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TESI DI LAUREA

"BUILDING RESILIENCE IN SUPPLY CHAIN MANAGEMENT: THE POST COVID-19 EXPERIENCE IN BTOB MANUFACTURING FIRMS"

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Firma dello studente

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Contents

Introduction

The paper opens by embracing the direction traced by some authors in an attempt to form a supply chain theory, trying to offer different definitions of the concept in order to have a clearer and more complete image of it, as a key element of the research, before deepening the study in various nuances, starting from supply chain management.

This is followed by an in-depth theoretical study linked to technology in this context as a flexible element, also involving information technology with a view on its integration.

Theoretical research then moves on to supply chain systems, which can be applied to the planning and execution phases, also making reference to advanced planning and scheduling systems (APS).
The study continues with performance measurement in order to understand which may be the weak points of the supply chain and how to assess them and, in the part immediately following it, the scenario on a global and national scale hit by the Covid-19 pandemic is narrated.

Within this theoretical framework and the narration mentioned above, two empirical analyses are inserted: the first one aims to investigate both the impact that Covid-19 had during the two phases and the echo foreseen in the so-called "new normal" on the Italian manufacturing fabric of business-to-business companies, work which was carried out during the Managerial Lab 2 course, while the second one is based on the first effort deepening, also theoretically, the concept of supply chain resilience, with a particular focus on three of its declinations individuated in the literature such as procurement, post-disruption management and blockchain technology by the analysis of four different Italian manufacturing realities with distinct characteristics, so as to represent by induction a wider spectrum of companies.

All the companies belonging to the focus group have an international presence and, in this case, Bergi spa is configured as a traditional company, θ as a technological and global company, Idylium as an emerging and innovative reality and Salvagnini Italia spa as a company that combines innovation and tradition.

Each survey is marked by a descriptive section of the cluster, one dedicated to what was collected from the interviews, i.e. the findings, and one where there are elements that derive from the careful observation and analysis of the data obtained, i.e. the implications.
The work closes with the conclusions reached by the effort made during the whole research.

CHAPTER I: Supply Chain Theory

1.1 Supply Chain Definition

The concept of "supply chain" is generally referred to as the alignment of firms that bring products or services to market (Lambert, Stock and Ellram, 1998) where the chain is, according to Bowersox and Closs (1996), the disposition of both wholesale and retail intra-company units and extra-company agents through which a service, a commodity or product is marketed.

In such – as it is also known as – 'channel construct', the existence of a 'dependence' subsists if one or more elements are linked in connection with another agent belonging to that channel (Lambert et al., 1998; Håkansson and Snehota, 1995).

The Lambert et al 'alignment of firms' refers to the series of transactions on the business to business market that any finished product undergoes after its transformation from raw materials to customers, also taking into consideration the many actors involved as the supply chain includes suppliers, warehouses, retailers, manufacturers, transporters, wholesalers and other intermediaries. For example, when a final consumer buys a bottle of Coke, he/she purchases it from an intermediary such as a supermarket or a bar, not directly from The Coca-Cola Company and the product has been gone through several stages on the business to business market through negotiations and transports among the different channels: The Coca-Cola Company, the wholesaler, the retailer and the final consumer (Căescu and Dumitru, 2011).

However, the increasing importance of its functioning and development turned this subject into an important field of studies for academicians who originated multiple definitions through the years.

Chen and Paulraj (2004) stated that "a typical supply chain is a network of materials, information, and services processing links with the characteristics of supply, transformation and demand". An illustration, Figure no.1.1.1 can be found below:

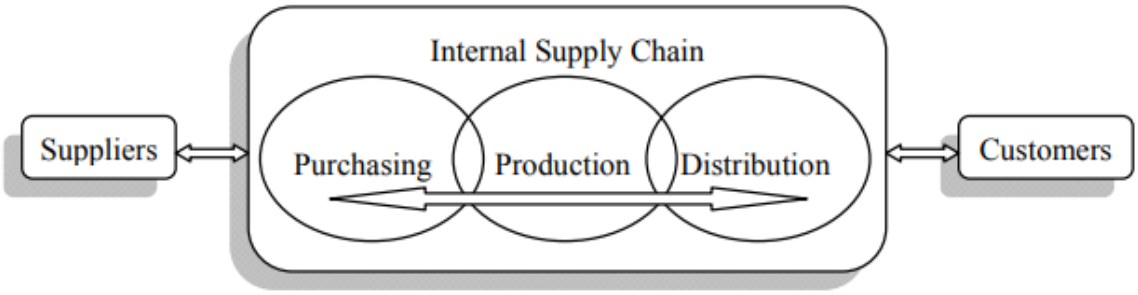


Figure no.1: An illustration of a company's supply chain

Source: Chen and Paulraj, 2004

There are three traditional stages in the supply chain: procurement, production and distribution.

Beamon B. (1998) defines Supply Chain as "a structured manufacturing process wherein raw materials are transformed into finished goods, then delivered to end customers".

Bridgefield Group (2006) defines Supply Chain as "a connected set of resources and processes that starts with the raw materials sourcing and expands through the delivery of finished goods to the end consumer".

Pienaar W. (2009) defines Supply Chain as "a general description of the process integration involving organizations to transform raw materials into finished goods and to transport them to the end-user".

The over-mentioned definitions focus on the fact that goods flow from the origin to the destination and, within such process, different activities take place, also adding value to the raw materials thus transferring final products to customers.

However, other and more complex Supply Chain definitions were given, by covering a wider view of its function and area of interest: for example, it is also important to take into account that this concept includes external and internal corporate associates as well.

An exemplifying opinion was given by Chow, D. and Heaver, T. (1999) who considered Supply Chain as the group of parties involved in the provision of goods to consumers (e.g. retailers, distributors, transportation operators, manufacturers and suppliers).

Little, A. (1999) defines a Supply Chain as "the combined and coordinated flows of goods from origin to final destination, also the information flows that are linked with it".

Chopra and Meindl (2007, p.3) believes that "a supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance, and customer service".

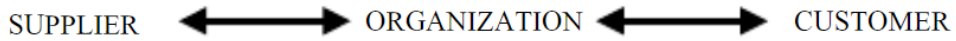
Mentzer, J., Witt, W. D., Keebler, J., Min, S., Nix, N., Smith, D. & Zacharia, Z.(2001) defines Supply Chain as "a set of entities (e.g. organizations or individuals) directly involved in the supply and distribution flows of goods, services, finances, and information from a source to a destination (customer)" and it is described as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer".

Furthermore, as stated by Mentzer et al. (2001), three degrees of complexity can be identified as far as supply chain is concerned: a "direct supply chain," an "extended supply chain," and an "ultimate supply chain".

The first one, see Figure no.1.1.2, includes three actors engaged in the upstream and/or downstream flows of services, finances and products: a company, a supplier and a customer.

Figure no.1.1.2: Direct Supply Chain

Source: Mentzer et al. (2001)



The second one, see Figure no.1.1.3, has also suppliers of the on-the-spot supplier, as well as customers of the on-the-spot customer, participating to the upstream and/or downstream flows of finances, products and services.

Figure no.1.1.3: Extended Supply Chain

Source: Mentzer et al. (2001)

The latter comprises all companies taking part in all upstream and/or downstream flows of products, finances and services from the end supplier to the end customer.

Figure no.1.1.4: Ultimate Supply Chain

Source: Mentzer et al. (2001)

Figure no.1.1.4 exemplifies the third degree of supply chain complexity by displaying how it can be problematic when coming to the ultimate supply chains.

"In this example, a third party financial provider may be providing financing, assuming some of the risk, and offering financial advice; a third party logistics (3PL) provider is performing the logistics activities between two of the companies; and a market research firm is providing information about the ultimate customer to a company well back up the supply chain. This very briefly illustrates some of the many functions that complex supply chains can and do perform" (Mentzer et al., 2001).

Taking into account what mentioned above, based on the number of members and the heterogeneity of business processes, one of the three degrees of complexity can be identified.

Moreover, any company can compose different supply chains such as the supply chain for sweets, for technology, for pets, for furniture and many others as in the case of IKEA, which represents the network nature and qualities held by many supply chains. Due to this fact, some organizations can have other companies as a partner in a supply chain, a competitor in another, a customer in a third supply chain, and a supplier in a fourth one, having an endless span of alternative supply chain configurations: some are brief and plain, like a small dairy shop purchasing milk directly from the farmer and some are tall and intricate like a tomato puree cannery whose providers are direct farmers and then they sell products through a retail network. The number of companies which coordinate material and information flows among various and numerous suppliers, manufacturers and distributors is increasing (Seifbarghy and Gilkalayeh, 2012).

Apart from its configuration and even in absence of management, whether the supply chain is controlled entirely by the organization or not, it still exists at least as a phenomenon of business (Mentzer et al., 2001).

According to Ayers, J. B.(2001) a supply chain is a "life cycle processes involving physical goods, information, and financial flows whose objective is to satisfy end consumer requisites with goods and services from diverse, connected suppliers". Such definition denotes the multifaceted nature of this concept because of the many activities covered by it (for example: transporting, sourcing, selling services and physical products, manufacturing), highlighting the importance of after sales operations like product support because of both the market life cycle and the usage life cycle with their differences related to durable goods and services (Ayers, 2001).

Three interrelated flow are mentioned in the latter definition, namely, material flows, informational flows and financial flows. The first one can be divided into three stages: purchasing, transformation and distribution. The second one can be seen as electronic data exchange or website linkages. The third comprehends suppliers and subcontractors payments for goods and services as well as those for final products made by customers to retailers (Waller, 2003).

The aforementioned flows are general components of an integrated supply chain model and include critical factors such as knowledge inputs (or intellectual inputs such as the design) into supply chains processes, physical distribution and the fact that information and financial components are equally important as physical inputs like components or prototypes.

It is also important to consider that the supply chain direction of flows is bilateral, implying that it doesn't go only forward, as in the typical orientation from first supplier to end customer, therefore there is a reverse chain too, which means that the supply chain can be flown back up by goods due to, among others, remanufacturing, repair, disposal or recycling and service. The latter can invest a crucial role as far as customer satisfaction, environmental protection and recycling are concerned.

Moise (2008) defines reverse logistics as "a set of programs or competencies aimed at moving products in the reverse direction in the supply chain (i.e., from consumer to producer) and related activities may include handling product returns, recycling, reuse of materials, waste disposal, refurbishing or remanufacturing".

Constructing Excellence (2015) provided a definition of Supply Chain which could partially summarize most of what stated above by using the construction field as an example "Supply chain is the term used to describe the linkage of companies that turns a series of basic materials, products or services into a finished product for the client. All construction companies, be they client, main contractor, designer, surveyor, sub-contractor, or supplier are therefore part of a supply chain. Because of the project based nature of construction and the way that procurement normally operates, they are usually members of different supply chains on different projects. Each company in the chain has a client – the organization to which the services are provided – but an integrated supply chain will have the objective of understanding and working wholly in the interests of the 'project client' ".

The last-mentioned definition holistic character is represented by the fact of recognizing the final consumer as part of the supply chain, thus also including retailers like Wal-Mart as contributors to downstream and upstream flows in supply chains. Furthermore, it highlights the presence of multiple linked suppliers, as well as other actors, together with the many different and implied kinds of configurations of supply chains.

With the help of such definition, it is easier to introduce Carter, Rogers and Choi (2015) vision of supply chain. The authors see it as a multifaceted concept which can be further described as relative, being both a network and a complex adaptive system which is bounded by an unclear horizon. The authors conceptualize it as a network citing Borgatti and Li (2009, p. 6): "SCM has not been just dyadic, as say, most of resource dependency has been, but has—through the notion of chains—implicitly considered paths through a network of firms".

Starting from the second half of the eighties with Thorelli (1986) and his description of supply chains within a market as "competing networks" and the beginning of the nineties with the belief that "No pair of firms operates in isolation from others" Ford (1990, p. 441), supply chain researchers have moved from the buyer-supplier dyad to triads as "the smallest unit of a network" (Mena et al., 2013, p. 59) also studying phenomena like buyer–supplier–supplier relationships and archetypes (Wu & Choi, 2005), coalition behavior of both buyer–supplier–supplier and buyer–buyer–supplier triads (Bastl, Johnson & Choi, 2013) , and the structural embeddedness of a supplier within a broader supplier network (Choi & Kim, 2008).

Carter, Rogers and Choi (2015), based on Bucklin (1970, p. 18) multi-organizational perspective, consider a network as a collection of nodes, being them autonomous decision-maker agents which

maximize their proper gain according to the parameters in which they operate (e.g. warehouses, manufacturers and transportation carriers) and define links as connections of nodes: flows of finance, information and materials, that is transactions, which take place between them. By this perspective, a supply chain is a network of nodes and links.

However, an important differentiation needs to be made: such system can be divided into 'physical supply chain' and 'support supply chain' (Figure no.1.1.5). The former is illustrated by a traditional supply chain model where the ovals represent nodes, agents with a location where activities take place adding time utility (Coyle, Bardi & Langley, 2003) while solid lines depict the physical transition of a product between two nodes, the aforementioned links.

It is also to be noted that there should be two additional links connecting nodes as movements include information and finance transitions, but they are both embodied by the dashed line displayed in Figure no.1.1.5.

The 'support supply chain' is defined by the agglomerate of nodes through which the physical supply chain of a 'focal firm' - meaning the combination of a specific firm and its particular product; namely, an 'agent'– is supported.

Support nodes comprehend, inter alia, financial institutions, brokers, and truckload transportation.

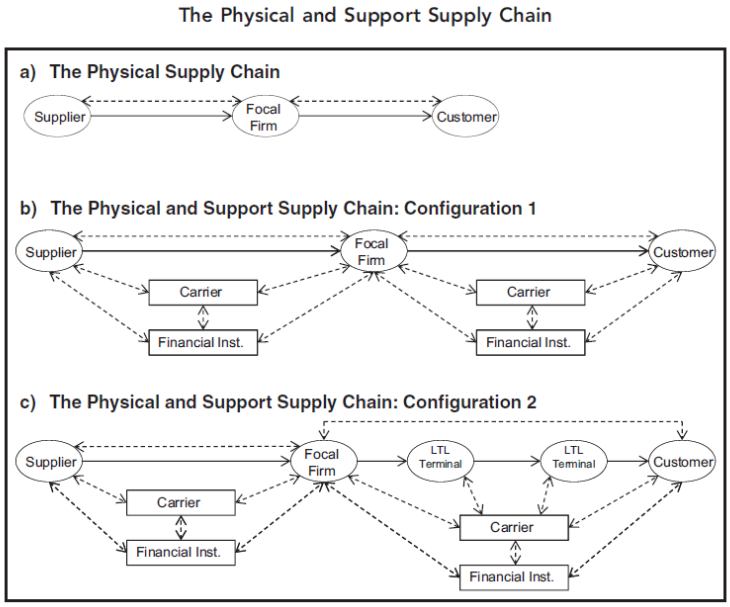
Figure no.1.1.5(b) shows the physical supply chain of Figure no.1.1.5(a) together with its portion of support supply chain. Rectangles represent nodes belonging to the support supply chain which are connected to those of both physical and support supply chains by dashed lines - depicting information and/or finance flows – instead of solid ones because focal firm's product in this particular context does not move through, for example, a financial institution.

Figure no.1.1.5(c) illustrates the case where a support supply chain node (carrier) operates a physical node in a supply chain (LTL terminal). The focal firm's product transits from the focal firm to the focal agent's customer of the physical supply chain by two warehouse terminals which represent nodes being permanent physical locations where the product is enriched by the addition of form, place and/or time utility.

Thanks to Carter, Rogers and Choi (2015) the conceptualization of the supply chain as evolved to a set of both a physical supply chain and a support supply chain, where agents like third-party logistic providers can be considered as either a physical or support node, having a more veritable picture of what activities of the supply chain add value.

Figure no.1.1.5: The Physical and Support Supply Chain

Source: Carter C . R, Rogers D.S, and Choi T.Y (2015)



Frankel, Bolumole, Eltantawy, Paulraj & Gundlach (2008) underlined the need of managing the supply chain as a system which is – in Holland's opinion - also self-organizing (Holland, 1995). However, given that Carter, Choi and Rogers agree on that, by considering the difficulty of trying to control and predict it, they highlighted that it is complex and adaptive as well, being a Complex Adaptive System (CAS), as coined by Choi, Dooley and Rungtusanatham (2001).

Furthermore, by recalling the concept of supply chain as a network of nodes, it is more immediate to look at the latter as a group of profit and cost centers which are in charge of managing resources and accountability with the aim of maximizing gains while operating upstream and downstream: upstream wise, a distributor will try to find the best manufacturers also enlarging its customer-base downstream, whereas, downstream wise, a manufacturer might opt for a Just-in-time (JIT) system implementation with its downstream or Vendor-Managed Inventory (MVI) with its upstream suppliers to set downstream handling centers.

As demonstrated by Choi & Hong (2002) through their study on the structure of supply networks with the focus on Honda, Acura and DaimlerChrysler, the supply chain is also relative to a specific product or agent, as the latter can represent an input for a company and an output for another, having a different usefulness based on the peculiar need they satisfy for the entities which participate to the system. The particular firm and product to which the supply chain is relative was defined 'focal firm' by Carter, Rogers and Choi (2015).

Given that a supply chain interacts with many other ones, many agents is at the convergence of multiple supply chains as in the case of the one which sells a product: it has the chance to see it in

both the upstream and downstream directions due to the raw material or part which takes part to the transformation process leading to the final product. Moreover, there are many different subjects involved both upstream and downstream: the former comprehends distinct agents who procure (e.g. first-tier suppliers) different assemblies, modules and parts, whereas the latter includes different agents according to the kind of product which is delivered by them.

As far as the Honda downstream is concerned, it has different first-tier suppliers for its Accord models and for its Acura CL/TL ones, as in the case of dealerships for its motorcycles and automobiles and they change also depending on the kind of raw materials, parts or assemblies needed such as center consoles and instrument panels (Choi & Hong, 2002).

However, there are also contexts in which an organization experiences the supply chain only by the upstream or the downstream point of view, as happens for a company that consumes within itself an Maintenance, Repair and Operations (MRO) item (e.g. cleaning and laboratory supplies, pumps, compressors).

Recalling the Constructing Excellence (2015) definition, it is possible to support the specification by Mentzer et al (2001) between supply chains and supply chain management: the former can be seen as a phenomenon which connotes businesses, commonly related to distribution channels, whereas the latter calls for significant and manifest management efforts by those who participate to the supply chain.

1.2 Supply Chain Management Definition

"Management is on the verge of a major breakthrough in understanding how industrial company success depends on the interactions between the flows of information, materials, money, manpower, and capital equipment. The way these five flow systems interlock to amplify one another and to cause change and fluctuation will form the basis for anticipating the effects of decisions, policies, organizational forms, and investment choices."
(Forrester 1958, p. 37).

Forrester highlighted the fact that organizational relationships are a relevant part of distribution management, also arguing their impact on the output of business functions such as sales and promotion, among others.

He demonstrated the influence of the order information flow on system dynamics through a computer simulation and his intuition has been a subject of studies ever since, also leading to the detection of the "Bullwhip Effect" (Lee, Padmanabhan, and Whang 1997). Also known as "Whiplash Effect", it can be seen in the Supply Chain by observing if the variance of orders sent to

the supplier is larger than the one of sales to the buyer, provoking an upstream propagation of the distortion in an amplified way.

Furthermore, Forrester, while picturing the future, imagined a scenario where the understanding of the interrelationships between corporate functions and businesses and their national economies, industries and markets would have become crucial, identifying key management issues and dynamics related to what is now recognized by business literature as Supply Chain Management (SCM).

The term has emerged and spread over the last decade of the XX century (Cooper et al. 1997). For instance, the words "supply chain" appeared on the 13.5% of the 1995 Annual Conference of the Council of Logistics Management session titles while in the 1997 conference the same number rose to 22.4%. According to La Londe (1997), the term was repeatedly utilized to picture corporate executive responsibilities while Ross (1998) underlined the "omnipresence" of SCM and related topics as trend topic of articles published on manufacturing, distribution, marketing, customer management, or transportation periodicals.

Mentzer (2001) has highlighted many reasons due to the increasing popularity of the concept in those years by observing main trends in global sourcing, time and quality-based competition and the rising environmental uncertainty while corporations have increasingly focused on global sources for their supplies, implying a more significant effort in finding more effective ways to manage in and out material flows for the company. Such implication has led to a change of perspective when dealing with relationships with suppliers, searching for a closer relation.

It has also been noted the market change: what once was a game changer then become normality. Earlier the last decade of the XX century, offering a defect-free product to customers in a quicker and more reliable way than the competition doesn't represent a competitive advantage anymore but it is a normal feature. Customers approach to market has changed as well: for instance, fast deliveries and undamaged products are now basic conditions of transactions, requiring a closer coordination with suppliers and distributors.

As far as marketplace uncertainty is concerned, it came as a result of the global orientation and performance-based competition, together with ever changing technology and economic conditions which require flexible supply chains and individual companies, meaning flexible supply chain relations.

The origin of the term, together with its history, has developed through a hundred years proceeding, ranging from labor intensive processes to the management of global networks, finding some recognition in the early 80s because of computer technology. In this context, according to Carter, Rogers and Choi (2015), the term was coined by two consultants Oliver and Webber (1982) when describing a new perspective of marketing approach so to overcome traditional approaches

managing integrated marketing channels, which they considered unsatisfying, whereas its introduction to academia was operated by Jones and Riley (1987) and Ellram and Cooper (1990) who asserted in 1985 that SCM was about dealing with the total flow of materials between suppliers and end-users. Furthermore, in Carter, Rogers and Choi (2015) opinion, the conceptual theory of supply chain management is to be addressed to Chen and Paulraj (2004); Cooper, Lambert and Pagh (1997) and Croxton, Garcia-Dastugue, Lambert and Rogue (2001) who had a conceptual theory building approach focused on identifying key constructs and processes which surround SCM, as well as developing coherent frameworks, while Mena, Humphries and Choi (2013) had a different approach based on an inductive, multiple case study with the aim of developing new theories of SCM. Other researchers tried to make it from within the SCM discipline itself rather than solely rely upon theories from other disciplines (Cousins, Lawson & Squire, 2006 ; Carter, 2011 ; Fawcett & Waller, 2011). Despite the wide acceptance of the term, both in academia and practice, there used to be "considerable confusion" regarding its meaning (Mentzer 2001). Tyndall et al. (1998) have seen the various lenses used by distinct authors who define SCM by different perspectives: some saw it by an operational point of view considering the flow of materials and products, some defined it as a management philosophy and some viewed it as a management process. According to Cooper and Ellram (1993), SCM was also conceptualized as an integrated system between vertical integration and separate identities as well as a management philosophy.

Such ambiguity pushed research to examine term and concept so to find the right factors which could build up effective SCM and its effects on corporate strategy and performance.

Supply Chain Management has contributed to put procurement, operations, and distribution together into a unique discipline and its development led to many different definitions as a natural outcome of its evolution (Smith & Hitt, 2005).

Since Oliver and Webber's coin of the term, the concept of SCM was applied in several ways (Jones and Riley, 1985, 1987; Houlihan, 1985, 1987; Snowdon, 1988).

According to Stevens (1989) and Jones and Riley (1987), it is believed that the management of business activities needs to be taken into account under three perspectives - strategic, tactical and operative – so to develop integrated channels.

According to Houlihan (1987) SCM aims at balancing business operations such as distribution, sales, production and promotion, also suggesting an year later (1988) that it concerns both the supplier-to-manufacturer and the distributor-to-end-user flow, anticipating in time the similar statement by Novack and Simco in 1991.

Ellram and Cooper (1990), instead, considered SCM as an integrating philosophy which was in charge of managing the entire channel flow supplier-to-ultimate-customer. Ritchie (1990) stated that the supply chain was a unique entity whose satisfaction delivery to customers was equal to the

weakest link in the supply chain. Stevens (1990) believed the SCM to be dealing with the flow of material provided to customers by suppliers, also adding value thanks to processes and distribution channels. Scott and Westbrook (1991) asserted that the supply chain is the chain that, starting from raw materials, connects every factor of the production and supply processes to end customers.

Langley and Holcomb (1992) considered SCM as a lens on the interactions of channel members so to create an ultimate product or service which could have the best comparative value for the final user. Cavinato (1992) focused on product flow value-addition concentrating on supply chains aware of the importance of relational factors for actively managed channels of procurement and distribution. Similarly, Christopher (1992) conceived the supply chain as a system of organizations with upstream and downstream links which contributes to adding value in the form of products and services for the end-consumer. Lambert (1992) saw the supply chain as the main entity whose objective is ultimate consumers' satisfaction. Towill et al. (1992) perceived the supply chain as a chain composed of material suppliers, production facilities, distribution services, and customers whose linkages consist in forwarding flow of materials and the feedback flow of information.

Turner (1993) stated that SCM is the overall of linkages which bonds suppliers of raw materials participating to the different levels of manufacturing, warehousing, and to the distribution to end-customers. Lee and Billington (1993) saw it as agglomerates of manufacturing and distribution sites which make the procurement of raw materials, transform the latter from intermediate to final products and distribute them to final customers at the end of the process. Ellram and Cooper (1993) studied SCM by the analysis and management perspective for the whole system, from suppliers to end-customer, with the objective of reaching the best solution for the entire chain. Johannson (1994) underlined the role of information in SCM suggesting that all participants in the supply chain should be aware of operations concerning procurement.

Harrington (1995) stressed the importance of bi-directional information flows which fringe all parties involved, meaning supplier's suppliers through to end-users. Carter et al. (1995) noted that the main objective of flows of goods between suppliers and ultimate consumers is to encounter customer service goals while reducing inventory costs as much as possible.

Coyle et al. (1996) reached the conclusion that companies in supply chains are 'partners' of their vendors and customers when it's time to bring a product to market.

Bechtel and Jayaram (1997) stated that SCM supports the concept of a 'business ecosystem' due to the given process framework which allows organizations to grow together, rather than fostering competition. Lambert et al. (1998) argued that the aim of SCM is to make competitiveness and profitability as efficient as possible for the entire supply chain, including the ultimate customers.

Lambert and Cooper (1998) observed SCM as the value addition to customers and stakeholders by products, services and information provided by original suppliers together with end users involved in key business processes which are integrated.

Chandrashekar and Schary (1999) also emphasized the integration and coordination of business operations across organizational boundaries.

The above review of opinions and definitions offers a picture according to which SCM is a business philosophy whose aim is to make an integration of resources, actors and activities of channels from the creation to the consumption of the final product/service. The implication is that SCM includes diverse types of dependencies in and between companies in channels from suppliers to consumers and/or from manufacturers to customers.

From the early 2000s, a wider and more compound approach to SCM has been structured, taking into consideration a broader range of business functions (Levy and Grewal, 2000).

Mentzer et al. (2000) argued that it is mainly about the management of inter-firm relationships, supporting the ability to 'partner' as a crucial skill to develop successful retail supply-chain relationships.

Chandra and Kumar (2000) highlighted the relevance of organizational relations which are also flexible, a strong coordination within the supply chain, an efficient communication inter- and intra-enterprise, also trying to outsource competencies which do not belong to the core ones, having a built-to-order manufacturing strategy, a prudent inventory management and oriented cost control.

In Min and Mentzer (2000) opinion, the SCM is made by two components which underline the importance of a 'functional integration' between a company and all others which participate to the same supply chain, also contributing to its overall competitiveness: the two factors are an integrated business philosophy and implementation actions.

Lummus et al. (2001) asserted that SCM comprehends production processes, customer-order management, logistic flows and the key information flows to keep track of all activities related to supply-chain nodes.

Dibb, Simkin, Pride and Ferrell (2012) defined supply chain management as the reduction of inefficiencies, costs and redundancies in marketing channels by creating a long term partnership among them, thus developing innovative approaches to satisfy selected customers.

In conclusion, after such literature review, it emerges that still more effort is needed so to find a unique definition of SCM, also dealing with the current conceptualization of the supply chain which might be either oversimplified by considering it as "just" a chain with suppliers, manufacturers and distributors, or very complex by seeing it as a very vast network of companies. Furthermore, relevance is often given to who are believed to be the main actors of the supply chain while not considering the many members who play an indirect vital role by participating to some important

activities such as storage, movement and product transformation. Moreover, it is to be noted the yet not explicitly defined means by which assessing the frontiers of the supply chain concur to such difficulty in defining and structuring a solid supply chain and SCM theory.

CHAPTER II: Supply Chain & Technology

2.1 Supply Chain agility and flexibility through Information Technology (IT)

2.1.1 Supply Chain agility

The concept of agility was initiated in academic environment by researchers of the Iacocca Institute of Lehigh University in 1991 (Bottani, 2009). Its first introduction took place in the field of manufacturing and within the concept of flexible manufacturing systems (Sarker et al.,2009; Sarker and Sarker, 2009; White et al., 2005). Since then, increasing attention has been paid on the term from both academic and commercial fields. As far as management information system was concerned, supply chain agility was kind of a new concept (Braunscheidel and Suresh, 2009). It was conceptualized as a wide and multi-dimensional construct, usually defined as the capability of supply chain functions to generate a strategic advantage by leveraging unpredicted market uncertainties, also turning potential and actual disruptions into competitive opportunities by collecting the right knowledge, requisite assets and relationships (Bottani, 2009; Braunscheidel and Suresh, 2009; Christopher, 2000; Khan and Pillania, 2008; Sambamurthy et al., 2003; Swafford et al.,2006a). Supply chain agility includes both the exploration and exploitation of market opportunities, also comprehending the capacity of generating innovative products and services in cost-effective and timely way (Overby et al., 2006; Sambamurthy et al., 2003; Sarker et al., 2009; Swafford et al., 2006a; Zhang and Sharifi, 2000).

A strong coordination of all legally separate - although interdependent by an organizational level – parties is needed in order to supervise and to maintain a close and effective relationship between, for example, suppliers, manufacturers and distribution (Lin et al., 2006; Yusuf et al.,2004). It makes a company decrease its manufacturing costs, foster customer satisfaction, cut non-value added activities, thus preserving a competitive position in a competitive environment (Bottani, 2009; Braunscheidel and Suresh, 2009; Lin et al., 2006; Narasimhan et al., 2006; Swafford et al., 2006a).

Resource Based View (RBV) sees organizational resources as predictors of organizational performance (Kearns and Lederer, 2003). RBV has been playing a role to recognize the circumstances for sustaining competitive advantages (Ray et al., 2005) and offers a solid framework so to analyze the relation between supply chain competence and firm performance.

Furthermore, a company willing to embrace the uncertainties and changes of a business environment so to overcome a competitive environment should mature core competencies.

According to Zhang et al. (2003, p. 176) competences underlines techno-logical and production knowledge at certain points along the value chain, while competencies are widely based and include the entire value chain.

Ngai, E.W.T., Chau, D.C.K., Chan, T.L.A. (2011) support the argument that capabilities can be noticed by customers, while competencies are internal and serve at sustaining these capacities.

According to the above-mentioned authors, supply chain agility is the capacity of a company to deal with market changes which could be spotted by customers utilizing a set of supply chain competencies that validate such capability.

Supply chain agility is believed to be rare, valuable, and imperfectly imitable as it is not about rules and procedures; they argue it is about "a complex philosophy of coordination and integration among different parties and functions along the value chain", sustaining competitive advantage by constantly understanding market changes and rapidly responding to them.

2.1.2 Supply Chain flexibility

Given that flexibility can be seen as the principal antecedent of agility (Conboy, 2009), when concerning the field of supply chain study, flexibility belongs to the distinct states which can be adopted by a manufacturing system, the capability of moving from a product to another together with the capacity of producing good quality products within a specific range (Stevenson and Spring, 2007).

Swafford et al. (2008) asserted that supply chain flexibility can be categorized into strategic flexibility and manufacturing flexibility, where the first represents the competence to recognize changes in the environment, select and apply resources to find promptly new solutions to changes, also understanding when to intervene rapidly when it comes to stop or alter such resource commitments (Shimizu and Hitt, 2004).

Manufacturing flexibility is the competence which facilitates the encounter between manufacturing resources and the different customer requests (Zhang et al., 2002, 2003) being linked to operational ability in order to enact the implementation of a strategic decision, whereas strategic flexibility is recognized as the ability to make rapid decisions while being committed to respond. Supply chain flexibility allows a company to be fast and strategic in reversing its actions and producing different mix of products in a quick and cost-efficient way, also thanks to competent infrastructures and labour resources which permit different operations to take place while the capability of the materials and procedural frameworks allows to generate different products and services. Swafford et al. (2006a, 2008) have found an empirically relevant relation between internal supply chain flexibility and agility.

2.1.3 Supply Chain Technology adoption antecedents

Various elements might impact a corporation decision to adopt and implement a specific technology. Kwon and Zmud (1987) studied antecedent innovation researches, also classifying variables which could influence technology adoption into five wide categories: individual, task-related, innovation-related, organizational, and environmental qualities. Kwon and Zmud (1987) consider such factors as those able to differ in degrees according to the context or technology. For instance, individual variables like age or education are often more significant than the adoption of a technology at an individual level rather than at an organizational innovation level where it is often up to committees to make decisions. In addition to this, task and innovation qualities of a technology might be isolated and examined when the study deals with individual technologies.
It is also to be taken into account the concept of ‘‘adoption’’ as it was defined by many authors in different ways, also distinguishing between adoption, development, diffusion, implementation, initiation and use. Appreciating such legitimate distinctions, it can be more generally seen as ‘‘the generation, development, and implementation...’’ of the technologies (Damanpour, 1991, p. 556).

2.1.4 Supply Chain and Information Technology (IT)

Information technology (IT) adoption has been playing an important role in innovation debate. In the US, 40% of new capital equipment investment is destined to technology by executives (Hitt and Brynjolfsson, 1996). Innovative information technologies generate impacts on many different areas: organizational structure, firm strategy, communication exchange, operational procedures, buyer–supplier relationships, and bargaining power (Bowersox and Daugherty, 1995; Lewis and Talalayevsky, 1997; Williams et al., 1997; Clemons and Row, 1991). IT might produce benefits to organizational productivity, flexibility, and competitiveness (Cash and Konsynski,1985) also enhancing the growth of inter-organizational networks (Daugherty et al., 1995). Information systems have begun so ubiquitous and prevalent that they are currently seen as a conditio sine qua non for doing business in competitive marketplace (Clemons and McFarlan, 1986; Dawe, 1994; Rogers, 1990; Rogers et al., 1992). Supply chain management (SCM) is considered as a crucial area for innovation and investment in information technology (Bowersox and Daugherty, 1995). The Global Supply Chain Forum stated that SCM represents ‘‘...the integration of key business processes from end-user through original suppliers that provides products, services, and information that add value for customers and other stakeholders’’ (Lambert et al., 1998, p. 1). Strategic alliances

and long-term collaborative relations between suppliers, logistics providers and customers followed the execution of SCM, due to the closer view that both suppliers and customers gained, ending adversarial approaches, thus converting relationships in partnerships (Tan et al., 1998) with the aim of maximizing competitiveness and profitability for the company, also having the whole supply chain network encompassing the ultimate customer (Lambert et al., 1998, p. 4). Information exchange between supply chain partners and its quality started to be seen as the main benefit of an integrated supply chain (Lee et al., 1997 ; Levary, 2000). Furthermore, updated information permits more precise inventory solutions to demand alterations, having more accurate inventory levels throughout the supply chain (Levary, 2000 ; Stank et al., 1999).

