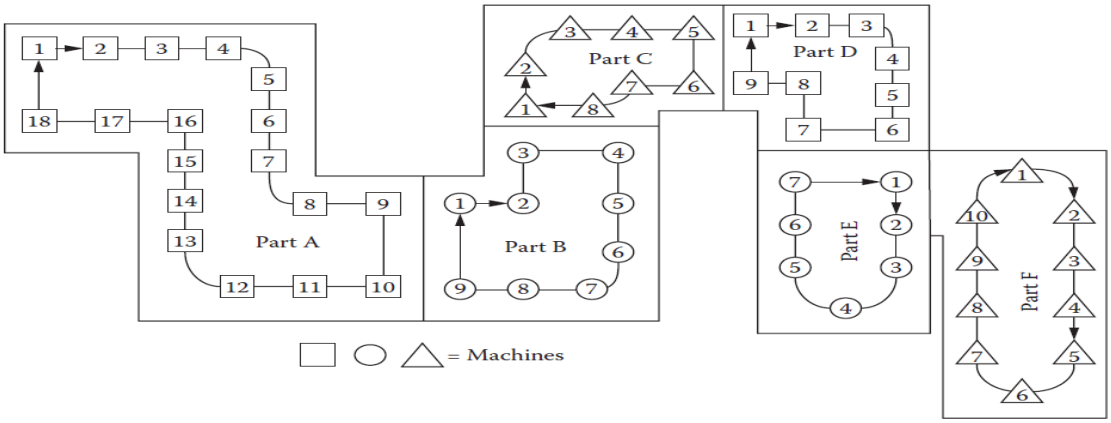

Figure 8: Combined line making six kinds of parts (A–F)

Source: Monden (2011, p.150)

Andon

Andon is an information system that warns the supervisor and the other workers about a problem. It can signal different problems, from machine errors through quality problems to shortages, according to the complexity of the system. Lean companies can rely on two systems: a simple call light positioned in a well-visible place near the problem, and/or an andon board that shows different numbers, one for each workstation or machine, with different lights, according to the type of problem (Monden, 2011, pp. 231-232). When there is a problem, the supervisor or a maintenance worker must go there to check; once arrived, it is necessary to turn off the light.

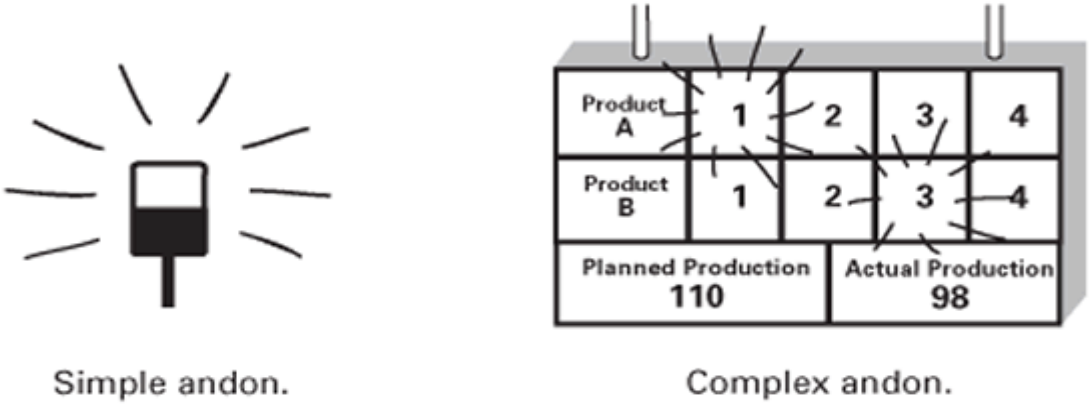

Figure 9: Andon

Source: Marchwinski and Shook (2003)

Poka Yoke

It is a simple and usually inexpensive mechanism that prevents operators from making mistakes. It is also called error-proofing, and it can highlight or prevent errors. Companies, for example, can design products that does not allow them to wrongly install their parts or can use photocells to detect mistakes (Marchwinski and Shook, 2003).

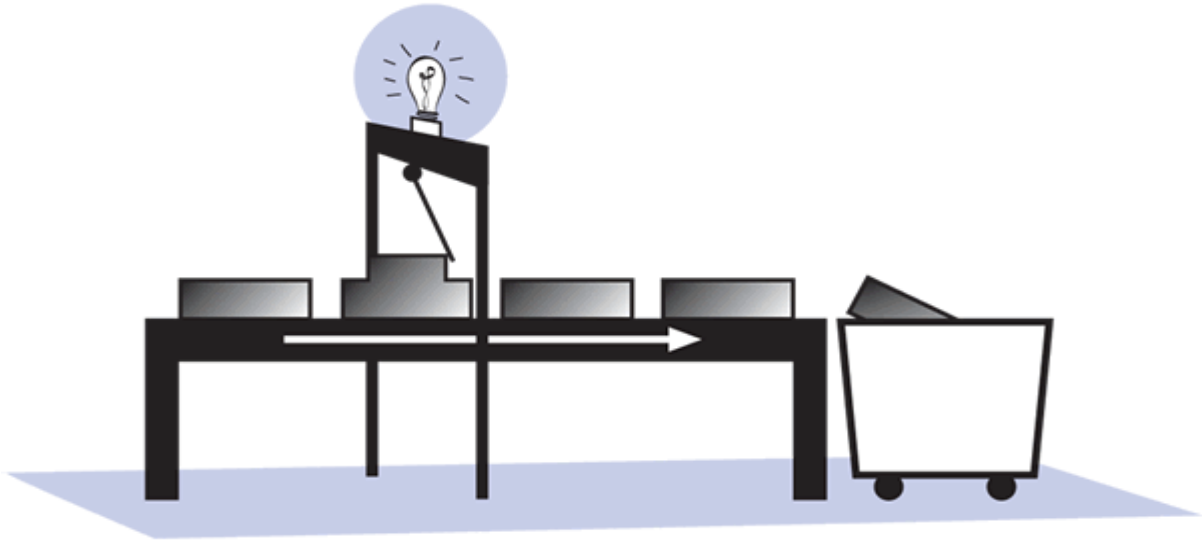

Figure 10: A contact-type error-proofing device

Source: Marchwinski and Shook (2003)

1.5 Lean beyond the factory floor

Lean is not limited to a production method but can also be applied to strategy, organizational form, marketing, and accounting. The aim is to apply the same ideas, but to other fields.

When defining the strategy, the company must remember that this must be aligned with the changes of the sector. Even if they are not as common as people think, they can be quite sudden; for example, if new players decide to enter the sector, the company may decide to focus on a niche. Otherwise, the threat may arise from a new substitute product (Furlan, 2018).

The strategy has the power to make the company unique, giving it a competitive advantage over competitors. It is about the definition of the value proposition and the arrangement of the value chain that has to be in line with the value offer. To define the strategy, there are two approaches. The traditional approach is top-down and starts with the sector's analyses to individuate potential threats; the company should use for this operation the Porter five forces framework. After the analyses, the company specifies the new strategy, initially on paper and then in practice. Instead, the new approach is bottom-up; therefore, the strategy arises from the gemba (the place where the value is created). To be precise, the strategy emerges by solving the main problems faced by the operators; in fact, once the main problems have been identified, leaders should share them, try to isolate their causes, and find solutions. The top manager, for example, can decide to improve the quality of the product or modify the offer, and, in this way, a new strategy emerges (Furlan, 2018).

Marketing has historically relied on quantity instead of quality, increasing, in case of problems, the number of hours worked, promotions, and sellers. Even if in the past the usual techniques worked, now the world is changing. Barriers are disappearing and competition is increasing with the result that it is more difficult to persuade potential prospects because they have more alternatives. Now, it is time for marketing to familiarize itself with the concepts of value and waste. To minimize it, the company must identify the different steps that lead to the purchase of the product or service, recognize the step in which the prospect is located, and customize the offer according to the step. When resources are scarce, businesses should prioritize segments and focus on prospects with a higher probability of purchasing, without forgetting to always respect people (Furlan, 2018).

The most used organizational form is the functional one; companies prefer this because it allows them to benefit from the economies of specialization. It has several advantages when the volume is high and the mix is low, or when the volume is low and the mix is high, but it remains

inefficient. The functional form maximizes the individual areas, but this does not mean that it maximizes the whole process. Customers do not care about functional performance, but only about the output, i.e., processes; they are horizontal and common to all companies. As written previously, it is possible to distinguish between the processes of problem solving, physical transformation, and information management. The idea is to allocate resources to them while maintaining, at the functional level, the support functions. Each process consists of subprocesses or value streams (Furlan, 2018).

Financial accounting, directed at external stakeholders, must be used together to lean accounting because traditional indicators can lead to worse decisions. Lean accounting information can be summarized in a box score that is divided into three parts and refers to a specific value stream. In the first part, there are operational indicators that care about the value stream differently from traditional ones that focus on maximizing the performance of the function. They concentrate on flow (stock cover, stock turn, production lead time, and delivery lead time), quantity (percentage of defective products), and productivity (revenues or volume per employee and OEE). The utilization rate per se is useless, and it risks resulting in a higher inventory; what matters instead is how the company uses the more time available after having reduced waste. For this reason, lean accountants care instead of the total capacity, obtained summing the capacity utilized for value added activities, that utilized for non-value added activities, and that not utilized (second part). Finally, a profit and loss statement is derived for the value stream; this means assigning at the value stream (profit centre) all the costs and the revenues with the only limit that the costs must be controllable. This document, differently from that directed to external stakeholders, gives priority to cash; therefore, it records the expenses when they result in an exit of cash (Furlan, 2018).

1.6 Conclusion

The history of this system started when Kiichiro Toyoda created Toyota Motor Company at the beginning of the 20th century that, after some difficulties at the beginning, grew exponentially even thanks to the work of Taiichi Ohno. In 1960, the advantages of Toyota over the other companies were substantial, and it also started to promote Lean to suppliers and dealers developing a lean supply chain.

The aim of lean thinkers is to achieve the shortest lead time, the lowest cost, and the highest quality by producing only on the basis of customer requests and in the quantity and time

requested (Just in Time). This is different from the traditional principle of producing for inventory just in case an urgent order arrives. For producing Just in Time, it is necessary to have machines able to detect defects and stop in case of abnormalities; the same idea can be applied in the manual line (Jidoka). The goal cannot be reached when there is variability; to maximize stability, the work must be standardized, the machines, tools, and equipment have to be reliable, and the only way to deviate from standards is through kaizen activities.

Lean is about maximizing the value for the customer and eliminating waste (muda), defined as every activity that does not add value, and therefore for which the customer is not willing to pay. Ohno has identified seven types of waste: overproduction, which is the most serious and can create the other types of waste, excess inventory because Lean does not mean zero inventory, excess motion, transportation, over-processing, waiting, and defects.

A company to be lean has to follow five principles. According to the first principle, the company must look with the perspective of customers when creating value, ignoring the existing assets, technologies, and needs of shareholders and designers. The second principle involves identifying all activities of the value stream and eliminating those that do not add value. The next step is about the introduction of flow that allows the company to easily reduce human effort, space, and inventory. After this introduction, the company has to be sure to produce only what customers want; for this reason, the pull principle plays a crucial role because it involves producing only after an order from a customer. The full potential of Lean cannot be achieved without the fifth principle, according to which improvement is an endless process that never stops.

Lean is not limited to a production method, but can also be applied to strategy, organizational form, marketing, and accounting. The strategy should arise from a bottom-up process (from the gemba), where top managers should try to identify the main problems, their causes, and possible solutions. After this process, the top manager may decide, for example, to change the offer, and in this way, a new strategy arises.

In a world where the competition is increasing and the customers have many alternatives, the traditional approach to marketing does not work. It is necessary to significantly reduce waste and focus on the best opportunities.

Companies prefer the functional form, but it is not efficient. In fact, even if it maximizes the individual areas, this does not mean that it maximizes the whole process. Instead, companies should assign resources to processes.

Finally, even if financial accounting is necessary for external stakeholders, companies internally should use lean accounting that can be summarized through a box score and allow them to take better decisions.

Chapter 2: Lean Management and resilience

2.1 Introduction

This chapter aims to investigate the ability of lean companies to overcome threats and adversities.

The paragraph on resilience starts with a description of recent years characterized by a substantial increase in terrorist attacks, labour problems, natural disasters, and many other issues. At the beginning of the paragraph, the chip shortage, as one of the actual problems that companies have to face, and its future developments are accurately presented; the main result is the increase of instability underlined also by the supply chain volatility index that gives a measure of the overall volatility. Therefore, companies have to deal with challenges and adversities; in other words, they have to become resilient. Once resilience has been defined, the abilities to respond, monitor, anticipate, and learn that characterize resilient systems are presented. The four abilities can be used to derive a resilience profile of the system to understand how resilient it is.

Resilience is a well-known topic that, over the years, has been analysed from different perspectives; here, the ecological, supply chain, and operational fields have been briefly defined. The paragraph ends with a focus on the last two perspectives that will successively have a key role.

The paragraph on functions and dynamic capabilities starts with the sense that contains the case of Nokia and Ericsson, build, reconfigure, re-enhance, and sustain functions of resilience; then, it introduces the concept of dynamic capabilities that can be proactive or reactive and represent the way to overcome challenges. This is formalized with the “Spring” model, where the development of these capabilities represents the way to achieve the established business objectives in the presence of threats and adversities. In the last part of the paragraph, the dynamic capabilities are classified into four categories (integration/coordination, learning, reconfiguration, and delivery) and, in the next paragraph, put in relation with the previously defined functions; in this way, different items for each capability have been defined and used to analyse the resilience of lean companies.

The paragraph on resilience in lean companies contains the summary of this analysis. The aim is to say whether or not lean companies can be defined as resilient.

2.2 Resilience

The world is changing, and companies have to face many challenges nowadays. The number of natural disasters, terrorist attacks, labour problems, and delays increased significantly, with important consequences for the companies hit by them.

An actual issue is that regarding the chip industry. When demand suddenly increased, companies were unable to react; this affected, above all, the car makers with many of them forced to temporarily close their factories. This problem did not spare even Toyota, but it is not limited only to the automobile industry; in fact, the shortage relates to all the chips, and the products involved vary from game consoles to washing machines. When the pandemic arrived, the situation collapsed; it forced many employees to work from home, so they started ordering electronic devices which resulted in a huge increase in demand. Figure 11 shows that the revenues of the pc market in Italy increased by 500 million only in 2021; the trend is similar even in the other countries. The launch of new game consoles from Microsoft and Sony that placed huge chip orders, and the increasing interest in cryptocurrencies worsened the problem (The shortage of semiconductors, 2021).