Levary (2000, pp. 25–26) asserted that the advantages of supply chain integration encompass:

1. Minimizing the bullwhip effect
2. Maximizing the efficiency of conducting activities along the supply chain
3. Minimizing inventories along the supply chain
4. Minimizing cycle times along the supply chain
5. Achieving an acceptable level of quality along the supply chain.

Notwithstanding the widespread awareness of the importance of SCM for the company success among more than 90% of North American manufacturers, only 2% rate the quality of their organizations' supply chain activities as ''world class'' (Thomas, 1999). Such an extreme and net disparity may be explained by the degree of difficulty that firms face to integrate logistics operations both between them and within their borders while finding adequate information technologies. A key for a productive SCM is an efficacious management of strategic alliances (Monczka et al., 1998; Whipple and Frankel, 2000) together with broad data management competences and advanced inter-organizational information systems to operate a more wide information exchange (Gustin et al., 1995; La Londe and Masters, 1994; Bowersox and Calantone, 1998; Stank et al., 1999). Innovative information technologies enable more precise and updated information transfer, obtaining a higher degree of visibility of demand and inventory throughout the supply chain. Some researchers sustain that IT is the most pivotal factor to logistics and SCM upgrade (Dawe, 1994), while 34% of logistics executives believe that technology is the most crucial element for the improvement of logistics abilities (Bradley et al., 1999).

IT is also an element of flexibility: according to Nelson et al. (1997), as well as Conboy (2009), IT flexibility definition starts from the IT infrastructure capability to adapt to both incremental and revolutionary alterations in the business or business process with minimal penalty to current time, effort, cost, or performance. There are three main characteristics: (1) connectivity, meaning the capability of IT components to relate to other components within the organization or with other organizations; (2) compatibility, the capability to share information across any information

technology component within the organization or with other organizations; and (3) modularity, which consists in adding, modifying, and removing information technology components without negatively impacting on performance (Byrd and Turner, 2000; Fink and Neumann, 2009). IT flexibility yields sustain to the organizational supply chain to be ready to face to unforeseen market alterations and conditions not increasing costs or time needed (Byrd and Turner, 2000). In particular, inter alia, it makes the company able to seamlessly integrate new technological components, such as RFID, with already-in-place IT infrastructure. IT flexibility permits the corporation to foster its IT infrastructure easily and in a cost-efficient way according to the market situation, making the company prepared to encounter and solve market changes accurately. The simplicity of adapting the already existing technology component in IT systems gives the company the chance and ability to advance the supply chain operation not affecting performance. Such a valuable competence can sustain any need for change in the supply chain system in responding to market alterations. As a consequence, IT flexibility participates to the evolution of better supply chain agility.

2.1.5 Information Technology (IT) know-how

IT has supported the development of global supply chain markets; it has had an impact on the relationships among manufacturers, customers and suppliers, accelerating and visualizing the product, financial and information flows which have to be precise and quickly delivered to better analyze the supply chain. IT consists in a crucial support to supply chain agility, depending on the degree of knowledge about information technology as well as its effective use in order to manage information within the firm (Tippins and Sohp, 2003). Moreover, it invests a crucial role in activating the sensing and response competences of a company (Fink and Neumann, 2007; Lin et al., 2006; Overby et al., 2006; Sambamurthy et al., 2003). Examples of IT that foster supply chain capabilities are (1) mobile and wireless technologies [e.g., radio frequency identification (RFID) and sensor network technologies] for real-time data collection; (2) integration technologies (e.g., extensible mark-up language (XML) and Web services) for real-time monitoring of events through portals; and (3) business process re-engineering and management tools for business process automation and redesign of supply chain system or enterprise system.

It is important to synchronize all fundamental IT activities to reach supply chain agility. For this reason, it is advisable for the top management of a company to build up a strategic IT plan for supply chain agility and assess its impact on supply chain performance. Considering what previously mentioned, having strong IT competences can evidently contribute to supply chain responsiveness thus enabling the supply chain to accomplish a high degree of visibility,

connectivity and flexibility. Among different IT competences, IT integration and IT flexibility are considered among the best contributions to supply chain agility.

2.1.6 Information Technology Integration

Information is at the basis of global supply chain competitiveness. IT integration represents the linkages between information systems and information circulates among distinct functions and supply chain parties, generating an efficient virtual supply chain (Knapp et al., 2006; Lin et al., 2006). IT integration concurs in coordinating supply chain functions and partners through the sharing of information linked to demand forecasts, production schedules, inventory, and production quality which set supply chain activities (Li et al., 2009). Furthermore, IT integration reinforces knowledge sharing along the supply chain. It also encompasses the knowledge transfer with partners up and down the supply chain, permitting the collaboration and the creation of synchronized replenishment plans.

IT integration yields efficient, timely and transparent business information to the adequate parties, saving time in sharing knowledge and information (Pearcy and Giunipero, 2008), also reducing time in responding to unpredictable events and market alterations (Angeles, 2009; Mondragon et al., 2004; Swafford et al., 2006b). IT integration helps reaching a seamless flow of information and brings relevant support to the flow of physical resources and cash. An integrated information system gives different members of the supply chain access to the operational information related to other functions or departments. In particular, suppliers can revise the inventory information of their customers and organize the required activities so to deliver stock on time. In addition to that, having a well-integrated IT system gives the manufacturer the opportunity to constantly have the whole picture of the status of the supply chain being able to promptly intervene in case of sudden changes in demand, inventory or even difficulties with logistic service providers. The detected situation can span from suppliers to distributors thus calculating, for instance, the time needed to respond to changes in the market.

Hence, thanks to IT integration, it is possible to foresee resource flows, having more efficient ones. Efficient flows of information and materials support companies in keeping track of market needs and allows the organization to redistribute resources in a responsive way. Even though Swafford et al. (2008) did not find a relevant relation between IT integration and supply chain agility, the association between the two is reinforced by the inter-organizational IT integration which enhances better supply chain agility by bringing real-time information exchange and sharing among supply chain partners.

2.2 Supply Chain Systems: Supply Chain Planning Systems and Supply Chain Execution Systems

The Supply Chain Management (SCM) paradigm is virtually present in all industry sectors with the manifest goal of supply chain optimization, where the planning process plays a key role (Jespersen & Skjott-Larsen, 2005). Such activity is needed so to reach a balance between supply and demand, represented by the chain which engages from primary suppliers to final customers, in order to deliver superior goods and services thanks to the optimization of supply chain assets. The latter is a very difficult task as it implies the simultaneous synchronization of a wide range of complex decisions, often facing issues which can interfere with the process such as conflicts of goals and stochastic behaviours in place (Lin et al., 2007; Camarinha-Matos and Afsarmanesh, 2005; Schneeweiss and Zimmer, 2004; Terzi & Cavalieri, 2004; Min and Zhou, 2002; Simchi-Levi et al., 2000).

Taking into account the difficulty related to supply chain planning, information technology (IT) tools can consist in a direct or indirect support in dealing with it. These sets are employed, inter alia, with regards to delivery planning and coordination, inventory management, information integration, order fulfilment. In such a complex context, the various supply chain difficulties are dealt with one of the leading IT tools for Supply Chain Management: Advanced Planning and Scheduling (APS) systems. For instance, they allow users to cope with decision planning at a strategic, operational and tactical level.

The planning of these extents is supported by computer APS systems which operate distinct functions. Basically, APS are computer assisted planning systems that put forward various functions of Supply Chain Management such as procurement, production, distribution and sales, at all levels mentioned above (Stadtler, 2005). These systems contribute to a quantitative model-driven perspective on the role of IT in bearing Supply Chain Management, thus making use of advanced analysis and supply chain optimization methods. Not being a coincidence, APS systems came as a natural result of the evolution of planning approaches for the manufacturing area since the 1970s (Martel & Vieira, 2010) where the sole system approach was Material Requirements Planning (MRP). The latter was replaced by the Manufacturing Resources Planning (MRP II), then by the Distribution Resources Planning (DRP) and finally by the Enterprise Resources Planning (ERP systems) in the 90s. APS systems emerged as a complementary solution to ERP systems as the latter are more transactional systems than planning ones, whereas the former are more planning systems (Stadtler, 2005). In fact, ERP's planning capabilities alone are restricted in absence of an APS system, even though they are crucial to the planning process.

Notwithstanding the improvement in this domain, some fundamental changes are engaging the key supply chain technology.

2.2.1 Advanced planning and scheduling systems (APS)

The planning process represents the core of APS systems. It identifies different scenarios for future activities and suggests good strategies which can be the best ones (Fleischmann et al., 2004) also taking into consideration the goals of the decision-maker, together with the limitations characterizing the context where the company lives in.

According to Santa-Eulalia et al. (2011) the main traits of APS are:

• Integral planning: the organization of the whole supply chain. Attention can be paid on issues related to the internal supply (i.e. a single company having different production sites, or distribution centres) and the entire supply chain (i.e. from suppliers to customers).

• True optimization: APS systems utilizes advanced analysis and supply chain optimization technology (heuristics or exact ones) to execute planning and scheduling activities. Solutions to optimization issues are demanded in environments characterized by hurdles or where resources are restricted. These resolutions are often required when one of the two between demand and supply are constrained, not allowing the right match of both (Lapide & Suleski, 1998). The exploited optimization approaches are heuristics (comprehending also scheduling methods such as the theory of constraints or the theory of simulated annealing), scenario planning (what-if analysis), time series analysis, linear and mixed mathematical programming, forecasting analysis and constraint programming. For those interested in APS main quantitative issues, Santa-Eulalia et al. (2011), suggest Van Eck (2003), Shapiro (2000), and Lapide & Suleski (1998).

• A hierarchical planning system: APS are considered to be hierarchical planning systems (Stadtler and Kilger, 2004; Hax and Meal, 1975) characterized by an architecture which is represented by the organization of the system, together with its hierarchy and integral planning, and its engine, the performance of planning activities. In terms of APS structure, according to Meyr & Stadtler (2004), a typical system is composed of agglomerations of sets of building blocks - Meyr & Stadtler (2005) propose some typical ones - concerning different horizons and types of decisions: short-term at an operational level, mid-term and long-term at a tactical level and long-term at a strategic level.

• Strategic network planning: a long-term planning usually addressed to plant allocations and to design the physical distribution of the network. Moreover, it can support other types of decisions such as those concerning market strategies like the positioning of a specific product.

• Demand planning: it involves a wide span of time by representing long, medium and short terms sales forecast, according to either quantitative or qualitative approaches. The result of the effort is find the expected demand, input of many other building blocks.
• Demand fulfilment & ATP (available-to-promise): an interface dedicated to customers that tracks orders from entry to delivery. It comprehends order promising, due dates settings and shortage planning.
• Master planning: its aim is to find a balance between demand and capacity over a medium-term planning interval, also organizing procurement, production and distribution.
• Production planning and scheduling: planning and scheduling is operated within each site, instead of between sites as master planning does by coordinating the planning activities. Production planning is used for lot-sizing, and scheduling is destined to machine sequencing and shop floor control, two planning tasks.
• Distribution planning: it is more detailed in dealing with materials flows than master planning, also being in charge of the direct transport of goods to customers or the indirect one via warehouses and cross-docking.
• Transport planning: the objective is to sequence customer locations on a vehicle's trip through vehicle routing.
• Purchasing and material requirement planning: it represents a further developed planning manner compared to traditional bill-of-material explosion and ERP ordering of materials. By using alternative suppliers, quantity discount and lower/upper quantity analysis, it operates advanced purchase planning.

According to Rodhe (2004), other APS building blocks can be added to the previously mentioned ones, such as their coordination with other systems, like Online Transaction Processing (OLTP), as ERP or legacy systems, or data warehouses.

As a hierarchical planning system, an APS is in charge of coordinating and integrating information between building blocks: there are horizontal and vertical information flows. The first set all building blocks with regard of customer needs (customer orders, sales forecasts, internal orders for warehouse replenishment, and purchasing orders for suppliers). The latter consist in a tool in order to organize lower level plans through the results of higher level plans (downward flows), or a mean to inform upper levels about the performance of the lower level (upward flows) (Fleischmann et al., 2004).

APS systems are composed of building blocks which can be very flexible and can be configured in many ways, or even bought and installed separately. Flexibility is given by the engine they are provided, meaning the mathematical approach used like models and algorithms.

Gaudreault et al. (2007), Chen & Ji (2007), Lee et al. (2002) and Kuroda et al. (2002) produced diverse studies on this topic.

However, when considering which system to choose for a company with its requirements, other crucial aspects need to be considered:

• Experienced consulting ecosystem: is the consulting partner proficient on the tool? How is the success rate of companies which implemented that specific system?

• Vendor pricing model: is it better to buy the solution to get the right Return On Investments (ROI) or should the payment be effected by a deployed model?

• Deployment flexibility: can the implementation be phased thanks to a not-so-narrow technical flexibility or is it better to deploy it in a unique solution so to reach the right cost/benefit equation?

2.2.2 A typical implementation project

An APS implementation project requires first a planning phase where to collect insights and pieces of advice in the field of interest. Due to this plan, companies can have a more specific idea on what to do and what to avoid in order to limit the APS implementation risk of failure.

Typically, APS implementation projects are operated with a methodological approach which often does not take into consideration critical transformation aspects that could contribute to a successful APS implementation. These are:

• Unified Vision: are all stakeholders aligned on expected benefits and risks from the APS project? Otherwise, there is a high probability of frustrations.

• Clear Strategy: is there a detailed picture which outlines all necessary organizational transformations to obtain such benefits?

• Structured Processes: they represent a key dimension as APS systems require a coherent and streamlined planning process while business rules and decision criteria need to be explicit and clear for the company.

• Aligned KPIs: not having aligned indicators can vanish all efforts to streamline the supply chain ending up in wasted efforts. It is crucial to revise KPIs in order to guarantee a coherent incentive structure, also taking into account intrinsic supply chain trade-offs.

• Aligned Organizational Structure: it can help with eliminating dysfunctional empowerment by taking into account all supply chain dependencies and defining each role and responsibility.

• Educated and Prepared People: transformation takes place with the support of an agglomeration of individual changes where education and training play a key role. Moreover, contrarily to what happens with ERP, users can quit an APS system and come back to spreadsheets with no important

consequences, at least in the short term. In conclusion, an effective change management needs user involvement, persuasion and behavioural orientation.

• The right Technology: technology enacts business processes, so, from a certain point of view, process and technology are like the same thing.

2.2.3 Supply Chain Execution System

Planning has its focus on future developments, finding options for future activities and yields guidelines for their implementation while are made and take place outside of the planning system.

Due to this fact, there are planning intervals where unexpected events emerge because of the time gap between planning and the final implementation. Not all decisions are programmed into the planning system, leaving some degree of freedom to revise and modify the plan until the final execution is enacted, where "execution" stands for a set of activities which enables control. As a consequence, on the contrary of the instructions illustrated in a planning system, decisions for execution cannot be revised.

An "execution system" takes in charge decisions of a higher–ranked planning system, controlling the validity of the assumptions at the basis of the plan, putting in addition further details (i.e. the assignment of transport activities related to production orders) and – when there are no unforeseen events – leads the overall decisions to final execution. However, in case of the happening of unexpected events, such as machine breakdowns, the role to find what is wrong and to promptly react belongs to the execution system.

Minor problems can be addressed directly by the execution system directly. In case of the occurrence of relevant issues, an "alert" should be sent to the planning system, in order to initiate an extraordinary re-planning. The planning is event-driven and makes the usage of HPS easy, also making it flexible.

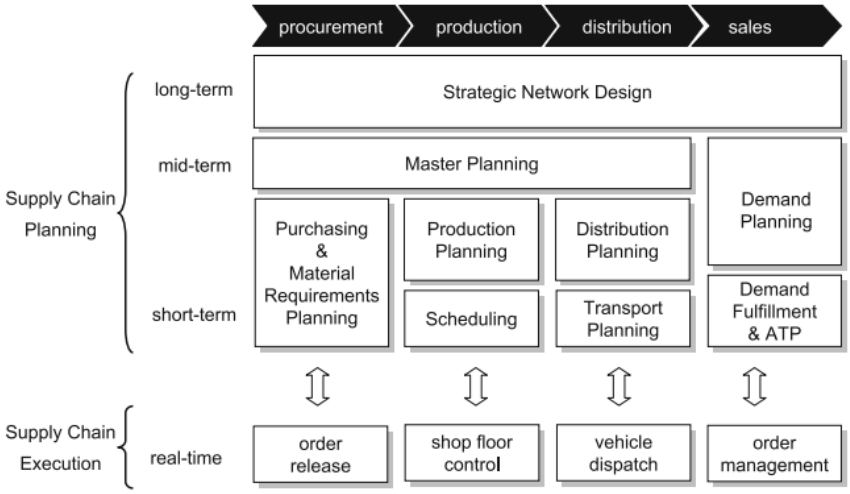
An important feature is an efficient communication system to guide alerts on happenings to the important planning levels and tasks. Furthermore, the result of a single planning task can origin alerts for other plans.

In this scenario, APS systems can first be feared to be among the promoter agents of humans substitution by machines, as they try to computerize planning. This is due to the three principal advantages of APS: information can be visualized, planning time reduced, optimization methods allowed. Hence, there is still the need of human knowledge, experience, and skill to fill the gap between model and reality. However, it is to be considered that planning systems, even if very advanced, remain human decision-makers support systems. Moreover, in event-driven planning, it

is typically the human planner who decides whether it is needed to revise a plan or not. Finally, humans remain still those responsible for data, function and results.

Figure no.2.2.1: The Relation between APS and Supply Chain Execution Systems

Source: Stadtler H., Meyr H., Kilger C. (2015)



As shown by Figure no.2.2.1, the Supply Chain Execution Systems (SCES) connects the phases of preparing decisions with the APS and the ultimate implementation of them put into practice, meaning their execution, representing the bridge of the gap between preparing decisions in an APS and the final implementation of these decisions in practice (‘‘execution’’). Software modules for supply chain execution also deal with the supply chain processes of distribution, procurement, production, distribution and sales. However, the planning tasks included there are related to the execution, comprising an even shorter–term planning horizon. For instance, SCES may be used for transportation execution (including tracking and online response to customer requests, tracing material handling and order transmissions to suppliers). When required, they can support the planning instructions of APS adding more details (i.e. thanks to human support), but they mostly check the correct execution of decisions set by APS.

The execution step includes the realization of an adjusted plan between the partners. It drives to activities in transactional systems (e.g. SAP R/3) such as entering production or replenishment orders. Shop floor control systems assist “track and trace” of orders and material flows, resource loads and staff assignments.

Furthermore, an online monitoring of the execution processes makes real–time response to unexpected events possible.

SCES are strictly paired to APS through alert management systems which are called Supply Chain Event Management (SCEM) systems. Hence, they can get over statistic planning intervals linked to

traditional rolling horizon planning, also giving room for a flexible and responding event-driven planning.

In conclusion, the confines between APS' and SCES' functionality are not easy to be specified. For instance, the order promising function may belong to both APS and SCES. Typically, ATP quantities are divided into customer groups inside an APS, while the SCES can execute both online research of free ATP and real-time reactions. The rules for ATP consumption can be programmed in the APS and sent to the SCES as commands or they might be personalized directly from the SCES.

CHAPTER III: Supply Chain & Performance Measurement

3.1 Introduction to performance and measurement

In order to be more competitive in the context of global markets, companies aim at delivering products and services in both an efficient and effective manner and a key factor is represented by the effort in designing and coordinating supply and distribution systems through supply chain management (SCM). According to Fisher (1997), SCM performance can be seen as the match or mismatch between the kind of product or service supplied and the design of the supply chain itself. At the beginning it was more confined to typical areas such as purchasing, distribution and logistics. After some years SCM has developed as an inquiry area, also extending itself so to encompass various fields like supplier collaboration, supply network structure and supplier relationships. It is relevant to underline the distinction between service supply chains and manufacturing supply chains as in the former ones human labor plays an important element of the value delivery process, the decision process takes place locally and the variability and incertitude linked to outputs is high due to the human involvement, whereas, in the latter, physical procedures of a product bring to standardized and centralized patterns and controls. Furthermore, service supply chains distinguish themselves from manufacturing ones also as far as keys of efficiency are concerned, as for the first they are represented by management of capacity, flexibility of resources, information flows, service performance and cash flow management. These issues are quite different from manufacturing supply, although there are also some points in common for both kinds of supply chains, like the fact that demand management, customer relationship management and supplier relationship management are crucial factors (Ellram, Tate and Billington 2004).

The approach towards a better supply chain management has come through the implementation of different techniques and methodologies such as Just-In-Time (JIT), Lean Production, Total Quality Management, Kaizen and computer generated Enterprise Resource Planning schedule (ERP).

By considering Thomas and Griffin (1996) conceptualization of Supply Chain Management (SCM), according to whom it consists in the ultimate state in the evolution of purchasing, procurement and other supply chain activities, the operational level is represented by the agglomeration of functions such as the storage and the distribution of goods, as well as their buying and seeking, whereas the strategic level includes the transformation of the way through which manufacturing and non-manufacturing operations encounter customer needs.

Furthermore, importance is to be given to the organization of process oriented cross-functional teams which have to be aligned to the other companies so to guarantee a seamless flow of resources along the supply chain thus reaching better supply chain effectiveness (Trent and Monczka, 1994). Such teams can contribute to minimizing or eliminating department barriers also getting over the downsides of specialization which, according to Fawcett (1995), can spread the know-how of all value adding activities so that nobody has complete control over the process. These groups help also the creation of modern supply chains by pushing wider integration of organizations with their suppliers and customers.

Currently, many companies have tried to break both inter and intra firm barriers to generate supplier partnerships and strategic alliances, meaning more collaborative and tight relations between firms and their upstream and downstream customers, aiming at limiting uncertainties and fostering the control over supply and distribution channels.

Such alliances usually serve to augment the financial and operational performance of each channel which participate across cuts in total cost and inventories and raise the sharing of information (Maloni and Benton, 1997). The evaluation of the relationship between manufacturers and suppliers changes because it is not solely a matter of price, but it also takes into account the collaboration potential of working together providing services, product design and technological innovation. The evolution of this perspective has had a relevant effect by extending the horizon of SCM throughout a wider integration of suppliers with companies. The increase of globalization, the improvement in information availability and the reduction of barriers to international trade are among the principal factors which promoted the evolution and spread of SCM.

Moreover, the advent of computer generated production schedules, together with the increasing relevance of inventory control and the proliferation of government regulations and actions like the foundation of the European single market and the guidelines of General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO), have stimulated the further development of already existing trends in SCM, also creating new ones. Supply chain integration is required to control the operating systems flow which is linked to inventory control and activity system organizing the entire range of resource and time limitations.

An operating system which supplements the flow of control has to encounter the wide competitive and strategic targets of cost, dependability, flexibility, quality and speed (Slack et al., 1995; Gunasekaran et al., 2001; DeToni and Tonchia, 2001).

The control activity is crucial due to the variability of both customer needs and supply chain performance. It is then fundamental to measure supply chain outputs from its processes so to compare them with specific sets of standards. The more the process parameter values keep on being sort of constant and within a specific range, the easier it is to control them. Due to the possibility of

comparing between planned and actual parameter values, the management can intervene by implementing some reactive measures so to improve the performance or realign the monitored value to the defined value.

For instance, an analysis of the layout of facilities could unveil the reason of long distribution time, high transportation and movement costs and inventory accumulation. By applying adequate approaches such as re-engineering facilities, it is possible to face important issues thanks to close monitoring and some improvements which took place via analysis of the new design. Hence, having control over processes in a supply chain is important to improve performance and it is achievable through measurement: efficient processes are fundamental for better SCM.

The hierarchies in function are represented by the strategic, operational and tactical levels where policies and trade-offs take place so to exert the right control (Ballou, 1992). Rushton and Oxley (1989) structured this hierarchy on the time scope for activities and the appropriateness of decisions, together with the effects of different levels of management.

Top level management ruling is affected by strategic level measures such as competitiveness, policies, corporate financial plans and the level of constancy to organizational goals. Those measures specify what results are to be achieved through the meeting of performance targets enabled by the tactical level which contribute to resource allocation and measuring.

Measurement of performance yields high relevant feedbacks on mid-level management resolutions. Operational level measurements and metrics need precise data and estimate the results of decisions of low level managers. Supervisors and workers are in charge of achieving operational targets so to accomplish also tactical objectives. Many companies leverage constant improvement as a mean to foster their main competitiveness utilizing SCM. Many firms didn't manage to maximize their supply chain's potential due to their failures to implement the performance measures and metrics needed to completely integrate their supply chain to maximize both efficiency and effectiveness. Lee and Billington (1992) asserted that different sites of a supply chain can't reach the desired maximization when the pursue of different goals is enacted independently.

Many organizations have a clear picture on how relevant financial and non-financial performance measures are, however, they often fail to place them in a balanced framework. According to this topic, Maskell (1991) suggests that organizations should cope with the fact that constant control of manufacturing and distribution operations is often dealt in a more efficient way thanks to the support of non-financial measures, whereas financial performance measurements are fundamental when making strategic options and external.

Performance measurement and improvement metrics should have as an aim to truly seize the core of organizational performance. A measurement system should smooth the allocation of metrics to where they would be more adequate. In order to perform an effective performance measurement,

also improving processes, measurement goals have to reflect organizational targets while the selection of the metrics should take into account the balance between financial and non-financial measures which can concern strategic, tactical and operational levels of decision making and control.

3.2 Performance measurements and metrics in SCM

While considering performance measurements and metrics in supply chain management, metrics for order planning are to be taken into consideration, as, for example, for the order entry method: it is a method which defines the approach and the degree of customer requirements conversion into information interchange through the supply chain.

Order lead-time is the total order cycle time, also named order to delivery cycle time, is related to the time passed between the registration of the order of the customer and the delivery of ultimate goods to him/her. The decrease in time in order cycle brings to a decrease in time in supply chain to respond to events, and, while being a fundamental performance measure and a fount of competitive advantage (Christopher, 1992), it affects customer service in defining competitiveness.

The customer order path represents the route that an order does, being another relevant measure which can help in defining how much time to allocate to the different channels.

Another variable of evaluation is the supply link: typically, supplier performance measures are established on price variation and refusal of receiving on time delivery. For a long period of time, the choice of suppliers and products used to take place according to price competition, paying little attention to other important criteria such as quality, reliability, etc.

Evaluation of suppliers is necessary to this kind of evaluation and involves some measures concerning strategic, operational and tactical levels of the supply chain in terms of customer satisfaction, efficiency, flow, integration and responsiveness. For instance, at a strategic level measures encompass cost saving initiatives, supplier pricing against market, lead time and time against industry norm. At a tactical level they encompass booking procedures, cash flow, capacity flexibility and the efficiency of purchase order, while at an operational level they comprise the ability to avoid complaints, the adherence to developed schedule and defect free deliveries. Long-term ability to satisfy customer needs has to be analyzed periodically by purchasing and supply management. There are some areas which require more attention such as the supplier general growth plans, future design, role of purchasing and supply management in the supplier's strategic planning, potential for future production capacity and financial ability to support such growth (Fisher,1997). Supply chain partnership is a buyer and seller cooperative relationship that exploits the interdependence and collaboration on a specific project or a specific purchase agreement

(Ellram,1991; van Hoek, 2001). This kind of partnership urges direct, long-term association, promoting mutual planning and problem solving efforts (Maloni and Benton, 1997).
The parameters which has to be taken into consideration in evaluating partnerships are those that promote and reinforce them. Partnership development built on these criteria can result in win–win partnerships, bringing to more efficient and more integrated supply chains.

3.2.1 Measures and metrics at production level

Typically, when the company owns the production site, it finds the necessary goods, plans the order and then makes/assembles products and such activity has a significant impact on product cost, quality of the product, speed of delivery, its reliability and flexibility (Mapes et al., 1997; Slack et al.,1995). While constituting a key part of the supply chain, it is important to measure and constantly improve production.
Adequate and effective production metrics are:

- Range of product and services: Mapes et al. (1997) suggests that plants in charge of manufacturing a wide range of products are slower in introducing new products than those having a restricted product range. The first class of plants is also less likely to perform well in value added per employee areas, delivery speed and reliability. It appears as a clear consequence that product range impacts supply chain performance.

- Capacity utilization: the capacity related to the determination of the activity level in a supply chain is relevant. Slack et al. (1995) asserts that the effects of capacity level on production performance are directly visible in the speed of response to customer demand through its impact on flexibility, lead time and deliverability.

- Effectiveness of scheduling techniques: scheduling is the activity that is linked to the time or date on activities which have to be brought through. This planning helps defining the way through which resources will flow in an operating system and it can significantly affect production as well as supply chain performance. For instance, the presence of JIT, MRP and ERP techniques in schedules brings determined effects on purchasing in terms of time and size of the assortment. As far as supply chains and scheduling are concerned, given the dependency of the latter from customer demand and supplier performance, scheduling tools have to be considered by such perspective (Little et al.,1995).

Delivery is one of the most impacting variables of the supply chain, one of the principal in determining customer satisfaction, so it is always good to measure the delivery link, also in order to

improve the quality of delivery so to be more competitive. The study of links in distribution systems becomes relevant so to understand where and what to improve in such a dynamic and ever changing context like the pattern of a distribution structure, being it poorly predictable and a key player of the whole system (Rushton and Oxley,1989).

Stewart (1995) suggests that improvements in delivery performance can be set in place thanks to lead time reductions as well as efficient interventions on on-time delivery. The latter can be utilized as a mean to further understand the quality of customer service, which – according to Christopher (1992) – can be seen as the mix of delivery reliability and order completeness. Also the percentage of finished goods in transit related to delivery represents, if high, low inventory turns, bringing to unhealthy augmentations in swamped capital. Many are the elements which can affect delivery speed, encompassing vehicle speed, driver reliability, frequency of delivery and location of depots. In order to reduce inventory levels, it is useful to improve efficiency in one of these areas (Novich,1990). It is important to keep track of notes invoiced in a very precise way: invoices show the delivery date, time and condition of goods when received. Perfect delivery can be measured thanks to the confrontation of the pre-established agreement with real time scenario, also identifying improvements to make. To evaluate delivery performance, flexibility of delivery systems to encounter specific customer needs is another important factor as it reflects the flexibility shown in satisfying a particular customer delivery requirement such as exact places, specific modes of delivery and peculiar packaging (i.e. customized). Such kind of flexibility might affect decisions on customers order placement, hence, being considered as a relevant variable in holding and charming customers (Novich, 1990).

One of the most significant researches regarding logistics concerns the efficient design of distribution systems which are also built in a cost effective manner by analyzing the total distribution cost. Such study requires a complete comprehension of total distribution, in order to apply adequate trade-offs so to constitute the basis for planning and reassessing an effective distribution systems. The importance of considering transportation costs while estimating total logistics costs was underlined by Thomas and Griffin (1996) by sustaining that the first is a relevant factor as it accounts for more than half of the latter. Dealing with distribution costs, individual costs are measured as well as their effects on customer service so to incentivize trade-offs that bring more efficiency and efficacy to the distribution system.

3.2.2 Assessing customer service and satisfaction

Assessing customer service and satisfaction can effectively be done by studying flexibility, customer query time, after sales customer service measures, the role of logistics cost in a supply chain and

information processing cost. It is one of the most critical factors through which supply chains are competitive. Flexibility represents the capability to yield products/services to respond to individual customers demands. Some variables to take into account to assess flexibility encompass: (i) product development cycle time, (ii) machine/tool set up time, (iii) economies of scope (Christopher, 1992) — related to the production of small amounts of wider range such as JIT —and (iv) number of Inventory turns.

Customer query time refers to the time needed by a company to reply to a customer query with the required information. It is normal that a customer can question about an order status, delivery or stock availability: satisfying customers by giving a rapid and precise response is fundamental.

After sales activities are very crucial to customer service as it represents valuable feedbacks which can be implemented to improve supply chain performance and such supply chain function keeps on playing an important role even after the receiving of the goods by the customer.

Total logistics cost is a financial measure that can be an helpful factor when assessing the efficiency of a supply chain as it is fundamental to analyze the financial impact of ample level strategies and practices that participate to the flow of products in a supply chain. Given that logistics is a cross-functional, it becomes then relevant to measure the impact of actions that can affect costs in one area, also influencing costs associated with other areas (Cavinato, 1992). For instance, changes in capacity can have important effects on costs associated with inventory and order processing.

Hence, total cash flow time represents a metric measure to define the productivity of assets in a supply chain.

Due to the constant increase in customer service queries, an efficacious inventory management of the supply chain is fundamental (Slack et al., 1995). Moreover, the total cost linked to the inventory can be divided into opportunity cost, meaning warehousing and capital and storage, cost related to the starter inventory level and work in progress, service costs such as those coming from stock management and insurance, cost of finished goods encompassing those in transit as well, risk costs like those related to damage, deterioration and pilferage, costs referring to scrap and rework and costs in reference with too little inventory accounting for lost production and lost sales (Stewart, 1995; Christopher, 1992; Slack et al.,1995; Lee and Billington, 1992; Levy, 1997).

Information processing cost comprehends costs such as order entry, order follow/updating, discounts and invoicing. By making a survey and analyzing its results, Stewart (1995) found that information processing cost has the biggest incidence to total logistics cost. Information technology is transitioning from a general passive management assistant with the help of databases, to a highly advanced process controller which can control activities and opt for an adequate route for information. Modern information technology has made possible a greater integration of modern

supply chains thanks to its ability in yielding on time, precise and trustworthy information (Naim,1997; Benjamin and Wigand, 1995).

3.3 Performance measurement in a SC: a framework

A. Gunasekaran et al. (2004) created a framework for performance measures and metrics as shown in the Figure below, taking into account the four main supply chain activities/processes, meaning planning, sourcing, making/assembling and delivering. Such metrics have been categorized into strategical, tactical and operational so to make the suitable level of management authority and responsibility for performance. The authors suggest to implement the same approach in the development of an SCM performance measurement program. Managers and/or consultants can spot measurements, rank them by relevance according to the methodology illustrated (Figure no.3.3.1), build a similar matrix so to delineate the supply chain activity/process which has to be assessed, as well as the level of management and the kind of measure to pair it with.

Figure no.3.3.1: Supply Chain performance metrics framework

Source: A. Gunasekaran et al. (2004)

Supply chain performance metrics framework

Supply chain activity/ process	Strategic	Tactical	Operational
Plan	Level of customer perceived value of product, Variances against budget, Order lead time, Information processing cost, Net profit Vs productivity ratio, Total cycle time, Total cash flow time, Product development cycle time	Customer query time, Product development cycle time, Accuracy of forecasting techniques, Planning process cycle time, Order entry methods, Human resource productivity	Order entry methods, Human resource productivity
Source		Supplier delivery performance, supplier leadtime against industry norm, supplier pricing against market, Efficiency of purchase order cycle time, Efficiency of cash flow method, Supplier booking in procedures	Efficiency of purchase order cycle time, Supplier pricing against market
Make/ Assemble	Range of products and services	Percentage of defects, Cost per operation hour, Capacity utilization, Utilization of economic order quantity	Percentage of Defects, Cost per operation hour, Human resource productivity index
Deliver	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule, Effectiveness of delivery invoice methods, Percentage of finished goods in transit, Delivery reliability performance	Quality of delivered goods, On time delivery of goods, Effectiveness of delivery invoice methods, Number of faultless delivery notes invoiced, Percentage of urgent deliveries, Information richness in carrying out delivery, Delivery reliability performance

The authors highlight that this should be considered as a starting point for an estimation of the importance of supply chain performance measurement.

Participants of the survey that A. Gunasekaran et al. (2004) structured had to tell if their Return On Investment (ROI) had reached expected levels following the implementation of contemporary supply chain management (SCM) practices. The 76% positive feedback represents the benefits from making an aware effort to managing supply chains, having generated financial returns for participating firms. It also emerged that a proactive approach to SCM is recommendable to companies willing to foster competitiveness while SCM literature illustrates that efficacious SCMF assists in winning customers and improving customer service. The benefits generated by SCM on market share has been noted by the 66% of the respondents, yielding evidences of the strategic importance of successful SCM. Potential positive effects of SCM make it alluring, but performance measurement and improvement studies through the supply chain always play a crucial role.

It is important that all supply chain members are engaged with same objectives like customer satisfaction and fostered competitiveness with a complete performance measurement program adaptive and flexible enough to encounter the ever changing needs of participants as high quality SCM programs enhance cross-functional and intra-organizational process of planning and control, thus achieving a more complete supply chain integration. For these reasons, a common discussion and sharing of ideas among the company, suppliers and customers could lead to a more concrete and solid assessment and improvement of SCM performance.

3.4 SCM initiatives

As SCM can origin competitive advantage, it is also important to understand what SCM strategies can be implemented as well as what initiatives are believed to be more significant by managers of companies whose aim is to produce competitive success. A study conducted by Sengupta, K., Heiser, D.R. and Cook, L.S., (2006) identified some SCM practices considered as priorities by firm's managers through the analysis of tasks pursued by the organization in that time in relation to what participants considered as a future priority within the global market context.

Sharing information, level of product and service customization, building long-term relationships and hedging methods are defined as the crucial initiatives linked to SCM. In particular:

- (SHARE): Information are related to inventory levels, demand forecasts and pricing while being shared with supply chain partners. This variable is seen as very significant due to its effects on coordination.

- (PRODUCT): it's a key factor which encompasses both products and services for both manufacturing and services sectors, taking also into consideration the level of product and service customization and it helps in defining the demanded flexibility of a supply chain.
- (RELATION): structuring long-term relationships with supply chain partners helps developing solid collaborations and fostered administrative efficiency, also creating chances for a more effective organization in business decisions (Hahn, Pinto and Bragg 1983; Choi and Hartley 1996; De Toni and Nassimbeni 1999).
- (HEDGE): hedging risks while talking about SCM strategies is useful when willing to try to prevent supply chain disruptions through techniques such as keeping multiple suppliers, maintaining finished goods inventories and holding a reserve capacity (Shanahan 2004; Kawtummachai and Nguyen 2005; Sheffi and Rice 2005). Thanks to the leveraging of the supply chain partners, an organization might reduce its vulnerability to risks related to the production and delivery of products to the marketplace.
- (PLAN): Advanced planning systems are widely utilized in the manufacturing sector to foster transparency and communication concerning supply. The traditional implementation of advanced planning systems requires large capital and managerial investment (Zuckerman 2005).
- (INTERNET): it represents a crucial tool for collaborating and coordinating supply chain partners
- (SNET): the supply network structure comprehends supplier certification, rationalization of the supply base, outsourcing-related decisions and upstream supply chain for a company. It traditionally includes the number of suppliers and stages in the supply chain (Frohlich and Westbrook 2001; Li et al. 2005).

3.4.1 SCM initiative performance metrics

Specific supply chain strategies have effects on organizational performance as also demonstrated by prior research and industry practices. Tan (2002) studied both SCM and evaluation of suppliers and firm performance. Manufacturer, suppliers and customers are three elements that, if integrated, can bring to the achievement both of financial and growth targets.
There have been other research studies which opted for many different performance measures to verify the validity of some SCM strategies. For instance, Li et al. (2005) decided to concentrate on delivery dependability and time to market to check the predictive significance of their six SCM constructs.
Chen and Paulraj (2004a,b) have chosen supplier performance and buyer performance to measure the links between customer responsiveness, financial performance, strategic purchasing and supply management of the buying firm.

Vickery, Jayaram, Droge and Calantone (2003) studied the performance consequences of an integrated supply chain strategy, with customer service performance followed by financial performance as performance constructs.

Narasimhan and Kim (2002) investigated the impact produced by SCM relationships between diversification, firm performance through sales growth, integration, market share growth and profitability.

Tan (2002) chose competitive position, customer service and product quality as performance measures, also asserting that the absence of a consensus concerning cross-industry measures of organization performance, it can be transformed into operational due to the confrontation between perceptions of the management on firm's performance and the main competitors.

The operational performance metric assesses the differences between the individual performance of a company and those of its competitors, based on an evaluation of three elements which enable operational excellence: delivery, speed and quality.

The financial performance is assessed through the confrontation of the relative cost scenario and the profit-related performance.

3.4.2 SCM initiative: Managerial implications from Sengupta et al. (2006)

Taking into account the investigation made by Sengupta et al. (2006), some figures can be studied in order to better understand some useful managerial implications presented in his paper.

Figure no.3.4.1: Correlations by sector between SCM strategies and operational and financial metrics

Source: K. Sengupta et al. (2006)

CORRELATIONS BY SECTOR BETWEEN SCM STRATEGIES AND OPERATIONAL AND FINANCIAL METRICS

	Performance Metrics			
	Operational Metric		Financial Metric	
SCM Strategies	Manufacturing	Service	Manufacturing	Service
SHARE	0.167	0.339*	0.245*	0.233*
PRODUCT	−0.077	0.388*	−0.022	−0.148
RELATION	0.178	0.135	0.342**	−0.087
HEDGE	0.248*	0.177	0.311**	−0.056
PLAN	0.144	0.242*	0.230*	0.217
INTERNET	0.058	0.217	0.157	0.035
DNET	0.113	0.318**	0.243*	0.292*
SNET	0.031	0.160	0.193	0.027

*0.05 significance level.
**0.01 significance level.
SCM, supply chain management.

The analysis displayed in Figure no.3.4.1 establishes the effects of specific SCM strategies on operational and financial performance for manufacturing and service sectors. The evidences coming out from the observation of the table shows differences between the two sectors and the consequent managerial implications. First, there is a variation of predicting performance in choosing the most adequate strategies depending on and within each sector. For instance, operational performance is foreseen by means of hedging risk strategies whereas financial performance is forecasted by attention to supply network and tightness of long-term relations. Second, the effects of determined SCM strategies on performance changes depending on the sector to which it belongs.

For example, service sector operational performance is linked to the approach of sharing information with supplier chain partners and the level of product customization relative to their competitors, whereas manufacturing operational performance is foreseen due to the strategy chosen for enacting hedging risk. As a consequence, it is not advisable to generalize across sectors, hence organizations from both manufacturing and service sector have to take into account the sector-specific implications while benchmarking techniques from other sectors.

Moreover, some factors which were believed to have great impact on organizational performance can also not represent a mean of differentiation for a company from its competitors anymore, such as INTERNET and SNET: it is widely spread among both manufacturing and service companies the usage of both manufacturing and service organizations. In any case, such technology application doesn't appear to justify either financial or organizational performance outcomes. Probably the use of the internet is so common that it doesn't constitute an added-value for a superior performance when confronted an organization with its direct competitors, as for the SNET factor.

The consequence of such finding is the fact that strategies related to selection and certification of suppliers and rationalizing the supply base does not produce important effects on organizational performance. Likewise, the level of product and service customization compared to competitors does not appear to have an impact on the performance of manufacturing organizations, whereas it does affect service sector performance.

CHAPTER IV: Empirical investigation of BtoB Italian manufacturing firms

4.1 Covid-19: a global scenario

The objective of this section is to provide a general overview of the different and multiple impacts that the pandemic has had, and is still having, on economic realities. Information and ideas deriving from white papers, publications and articles have been collected, always keeping a microeconomic focus in the research. In particular, the principal challenges encountered, the skills and resources that have been put into play to build a resilient and flexible operational base and business management will be studied and also the opportunities that the advent of the health emergency has brought.

On January 10, 2020, the World Health Organization (WHO) decided to write and distribute to all nations a technical guide which included indications on how to identify the virus and how to treat infected people, based on the recent lessons learned. Only on January 12, China declared that the Coronavirus sequence was isolated and the next day the first case of infection took place outside the Chinese territory, in Thailand. After confirming the transmission of the virus through the relationship between men, a total lock-down obligation was immediately imposed to the city of Wuhan on January 23. During this period citizens were forced to stay at home, which became their place of work, leisure and education for more than two months. Highest level security measures were adopted: roads were blocked so to avoid in-coming and out-coming flows making cities empty. In addition to that, applications were created to with the aim of tracking the movements of people who were fined large sums of money in case of being caught outside their domiciles.

On January 30, while the number of infections was continuing to rise in a frightening way, the WHO declared that the epidemic had become a real global health emergency, thus officially becoming a pandemic; more precisely it was labeled Public Health Emergency of International Concern (PHEIC). Since the validation of the International Health Regulations (IHR) in 2005, it was the sixth time that the WHO had declared a health emergency of this magnitude, which counted, after just one month, more than 7,000 confirmed infected cases in China and 82 in other countries. Unfortunately, the expansion managed to reach any part of the globe, while data did not seeming to stop increasing.

In South Korea, as well as in Italy and the United States, numerous cases of death began to occur and this forced the WHO to declare the existence of a pandemic on 11 March, 2020. From that date all nations followed their own regulations in order to contain as much as possible, in limited areas,

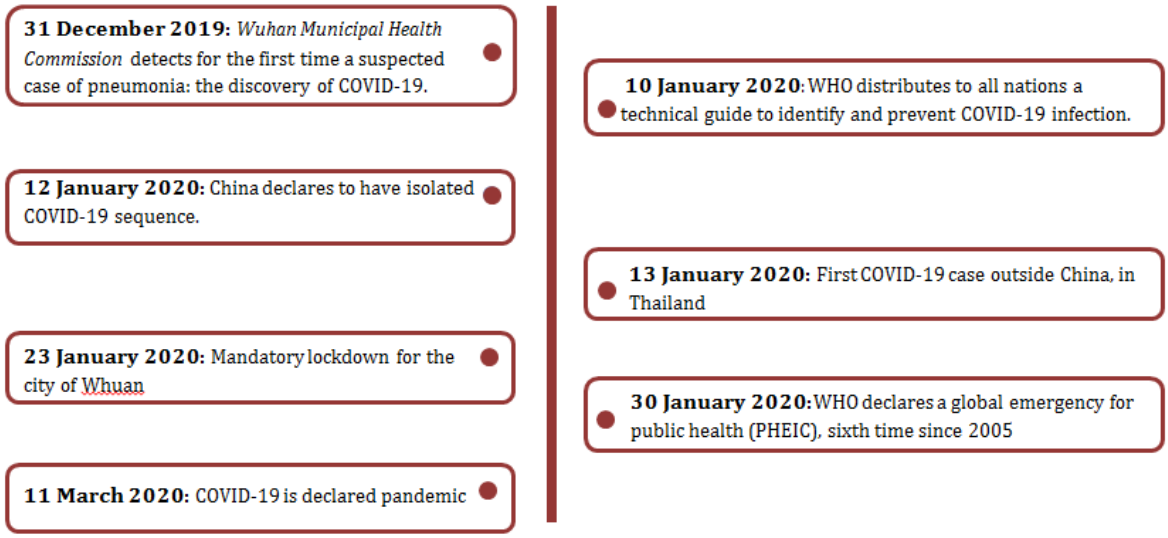
this "invisible evil". Questions and doubts regarding the spread of Covid-19 remained numerous and did not receive a precise answer while a fact was announced by the World Health Organization (WHO) asserting that the origin is to be found within the animal kingdom, thus excluding all false and unfounded theories and conspiracies that associated the same with voluntary creation by some Chinese researchers.

On December 31, 2019, several cases of a suspected and unknown form of pneumonia were detected for the first time in Wuhan, the capital of Hubei province, a densely populated city and main hub for international trade located in Central China. A few weeks later, the discovery of a new virus was officially announced: Covid-19.

Figure no.4.1.1 reports the chronicle of Covid-19 at an international level.

Figure no.4.1.1 Coronavirus chronicle

Source: Personal Elaboration



The virus spread very quickly, and, as of today, October 5, 2020, there are 34.804.348 globally confirmed cases.

Figure no.4.1.2 illustrates the global mapping of confirmed cases which shows how much the virus is jeopardized.

Figure no.4.1.2: Confirmed cases map

Source: WHO Coronavirus Disease (Covid-19) Dashboard

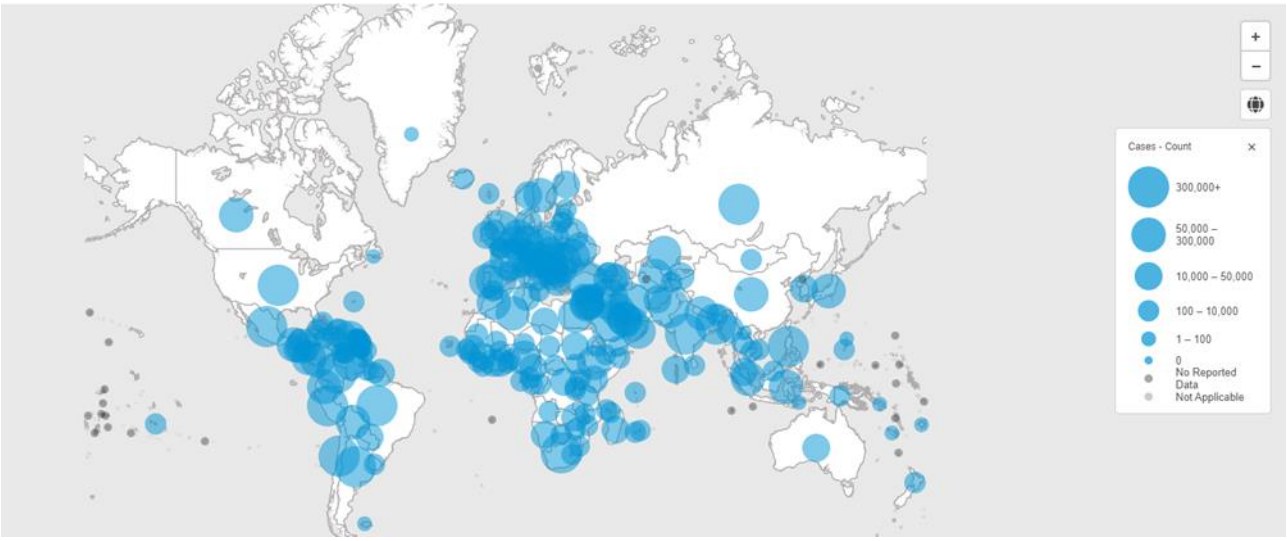
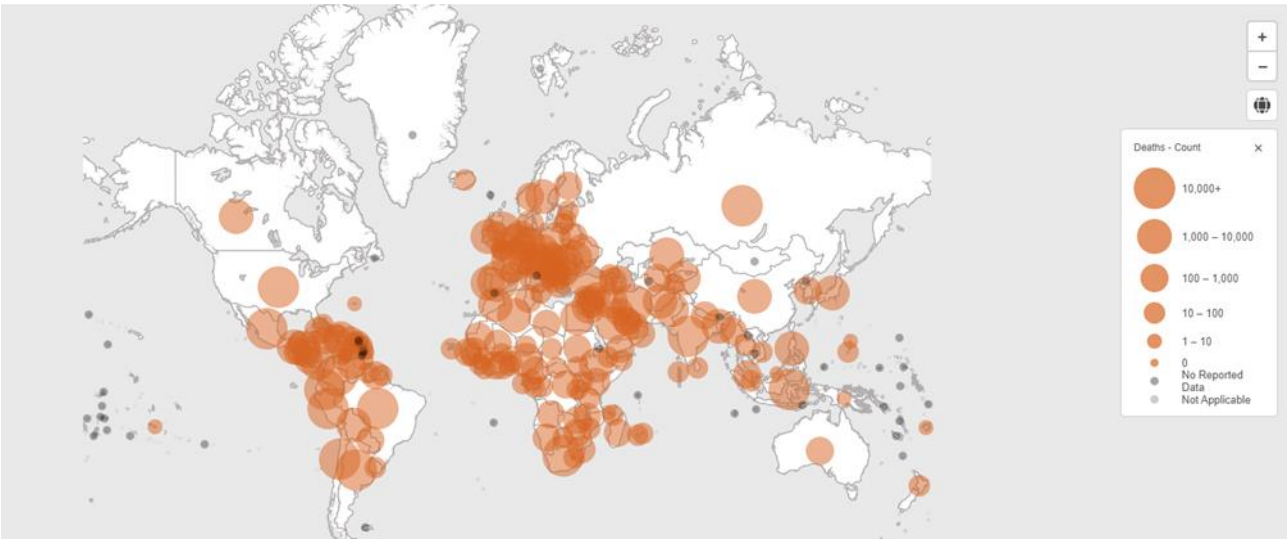


Figure no.4.1.3 depicts death cases globally spread.

Figure no.4.1.3: Death cases map

Source: WHO Coronavirus Disease (Covid-19) Dashboard



Such pandemic, a part from being a frightening and unexpected threat for the health system and the health of citizens around the world, has had, and still continues having, significant and drastic repercussions on the world economy. Economic activities around the world have faced a number of challenges, threats and opportunities. Only the companies that have shown strong resilience, reactivity and agility have emerged as winners from this moment characterized by strong uncertainty and volatility.

4.2 Covid-19: the Italian scenario

Moving from the global picture to the Italian case in particular, the restrictive measures against Coronavirus started to be implemented on February 1, 2020, when Angelo Borrelli, head of Italian civil protection, declared that the state of emergency also involved the Italian country, confirming the declaration only two weeks later, on February 21, 2020, date when the first case of Coronavirus in the Lombard municipality of Codogno took place. In the following three days, six regions of Northern Italy such as Lombardy, Veneto, Piedmont, Emilia Romagna, Liguria and Friuli-Venezia Giulia were forced to close schools and all universities with the recommendation to stay at home as much as possible so to slow down the spread of the virus.

Taking into account the increasingly evident global threat at the beginning of March which is not finished yet, the President of the Council of Ministers Giuseppe Conte signed a series of decrees lasting 15 days each, as equal to the reference period for the incubation of the virus. With the first Decree Law of March 8, 2020, n.11, there was the declaration of the beginning of the lockdown which has heavily been affecting the nation for several months. In phase 1 of the block, all movements were prohibited unless extremely necessary or for proven work needs, any form of gathering of people in public places, places of culture were closed and there was the obligation of closing bars at 18.

On March 11, 2020, the World Health Organization declared a global pandemic and, in Italy, 10.000 infections were exceeded. Many other decrees law were issued in these two months to contain the spread of Covid-19 as much as possible and in order to reach phase 2 of restart as soon as possible.

«We have no choice: now it is time to protect ourselves and people we love. For this reason, the government has made the decision to make a step further: to close every productive activity at a national level, except for those strictly necessary, essential, crucial for granting fundamental goods and services». These words were pronounced by the prime minister Giuseppe Conte at the ouverture of the national live streaming, the 21st March 2020. This date marked the moment in which the health crisis formally enacted an economic crisis as well, bringing the Italian country into times of recession.

Since the signature on the 22nd March 2020 n.35 law decree , industrial activities, both commercial and productive, have been completely stopped, apart from those supplying public utility products and services. Such decree listed all ATECO codes belonging to protected activities which were allowed to continue, although it was then replaced by a second version which was more complete and can be found as the attachment n.1 of the 25th March 2020 n.19 law decree.

Some of the main activities that had to keep on providing goods and services to customers were supermarkets, basic necessities goods shops, pharmacies, transports, banking, postal, insurance and financial services. Other companies like restaurants and every "non-essential" industrial or commercial activity, thus having a different ATECO code with respect to those listed in attachment n.1 of the decree had to close and stay closed until the May 2, 2020.

Specifically, the restart officially began on May 3, 2020, the date on which culture, economy and education finally seemed to come back to normality.

The productive firms lockdown has generated many problems to Italian companies: many organizations have suddenly been obliged to implement organizational and operational adjustments so to guarantee a sufficient safety level to all collaborators and an efficient one in order to face to the new scenario. Similarly, it is immediate to imagine the difficulties encountered by many of the productive activities along the production chain which supplied specific operations or products to ATECO protected companies and were obliged to close, constituting – as predictable – a bottleneck of the whole supply chain.

After having formed a solid awareness of the extent of the economic crisis that concerned the entire Italian nation in the months of April and May, an urge of building a literature review which could highlight all challenges, opportunities and threats that economic realities faced all by themselves utilizing their own resources and lessons learned from the past. In the midst of the health emergency, many Italian and international companies have found the development of articles, insights and online webinars an useful tool to acquire knowledge, also having updates on procedures at an operational, managerial and organizational level which were demanded by such a violent crisis in order to survive, coming out as renewed winners.

The current literature is very multifaceted with regards to topics treated in the articles. Some of them mainly focus on business problems that arose during the lockdown period, providing strategic and support advice for all those realities that have found themselves experiencing very critical management situations. Other articles analyzed the skills and resources to use and develop in order to generate a resilient and flexible work context for the present and the future.

However, most publications study the emergency and the consequent economic crisis by a positive perspective as it built opportunities as well, being an accelerator that will push even the most traditional business models towards a structured and effective innovation and digitization of processes, services and work.

Companies all over the world are now called to resist and rethink their economic logic, putting into complete discussion, the traditional business models that until last March were not considered and now revealed themselves to be fragile and no longer resistant. At this stage, a real shift from the old paradigms towards more sustainable, strategic and proactive models is required, in order to be

capable of surviving to new and unpredictable far-reaching exogenous factors, even in the long term,.

4.3 Methodology and champion description

This research aims at investigating the impacts of Covid-19 on Italian BtoB manufacturing companies. Through the analysis of the business model, thanks to semi-structured interviews, it was possible to collect various information in order to understand possible solutions in a resilient key and study the main characteristics of the Italian manufacturing firms, observing the weak points and strategic areas of intervention that needed to be taken into consideration. In particular, we tried to use an inductive approach to tackle new issues and contextualize them, basing the work on a qualitative exploratory research of various business cases. Information was collected in detail, trying to identify the main challenges that have been encountered and had to be addressed. The behavior of the companies was then studied, focusing on their reactions evaluated within the contextual frame of reference so to be able to draw conclusions. In order to achieve the purpose of the research, the study was characterized by a more theoretical logical matrix than a purely more statistical one: consequently, no models were developed, but an attempt was made to collect the necessary information, analyze it and come to conclusions.

Telematic tools have been used in order to make the necessary interviews to collect the important pieces of information needed to have a clear picture of issue while I was, together with other researchers, in charge of finding the most suitable workers to involve in the study. We found personas from top-middle management, to have direct insights related to the companies they work for. As a first step, interviews have been organized, meetings have been recorded and conversations have been written down, making transcripts. As a second step, the latter have been codified so to focus on data categorized by first orders, second orders and aggregates, as illustrated by Voss et al. (2002) (see Appendix A1, A2).

Structures used for the interviews changed according to the related emergency phase, named “Phase 1” and “Phase 2” (see Appendix B1, B2).

All material, meaning the entire appendix, interviews to Italian firms and coding, was produced in Italian and then translated into English.

The first depicts the very beginning emergency scenario when the Italian Prime Minister declared the official start of a national lockdown which would have made all activities that were not believed to be of primary importance stop to run. As a consequence, firms had to find effective and immediate, although not perfect, solutions which could have allowed them to survive, so a relevant role was played by the so-called quick & dirty responses, the adoption of which was rapid due to

the very unstable context in order to soothe the impact of the pandemic. In this field also emerged the importance of digital technologies, which was a variable that has been analyzed more in detail to better allocate it into the disruptive context by observing if it could be a tool that could facilitate a firm adaptation, with a focus on production processes and the deployment of services. Moreover, effort was made in taking into consideration the fundamental actions to be taken into account, thus implementing them with the aim of getting ready for the reopening notwithstanding limitations and effects on operations such as the impossibility of performing services to customers directly or the safety distance that needs to be kept between workers.

Interviews took place during both Phase 1 and Phase 2, following a one-to-one setting. The former was characterized by a more relevant impact on field service operations (FSO), the latter underlined the effects on operations and business model, while both of them highlighted two main aggregate topics: specific affected areas and resilience. Interviewees were also steered to self-assess various characteristics and facts related to the firms they work for, such as the level of readiness of the organization, the analysis of threats and opportunities, the extent to which the company was quick and effective in solving problems and so on and so forth. Importance was given to the transition from the "old normal" to the "new normal", so from phase 1 to phase 2, when a number of activities has come back to work, finding and implementing new ways to deal with the presence of the virus. In that period of time, the structures of the interviews were modified according to the ever changing scenario, giving more importance to the effects produced by Phase 1 by backward-looking to that situation through the study of the factors which were most impacted by the emergency, also paying attention to the responses that those firms had by comparing their initial design to the second one to verify if the former approach was developed into a latter or rejected and substituted.

By including twenty-four manufacturing firms which belong to diverse industries, the cluster aims at representing the Italian manufacturing sector with a focus on Business-to-Business (BtoB) companies in order to see the impact that Covid-19 had on those organizations. Due to privacy policy reasons, all actual company and interviewees names have been substituted by company codes and counterfeited names.

The aggregate was divided into two sub-clusters: phase 1 and phase 2. Table 4.1 below shows a picture of the composition of the former while Table 4.4 illustrates the structure of the latter. Both groups of companies were represented by specifying industries they belong to, their position within the supply chain - either being an Original Equipment Manufacturer (OEM) or an Original Equipment Supplier (OES) -, whether they were ATECO protected or not, the type of lockdown they had and the intensity of the economic impact accused from the Covid-19 crisis.

4.3.1. Phase 1 cluster description

α is a manufacturing firm which operates in the agricultural machinery industry. It is a global player which strives to be a role model as far as technology, innovation and sustainability are concerned. It is an Original Equipment Manufacturer (OEM), as all other companies of the cluster. It is a key component for many supply chains belonging to various α partners.

β is an OEM making business in the foodservice equipment industry which has a wide portfolio of firms with solid experience. It is a company focused on systems and process innovation, also promoting food-related traditions that has registered a strong economic impact from Covid-19 crisis which made it face a complete lockdown.

γ is a globally extended and very solid company which counts many sales branches nationwide and some facilities spread all over the world. It is specialized in polyethylene terephthalate (PET) packaging and it belongs to the ATECO protected firms which were allowed to continue their activities during the general lockdown.

δ is a firm that plans, produces and sells machines and flexible systems to shape and work on metal sheets. This OEM operates in the engineering industry and has a wide and international supply chain. It is focused on technology and innovation, providing a large array of machine tool products.

ε is a family-run group which operates internationally in the engineering sector while being leaders for both technology in machine tools and laser for industrial purposes, also offering software solutions for high-tech companies.

ζ is an OEM that offers packaging solutions and which was characterized by a so-called winner lockdown, meaning that it benefited from positive effects derived by the emergency, so the registered economic impact was very weak.

η is a company that works in the agricultural machinery industry and aims at improving process efficiency and innovation. It has many dealers spread all over the world and offers a wide range of products and services.

θ is a firm which runs its activity in the automation industry by offering products such as the automation of processes, metal control systems and steel refinement. It also supplies fully electronic distribution systems, sensors and other special tools.

Table 4.1 Company data: phase 1 cluster categorized by industry, supply chain position, ATECO protection, type of lockdown and economic impact.

PHASE 1 COMPANY CLUSTER					
Company Code	**Industry**	**Supply Chain Position (OEM/OES)**	**ATECO protected (Yes/No)**	**Lockdown Type (Complete/ Partial/Winner)**	**Economic Impact (Positive/Strong / Medium/Weak)**
α	Agricultural machinery	OEM	No	Complete	Medium
β	Foodservice equipment	OEM	No	Complete	Strong
γ	Packaging	OEM	Yes	Partial	Medium/Strong
δ	Engineering	OEM	No	Partial	Weak
ε	Engineering	OEM	No	Partial	Strong
ζ	Packaging	OEM	Yes	Winner	Weak
η	Agricultural machinery	OEM	Yes	Partial	Medium
θ	Automation	OEM	Yes	Partial	Strong

In order to better contextualize the content of the research, after having a picture of the company cluster through Table 4.1, Table 4.2 illustrates interviewees categorized by titles and specializations, while Table 4.3 shows data sources and methods.

Table 4.2 Phase 1 participants data: titles and specialization of phase 1 sub-cluster.

PHASE 1 PARTICIPANTS CLUSTER			
Company Code	**Participant***	**Title**	**Specialization**
α	Achille	Director, After Sales & Spare Parts	Sales; Procurement
β	Nausicaa	Operations Manager	Operations

γ	Menelao	Business unit director–development & technology integration	IT; Marketing
δ	Elettra	International service manager	Sales; Service
ε	Cleopatra	CEO	Legal; Operations
ζ	Ettore	Business Development Director	Marketing; Operations
η	Penelope	Global sales & operations planning, Site process transformation	Sales;Operations
θ	Agamennone	Executive Vice President,	R&D;Operations

Note: *Pseudonyms, not actual names

Table 4.3 Phase 1 participants, data sources and methods used to make the interview, its duration and the tool used to make it.

PHASE 1 DATA SOURCE, METHOD PARTICIPANTS CLUSTER			
Company Code	**Participant***	**Data Source/Method**	**Tool**
α	Achille	Semi-structured interview: Lasted: 43 min.	Skype
β	Nausicaa	Semi-structured interview: Lasted: 48 min.	Skype
γ	Menelao	Semi-structured interview: Lasted: 50 min.	Skype
δ	Elettra	Semi-structured interview: Lasted: 69 min.	Skype
ε	Euridice	Semi-structured interview: Lasted: 25 min.	Skype
ζ	Ettore	Semi-structured interview: Lasted: 30 min.	Phone

η	Penelope Ettore	Semi-structured interview: Lasted: 25 min.	Phone
θ	Agamennone	Semi-structured interview: Lasted: 28 min.	Microsoft Teams

Note: *Pseudonyms, not actual names

4.3.2. Phase 1 subsample findings

From the analysis of the interviews that took place in the period suited to phase 1, various evidences emerged, the first of which are immediately referable to the national political management of the crisis: an imprecise and confused use of the ATECO code as a tool for identifying key companies in order to guarantee the normal functioning of the supply chains deemed essential and the issuance by the Government of frequent decrees with sudden additions, corrections regarding significant novelty factors, and never definitive communications. Both have exacerbated the already precarious situation, giving rise to further uncertainty, but the first was particularly recognized as a cause of uncertainty due to the closure of activities functional to protected ones, creating serious misalignments. In fact, with regard to the ATECO code system, companies have mainly emphasized the inadequacy of this in understanding and respecting some strategic and close interrelationships between different sectors that allow for the proper functioning of the supply chains on which the national economy is based. For example, the activities of agricultural companies have been allowed to continue, without taking into account that they use machinery supplied by companies in the mechanical industry, which had been stopped by the Government, when in turn some of the latter resort to using components supplied by other entities obliged to suspend the activity. The ATECO code, therefore, would have prevented a farm from buying the spare parts needed to repair a machine breakdown due to the blockage of the upstream supply chain. Many of the interviewees reported an incomplete planning of the Italian system due to the lack of security and certainty in the action which also led to regulatory gaps and important management difficulties, as also attested by some companies. The trade unions also contributed to the complexity of the context, limiting potentially relevant choices for the resolution of some problems. Bureaucracy, which is particularly suffered by most of the companies interviewed, is the first enemy of fluidity and simplicity of response to the crisis. In this regard, a manager of the γ company stated: «There is still uncertainty deriving from the question of ATECO codes, it is all to be defined, everything to be clarified ... Yesterday it was not yet clear, we had foreseen the closure, but today and tomorrow also because

the union is involved. It is a question of understanding what the President will decide on how to move. In the end, you can say “I'm going to close, I close” in August in anticipation of it and then I leave later. We are also evaluating how to move towards the issue of layoffs rather than the granting of holidays for employees: reduce the residual holidays accumulated in previous years until exhaustion, scale the paid annual leave (PAR) of previous years for, let's say, the employees who will explicitly request it, and then you can get to suspend workers with the ordinary supplementary fund (CIDO)».

As far as the management of health crises is concerned, the dense introduction of new decrees, not always clear, has caused the implementation of more stringent solutions than those already in force, not giving companies the opportunity to take action in time and implement them in proper way. In this regard, one of the interviewees spoke of a "run-up to the latest decree", as well as trying to keep up with the communications of new measures and new information of various relevance for the business.