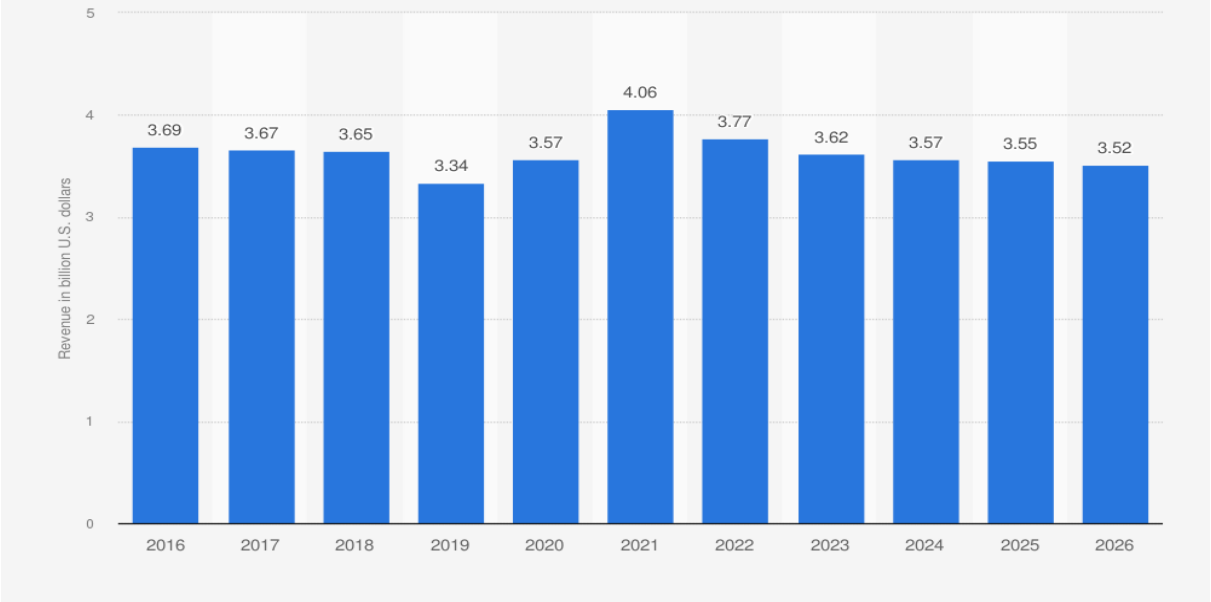

Figure 11: Revenue of the PC market in Italy from 2016 to 2026 (in billion U.S. dollars)

Source: Statista (2022)

Most of the capacity is in Asia, where chip makers worked tirelessly during the pandemic. South Korea and Taiwan, where the two main producers are located, registered only few deaths, but also in Wuhan, the workers did not stop. The problem is related to the industry that has always

been characterized by cyclicity, given its inability to react to changes in demand. In fact, a new high-tech plant may cost tens of billions, and even using a cheaper technology there are problems. If, together with this, the technology rivalry between China and the United States is considered, the result was the creation of the perfect storm (The shortage of semiconductors, 2021).

It is difficult to say how long the shortage will last, but some years could be necessary. Governments are trying to improve the capacity with the United States and Europe in pole position, and the main companies are also investing heavily; Samsung Electronics, Intel, and TSMC will spend twenty billion dollars each (The chip shortage, 2021).

A sign that the world is changing is given by the increase in protectionism that creates many problems for the actual globalized economies. The shortage of lorry drivers in Britain, the flue shortage in India, and the problems in America are all due to the growth of protectionism (The shortage problem, 2021).

Supply chains are becoming very risky because of delays, disruptions, forecast problems, excess capacity, and many other risks that can have an important effect on the performance of the company; the impact clearly depends always on the company's reaction and the preventive measures implemented. An example is given by the fire at Royal Philips Electronics in 2000 that affected, among others, Nokia Corp. and Ericsson but in very different ways. In fact, Nokia was able to limit the negative impact thanks to the use of many suppliers and its responsiveness. Ericsson, on the other hand, had only Philips as a supplier and did not immediately understand the gravity of the situation, losing 400 million in revenues.

Delays occur when a supplier is not able to react quickly to changes in demand; they can be due to the low quality of the supplier's products or its attempt to achieve a high utilization rate. Delays are for sure more predictable than disruptions caused by strikes, natural disasters, supplier bankruptcy, or war. Bankruptcy or a fire at a supplier's plant, especially if the company does not have alternatives, can force the company to close the factory. The impact can be global or limited to some companies. Companies, usually to reduce costs, also outsource critical production steps, but this can involve many risks because it can undermine the firm competitive advantage; it is known as intellectual property risk and can occur, for example, when competitors use the same outsourcer. In making decisions, firms rely on forecasts, but they are wrong by definition and can result in excess inventory or product shortages. Errors occur when, for some reason, information is distorted, and the severity of the consequences increases with the raise of the distance from the customer. Together with these, there are many other risks such

as excess inventory risk, the cost of holding inventory can be very high, and excess capacity risk; the latter can cause heavy losses and probably will be faced by chip makers in the near future. When companies buy supplies, they should always take into account the fluctuation of the exchange rate, as well as consider the risk of being unable to collect receivables from customers (Chopra and Sodhi, 2004).

The supply chain risk increased dramatically since the financial crisis of 2008; clearly, even before there have been shocks or crises, but what companies are experiencing now is new. Christopher and Holweg (2011) have defined this period as " the era of turbulence" to underline the fact that the old single-sourcing strategy is no longer possible. All the different actors have to consider that the environment is becoming unstable. They defined a crisis in terms of the effect it has on some parameters that take into account the price of stock market, the raw materials price, and the shipping cost plus two exchange rates and an interest rate. Then, they computed for each of them the coefficient of variation because it allows the company to make comparisons when the means and the units of measure are different. Finally, they computed the mean among all the previously derived coefficients of variation and named the result the supply chain volatility index. The main advantage of this index is that the increase of one parameter will not substantially influence it. In fact, with all the previous shocks, such as the increase in the oil price, the terrorist attacks, or the bubbles, it remains stable; this is the signal that the companies came from a period of relatively stability. When the index is computed for a specific period of time, it shows a measure of the risk in the supply chain; in 2008 it was equal to 0.254, and the previous period with a comparable level of volatility was in 1973 when it was equal to 0.166 (Christopher and Holweg, 2011).

Given the high volatility present in the environment, companies need to be able to deal with shocks and adversities. They cannot be ignored because otherwise the survival of the entity could be compromised. For this reason, it is useful to introduce resilience as the ability to deal with challenges and adversities. As shown in Figure 12, shocks move the company away from its development path; in order to return to it, countermeasures are necessary. In the next paragraph I will introduce the "Spring" model that will clarify what is necessary to reach the organizational objectives despite problems.

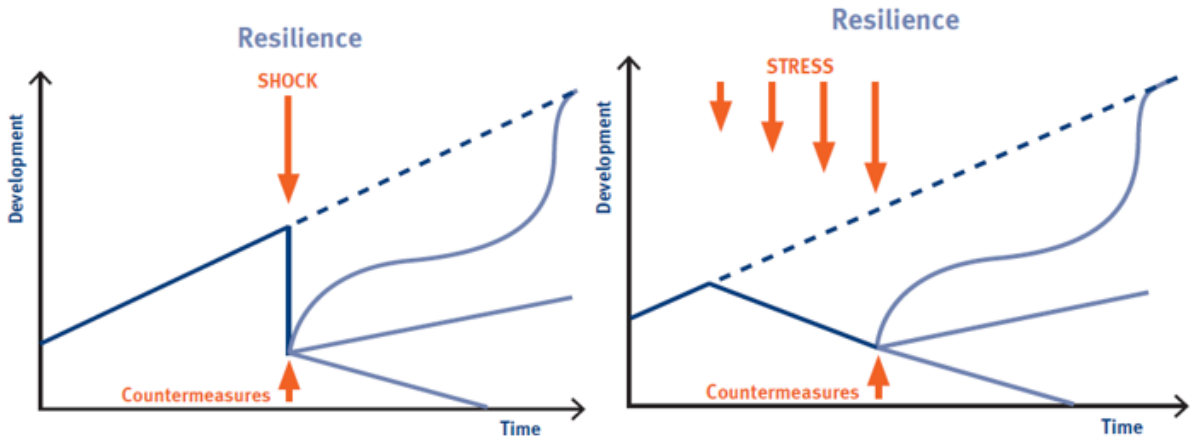

Figure 12: The effect of shocks and stresses on development pathways depending on different levels of resilience

Source: Mitchell and Harris (2012)

Resilience is the ability to overcome threats and to bounce back; it involves returning to the previous functionality quickly maintaining, more or less, constant the performance despite the presence of difficulties. The main obstacle for managers that grow up in a period of relative stability is to identify the threat; consequently, they need to increase familiarization with the new environment and try to overcome the denial and resistance to change that may characterize their companies. Only accepting the high degree of volatility, the company can move the first step toward resilience. A change affects the company also at a high level, and it can make obsolete the strategy and the business model; therefore, it is important to constantly adapt them to the new circumstances (Demmer et al., 2011). Instead, managers often ignore the new ideas that an entrant brings, losing the opportunity to make adjustments of their business model. Resilience develops over time and can be seen as a process that starts with the understanding of the shock and finishes with the absorption of the variation. It can start even before a shock, putting in place pre crisis actions that help limit the impact of a future threat. A company faces many types of issues; they can be one-off or recurrent, with high or low probability, and cause serious or small damage. One question could be whether or not they are all part of resilience, but the answer, obviously, is yes; in the end, it includes all the problems that an entity can face independently of the duration or other features. As said before, it is not limited to the moment of occurrence of the crisis and the following period but also includes the previous period with all the actions necessary to mitigate or prevent a potential problem. Here, the border with risk management is very narrow; managers, as stated by Mitchell and Harris (2012), could derive a table with the potential risks and the corresponding actions to reduce the risk. The problem is that there are many potential risks and the resources are scarce, so companies should define resource prioritization rules, perhaps considering the likelihood and likely impact.

In resilience, as should be clear, there are two crucial steps. The first is preparation with the idea of restricting or preventing negative consequences. Investments in the first phase can ensure the survival of the company, such as the building of a powerful network that detects the first signals of a change. Within this step there are also the investments made to develop mitigating capabilities which will be treated in detail in the next paragraph. The second step is named restoring and is what many people associate with resilience; they view it as an adaptation process where the early identification of a crisis and the subsequent actions are very important. As stated instead, resilience also includes the pre crisis actions together with the restoring step (Williams et al., 2017). The latter plays a fundamental role because there are many types of crises, and some cannot be anticipated. When this situation occurs, companies need to be able to catch its signals as soon as possible; otherwise, it can become too late. A resilient entity should identify the necessity to change before this becomes the only option available.

In the presence of uncertainties, individuals must be able to detect and analyse changes in the environment and plan appropriate actions promptly; these are known as positive cognitive responses and are essential to overcome difficulties. It means that individuals should be able to deviate from routines to identify the actions that will maintain the positive functioning of operations. Once the strategies have been identified, the next step is the execution of actions, where the planned activities are executed; there are specific actions that allow the organization to recover from a difficulty. The latter and the cognitive responses take place within a context that has an important effect on them. In fact, organizations have different levels of information sharing and degrees of depth of relationships. In order to build resilience, the exchange of information and the relationships that employees have with each other play a significant role. Going beyond the organizational level, firms should take great care of social capital because partners in the network can provide useful hints and resources (Williams et al., 2017).

Resilience is also affected by previous experiences of individuals; if an individual has already overcome a threat in the past, he can exploit that experience with the new threat. The same is true at the organizational level; previous experience is very useful because an entity already knows what processes to activate. Obviously, this can work only if the threat is similar to that already experienced (Williams et al., 2017).

In the end, resilient systems (individual, organization, or others) are characterized by four abilities that give a structure to what has been described above (Hollnagel, 2013; Gayer et al., 2022):

1. The ability to respond

   Companies need to be able to respond to threats, adversities, and changes in order to survive. Before responding, it is necessary to individuate that something is happening, understand the event, and identify the appropriate response. Once an event is identified, the degree of importance has to be defined because only sufficiently serious adversities require a response. It must be efficient and arrive within an appropriate time in order to determine the desired change. Entities can have prepared actions or, otherwise, should be capable of making the necessary adjustments.

2. The ability to monitor

   It is focused on the system itself and the environment with the idea of detecting threats and adversities that will become a reality in the near future. Many times, companies use lagging indicators, but there is a trade-off between the degree of certainty that the indicator provides and the probability of success in overcoming the threat.

3. The ability to anticipate

   Monitoring is surely useful, but it is also valuable to look at a more distant point in time with the idea of anticipating faraway threats and adversities. For being able to do the anticipation, the functioning of the system must be well known, and the system and the environment must be stable enough for their descriptions to remain valid for a sufficient period of time. Clearly, this reasoning is also applied to potential opportunities.

4. The ability to learn

   Learning is referred to as a change in behaviour due to past experience; as already stated, events need to have some degree of similarity. When learning occurs, it must be possible to verify that it is happened; in fact, when the new behaviour does not produce the expected results, learning is not occurring or is wrong. Experience derives from previous adversities, but, given that there are more positive events and near misses than events that go wrong, it may also be useful to learn from them.

Once these four abilities have been defined for a particular system, it is possible to derive the resilience profile of it, thus understanding how resilient the system is (Hollnagel, 2013). The process is not complicated, but for a better understanding, it may be beneficial to rely on some visualization tools, such as star and radar charts. The first step involves carefully defining and describing the system, specifying its boundaries, and the people and resources that belong to it. In the next step, for each ability, the entity defines a set of relevant items, such as the list of events for which the company has a prepared response, the background for choosing them, the relevance of the events listed, the presence of a threshold for triggering a response, and the speed (in the case of the ability to respond). When the company has defined the list of items

(for each ability), it defines a set of questions for each item. These have to consider the system at which they are referred; it is not possible to use the same questions for all the organizations, but they should vary at least according to the sector, taking into account that each entity has its peculiarities. In the next phase, competent people, with appropriate experience in the specific item, provide responses on a particular item; then, they are assessed using always the same scale that goes from missing, when the capability of the system related to a specific item is totally absent, through deficient, unacceptable, acceptable, and satisfactory to excellent, when the capability of the system exceeds on a particular item. To complete the process, the firm records the score for each item based on the responses to the questions. When the company puts together the performance for all items of a specific ability, it has an improved understanding of the current situation. These results can be better visualized using a star chart with a number of axes equal to the number of items and, for each axis, six different levels from missing to excellent. Repeating the work for all abilities, the entity gets its resilience profiles. Obviously, the performance may not be the same for each item, but, according to the system, some items may be more important than others. Finally, it is possible to visualize all the abilities in one star chart with an axis for each ability; it is only necessary to convert the scores of the items into numbers, deriving, through a system of weights, a score from zero to five for each ability. This process works better when repeated three or even four times per year, so it is possible to follow the progress for each item or ability. An advantage of giving priority to relative indications is that the way in which the absolute indications are got loses importance (Hollnagel, 2013).

Until now, the four capabilities have been analysed separately, but they are very interconnected. Considering, for example, the ability to respond to threats, the link with monitoring, that can enhance the responsiveness and quality of the responses, is immediately clear. Learning and anticipation, instead, can improve the efficacy of monitoring; in fact, previous experience and forecast future threats can provide insight into what to look for. What matters to anticipation are people and their past experience that help anticipate future adversities. In turn learning is for sure derived from past events that can teach useful lessons, but past responses are also important because they can teach what works in the presence of a specific adversity (Hollnagel, 2013).

Resilience has been analysed in different disciplines that while sharing some things, have their own peculiarities.

Holling (1973) defines resilience from an ecological point of view and measures it through the probability of extinction. A system can be defined as resilient if it is capable of overcoming challenges and adversities. He compares resilience with stability as two possible behaviours of

a system; stability occurs when a system is able to return to an equilibrium in the presence of adversities. Stability depends on the recovery speed and the fluctuation experienced; in fact, stability improves when the speed increases and the fluctuation decreases. He also observes that with low fluctuation, resilience is less likely. The difference between stability and resilience is at the level of the equilibrium; stability implies the return to the previous state, instead resilience is based on a new equilibrium. Resilient systems, in the case of threats, go through four different steps from rapid growth to reorganization (Ponomarov and Holcomb, 2009).

The supply chain field is critical for companies because high performance cannot usually be obtained without resilient supply chains. For clarity, the extension of the supply chain involves all organizations, from raw materials to the delivery of the product to the final customer. Lately, the number of threats and adversities at this level is increasing, creating serious problems for the companies involved; the criticality of the supply chain is growing mainly due to some current trends, such as globalization, outsourcing, and the increase in the number of terrorist attacks. An important part of resilience is represented by risk management that focuses on mitigating risks. Therefore, the detection and assessment of risks and the identification of appropriate strategies help the company build resilience. It is defined as the ability of a system to put in place measures to mitigate risks, quickly respond, and recover in case of adversities while maintaining normal functionality (Ponomarov and Holcomb, 2009). Therefore, it has several components, one of which is the ability to adjust. It does not necessarily imply the achievement of a new and better equilibrium, because it is also possible to return to the previous one.

The last discipline to consider refers to operational resilience which is the ability of a system to adapt when threats and adversities occur. Today, companies need to be available 24/7 with important consequences. Supermarkets are now open in the evening and the same is true for schools because customers want this. The main result is that companies are more exposed to potential problems. Therefore, to maintain this level of availability, operational resilience is required. Companies need to be prepared and able to recover quickly while maintaining the functionality of the system. Operational resilience is also linked with competitiveness and reputation, because without these a company cannot be resilient (Frost et al., 2000).