A direct impact of the uncertainty brought about by the aforementioned elements was the weakening of the forecasting capabilities of the companies heard during this first phase: not surprisingly, η predicted a rapid return to normality, while the management of ε wanted to underline the difficulty in thinking of a positive scenario until clearer and more unilateral communications are obtained, demonstrating that forecasts are decidedly discordant. It is widely recognized that in the business environment it is not possible to make certain forecasts, but that the only way to approach them is to use context data to try to anticipate the direction of evolution of events to measure them with fair approximation. As uncertainty grows, forecasts will be less and less effective, risking not to identify serious threats to your business. This underlines the increase in the level of complexity for companies that were already in difficulty due to the advent of the coronavirus, since the national political-regulatory context has not favored the possibility of finding a semblance of balance in an already difficult situation, per se highly unstable. What the interviewees reported is precisely that additional factors of unpredictability have been added, resulting in the inability to adequately identify the best actions to take to respond to the emergency. The uncertainty then also manifested itself in terms of sales, where, following the slowdown in the distribution chains and the limitations related to the mobility of people and the fearful orientation of consumers towards the market, there was a significant and sudden decline that saw a reduction in the turnover of companies, with evident repercussions in the short term and implications in the medium-long term.

Many respondents offered parallels with the sales trends of the previous months or of the same period last year, pointing out important contractions. Differences also emerged between the consequences on the basis of the trade region: for example, in Southern Italy there was stronger evidence regarding the decline in sales for some companies, just as for others there is some

optimistic feeling of recovery. of what is lost and of normalization in the long run. Furthermore, in some cases, such as that of company β, there has also been distinct speeds of demand based on whether it was an internal or external market: the company reported how, from the point of view of the after- sales, foreign demand continued at good levels, while for the Italian market there were problems of uncertainty and those related to the closure and limitations that characterized the first phase of the crisis.

Another problem was linked to the procurement of personal protective equipment (PPE), which could not be easily found in the initial stages of the pandemic: «Another problem that arose following the outbreak of the pandemic concerns the finding of PPE, for us it was not easy because even in the company recovering them was not easy ... To say, I personally tried to buy on Amazon and nothing, on Ebay, and therefore also here to find channels to get the dpi. .. because in any case in the company it is also important to protect others. The company did not give them to me», as reported by the company γ.

The impact of the crisis has also occurred significantly on the offer of products and above all services, in fact various production activities have been interrupted, while the provision of services has had to pass through the remote offer such as training activities, telephone assistance, commercial activities, but also the shipment of spare parts. However, the most significant effects occurred for Field Service Operations (FSO) due to the fact that the mobility of technicians aimed at installation and maintenance activities was blocked following the rules imposed to limit the spread of the pandemic.

The disastrous impact on these operations has been limited by some companies such as γ through the management of international operations involving foreign and local branches thanks to the use of local technicians, managing to enact the necessary operations, also avoiding the movement of technical personnel. «To remedy the difficulties encountered in relation to FSOs, we started organizing the activity, so at an international level we basically work with local branches, while in Italy we manage it with Italian technicians».

However, not all companies were in the position to do so and one of these was ζ, which did not have the opportunity to resort to an international service structure capable of offering high operational performance, observing the complete interruption of its FSO activities: «The technician is currently not going anywhere, obviously. Even if he wanted to, he cannot, and in any case we could not guarantee the necessary safety conditions for those who were to leave, so we, as a company, cannot do it».

The situation of the FSOs also offered interesting insights regarding the location of the decline and its extent: as regards the framework of the δ company, Italy saw field service activities stop

completely, while the rest of the world proceeded, albeit in a more controlled and certainly lesser manner, quantifying its operations at around 30%.

No less important was the effect on the spare parts market where, due to the orientation of some companies that have pushed themselves to make large stocks in a precautionary manner in order to possibly face a second crisis, there was a sudden increased demand.

Another type of impact was that which occurred on the supply chain, since, although several companies had had to close in spite of others that had been protected by the ATECO code, some three of the activities that had remained open were those involved in the supply of parts of turnover, therefore many spare parts supply activities, although continuing, had suffered slowdowns due to the limitations imposed on the transport sector, as highlighted by the company α. Consistent with this problem, there have been many critical issues related to the entry and movement of trucks at customer sites, having to respect the rules of interpersonal distancing with a consequent slowdown in shipments, both due to general drops in demand for spare parts caused by the reduction of customer operations, both due to the increase in management costs deriving from the increase in warehouse stocks. The company η suggests congestion of the supply chain with respect to a strong and concrete disruption.

However, the supply chain has seen decidedly strong and negative effects on the supply chain, with particular reference to warehouse management, which, due to past strategic choices aimed at streamlining stocks, proved to be inadequate in responding to a pandemic like Covid-19.

In reference to this theme, γ argued that: «Following the adoption of past strategies, we are inclined to have no warehouse and we said well, I avoid filling up the warehouse, so we are in trouble on that now. We respond on the emergency parts, but on the parts we say of "high turnover" we have problems, because in any case whoever supplies them to me is stopped».

The relevance of the aforementioned declaration derives from the fact that it illustrates which types of stocks have been most affected by the effects of the crisis, apart from underlining the complexities encountered with regard to warehouse management. The effects were similarly reproduced also with regard to custom spare parts, as well as for customizable stock goods due to the blocking of various suppliers as a result of the lockdown, as the company ε points out: «The problem occurs when I receive a request for a particular design, therefore customizable, then I'm in trouble». The production cycle of these spare parts involves a more complex processing than that necessary for a standardized product, with the result that collaboration with other partners is sometimes essential to satisfy the customer's requests. In response to these contingencies, the γ company has expressed its intention to limit the impact through: «the resources of local branches trying to understand how to possibly use the local warehouses and understand where the parts are».

Another important testimony was provided by the same firm regarding the repercussions concerning the spare parts business since it suffered negative effects on its production capacity, as the main suppliers were forced to close due to the lockdown: «production capacity to which we are traveling, well it is difficult to establish, but it is clear that you have had a strong reduction. In other words, you block everything with this block today. Because in fact, it is true that I can work as a company that works perhaps for food sectors, but it is also true that those who make me the pieces to be assembled on the machines, eh! That is, they are stationary. Because in theory you should go back in the supply chain and say 'okay you do (...) but the parts are made by supplier A, B, C». With the forced blockade of all activities, the lockdown has mainly impacted on the demand for orders and the revenues of companies, on the supply chain and on the offer of products and services. Countless companies that participated in the study shared the halving of revenues and several orders as the data of the first two weeks of lockdown. However, it should be noted that there are multiple types of experiences related to the crisis, as, for example, the company η is reputable as a "winner" type case study since, although initially had to close because it fell within the category of agricultural mechanization industry - which was not included in the first ATECO list protected as it is not agricultural activities, despite the functional and strategic role they played within the same supply chain - it was subsequently possible return to the production and maintenance of agricultural machinery to support the food chain. The close interdependence between the two types of company pushes the management to have a decidedly optimistic approach regarding the possibility of recovery. Quoting verbatim: «We have not seen serious repercussions with regard to the order book, so that's important, that order book is still there». And again: «the world of agriculture has indeed suffered the repercussions, but it has an intrinsic resilience that is capable of reacting in a very short time, so much so that this can be seen from the prices of wheat which immediately went back up». Based on this, expectations of a prompt return to pre-crisis levels are understood. There is another element of great importance, namely the belonging of some companies in the cluster to international groups with branches or partners present in China: this seems to be an element of resilience and from these it has been possible to ascertain that forced closure was not always totally unpredictable. One of the most relevant benefits seems to be that of receiving indications of procedures and standards to be followed, thus being able to rely on the other affiliates/subsidiaries, arriving in advance at fundamental preventive or strategic measures in dealing with an epidemic or catastrophe. In this case, some companies having contacts with other offices located in China, have known in advance how to behave with regard to internal corporate conduct rules, limiting the otherwise more significant effects. Those who had contacts with the Chinese reality had the opportunity to be promptly warned of the impending arrival of the virus that would have caused the emergency in Italy and in the world, putting various companies in the position to take adequate measures in view

of the fight against pandemic through the procurement of PPE, often coming from the same Chinese collaborators, as well as being able to design emergency health management plans. Therefore, task forces and strategic plans were structured, albeit not being able to foresee such a dramatic state of affairs as to lead to the total closure and blocking of activities. The high uncertainty of the moment and the unexpected violence of the facts forced companies to adapt in a very short time with necessary adjustments to the initial plans in order to cope with the Covid-19 crisis. Where there has been a significant commitment to standardize emergency plans and emergency approach procedures by the parent company in coordinating other related companies, a sufficient general level of preparation for difficulties has emerged.

Following the initial preparation of which some companies have benefited, some solutions defined quick & dirty have arisen, i.e. temporary solutions aimed at solving a problem in a short time and in the most complete way possible, while admitting the natural imprecision of some of them by virtue of the context in which they were created. Regarding this, the company ε seemed to be one of the most representative: the company was forced to complete a total closure of its offices, but the management was ready to face the situation starting to prepare well in advance, since the first part of February, thanks to the information obtained from the monitoring of its branches in China. For these reasons, the company was able to respond quickly to this block by organizing multiple activities that made business continuity possible: teleworking - of which they had already experienced - was operated while maintaining active telephone technical assistance, carrying out commercial activities and generating video material aimed at training its staff, as well as some videos to instruct customers on the use of the machinery. This flexibility and readiness was the manifestation of ability on the part of some companies to adapt and capitalize opportunities, for example in being able to seize such a complex moment to give life to a series of projects that had remained pending due to lack of time as they were considered marginal. In the emergency it was therefore also possible to exploit some potential to the maximum and about this and the quick & dirty solutions, as asserted by the company ε: «at this moment we must try not to focus on the problem but to focus on the solution and accept the imperfect solutions». In this scenario, the remotization of services has established itself, as has the implementation of smart working, the real protagonist of the crisis.

In particular, the ability to reorganize work activities typically carried out in presence through an adaptation of their remote performance during the lockdown period has allowed the maintenance of acceptable operating thresholds, without having to resort massively to holidays or layoffs, limiting the consequences in terms of costs and customer satisfaction. It is clear from the sample that the adoption of smart working has certainly participated in the continuity of work activities, even if it was not possible to have all the staff in place to work and it is widespread opinion in the cluster that

this way of working was even more important in the first phase of the crisis for promptness and effectiveness.

The transition from offline work to the online version was facilitated by the use of teleworking tools such as Skype, Zoom and other platforms, finding complexity in the technological infrastructures available to workers at home. Not all companies have easily leveraged VPNs, telephone solutions and fiber to overcome the problem of data transmission in considerable quantities and the security levels of home networks that are not always sufficiently stable and reliable available to employees.

What easily managed the cluster of companies interviewed was the transition to smart working, which then became the main business tool for resilience, considering the quick and dirty solutions, allowing the business a certain continuity. As attested, especially by the δ company, the greatest limitation of this means of great flexibility was the complexity in being able to monitor employees in smart working, thus lacking valid feedback to be able to judge their work in order to maintain certain established levels of productivity. From this phase, the need to increase investments aimed at implementing smart working, to raise the level of staff training and consequently to adapt the corporate organizational structure, emerged. Two distinct behaviors should be noted in the digital landscape of the firms examined: the company η, for example, has intensified its use of the virtual assistance system it provided through the use of Google Glasses, while the organization ε has specifically created a platform support for virtual assistance in order to respond to customer needs remotely, managing to implement remote installations, always for a fee, ensuring good proximity to customers albeit in different parts of the world. The companies - as in the case of α - that have not adopted any solution of this kind, have not been able to take action, thus losing the possibility of earning. With regard to the dynamics of spare parts for these last organizations, it was taken over through the shipment of parts and telephone assistance. The interviewee asserted that: «if a machine is stopped in a field and needs to replace a part, you cannot do much digitally», demonstrating and confirming resistance to more advanced forms of digital servitization, convinced of the insuperability of some limits exceeded by the cases mentioned above.

Some companies, such as γ, have understood the crucial role of smart working also in the future, labeling it as “an integral part of the way people work” by virtue of the decidedly positive experience in the period of the pandemic. However, this tool is not enthusiastically embraced by all the realities studied: some still prefer the offline environment, citing the choice to the preference for greater human contact capable of cultivating and maintaining certain types of relationships, as in the case of consolidated collaborations or partnerships in progress. Despite this, it is undeniable that Internet of Things (IoT) solutions have represented an added value for the tracking of activities in real time, which has allowed the implementation of condition monitoring and the limitation of FSO activities. It should not be underestimated that the use of agile work practices are not immediate for

all business areas based on the related areas. In fact, the use of this kind of solutions has proved to be more adequate and fruitful in the company sectors where human interaction can be overcome avoiding losses of a productive or operational nature, as in the case of the sales, marketing, human resources and information and communication areas technology (ICT), while in other areas such as production, research and development and logistics the adoption has posed various problems due to the difficult remote control, even respecting certain established standards.

The crisis has also caused a slowdown in terms of company growth, as some development plans had to be set aside: this is the case of the area dedicated to δ's service, for which an investment plan was planned that has been revised. In general, the sample showed a good readiness in the emergency approach phase which led to the organization of a task force dedicated to the Covid-19 situation, often composed of complementary figures to be able to inform and transversally protect all areas of the business, organizing to plan resilient solutions to the difficult context.

However, the difficulties were also seized in terms of opportunity with regard to training, as some companies have organized webinars and online courses to train staff on the use of digital tools, as well as on other corporate organizational aspects. In this context, a suitable IT structure has also granted a containment of the impact on some operational activities.

4.3.3. Phase 1 subsample implications

From the study of the evidence of the subsample examined, it was possible to see how the uncertainty deriving from the initial regulatory vacuum - which also ignored functional dynamics among the companies by not including among the ATECO protected companies some realities essential for the functioning of the industrial machine - and the lack of clarity of government communications was perceived.

In this context, companies had to find solutions that were as quick and effective as possible, albeit incomplete, so-called quick & dirty, which showed weaknesses on which to work, as well as unexpected strengths, finding in smart working an excellent ally, even if criticized because of the difficulty in monitoring workers' performance, thus failing to assess their performance efficiently. Digital has therefore emerged as the resolver of various complexities linked to the crisis, the first and most important of which were the serious repercussions on field service operations and supply chains, which also saw renegotiations and reorganizations, and the sharp drop in demand.

In addition, it emerged that a more solid digital culture and a digitalization more present in business realities could have contained some of the negative effects of the crisis that the emergency had put in place, with the result of making firms more resilient to the Covid-19 pandemic. It is no coincidence that organizations that had already invested in digital technology and services have

been able to virtualize some activities through teleworking, thus being able to contain the impact in a more structured way than other companies less prone to digital transformation.

In some cases, there has been an increase in the number of requests for assistance from companies sensitive to the issue, also demonstrating a certain awareness of the use of digital tools on the client side. This evidence implies a paradigm shift in the future in the approach to the use of these tools, which has been shown to reduce the impact of any emergencies, allowing firms to continue to create value for their clients even during the crisis.

It has also been found that belonging to an international group can facilitate the management of the effects of disruptions, as in the case of field service operations because of the possibility of relying on foreign subsidiaries that can respond to the needs of clients locally in order to be able to follow up on agreements entered into in the contract.

However, some companies have failed to contain the impact on these latter operations due to a misconception, too sticking to tradition, giving the evidence that those who follow a traditional line of business are less resilient than out-of-the-box companies.

The Covid-19 has acted as an accelerator of digital transformation with a particular focus on digital service-servicing: the process of transition to digital service-servicing may be easier for original equipment manufacturers who are in close contact with end-customers and can leverage the installed base to expand their service offerings in the direction of digital service. In this case, the role of remote monitoring and remote conditioning, services that many companies interviewed have chosen to implement with the aim of maintaining a certain proximity to customers, cultivating the relationship between the company and the end customer and guaranteeing them efficient solutions with the continuation of the activity even in disruptive contexts. In this regard, augmented reality solutions seem to be a tool of significant importance.

Through greater digitalization and the implementation of the above mentioned tools, it is possible to collect a series of big data that allow to have a very clear and complete picture of the client's situation, being able to mitigate the risk linked to the supply chain and to different company dynamics, thus making firms more agile and resilient.

In fact, companies that had already implemented and structured strategic and forward-looking technological investment plans, having therefore believed in the importance of digital training by forming prepared teams and having built a solid internal technological infrastructure, have shown greater agility in the pandemic context, benefiting both in terms of operations and productivity.

In conclusion, investment in technology, confidence in digital and its solutions - such as smart working -, digital servitization and membership of international groups seem to be among the most significant factors in resilience to today's and tomorrow's catastrophes, although much still seems

necessary for the various players to be more aware of the key role played by these factors in terms of flexibility and agility.

4.3.4. Phase 2 cluster description

A is an OEM which offers basic services related to the design, the manufacturing and selling of agricultural and industrial feed mixer wagons at a worldwide level, being a family-run international player with a wide network of branches, distributors and retailers. It strives for innovation and efficiency.

B is a mechanical company which repairs lorry and is the Italian market leader in the production of iron work machines as far as serial production is concerned. This OEM registered a strong economic impact even though it was ATECO protected.

C is a firm that operates worldwide, also being a global leading company of equipment, machines and plants to carry out all the industrial operations of marble, granite and ornamental stone. This organization counts different branches abroad and close to a thousand employees. It is very attentive towards research and development and innovation.

D is a company specialized in high quality systems, processes, and services for the Pharmaceutical and Healthcare industry. It owns many production and commercial sites located on different continents. This firm had a winner lockdown as it benefited from the crisis thus registering a positive economic impact of the latter, in this case also helped by the fact of being ATECO protected.

E is an OES organization which belongs to the Food and Beverage industry and it represents one of the least affected among all other cluster companies. Higher and new hygiene standards have been set. It has faced a sudden increase in demand in the crisis short run, changing the product mix to encounter it and implementing new strategies.

F is a company which offers easy to use products such as rotary screw compressors, piston compressors, dryers and other products for air treatment and pneumatic accessories with designed applications from all sectors that require compressed air, also focusing on technological innovation and is. It sells compressors, dryers and accessories. It has an extended network distributors widely spread across the world.

G is a firm that is global leader in supplying ancillary equipment and services to the plastics industry. The company counts more than a thousand employees, many production plants and a number of service and sales companies worldwide. It strives for process innovation through constant learning and close relationship with its partners. It represents the case of a winner lockdown ATECO protected firm.

H is a company that provides for innovative and high-end technology solutions for the hydroelectric industry, having important echoes in many different sectors. It is part of a globally present group with dozens of thousands of workers, being one of the biggest family-run businesses.

I is a manufacturing firm that produces cooking professional tools in the Food and Beverage industry. This OEM is ATECO protected and such firm had a weak economic impact.

L is an enterprise which produces chemical products and finds solutions for enology technologies, breweries and mineral water, being in charge of the analysis and the management of filtration and microfiltration, plants sanitization, products sterilization and the microbiological control on wine, beer, water and liquids.

M is one of the most important international activities in the metering industry specialized in domestic and bulk meters also through remote reading for an efficient usage of data and thanks to their exchange in both short-range and long-range networks.

N is a certification body, over the years, the company has increasingly expanded its activities, including a wide range of services, aimed at the public and private sectors, available throughout the national territory. Its certification body deals with: certification, inspection and checks of lifts and hoists, checks of electrical grounding systems, checks of work equipment, design checks, organic certification, integrated production.

O is an OES operating in the refrigeration sector: it is a reliable global supplier for the design, manufacture and sale on the world market of heating elements and systems for domestic and industrial use. It provides basic professional services to hospitality and catering organizations such as hotels, restaurants, schools, hospitals, canteens, bars and supermarkets.

P is an OES firm that belongs to the electronics industry and is now present all over the world with specific sales offices, always pushing on made-in-Italy. Its focus is on product quality, innovation and customer satisfaction, by spanning from simple electrical installation, which is often related to safety, to modern home automation systems.

Q is a leader in the evolution of control technology and humidification for air conditioning and refrigeration trying to offer products able to support customers with the most efficient energy savings solutions, also being customized thanks to data-driven services through its IoT platform. Research and Development, innovation and technology are the keys of its success.

R is an OEM which belongs to a group and it is a player in the energy industry, which designs, manufactures and markets smart gas meters that are innovative in measurement technologies and communication functions. Its products can improve the way in which gas is measured, sold and used, enabling a more transparent relationship with the end customer and his awareness of energy

Table 4.4 Company data: phase 2 cluster categorized by industry, supply chain position, ATECO protection, type of lockdown and economic impact

PHASE 2 COMPANY CLUSTER					
Company Code	**Industry**	**Supply Chain Position (OEM/OES)**	**ATECO protected (Yes-No)**	**Lockdown Type (Complete/ Partial/Winner)**	**Economic impact (Positive/Strong/ Medium/Weak)**
A	Agricultural machinery	OEM	Yes	Partial	Strong
B	Oil & Gas	OEM	Yes	Partial	Strong
C	Marble machinery	OEM	No	Complete	Strong
D	Pharmaceuticals products	OEM	Yes	Winner	Positive
E	Food and Beverage	OES	Yes	Winner	Positive
F	Pumps and Compressors	OEM	Yes	Partial	Medium
G	Rubber & Plastic	OEM	Yes	Winner	Medium
H	Energy	OEM	Yes	Partial	Medium
I	Food and Beverage	OEM	No	Partial	Weak
L	Chemical products	OEM	No	Winner	Weak
M	Energy	OES	Yes	Partial	Medium
N	Packaging	OEM	Yes	Winner	Weak
O	Refrigeration	OES	No	Partial	Medium/Strong
P	Electronics	OES	No	Partial	Weak/Medium
Q	Refrigeration	OES	Yes	Partial	Weak/Medium
R	Energy	OEM	No	Partial	Weak

Table 4.5 shows Phase 2 participants data: titles and specialization of phase 2 sub-cluster.

PHASE 2 PARTICIPANTS CLUSTER			
Company Code	**Participant***	**Title**	**Specialization**
A	Marte	Direttore service	Service; IT
B	Euridice	Sales Manager	Sales
C	Sofocle	IT Manager HR generalist	IT; HR
D	Eschilo	Digital director	IT
E	Euripide	Chief Operations Officer	Operations
F	Clitemnestra	General Manager	Marketing; Operations
G	Antigone	CTO	IT
H	Pericle	Sales & Project manager	Sales; Marketing
I	Ulisse	CEO	Sales; Operations
L	Cassandra	CEO	Legal; Operations
M	Fedra	Sales and Marketing Manager	Sales; Marketing
N	Ecuba	EVP Product Supply & Industrial Base Manage	Production
O	Patroclo	BU director	Marketing; Production
P	Medea	CIO	IT; Operations
Q	Paride	Group sales and Marketing Process Developmen	Sales; Marketing
R	Prometeo	Digital Transformation Manager	IT

Note: *Pseudonyms, not actual names

Table 4.6 shows Phase 2 participants, data sources and methods used to make the interview, its duration and the tool used to make it.

PHASE 2 DATA SOURCE, METHOD PARTICIPANTS CLUSTER			
Company Code	**Participant***	**Data Source/Method**	**Tool**
A	Marte	Semi-structured interview: Lasted:72 min.	Skype
B	Euridice	N/A	Written aswers
C	Sofocle	Semi-structured interview: Lasted:73 min.	Skype
D	Eschilo	N/A	Written aswers
E	Euripide	Semi-structured interview: Lasted:28 min.	Skype
F	Clitemnestra	Semi-structured interview: Lasted:41 min.	Microsoft Teams
G	Antigone	Semi-structured interview: Lasted:57 min.	Microsoft Teams
H	Pericle	Semi-structured interview: Lasted:34 min.	Skype
I	Ulisse	Semi-structured interview: Lasted:45 min.	Phone
L	Cassandra	Semi-structured interview: Lasted:68 min.	Skype
M	Fedra	Semi-structured interview:	Jitsi Meet

		Lasted:39 min.	
N	Ecuba	Semi-structured interview: Lasted:48 min.	Skype
O	Patroclo	Semi-structured interview: Lasted:49 min.	Skype
P	Medea	Semi-structured interview: Lasted:20 min.	Written aswers
Q	Paride	Semi-structured interview: Lasted:51 min.	Skype
R	Prometeo	Semi-structured interview: Lasted:67 min.	Skype

Note: *Pseudonyms, not actual names

4.3.5. Phase 2 cluster findings

Phase two began on May 4, the date on which the production sites returned to operation. Consequently, the focus of the interviews that took place in this period is attributable to the months of March and April, where the will was to investigate the effects of the lockdown in order to closely observe the resilient capabilities of companies in order to overcome the obstacles that the emergency health has generated. The analysis, which mainly concerns the business model, then goes on to outline what is expected to be the new normal. The companies in the sub-sample involved are shown, under anonymity, in Table 4.4.

There are undoubtedly two main elements of the study of this phase, which can be summarized as macro-concepts, such as the areas of impact of the crisis and resilience to go and see through the evidence gathered what were the key characteristics of the approach of the companies that successfully fought against complexities, observing what solutions were adopted to be resilient.

From the sample analyzed, the direct impact on operations is examined with also the analysis of the business areas that seem to have been most affected, namely those of Field Service and Supply Chain. It also deserves attention that a dimension of uncertainty reoccurs due to the fact that the

lockdown has also hindered the relative efficiency of the management of the degree of staff employment in many cases in which there was no decisive orientation or recourse to staff to full or reduced speed. Insecurity is increased by the dynamics inherent in bonuses and applications for incentives, the disbursement of which has often lacked clarity and timeliness, such as the Calenda plan. However, it should be considered that in this phase, unlike the previous one, more concrete opportunities and a more constructive attitude are seen on the part of many companies.

Furthermore, it is not negligible that we can see the setting up of task forces by all the firms examined with the aim of dealing with crisis management.

One of the aspects that emerged from the survey carried out was the decrease in turnover, with repercussions on operations, in particular for companies G, H and I which showed the difficulties encountered due to the pandemic: G, despite being ATECO protected with the possibility of operating in a full-capacity regime during the crisis, it recorded a reduction in the order portfolio due to greater prudence on the side of customers, who opted for a postponement of the closing of contracts in 50% of cases. Also note the role that the use of the local-for-local business model has played in facilitating the approach to the pandemic. Company I, on the other hand, unprotected ATECO operating in the catering sector, highlighted the impact on the creation of value. Due to the fact that this reality offers a durable instrumental good such as professional kitchens, it is assumed that the most difficult complexities to face will take place mainly in the medium-long term, due to the very strong effects on the reality of catering: «surely we will have repercussions in the future because there will probably be fewer new openings, less renewals, and obviously we are evaluating the impact on the medium term». The impact is estimated to refer mainly to a decrease in the number of future orders, an issue that management reassures to be addressed through its ability to «adjust the company's production capacity» together with the idea of giving shape to a new line of complementary products to those that make up the core business, to have a wider range of products capable of mitigating the risk. Company H had a decidedly opposite impact compared to the other two companies already mentioned, since it recorded an increase in requests for interventions during the health crisis, with benefits on production. Part of the resilience in this case was given both by the fact of being an activity ATECO protected, both by being part of the energy sector. The uncertainty generated in the period and feared also in the future, however, led firm H to hypothesize a future decline in productivity and, consequently, in operations. Another apprehension that emerged from the meeting with this company concerns the possible changes that this crisis could have on the supply chain, envisaging substantial changes for countless sectors, including related ones. A positive experience, similar in some ways to the one just described, was lived by D, a company that witnessed an increase in production in the sector in which it operates, namely the pharmaceutical one, considered a key area in the fight against the pandemic and in its management.

In the case of companies with production sites in Italy and in the world, it was clear that the impact on operations has characterized the Italian production sites in a more significant way, as happened for company R, which recorded a quantifiable operating loss around 5 and 10% on an annual basis.
From the point of view of administrative operations, there have been cases in which companies have suffered a loss of operations equal to 50%: this is the case, for example, of firm L, where it is presumed that the greatest effects will occur more in the medium-long term with a more significant impact as regards the payment and billing system that brings with it deferred revenues, since different dynamics inherent in cash flow will come into play in an economic context that is always uncertain and unpredictable.
In this phase, as reported by company R, the limit linked to the mobility of installation personnel remains of great importance, conditioned by the reduced mobility that did not allow the operators to perform a very important function for the company, strongly hindering field service activities.
In fact, it also emerged that, as in phase 1, some companies offering maintenance services have seen a contraction in the offer of services precisely because of the limited possibility of travel. The decline in sales remains a reality, always marked by the problems just described, with the interesting difference that a part of the demand that could not be satisfied was partially covered by the sale of inventories.
Companies G and D have shown the negative effects that the lockdown and the consequent limitation of mobility have had on the field service activities: in particular, the former has found serious complications concerning the provision of installation services for its systems at customers' production sites, while deliveries of the same products occurred on a regular basis. This degree of complexity is due to the current regulations regarding the containment of infections, which constituted a significant limit to the movement and industriousness of the technicians who had the task of carrying out the installations, in addition to the fact that it was often the customer in the first place to deny entry and visits to technicians in order to avoid gatherings at the production sites. «With the return to normal, fortunately FSO's activities are gradually resuming. So everyone is now letting us access their production sites to make plant visits, set up installations and so on».
This company, having suffered in particular the limitations to FSOs, suggested a gradual approach with a view to returning to normality, especially in relation to the Italian reality, where customers began to return to open at the entrance of the workforce of providers of services within their sites. The activity is then resumed in compliance with safety standards, through the use of personal protective equipment, obviously respecting the rules relating to social distancing.
Company D also encountered difficulties in providing services such as plant visits, installations and after-sales activities. The reason for these complexities is also attributable here to the lockdown, but, unlike G, firm D, where possible, has chosen to carry out the procedure remotely and this path

has been possible due to previous investments with the aim of strengthening a digitalization of the internal structure and business processes: «since we were unable to move due to lockdown, we did not have the opportunity to carry out visits and assistance or after-sales interventions in the presence of our customers' production sites. However, we have made up for it where possible by carrying out these activities remotely with digital systems».

As regards the supply chain, company O in particular shared the need to shorten its structure due to the overabundance of intermediaries, constituting an important block to flows, once forced to close due to the lockdown. Company C has brought evidence related to the spare parts market and its prices, through testimonies related to its spare parts center located in Belgium, thanks to which it has been possible to continue to satisfy customers abroad and offers as a starting point the recognition of the strategic nature of the local-for-local business model, underlining the need to rethink it in the light of the events related to the Covid-19. If the central spare parts warehouse had been located in Italy, difficulties would also have been found in providing that service, due to the blocking of the foreign borders and the difficulties encountered in the transport sector during an emergency.

The difficulties related to the Supply Chain due to the tightening of logistical complexities both in the -in and -out phase of the goods have prompted some companies to stock up. Furthermore, the rethinking of common spaces and production has helped to ensure a good continuity at the production level which has partially compensated for some problems that occurred in terms of the supply chain and which is demonstrated by the fact that, at the aggregate level, particular discontinuities in the relationship with customers.

One element certainly in common by almost all the companies interviewed in phase 2 is undoubtedly the readiness from a digital point of view. This was possible thanks to the possibility of resorting to an appropriate technological equipment with respect to the scenario created, being able to rely on an excellent level of agility and serenity with regard to the way to deal with the problems arising from the health emergency. Technologies therefore played an important role in this phase, as claimed by several companies, in particular by O and F who declared that in the absence of certain technological tools, many activities could not have been completed during the lockdown: among the other things, this allowed them to maintain commercial relations with customers and carry out repairs remotely, making up for the absence of technicians not in the ability to reach customers' production sites, also going to save a lot on travel costs and business trips.

In addition, precisely in this regard, there have been realities such as that of company L which have confirmed the significance of the role of investments in digital technologies, not downsizing them from a current and future perspective.

However, it is interesting to note that for some realities there is a strong interest in offline modes which continue to be considered more effective than online ones, as in the case of R who prefers to provide training through the first kind of modality over the second, with evaluations which also lead to a facilitation of distance selling, believed to be a value added for the future. However, company N has shown how an approach in favor of digital brings with it a strong incentive to raise awareness on the topic of research and development, with a better inclination to invest in this sense, sometimes leading to the creation of new patents. This awareness, like that already manifested by L, leads to the independence of digital investments from crises.

A company that believed in the usefulness of digital media even before the Covid-19 crisis, such as G, for example, had already opted for enterprise resource planning (ERP) systems, as well as cloud platforms for data analysis and collection (Microsoft Azure) and virtual private network (VPN) systems. These technological equipment have proved to be valid resilience tools as they have allowed the firm to organize responses to the complexities of the emergency quickly and effectively, contributing decisively to the continuity given to operations.

Similarly, company D has implemented several digital projects which then formed the basis for the development of new and innovative solutions during the pandemic: «this period was also propitious to develop new solutions that can also be evaluated at the end of the emergency. In this way, the company will increasingly go in the direction of becoming a real 'smart factory'». Digital technologies have therefore collaborated to minimize impacts, facilitating the relationship between customers and suppliers. Video call tools were also used, with the support of agile work logics, including most of the company staff. Employee training was provided through various digital channels, thanks to previous investments that have helped the transition from physical environments, offline, to digital spaces, online, with the result of being able to offer continuous training to staff. Company I is of the same opinion, emphasizing how the previous use of technological tools has made companies able to offer better quality and more agile responses than the Coronavirus.

During Phase 2, assessments can be made regarding remote migration, a passage that has proved to be facilitated by the presence of suitable tools, effective use programs and training dedicated to smart working which has taken on more and more weight and upset some company dynamics: firm L, for example, completely revised its organizational structure linked to the commercial network, eliminating the numerous offline appointments from the agenda that were previously occasions for discussion and meeting. The online reality has convinced more, prompting L to focus heavily on this tool which has allowed greater flexibility even in the phase of adaptation to the context of uncertainty. However, the intense use of it has also highlighted negative aspects such as overworking.

The shift to online solutions required by the job crisis as far as remote working is concerned has been less destabilizing than it has been for those who have never done it before. As said by company F, the top management had decided to focus on the use of Teams before Covid-19, revealing itself to be a choice made almost «as if they already knew that a pandemic would happen». Company C experienced an opposite situation, considering smart working incompatible with its corporate culture due to the great consideration of human relationships, the close collaboration between its collaborators, finding itself in great difficulty during the application phase as well as in looking for some activities so that they can be done from home. To do this, the robustness of the company's IT structures was verified to be robust, the availability of the personnel of the necessary devices and the stability of the internet connections, with the result that only a limited number of employees were able to perform work from home. For this reason, company C does not foresee the future use of teleworking, being the only one in the cluster to reject it, pleading the blame for corporate cultural reasons. However, it should be considered how, despite the intention to use smart working as little as possible, the company must resort to holidays and layoffs in order to manage the staff who are unable to attend the office due to the restrictions imposed by the Government, having to pay for this by managing the management complexities and costs that this condition brings with it.