In the actual environment, the rate of change is particularly high, exposing companies to a significant operational risk; here, some main drivers will be presented. Globalization is the first driver, and the main outcome is the greater pressure placed on companies that need to find new ways to compete. With the increasing concern for the environment, safety, health, and customer rights, the related regulations and sanctions in case of misbehaviour have also become more

stringent. Another driver is the growth of intangible risks that cannot be insured; in fact, even if the largest companies have the resources to overcome problems at their plants or facilities, these new risks are more difficult to face and traditional protection against risk is not possible. Better awareness of employees, customers, and companies resulted in a very high number of litigations (Frost et al., 2000). Now more than in the past, businesses have to pay attention on granting equal opportunity, safety in workplaces, a healthy environment and products; otherwise, they may be sued and forced to pay large sums of money. Companies in the past have been responsible for accidents and environmental disasters without major consequences, but now this is no longer possible.

These factors may force the company to change, but with the increase in the rate of change, also the operational risk raises. For example, the introduction of a new technology usually does not create problems, but its implementation, when made at the wrong moment or way, can disrupt operations, such as Dow Chemicals that spent half a million and many years to implement its ERP system, and, almost immediately, it became obsolete (Slack and Brandon-Jones, 2019, p. 499). The same is true with an increase in the volume of transactions not followed by a strengthening of the management team or with mergers where integration can be quite challenging. Another risk is given by the product development process that in the case of pharmaceutical companies may involve several years and money, and, in any case, the probability of success is quite low (Frost et al., 2000).

The focus of the next paragraph will be on operational and supply chain resilience that are very interrelated; they are clearly overlapped with also some important differences. Many times, operational resilience is considered part of supply chain resilience (Birkie et al., 2014).

2.3 Functions and dynamic capabilities

An alternative way to define resilience is through its five core functions. Birkie et al. (2014), considering the supply chain and operational resilience, has identified the reconfigure, re-enhance, build, sense, and sustain functions.

- Sense

  Resilience is the ability to face adversities that are not easy to predict. This function is based on the idea that usually there are circumstances signalling the arrival of a threat (Birkie et al., 2014). To be resilient, a company needs to be able to identify these signals

as soon as possible. This function is frequently associated with the warning capability that refers, within a supply chain, to the ability to detect adversities and share related information with all involved companies. Interestingly, they are useful not only for detecting a threat prior to its occurrence or at the same moment, but also if the detection follows the challenge; in fact, when the threat is detected at a subsequent moment but before the forecast time for the products, in case of, for example, an overload that does not allows the company to deliver the promised items, to arrive at the facilities of the customer, it has time to search alternatives.

Warning capability can limit the negative consequences of a threat; for this reason, companies need to develop this capability. It is not required to have a complex system; an email may be necessary. Usually, large companies have a very large quantity of data that makes difficult to promptly analyse all of them; here, a reporting based on exceptions can be necessary. For example, a truck delay can be investigated only when it is greater than 12 hours and the same can be true with trains and ships. A possible simple system is based on regular emails from suppliers with updates about problems that are too small to be noticed but could become very disruptive in the future. For example, a strike can cause many problems, but its signals can be detected months earlier. When negative events occur, information needs to flow faster; many times, prompt communication about a supplier problem can avoid a slowdown in production. To achieve the benefits of the warning capability, companies need to have a high visibility on their suppliers, but also on suppliers' suppliers (Craighead et al., 2007).

A way to detect issues early is through interviews with internal and external stakeholders (customers, suppliers, and employees) who may have noticed some trends. Interviews should be made by experts because there are some misleading issues; in fact, opinions by a person may not be indicative for the entire entity, and they can lead the interviewer off-road, but, at the same time, they can signal potential problems. The results should be summarized in a report and appropriately discussed. To validate the challenges identified, surveys are very useful (McManus et al., 2007).

Companies should pay more attention to the likely events and their consequences, instead of focusing only on the well-known past crises. Consequence Scenarios is a technique, described by McManus et al. (2007), which helps to identify potential problems and the range of their effects through four scenarios; then, the idea is to establish strategies to face them. The main advantage is the possibility to use the strategies established for an event for another one that has the same consequences.

An example of the importance of this function is represented by the government that monitors rainfall and forecasts the effects on rivers. The information is then provided to appropriate agencies and made public. Another notable case is that of Nokia and Ericsson. In 2000, a fire in a Philips building damaged many of the chips directed to Nokia and Ericsson; as soon as possible, Philips alerted them that reacted in different ways. Nokia immediately asked Philips to provide daily information on the situation and organized a team to find a solution; in this way, it has been able to avoid the negative consequences and steal market share from its competitor. Ericsson instead did not react immediately and, in the end, lost 400 million of revenues (Sheffi, 2007).

Within the sense function, there is also the consideration of near misses that can provide insights about possible future threats, allowing a company to prepare strategies to avoid their happening. For example, in 1999 after ignoring a signal of stop, a train engineer caused the death of 31 people, but this distraction was not the first; in fact, in the previous years there have been eight near misses (Sheffi, 2007). Organizations cannot ignore them; the proper identification and analysis can prevent a larger problem in the future.

- Build

  With the previous function, the company has identified some potential threats, but this is not enough to be resilient. The build function refers to the development of the proper capabilities to be prepared when a disruption occurs; in fact, the capabilities are built before a potential problem or immediately after its occurrence (Birkie et al., 2014).

  The main lesson of the Philips case is that the ability to quickly respond to challenges plays a crucial role; it underlines the importance of being resilient. Nokia has previously been able to increase its market share at the expense of its competitor; companies need to be resilient. To improve this capability, organizations can rely on redundancy or flexibility.

  Redundancy is usually based on excess inventory, low utilization rate, and multiple suppliers; they all imply higher costs that are the premium to pay for the benefits. Excess inventory, in particular, can be very costly, so companies have to balance the benefits with the holding costs. The same is true with multiple suppliers and a deliberately low utilization percentage (Sheffi and Rice Jr., 2005).

  Alternatively, the company can build flexibility; it refers to the development of the capabilities necessary to detect early and quickly respond to problems. In the end, it is the capability to adapt to challenges. Supply chains include many elements (Figure 13), one of which is supply. The presence of a single supplier can be very dangerous for

companies, like in the case of Land Rover where the chassis frames supplier of the Discovery model went bankruptcy creating many problems to the company, especially because it discovered the issue only when the chassis frames stopped to arrive. To avoid this risk, many companies increased the number of suppliers, but there are also other approaches; in fact, an alternative is to build a deeper relationship with a single supplier. To have flexibility, it does not matter only the procurement strategy, but it is also important the alignment with the type of relationship; in case of a single supplier, companies have to develop very deep relationships.

The second component of the supply chain is the conversion process; in order to be flexible, it must be able to adapt to disruptions. Some help, in this sense, is provided by standard processes; they ensure that an activity is performed always in the same manner, facilitating the replacement of an absent employee. Another useful feature is the interoperability of plants, such as the Toyota plants that are designed to produce both local products and items of other countries (Sheffi and Rice Jr., 2005).

The third component is the distribution that needs to recover quickly in case of disruptions. With a disruption, companies have to decide the criterion for customer prioritization; it can be based on the duration of the relationship, the service cost, or the long-term value. An important thing is to maintain the same criterion even in the moments immediately after the disruption; in this way, the company can preserve its customer relationships. To increase flexibility in distribution, companies can adopt a model based on selling what they have using service representatives and changing the price to align with customers. When an earthquake interrupted the flow of chips for two important companies such as Apple and Dell, this model allowed Dell to increase the earnings in the third quarter by 41% compared to the previous year. Another useful practice is based on postponing the customization until the orders from customers are known. Keeping the products in this intermediate state, it is possible to align with the preferences of customers (Sheffi and Rice Jr., 2005).

Another component of the supply chain is the control systems that have the function of quickly detecting abnormalities even before their causes are felt. By granting shipment visibility, the customer can immediately notice potential problems. The use of bar codes is another practice that helps identify where all materials and products are located.

The last component is the corporate culture which greatly contributes to resilience. Many times, the company reaction cannot be explained with a particular action but is more related to its mindset, as in the case of Nokia. The successful reaction of Nokia is

explained by its deep relationships with suppliers but also by its mindset of quickly acting in the case of adversities (Sheffi and Rice Jr., 2005).

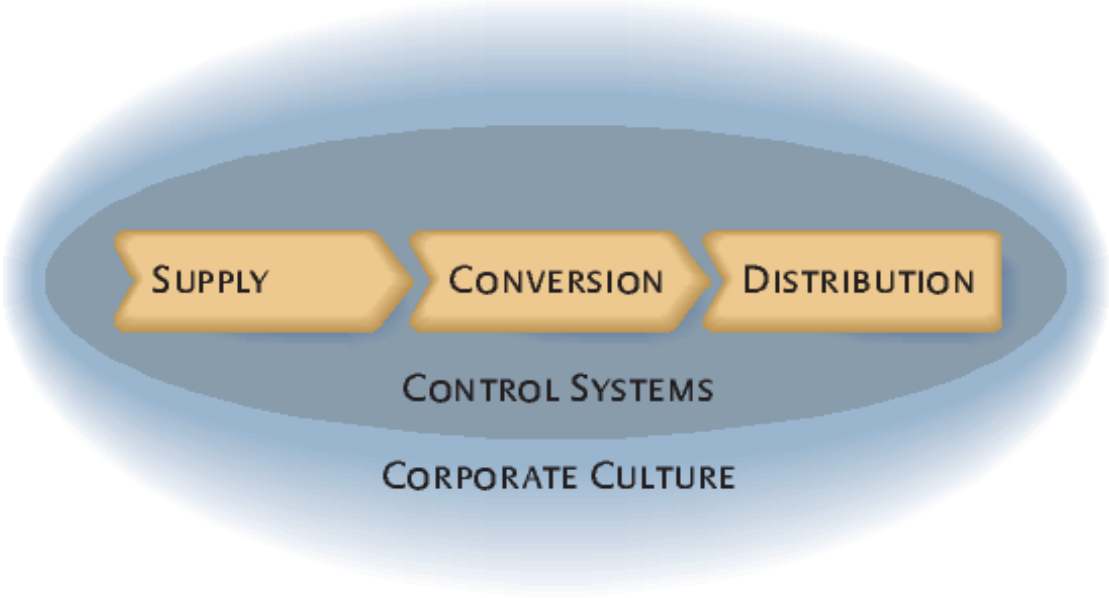

Figure 13: Supply chain elements
Source: Sheffi and Rice Jr. (2005)

- Reconfigure

  The build function introduced some practices useful to reduce the impact of future threats, but the company also needs to be ready and act quickly when a disruption occurs. The reconfigure function refers to the ability of the company to adapt after the occurrence of a threat; clearly, the reaction is conditioned on the available resources. In case of unexpected events, the adaptation involves the entire organization at all levels. Focusing on the supply chain, a common error is to think that the adaptation regards only the supply side, meaning that a firm changes suppliers or supplies; instead, it also includes the demand side. An example is the previously seen model of selling what the company has; in fact, generally speaking, it is a method that enhances flexibility, but when applied after a disruption, it is within the domain of this function (Birkie et al., 2014). When an earthquake blocked the supplies of chips to two large companies like Apple and Dell, they reacted in different ways. Apple, in particular, has not been able to adapt to the new circumstances and has been forced to stop the launch of the new products offering to refund customers; in the end, even if some of them chose a different version of the product, many customers did not have bought anything else, resulting in decreased sales. Instead, the Dell model permitted its competitor to speedily adapt to the new circumstances and to increase revenues (Craighead et al., 2007).

The warning capability is very important for the sense function, but there is also another mitigation capability that instead belongs to the reconfigure function. It is called recovery capability, and within a supply chain, it refers to the ability to restore product flow through collaborations with the affected entities and using the available resources. A supply chain is made up of different nodes linked by the product flow, and a problem in one of them can easily slow down or stop it. An example can be the already seen case of Philips where a lightning caused a fire that stopped or slowed down the production of chips for Nokia and Ericsson.

The development of this capability helps the company reduce the impact of a disruption and improves the speed of recovery. Usually, it is granted through buffer inventory such as a car maker that has some suppliers overseas and so decides to keep a small number of products in each port paying the rental fee even if they are not used but remain there. This appears to make no sense to competitors and even to some managers of the same company when normality persists, but as soon as a disruption occurs, the company can continue producing when competitors have to stop. In a supply chain, together with the use of buffer inventory or other types of resources, such as human capital, it is also important to establish cooperation and communication among its members; for example, through frequent calls, all companies have accurate information available that is used to make better decisions. Recovery capability can also be proactive, such as the case of a company that, after understanding the risk of relying only on a port, decided to move part of the products to another port, limiting the dangerous effects of a strike (Sheffi and Rice Jr., 2015).

- Re-enhance

  After a threat, the performance of the company suffers, but resilient entities are able to quickly return to previous level or even higher one. Therefore, this function refers to the ability of the company to remain competitive even during and after an adversity (Birkie et al., 2014).

  The company can measure the performance using many different metrics and use the chosen one to analyse the impact. As written previously, before a disruption, the company can take several actions to improve the ability to detect and limit the impact of an adversity. When the impact occurs, the performance may not be hit immediately, even if it is possible; therefore, initially the only visible signal may be a small deterioration of the performance, but soon the full impact is experienced, and here the performance suffers greatly. Immediately after the threat, the company will take some actions to limit damage, but what matters is the recovery that begins immediately

afterward, in its early phases. To respect the defined production schedule, the company may temporarily increase the working hours or the utilization rate. Sometimes, especially when the trust of the customers is compromised, there can be long-term effects on performance that do not permit the return to the previous level (Sheffi and Rice Jr., 2015).

- Sustain

  A resilient company should be able to achieve the established business objectives (Birkie et al., 2014). After an adversity, companies should not stop production otherwise, they may lose customers, such as the case of the Japanese shoe producer whose customers have been forced to change supplier after an earthquake and they never came back (Sheffi and Rice Jr., 2005).

In line with resilience is the idea that companies can survive only if they have a sustainable competitive advantage; it allows them to achieve superior returns with respect to competitors. There are different approaches that explain how it is possible to achieve higher profits than competitors, such as the competitive forces approach firstly defined by Porter. It measures profitability at the industry level, looking at the industry, industries, or sub-industry where the company competes. Porter states that profitability depends on five forces: suppliers, buyers, substitutes, new entrants, and industry competitors. They can reduce the attractiveness of an industry. Consequently, companies should try to limit them; the competitive forces approach is based on the idea of monopolist rent, and a company to earn it should position itself to limit the influence of these five forces (Teece et al., 1997). Instead, according to the resource-based view, the competitive advantage of a company depends on its resources; in fact, it is conditioned on the possession of valuable, rare, inimitable, and non-substitutable resources. Companies with them can earn superior profits under the assumption that organizations are heterogeneous. Otherwise, if all companies have the same resources, there cannot be a competitive advantage. This theory does not explain what happens with changes in the environment because, when they happen, companies need to modify their resource mix to adapt to the new circumstances, but this is not described by the resource-based view; it does not specify how to renovate existing resources that can become obsolete. For this reason, it is useful to introduce the concept of dynamic capabilities. This view does not summarize a company as a mix of resources; it does not have a static view of the organization but proposes that there are also processes to renew the stock of existing resources. Without these processes, it is not possible to have a sustainable competitive advantage; therefore, the only presence of VRIN resources is not necessary because maybe it can grant short-term profits as soon as the environment remains stable, but in the long-term companies need to be able to adapt (Ambrosini and Bowman, 2009). Considering

successful companies, such as Apple, Toyota, and others, it is surely true that they focus on the possession of valuable resources, but this is not the only aspect; in fact, they are also characterized by their ability to adapt.