Companies G and D have instead implemented the video call tools in such a way as to preserve a certain level of operations and, at the same time, to comply with the safety regulations required to manage the containment of the pandemic. G, not accustomed to using tools such as, for example, Microsoft Teams, Skype and Zoom, before the crisis, they appreciated the benefits: «an interesting thing, which we practically did not use before, because we are more inclined to travel and face-to-face with the customer, are the video call tools. I think this will have to be reviewed on our part». The company also felt the need to change the paradigm: «we have noticed that many things can be managed like this. Skype and Microsoft Teams are tools that have proved to be really useful and we are particularly satisfied».

The limits of smart working should also be underlined, i.e. the evident impossibility of adoption as regards production activities, as well as the strong limit of effectiveness represented by the degree of adequacy of the technological equipment, without also counting the associated risks the security of data and information that hindered the performance of even simple tasks. It is also difficult to evaluate performance, in addition to the difficulty of interacting and communicating with collaborators on virtual platforms. Several companies have expressed their willingness to implement this tool and insert it into their business model for the future.

Still from a digital perspective, many companies have chosen to continue to invest in digital servitization-oriented logic, with particular attention to technologies related to the product-service

system. G, for example, will give continuity to its investments in remote condition monitoring, in fact its CTO states that: «all our machines can be connected to our proprietary network, with a software that fully supervises them, to which we can access to check the operating conditions. It is clear that everything can be improved and even on this we have plans for improvement and implementation, but there were already pre-Covid-19, it was all already part of our development initiatives».

Similarly, the H company will focus more on tools capable of informing product design, «we will certainly continue to push tools about the use and analysis of data, so that we can better respond to customer requests».

Company D, on the other hand, considered 3D printing and remote condition monitoring to be the key technologies in which to invest as much as possible in the future. The first solution would allow to be able to print the necessary spare parts, thus trying to avoid supply problems and to encounter the difficulties faced in the current health emergency. The second, on the other hand, would give the company the opportunity to offer an increasingly suitable service with respect to the requests of the end customer, thanks to a better use of the big data collected by leveraging products and its own installed base.

Those that represent concrete challenges to the adoption of logic related to digital servitization deserve further investigation: the first is certainly to guarantee IT security to customers who, probably, will be more inclined to share their data with their OEMs, thus allowing the company to increase the number of accesses to their VPNs. Through this choice, the firm was therefore able to structure a more efficient service offer so as to better meet customer requests even in difficult contexts such as that of Covid-19.

On the other hand, some companies such as H believe that the mobility of technicians is at the center of the challenge concerning digital servitization. The FSO area has emphasized the need to invest more significantly in order to find tele-service solutions capable of limiting the number of visits to the customer, while maintaining the same level of quality of the service offered. «Especially I, who follow the commercial sales part, even in the service, I have to make sure not to lose contact with the customer and the fact, perhaps, not being able to visit him regularly certainly does not help. So this is a bit of the challenge».

The crisis has also highlighted the usefulness of tools such as augmented reality in terms of digital servitization, although it seems that its implementation is still considered marginal.

Ultimately, an aspect of great importance was the adoption of an international business model to address the negative effects generated by the crisis. An example was that of company G, which had benefited greatly from its widespread organization in dealing with the emergency: «Fortunately, our organization is very widespread, we have twenty commercial service organizations around the

world, therefore in the continent we have service centers and we managed with them». Many companies among those interviewed coordinated multiple activities by resorting to and supporting foreign branches, guaranteeing the provision of service to local customers, getting to understand that they must continue to invest in terms of opening of foreign branches, since the model of local-for-local business proved to be effective in managing the pandemic, «also following what our business model is, so producing on every continent for that specific market has helped us here at this stage».

4.3.6. Phase 2 cluster implications

From the study of the results of Phase 2 it has been possible to identify some problems that have materialized over time, such as, for example, in the case of FSOs, due to the fact that certain dynamics such as the very limited mobility of personnel have characterized both phases. Similar events occurred also with regard to the supply chain, with the peculiarities of the second phase, such as the rethinking of the common spaces implemented by the companies in compliance with the regulations, resulting in an increase in generalized security that allowed a good level of productivity, going beyond some difficulties typical of phase 1. This made it possible to avoid having particular discontinuity in the relationship with clients on the part of many companies.

The effects that have affected operations have seen a greater concentration in Italian production sites, with significant repercussions also on administrative staff, which have led a number of companies to make generous use of redundancy funds, forced holidays and other flexibility tools. Moreover, the scenario worsened due to future uncertainties linked to medium-long term cash flow due to the difficulties in the delivery of orders, their decline, and the problems inherent to the receipt of invoices falling due that would risk ending up unpaid. Another element that characterized this phase was the use of company incentives and bonuses, signaling the complexity of accessing certain solutions or obtaining them, generating problems in the reception phase, which did not always happen correctly.

The complexities of mobility with regard to technicians and the restrictions imposed by the government's legislative framework have prompted many companies to invest in teleservice solutions in the future in order to be able to implement FSO's activities remotely with the support of tools such as augmented reality to ensure excellent performance and cultivate relationships with clients. The difficulty in finding spare parts due to the interruption of some international supply chains could result in increased investments in technologies such as 3D printing, having the possibility to produce elements with greater autonomy, minimizing any risks in case of closures and problems along the supply chain.

Most of the companies in the sample were already heavily digitized in the run-up to the pandemic, leveraging the robust IT infrastructure that enabled them to react quickly to the uncertainty generated by the Covid-19. The investments already underway aimed at improving the company's technological and IT infrastructure have allowed an easy and fast reorganization of the workforce, giving staff the possibility to work thanks to the use of video call tools that have further facilitated the management of certain business practices, putting the top management of companies in a position to establish virtual contact with key employees and to be able to opt for concrete solutions in a dynamic scenario, characterized by uncertainty, avoiding the movement of people. The completeness of the IT equipment has also enabled companies to carry out staff training entirely on digital channels.

The digital sector has seen companies that have understood the crucial importance of investing in technologies, making them independent from the crisis, highlighting the strategic return of deciding to invest in digital servitization, also leading to new patents and more innovation. As far as digital tools in particular are concerned, within the cluster there were examples of companies that were able to implement smart working in an adequate way, benefiting from it in a resilient way, while other companies observed the problems that the tool brings with it, namely the difficulty of being able to measure the performance of employees in order to maintain certain standards of performance and the fact that they were not able to really detach the two phases: work and leisure time, from which overworking derives. All this has certainly upset certain organizational paradigms, such as those concerning the sales network or more typically client contact roles.

Digital technologies have, therefore, played a fundamental role in keeping some company activities open or in place, giving staff the possibility to carry out their work anywhere in the world thanks to the use of virtual private networks systems, tools that have enabled the transmission of significant volumes of data in a short time. The sensitivity shown towards investments in these technologies has facilitated immediate interaction between companies, customers and suppliers, offering continuity in the relationships between these players.

The firms have shown how tools for the analysis and collection of data from installed based products will be used, also extending the scope of the budget for investment in remote condition monitoring means, so as to be able to develop thicker service offers in order to offer a more efficient product-service system, like offers related to performance management (pay-for-performance), as well as full-risk service offers. Through these components, together with the increased and yet increasing customer awareness of the advantages of the above mentioned solutions, companies have been demonstrating to get more prepared for uncertain contexts such as that of Covid-19.

Phase 2 also appears to have offered more prospective and optimistic optics, opening up new opportunities, such as business diversification. In some cases it has led to the extension of the company's network of contacts and given rise to renegotiations and reshaping that have revolutionized entire industries. In addition, it has allowed the anticipation of some activities that were planned much later in time or indefinitely, succeeding instead in concentrating and implementing them as for the staff training that some companies have carried out through e-learning formulas.

The context of crisis at Covid-19 has stimulated the creation of contexts of solidarity within which new social bridges have been built and has led to a review of the modus operandi with regard to some company projects and what may be the actual objectives, sometimes outlining new horizons.

In conclusion, Phase 2 contributed to the testing of digital and quick & dirty solutions, highlighting their merits and defects and showing what was really functional or not. Entire organizational paradigms have been changed, sometimes implementing entire sector revolutions, with new possible growth and market opportunities. Ultimately, it has redesigned the priorities of several companies, praising the local-for-local business model, accompanied by a strategy based on the international presence of the company, constituting for many realities a real resilience factor in mitigating the impacts and risks arising from the pandemic. In this sense, it is evident that the intention of the companies is to continue in this direction or to reach it through investments in foreign offices and branches, in order to try to ensure proximity to the customer and ensure proper supply management.

CHAPTER V: Supply Chain Resilience (SCRES)

5.1 Introduction

The term resilience has Latin roots, as ‘resiliō’ used to mean to spring back; to recoil; to rebound (Babylon Online Dictionary, 2011). Nowadays, in modern English the verb ‘to resile’, based on the 11th edition of the Oxford Concise Dictionary (2008), stands for recoiling to resume a former size. In science, the resilience concept is firstly addressed to engineering, meaning the quality of a material to be capable of storing strain energy and then to unload it so that this energy could be recovered, not being broken or deformed (Gordon, 1978; Avallone, 2007). In other words, a resilient material can recover from strain or deformation due to a compressive stress (American Society for Testing Materials, 2005). During the last forty years the concept of resilience has been applied to a number of disciplines, being recognized by many different scientific fields such as ecology, social engineering, psychology, economy, and organizational management always having own definitions and research perspectives.

Moreover, recently, devastating earthquakes, political turmoil, fuel crises, diseases and terrorism have proven to represent crucial events which have generated persistent problems, often resulting in the disruption of the possibility for many companies to produce and distribute their products (Singhal et al. 2011; Sodhi et al. 2012; Mandal, 2012; Chen et al. 2013; Sawik 2013). These events have pushed many academics and practitioners to study and try to find solutions in order to contain potentially disruptive effects of catastrophic events by making efforts in building more resilient supply chains. For instance, a survey conducted by the World Economic Forum (2013) illustrated that more than 80% of firms are attentive with respect to the resilience of their supply chains. Furthermore, the academic support towards the approach of mitigating risks in case of disruptions by creating Supply Chain Resilience (SCRES) has risen (e.g. Murino et al. 2011; Brandon-Jones et al. 2014; Geng et al. 2014). By being provided of SCRES, companies are supposed to be able to rapidly recover from a disruptive event in one of two ways: coming back to normal or developing thus reaching a better level of operational performance (Shuai et al. 2011; Mandal 2012). As a matter of fact, an organization which reacts to a disruption in a more solid manner than its competitors can make further steps with its market position. For instance, Craig et al. (2014) empirically studied Hugo Boss’s supply chain and discovered that there was a relevant positive relation between SCRES and customer demand, thus getting to the conclusion that being provided of a resilient supply chain can be significant for both short-term survival and to long-term competitiveness.

Most of the disruptions encountered by firms and supply chains are external (e.g. natural disasters) or made by men (e.g. terrorism), but others are originated within the boundaries of the supply chain as sometimes the impact of a disruption is also intensified by the strategy implemented by the company.

For instance, the adoption of lean manufacturing and single-sourcing policies can be useful in cutting costs and develop better coordination, but they can also make supply chains lacking of spare capacity to respond to contingencies, thus being more subjected to disruptions (e.g. Tang, 2006a; Zhao et al. 2011). Hence, company's internal operational decisions may strengthen its weakness to exogenous threats. Another problem is also represented by the increasing interdependence of contemporary firms in global supply networks (Finch, 2004; Diabat et al.2012) which, as underlined by many authors, highlights the need of a company to be sure that its supply chain is resilient (e.g. Rice & Caniato 2003; Erol et al. 2010; Carvalho et al. 2012d). If a supply chain is not resilient, a disruption to a single node may results in a reduction of capacity or interruptions that regard the supply chain as a whole (e.g. Craighead et al. 2007; Wakolbinger & Cruz, 2011). A vivid example of this situation is represented by the 2011 Tohoku Earthquake and Tsunami in Japan that generated supply chain disruptions which resulted in global repercussions that have affected Thailand, Taiwan, Canada, Australia, the United Kingdom and the United States (Reserve Bank of Australia 2011). Such disruptions jeopardized around the globe and impacted the whole global manufacturing supply chain (Brennan, 2011).

The key role of creating resilient supply chain is expressed by the effects that a disruption can reproduce on a company (Carvalho et al. 2012c) like – as it was demonstrated – relevant financial and operational losses to organizations (e.g. Ponomarov & Holcomb, 2009; Stecke & Kumar, 2009; Ponis & Koronis, 2012) such as reductions in stock market value, e.g. of 10% (Hendricks and Singhal, 2003), falls in operating income, e.g. of 107%, return on sales, e.g. 114%, and return on assets, 93% (Hendricks & Singhal, 2005). Moreover, cases of fully dismantled and never adjusted supply chain can be found (Tang, 2006b; Xu et al.2014).

The specific study of the SCRES concept has taken place in the early 2000s, where the first definitions were emerging (e.g. Rice & Caniato, 2003; Christopher & Peck, 2004). Starting from that period, many studies on the field have been done, both through methodological approaches like surveys and case studies and some theoretical methods, but there is still some lack of agreement with regards to the definition of SCRES (Spiegler et al.2012; Mensah & Merkuryev, 2014).

5.2 Resilience in the field of psychology

Garmezy (1973) was the first psychologist initiating the term resilience to the academic field after having worked for over fifteen years concentrating on the precedents of developmental psychopathology, studying children of mentally ill parents with high risks of disorders development. Notwithstanding this aspect, his efforts demonstrated that many children of schizophrenic parents weren't affected by psychological illness as a consequence of their growing up with them (Coutu, 2002). He reached the conclusion that the outcome was given to the fact that there had to be a precise quality of resilience dealing with the stress of a very difficult context. The result built on the term childhood resilience permanently placing it both in theoretical and empirical research of developmental psychopathology for a very long period of time (Masten, 1990). From those years forward, resilience has also spread across other branches and the study of it in psychology, in Luthar et al. (2000) opinion, has extended its pertinence to encompass different adverse conditions like chronic illness (Kralik et al., 2006), catastrophic negative life experiences (Masten & Obradovic, 2008) , urban poverty (Anthony, 2008) and community violence (Copeland-Linder, 2010). The '3Cs' of human resilience – as Reich (2006) named them - are three main principles that offer a psychological perspective on natural and man-created disasters and their implementation aims at planning and responding to disasters. They are:

- Control: for instance, setting his/her own target, it's when individuals are in the position of restoring control over their lives
- Coherence: for example, the mitigation of risk imposed by a disruptive event through fostering understanding, meaning, a direction.
- Connectedness: e.g. finding the key informational and emotional support thanks to the reestablishment of solid relationships with other people.

The most important aspect that needs to be underlined is that psychology understands and highlights a relevant contrast to the consideration of resilience as a 'super material' (Porac, 2002) by showing its developmental nature as in the case of an entity which is capable to continue to implement internal and external resources so to overcome stressing problems. Hence, it seizes the perspective which is often ignored when talking about organization theory: resilience is the ability to recoil from difficulties being stronger and more resourceful (Sutcliffe & Vogus, 2003).

5.3 Resilience at an organizational level

As far as the entrepreneurial context is concerned, the conception of organizational resilience has risen in a relative recent organizational theory tradition which includes awareness from both coping

and contingency theories (Gitteli, 2008). Sutcliffe & Vogus (2003) state that the concept of organizational resilience has been utilized as a reference to:

i) The capability of a firm to retain strain and maintain functioning or make it better even in the case of many difficulties

ii) The ability of a firm to recoil from unexpected and negative events.

It is to be taken into account that there is a relevant overlap with the notion of organizational agility defined by Sharifi and Zhang (1999) as the capability of dealing with unforeseen challenges, also surviving new threats of business environment and seizing new opportunities by riding the changes. Basically, there are two discrete approaches that can be found in literature study on the matter:

1. A school of thought believes that organizational resilience is the ability to recoil from unforeseen, strained, negative situations and to come back to where they were left off.

2. Other scholars see the concept beyond past the reconditioning also encompassing the development of new capabilities and an extended competence of keeping the economic pace being able to produce new opportunities as well (Lengnick-Hall et al., 2011; Ponis & Koronis, 2012)

Table 5.1 Definitions of Organizational Resilience

Source: Ponis et al. (2012)

Definitions of Organizational Resilience	
Wildavsky (1988)	Resilience is the dynamic capacity of organizational adaptability that grows and develops over time
Horne & Orre (1998)	Resilience is a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior
Mallak (1998)	Resilience is the ability of an individual or organization to expeditiously design and implement positive adaptive behaviors matched to the immediate situation, while enduring minimal stress’

Coutu (2002)	The ability of an organization to face reality with staunchness, make meaning of hardship and improvise solutions from thin air.
Sutcliffe & Vogus (2003) & Vogus & Sutcliffe (2007)	Organizational resilience is the maintenance of positive adjustment under challenging conditions such that the organization emerges from those conditions strengthened and more resourceful.
Hamel & Valikangas (2003)	Organizational Resilience refers to a capacity for continuous reconstruction. It requires innovation with respect to those organizational values, processes, and behaviors that systematically favor perpetuation over innovation.
Fiksel (2006)	The capacity of an enterprise to survive, adapt, and grow in the face of turbulent change
Lengnick-Hall et al. (2011)	The firm's ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival

The definitions presented in Table 5.1 have the same point of view related to organizational resilience as not just a restoration ability but also a skill that requires flexibility, improvisation and the capability to survive adversities of the context (Ponomarov & Holcomb, 2009). As a consequence, as Legnick-Hall et al. (2011) argue, organizational resilience is linked to dynamic competition and the capacity of a company to incorporate complexity thus overcoming complicated situations strengthened and with wider experience respect to the time before the disruptive event. In conclusion, the developmental perspective of resilience, as Sutcliffe and Vogus (2003) assert,

requires potential resources which that can be mixed, dismantled and recombined in new contexts as challenging scenarios emerge. The activation of resilience is a topic treated by Powley (2009) who proposes the companies to start the recovery process following a disruptive event, reestablishing key organizational relationships, recovering and empowering organizational practices.

5.4 Supply chain resilience (SCRES)

The current unreliable and dynamic business domain needs a key re-measuring of contemporary supply chains manner of doing business (Tatsiopoulos et al., 2004; Spanos et al., 2007) while being permanently demanded by both competitors and customers to create more customized and complex products also granting low production costs, high quality of the product and global customer reach (Ponis & Spanos, 2009). The contrast between such a difficult reality and the emergence of natural and man provoked disruptions, in a volatile context of financial uncertainty and in-process crisis, have made some neglected concepts like supply chain resilience and vulnerability as priorities for the supply chain research. Barksh and The Clute Institute Kleindorfer (2009) argue that main motivation for the augmentation of interest the in disruption management and, as a consequence, supply chain resilience and weakness issues is the awareness related to the extent of both direct and indirect losses caused by disruptions in the supply chain. As a consequence, Supply Chain Resilience (SCRES) is recently seen as a crucial element of Supply Chain Risk Management (SCRM) (Ponomarov & Holcomb, 2009), and a sort of new and understudied management field of research. According to Christopher & Peck (2004), SCRES is a scientific domain of research in its predominance and this was supported by Falasca et al. (2008) who asserted that resilience was introduced a few years ago in the supply chain management literature and has currently turned into a more broadly appreciated topic and Craighead et al. (2007) spotted a stream in academic and practitioner publications in a number of disruption related themes, one of them being supply chain resilience. The relevance of SCRES in the domain of contemporary global supply chains is further proved by the latest Gartner's Supply Chain Top 25 report (2011), where researchers considered resilience as being the one of the four main themes of 2011, asserting that supply chain leaders understood the need for supply chain resilience while being, as organizational resilience, a multi-dimensional and multidisciplinary phenomenon (Datta et al., 2007a; Ponomarov & Holcomb, 2009). In the past years, there was a SCRES discussion on whether it is part of supply chain vulnerability studies (Svensson 2000; 2002) or it represents an element of supply chain risk management (Juttner et al., 2003). Juttner & Maklan (2011) contributed to a more structured conceptualization of supply chain resilience which deals with the empirical identification and

exploration of its connections to other concepts with regards to supply chain vulnerability (SCV) and supply chain risk management (SCRM). A primary brief definition of SCRES was given by Christopher & Peck (2004) who, after having made a study on creating the resilient supply chain, assert that resilience is the capacity of a system to come back to its original state or move to a new, more efficient state post-disruption. During the same period, Sheffi (2005), who was following a three years research project on organizational resilience in MIT, made an interesting step arguing that SCRES don't imply the capability of managing risks but also the opportunity of a supply chain to find a better positioning than competitors thus having benefits from disruption.

In conclusion, the term Supply Chain Resilience (SCRES) has taken prominence in the literature by calling upon many different perspectives of "resilience" which have been applied to multiple disciplines where such concept has acquired importance. In fact, various researchers had their say on both the multidisciplinary and multidimensional identity of resilience (e.g. Ponomarov & Holcomb 2009; Bhamra et al. 2011; Ponis & Koronis 2012; Spiegler et al. 2012). The heterogeneity of the character of resilience literature – extended across a number of domains – and the wide concept of its meaning has pushed researchers to underline the issue that regards the absence of a common definition of SCRES in the literature (e.g. Spiegler et al. 2012; Mensah & Merkuryev 2014). Since then, many researchers have found new definitions of SCRES and in the table below there are some definitions emerged from the articles reviewed (Table 5.2).

Table 5.2 Definitions of Supply Chain Resilience
Source: Personal integration of Ponis et al. (2012)

Existing Definitions of Supply Chain Resilience from the Literature	
Authors	**Definition**
Barroso et al. (2010)	SCRES is the supply chain's ability to react to the negative effects caused by disturbances that occur at a given moment in order to maintain the supply chain's objectives.
Brandon-Jones et al. (2014)	SCRES is defined as the ability of a system to return to its original state, within an acceptable period of time, after being disturbed
Carvalho et al. (2011b)	SCRES is concerned with the system's ability to return to its original state or to a new more desirable one after experiencing a disturbance and avoiding occurrence of failure modes.

Carvalho et al. (2012b)	SCRES is the ability of the supply chain to cope with unexpected disturbances.
Christopher & Peck (2004)	SCRES is the ability of the supply chain to return to its original state or move to a new, more desirable state after being disturbed.
Christopher & Rutherford (2004)	Resilience is the ability of a system to return to its original (or desired) state after being disturbed.
Closs & McGarrell (2004)	SCRES is the supply chain's ability to withstand and recover from an incident. A resilient supply chain is proactive - anticipating and establishing planned steps to prevent and respond to incidents. Such supply chains quickly rebuild or reestablish alternative means of operations when the subject of an incident.
Datta (2007)	SCRES is not only the ability to maintain control over performance variability in the face of disturbance but also a property of being adaptive and capable of sustained response to sudden and significant shifts in the environment in the form of uncertain demands.
Datta et al. (2007)	SCRes is not just the ability to recover from mishaps, but is a proactive, structured and integrated exploration of capabilities within the supply chain to cope with unforeseen events.
Datta et al. (2007)	Resilience of the supply network is the ability of the production–distribution system to meet each customer demand for each product on time and to quantity.
Erol et al. (2010)	Resilience is a response to unexpected or unforeseen changes and disturbances, and an ability to adapt and respond to such changes.
Falasca et al. (2008)	SCRES is the ability of a supply chain to reduce the probabilities of a disruption, to reduce the consequences of those disruptions when they occur and to reduce the time to recover normal performance.
Fiksel, (2003;2006), Pettit et al. (2010)	SCRes is the capacity for complex industrial systems to survive, adapt, and grow in the face of turbulent change.

Gaonkar & Viswanadham (2007)	SCRES is the ability of a supply chain to maintain, resume and restore operations after a disruption.
Guoping & Xinqiu (2010)	SCRES is the ability of the supply chain to return to its original or ideal status under emergency risk environment.
Longo & Oren (2008)	Resilience is a critical property that, in a context of supply chain change management, allows the supply chain to react to internal/external risks and vulnerabilities, quickly recovering an equilibrium state capable of guaranteeing high performance 44 and efficiency levels.
Pettit et al. (2010)	Supply chain resilience is the ability to survive, adapt and grow in the face of turbulent change.
Ponis & Koronis (2012)	SCRES is the ability to proactively plan and design the supply chain network for anticipating unexpected disruptive (negative events), respond adaptively to disruptions while maintaining control over structure and function and transcending to a post robust state of operations, if possible a more favourable one than that prior to the event, thus gaining a competitive advantage.
Ponomarov & Holcomb (2009)	SCRES is the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.
Ponomarov (2012)	SCRES is the adaptive capability of a firm's supply chain to prepare for unexpected events, respond to disruptions, and recover from them in a timely manner by maintaining continuity of operations at the desired level of connectedness and control over structure and function.
Rice & Caniato (2003)	Resilience in the supply network environment is the ability to react to unexpected disruption and restore normal supply network operations.
Sheffi (2005)	Resilience in terms of the corporate world is the ability of the company to bounce back from a large disruption including the speed with which it returns to a normal level

	of performance.
Shuai et al. (2011)	Resilience is defined as the rapid recovery ability to equilibrium after the supply chain is attacked by a disturbance and we use the recovery time to measure the ability.
Xiao et al. (2012)	SCRES is the supply chain's ability to return to the original or ideal status after external disruption and includes both the abilities of adaptability to the environment and recovery from the disruption.
Yao & Meurier (2012)	Supply resilience is defined as the ability to bounce back from disruption

Tukamuhabwa et al. (2015) have also identified the core attributes of some of the definitions listed above. They can be found in the table below (Table 5.3). The two SCRES definitions by Ponis & Koronis (2012) and Ponomarov (2012) can be considered the most complete as they encompass most of the attributes listed in Table 5.3, such as capacity, recovery, adaptive capability and response as well as control connectedness whereas the aspect of cost effectiveness, like in many definitions, is not taken into account, as it can be seen by noting its absence in the table. The latter is believed by the World Economic Forum (2013) to be able to coexist with resilience not having a stronger negative impact and, in theory, should be complementary. Likewise, Ishfaq (2012) sustained that SCRES can be reached also not sustaining excessively high operational costs. In spite of the fact that resilient supply chains may not be the ones characterized by the lowest costs (Carvalho et al. 2012b; Carvalho et al. 2012c), attention should be addressed to the incompleteness of any definition of resilience in an economic system that does not encompass cost considerations. Costs related to disruptive events in a supply chain disruptions should be minimised in an effective manner (e.g. Lee 2004; Wagner & Neshat 2012) while it is to be said that cost efficiency has been recognized as an attribute of resilient systems (e.g. Fiksel 2003) and a key role is played by a quick and structured approach to cost reduction adopted by resilient supply chains (Xiao et al. 2012) . Furthermore, SCRES should not be seen as a mere capacity of dealing with risk, but also the capability to react to it in a more solid and more cost effective way than competitors, also being able to acquire competitive advantage throughout the process (e.g. Hamel & Valikangas 2003; Yao & Meurier 2012). Tukamuhabwa et al. (2015) defined SCRES as: the adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost effective

recovery, and therefore progress to a post-disruption state of operations – ideally, a better state than prior to the disruption.

Table 5.3 Main features of some of the already existing SCRES definitions

	Main features of SCRES											
	Failure modes	**Ability/ Capability**	**Adaptability**	**Preparation**	**Response**	**Recovery**	**Time**	**Original state**	**Better state**	**Control /connectedness**	**Robustness**	**Competitive advantage**
Barroso et al. (2010)		■			■			■				
Brandon-Jones et al. (2014)		■					■	■				
Carvalho et al. (2011b)	■	■				■		■	■			
Carvalho et al. (2012b)		■	■		■							
Christopher & Peck (2004)		■			■	■		■	■			
Christopher & Rutherford (2004)		■			■	■		■	■			
Closs & McGarrell (2004)		■		■	■	■	■					
Datta (2007)		■	■		■			■	■			
Datta et al. (2007)		■			■		■					
Erol et al. (2010)		■	■		■							
Falasca et al. (2008)		■		■	■	■	■	■				
Gaonkar & Viswanadham (2007)		■			■	■		■				
Guoping & Xinqiu (2010)		■				■		■	■			
Longo & Oren (2008)					■	■		■	■			

Pettit et al. (2010)		■	■		■				■			
Ponis & Koronis (2012)		■	■	■	■	■		■	■	■	■	■
Ponomarov & Holcomb (2009)		■	■	■	■	■		■	■	■		
Ponomarov (2012)		■	■	■	■	■	■	■	■	■		
Rice & Caniato (2003)		■			■	■						
Sheffi (2005)		■				■	■	■				
Shuai et al. (2011)		■				■	■	■	■			
Xiao et al. (2012)		■	■			■		■	■			
Yao & Meurier (2012)		■			■	■		■				

5.4.1 SCRES Operationalisation

By taking Tukamuhabwa et al. (2015) SCRES definition into account, four aspects can consequently be considered and measured such as readiness to disruption, reaction to the event, recuperation from it and competitive advantage after it. At the same time, SCRES strategies or capabilities should be targeted to maximize these features also minimizing costs and operating timely. Furthermore, the adaptive ability is at the core of the four facets and to adapt reflects the unapparent capacity that a supply chain has to provide for different reactions to encounter the nature of the threats to be tackled. As a consequence, supply chain's factors may be altered so to structure an adequate response to a disruption rather than picking up from an already established set of solutions. The supply chain capacity of a company to adapt can be detected by the approach assumed by the organization to respond to unexpected supply chain, and it's an ever developing quality which evolves together with supply chain's solutions. Supply chains may learn from disruptions and relative responses, thus becoming more resilient to equivalent threats which can take place in the future, also acquiring new skills. Nishiguchi & Beaudet (1998) have illustrated the case that followed the unpredicted 1997 fire which hit Aisin Seiki's Kariya plant, Toyota's key supplier of a critical element related to vehicle manufacture: P-valves. Despite the absence of a pre-established recovery plan, a quick response was possible thanks to the supply network ability to

adapt due to strong relationships between the company and its suppliers. Such a tight bond allowed a smoother and effective coordination and self-organization which encompassed the arrangement of alternative p-valve production sites at suppliers utilized to lay out other components. So, in case of another equivalent disruptive event, the supply chain should finds itself more comfortable in facing this kind of situation in order to contain it. The resilience triangle (Bruneau et al. 2003; Cimellaro et al. 2010; Zobel 2010), as shown in Figure no.5.4, that takes into account elements such as recovery time, the performance level and loss estimation, is the most appreciated tool to measure the resilience of a system.

Figure no.5.4 The original resilience triangle (adapted from (Bruneau et al. ,2003))
Source: Zobel, C.. (2010) . Comparative visualization of predicted disaster resilience.

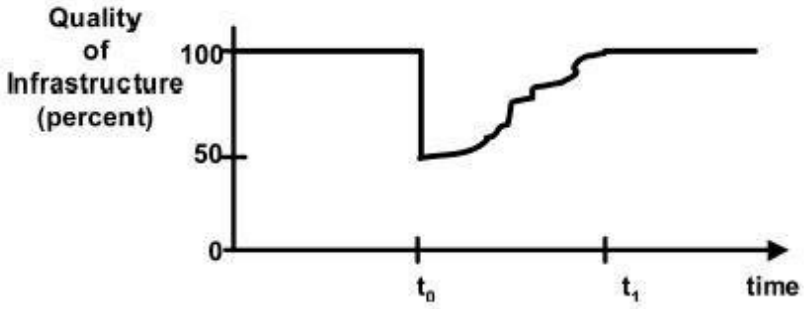


Figure no.5.5 Adapted version of the original resilience triangle (Tukamuhabwa et al., 2015)

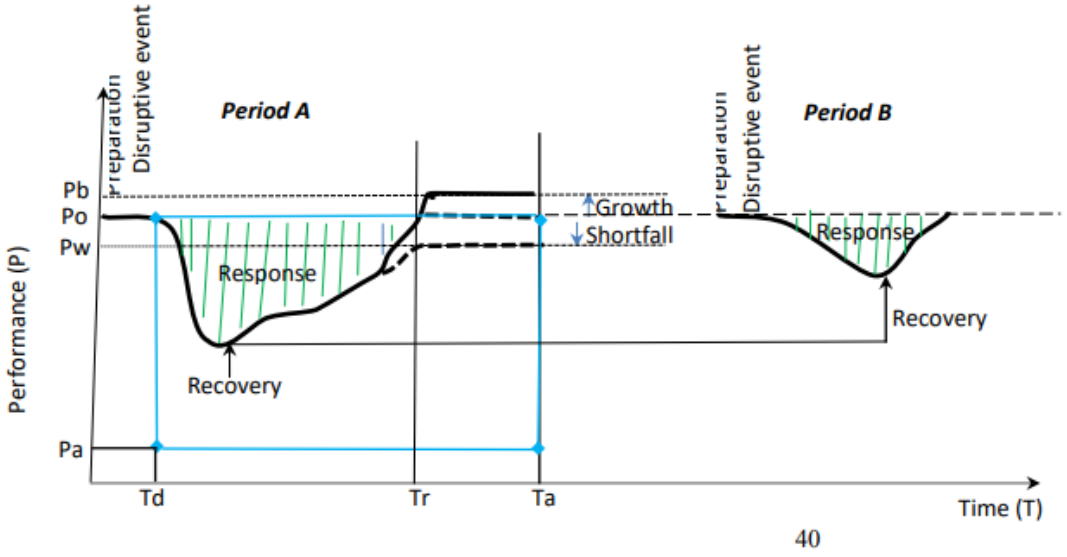


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Figure no.5.5 represents the four principle features of Tukamuhabwa et al. (2015) SCRES definition. Resilience is illustrated as a process where a supply chain goes through a number of disruptive events and is forced to enact many different responses and adaptations. A first disruption is depicted as Period A where a significant loss occurs, whereas Period B is linked to a second disruptive event where a smaller loss has taken place, maybe as a result from the learning process had because of the first disruption. An important piece of information would be given by the calculation of the shaded shape area above the performance curve highlighted in Period A, which allows the assessment of the loss in performance after a disruptive event as well as the time needed for recovery. After having traced a cut-off point, the aforementioned area can also be used to measure subsequent growth. By confronting the two 'triangles' in Period A and Period B, there could also be a more effective way of measuring whether the supply chain is getting more and more resilient over time. Po reflects the normal performance level previous to the disruption and Pa is the minimum performance level which can be accepted else operations are believed to collapse. Pb and Pw stands for best and worst performance level as results after recovery. Td is the time when a disruption begins, Tr is the actual recovery time, and Ta is the maximum acceptable recovery time. In conclusion, Figure no.5.5 can be a useful approach even though it must be taken into account that SCRES assessment is partly subjective and context specific. For instance, decision makers may circumstantially define what accounts for an acceptable recovery time (Ta) (Cimellaro et al. 2010).

5.4.2 Main strategies for a resilient supply chain

By collecting the most commonly cited SCRES strategies in literature, the four most critical strategies for SCRES appears to be: increasing flexibility, creating redundancy, forming collaborative supply chain relationships and improving supply chain agility (e.g. Longo & Oren 2008; Jüttner & Maklan 2011; Ponis & Koronis 2012).

Some of them can be interconnected or can support each other, as in the case of the facilitation that can be offered by the creation of social capital and relational competences with respect to collaboration. Agility can be reinforced by velocity and visibility (Christopher & Peck 2004). Disruptive events might be mitigated by collaboration even at an earlier stage than their existence through information sharing facilitation, supplier development and security creation. It may also be utilized to support the recovery which follows a disruptive event by fostering supply chain actors to share resources and to respond in a coordinated manner (Nishiguchi & Beaudet 1998; Scholten et al. 2014).

As far as the concept of flexibility is concerned, Erol et al. (2010) defines it as the capacity of an organization to promptly adapt to changing contexts and stakeholders with minimum time and effort. Some practices that can foster SCRES flexibility are suggested by the literature: flexible transportation, flexible supply base, order fulfilment flexibility, postponement and flexible labour arrangements (e.g Christopher and Holweg 2011; Tang 2006b; Pettit et al. 2013). For instance, it is believed that during crisis resilience is facilitated by postponement deferring demand to a future period (Tang 2006b). Hence, flexibility generates SCRES by increasing adaptability in turbulent events (e.g. Christopher & Holweg 2011). Moreover, it supportS a supply chain's quick reaction and recovery, and this may be strengthened by the accessibility to other options (redundancy), comprehending different suppliers (e.g. Sheffi & Rice 2005). Flexibility makes resources more easily reemployed as well, as it in the cases of transportation and labour resources (Pettit et al. 2013). Flexibility may concern both the enterprise and the supply chain (Stevenson & Spring 2007).
A second important strategy is represented by building redundancy: the concept of redundancy comprehends both the strategic and the selective utilization of spare capacity and inventory which may be required during a crisis to face to as in the case of supply shortages or demand surges (Christopher & Peck 2004). Building redundancy can be costly for creating resilience. For instance, spare capacity can concur in reducing possible vulnerability and building resilience along the critical path (Christopher & Rutherford 2004). As far as redundancy is concerned, SCRES can be obtained also through the consideration of specific elements such as geographical location and the total (global) demand. For instance, if redundant suppliers are alongside a disrupted supply network, the event might have an impact on them like in the scenario of an earthquake or flood. At the same time, imagining a picture where there are three suppliers based in different continents each, with a capacity of 60 units, comprehending 10 units of 12 excess capacity, then the total global capacity would be equal to 180 units. In addition to this scenario, if the total (global) demand is 150 units and one of the suppliers faces a significant disruptive event making it close the business, the global capacity would become 120 units, hence not matching the global demand of 150 units. The aim of the example is to illustrate the high degree of interconnection that there is in global systems, becoming inadequate to segregate the supply chain from other global systems due to the fact that adaptation pressures or threats in such systems may have an impact on the supply chain's resilience too. Moreover, it is also stated that redundancy encompasses the duplication of capacity so to keep operations going during a failure (Rice & Caniato 2003), also being recognized as a path to flexibility (e.g. Jüttner & Maklan 2011; Kristianto et al. 2014). In fact, Johnson et al. (2013) studies discovered that redundancy augments flexibility, also smoothing the response by way of the adaptable deployment of resources, thus supporting the avoidance of delay, also increasing SCRES. In spite of the close bond between redundancy and flexibility, the latter may also be obtained in

different ways such as installing multipurpose machines, creating flexible contractual arrangements and employing a multi-skilled labour force. Due to the commonly shared belief among scholars that flexibilities which do not automatically depend on redundancy save resources, many different academics have opted for them (e.g. Christopher and Holweg, 2011; Thun et al. 2011).

It is also important to take into consideration the role of collaboration in a supply chain: Pettit et al. (2013) argue that it concerns the capacity to work effectively with different players for a common interest in areas such as forecasting, postponement and risk sharing. It may also include information exchange, which may mitigate risks, augment transparency and smooth the generation and sharing of knowledge that may be used to tackle supply chain risks and uncertainties (Christopher and Peck, 2004). Collaboration may make supply chain partners able to practice costs sharing which regards the creation of resilience and security (Barksh and Kleindorfer, 2009). Furthermore, it has impact on the processes implemented by supply chain partners to guarantee supply chain recovery (Ghadge et al. 2012). For instance, collaboration can ease resource sharing and other complementary abilities that are required by a disruptive event in order to recover from it (Scholten et al. 2014). It supports SCRES by allowing supply chain partners to help each other in case of disruption (Jüttner and Maklan, 2011) and to produce a flexible and coordinated response as in the aforementioned case of Toyota (Nishiguchi and Beaudet, 1998). Such example reminds the role of some practices in supply chain relationships, like just-in-time supply and single-sourcing supply partnerships in generating downsides which have to be swept for the benefits of these practices, as solid networks which could potentially smooth a quick response to a crisis.

Importance is to be given also to the concept of agility in a supply chain, meaning, according to Christopher and Peck (2004), the capacity to promptly react to unforeseeable alterations in demand or supply; this may be obtained thanks to a quick change business processes and systems related (Erol et al. 2010). The first also asserted that supply chain agility is fundamentally constituted of visibility and velocity. The former concerns the capability to see through the whole supply chain (Christopher and Peck 2004), allowing a lucid view of the entire chain - which may be useful in spotting signals of upcoming disruptive events – also implying awareness of the supply chain's assets and environment state (Pettit et al. 2013). This may also permit to circumvent overreactions, not necessary interventions and ineffective decisions in contexts of risk (Christopher and Lee, 2004). Moreover, it allows the supply chain to react from disruptions by the way of, inter alia, identifying vulnerable suppliers, thus giving enough time to find countermeasures against potential failures (Jüttner and Maklan, 2011). For instance, Procter & Gamble planners have tried to reinforce their supply chain visibility by implementing monitoring tools to map the supply chain in order to increase threat awareness and to receive timely warnings of potential disruptive events (Saenz and Revilla, 2014). These two authors further pictured how supply chain visibility was useful to Cisco

in improving its agility and resilience in response to the Japanese earthquake and tsunami of 2011. In the twelve hours which followed the disaster, Cisco was able to trace its supply base beyond tier one suppliers (more than 300 suppliers) and it managed to do it as well for its customers within twenty-four hours. This concurred in building an organization SCRES agenda thus surviving the impact of the disaster (Saenz and Revilla 2014). The latter element of agility – supply chain velocity (Christopher and Peck, 2004) – pays attention to the momentum of flexible adaptations (Stevenson and Spring 2007), and hence defines the recovery speed of the supply chain from a risk event (Jüttner and Maklan 2011) .

Table 5.6 reports twenty four different strategies in order to reach SCRES, being listed together with the corresponding authors who have found and investigated the particular strategy. They have been divided into two categories: proactive and reactive strategies.

Table 5.6 Main common SCRES strategies in literature.

Source: Tukamuhabwa et al. (2015)

Type of Strategy	Authors	Supply Chain Resilience Strategies
Proactive Strategies	Mascaritolo & Holcomb (2008)	*Appropriate supplier selection* – Using selection criteria that can help to minimise disruptions and their impact, such as political stability in suppliers' territories, quality, capabilities (e.g. technological), financial stability, business continuity, reliability, etc
	Ponomarov & Holcomb (2009); Ponomarov (2012)	*Building logistics capabilities*– Capabilities for managing supply and information flows necessary for minimising vulnerabilities, e.g. risk hedging capabilities, information technology upgrades, and information sharing.
	Rice & Caniato (2003); Pettit (2008); Barksh & Kleindorfer (2009); Pettit et al. (2010); Park (2011); Fakoor et al. (2013)	*Building security* – Measures to protect the supply chain against deliberate disruptions, e.g. theft, terrorism & the infiltration of counterfeits
	Johnson et al.(2013) ; Wieland & Wallenburg (2013)	*Building social capital and relational competences* – Effective communication

		and information sharing before the risk event increases risk awareness and limits vulnerability, e.g. communication, cooperation, trust, reciprocity, etc.
	Barksh & Kleindorfer (2009); Borekci et al. (2014)	*Coopetition* – Creating and maintaining collaboration between competitors so as to gain from synergies, e.g. sharing resources for building security & resilience.
	Tang (2006a, 2006b); Urciuoli et al. (2014)	*Creating appropriate contractual agreements* – Long term and short term contracts that can enable flexibility in supply to minimise shortages.
	Stewart et al. (2009); Urciuoli et al. (2014)	*Creating public-private partnerships* – Contractual agreement between a public agency and a private sector entity to share skills & assets, risks and rewards in order to deliver services or facilities to the general public. It increases government interest in private entities' supply chains.
	Christopher & Peck (2004); Sheffi & Rice (2005); Sheffi (2005); Xu (2008); Zhang et al. (2011); Mandal (2012); Leat & Revoredo (2013)	*Creating risk management culture* – Ensuring that all organizational members embrace supply chain risk management, and this involves, e.g. top management support and firm integration/team work.
	Golgeci & Ponomarov (2013)	*Increasing innovativeness* – The motivation and capability to seek and invent new business ideas, e.g. new products, technologies, processes and strategies that can reduce vulnerability.
	Glickman & White (2006); Datta et al. (2007); Lakovou et al. (2007); Longo & Oren (2008); Pettit (2008); Pettit et al. (2010); Zhang et al. (2011); Carvalho et	*Increasing visibility* – The ability to see through the entire supply chain (all nodes and links), which helps to identify potential threats.

	al. (2012b); Saenz & Revilla(2014)	
	Boone et al. (2013)	*Inventory management* – The strategic alignment of inventory management using a system-wide approach to minimise inventory risks
	Rice & Caniato (2003); Christopher & Peck (2004); Xu (2008); Kong & Li(2008); Ponis & Koronis (2012); Ponomarov & Holcomb (2009); Lakovou et al. (2007); Jüttner & Maklan (2011); Scholten et al. (2014)	*Knowledge management* – Developing knowledge and understanding of supply chain structures (i.e. physical and informational), and the ability to learn from changes as well as educate other entities.
	Urciuoli et al. (2014)	*Portfolio diversification* – Indulging in different products to reduce dependence on particular products and suppliers.
	Tang (2006b); Leat & Revoredo (2013)	*Supplier development* – Facilitating suppliers with incentives, e.g. financial, training and technical knowledge to improve efficiency, commitment and reliability.
	Rice & Caniato (2003); Christopher & Peck (2004); Datta et al. (2007); Mascaritolo & Holcomb (2008); Pettit (2008); Ji & Zhu (2008); Bakshi & Kleindorfer (2009); Ponomarov & Holcomb (2009); Pettit et al. (2010); Pettit et al. (2013); Barroso et al. (2010); Erol et al. (2010); Peters (2010); Jüttner & Maklan (2011); Zhang et al. (2011); Park (2011); Soni & Jain (2011); Mandal (2012); Ponis & Koronis (2012); Carvalho et al.	*Supply chain collaboration* – The ability to work effectively with other supply chain entities for mutual benefit, e.g. sharing information and other resources to reduce vulnerability.

	(2012b); Leat & Revoredo (2013); Fakoor et al. (2013); Scholten et al. (2014)	
	Datta et al. (2007); Diabat et al. (2012); Carvalho et al. (2012a); Mandal (2012); Leat & Revoredo (2013); Scholten et al. (2014)	*Supply chain network structure/ design* – Constructing the supply chain network for resilience, e.g. balancing redundancy, efficiency, vulnerabilities, etc.
	Soni & Jain (2011)	*Sustainability compliance* – Compliance to economic, social and environmental requirements to mitigate associated supply chain risks, e.g. reputational risks.
	Kong & Li (2008); Erol et al. (2010)	*Use of information technology* – Information technology enhances connectivity and supports other resilience strategies, e.g. visibility and collaboration, which can help in signalling potential disruptions.
Reactive Strategies	Ponomarov & Holcomb (2009); Ponomarov (2012)	*Strategies Building logistics capabilities* – Capabilities for supply and information flows, e.g. to reduce cycle times, increase delivery competence, knowledge management and customer service to quickly recover from a disruption.
	Johnson et al. (2013); Wieland & Wallenburg (2013)	*Building social capital and relational competences* – Effective communication, trust and information sharing can enable rapid access to resources necessary for recovery, e.g. communication, cooperation, trust, reciprocity, etc.
	Glickman & White (2006); Tang (2006b); Pettit (2008); Mascaritolo & Holcomb (2008) Pettit et al. (2010); Park (2011); Vlachos et al. (2012); Urciuoli et al. (2014)	*Contingency planning* – Anticipating potential events and specifying the measures to deal with supply chain risks and disruptions before they actually occur, e.g. by forecasting and monitoring early warning signals.

	Rice & Caniato (2003); Christopher & Rutherford (2004); Sheffi (2005); Sheffi & Rice (2005); Peck (2005); Tang (2006b); Lakovou et al. (2007); Xu (2008); Ratick et al. (2008); Longo & Oren (2008); Ji & Zhu (2008); Zsidisin & Wagner (2010); Carvalho et al. (2011b); Park (2011); Azevedo et al. (2011); Diabat et al. (2012); Carvalho et al. (2012d); Ponis & Koronis(2012) ; Vlachos et al. (2012); Xu et al. (2014); Urciuoli et al. (2014); Saenz & Revilla (2014)	*Creating redundancy* – The strategic and selective use of spare capacity and inventory that can be used to cope with disruptions, e.g. spare stocks, multiple suppliers and extra facilities.
	(Tang 2006b); Urciuoli et al. (2014)	*Demand management* – Mitigating the impact of disruptions by influencing customer choices through, e.g. dynamic pricing, assortment planning and silent product rollovers.
	Christopher & Rutherford (2004); Christopher & Peck (2004); Kong & Li (2008); Tang & Tomlin (2008); Longo & Oren (2008); Ji & Zhu (2008); Erol et al. (2010); Peters (2010); Carvalho et al. (2011b); Ponis & Koronis (2012); Carvalho et al. (2012b); Mandal (2012); Scholten et al. (2014)	*Ensuring supply chain agility* – The ability to respond quickly to unpredictable changes in demand and/or supply.
	Rice & Caniato (2003); Sheffi, (2005); Sheffi & Rice (2005); Tang (2006b); Glickman & White (2006); Lakovou et al. (2007); Datta et al. (2007); Xu (2008);	*Increasing flexibility* – The ability of a firm and supply chain to adapt to changing requirements with minimum time and effort.

	Pettit(2008); Ratick et al. (2008); Tang & Tomlin (2008); Mascaritolo & Holcomb (2008); Longo & Oren (2008); Ji & Zhu (2008); Zsidisin & Wagner (2010); Pettit et al. (2010); Erol et al. (2010); Zhang et al. (2011); Azevedo et al. (2011); Soni & Jain (2011); Carvalho et al. (2011b); Park (2011); Xiao et al. (2012); Ishfaq (2012); Diabat et al.(2012); Carvalho et al. (2012a); Ponis & Koronis (2012); Vlachos et al. (2012); Carvalho et al. (2012b); Fakoor et al. (2013); Azevedo et al. (2013); Mensah & Merkuryev (2014); Geng et al. (2014)	
	Longo & Oren (2008); Carvalho et al. (2012b)	*Increasing velocity* – The pace of flexible adaptations that can determine the recovery speed of the supply chain from a disruption.
	Longo & Oren (2008); Pettit (2008); Pettit et al. (2010); Soni & Jain (2011); Carvalho et al. (2011b); Zhang et al. (2011); Azevedo et al. (2011); Azevedo et al. (2013); Brandon-Jones et al. (2014); Saenz & Revilla (2014)	*Increasing visibility* – The ability to see through the entire supply chain (all nodes and links) so as to effectively respond to a disruption.
	Rice & Caniato (2003); Sheffi (2005); Datta et al. (2007); Mascaritolo & Holcomb (2008); Pettit (2008); Ji & Zhu (2008); Ponomarov & Holcomb (2009); Pettit et al. (2010); Pettit et al.	*Supply chain collaboration* – The ability to work effectively with other supply chain entities for mutual benefit, e.g. sharing information and other resources necessary for response and recovery.

	(2013); Erol et al. (2010); Peters (2010); Jüttner & Maklan (2011); Zhang et al. (2011); Park (2011); Soni & Jain (2011); Barac et al. (2011); Carvalho et al. (2011b); Ponis & Koronis (2012); Leat & Revoredo (2013); Scholten et al. (2014)	
	Kong & Li (2008); Erol et al. (2010)	*Use of information technology* – Information technology enhances connectivity and supports other resilience strategies, e.g. visibility and collaboration, which can help in coordinating responses to disruptions.

Source: Tukamuhabwa et al. (2015)

By looking at Table 5.6 information technology appears crucial to most of the strategies and it is also evident from it that the literature underlines more proactive than reactive ones. While managers can prefer such strategies for the prevention and not the tackling of a disruptive event, also supporting the prosecution of 'operations as normal' with the minimization of the precariousness, others can be unsure to opt for proactive strategies as the justification of such investments is not immediate because of the mitigation of a probable disruption that may not ultimately take place. In conclusion, it is important to be noted that some strategies may be organized and structured before a disruption but only implemented after the disruption as in the case of redundant suppliers who were chosen before the event but only contracted afterwards.

5.5 The role of procurement in SCRES

Procurement is no longer considered a function of secondary importance with respect to the business, since it plays a very significant role within the company management due to the fact that it deals with the purchase of specific resources, often essential, for carrying out internal operations. As far as the literature is concerned, the terms "procurement" and "purchase" are often used interchangeably; however, some authors (Ellram and Carr, 1994; Monczka et al., 1998; Lysons and Farrington, 2006; Miemczyk et al, 2012) consider the former as the evolution of the latter, often

associated with mere cost cutting, being too often seen as a modest corporate function in charge of planning, implementation, evaluation and control of purchasing decisions (Szwejczewski et al., 2005; Paulraj and Chen, 2007), as well as resource and supplier management (Ellram and Carr, 1994; Lindgreen et al., 2013). As a result, in such a volatile market environment, the potential of this activity in terms of competitive advantage has been understood, thus expanding its scope of action. It is necessary to take the issue into account both in external and internal logic, so that internal requirements can be aligned and synchronized with external resources in order to pursue and, subsequently, achieve the desired business results (Chicksand et al., 2012). From an external point of view, authors such as Monczka et al. (1998) and Castaldi et al. (2011) suggest that procurement should be observed as a frontier function to protect the firm's interests (Ellram and Birou, 1995; Lindgreen et al., 2013) according to which it is responsible for the cost of the product or service, delivery times, product quality and supply decisions, such as the selection of suppliers or the relationship with them (Nix, 2001; Szwejczewski et al., 2005; Castaldi et al., 2011), while, from an internal point of view, purchasing managers can be seen as information providers who share pieces of information such as pricing, logistics data, dealers' capacity and so on and so forth to different company functions, as well as to internal customers who take care of purchases according to needs (Szwejczewski et al., 2005). Hence, the importance of cross-functional integration between procurement and other functions in order to increase the visibility of flows, allowing top management to make decisions in a more transparent, concrete and effective way (Chiang et al., 2012). In this sense, some authors such as Foerstl et al. (2013) stress the importance of structuring an inter-functional team in purchasing and procurement management, with the implicit condition that this integration sees the collaboration and sharing of information between buyer and supplier in several phases, overcoming the concept of a trivial sales-supply relationship between buyer and supplier (Agndal and Nilsson, 2007; Castaldi et al., 2011). In analyzing the different types of relationship between the two parties, Christopher and Jüttner (2000) and McDonald and Woodburn (2007) identified the following types: basic, cooperative, interdependent and integrated. They allow entire companies to maintain their operations, ensuring a good agility of response to various problems with which companies can interface, such as business interruption. It is now widely accepted that procurement has a leading role within the company framework, especially for its function as an accelerator of competitiveness even in unstable environments (Lawson et al., 2009, 2012). It is also of strategic importance in terms of resilience of the supply chain for its contribution to the resolution of internal and external organizational issues. The latter may concern different types of disruptions that may affect specific supply chain nodes. Provided that they are not all predictable, what is certain is that there are elements that hinder the creation of resilience, which therefore need to be identified in order to be able to prevent or combat them quickly. The literature

has tried to identify certain enabling and deterring factors, but it has not yet been able to separate them clearly because many of them are interconnected. Some obstacles are represented by variables such as complexity, financial weakness or lack of one or more of the following: capacity, collaboration, coordination, control, information, integration, flexibility, knowledge, visibility, trust, long lead times and long distances. Some enabling elements have been identified in flexibility, redundancy, visibility, agility, collaboration, integration, information sharing, financial strength, coordination and control, trust, supply chain design, risk management, company's knowledge, alignment, velocity and acceleration.

Among the above mentioned enablers, it must be said that the concept of flexibility can be declined in various ways through different developments, in fact one can think of flexibility in terms of procurement (Zeng, 2000; Tang, 2006a,b; Pettit et al., 2010; Chiang et al, 2012; Simangunsong et al., 2012), in terms of product (Chiang et al., 2012; Simangunsong et al., 2012), in terms of process (Rice and Doggy Style, 2003; Chiang et al., 2012; Simangunsong et al., 2012) and flexibility in terms of transport (Tang, 2006a,2006b; Spiegler et al., 2012).

When looking at flexibility under the supply lens, as operated by Yi et al. (2011), the strategic aim of applying this model is to ensure the availability of suppliers to support them in case of need thanks to the good quality of materials on which to rely. In this regard, Jüttner and Maklan (2011) highlight how procurement flexibility can prove to be a key resilience factor due to the fact that low-cost sources of supply can be shifted to the cheapest solution or companies' bargaining power in the context of pricing negotiations with their suppliers. Observable benefits on cost reduction, critical routes and delivery times should also be taken into account (Carvalho et al, 2012). Having a flexible supply base provides the agility needed to achieve a good level of resilience thanks to reactivity in contexts of uncertainty. Moreover, as highlighted by Sheffi and Rice (2005), this feature contributes to hinder possible opportunism on the part of suppliers, asserting, together with other authors (Zsidisin et al., 2000; Christopher and Lee, 2004; Stecke and Kumar, 2009; Colicchia et al., 2010; Zsidisin and Wagner, 2010; Christopher and Holweg, 2011) how risky it is to rely on a single supplier. It therefore follows that the inability to be flexible is widely accepted as one of the most important barriers to the normal flow of production and product delivery. On the other hand, as stated by Christopher and Peck (2004) and Sheffi and Rice (2005), accepting this risk, relying on one or a few suppliers could lead to an improvement in the quality and cost of end products by investing in supplier relationships. In addition, increasing information sharing and relieving the supplier of certain responsibilities would lead to an increase in agility towards greater efficiency (Christopher, 2000; Christopher and Jüttner,2000). This quality is essential for global sourcing as it allows for shorter response times to supply disruptions (Christopher and Holweg, 2011).

Christopher (2000) also highlights how companies typically have a small supplier base, focusing on building strong relationships with a high level of connectivity in terms of information sharing. It is clear that finding the trade-off between single or multiple sourcing, Simangunsong et al. (2012) highlights how a balanced use of suppliers can help generate resilience in the supply chain so that reasonable material quality, product cost and reliable delivery can be maintained. Moreover, considering the cases where suppliers are few or only few, an essential factor to take into account is the financial situation of the supplier, since, as pointed out by Zsidisin et al. (2000, p. 188), there is a risk that a supplier, being unprofitable, may close the business or face serious difficulties that could put him at risk, so financial strength is also a factor of elasticity that affects the procurement activity.

Another strategic factor is undoubtedly represented by collaboration, which can help to achieve the effectiveness of the supplier's management team, while speed and acceleration are more typically attributable to the location of suppliers (Tang, 2006a; Zsidisin and Wagner, 2010). The improvement of this feature is highlighted by Christopher and Holweg (2011) as an element of risk reduction related to sourcing, especially if global, always assuming that there is a good relationship of trust, otherwise, the scenario imagined by Christopher and Lee (2004) would materialize in a relationship of poor collaboration and visibility upstream of the supply chain, resulting in inaccurate forecasts, inventory and higher purchasing costs.

A recognized quality of great importance for companies is the prudent management of inventories, however, this is not enough, as preventive action must be taken in the event of crises and emergencies. Sheffi (2001) has identified two ways of using the warehouse: centralized and dispersed. The first allows firms to react promptly, drawing on the abundant capacity located in a specific area considered strategic and able to make up for shortages in certain areas. In recent years there has been a widespread tendency to reduce the number of warehouses and stocks with a view to reducing costs, but this can prove to be a weak point in the event of unexpected complications that could put the company in difficulty in meeting emergency needs (Stecke and Kumar, 2009; Christopher and Holweg, 2011). Provided that one or the other method does not reduce the probability of disruptive events occurring, Zsidisin and Wagner (2010) and Carvalho et al. (2012a) emphasize the safety stock as an effective tool in emergency situations, a subject already dealt with by Sheffi (2001), also specifying the difference between emergency stock and safety stock. The former is used to contain fluctuations in daily demand, going in the opposite direction of the emergency stock, which is used to conserve a redundant stock to contain the impact of emergencies or external disturbances. Stecke and Kumar (2009) highlight the benefits that can be deduced from the creation of redundancy with regard to critical factors that should be maintained with limited investment. Zsidisin and Wagner (2010) also argue in favour of short supply chains, pointing out

that long supply chains can encounter greater and more volatile difficulties such as political instability, while Christopher and Holweg (2011) focused more on the blockage that can constitute an element of the supply chain once it is hit by a strong disruption, due to the eco-produced through interconnections between companies. For these reasons, it can be inferred that a complex network can see its vulnerability increase and a reduction in agility along supply chains (Yang and Yang, 2010). Consequently, collaboration is necessary, as is interorganizational alignment between supply chain members (Pettit et al., 2010).

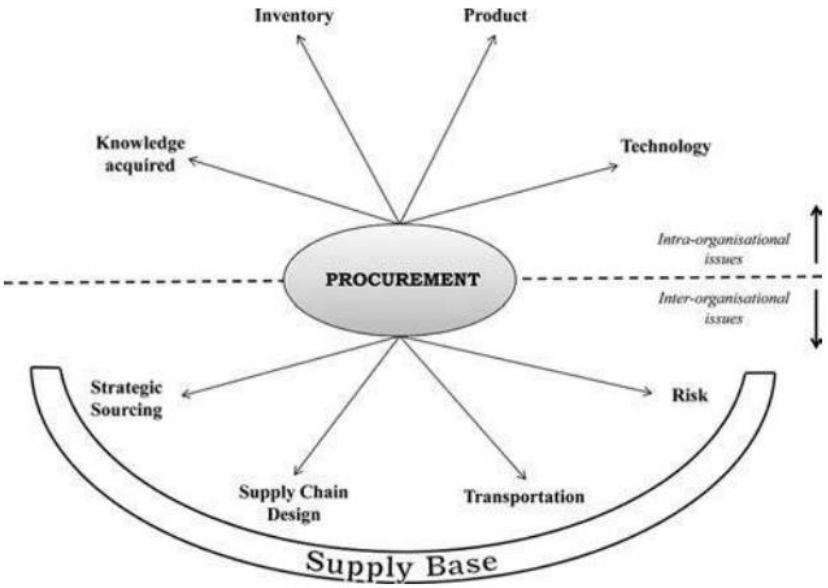
In addition, easy access to visibility, combined with good alignment should enable inventory monitoring, as well as identifying the complexities taking place upstream in the supply chain, with the ability to observe demand and supply conditions to manage purchasing programmes (Christopher and Peck, 2004; Sheffi and Rice, 2005). The rethinking of the network design could contribute to an increase in visibility and alignment, with a consequent risk mitigation (Tang,2006a; Christopher and Holweg, 2011; Blackhurst et al.,2011; Carvalho et al.2012a). Ponomarov and Holcomb (2009, p. 137) state that "risk assessment and risk sharing among members of a supply chain is an essential element of risk mitigation". Risk management appears to be a core activity in the supply chain. Stecke and Kumar (2009) and Blackhurst et al. (2011) have developed tools such as referral, mass customization and centralized inventory management to achieve a modular product. Transport flexibility, on the other hand, is best applied when the context is uncertain and unexpected events occur (Sheffi and Rice, 2005; Tang, 2006a; Stecke and Kumar, 2009). Technological tools are also considered to be effective means for the flow of information that, for example, can take place between functions and companies. The above can be summed up by pointing out that procurement has proved to be a key factor in that it covers the interface function capable of rapidly communicating changes through market demand to suppliers (Chiang et al., 2012), a quality that can have a significant impact in a context of uncertainty (Lee et al., 2009). It has also been observed that both enablers and resilient barriers are closely linked to supply chain activities, which in turn can make a significant contribution to the creation of resilience in the supply chain. In conclusion, it was not considered necessary to also argue the barriers as exactly opposite to enablers.

It remains to deal with intra- and inter-organizational issues and try to understand them in general terms precisely in the light of the influence that enablers and barriers have on supply chain resilience seen as a dynamic set of conditions within the supplu chain system (Mitchell and Harris, 2012).

Intra-organizational issues have been classified in the areas of acquired knowledge, inventory, product and technology, while inter-organizational issues relate to strategic sourcing, supply chain design, transport and risk. In the first case, the knowledge acquired represents a crucial

characteristic for overcoming adversity because it groups together the lessons learned from previous crisis and complexity situations, not to mention the daily component that is cultivated through internal communication between company departments. With regard to the inventory, it is stressed that there are many possible solutions to manage it in order to return to normal activities and performance as quickly as possible. As far as products are concerned, their flexibility could be a useful strategy in critical situations, but support for the other factors mentioned, such as strategic sourcing and inventory, would also be essential. Finally, the role of technology, particularly information technology (IT), in supporting the resilience of supply chains is strongly valued, as demonstrated at the World Economic Forum (2013), recognizing, inter alia, how it promotes data sharing and visibility. Figure no.5.5.1 shows supply chain resilience under a procurement perspective.

Figure no.5.5.1 Supply chain resilience creation by a procurement point of view, considering both intra- and inter-organizational issues
Source: Pereira et al. (2014)



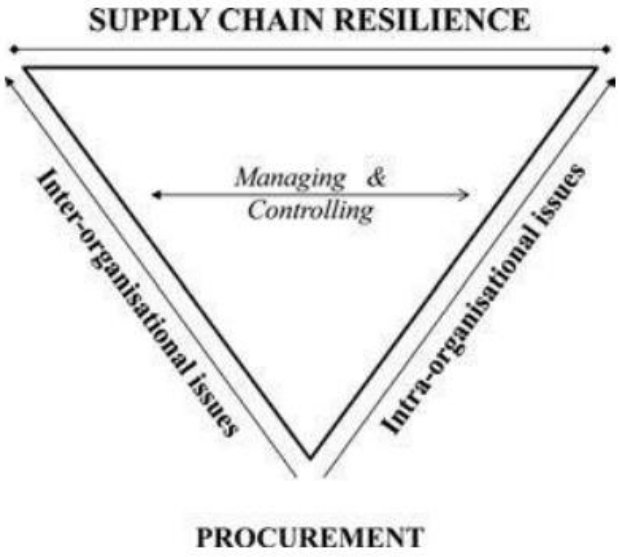
Turning instead to inter-organizational issues, it is very important to deal with strategic sourcing through four fundamental issues:
- Developing a good relationship with suppliers in order to facilitate decision-making in a strategic and effective way.
- The design of the supply chain must be aimed at reducing difficulties in order to improve the alignment of flows throughout the supply chain.
- Modes of transport of products

- A constant monitoring of the supplier risk through a precise evaluation carried out by the procurement managers.

The general framework should also include the analysis of possible compromises that could involve each of the issues listed above, so that managers have a clear understanding of the current situation of the market, the environment and the functioning of the company in order to make informed and less biased decisions. In conclusion, taking into account enablers and barriers, intra- and inter-organizational issues, strategic sourcing issues and their management, a resilient supply chain can be achieved. The Figure no.5.5.2 summarizes the logical process described so far.

Figure no.5.5.2 Supply chain framework for reaching resilience via intra and inter-organizational issues

Source: Pereira et al. (2014)



5.6 The role of disruption management in SCRES

In a reality like the present one, which is definitely interconnected, the possibility of a supply chain interruption is largely taken into account by different companies and organizations (Skipper and Hanna, 2009) and can take place for example during a labour force strike, extreme weather conditions (Blackhurst et al., 2011) or a lockdown, as recently happened. This event may be in direct relation to any unexpected event, affecting the normal flow of goods, materials and/or services (Craighead et al., 2007). It has already been possible to observe the fragility of supply chains when subject to unforeseen disruptions on occasions such as, for example, the earthquake in Japan in 2012 which had a strong impact on the international scene due to the effects on the supply chains of the automotive and technology industry in Europe. The fact that there are supply chains that are able to recover earlier than others in the context of severe and unexpected disruptions has

promoted a lively debate on the issue of supply chain resilience (Jüttner and Maklan, 2011). This last topic is based on the fact that not all risks are avoidable (Jüttner and Maklan, 2011), showing resilience as a proactive and holistic approach to supply chain risk management, pushing the realities involved to make risk analyses and assessments. Christopher and Peck (2004) studied possible enablers of resilience development, highlighting four key capabilities: (1) supply chain (re)engineering, (2) collaboration, (3) agility and (4) risk awareness. These resilience components are based on the integration and coordination of resources that often cover different functional areas, emerging from supply chain processes (Jüttner and Maklan, 2011).

In cases where companies are in the midst of a major disruption, companies with strong supply chain strategies are more likely to be able to effectively sustain the ability to carry out their operations (Tang, 2006), so as to try to avoid possible negative effects, also allowing them to resist change without having to change their stable configuration in order to adapt it to the crisis (Wieland and Wallenburg, 2012). To do this, it is essential that all members of the chain are prepared on the network (Christopher and Peck, 2004; Ponis and Koronis, 2012; Ponomarov and Holcomb, 2009) so that all actors are aligned in case of disruption (Jüttner and Maklan, 2011). Mapping the supply network helps to understand the role of each factor and what mechanisms are currently in place (Harland et al., 2003). The collection of this data can focus management's attention in order to implement a proper prioritization of planning (Sheffi and Rice, 2005), so that processes and structures capable of absorbing risk are already in place when the risk materializes (Wieland and Wallenburg, 2012).