Dynamic capabilities connect with the resource-based view and refer to the processes that create, build, reconfigure, and integrate the resources of the company in order to adjust to a change in the environment. In the end, these processes act on the resource base to align it with the new conditions. A company may also overcome a crisis because of luck or, in any case, unintentionally, but when this occurs, the dynamic capabilities have nothing to do with it because they imply deliberate and intentional processes. They act on the resource base to promote its improvement and make the company more competitive; therefore, the created resources need to be useful to maintain the competitiveness of the company. Dynamic capabilities have different functions; some enable the organization to create new resources, others to reconfigure resources, and others to integrate them (Ambrosini and Bowman, 2009).

The idea is that companies exploit these capabilities to overcome difficulties; therefore, a resilient organization must have these capabilities that can be proactive or reactive (Birkie et al., 2014). Proactive capabilities are used before the occurrence of a potential adversity in order to avoid negative consequences; instead, reactive capabilities are used after an adversity with the aim of limiting the impact and facilitating recovery. Companies should have both because during a crisis it could be fundamental both the detection of a potential threat far before the impact and the presence of measures that grant a quick recovery after the impact. There are many examples of proactive measures, such as Nokia's long-term and deep relationships with its suppliers that have been useful immediately after the problem at the Philips plant to obtain additional supplies. Other examples are the ability of Nokia to detect a threat early and the process of postponing customization as late as possible of Dell which gives it more flexibility and higher returns than competitors (Birkie et al., 2014). As written, reactive capabilities are equally important and, without them, a company cannot be truly defined as resilient.

Companies have always had to deal with adversities and threats with the potential to cause serious damage, but lately their number has grown considerably (Wu, 2011). Financial crisis, energy price volatility, and terrorist attacks together with the higher interconnectivity and mutual dependence of companies have increased the stress on them; these factors increased the bankruptcy probability of weaker companies, but, given that all companies are interconnected, a problem in a company creates problems for all others and the entire system is put under pressure. Wu (2011) called this the "risk society".

Companies, against threats, are not inert, but, according to the "Spring" model, dynamic capabilities should be exploited to reach established business objectives independently of the occurrence of events. Dynamic capabilities can be deployed to detect and limit the impact of a threat and to ensure quick recovery.

The model is characterized by different elements; the starting point is an initial situation that is the result of the past, and, on the other side, a mission or objective that is the target to reach within a specific time. To achieve the target, it is necessary to specify a strategy; in an ideal state, there are only these elements, but the reality is quite different. In the risk society, many adversities could prevent the achievement of the business objectives that are all the targets established by the company. In the model, the dynamic capabilities are represented as springs that absorb the impact of an event (Figure 14). As written previously, these capabilities allow the organization to modify the resource base in order to align with the new conditions in the environment. An event can have different consequences as it can determine the modification of the strategy, impact a dynamic capability, or change the business objectives (Wu, 2011, pp. 287-289).

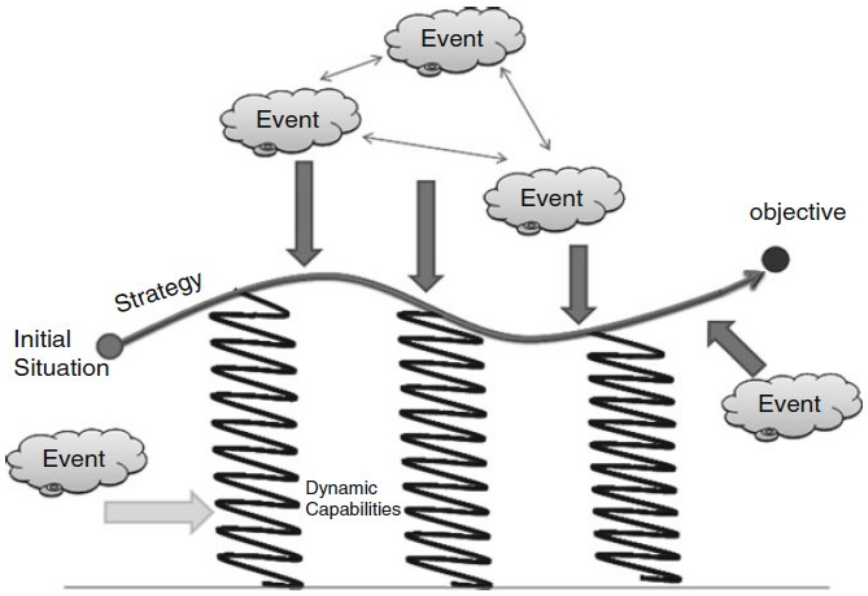

Figure 14: The "Spring" model

Source: Wu (2011, p. 288)

Dynamic capabilities can be classified into four categories (Wu, 2011, pp. 289-290):

1. Integration/Coordination

   In the economy, coordination is granted by the system of prices; instead, within organizations, it is a duty of managers. Integration/Coordination needs to be performed

efficiently because it is directly related to many performance measures, such as in the automobile sector, where companies have different ways to coordinate the activities from concept to market, and this is reflected in the lead time necessary to develop the product and in the quality (Teece et al., 1997). Coordination capabilities have an internal focus and refer to the management of all the internal activities, also including the way in which information is transmitted. The way in which information is processed has a significant effect on quality compared to automation or capital investments. Instead, integration has an external focus; for example, in the new environment, companies need to be well integrated with the technologies and activities of suppliers (Teece et al., 1997).

2. Learning

   The learning capability is responsible for improving how tasks are performed; clearly, improvement as an outcome is the result of the continued repetition of a task and the execution of tests to verify what has been learned and provide additional learning. It surely depends on the individual abilities but, in the end, occurs within the organization and is dependent on it. Communication is necessary to have the required exchange of knowledge (Teece et al., 1997).

3. Reconfiguration

   Reconfiguration capability allows a company to change containing costs that otherwise can be very high. It is conditioned on the capability to scan the environment and needs to be performed quickly and before the competitors to provide benefits. It can be learned and improved when changes are executed frequently (Teece et al., 1997).

4. Delivery

   This capability is very important for the company because it refers to the execution of the activities necessary to create a product or service.

2.4 The ten items of resilience

Therefore, resilience is the ability of the company to overcome pressures and achieve the established business objectives by exploiting dynamic capabilities.

In this paragraph, the five previously defined functions are put in relation with the dynamic capabilities (Table 3).

Dynamic capability	**Function**
Scan environment to identify threats and opportunities (learning)	Sense
Persistent communication and coordination among multiple forms of expertise (integration/coordination)	
Build staff experience and knowledge sharing (learning)	Build
Learn from previous experience (learning)	
Long-term customer-supplier relationships (integration/coordination)	
Speed and effort of recovery and enhancement (integration/coordination; reconfiguration)	Re-enhance
Shift leadership to people who have answers to the current situation (integration/coordination; reconfiguration)	
Align value proposed by company and expected by customer (Delivery)	Sustain
Shift demand across time, market, or product (Delivery)	Reconfigure
Information sharing and dissemination, VMI (integration/coordination)	

Table 3: Resilience functions and dynamic capabilities

Source: Adapted from Birkie et al. (2014)

Scan environment to identify threats and opportunities

Scanning activity is the first step in the company's adaptation to the environment and is based on the detection of potential opportunities and threats, the evaluation of their likely impact, and the diffusion of related information within the company; the latter is frequently overlooked but builds awareness. The external environment is not limited to the groups that directly influence and are influenced by the organization, such as suppliers, creditors, local community, workers, governments, and workers' association, but it also includes the forces that may affect the company in the long term, such as the culture and the technology (Hagen and Amin, 1995). Scanning is performed by managers who decide what to look for, but this is surely linked with the overall strategy of the company; clearly, different strategies have different requirements. According to Porter, cost leadership and differentiation strategies are the most important; a company adopting cost leadership aims to be the organization with the lowest costs in the market and pursues efficiency among all other objectives. Instead, the differentiation strategy wants to differentiate the company from competitors. The implication is that the strategy influences the scanning activities; in fact, research executed by Hagen and Amin (1995) showed that companies focused on differentiation care more about opportunities and the satisfaction of customers' requirements. On the other hand, companies that rely on cost leadership instead focuses on threats from competitors and regulators.

Once the environment has been scanned, the company can place the identified threats in a matrix that defines an adversity in terms of its consequences and the probability of its occurrence. The matrix defines the vulnerability of a company to defined threats and allows managers to focus their attention on them (Sheffi and Rice, 2005). The likelihood and consequences are affected by the actions of managers, and therefore the matrix should be constantly updated. The two variables depend on the specific organization because, for example, the damage of a terrorist attack and the probability are not the same for all companies. The impact is greater for a company with only one distribution centre compared to the case in which there are several centres (Sheffi and Rice, 2005). When the company has defined the matrix, it should establish the strategies that will limit the danger; then, the matrix should be modified accordingly. For example, strategies that limit the probability of sabotages and redundancy can be very important.

Scanning the environment has several benefits, because it allows the company to think about strategies to limit damage or prevent it from happening. On the other hand, ignoring the environment can be very dangerous, as in the case of Toyota. In 2009, an accident of a Lexus caused the death of all the people inside; in the moments immediately before, they clearly said

that the car had suddenly accelerated without having the possibility to brake. When this accident became public, other cases have been discovered, and several complaints have been sent to competent authorities (Heller and Darling, 2012). The authority investigating the case has declared that the cause was related to the floor mat that blocked the accelerator pedal. Immediately after, Toyota started recalling many vehicles to solve the problem, even if it was forced to apologize because it provided misleading information stating that there was no defect. The investigation of the authority started some years earlier in 2007 after more than 20 episodes of unwanted accelerations. With the recall in 2009 Toyota fixed the problem of floor mats and also added a programme that stopped the acceleration pedal when the brake pedal is pushed. The surprising thing is that this problem was not only related to 2009 or 2007 but Toyota has ignored more than 1000 complaints over the past 8 years. Then in 2010, a new incident due to an unwanted acceleration killed all the people in the Toyota vehicle, and the company was forced to a second recall. This time, the action has regarded many of the automobiles in the United States together with Europe and China. The result of not listening to the environment has been a huge decrease in sales, a reduction in the trust of customers in Toyota, and more than 26 million in fines (Heller and Darling, 2012).

Despite this specific case, Toyota and lean companies should perform the environmental scan very well; in fact, this practice in the automotive sector was first pioneered by Toyota and its dealers. The distribution system of Toyota, at least in Japan, was quite different from the rest of the world; here, dealers sold cars door to door. The process, as described by Womack et al. (2007, pp. 185-186), started with the dealers that derived a profile for each household and then periodically visited the customers. During visits, they asked questions about the cars the client had, preferred features, complaints, and time required to change cars. Finally, this information was transmitted to the team responsible for the development of the new product. The result of the process was a true scanning activity with the goal of keeping the company aligned with the customers. Clearly, this process has not been replicated outside of Japan, and even in Japan it has changed, but it demonstrates the attitude of lean companies toward environmental scanning. The importance of this activity for all lean companies is also underlined by the first principle, according to which companies carefully define what is important to customers.

Persistent communication and coordination among multiple forms of expertise

Resilient companies are able to overcome adversities, but this process can involve different processes and different companies. A part of resilience is the early identification of the warning signals, through the analysis of past data and the study of near misses. After understanding past data, the company can better forecast potential threats and adversities and put in place appropriate strategies. Another part of resilience is the reaction and the ability to adapt when a threat hits the company. Some threats are unforecastable and consequently the company needs to be able to recover quickly. The last part of resilience is learning; in fact, past threats and reactions create knowledge that is accumulated and help the company with successive adversities (Park et al., 2013).

After specifying this process, it is clear that resilience involves communication and coordination among multiple forms of expertise; if the data used by the company to identify the warning signals come only from the company, they might not be significant because they are too limited. In order to solve this problem, the company may collaborate with other organizations, but this requires frequent and effective communication and coordinated actions, plans, and strategies. At the same time, when the company changes to adapt to external circumstances, partners may also need changes, or the company may change because other companies are changing (Park et al., 2013). The communication of information and the coordination of actions is not only relevant externally among organizations, but it is equally important within the company. Many times, companies overlook the importance of communication and coordination between production and engineering and design products without considering the constraints of production. When this occurs, additional work is needed and the company loses time and money for a problem that should never occur (Iansiti and Clark, 1994). Communication and coordination among employees with different experiences are valuable also inside the development team with the main result of improving the hit rate and reducing the development time.

Toyota proved to be very efficient in developing new models compared to other companies. This is for sure due to its superior ability in managing the development process, coordinating employees, and communicating information.

The development process is very complicated because it involves complex interactions between many experts. Western companies usually rely on matrix structures where there are project teams and functions, but the problem is related to the role of the project managers; in fact, they

act more as coordinators than managers with employees that are evaluated and respond to functional managers. Another issue concerns the process that, many times, is sequential and, therefore, it takes a long time. Even lean companies use matrix, but here employees remain in the project for its entire life with a leader that is a true manager. Employees are evaluated on the basis of their performance on the project that is simultaneous and has a high number of employees at the beginning, in order to solve early all the problems, and then it decreases. The result is that a new product requires, on average, only 1.7 million hours and 46 days compared to the 3.1 million hours and 60 days for the other companies that also employ twice as many people (Womack et al., 2007, pp. 105-118).

Build staff experience and knowledge sharing

To be resilient, companies have to emphasize both internal and external knowledge sharing. The former can be increased through project teams with employees from different functions, improved communication, and the use of standards. The exchange of external knowledge is equally important because threats come from outside the company. A good practice is to look to other industries for new ideas and information; this can be useful to protect from the substitution threat and to discover new technologies early. Companies can improve the external knowledge network in different ways, such as participating in meetings with other entrepreneurs in the area or in the industry, where valuable information can be obtained. Another practice involves the development of partnerships with universities or research centres that can be useful to identify warning signals; otherwise, companies can also rely on partnerships with companies from other countries (Demmer et al., 2011). These practices allow the company to expand its knowledge network, where knowledge sharing occurs.

Knowledge sharing is also effectively promoted by lean companies and, in particular, Toyota that has created a network called “Toyota Group” based on a philosophy of mutual development and prosperity. It successfully created a strong network identity that has facilitated the sharing of valuable knowledge. This identity has been created through several actions. The first is the definition of supplier associations that group suppliers that are geographically close to discuss specific arguments, such as costs, safety, or quality. Important is also the creation of consulting teams that help suppliers improve their efficiency for free. Toyota has also created teams with only key suppliers that meet regularly with the aim of improving together in a defined area that changes every year. One of the best strategies to promote knowledge sharing is the exchange of employees among companies (Dyer and Nobeoka, 2000); in fact, Toyota regularly sends its employees to suppliers to help them and, at the same time, welcomes employees from suppliers.

Resilient companies also have to build employee experience; in Toyota, all workers start from the place where the value is created, the production line. Managers continually test employees with gradually more challenging problems to verify their skills (Womack et al., 2007, pp. 203-205).

Learn from previous experience

An important part of resilience involves learning from previous experience. The idea is to exploit the knowledge accumulated during past threats and subsequent reactions to improve the effectiveness of future strategies; in fact, if the company has already faced a particular adversity in the past, it should know whether or not a particular strategy works.

Sometimes, before an adversity, there were also several near misses that did not cause damage but were very close to do so; it is important to analyse them otherwise the consequences may be very bed, such as the case of the incident with train that caused the depth of 31 people but before there have been eight near misses that, if correctly analysed, they could prevent the disaster (Sheffi, 2007, p. 55).

One of the biggest lessons has been learned from the terrorist attack of 2001; here, companies have understood for the first time how vulnerable they were to a threat. They discovered their interdependence and the weakness of the supply chain and started actions to protect themselves from adversities. One of the main consequences has been the introduction of strong screening processes that were no longer limited to the selection of employees but also included the ongoing tracking and monitoring of all employees and third parties with knowledge and security access (Rice and Caniato, 2003).

Previous experience is also important for lean companies and is the basis for continuous improvement mentality. Continuous improvement is realized by moving from one standard to another standard; therefore, the existing standard becomes the reference point from which a better arrival point is defined. The PDCA cycle defines the process to follow to introduce an improvement; the starting point is always a problem that needs to be accurately analysed to identify the root causes. Once these have been defined, the employees search and implement an efficient and effective solution. This process is entirely documented through the A3 tool that is one of the reasons for Toyota's success. It, similarly to what has been seen previously, documents all the solutions tried and their results, making it effectively possible to learn from the previous experience.