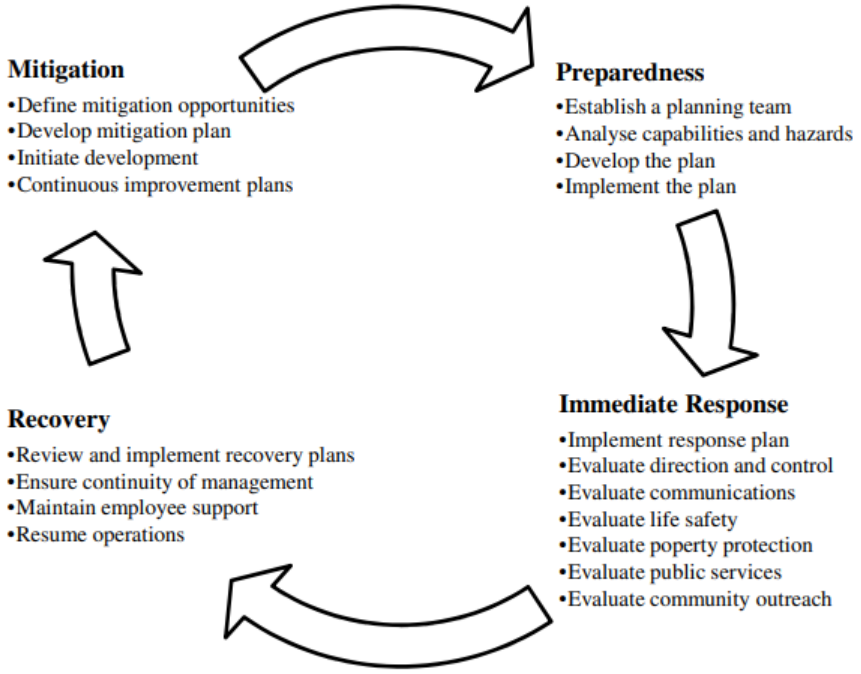
The disaster management scenario is a good opportunity to analyze the resilience of the supply chain, due to the typical characteristics of such crises, their frequency, scale and heavy impact of disasters that undermine the sustainability of communities, businesses and their resources around the world. As can happen with natural disasters, for example, where, although it is always difficult to try to identify the areas most exposed to low probability and high impact disasters (e.g. an earthquake or tsunami), vulnerable areas at risk are identified (Peck, 2005; 2006), so can supply chains. This would enable practices and resources to be put in place to minimize the possible impact of disasters at an earlier stage, thereby building resilience. Disaster management organizes and manages both resources and responsibilities for the humanitarian aspects of emergencies in order to reduce the impact of disasters (The International Federation of Red Cross and Red Crescent Societies, 2013). In such a scenario, supply chain management provides support to 80% of all activities that contribute to cost savings and greater operational efficiency in the planning, delivery and distribution of relief goods (Van Wassenhove, 2006).

Disaster supply chain management is composed of unpredictable factors such as large-scale operations, irregular demand, unusual constraints in case of major emergencies and unreliable or

non-existent information on supply and transport (Kovács and Spens, 2007), unlike general SCM, where the elements are predictable: a predetermined set of suppliers, production sites and stable or at least more predictable demand. In such a context, the engineering of a distribution network is complex because of the unknown characteristics linked to the disaster, such as where it will occur, to what extent and of what nature (Beamon, 2004; Holguín-Veras et al., 2012). It should also be taken into account that many organizations skilled in disaster management have a supply chain lead time very close to zero, due to the unpredictability of the occurrence of a crisis, with effects on supply, stock availability and distribution. This results in great importance linked to a company's supply chain's ability to be agile. It is also underlined that no single actor has the possibility to use sufficient resources to face difficulties effectively and independently (Balcik et al., 2010), which underlines the importance of collaboration within the disaster management sector. The fact that there are competent realities in dealing with and managing disasters and the resulting problems related to the various regular disruptions in the flow of material and information (Blecken, 2010) leads even more to an exploration of the processes used during disaster management to better understand how supply chains need to be structured to be resilient. Helferich and Cook (2002) identified proactive and reactive disaster management processes in the supply chain. In contrast to traditional disaster management that takes place in a contextual and reactive manner, a strategic and planned four-step framework for effective and efficient long-term crisis resolution has been developed. This framework has been widely used in humanitarian supplu chain management (Kovács and Spens, 2007; Natarajarathinam et al., 2009; Pettit and Beresford, 2005) by combining proactive mitigation and preparedness components with reactive immediate response and recovery factors. Proactive measures are used to find a solution to disruptions in order to limit and verify potential risks (Tummala and Schoenherr, 2011). The difference between mitigation and preparedness must be taken into account: the first concept requires the application of solutions aimed at preventing the occurrence of a catastrophe, reducing the extent of possible effects, while the second involves preparing the response to the disaster so that it is as effective and efficient as possible (Altay and Green, 2006; Tomlin, 2006).

Planning in advance preparation, mitigation and prevention, actions with the aim of reducing the risk of disasters, can lead to a better resilience to disasters, including through it the information that communication on technology and earth observation tools can offer (The Montpellier Pane, 2012). This activity is contrasted with the reactive processes that occur after a disruption has taken place, including long-term actions, once the first effects have been overcome, to stabilize and restore a certain state of normality in the structures (Altay and Green, 2006). As illustrated in Figure no.5.6.1, the four phases are cyclical, non-linear, and may even occur simultaneously: there is often a parallelism between mitigation and reconstruction efforts (Maon et al., 2009).

Figure no.5.6.1 Four phases of disruption management (Scholten et al., 2014)



The Figure above illustrates the fact that the long-term vision in processes aimed at effective and efficient disaster management is fundamental to make proactive decisions to contain the effects of unexpected events in conjunction with reactive decisions aimed at overcoming impact (Natarajarathinam et al., 2009). In agreement with the resilience vision of Ponomoarov and Holcomb (2009) as an emerging field in emergency management research, Scholten et al. (2014) supports the direct correlation between the four above mentioned phases of resilience, being also of the opinion that resilience capabilities of the supply chain and processes, or phases, of disaster management also have a correlation between them.

5.7 The role of blockchain in SCRES

The block chain technology (BT) that lies behind the logic of the bitcoin world, while on the latter there is no end to the lively interest, has become a central topic of debate in the business community. Through his study, Holden (2017) showed that about 39% of about 400 company founders, executives, managers and information technology (IT) specialists who were the subject of his interview admitted that they had thought about implementing BT or were close to doing so. BT has increasingly become a topic of discussion for many supply chain managers. The Eye for transport report (2017) found that almost 62 per cent of the supply chain managers who participated in the interview confirmed that they were using BT technologies. At an aggregate level, the

estimated growth in business value added of a supply chain is expected to grow to $176 billion by 2025 and to exceed $3.1 trillion by 2030 (Gartner, 2017). Whatever their expectations, many businesses are unfamiliar with the use of the blockchain and its multiple application solutions, both internally and externally. According to a study where several marketers were interviewed, 88% of them positively recognized its potential, but 15% would be able to explain the technology to their clients (Annalect, 2017). Other managers do not know what the expectations for BT are (Langley, 2017), although there is growing interest in explaining the mechanism so that they can apply the technology properly and manage it properly. BT is a peer-to-peer (P2P) IT network that maintains records of digital asset transactions, using books of account instead of traditional databases that are usually centrally controlled by intermediaries such as banks, credit agencies, governments and accountants. The fact that BT is a decentralized, encrypted and open system attracts the trust of many and generates unprecedented security benefits. This nature makes the tool almost immune to hacking attacks that often affect large centralized intermediaries such as banks, as the blocking chain is able to track all transactions. The complexity of hacking a specific blockchain block is that the hacker would also be forced to unlock all previous blocks throughout the history of that blockchain. In this scenario, BT offers a way to securely shape a tamper-proof business and transaction log (Fallahpour, Shirmohammadi, Semsarzadeh, & Zhao, 2014; Lemieux, 2016). The security of the blockchain can also be increased through the privatization of blockchain networks, which can have a limited membership, comparable in some ways to that of an intranet, by being able to restrict access to such networks instead of having them public. The acceptance of BT on a large scale as a means to increase the benefits of security and revolutionize the offering will need the support of multiple success stories. In order to understand the following arguments about BT, it is important to understand how it works.

Figure no.5.7.1 shows how nobody owns a chain of blocks; blocks cannot be deleted by others and cannot be added. Through the blockchain it is possible to transfer one's assets - including intangible ones - without the risk of hacking and shaping silos that hinder interactions between trading partners. Beyond the undoubted security benefits, BT can also contribute multiple managerial benefits to what are day-to-day business practices (Maruti Techlab, 2017; Takahashi, 2017), among which are of particular importance:

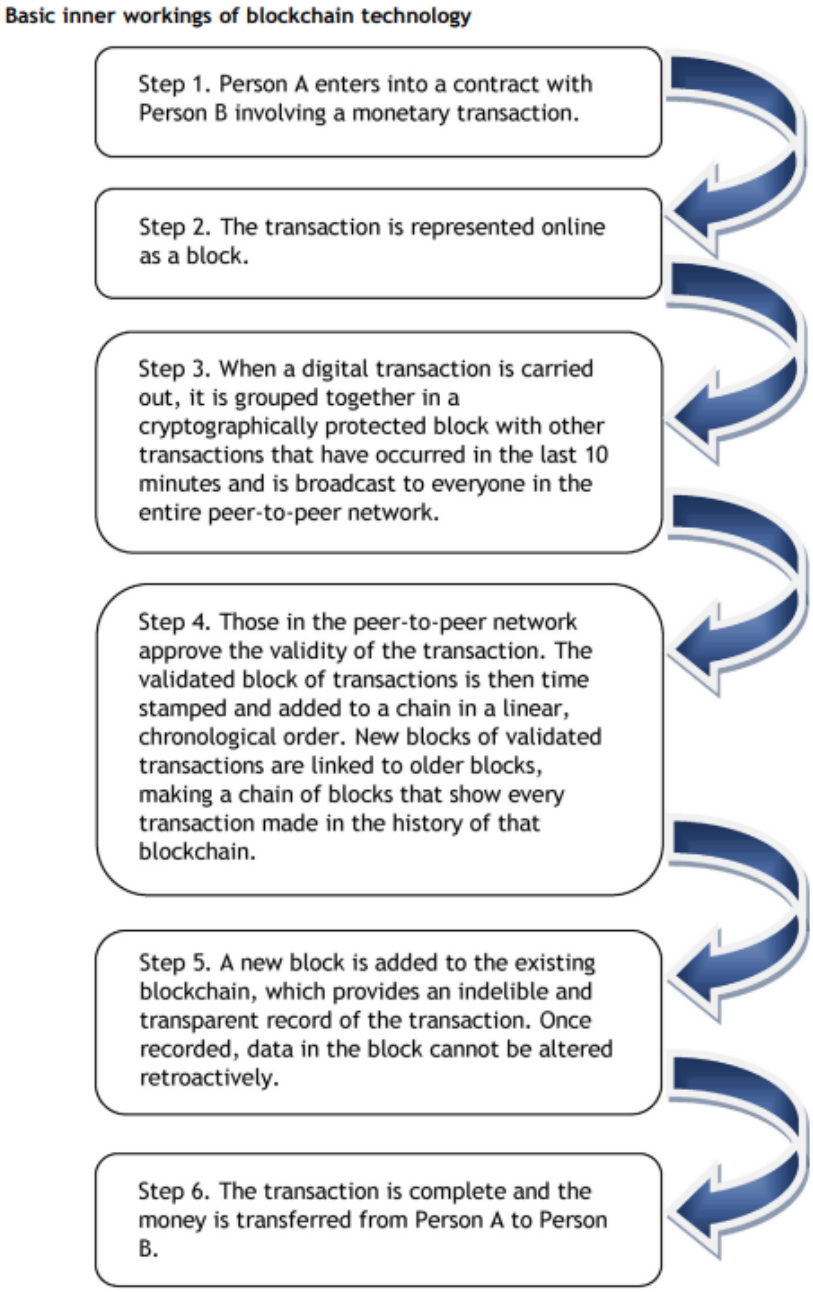
- Reducing costs and transaction time through blockchain platforms, where no third party involvement is required;
- Improved visibility throughout the supply chain, the result of more complete transparency achieved through the use of open registers that can be consulted by anyone;

- Improved connectivity between trading partners due to the integration of the digital and physical worlds (Maruti Techlab, 2017; Takahashi, 2017), which includes shared visibility of transactions and information flows throughout the supply chain.

Through the support of technologies such as Application Programming Interface (API), Electronic Data Interchange (EDI) and Extensible Markup Language (XML), BT is able to lead to faster and more verifiable interactions with unchangeable data exchange between supply chain partners (IBM, 2017). Given these many advantages, BT brings with it a number of implementation challenges, including technical expertise gaps, the ability to have the right infrastructure, scalability difficulties and limits on financial resources for BT's investments. It follows that it is important to develop management strategies to overcome these challenges in order to make the most of BT. It is also important to point out that most of the research on blockchain has been dedicated to the deepening of bitcoin systems and possible application solutions such as intelligent contracts, financial services and licenses (e.g. Crosby, Pattanayak, Verma, & Kalyanaraman, 2016; Mainelli & Smith, 2015; Raval, 2016; Tapscott & Tapscott, 2016; Underwood, 2016; Yli-Huumo, Ko, Choi, Park, & Smolander, 2016).

Figure no.5.7.1 Blockchain technology basic functioning

Source: Min (2018)



As the blockchain is a decentralised mesh network of computers connected to each other, and not connected to a central server, its operations are managed at different levels, shaping the protocols for applying BT. Here is a structure similar to a blockchain architecture, composed of five modules, as it can be observed in Figure no.5.7.2:

1. Data source module, it supports the creation of a blockchain in registers in the shared and distributed database version. Unlike traditional databases, they do not use the client-server network supervised by a designated central authority. In order to gain access to databases,

authentication of a user's credentials by the central authority is not required, which can often be subject to hacking and tampering. Those who participate in the P2P network examine the new additional elements of the blocking chain through consent, thus preventing possible data tampering. It is the responsibility of each user to prove that the data being recovered is not corrupted and is not altered during registration. Specifically in this module, it is possible to read and write the data exclusively with the aid of the query, while the recovered data are updated and deleted.

2. Transaction Module, allows the validation of a transaction and the writing of a new one, where by transaction it is meant the transfer of value between the seller and the buyer, changing the status of the data inside the block. The records transited within the block do not have to change because a new record can alter the status of the data within the past records (Radius, 2017). The form in this section starts with a transaction agreement between the buyer and the seller. Once this is done, this step is transferred to the Peer-to-Peer (P2P) network and the miners, i.e. the computers in the P2P network, and is collected, processing the block with the rewards. This is then validated and then disseminated by the miners in unalterable mode throughout the P2P network. In the context of this module, an input is a reference to an output of a previous transaction (for example, output 1 in Figure no.5.7.2). A transaction is often referred to several inputs. When it is a new transaction, all the input values are added together (for example, input 2 in Figure no.5.7.2). In cases similar to the latter, there must be equilibrium between the total value of the inputs and the total value of the outputs, or, at most, the former must be higher than the latter.

3. Block creation module, where a file with the block name contains the permanently recorded transaction data. It then takes shape the block chain where a block is connected to pre-existing blocks and then structured in a linear sequence over time. However, it is important to note that a new block cannot become part of the P2P network without extraction, i.e. the process through which it is entered into the public ledger transaction record in relation to transactions passed through the resolution of complex mathematical puzzles.

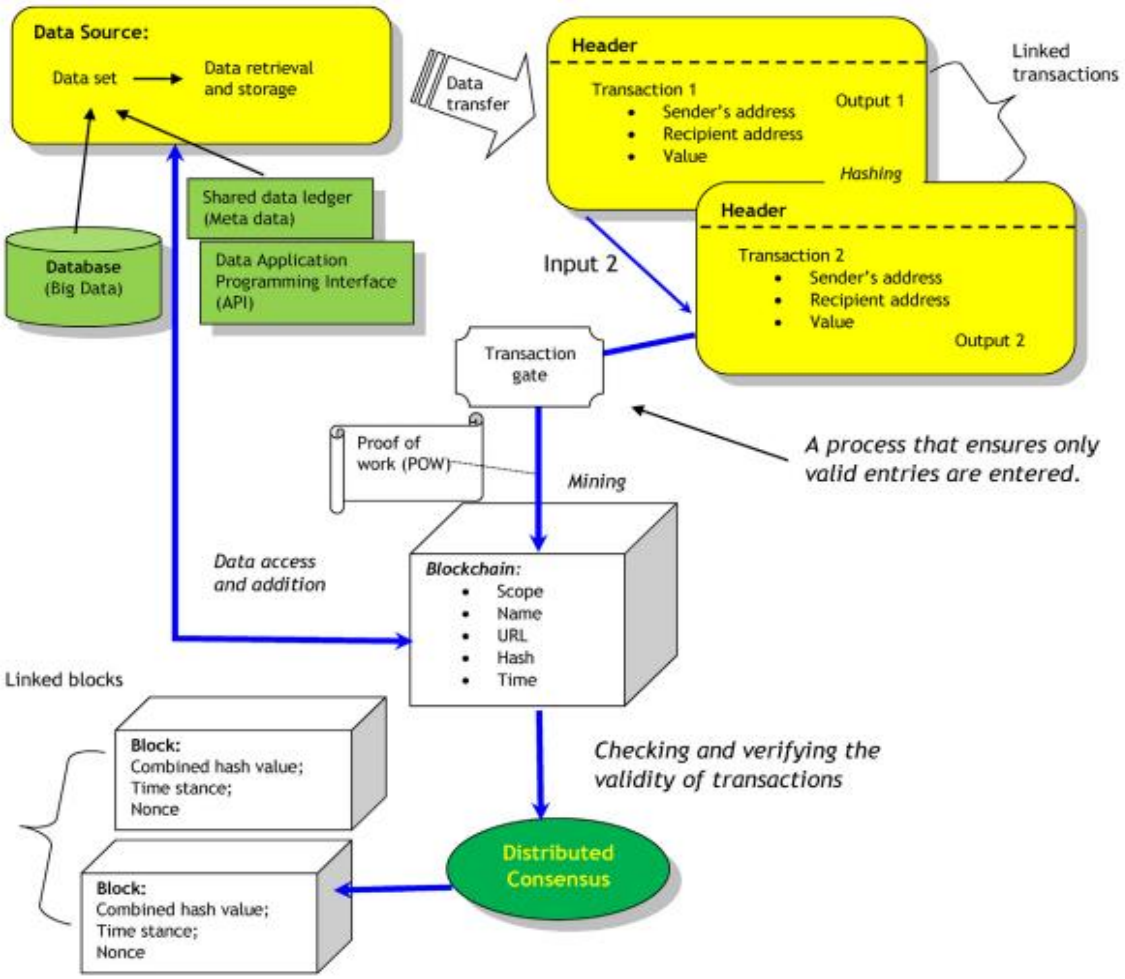
4. Consensus form, i.e. the validation of transactions by means of proof of work, proof of stakes or the Byzantine fault tolerance consensus algorithm. This module is essential to preserve the importance of the transaction data recorded on the blocking chain and to safeguard the transaction and the blocking order. This is where the optimal selection of a

consent mechanism that prevents corruption of the data recorded on the blocking chain takes place.

5. Connection and interface module, which facilitates the user experience of web interfaces between users - including those without encryption, technical or legal skills - through the integration and synchronization of all IT platforms, software (such as bitcoin portfolios) and algorithms required for blockchain applications. This module makes it possible to retrieve real-time information on the contractual status and tracking of transactions carried out by mobile devices. It also facilitates integration between different companies or industries by connecting them to each other and sharing digital resources seamlessly. This tool improves interoperability by enabling the construction of different partnerships between different companies, enabling an increase in business value with shared blockchain solutions.

Figure no.5.7.2 Basic architecture of BT

Source: Min (2018)



The fundamental prerequisite for BT architecture is collaboration in the supply chain for it to be a success. Hence the importance for companies to share common strategic objectives in order to pool resources such as IT investments and mitigate risk through such collaborative partnerships. It is important to consider how, of course, the various partners in the supply chain should implement a complete sharing of transaction data, along with the inherent proprietary and sensitive information. This raises the question of who is the company in the P2P network and which partners to rely on. It may happen that the focal company refers to a channel captain capable of managing considerable resources, also having significant bargaining power over other elements of the supply chain such as suppliers and distributors. Having this role, the focal company can be at the forefront of the BT initiative, supporting its business partners to implement BT solutions. In other words, the focal company has a responsibility to act as a facilitator to structure BT's architecture and bring its supply chain partners to an efficient use of BT. In imagining a classic focal company profile one can easily think of a large multinational corporation (MNF) that has a network of production and/or distribution facilities underneath it that can rely on qualified personnel and a consolidated IT infrastructure. The MNFs that fall within this profile include Fortune 500 companies. In conclusion, an important role within the P2P network can also be played by reliable partners such as certified suppliers, generating or adding a block in the chain of blocks.

A supply chain often finds the intertwining of different business functions and national boundaries involving a wide network of business partners, becoming more vulnerable and exposed to the risk of disruption. It is therefore essential to analyze potentially weak links to measure their level of risk.

An approach in this direction may be the following:

1. Identifying business or supply chain partners and establishing points (or nodes) that are also capable of entering into supply contracts.
2. Mapping the supply chain, such as flows of cargo, containers, capital, documents, or the transaction process and related information flows to collect data to identify possible weaker links, as well as the level of exposure to risks and threats, including cyber-attacks.
3. Categorizing and assessing vulnerabilities based on the risk assessment with the relative degree of risk or probability of occurrence (C-TPAT training seminar, 2010).
4. Developing action or contingency plans for risk mitigation. An example could be a Radio Frequency Identification System (RFID) capable of identifying risks of potential security breaches by automatically capturing data on vehicle movements, such as port entry and exit dynamics and the intersection of shipping documents and cargo manifests. Some trends in data that might be suspicious can be identified, as in the case of the study of points of origin from countries at high

risk of terrorism (Min & Shin, 2012). Following this example, it is easy to see how port security could be enhanced by the possibility of rapid and effective detection.

5. Implementing a system for the control and monitoring of risk mitigation efforts, so as to verify that the plan is meeting the necessary timeframes and see improvements in security.

Although BT is rarely used, it can play an important role in security issues, including strengthening supply chain connectivity. This is hacker-resistant, tamper-proof, and unchangeable, due to its distributed accounting and network verification process. It also offers automatic tracking with the ability to share indelible historical records across the P2P network. In addition, it should be noted how nodes and arches can be inserted within the supply chain structure and used to identify both organizational and network risks. Through these different areas of application, where risk is studied and limited, solutions can be found to improve the resilience of the supply chain. These remedies should comply with the following basic principles to improve supply chain resilience.

First of all, as anticipated, risks can be prevented by identifying possible sources, such as bottlenecks, potential strikes, ports at risk.

It is possible to limit the extent of the effects of supply chain disruptions by means of tools such as insurance, specific stockpile policies, buffering.

Action can be taken to improve the flexibility of the supply chain in order to respond smoothly to supply chain disruptions, including by enhancing the company's readiness to respond quickly to unexpected events.

There are in particular some areas of the supply chain that could be affected by BT, such as smart contracts, asset tracking, secure and error-free order fulfillment and cybersecurity.

As far as smart contracts are concerned, these are contracts that can be translated into computer codes that can be stored and replicated within the computer system that is controlled by the computer network and coordinates the block chain. Because of their nature, they are a very useful means of exchanging shares, money, property, or anything of value through transparent means, overcoming the need to use the service of intermediaries (Blockgeeks, 2017). The resulting reduction in transaction times and costs is not negligible, due to the fact that smart contracts can be executed autonomously. If the Internet of Things (IoT) was also incorporated into the blockgeeks chain, contract fraud could also be identified and prevented.

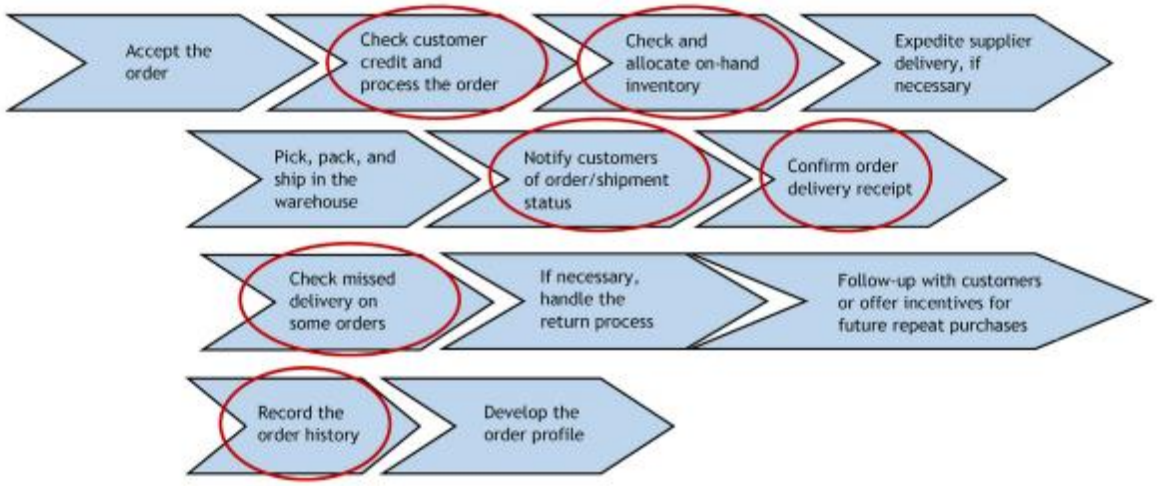
Asset tracking is also feasible: as soon as assets, whether tangible or intangible, are represented in the blocking chain and their ownership cannot be changed, unless changes are made by the owner. BT behaves like a complete and publicly visible ledger that performs the continuous tracking and recording of all activities related to the supply chain of a particular asset. BT allows the user to retrace the reverse route to the origin of an asset. The blockchain prevents transactions of fake or

counterfeit goods from taking place, giving the possibility to trace the goods very easily as they pass from one actor in the supply chain to another, while also being able to limit the risks of loss and damage during transit.

Order fulfillment is safe and error-free: by offering easily accessible customer records, BT can speed up order fulfillment processes within the supply chain, having the ability to quickly check the customer's credit history, verify inventory status, assess finances, track order or shipment status and execute everything with extreme transparency throughout the order fulfillment process, as can be seen in Figure no.5.7.3. By automating the order fulfillment phases, BT will be able to reduce errors in this phase, also considering that BT's visibility is open to anyone participating in the P2P network, allowing a complete and deep awareness of the order fulfillment process.

Figure no.5.7.3 Areas where BT could be implemented in the order fulfillment process

Source: Min (2018)



Last but not least, the theme of computer security which is guaranteed by the nature of the blockchain which cannot be altered and the fact that every computer in the P2P network constantly checks the information stored on it. In particular, BT is a very useful tool for accounting and payment verifications, such as goods or international payments, since the accounting cannot be modified by anyone. As a result, it is an excellent mean of tackling the risk of cybercrime and hacking.

BT's management benefits can be summarized as increased trust between supply chain partners, P2P connectivity, fraud detection and prevention, resource integrity, improved order fulfillment, reduced transaction costs and public transparency. However, to be fair, it is also important to highlight BT's revolutionary and complex role, with the resulting shortcomings and challenges associated with its implementation, such as scalability, interoperability and government regulatory issues. In addition, a blockchain requires the processing and validation of every single transaction,

requiring massive computing power and a high bandwidth internet connection, not always immediately accessible. Moreover, if these issues were addressed through the centralization of its validation process, it would lose its original purpose, not even finding other interoperable and compatible platforms to have optimal combinations.

5.8 An empirical investigation

5.8.1 Methodology and champion description

The purpose of this research is to deepen the analysis already carried out during the investigation on the impact of Covid-19 on the BtoB Italian manufacturing companies illustrated in the previous chapter, in order to test what has been highlighted by the theoretical study and by some literature gaps that this paper tries to observe more closely. Thanks to the study of a part of the literature, it was possible to identify three of the main factors characterizing resilient supply chains: procurement, disruption management and technology, with particular attention to blockchain. As it can be seen from what has been illustrated in the previous paragraphs, procurement has a very strategic role within the supply chain, covering a key function which, if well managed, can constitute an added value, which can also result in a strong competitive advantage. In fact, depending on how it is orchestrated, it can offer companies the possibility to respond flexibly to possible crises, through wise inventory management policies, for example. Disruption management, on the other hand, can help to strengthen the entire chain because it offers the possibility of preventing certain scenarios before they become concrete problems to be solved. Finally, technology can be a key factor in dealing with an emergency because of its different possible applications, as well as how it can make some solutions truly effective and efficient. The blockchain is one of the highest expressions of technology in terms of sharing and protecting various types of data, representing a very good and not very widespread solution. The analysis of these three major variables of the supply chain system was carried out through semi-structured interviews with companies selected for their profiles: Bergi spa is a traditional Italian manufacturing company and leader in its sector, θ is a company with a high technological quotient and of great international standing, Idylium is an innovative and emerging company, recently born and grew up in the middle of the pandemic and Salvagnini Italia spa is a company with an extensive and global supply chain. The medium used was the telephone and the attention was focused on the study of the main characteristics of the companies interviewed, focusing on how much has worked in the context of the emergency in view of resilient supply chain and what is replicable or insertable for future scenarios, where other events could occur leading to interruptions of the chain itself. The exploratory research carried out is qualitative and has been carried out with an inductive approach

to the chosen business cases. The information has been gathered in detail, trying to identify the main challenges that have been encountered and that need to be tackled in relation to the three magnifying lenses selected as an in-depth study. Gaps to be filled have been observed and effective solutions used to make assessments have been investigated. In order to respect the aim of the research, the analysis has been placed within a logical matrix that is more theoretical than merely statistical: the result is the study of the information needed to produce a circumscribed and clear survey, without therefore developing any model.

For a more transparent, specific and complete research, I have endeavoured to involve the top management of the identified realities - which I would like to take this opportunity to thank again - in order to have a direct, coherent and all-round vision of the companies. As a first step, telephone interviews were organized, the conversations of which were recorded for greater precision and clarity in reporting the elements that emerged during the various comparisons. As a second step, these were transcribed and analyzed in order to focus on the key concepts of categorized data for first orders, second orders and aggregates, as illustrated by Voss et al. (2002) (see Appendix A3).

For the interviews, the organized structure (see Appendix B3) was used according to the particular characteristics of the company interviewed in such a way as to get the most out of what was witnessed.

Following a one-to-one approach, the interviews took place at a late stage three, i.e. what was thought to be the new normal, being close to the fourth stage, in the air of new decrees that would go in the direction of trying to contain a second wave of contagion really close that will result in the delimitation of high, medium and low critical areas. The companies interviewed therefore did not yet feel the pressure of a possible lockdown, but, on the basis of what they witnessed in the hypothesis of a similar situation, they proved to be calm and ready to face the situation, even if not in a permanent way. The companies have outlined their procurement structure, their vision of disruption management and the contribution of technology. In this context, there was a strong appreciation of the lean logic and the difficulty of its application, the underestimation of the theme of the management of unlikely events and the very low distribution of the blockchain. Within this analysis, a more detailed observation was made of the position of procurement within the supply chain of each business interviewed, in order to measure the consideration of this function in its own company context, with the desire to verify whether it was treated as a function or as a process. The propensity to lean manufacturing, possible hybrid solutions with stockpiling, centralized or decentralized stock management and integration in the various divisions was also analyzed. Including diverse manufacturing companies with distinct profiles in terms of company size, supply network, market share, supply chain extension, risk aversion, innovation sensitivity, variety in technological equipment, time in the business life cycle and cost and revenue structure, the intention

was to offer a magnifying glass on three essential variables of a cross-section of the BtoB Italian manufacturing sector that could represent a large part of the diversity of the realities that make it up. For privacy policy reasons, formal permission was requested from each company involved and interviewed to use its name, as well as the data collected: for this reason the names of three out of four companies are shown, with the interesting fact that the one company which is anonymously cited happens to be one of the same interviewed even in phase one, prior to this period.
Table 5.7 shows the complete picture of the composition of the focus group through data such as the name of the company, the industry it belongs to, its position within the supply chain, whether it is ATECO protected or not, the type of lockdown faced and the economic impact resulting from it. Table 5.8 illustrates the participants with details of their name, title and main scope of reference. Finally, Table 5.9 presents the names of the participants, the source of the data, the collection methodology, the duration of the interview and the tool used to do it.

5.8.2 Focus group description

Bergi spa is an OEM company founded in 1965 by Mr. Giovanni Bergozza and one partner that manufactures leather processing machines. The company commits in different industrial fields such as the textile sector with the trademark Bertex, the leather sector with the trademark Bergi and in the paper-cutting sector by purchasing the company Pizzolato and it is considered and recognised as a leading brand in the sector.
In 2005, it created the Bertech division: a branch devoted to developing automatic systems for the leather handling because the company does not only design and assemble machines. In fact, it is divided into two main units: Gambellara Unit where there are all the latest generation machine tools for the production of the components of the machines and the Arzignano Unit where there is the machines' assembling and the R&D department. Therefore, the company working fields are many different ones: automotive, garment, leather goods, shoe upper and upholstery.
The elements that stand for Bergi and its trademarks are: a sales area close to market requirements, a constant research of new solutions, the continuous interchange of ideas and suggestions between companies working in different sectors and the dialogue with the customers to develop user's friendly machines of increasingly-high performance. All trademarks of the group (Bergi, Bertech, Bertex) design and build their products internally, while the sales network is widespread in all countries and uses local agents and engineers constantly trained and supported by Italian area managers and engineers. The productive process follows these steps: the technical department is in charge of creating the 3D development of each project, the creation of the prototype follows, then there is the development of each single component. After the mechanical processing in our

premises, where control panel, wiring and software programs are assembled internally, internal tests are run and recorded. In conclusion, a specific department follows the packing and shipment of the product and, as a final step, installation and assistance on the machines is done. Nowadays, after more than 50 years of presence in the market, Bergi is considered a leading company and a reference point among the most advanced and dynamic firms of the sector and it keeps a prominent place both in the national and in the most important foreign markets. This appreciation found its endorsement in the year 2003 when Bergi was appointed the gold medal for the internationalization.

Θ is a firm which runs its activity in the automation industry by offering products such as the automation of processes, metal control systems and steel refinement. It also supplies fully electronic distribution systems, sensors and other special tools.