Long-term customer-supplier relationships

Collaborations with suppliers have many advantages for the involved companies and play an important role in ensuring supply chain resilience. There is a collaboration when independent companies choose to work together. It is important because companies can forecast many adversities, but some are unpredictable, and, in this case, collaborations can help them recover quickly. They also grant early detection of events but require common goals to be effectively established. In the end, the influence of collaboration on resilience is not direct; in fact, collaborations increase visibility, flexibility, or/and velocity that ensure the resilience of the supply chain (Scholten and Schilder, 2015). Velocity refers to the time necessary to recover; instead, visibility refers to access to valuable, relevant, and on-time information. In collaborations, partners must be available to share relevant, valuable, and on-time information and to communicate frequently and effectively. These practices improve flexibility, velocity, and visibility; clearly, visibility depends on the type of information shared and the mode of communication. The right type of information, if provided in time, can also improve the velocity, giving customers the time to react. The same is true in the opposite direction because information about a customer problem can help the supplier plan for missed deliveries. Healthy relationships are based on resource sharing with partners and decision synchronization that try to increase efficiency at the supply chain level. Resource sharing also refers to the exchanges of personnel to help the company recover; in this way, the resilience of the company increases (Scholten and Schilder, 2015). This is similar to Toyota's practices, such as personnel exchange and site visits, to spread the lean principles to its suppliers. Relationships are usually characterized by mutual dependency that has a positive effect in terms of information and resource sharing, better communication, joint problem solving, and incentive alignment that in exchange increase resilience. The advantages are the same if the dependence of the two companies is toward a third entity. Partners that work together usually get a better understanding and ability to respond to the environment; the knowledge created improves velocity and visibility, and therefore resilience. A useful activity is to analyse past problems with partners to identify better ways to respond and warning signals; in this way, a company can effectively reduce the time necessary to recover (Scholten and Schilder, 2015). In the end, relationships to improve resilience must be characterized by information and resource sharing, frequent and effective communication, decision synchronization, joint problem solving, incentive alignment, mutual dependence, and knowledge creation.

The practice of collaborations is widely used by lean companies; when Womack and Jones (2007, pp. 141-196) described the way in which dealers and suppliers are organized by Toyota, they defined many of the features seen above.

Initially, in the automotive sector, the system utilized by Ford was based on the internal production of all the required parts; successively, it started to ask completely independent companies to produce the necessary parts and forced them to compete against each other. General Motors has proposed an alternative way that mainly utilized decentralized divisions to produce the parts needed. In order to promote cost reduction and efficiency, the divisions become independent profit centres, making them responsible for their performance. In detail, in the United States and Europe, the process involved many suppliers for each part, but when a large investment is required, clearly, the number decreased. The suppliers proposed a price and the one proposing the lowest price won the race that involved a contract of usually one year. Suppliers received drawings directly from the assembler and had to respect quality and delivery standards otherwise they were fired; clearly, information sharing was not possible because this would have compromised the results of the future races for supplies. This situation is similar to that of dealers. Ford did not care much for customers and dealers; it tried to keep dealers small. The main activity of marketing was to grant incentives to ensure the sale of all cars; at the same time, salespeople had little knowledge about the product, interest in the customer after the sale, and incentive to share information with the assembler (Womack and Jones, 2007, pp. 141-196).

Instead, the Toyota way is quite different; suppliers are defined at the beginning of the development process among those that produce the same parts for the other models. Suppliers have employees in the development team where the general design of each part is defined. Usually, detailed design and engineering are left to first-tier suppliers, but for the most important parts, it is performed directly by the assembler. At the beginning, the assembler defines a target price, and then tries to find a way to make the product respecting this target and granting a profit for itself and for suppliers. Suppliers are evaluated on the basis of quality, delivery, and cost reduction performance; clearly, this system to work requires the sharing of information about cost and production performance (Womack and Jones, 2007, pp. 141-196). An interesting assumption is that of decreasing costs; in fact, in mass production, suppliers fixed a price below the cost, hoping then to increase it over the years. Here, instead, the supplier and the assembler define a shared learning curve, and when the performance is not reached, the assembler helps the supplier to improve it. Suppliers are also organized in associations where they share production techniques and innovations. At the same time, dealers are organized in channels that have some members in the development teams. Each channel has independent,

partially owned, and owned dealers with well-trained salespeople who collect information about customers, immediately shared with the assembler. They also have long-term relationships with the company (Womack and Jones, 2007, pp. 141-196). This type of collaboration with suppliers and dealers grants all the features written above that ensure reliance.

This system is not limited only to Toyota but has been replicated by other lean companies as a best practice and has the main advantage of ensuring resilience.

Speed and effort of recovery and enhancement

Resilient companies need to be able to recover quickly from adversities; this, as already seen, is affected by mitigation capabilities that can also consider the opportunities. There are two mitigation capabilities, the recovery and warning capabilities. The former, within the supply chain context, is the ability to overcome problems that threaten the product flow. It can be enhanced through several actions, such as, in the case of a distant overseas supplier, the presence of a small quantity of its product in each port for which the company pays a rental fee even if it is not using it, because, in this way, the customer can continue to work even in case of problems at the facilities of the supplier. Together with resources, communication is also important; all the parties involved should meet frequently in this way all know what the others are doing, and the main result is the coordination. Actions can be proactive, when executed before the disruption, or reactive. Even if proactive actions are better, the main benefits of both are related to the reduction of the severity in disruption and the increase of speed of recovery (Craighead et al., 2007).

The warning capability refers to the detection of a threat before its occurrence, when it occurs, or also after its occurrence as soon as the detection occurs before the time that would be necessary for the products to arrive to the customer. The spread of related information to the parties involved is equally important. It can be based on weekly emails that report the problems with employees, regulations, and other issues, exception reporting, or other, and it has the advantage of reducing the severity of a threat (Craighead et al., 2007). It is usually referred to threats, but the reasoning is the same for opportunities.

Lean companies have deep relationships with suppliers that can help them detect potential or actual threats, and the association of suppliers helps to spread the information in the entire network; at the same time, the continuous improvement is based on the detection of a problem, because without problems there cannot be improvement. The suggestion system, frequently used by lean companies, can help identify problems and opportunities; therefore, Lean

Management brings to the early detection of threats, and the related companies have a good warning capability. Given their collaborations with suppliers and the use of more than one supplier for each product, in the event of a problem, they are able to reroute the product flow, overcoming the difficulty in this way. A problem in terms of resources can be the low amount of inventory. The recovery capability requires communication and cooperation that are also very important for lean companies; in the end, even if the low amount of inventory can be a problem, lean companies perform well when considering the speed and effort of recovery and enhancement.

Shift leadership to people who have answers to the current situation

Usually, organizations are based on an authority hierarchy where decisions are taken by employees at the higher levels; the problem is that these employees are distant from the shop floor, receive only filtered information, and maybe they are there for political decisions. In the end, they do not have a clear idea of what is happening (Weick and Sutcliffe, 2011, pp. 73-80). In “the era of turbulence” characterized by difficult to predict threats, this can be very harmful because they are unable to make the best decisions and act quickly. Usually, before threats, there are warning signals that are seen by lower-level employees. In order to quickly adapt, organizations should delegate decisions to lower-lever workers who can take decisions with greater speed. Good managers should be able to ask for help; usually, this is seen as a signal of weakness, but instead, the ability to recognise one’s limitations is, clearly, a strength. The idea is to give priority to expertise that is a complex bundle including also experience; resilient companies need to rely on expertise in the presence of unexpected events. When this occurs, within the company, an informal network that pools together employees with knowledge should be created with the aim of helping the company to recover quickly; once the problem is solved, this network disappears (Weick and Sutcliffe, 2011, pp.73-80).

The main feature of lean companies is continuous improvement that is very difficult to achieve because it implies continuity and a change at the cultural level; in fact, it is based on daily improvements made everywhere by everyone. It is a continuing challenge to existing processes and ways of performing tasks. To achieve this, leadership plays a very important role because it has to promote and install a new mentality that many companies fail to achieve. Within lean companies, leaders have also to continuously improve; in particular, they need to be able to identify their weaknesses and improve in order to develop complete knowledge of all processes. Traditionally leaders also have to solve all the problems, but the continuous improvement mentality requires instead to promote problem solving processes. To improve this ability, employees need to receive challenging problems to solve and be free to make errors; therefore,

the focus is on the individual and his/her development that has to occur directly in the gemba, the place where the value is created (Dombrowski and Mielke, 2014). Decisions should not be taken in distant offices, but leaders should be as close as possible to employees and gemba, that is where the problems occur, to take better decisions.

In the end, within lean companies, employees play a very important role because they are responsible for problem solving; hence, with respect to traditional companies, this responsibility is delegated to them. Another important point is the development of leaders and workers and therefore of their knowledge and expertise; consequently, many of the features necessary to be resilient are also promoted by Lean Management.

Align value proposed by company and expected by customer

The market is now very unstable and companies are facing many difficulties; in fact, on the one hand, the competition is increasing, and, on the other hand, customers have better information and more choice. This has rapidly decreased the margins of companies and questioned their survival; therefore, now resilience becomes very important. The main problem of organizations is that they focus on their products and services without taking care of customers; in case of acceptance problems, they use the price lever, but this is not the right strategy. Companies should instead give priority, above all, to customers, maximizing in this way the customer value (Gulati, 2010, pp. 6-15). This problem has already been faced with lean companies where a central issue regarded the potential distortions that can occur; in fact, sometimes companies make the error of giving priority to shareholders or engineers. The latter literally create products looking only at the complexity of the features without considering customers. One of the main mistakes is to consider existing assets and technologies in the equation, when instead the only priority should be customers.

Many companies have understood the importance of customers, and, formally, they state to be truly customers centric, but this is very difficult to achieve; together with the companies that focus entirely on products, there are also companies that effectively collect a lot of information about customers and their needs, therefore, they have a good understanding of them, but still remain focused on products (Gulati, 2010, pp. 6-15). Another problem is related to companies that, despite their attention for customers also at the product level, are constrained by their boundaries. The starting idea of Henry Ford was to produce all internally, applying the mass production principles, but this is no longer possible. Companies have to rely on external partners and focus on few key activities that they can provide efficiently; therefore, the integration of external activities becomes very important. The company should carefully select the best

partners and define a shared customer view. One of the main problems is that each company can define value differently according to its needs; instead, customer value is maximized with a shared customer view. Another possible strategy is to use partners to satisfy different and, at the same time, close customers' needs in order to provide a better customer experience (Gulati, 2010, pp. 175-181).

These ideas are exactly reflected in the first lean principle, according to which the value should be defined by customers even if it is created by the company; in fact, companies should carefully identify the features for which customers are willing to pay. This may involve a new dialog with customers and the other companies in the value stream. Once value has been correctly defined, it needs to be frequently updated, becoming part, in this way, of the kaizen mentality.

Shift demand across time, market, or product

In recent years, the uncertainty has increased significantly, exposing companies to a high supply chain risk; to overcome potential adversities, there are various mechanisms. One of these regards the supply, but sometimes this mechanism is useless in the presence of particular conditions, such as when the supply capacity is fixed. When this occurs, companies can reduce the risk by manipulating the demand. In this situation, companies may try to shift demand across time using, for example, the yield management to push customers from the peak period to the other periods, such as in the case of hotels. By adapting the price to the period, the company can maximize profits. Organizations can offer discounts to push customers to anticipate their purchases, this is frequently used by service companies, such as in the airline sector; in fact, travellers are less willing to pay and make their purchase quite in advance compared to businessmen that have a higher reservation value and their trips may not be planned. Companies can also offer discounts to postpone demand; if the airline company is able to move part of the customers to a later flight, this is for sure useful in case of a disruption. Alternatively, companies can shift demand across markets or products. The former refers to the transfer of part of the unsold inventory from the first market to the second market, under the assumption that the product seasons in the two markets are not overlapped; instead, the latter refers to the ability of the company to move the demand from one product to another. This can occur in different ways, such as increasing the substitutability of the two products; in this way, the company can exploit the inventory of a product to satisfy the demand for an out-of-stock product. This shift also occurs when a product has a superior performance and quality compared to the other, or the company can use the price lever; it can modify the degree of substitutability by increasing or decreasing the price, such as in the case of Dell (Tang, 2006). After an earthquake, it has changed the price of its products to move customers toward the products that have not been hit;

with this strategy, it has been able to substantially increase its revenues differently from Apple that suffered the shortage.

As written previously, these practices require the use of discounts, promotions, and inventory. The problem is that lean companies are reluctant to use promotions because it is not possible to forecast the number of products that would be required. They imply an important increase of the demand above the average during which the company relies on overtime and a subsequent decrease characterized by excess capacity and rework (Womack and Jones, 2003, p. 81). For these reasons, lean companies avoid promotions. Lean companies are not against inventory, but surely their philosophy implies to minimize it; therefore, they may not be able to use this mechanism to overcome a problem.

Information sharing and dissemination, VMI

Information sharing is an important part of the warning capability, where it can occur through weekly emails, reports of exceptions, and calls (Craighead et al., 2007). Information must be shared with all parties involved and disseminated throughout the organization.

Products with a long life cycle require accurate information about demand, but the problem is that companies do not directly observe demand; in fact, they forecast demand on the basis of orders from customers. This produces a growth of the variability of orders with the increase of the distance from customers and is known as the bullwhip effect. It has several consequences for the company, such as the worsening of the performance, the increase of the inventory level, and the reduction of the service level (Tang, 2006). Information sharing and vendor managed inventory are two possible strategies to reduce this problem and are, clearly, interrelated. The exchange of information can regard the demand forecast, inventory level, and customer demand; otherwise, the company has only the information about orders and maybe demand distribution. This practice can help the manufacturer reduce costs and overall inventory but may have no benefits to retailers; for this reason, the company can offer discounts and a reduction in lead time to the client. The main obstacle to the exchange of valuable information is related to the fear of losing it and exposure to the opportunistic behaviour of the vendor (Tang, 2006).

Instead of offering discounts, the manufacturer can also provide a service called vendor managed inventory, where it becomes responsible for the ordering decisions as soon as an agreed minimum inventory level is maintained; therefore, the vendor gets information about the inventory of the client and the related customer demand after the promise to reduce the inventory management costs of the client maintaining or even improving the service level. At the same time, the manufacturer receives important benefits related to better coordination

between production and logistics, reduction of inventory level, and reduction of costs. When information is shared, efficiency and visibility in the supply chain and responsiveness to customer demand increase (Tang, 2006).

Lean companies exchange many types of information both internally and externally. As written previously, when the lean way of managing relationships with suppliers has been introduced, an assumption of that system, to work properly, was the exchange of detailed information about costs, production performance, and demand. Information is also exchanged internally through a technique known as visual management that implies showing to all employees what is happening and the difference with the planned situation. It utilizes simple devices, such as computer screens and lights (Slack and Brandon-Jones, 2019, p. 528). The use of lights to signal problems is known as andon and, depending on the complexity of the system, it can be used to indicate shortages, quality problems, and/or machine errors. The same is true for the poka yoke, where the use of photocells can signal the presence of errors.

2.5 Resilience in lean companies

The "Spring" model specifies that resilience depends on dynamic capabilities that are represented as springs capable of absorbing threats (Wu, 2011, pp. 287-289). In the previous paragraph, different dynamic capabilities have been analysed, and the results show that lean companies have many of the features necessary to be resilient; clearly, they are not all present at the highest possible level, and, in any case, the level varies from company to company and according to the industry.

The items presented in Table 3 are linked to the functions of resilience, and I will also maintain this division during this paragraph analysing the different items and without going into the details of the four dynamic capabilities.

The activity of scanning the environment to detect threats and opportunities and the diffusion of the related information allows a company to think about strategies to prevent or limit the impact of adversities and to exploit opportunities (Hagen and Amin, 1995). This has a clear benefit in terms of resilience and is also done by lean companies. The salespeople of Toyota, at least at the beginning in Japan, were famous for visiting customers and gathering information about complaints and preferences transmitted, immediately, to the development team (Womack et al., 2007, pp. 185-186). The constant monitoring of the environment is also suggested by the

first principle according to which the value is defined by customers and its definition needs to be constantly updated. Communication and integration among multiple forms of expertise is equally important for resilience and lean companies; in particular, Toyota has shown superior capabilities in the management of the development teams composed of employees from different functions that remain in the team for the entire life of the project and are assessed on the basis of its performance (Womack et al., 2007, pp. 105-118). The same is true externally with suppliers. Lean companies effectively promote the exchange of knowledge, as in the case of Toyota which has created a network with its suppliers with the aim of promoting mutual development and prosperity. When the ability to learn from the previous experience is analysed, the continuous improvement principle has to be taken into account because it takes the existing standard as reference for defining a better arrival point; in any case, the process for introducing an improvement involves the analyses of the solutions previously tried. To reduce the time necessary to recover and improve resilience, long-term relationships with suppliers and customers, as Toyota does with its network of dealers and suppliers, are very important. The ability to recover quickly is also affected by the possession of warning and recovery capabilities; lean companies have a good warning capability, but their policy of minimizing inventory may decrease their recovery capability. This policy and the adversity of lean companies toward promotions and discounts also have a negative effect on the ability to shift demand across time, market, or product; differently, their delegation of power to employees, the focus on the development of knowledge and expertise, and the customer-centric philosophy improve the ability to overcome or avoid threats and adversities. The last aspect to consider is the exchange of information both internally and externally. Externally, the way of managing the relationships with suppliers involves a large exchange of information, instead, internally this is granted by the visual management technique.

2.6 Conclusion

Recently, the number of threats and adversities has increased considerably starting with the actual chip shortage through strikes to wars. To understand the instability of recent years, Christopher and Holweg (2011) have defined the supply chain volatility index that, considering different parameters, such as the shipping cost, the raw materials price, an interest rate, and others, has as outcome a measure of the overall volatility; therefore, resilience, defined as the ability to overcome threats and adversities, becomes very important also because shocks can move the company away from its development path. Resilience includes two important parts. The first is focused on preventing negative consequences; instead, the second includes the adaptation process, where the early identification of a crisis and the subsequent actions are very important. Resilience has four core functions. The sense function starts from the assumption that there are signals indicating the arrival of a threat, and companies need to be able to identify these signals. It encourages the development of warning capability and the analysis of near misses; however, this is not enough to be resilient. Companies must also be prepared when an adversity occurs; in this case, there are some capabilities that need to be built (build function). These are practices that reduce the impact of future threats, but companies also need to be able to adapt when hit by a challenge (reconfigure function). When this occurs, the performance of the organization suffers, but it has to remain competitive even during an adversity (re-enhance function). The sustain function refers to the ability of the company to reach the established business objectives.

Given the high number of challenges, it is important to introduce the concept of dynamic capabilities. They allow the company to modify the resource mix in order to adapt to the new circumstances; in the model defined by Wu (2011), they are represented as springs capable of absorbing shocks. The resilience analysis of lean companies is performed on ten items that represent the four categories of dynamic capabilities (integration/coordination, learning, reconfiguration, and delivery). The analysis shows that lean companies perform well in terms of resilience. Clearly, the items are not all present at the maximum level, but lean companies own, at a high level, many of the presented items; in any case, their level varies with the company and the industry.

In the end, there are problems only when resilience is based on the use of discounts, promotions, and inventory. It is also important to specify that lean companies are not against inventory and, therefore, with the increase of volatility, lean companies also increase the inventory level.

Chapter 3: The role of workers in resilience and Lean Management

3.1 Introduction

The previous chapters have presented Lean Management and resilience, but the contribution of workers is an overlooked aspect of both.

The paragraph on workers and resilience introduces two key elements of resilience (the shift of leadership to people who have answers to the current situation and knowledge sharing) where the contribution of workers is clear; in fact, knowledge sharing requires the willingness of workers to exchange knowledge, and the shift of leadership to people who have answers to the current situation is based on the idea that decisions should be taken by the individuals near the problem because they can decide better and faster (problem solving). The problem solving capability is treated in the first section that presents the analytical, creative, and practical intelligence useful for solving a problem. The second section is based instead on the topic of knowledge sharing that is important because knowledge resides in the mind of workers; therefore, companies have to create an efficient process of knowledge sharing. This section analyses the nature of knowledge, motivation, opportunities to exchange knowledge, and culture that are the barriers to the exchange of knowledge.

The next paragraph is on workers and Lean Management that is a philosophy with the aim of minimizing waste and maximizing customer value with a huge contribution from workers, necessary to reach both objectives; therefore, this paragraph analyses the consequences for them. This philosophy is based on the idea of producing with the least possible number of workers and on continuous improvement, carried out everywhere and everyday by everyone, that have important consequences for workers; in fact, even if data suggest that lean production outperforms mass production, these results could be achieved either exploiting workers or through the higher commitment, loyalty, and responsibility granted by Lean Management. Finally, teamwork and its benefits are presented, both for employees and the company.

Resistance to change is the topic of the last paragraph that presents this problem common to both resilience and Lean Management. Blinded by the success of Toyota, many companies have adopted the lean philosophy, but in the end, they have not been able to achieve the same results. The problem is related to continuous improvement and the overlooked change of mentality that it implies. At the same time, the increase of the instability in the environment forces companies to change frequently in order to adapt to the new circumstances. However, both Lean Management and resilience have to deal with resistance to change in workers.

3.2 Workers and resilience

Workers play a very important role in ensuring the resilience of the company. As previously written, knowledge sharing and the shift of leadership to people who have answers to the current situation are two key items of resilience, on which the paragraph is focused; here, the role of workers is clear. Knowledge sharing is emphasized internally through the creation of project teams, the enhancement of communication, and the use of standards, but it takes place only if workers exchange knowledge. The shift of leadership to people who have answers to the current situation is the other key item that underlines the importance of delegating responsibilities to workers near the problem so that they can make better and faster decisions (problem solving); therefore, once again, workers are very important.

3.2.1 Problem solving

The link between resilience and problem solving is obvious because there cannot be resilience without the ability to solve problems. In this new era, where many threats are unpredictable, this duty should be left to the workers closer to the threat; otherwise, problems are more difficult to overcome. The main issue is that workers, in the face of a challenge, can react emotionally, losing sight of the problem; expressing feelings and emotions is not wrong per se, but during a threat, extremely emotional workers may not be able to find a proper solution. Emotions also have positive effects on resilience because they affect cognitive skills; in fact, positive emotions increase cognitive skills that, in the end, increase resilience. They are usually derived from everyday life, such as playing sport or hanging out with friends, and can make workers more attentive to details. On the other hand, negative emotions, such as fear and anxiety, have an adverse effect on cognitive skills and resilience (Siebert, 2005, pp. 53-55).

There are different and interrelated types of intelligence that workers can use to solve a problem. Analytical intelligence is one of these, and it refers to the use of reasoning and analysis in order to better understand the problem; in fact, the first step involves understanding the current threat, its relevance, and the time available to find a solution. The worker then has to define the desired outcome and the possible strategies to reach it. Each strategy has potential effects that need to be considered when choosing the best one. After this choice, the worker has to take the appropriate actions, in line with the strategy, to achieve the desired goal and has to collect data

on their results in order to gain appropriate feedback. Finally, the person may need to correct the actions to reach the desired outcome (Siebert, 2005, pp. 56-60).

Analytical intelligence can be useful with many threats and adversities, but sometimes a different type of intelligence is required. Creative intelligence refers to the search for unusual solutions that cannot be found with logic; in fact, logic can limit, in some situations, the ability to find solutions. The initial assumption is that people have, more or less consciously, a lot of information that comes from their life experiences; they only need to access this information. To obtain this access, they have to discard logical reasoning and any other barrier to their imagination; many times, a solution can be found by stopping thinking about the problem and focusing on something relaxing. The first step to improve this intelligence is to absorb a lot of information without making judgments and eliminating any form of self-censorship; in fact, curiosity is an important feature of creative people. Once the process has started, it can be useful to list in a paper all the ideas (Siebert, 2005, pp. 60-65).

Solutions can also come from practical people; this is the third kind of intelligence that is independent of the person's IQ. Consequently, a high IQ does not grant a high practical intelligence. To find a solution, an advice can be to take the point of view of the observer and, therefore, to remain emotionally distant from the other people of the group hit by the same difficulty; in fact, an emotional reaction can waste crucial time. As soon as people stop struggling with reality, they can start to focus on solutions (Siebert, 2005, pp. 66-68).

Companies can exploit and use these types of intelligence or problem solving in combination to gain a competitive advantage over competitors; in fact, in an era with a high rate of change, the ability to find solutions can make the difference. For this reason, companies should develop effective problem solving processes. The required type of intelligence varies with the threat; in case of unexpected adversities, creative intelligence is better than analytical one; instead, the opposite is true with familiar settings (Siebert, 2005, pp. 68-70). In any case, the aim of the company must always be to increase the customer value.

An issue of problems is that they increase the stress of workers; to reduce it, workers can apply problem solving to future problems that it is possible to predict. In this way, they have a ready to use remedy; this process involves identifying the potential problems and a strategy for solving each of them. The preparation of a plan has positive effects for workers who experience less stress (Siebert, 2005, pp. 68-70).

3.2.2 Knowledge sharing

Knowledge sharing refers to the exchange of knowledge that can occur at different levels; the level of individuals is the most important because it affects all the other ones. Knowledge resides within workers, and therefore companies have to improve the efficiency of the knowledge sharing process that is critical for the long-term success of organizations. Knowledge has limited value if it remains within the minds of workers and is lost when workers leave the company. Knowledge is a complex bundle and, for sure, it is related to the task performed by the worker, but it also includes the experiences and the abilities. The sharing occurs as a voluntary act between the sender and the receiver through interaction and has as main result the learning at the individual level; successively, the individual learning is translated into organizational learning. This process pushes the performance of the company far above what an individual alone could do with the main result of improving innovation. Therefore, this process represents the way to achieve a better result in the market, but it is highly dependent on individuals (Ipe, 2003). It also improves customer satisfaction and shareholder value.

To achieve these advantages, companies must remove barriers to knowledge exchange. The first element to consider is the nature of knowledge; the main distinction is between tacit and explicit knowledge. The former is not easy to communicate and is dependent on the personal experiences of the individual; instead, the latter can be easily shared and communicated, but this does not mean that it is actually shared. This refers to the distinction between knowledge that is standardized and completely independent of the original source and the knowledge that is instead held by the person. Independently of the distinction between tacit and explicit knowledge, its value is also important; both individuals and organizations give value to it. The propensity to exchange decreases when the workers perceive that their value decreases with the sharing of knowledge (Ipe, 2003).

The second element to consider is motivation; in fact, sharing is a choice of the individual that must be motivated to do this. Frequently within organizations, workers with valuable knowledge have more power than others; companies that promote this situation will experience low knowledge sharing because workers would lose power. Reciprocity can, instead, increase motivation; it refers to the mutual benefit derived from the exchange of knowledge. When the sender expects to receive benefits from the recipient, even if the time is uncertain, motivation increases. A potential obstacle in this situation is given by the fear of being exploited. Trust is partially related to reciprocity and has the advantage of explaining the actions of individuals; when the sender thinks that the recipient is not contributing equally, the knowledge sharing

decreases. Sometimes companies to motivate employees use a system of rewards and penalties that has been shown to be efficient in promoting knowledge sharing; there are tangible and intangible rewards. The former should be used with attention because in some situations they decrease motivation and, in any case, they are not able to sustain this process in the long term (Ipe, 2003).

The opportunities to exchange knowledge are the third element to consider and can be formal or informal. Formal opportunities are explicitly established by the company with that specific goal and refer, for example, to teams that bring together people with different expertise. The company to improve the effectiveness of the process can regulate the way in which knowledge is exchanged, but the problem is that it is mainly exchanged informally; in fact, the companies tools work only with explicit knowledge. Individuals exchange tacit knowledge through relationships and the social network, where communication and trust become crucial to reach the goal (Ipe, 2003).

The last element to consider is the culture that includes the norms and values of the organization. It is important because it affects the behaviour of employees and, hence, can promote knowledge sharing (Ipe, 2003). An obstacle to this goal is the presence of norms that protect knowledge at the individual level. The problem is that culture is difficult to define and change, and companies do not pay attention to it; even if it can change during the life of the company, this process requires years. The culture of the workplace may not correspond to the organizational culture; this is affected by the social culture and affects the functional or business unit culture. Cultures can be classified according to sociability and solidarity; these characteristics are used to compare different cultures that, more or less strongly, promote knowledge sharing. Sociability is the measure to which friendship-based relationships are promoted within the organization; instead, solidarity refers to the promotion of mutual support among workers. In the end, they make the link between culture and knowledge sharing clearer, given that the former affects the interactions between workers and the willingness to help each other; it also defines the valuable knowledge. A knowledge sharing culture is characterized by high sociability and solidarity, and as written before, relationships that promote the exchange of knowledge. Workers also value fairness of promotions and rewards at both the outcome and process level; the result is the increase in trust and commitment. Finally, companies have to recognize the work of individuals; independently of the type of recognition, this increases the willingness to work beyond the call of duty that, in the end, also increases teamwork (Smith and McKeen, 2003).

Even if the four factors have been analysed individually, they are very interrelated; to be precise, culture affects the other three. In fact, culture defines the valuable knowledge and can encourage relationships and mutual support. The exchange of knowledge does not require the presence of all these elements, but clearly, this would create the best conditions. For example, the high value of the knowledge held by workers can discourage sharing, but the offering of high rewards can reverse the trend (Ipe, 2003).

3.3 Workers and Lean Management

Lean Management has been initially developed by Toyota and Taiichi Ohno but successively has spread far beyond Japan and the automotive industry. Many companies know it as the philosophy that minimizes waste and maximizes customer value, but the impact on workers is less clear; in fact, this system requires a huge contribution from workers. They are necessary to reach both objectives, and therefore it is also important to analyse the consequences from their point of view.

Understanding their role within lean companies is a necessary step before proceeding with the analysis. An implicit assumption is the idea of producing using as few workers as possible that, together with the variability of demand, has important consequences for the workforce. Here, workers need to be reliable because absenteeism can create serious problems, but flexibility is even more required. Employees have to adapt to the prevailing circumstances and be able to perform different tasks according to the requirements; consequently, lean companies are highly focused on training and development (Holman et al., 2005, pp. 15-30). The best-known principle of Lean in the world is kaizen that is frequently translated as continuous improvement. It refers to the ongoing improvement of efficiency but also to the constant development of new products for the market; this process is carried out everywhere and everyday by everyone, also including the shop floor workers who become responsible for problem solving. This means that they are actively engaged in searching for solutions to the problems they face; with this goal, many companies have started to introduce suggestion systems. The continuous improvement system also has consequences for human resource practices that have to ensure performance, motivation, and flexibility (Holman et al., 2005, pp. 15-30). The main change for workers within lean companies is that they become responsible for maintenance and quality check tasks.

Data clearly suggest that lean production has a better performance than mass production, but the consequences for workers are less evident (Babson, 1995); in fact, this result can be due to

either the exploitation of workers or to the higher commitment, loyalty, and responsibility granted by Lean Management.

Workers in lean companies have three different roles; the first is called “doing” work and refers to the physical effort required to work. It is an overlooked aspect of lean production, but it is an important part of the job that is perfectly shared with mass production; an important aspect of mass production is the division of labour that is also present in lean companies. The difference between these two systems is related to the other two roles of workers. With Lean Management, workers also become responsible for the “thinking” work; as previously written, continuous improvement is an important principle, and workers are responsible for it. This is totally different from mass production that separates the thinking part from the physical one (Babson, 1995). Consequently, this new concept changes the training programs that have to develop the ability of employees to contribute; in this way, it is possible to exploit the tacit knowledge related to the performed task. Mass production has the same goal, but the realization is totally different because it instead ignores workers. To improve the efficiency of the process, training programs should also provide knowledge about the overall production system. Clearly, this does not mean that engineers and managers become useless, but they are still responsible for the initial specification and have to approve the potential changes. The third role is called “team” work. In mass production, differently, workers are seen as perfectly substitutable, and the only important thing is to maintain production flow. This has a negative impact on morale and absenteeism. Instead, lean companies focus on teamwork that grants commitment and cooperation. Within teams, the leader has an important role; it replaces the old foreman with the idea of providing support and coaching to the other members. Lean companies also care of teamwork as a synonym of cooperation; with the idea of promoting the relationship with the company that has the advantage of creating alignment with its goals focused on resilience and performance (Babson, 1995).

Therefore, employees expect a completely different way of organizing work, but many times they find only a slight refinement of the previous system; as stated by Holman et al. (2005, pp. 15-30), in many lean companies the authority of workers remains limited as their involvement in decision making. As in mass production, they perform routine tasks and do not have autonomy. Despite this, companies try to reach the promised advantages through surveillance and coercion, but the result is a culture that is not characterized by cooperation; here, instead, workers see teammates as enemies, and the result is the reduction of commitment and of the willingness to contribute to continuous improvement. In this environment, often workers try to actively resist through strikes and other actions. The difference of this situation with the

promised advantages of work satisfaction, flexibility, commitment, and autonomy is due to the wrong implementation of lean philosophy.

As already written, workers within lean companies are organized into teams that have several benefits not only for them but also for the employer. Not all forms of cooperation among workers can be defined as a team, but it requires specific characteristics. Reliance is one of the most important and refers to the interdependence that is created within these systems. It can occur at the task level when the task of an employee is dependent on the task of the previous employee; here, it is possible to identify a clear workflow, but the complexity can also increase. In this case, the interdependence is reciprocal, as in the case of patients, nurses, and doctors, where the patient is welcomed by nurses, then is received by a doctor, and finally, the patient returns to the nurses. Even if this type of interdependence is weak, it also regards outcomes and rewards as in the case where the individual reward depends on the results of the entire group. Every team also has a clear purpose, in line with the goals of the enterprise, and well-defined boundaries that create a recognizable social entity in which members can identify (Holman et al., 2005, pp. 91-105). Organizations can use teams for different purposes and sometimes for limited time, but in this paragraph, the reference is to a way of organizing work.

Work teams are becoming very popular with a constant growing number of companies that choose to adopt this system for its promised advantages; the trend is the same for the entire world. Even workers welcome teams because the benefits also regard them. Teams promise to companies the increase of productivity, but the link is not direct; in fact, the main innovation is the delegation of control to the team itself that substitutes the hierarchy. When control is delegated to peers, it has a greater effect on behaviour and allows the team to make quick decisions; in this way, workers can solve the problems immediately. The main result is the increase in accountability that contributes to developing a sense of responsibility; this, in the end, increases the effort of workers and therefore the productivity. Another advantage is related to the better quality. When an individual faces a problem, he or she has only few resources available; instead, with a team, all the resources of its members are accessible. This increases the likelihood of solving a problem and also of creative outcomes. As mentioned previously, a team replaces the need of managers and administrative personnel; therefore, it substantially decreases the operating costs (Holman et al., 2005, pp. 91-105). Workers, instead, benefit from the improvement of work satisfaction, autonomy, variety, and multi-skilling.

Given these promised benefits, sometimes the reality can be quite different. Even if data suggest that teams actually lead to higher productivity, quality, and sales, there are also cases in which they are only mirages because the context is not right, teams do not receive adequate support,

or the interdependence is too low. In this situation, the team-based work organization is not effective. As previously explained, interdependence is an important requirement that can also be the result of the technology used; alternatively, it can be the result of a managerial decision, such as the idea of grouping together employees that perform different functions. When all members perform the same function, the interdependence decreases. Finally, an effective, even if less powerful, strategy is to define a common goal that involves all members. Another requirement is the presence of the right culture that needs to promote collectivism (Holman et al., 2005, pp. 91-105). Individualism reduces the effectiveness of teams and discourages cooperation. Teams perform better in the presence of high uncertainty where it is difficult to predict exactly what will be required; here, the benefits of this system, such as the ability to take quick decisions, are better exploited. As stated by Holman et al. (2005, pp. 91-105), the impact on productivity depends also on the team composition that includes many elements. Effectiveness is surely related to the abilities present in the team; when many employees are together, the abilities to communicate and resolve disputes are clearly important, but there are also problem solving and coordination to consider. Composition is also a matter of numbers; even if it is not possible to establish a precise number, companies have to consider that communication problems and conflicts increase together with the growth of the resources available. Consequently, there is a point where the disadvantages overcome the advantages. The last aspect to consider is the homogeneity that can regard different aspects. Functional heterogeneity allows members to find better and quicker solutions, but instead personality heterogeneity decreases effectiveness (Holman et al., 2005, pp. 91-105).

Work teams are based on cooperation, but this is highly dependent on the development of trust. Without it, the effectiveness of the group decreases because members will try to reduce their dependence on the others or resist changes that would increase it. Within teams, conflict is usually seen negatively but can also lead to better results.

Teams are very important in lean organizations and are one of the main innovations introduced by Japanese companies. They are guided by a leader that is responsible for coordinating the workers and replaces the Western foreman. This is very distant from the team compared to the Japanese counterpart who is effectively a member of the team. Leaders have to be well trained to be ready in case of unexpected fluctuations in demand to perform the necessary tasks. They have close relationships with the other employees and are also responsible for their assessment and of the allocation of work; in fact, here, responsibilities are assigned directly to teams (Benders and Van Hootegem, 1999). The work is organized through standards, and the only way to deviate from them is through continuous improvement that becomes a responsibility of

workers; here, for the first time, they are legitimized to suggest improvements. Japanese companies have been able to develop a higher sense of membership that is also due to cultural reasons; for them, teams are very important and the same is true for collectivism as the opposite of individualism. This is also reflected in their team-based structure, where teams are part of larger groups that have their own leaders (Benders and Van Hootegem, 1999).

3.4 Resistance to change

Resistance to change is a common problem in both resilience and Lean Management. The success of Toyota and its extraordinary performance pushes many companies toward lean philosophy with the aim of achieving the same advantages, but often this has not happened; in fact, only a small fraction of companies that choose to adopt lean techniques experience a significant performance improvement. The problem is that companies overlook lean implementation, associating Lean only with a set of techniques. Lean instead requires a change in mindset. Companies sometimes think that the high innovation rate of Toyota is the result of a single very innovative person, but this is a huge misunderstanding; instead, this is reached through continuous small improvements made everywhere and everyday by everyone, repeating continuously the PDCA cycle (Liker and Rother, 2011). Therefore, the promised benefits cannot be obtained by only introducing new tools and techniques, such as heijunka and kanban, because one of them per se does not improve performance. For example, heijunka should be seen more as a target condition to reach, overcoming all the obstacles in between. Frequent changes are the direct consequence of continuous improvement with workers that try to resist them because this increases confidence and security; in other words, they resist change. Toyota overcomes the problem through the improvement kata that focuses on the development of solutions. It is a way to make continuous improvement possible, through the PDCA cycle, that starts by defining the direction; then, workers define the target condition and analyse the current one, and finally, they conduct experiments to reach the target conditions (Liker and Rother, 2011). Toyota has implicitly used this technique for years by giving new workers a difficult challenge without the solution but with the help of a coach in order to develop the problem solving capability.

Recently, the instability has increased significantly, and this has direct consequences for companies. Their environment is characterized by labour problems, shocks, natural disasters, and new regulations and technologies, and they usually are difficult to predict; therefore,

companies need to be able to overcome threats and adversities. This is called resilience and is becoming critical to the survival of companies. It includes both pre crisis actions, necessary to avoid or limit the impact of potential threats, and the adaptation process that is required because some events cannot be predicted. Therefore, to survive, companies need to change, but usually the reactions to it are not positive; in fact, employees will try to resist as soon as a change is proposed. This negative attitude can be the result of fear or a wrong culture and consequently increases the rigidity of the enterprise. When a change is required, employees compare the benefits with the costs, and if the costs overcome the benefits, they will try to resist (Laidoune et al., 2021).

Hence, companies need to be able to change; it represents the major challenge of these years, and many managers are trying to develop this skill. Surely, its absence leads to the decline of the company, but at the same time, too much change can also be damaging. The change can be anticipatory, when it is planned in advance for an expected event, or reactive, in the case in which the event cannot be anticipated. Another useful distinction is between strategic and incremental change; the latter occurs when it affects only a subunit of the company, such as the introduction of the night shift, and the former instead alters the strategic direction of the company. As stated by Kreitner (2012, pp. 426-436), these can be combined to define four types of change (Table 4).

1. Tuning
   It is an incremental change and is made to anticipate future threats and adversities.
2. Adaptation
   It still belongs to incremental changes but is done as a reaction to unplanned shocks, such as the case of Dell that will be treated in the next chapter. Briefly, it decided to modify its business model as soon as the circumstances in the environment changed, moving from selling directly to customers to exploiting retailers.
3. Re-orientation
   It affects the strategic choices of the company and is made in advance.
4. Re-creation
   It is reactive and belongs to strategic changes. An example is the decision of Bill Gates to turn Microsoft into an internet company even if initially he had defined it negatively.

Changes affect employees personally because they may imply, for example, a new job or a new superior; consequently, managers need to be able to deal with changes and resistance to change.

Workers resist changes for different reasons; many times, companies introduce changes suddenly without the proper introduction, but this can be disorienting and lead to negative reactions. Other times it is just because of the preference of employees for the status quo, but, in any case, adequate training is always required. Sometimes, it is the consequence of anger, distrust and fear, or it is just the wrong time. In the end, it can be the result of different factors, even of culture, but companies need to implement the right strategies to avoid it. One possibility is to clearly communicate the reasons for the change through multiple media; alternatively, resistance to change decreases with the direct involvement of workers in the design and implementation of the change and providing the appropriate support. Otherwise, managers can also rely on negotiation, manipulation, co-option, or coercion (Kreitner, 2012, pp. 426-436).

Anticipatory	Tuning	Re-orientation
Reactive	Adaptation	Re-creation
	Incremental	Strategic

Table 4: The four types of change

Source: Adapted from Kreitner (2012, p. 429)

3.5 Conclusion

Workers play an important role in both problem solving and knowledge sharing. Problems should be solved by workers that are closer to them, but, in these situations, it is crucial to remember the effect of emotions; in fact, positive emotions increase cognitive skills, instead fear and anxiety have a negative impact. Workers can rely on analytical intelligence based on the use of logic and reasoning, creative intelligence to find unusual solutions, or practical intelligence that is not related to the IQ of a person. These types of intelligence or problem solving can be exploited and used in combination. Knowledge sharing arises from a voluntary act between the sender and the receiver, where, subsequently, the individual learning is translated into organizational learning. There are four barriers to the exchange of knowledge; one of these is the nature of knowledge that distinguishes tacit from explicit knowledge with the former that is very difficult to communicate. The second is the motivation that is affected by elements such as fear, trust, rewards and penalties system, and reciprocity. The opportunities to exchange are another barrier and can be divided into formal or informal but, in the end, knowledge is mainly exchanged informally. The last barrier is culture; here, high sociability and solidarity, fairness of promotions and rewards, and recognition of the work of individuals contribute to the exchange of knowledge.

Lean Management has important consequences for workers because they need to be reliable, flexible, and problem solver; they also become responsible for maintenance and quality check tasks. Consequently, they need to perform the “doing”, “thinking”, and “team” works. The latter is an important aspect of lean companies that has several advantages for both the workers and the employer, but sometimes the reality is quite different. To be efficient, teams require the presence of uncertainty, trust, the right culture, a common goal, and interdependence.

Resistance to change is an important issue common to both resilience and Lean Management. Toyota has understood that continuous improvement cannot be the result of the implementation of a technique, but it implies a change of mindset made possible by improvement kata. At the same time, despite the need for companies to change to adapt to new circumstances, employees will try to resist. Workers resist changes because they prefer the status quo, the moment is wrong, the training or introduction are not adequate, the culture is wrong, or because of anger, distrust, or fear, but managers need to be able to implement the right strategies to avoid it.

Chapter 4: Some interesting case studies

4.1 Introduction

This chapter presented the case studies of three companies that, thanks to the elements seen in the previous chapters, were able to quickly overcome many of the difficulties faced in their lives. Dell, Nokia, and Toyota are the three selected companies with a long life known for their resilience because they overcame some very disruptive challenges that instead caused serious problems for their competitors. As specified in the first chapter, Toyota is famous for having developed the lean philosophy that has been repeatedly questioned for its resilience. As written in the second chapter, lean companies have many of the features needed to be resilient; however, this does not contain detailed examples. Here, the case of Toyota is presented, but it is not the only lean company; in fact, even Dell has adopted this philosophy. This chapter clearly shows that the lean philosophy is not a limit but rather contributes to make the company resilient.

The paragraph called the case study of Dell introduces the history of a company that chose to sell computers directly to customers, eliminating retailers. The daily or even hourly price changes to match demand exactly to its capacity are an important characteristic of its business model. Totally in line with lean philosophy, it has long-term relationships with suppliers based on information sharing, low inventory, and a make-to-order system. Dell proved to be able to quickly react to challenges, such as after the earthquake in Taiwan. However, this is not the only difficulty faced by Dell; in fact, in order to align with the prevailing circumstances, it changed its business model and, finally, also its sector.

The paragraph called the case study of Nokia presents the history of a company born from a merger in 1967. Nokia has managed to successfully sell its handsets in the United States, but despite this success, the internationalization process has also been characterized by important failures. However, the company has been able to overcome all the difficulties and fully understand the potential of mobile phones. This paragraph presents how Nokia overcame a potential disruptive challenge, such as the disruption of the supply of chips. Finally, companies always have to be ready because sometimes the positive results can hide important problems.

The case study of Toyota starts with a brief introduction to the company's history and then focuses on the new role of suppliers that started to provide complex systems requiring high abilities and close cooperation among companies. Therefore, the network of suppliers became a source of resilience, as in the case of Toyota.

4.2 The case study of Dell

Michael Dell created his company in 1983 with the aim of selling computers directly to customers. Customers could order their desired products according to their needs by phone or on the website with a wait of between 1 and 3 weeks. He has been able to develop the business in a short time; in fact, in 1986, the revenues were already equal to 34 million, and a few years later he decided to make the company public. Customers particularly liked the customization opportunities provided by the company at low prices; consequently, in 2000, it became the largest computer seller (Gara, 2021).

This success of Dell has also been due to Lean Management that can be seen, for example, in the make-to-order business model. Unlike competitors, Dell chose to be very close to customers, eliminating retailers and obtaining large advantages; in fact, the closeness made Dell able to better predict demand and be more reactive. This is in line with a fundamental feature of this sector that is characterized by fast and continuous improvement. During these years, another element of the business model has been the daily or even hourly change of prices in order to direct customer demand toward particular products and to match it to capacity (Bruun and Mefford, 2004). At the same time, the company also had long-term relationships with suppliers based on information sharing; they had direct access to inventory information with the main advantage of improving their ability to schedule production. This was useful when the lead time for a particular product from a supplier was quite long. In this way, Dell has been able to produce according to the demand of customers (pull principle). The main consequence of this business model has been the huge reduction of inventory levels, even if for some products with high lead time, inventory was still important; for some products, like some monitors from Sony, it directly sent a notification after receiving an order from a customer, and then Sony sent the product to Dell, allowing it to have practically zero inventory (Bruun and Mefford, 2004).

Dell has proven to be particularly resilient during its history, overcoming many challenges and responding promptly to changes. In 1999, an earthquake of magnitude 7.6 occurred in Taiwan, one of the most important countries for the production of chips and many other components. Even if the plants were not damaged externally, the absence of electricity for an entire day caused serious problems; in fact, it has been able to ruin many chips with serious consequences for their customers (Sheffi, 2007). Many famous companies relied on Taiwan for the supply of chips and other components, such as Apple and Dell; clearly, the impact has been highly dependent on the company and its structure. In the event of problems, the most important

principle has always been to protect customers from negative consequences. In this case, both companies relied on the lean philosophy with Apple that was proud to have only 15 hours of inventory. The products of Apple were famous for their innovative design, but there was also another element that distinguished Apple from Dell, the pre-order system. Customers had the possibility to see the features and prices of the products and could order them in advance. This system helped Apple better predict demand but was also a source of rigidity because it limited its possibilities. The company had just started to deliver the first products when the earthquake hit Taiwan, and in the same period, Motorola was unable to deliver the agreed volume of its fast processor. In the end, Apple decided to use a slower processor, and many customers chose to revoke their orders (Sheffi, 2007).

Dell has also been affected by the earthquake in Taiwan and by a problem with Intel that stopped the production of the promised products due to some performance defects, but it did not have a pre-order system and had only three days of commitments with customers; therefore, it was more flexible than Apple. Dell made orders to suppliers using forecasts, but then the product was assembled according to the effective demand; consequently, it configured the products with the available components and used the price lever to affect the demand accordingly (Sheffi, 2007). In the end, Dell has been able to increase revenue and market share.

A huge contribution to Dell's resilience comes from its culture that is extremely focused on short-term results, teamwork, communication, relationships, and spread leadership; in fact, the company requires a ROI of less than 12 months. As in many lean companies, within Dell the work is organized in teams, but here workers can belong to multiple teams at the same time and experiment many shifts with the aim of developing the social networks. Here, meetings follow well-defined rules, and reports are sent frequently. Employees are also encouraged to develop personal relationships and be leaders (Sheffi, 2007).

The history of Dell is full of threats and adversities and can be used as an example of the capability to react quickly. As written previously, the success of Dell was due to its decision to sell directly to final customers at reasonable prices, and in 2006, the revenues were equal to 56 billion (Chopra and Meindl, 2007). Online sales had several advantages, such as the possibility to offer customized products, but customers had to wait, and this was a problem for standardized products. It also allowed to reduce the inventory and facility costs, increasing only slightly the transportation costs; in fact, when the inventory can be located in few places and the company does not have its own shops, the costs decrease with positive effects on performance. However, the technology market is well known to change rapidly, and Dell has been forced to change; in fact, as the need of customization and variety decreased, starting from 2007, the company began

to rely on retailers, such as Walmart and Gome, and modified its structure accordingly (Chopra and Meindl, 2007).

Successively, sales started to decrease, but this has not been the end of Dell; in fact, in 2013, Michael Dell and Egon Durban concluded a very large leveraged buyout. They then completed the acquisition of EMC Corporation, the leader in the data storage business, and rapidly increased its value. In 2021, the value of Dell was four times higher than when it went private. In the end, they exploited the huge increase in data production and the related need to store and manage them (Gara, 2021). Many companies embraced the digital revolution, but this also increased the amount of data produced.

Table 5 presents the main elements that played a role in overcoming the difficulties.

Lean Management	**Items of resilience**	**Workers**
Just in Time	Build staff experience and knowledge sharing	Teamwork
Closeness to customers	Long-term relationships with suppliers	Problem solving
Reduction of waste	Shift leadership to people who have answers to the current situation	Knowledge sharing
Long-term relationships with suppliers	Align value proposed by company and expected by customer	
Information sharing	Information sharing and dissemination	
	Shift demand across time, market, or product	

Table 5: The link between Dell's case study and the previous chapters

4.3 The case study of Nokia

The modern Nokia is the result of a merger in 1967 of three companies focused in different sectors. Finnish Cable Works was the closest to Nokia; in fact, in 1930, it started working on telephones, and some years later, in 1963, it developed the first mobile phone for military use. In 1980, Nokia started its internationalization process, focusing mainly on computers, consumer electronics, and telecom equipment. The company has been able to successfully sell its handsets, initially with the Mobira brand, in the United States through a partnership with Tandy, one of the major retailers for consumer electronics; despite this success, the internationalization process has also been characterized by important failures with Nokia that concluded wrong acquisitions that resulted in a large waste of money (Doz and Wilson, 2017, pp. 16-34). The poor attention to the due diligence process led to the acquisition of weak companies with weak distribution channels that created serious trouble for a large conglomerate as Nokia; its problems increased with the fall of the Soviet Union that was one of the major markets for its products (Doz and Kosonen, 2008). However, the company overcame all the difficulties by early predicting future market trends and through an important reorganization where it chose to focus primarily on mobile communications. Nokia has been the first to understand the potential of mobile phones that could become more than simple terminals; after having competed in the computer sector, it understood the importance of design and user friendliness, thus establishing partnerships to acquire the necessary capabilities. In 1995, the sales growth rate was very high, but the company did not change accordingly; the issue was serious because this caused many logistic problems. Despite the dangerous situation, the company managed to overcome these problems, but it also quickly understood the risk of having two related businesses (mobile phones and networks); therefore, it started looking for potential opportunities to reduce the risk. For this reason, it instituted the Nokia Venture Organization. However, in the end, many of the new businesses have been abandoned (Doz and Kosonen, 2008).

Nokia overcame many challenges; one of the best known is the case that also involves Philips and Ericsson. In 2000 in New Mexico, a lightning caused a fire in a building owned by Philips, an important producer of chips used in electronic products. The fire immediately activated the firefighters and the competent staff. It was extinguished in 10 minutes, even before the arrival of the firefighters. Once they arrived, they performed the required security checks and judged the problem as solved. The related damage seemed limited and confined to that specific fabricator, but soon Philips would have discovered that the reality was very different. In Philips facilities and in that business, cleanliness is very important; otherwise, the delicate products

may be compromised. Here, in 2000, special air filters and specific procedures were in place to ensure the absence of dirt, but with the fire things rapidly changed; in fact, the shoes of the staff, that was forced by the situation to rush, and firefighters left dirt in the room that together with the smoke compromised the chips. Successively, they also discovered that the smoke was not limited to that fabricator, but, in the end, two out of four fabricators were compromised. This means that the chips of millions of cell phones have been ruined. They hoped to restart production in a week, and soon they alerted the two most important clients whose orders were affected, Nokia and Ericsson; therefore, the two organizations received an immediate communication about the situation, but they reacted in different ways (Sheffi, 2007).

When Nokia received Philips' advice, it was not worried because problems with a large supply chain occur frequently and companies rely on inventory to avoid stopping production; in this way, the disruption does not reach the final customers. In any case, according to their principles, problems had to be immediately addressed, and the related information had not to be hidden. Hence, they carefully observed the data on Albuquerque products and arranged daily calls to have new information on recovery. They understood that the problem was serious when Philips called to say that in order to align with the schedule, some months would have been necessary. The problem was serious because Nokia had to launch some new products that required Philips chips; therefore, Nokia organized a team of employees with different expertise and the necessary authority to find some alternatives and put pressure to move its orders to other plants with free capacity (Sheffi, 2007).

Ericsson received the same call of Nokia, but its reaction has been very different. Instead of acting, the employees decided to wait and did not communicate the problem to their superiors. Even when the delay accumulated, they did not provide the information; so, when superiors discovered the problem, it was too late because the Philips capacity was already covered by Nokia, and Ericsson had no alternatives (Sheffi, 2007).

In the end, the financial impact on Philips has been minimal, and the stipulated insurance covered almost entirely the damage. The situation is different for Nokia and Ericsson; Nokia did not suffer at all and improved its market share at the expense of its competitor. Ericsson has had the greatest impact, losing more than 400 million of revenues (Sheffi, 2007).

In 2006, results were very positive with revenues and profits that were both increasing; these masked the internal problems due to the new undigested organizational structure. Many managers agreed that it was creating many problems; consequently, Nokia tried a new reorganization with the aim of improving cooperation, but even this did not deliver the expected

advantages. Managers were still too focused on goals at the business unit level. Even if the performance is improved in 2007, there were already the first signals of the incoming change. In 2007, Apple launched its first iPhone and Google developed Android starting, in this way, a new era characterized by well-designed and touchscreen smartphones with a high number of apps; instead, Nokia's smartphones were still based on keypads and had an ineffective operating system with only few applications. It took another two years for Nokia to launch the first touchscreen smartphone, but it was full of problems and the market was no longer available. Therefore, the operating system was the key to compete in the new market, but the results of Nokia were not encouraging; its operating system was not at the level of competitors. It also tried to develop an alternative system, but even in this case, the outcome has been disappointing (Doz and Wilson, 2017, pp. 113-132). Despite pressure to find a solution, in 2010, Nokia was still a strong company. The alliance with Microsoft and the use of Android were two options to react to the ongoing crisis; the latter seemed the most obvious and capable of providing important advantages, but there were also different concerns. One of these derived from the fact that different players in the market were concerned about the resulting duopoly and of the dominant position that Google would have acquired, but there was also the fear for the loss of differentiation in the eyes of customers. In the end, Nokia chose to conclude an alliance with Microsoft that as it reacted slowly to the new trend. Finally, even the operating system of Microsoft showed many problems, and the profit from the mobile division decreased by 75% with Nokia forced to sell this division to Microsoft (Doz and Wilson, 2017, pp. 113-132).

Table 6 presents the main elements that played a role in overcoming the difficulties.

Items of resilience	Workers
Persistent communication and coordination among multiple forms of expertise	Teamwork
Long-term relationships with suppliers	Problem solving
Information sharing and dissemination	
Speed and effort of recovery and enhancement	
Shift leadership to people who have answers to the current situation	

Table 6: The link between Nokia's case study and previous chapters

4.4 The case study of Toyota

The history of Toyota Motor Company began with Kiichiro Toyoda who exploited the money obtained from his father's patent to establish this enterprise. In the beginning, the development process was slow and with many difficulties. During the Second World War, Toyota was forced to stop producing cars to support the military effort, and immediately after, a sales crisis created many problems. The first car of Toyota arrived in California with a lot of problems in 1957 but this did not stop its efforts; in fact, few years later, it has been able to conquer a dominant position in the American automobile market (Kreitner, 2012, p. 265).

Its history is full of adversities that would have put even the strongest companies in difficulty, such as the Aisin fire. The role of suppliers is changing, moving from providing mainly commodity products to complex systems that require high manufacturing and engineering abilities and, above all, close cooperation among companies; therefore, the way in which the network of suppliers is organized can provide a competitive advantage to the company,

becoming, in this way, critical in the competition with actual and potential competitors. The Japanese network is known for being characterized by close and long-term relationships with suppliers frequently based on cross-ownerships; consequently, it also becomes a source of resilience because it can help the company bounce back in case of adversities (Sheffi, 2007). This has been exactly the case of Toyota when a fire put out of use one of the Aisin Seiki's plants that was one of its most important suppliers of P-valves; in fact, it provided the 99% of P-valves to Toyota because it has been able to design production processes characterized by low costs and reliability. Although this product had a low price, it was quite complex and was used in all the automobiles of Toyota; consequently, the fire immediately led to the closure of many Toyota plants (Sheffi, 2007). This result has been the natural consequence of following the lean philosophy and its aversion to inventory. The fire occurred in 1997 when Toyota was relying on overtime and temporary workers to cope with the forecast increase of sales due to the upcoming sales tax increase. The situation was particularly serious because a Toyota stop would have meant a stop for many other companies and thousands of workers; therefore, it was necessary to return to the previous production level as soon as possible. Aisin Seiki immediately called Toyota and tried to find a solution to the problem. They asked for help from many companies, many of which responded positively, such as some of their suppliers but also unrelated companies; they provided the necessary help without paying attention to financial agreements but with the aim of increasing their business with Toyota. Recovery began with Aisin that established an emergency response unit to better coordinate efforts; in fact, the process involved many companies with different possibilities, capacities, and capabilities. As written previously, these products were very complex; therefore, Aisin maintained the responsibility of the final assembly, quality check, and final delivery to Toyota with instead the companies that responded positively to the appeal responsible for the physical production (Nishiguchi and Beaudet, 1998). Aisin provided all the necessary assistance to them, but the problem was that the production involved the use of machines difficult to find; it immediately asked for these machines not only from its suppliers but also from other organizations. However, in the end, it has been necessary to adapt the machines available, but this created another difficulty; in fact, the know-how of Aisin was related to its machines, thus limiting the ability to provide valuable assistance. Consequently, companies followed different approaches to produce the P-valves and collaborated to find solutions to common problems; clearly, production was not efficient because they were not confident with these processes and leaked the required skills and capabilities. At the same time, the responses have been different depending on the situation with some companies that delegated this production to their suppliers, others that set up temporary production sites (Toyota), and others that outsourced

some processes to produce P-valves (Denso). Before starting volume production, the participating companies had to send a prototype to Aisin to perform the necessary checks. Given that the assistance provided by Aisin was limited, the companies had to carry out experiments and use judgment. Luckily, Denso solved many of the problems of volume production and also played an important role in spreading the related solutions. The first prototype was produced after only two days from the fire, and then the attention focused on production; many companies followed the lean philosophy, so they had already developed the problem solving capability that is very useful in these situations. Given the particularity of the situation and in order to accelerate the recovery, employees have been moved according to the required tasks and, sometimes, even toward other companies, such as Toyota that transferred more than 300 employees to Aisin (Nishiguchi and Beaudet, 1998).

Even if companies participated in the recovery effort without the need of any formal agreement about the compensation because there was not enough time, they have been recompensated by both Aisin and Toyota; in fact, Aisin reimbursed all the direct costs and Toyota did even more by paying a sum equal to the 1% of the sales of the specific company to Toyota over a defined period of time. The companies then passed part of this to second-tier and third-tier suppliers. Even if full recovery of Aisin has required some months, a few days after the fire, Toyota had reopened many of its plants and a week after, it was working at its normal production volumes. The quick recovery has not been achieved without costs; in fact, Toyota lost more than 1 billion in revenues and had about 250 million in additional costs (Sheffi, 2007).

A similar disruption occurred in 2007 when an earthquake damaged a plant of an important supplier of customized piston rings. Even in this case, Toyota closed its plants for some days but then overcame the problem through its network of suppliers (Matsuo, 2015).

In 2006, Toyota had a market share of 15% in the United States, questioning the dominance of Chrysler, General Motors, and Ford (Kreitner, 2012, p. 265). These adversities are extremely important because they show that a lean company is able to overcome problems.

Table 7 presents the main elements that played a role in overcoming the difficulties.

Lean Management	**Items of resilience**	**Workers**
Flow	Build staff experience and knowledge sharing	Teamwork
Perfection	Long-term relationships with suppliers	Problem solving
Long-term relationships with suppliers	Speed and effort of recovery and enhancement	Knowledge sharing
Information sharing	Information sharing and dissemination	
	Shift leadership to people who have answers to the current situation	
	Persistent communication and coordination among multiple forms of expertise	

Table 7: The link between Toyota's case study and previous chapters

4.5 Conclusion

The earthquake in Taiwan caused serious problems for Dell because the country was one of the main producers of chips, but in the end, it reacted better than Apple that has been forced to use slower processors, losing many customers. Dell instead delayed the assembly; in this way, it was able to configure the products with the available components, using the price lever to affect the demand. Consequently, it exploited the difficulties of Apple and the other competitors to increase revenue and market share. Subsequently, when the need for customization and variety decreased, it was quick to contact two important retailers like Walmart and Gome. Finally, with the decline of the computer business, Dell quickly realized the need to store and manage data of companies that had embraced the digital revolution.

Similarly to the case of Dell, a lightning caused a fire in a Philips building and ruined the chips directed to Nokia and Ericsson. Nokia immediately arranged daily calls, created a team to find some alternatives, and put pressure on Philips to move its orders to the plants with free capacity, thus increasing its market share. Ericsson instead chose to wait, losing more than 400 million in revenues. Despite this successful reaction, Nokia was less ready to understand the new era characterized by well-designed and touchscreen smartphones with a high number of applications. Nokia's smartphone was still based on keypads and had an ineffective operating system; even the decision to ally with Microsoft to regain lost ground has been a total failure, and the profit of the mobile division decreased by 75%.

The close and long-term relationships of lean companies allowed Toyota to quickly react to a fire at one of the Aisin Seiki's plants. It completely disrupted the supplies of P-valves and forced Toyota to close many of its plants. Thanks to the problem solving ability and the adaptability of the companies in the network, Toyota reopened many of its plants few days after the fire, and a week after, it was already working at its normal production volume. This network has also been useful after the earthquake that damaged the plant of an important supplier of customized piston rings in 2007 and is the foundation of Toyota's success.

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