Idylium represents a recent and emergent company which was born close before the pandemic and grew during it. It produces mineral stone slabs - also known as sintered stone - in large format with small impact, as they are made of natural raw materials, 100% biodegradable and free of chemical emissions. Design, research and post-production are Made in Italy, while the production plant is located in L'Alcora, Spain, in the most famous European district for stone processing. Today Idylium is a company with a plant of over 40,000 m2, able to produce up to 2 mln of surface area per year and an international team of over 200 people who collaborate in the worldwide commercial expansion of the company and the management of operations along the Italian-Spanish axis. It also represents a case history because the real exclusives are: the whole tower and the back-press technology – along with its continuous veining kit -, the press able to generate a pressure of 500 kg per cm2, the glazing and decoration, the double-level kiln with temperature peaks up to 1250°C, the fully automated logistic system with a management concept developed exclusively for Idylium and a totally new process automation, never implemented before. Moreover, 95% of the company's production machines, which are run exclusively at its Spanish plant, are brand new.

The company considers technology as a creative tool. That is why it is tailor-made, with 95% of processes and machinery exclusive and patented, following the mission of producing an engineered material from the micro-level to support every design challenge.

It also cares about sustainability thanks to its virtuous circularity process that minimizes waste and strives to create, where possible, an environmental advantage.

Salvagnini Italia spa is an OEM company which is part of the Salvagnini group and operates in the field of flexible automation and industrial machinery for processing sheet metal. It designs machine tools for processing sheet metal, structured in a wide range of systems for maximum process efficiency. The company counts more than 840 professionals, 44,000 sqm operational headquarters and 2200 sqm showroom that contribute to making Salvagnini Italia the largest plant of the group. The latter is exclusively dedicated to sales: here it is possible to experience the potential of the

entire range of solutions that the company offers. The machines are interconnected and adaptive, able to exchange high level information among each other and with the external environment, according to the company's embrace of Industry 4.0 which indicates the use of cyber-physical systems (CPS) and digital technologies (cloud, IoT, Big Data) for improving work conditions and increasing the productivity and productive quality of plants, creating a collaboration between all aspects involved in the productive process, i.e. the operator, machines and instruments. Therefore, the company integrates the 4.0 concept among its solutions and has been doing it since 1985, when it produced the first automatic job shop (AJS) for lights-out production comprised of 12 interconnected systems that communicate with MRP. Today AJS indicates a set of Salvagnini systems that are orchestrated by the OPS process software for the intelligent integration between machines and the customer's ERP.

Some examples of 4.0 implementations by Salvagnini are OPS, MAC 2.0, flexible automation and Links. The first is the combinable and modular software that permits data exchange with the factory's information system through the connection with the company's ERP, being possible for every Salvagnini system to be equipped with OPS: from the order, to the generation of machine programs, to the return of product quantities and consumed materials. The second regards the intelligent closed chain sensors and proprietary algorithms developed in all Salvagnini product lines which permit every machine to adapt automatically in cycle to external variations (material being processed, temperature etc). Flexible automation is obtained through the original integrated solutions that allow Salvagnini systems to be suitable for being inserted in flexible production cells or lines, and to be able to produce the correct quantity of product, at the right moment, concentrating on added value operations, while minimizing WIP, waste and inefficiencies and reducing delivery lead-times. The latter is Salvagnini's IoT solution, developed on a maximum security Microsoft platform, guaranteeing continuous and effective monitoring of systems in production, also remotely, and allowing technical support to respond in a targeted and quick manner.

Table 5.7 Company data: focus group categorized by industry, supply chain position, ATECO protection, type of lockdown and economic impact.

FOCUS GROUP					
Company Name/Code	**Industry**	**Supply Chain Position (OEM/OES)**	**ATECO protected (Yes/No)**	**Lockdown Type (Complete/ Partial/Winner)**	**Economic Impact (Positive/Strong/ Medium/Weak)**
Bergi spa	Engineering	OEM	No	Complete	Medium
θ	Automation	OEM	Yes	Partial	Strong
Idylium	Mineral Industry	OEM	No	Partial	Weak
Salvagnini Italia spa	Engineering	OEM	No	Partial	Weak

In order to better contextualize the content of the research, Table 5.8 illustrates interviewees categorized by titles and specializations, while Table 5.9 shows data sources and methods.

Table 5.8 Focus group participants data by titles and specialization.

FOCUS GROUP PARTICIPANTS			
Company Code	**Participant**	**Title**	**Specialization**
Bergi spa	Mauro Bergozza	Chief Executive Officer	Sales; Procurement
θ	Agamennone*	Executive Vice President	R&D;Operations
Idylium	Luca Fanara	Chief Executive Officer	Sales; Operations
Salvagnini Italia spa	Dario Piccin	Director of Operations	Procurement;Operations

Note: *Pseudonyms, not actual names

Table 5.9 Focus group participants, data sources and methods used to make the interview, its duration and the tool used to make it.

FOCUS GROUP DATA SOURCE, METHOD PARTICIPANTS			
Company Code	**Participant**	**Data Source/Method**	**Tool**
Bergi spa	Mauro Bergozza	Semi-structured interview: Lasted: 29 min.	Telephone
θ	Agamennone*	Semi-structured interview: Lasted: 24 min.	Telephone
Idylium	Luca Fanara	Semi-structured interview: Lasted: 28 min.	Telephone
Salvagnini Italia spa	Dario Piccin	Semi-structured interview: Lasted: 43 min.	Whatsapp Videocall

Note: *Pseudonyms, not actual names

5.8.3 Focus group findings

The study of the research revealed a strong attention of the production system towards lean manufacturing, finding a general difficulty in its complete implementation. Bergi spa, underlines how it is a concept still to be studied and deepened, highlighting two nuances: in one case as a working mentality, in another as a growth process. In the first case, great importance is given to a solid corporate cultural preparation so that a system can be applied in a winning way, also taking into account how difficult it is to find suppliers who are able to give the necessary time and in the right way. Hence the difficulty of applying the model deriving from external agents, in addition to internal agents. Bergi spa, in this regard, stated: «it's clear that finding people who are willing to give you two or three or five pieces when they want you and at the precise day and time is not easy, then I'm telling you that we are way off track and we have to apply Lean in terms of the sense of principles to be applied in the company towards the working mentality. As far as the supply chain is concerned, it has to be something softer and therefore more stocked than a tighter Lean».

In the second case, on the other hand, lean manufacturing is part of a growth process involving the expansion of the production plant: the company has a production site that will see the construction of a totally lean shed with the support of consultants specialized in charge of supporting the complete lean transformation. Bergi spa in fact states: «We are still studying Lean and we are not applying it yet, precisely because we want to apply it to the new shed that is being built, so we started with the layout of the shed with Lean consultants before moving on to the total management phase».

A widespread difficulty was identified in the approach to this system by the interviewees, an element also highlighted by the company θ: «we cannot say that we fully adhere to Lean technology, from an organizational point of view, in particular, even though we have been trying for a long time».

Although such complexities are encountered by many, efforts are always made, as the company itself (θ). states: «Efforts are made to be Lean»

It supports the importance of moving from a more stockpiling oriented model to one that can better embrace the logic of lean manufacturing: «While we used to work on an absolute just-in-time basis, now there is a tendency to anticipate purchases of raw parts more and more, so as to give workshops a little more peace of mind when orders are placed. So it is moving towards light stockpiling from lean».

However, stockpiling seems to remain a key resource for certain types of raw materials linked to certain products, as claimed by Idylium: «Basically, we try to be and tend to be Lean, although, let's say, for certain types of goods we have to do some stocking first, but we tend to be there. Our production is a production that, although the model is both a just-in-time production and a made to stock production».

In the context of the extremes that can be represented by techniques that go in one direction or another, it seems that hybrid solutions between stockpiling and lean manufacturing can constitute an added value in a resilient key and in this regard the Salvagnini Italia spa case is very illustrative: «Salvagnini does not use any production model among those we say universally recognized, so we say assembly-to-ordeR, make-to-stock, make-to-order, engineer-to-order, etc. A momentary integration with a Just-in-sequence concept that is a bit more advanced than Just-in-time, because it integrates our suppliers within the operational production plan and intercepts any variation in real time and we go to manage the sequence of the codes on delivery, closes the delivery on time, because the sequences can change according to the product configuration. The stocks are managed in a diversified way by product, so something just-in-time, something just-in-sequence, we use all the part related to the kanban, security and reorder points, and then the classic MRP, Material Requirement Planning».

On the other hand, considering the broader picture when observing production, difficulties have been reported in maintaining certain production volumes, to the detriment of turnover and constituting probably non-recoverable losses, as witnessed by Bergi spa: «we have made a calculation and the production unit will not be able to get out the number of machines needed to recover». As well as the fact that the centrality of having a skilled workforce can lead to staff complexities in case of absences due to the quarantine of individual workers found positive, since level operators for the assembly and maintenance of their machines represent a scarce resource: «The problem is that to make industrial machines you need a skilled workforce».

It should be noted that some organizational measures, as in the case of Salvagnini Italia spa, have proved to be productive both from a purely productive and a security point of view, through the reorganization of shifts: «In production, we have shifts slipped from 6 hours using a couple of hours a day, almost until August, in the Covid-19 lay-off box to avoid any kind of assembly in the common areas».

It should also be noted that the lockdown was experienced in a different way from the distinct realities, as Bergi spa saw a long closure that was somehow offset by the long time taken by the orders that ensured that the stop did not produce too heavy damage, Salvagnini Italia spa experienced it as a "normal closure of a couple of weeks" due to the limited impact on the business and how, Idylium, on the other hand, seized that period - more limited due to Spanish legislation - as an opportunity to implement tests that would have required an economically costly stop, but which, in that context, was the right choice at the right time, even going ahead with the assembly of some machinery, so much so that the CEO Mr. Idylium, who has been in charge of the company's activities, has been able to take advantage of the opportunity to make the right choice at the right time. Mr. Fanara said: «We completed some assemblies that could also be done at a stop, when some assemblies, such as electromechanical ones, would be postponed to this summer».

Another very important evidence, in addition to the above mentioned production sector, is the supply base as a key strategic factor. First of all, it is important to point out that the sourcing of the companies is varied, as Bergi spa has shown a lot of attention to a predominantly Italian sourcing: «sourcing is mainly Italian, even if there is a little something abroad». Idylium, on the other hand, provides mainly local sourcing, opting for Spain, the country where the production department is located, while the services on offer have global roots: «No, our sourcing we say is 80%, as far as direct purchases are concerned, so for the operation of the plant, local, for our plant in Spain. As far as services and possible investments linked to the plants are concerned, on the other hand, we use them around the world, so this is the situation here».

Salvagni Italia spa has instead outlined a global profile for its sourcing, highlighting its degree of autonomy and independence: «Sourcing is a function that operates on paper at a global level, but

deals globally with suppliers of contracts across the various production sites. We make use of the factories' contracts and each one makes its own warehouse. In this sense they are decentralized hubs, since there is only a framework contract from which to draw, but each production unit is autonomous and independent in the procurement of materials from these strategic suppliers».

The supplier base has proved to be a crucial element in this phase due to the flexibility and flexibility it has granted to some players, as in the case of Idylium, which was able to renegotiate the terms with some key suppliers due to the direct relationship and integrated collaboration with them, also obtaining advantages also from credit institutions, in fact «we have renegotiated all financing, therefore, both with the main suppliers and with any credit institutions we have renegotiated the terms of repayment of the loans in terms of payment, extending the deadlines, partly by using state subsidies, partly by making ad personam agreements with individual suppliers». Idylium has recognized the strategical nature of some of its suppliers, without whom, if they did not also take precautions to always have valid alternatives to the main partners, they would risk not being able to produce, «It is an integrated relationship for the strategic ones, because without them we would not be able to produce, therefore it is integrated and certainly collaborative, in the sense that we establish alliances with strategic suppliers, even if we always try to have alternatives, so never have a single supplier». In addition, it demonstrated the benefits of having a fairly large supplier base when it found delays that could have undermined the production cycle and that were offset by the readiness of other agents in their supplier base, «we have not lost any suppliers, but these suppliers have in some cases had heavy delays that have been partially compensated for by some, others have a little march on us at the moment». In addition, in none of the cases analyzed was any supplier lost, perhaps forced to close due to the strong impact of Covid-19. With regard to the supplier base, both Bergi and Salvagnini pointed out that their suppliers were historical: the CEO of the first company, Mr. Mauro Bergozza, stressed that «we normally deal with historical suppliers», especially for reasons related to quality and the need for customization of their machines, while Mr. Dario Piccin, Salvagnini Italia spa Director of Operations, also highlighted how important a relationship of loyal reciprocity is «We have a number of historical suppliers with whom the relationship is integrated, in fact we do co-design activities, so for us the switch from one supplier to another is always very expensive and difficult to do, if not in conditions of absolute necessity. The fact that these suppliers are loyal suppliers and the company is loyal to them». It deserves special attention that for the latter company the relationship with its suppliers is so close, integrated and valuable as to make them participate in product design and to care about their needs in difficult times by granting advance payments and other support tools, «The company comes to them by granting advance payments or the purchase of goods that they keep from them and that we then collect over time: this happened, for example, in the lockdown when someone's closure, even

from a financial point of view, marked them quite a bit». Another way in which the two sides have come to grips with each other has been witnessed by Idylium with regard to discounts on late deliveries, for example, «Let's say that eighty per cent of these investments were made with three to four main suppliers, so there were also some important relationships that were a little outside the Covid-19's contingent situation. To date there have been no cancellations, but clearly we have asked suppliers to help us out by saying that where there was no financing or direct payments, we have asked them to pay discounts, etc., in return for any delays in supplies».

Besides procurement, another relevant aggregate is represented by the post-disruption management for a resilient supply chain, which was a very interesting topic to analyze. Safety has become more and more important in such a context and all companies interviewed have made strong efforts in being compliant to the Covid-19 protocol, also implementing strong organizational decisions and hiring new people for dealing with this issue, as in the case of Bergi spa «Covid-19 protocol I have found it at best to our possibilities, at least we think we manage it properly and so we continue to do so. Now we also have a security consultant». Another signal of this commitment is represented by the measures taken, such as the adoption of additional protection devices: «I have also arranged for the use of glasses and top glasses, for extra protection. We disinfect once a week the company, the cars, every car when they are serviced». The uncertain dimension provided by the Covid-19 experience drove more attention to safety, as underlined by Salvagnini Italia spa «not knowing what would happen, to manage a slow restart, so all the constraints we had said in the protocol on the safety conditions to be applied within the production departments, including spacing, re-entry at set times, somehow pushed us to make a slow re-entry». For this reason, connected to the difficulty of managing such a disruptive and ever changing problem, some of the participants have structured task forces aimed at dealing with the situation, such as firm θ, which declared: «there is a permanent task force alongside the geb i.e. the executive board group that meets almost regularly to assess the time to time consequences and problems that various restrictions in various parts of the world can create for our business. the project involved the same top managers as θ, but, for the moment, the activity has been temporarily put aside, but it does not mean that the planned activities do not go ahead, but simply do not have an executive to report to, until we are out of this situation».

As far as risk management is concerned, company θ has stressed out the fact of having an internal academy dedicated to trainings for the whole staff at all levels, because knowledge is an important element of disruption management: «As far as training is concerned, on the other hand, we have an institution within θ that we do not define as a product, but rather as a service, called θ Academy, which is responsible for the training of all staff: continuous training for all internal staff who are also involved, on the one hand, in the recruitment of special professionals and, on the other, in the recruitment of emerging professionals from universities». Importance is to be given to risk sharing

actions such as networking and strategical collaborations which can lead to cost efficiency and technology know-how sharing: «There are some companies that have privileged relations with us, even partner sharing, or are in a network of companies with us and therefore provide technology to support vertical applications in the steel industry». Sometimes even companies which have different business natures can have common objectives. Moreover, it is to be recognized the importance that can be played by governmental funds in creating new collaborations and growth for some companies: « In our case, in particular, we have joined a project that we have partly supported with MISE funding that allows us to develop together with three other business partners completely different from θ a manufacturing platform that we share that has been assigned in terms of development to a local software house, which, in turn, guarantees perfect transparency of intent to all three stakeholders, in this case the three partners. We have set up a network of companies: it is a well-defined legal entity».

The third and crucial aggregate emerged from the research concerns the role of technology in a resilient supply chain in relation to the uncertainty that Covid-19 brought into the global economic framework, which also resulted in a digital transformation accelerator, as stated in particular by the company θ: «remote control or those projects that have undergone a sudden boost more important than others» and also « technology investment plan, especially in digital transformation, which was already very clear before Covid-19 and continues to be so. Let's say rather that it has accelerated». Such process has also been fostered and consolidated by the common choice among the interviewed companies to continue to invest in technology even though the difficult times, a line that has been confirmed by Mr. Piccin from Salvagnini Italia spa «the technology investment plan has not changed». Despite the awareness of the dematerialization of the office concept, as in the case of Idylium «even from the point of view of production sites we do not have, for example, anyone in the company has a desktop computer, but we have mobile laptop computers, because regardless of the Covid-19, there is a dematerialization of the office concept and it is an obsolete concept», the study has underlined the traditional use of Information Technology (IT) as a normal back up plan for remote assistance, as underlined by Bergi spa «if not directly with another help via Skype, or remotely, when we connect, and then remotely with a Skype call directly with the assistant's mobile phone to see together how, let's say, to carry out the test. We have seen that so far this has been more than enough». In the same way, information sharing is also commonly basic among cluster companies, so much so that it will be «typically by e-mail. We then have a software that notifies the supplier directly» in the case of Bergi spa, as also admitted by Salvagnini Italia spa «Sharing information with suppliers is done in the traditional way through applications set up in our traditional management system».

The modes of communication are also basic, as with Idylium: «even remotely, we have the possibility to check what is happening with the production data for the other platforms. For ordinary communication and meetings the Microsoft teams demo etc. etc. and a bit sharepoint. These are the tools we use» and some, like the company θ, underline the continuity with tradition «we continue to use our information system, a system called sharing purchasing».

In a context of tradition there is also a lack of conviction that investments in more complex platforms are suitable for less structured realities: «We are not, let's say, yet a company that has a structure, a complexity, that allows us to make investments on platforms, or something like that, our main supplier district is close to the plant, so we don't need to digitize that part of the supply chain procurement».

The use of the Internet of Things (IoT), on the other hand, is a countertrend, a tool that has made it possible to use remote conditioning and installation with decidedly positive returns for companies that have opted for it, both in terms of visibility of processes and the state of health of the machines: «On the other hand, from the post-starter point of view, the visibility of some critical equipment at a distance has changed, with, as I said, an asset management project that allows us to see vital parameters of some suppliers' machines, we speak of machines as whole systems, in order to guarantee maximum reactivity in assistance». The possibility of managing some essential data from afar leads to a strong continuation of the link between the company and its customers, avoiding to ruin some relationships because of the strong limit to mobility that does not allow the usual maintenance and installation of the machinery, in fact Bergi spa has highlighted that «thanks to the 4.0 technology we have been adapting our machines since 2018 for remote connection and therefore, not having the possibility to travel for Covid-19 reasons to many countries around the world, at least we were able to do remote installation, which helped us».

Technology has also found an opportunity with lockdown, as Idylium points out: «On the positive side there were several things, in the sense that, starting from the information systems with which we would have had to stop a plant in order to do a test, this allowed us to implement all the tests (IDY) at that time, being unable to do anything else» and offers transparency, which, as for Salvagnini Italia spa, the company seems to be very aware of, «placing of a node for each building site at the same time as each building site is opened, as a consequence the building site itself becomes a protuberance of θ, so from this point of view nothing has changed».

With reference to a quality such as the possibility of having a deep visibility on processes and the state of the art of things, despite its explicit usefulness and importance, an element such as the blockchain, maximum expression of transparency, still remains an unexplored tool. None of the realities interviewed said to adopt blockchain technologies, as admitted by the company θ: « No, we did not opt for blockchain solutions. On the other hand, as far as digital staff training is concerned,

let's say it has two gears: we have a conventional part that is probably still a few steps ahead in the use of the instrumentation and tools that the market makes available, but the change is still not adequate, while there is a part of the company that deals more intensively with high technology».

5.8.4 Focus group implications

The evidence emerging from the study of the new reference and in-depth cluster has highlighted positive aspects in each reality: Bergi spa is very seriously embracing the Lean philosophy, relying on qualified consultants to operate the paradigm and philosophy change, adding to the tradition the desire for improvement. The company θ is very attentive to the issue of training and sensitive to innovation and the global context, as demonstrated by the structure of an academy and task force dedicated to the fight against the pandemic. Idylium has demonstrated that a clear vision and mission, combined with a business with a precise and ambitious identity, can lead a young company born before the crisis to persist and grow, even despite it. Salvagnini Italia spa, on the other hand, has shown how procurement seen as a process and not as a simple function, together with courageous and innovative solutions such as the hybrid between classic production systems, can be resilient factors.

However, it was possible to identify problems such as the struggling of implementing a complete adherence to the lean production system, even in cases where the process of achieving this goal had been underway for some time. What emerged was the difficulty in conveying lean as a working philosophy within the company, as well as a system in itself, not to mention the fact that, in order to be effective, it is necessary for the entire network linking suppliers and customers to embrace this model. Moreover, the complexity encountered in the total adoption of this logic has led to stockpiling, which sometimes proved to be a correct approach due to some specific raw materials that required the latter system to be more efficient. Stockpiling has also been reassessed because of the problems that Covid-19 has caused, such as interruptions in the supply chain. In this context, Salvagnini Italia spa emerged as a winning case, offering a hybrid solution between stockpiling and lean manufacturing, also integrating elements typical of other production systems such as assembly-to-order, make-to-stock, make-to-order, engineer-to-order and the just-in-sequence concept, proving capable of intercepting any variation in real time, also respecting the product configuration. The stock, instead, is managed in a diversified way according to the product with the contribution of a mix between just-in-time, just-in-sequence, kanban security and reorder points and the classic material requirement planning (MRP). Also in the production context, there have been some impediments in the production of the necessary number of machines to cover losses and the obstacles that a period of pandemic crisis poses to companies that need a highly qualified workforce

that is not easily available on the market and that, if positive by Covid-19, would be decimated inevitably causing a stop in production, difficult to recover, at least in the short term. The production department has therefore had to undergo resilient changes such as the reorganization of common areas, work shifts and flexible tools such as redundancy funds.

As far as the size of suppliers is concerned, sourcing is very varied within the cluster analyzed, ranging from local to global sourcing, including other intermediate nuances. Great importance will be given to governmental measures, both national and international, in virtue of the second wave of the pandemic, to observe the effects on the different sourcing methods detected: for example, a purely local-national one in Italy will have to interface with the division of the regions into different states, according to the colours: yellow, orange and red, following different types of lockdown. As far as a global sourcing type is concerned, the risk will certainly be diversified, but the impact will depend on many more variables that vary from state to state, for example, a company in France, which in November 2020 is in a total lockdown, will have repercussions on the supply chain distinct from those of a company in a state where there is no total lockdown. The companies in the cluster will therefore find different impacts, depending also on the degree of autonomy and independence that the suppliers themselves will have. It has also been possible to study the reactions deriving from centralized and decentralized hubs in stock management, since one is not a more resilient model than the other, at least from the results obtained in this analysis, also due to the diversity in the approach to the pandemic of individual states, although a decentralized system would in principle guarantee a more solid risk mitigation. The analysis revealed a central role for the relationship between suppliers and customers, which has emerged as a good resilient factor based on the data collected. Most of the companies involved interface with historical suppliers with an integrated collaboration and even participate in the product design phase. In addition, in some cases, supply and payment terms have been renegotiated, where the players have come against each other, sometimes granting advance payments for materials, sometimes making discounts due to late delivery, sometimes buying excess stock from their suppliers and with other expedients, but always within a framework of deep loyalty between the parties. This resulted in even more consolidated relationships than before and the choice of not having unique, but different, suppliers paid in terms of delivery times and orders, since in some cases, suppliers were unable to meet certain commitments in terms of timing, but their shortcomings were offset by others who were more ready. However, the procurement framework sees a conception of procurement still too limited to it as a simple business function and not as a process, thus not taking full advantage of the great resilient potential offered by this factor. It is therefore commendable the approach in particular of a company that seems to be more aware of the potential of the medium. A paradigm shift is required for the durability of companies.

There is also very worrying evidence in terms of post-disruption management: none of the companies interviewed seems to be aware of the crucial role played by a careful study of the situation and the possible further drift that the pandemic may take. No permanent task forces were found, except in one case, however, which was left a little to itself: the result is a somewhat optimistic, superficial and approximate approach to the problem. The issue of security has been brought to the centre of the debate and company dynamics because of this emergency, but, apart from a few more specific measures, there is a poor long-term vision linked to the fight, or coexistence, with the virus and other possible disruptive scenarios. Companies limit themselves to respecting protocols as much as possible, to providing some additional protection devices, to rethinking some common space and some shifting criteria, but it is necessary to go much further than that: studying models to be applied from a preventive point of view, structuring concrete action plans in case of these eventualities, re-evaluating systems already in place, so as not to fall victim to the typical attitudes of business as usual. It is surprising how little weight is given to the continuous training of personnel, an element mentioned only by one reality, since constant updating brings new stimuli, new ideas, a streamlining of certain procedures and the overcoming of old habits. There was no way to go into as much detail as I would have wished on the subject of collaboration and networking as an element of risk mitigation, as emerged in particular in an interview, from which it is clear that the efforts of different realities that have converged in a common direction can offer resilience. The research has understood, even if partially, the contribution of government funds such as the MISE and how much they contribute as a stimulus to the growth and renewal of some realities.

The study also offered a lot of food for thought with regard to the theme of technology and pointed out that the approach to the medium is still too elementary, as it does not have such an awareness as to grasp its countless benefits. Just think of the topic of blockchain technology (BT): the leading mentality is that of business as usual, because of which companies do not seem able or willing to make consolidated changes, but bad habits, based on everyday life and on what they are always used to doing, with the result of ending up in self-satisfaction or organizational resistance capable of repressing any innovative ideas in supply chain risk management. As a result, there is a strong need for professionals with broader views and open to relatively emerging concepts such as those of BT. It should be borne in mind that a conventional risk management approach can lead to the mitigation of tangible and visible risks, such as theft or terrorism, but may be unprepared when dealing with invisible risks such as cyber-attacks, cyber hacking, counterfeiting, miscommunication, credit failures and contract fraud, which BT, through its peer-to-peer network, addresses in a more structured way with different and more robust levels of security. In this respect, there is an almost total lack of interest in this technology, which indicates a serious cultural gap that is not easy to

eradicate. It seems that the advantages offered by tools such as smart contracts, asset tracking and cybersecurity, just to name a few, are completely unknown to these companies. Technological tools and IT systems are still used in most cases in too traditional a way, as shown by the research that brings to light ways of sharing information between customers and suppliers that are still basic, the same IT systems as always and the use of classic means such as back up plans, such as Skype for meetings and remote assistance. This denotes a lack of technological sensitivity, combined with a limited assessment of the importance of transparency within the supply chain - see the point on BT - and more efficient information sharing.

It is therefore peculiar that investments in technology have not been reviewed and are focused on, despite the lack of awareness of the effects on the various areas of the business. This is also due to the fact that Covid-19 has nevertheless highlighted some of the potential of technology, increasingly dematerializing the office concept and accelerating an already slow digital transformation. On the other hand, the implementation of Internet of Things (IoT) tools is positive evidence, which has allowed various realities to collect important and vital data on the functioning of machinery and on some processes, giving the possibility to carry out remote installations and maintenance, a recognition rightly attributed to 4.0 technology and to the effort of some government incentives that have facilitated its entry on the scene. This tool has also enabled companies not to lose contact with customers and to make themselves felt present despite the physical impossibility of being there.

In conclusion, the overview should give pause for thought as there are urgent changes of mentality on processes, organization, prevention, security, business continuity and the use of technology. A cultural paradigm shift is needed, both organizational and digital.

Conclusions

The study of the theory has highlighted a still not definitive vision of the supply chain concept and an evolving and enriching, but yet unclear and unsatisfying, framework related to the supply chain management theory. On the other hand, the literature on the role of technology in the supply chain and its countless applications, also in a resilient key, is vast. Equally satisfying, and perhaps too varied, is the academic material on the subject of performance measurement of the supply chain and its management.

The situation painted by the analysis carried out during the empirical investigation of the manufacturing fabric of business-to-business in Italy in the context of the Covid-19 allowed a focus on the two phases that characterized this period, and an observation of their different repercussions: phase 1 was dominated by a strong uncertainty deriving from the initial regulatory vacuum, the lack of clarity of government communications and the management of ATECO codes, blocking some essential realities for the operation of the industrial machine.

From the in-depth analysis of Phase 1, Covid-19 has acted as an accelerator of digital transformation and it can be inferred that investment in technology, confidence in digital and its solutions - such as smart working -, digital servitization and membership of international groups seem to be among the most significant factors in resilience to today's and tomorrow's catastrophes, although much still seems necessary for the various players to be more aware of the key role played by these factors in terms of flexibility and agility.

As far as Phase 2 is concerned, the rethinking of the common spaces implemented by companies in compliance with the regulations produced a consequent increase in generalized security that has allowed a good level of productivity, overcoming some typical difficulties of Phase 1.

The crisis context of the Covid-19 stimulated the creation of solidarity contexts within which new social bridges were built and led to a review of the modus operandi of some company projects and of what could be the real objectives, sometimes outlining new horizons.

From an in-depth examination of phase 2, it can be seen that the contribution of this period has taken the form of experimentation with digital and quick & dirty solutions that have led several companies to redesign their priorities. The local-for-local business model, accompanied by a strategy based on the company's international presence, was highly appreciated by many companies as a resilience factor to mitigate the impacts and risks of the pandemic. Therefore, the manufacturing industry can only be warmly invited to evaluate these solutions.

Finally, from the focus group's study there is a lot of evidence on which to focus, one on all, the post-disruption management: the impression is that there is not enough awareness of the crucial role covered by this. Moreover, there is an almost total absence of permanent task forces and security is applied without a long-term perspective.

In terms of technology, the approach to the medium is still too elementary and its multiple potentials in terms of resilience are neglected for the benefit of transparency and security in the

supply chain, both in terms of data transmission and transactions, with the issues of traceability and cybersecurity.

In terms of procurement, there is a lack of complete vision of the advantage that this can offer if interpreted and implemented as a process, rather than a function.

In conclusion, there are still many efforts to be made in terms of innovation and competitiveness: the study has revealed the need for urgent changes in mentality on processes, organization, prevention, security, business continuity and the use of technology.

A cultural paradigm shift is needed, both at an organizational and a digital level, in order to be ready in case of future disasters and to make an essential fabric such as business-to-business manufacturing resilient.

Now it’s time for Italian companies to choose whether to be ordinary or to strive for excellence.

Appendix

Appendix A1: Coding collection of interviews, grounded theory Phase 1

Grounded Theory **Phase 1**

AGGREGATE DIMENSIONS	*SECOND ORDER THEMES*	*FIRST ORDER CONCEPTS*	*REPRESENTATIVE QUOTATIONS (Company)*
ELEMENTS OF UNPREDICTABILITY AND EXOGENEITY	**DIFFICULTIES INTRODUCED BY NATIONAL PROVISIONS**	Inadequacy of the ATECO system to guarantee the continuity of the necessary dies during lockdown	The x s.p.a. has an atheist code which is part of the production of tractors, or in any case agricultural products, and can therefore remain open. Campodarsego, on the other hand, where we produce tractor components, does not have this atheist code and consequently has to close. (α)
	HETEROGENEITY OF FORECASTS FOR THE EVOLUTION OF THE EMERGENCY	Negative expectations for the very short term (closing phase) and uncertainty about the possibility of recovery Expectations of	April I expect it to be even worse, because while in the first half of March we were under the illusion that it might be semi-normal, when we all realised that it was getting quite serious... it's clear that now all this is going to have a drag, in the sense that companies don't know when they will reopen, how they will reopen, so April will certainly be even worse. Then, we have to see when this lockdown will end if there will be a

		a rapid return to normal for "winner" sectors	chance to go back to normal levels. (ε) I do not expect us to see a worsening of the situation, in my opinion it will tend to be an improvement, more than anything else we need to understand what the times will be, but certainly an improvement, I believe that in any case the agricultural supply chain will be stimulated and will be guaranteed because it is strategic. (η)
IMPACT ON BM DURING LOCKDOWN	**NEGATIVE IMPACT ON REVENUES AND DEMAND VOLATILITY**	Strong negative impact on revenues Peak demand from customers for spare parts to protect themselves from supplier lock-ups The order backlog is unchanged due to clients belonging to protected ATECO codes	The impact is very strong, bearing in mind that in March we stopped practically two weeks or so, the impact has already halved revenues. (ε) Our warehouses are working, even after "hysterical" effects where our customers are asking us to send them the impossible(α) We have not seen any serious repercussions on the order backlog, so that's important, that order backlog is still there. (η)

	IMPACT ON THE SUPPLY CHAIN	Blocking activities leads to congestion of SC Impact on operations related to the transport blockade	There have been no serious disruptions in the supply chain, we have not recorded this, what we have seen most of all is congestion because everything is globalized, we had lead times, longer transit times on the supply of some parts, then now, for better or worse, the situation is stopped until the restart is allowed. (η) Banally, here is a problem that there is now concerning transport, because even the hauliers are hammered, they run less and many do not trust to go around. (α)
	IMPACT ON PRODUCT AND SERVICE OFFER	Total blockage of production activity Total blockage of FS's activities for limitation of travel and social distancing Continuity of remote services	The thing that is having the greatest impact these days is the shutdown of the factories. (α) The service operation is the most affected. The reason is that operators don't go around, so they don't go to do field service, I'm referring to tractors and earthmoving machinery. (α) All remote telephone support services have remained active. Therefore, we already had the telephone assistance service in place, so that

			one continues to work normally, the same goes for the spare parts service, tools, software... that is, everything that can be managed remotely in terms of assistance or even commercial activity is practically managed, so spare parts are supplied, tools are supplied to those who request them. (ε)
REACTION AND RESILIENCE FACTORS	**IMPORTANCE OF COMPANY SIZE AND CULTURE**	Greater preparedness to face the crisis thanks to the experience of subsidiaries in China	We were quite quick, having a factory in China, which was the first to be hit by this pandemic, and also strong in their experience, in their news, we understood what to do quite quickly (α).
		Favourable corporate knowledge and culture for emergency management	We had the necessary knowledge, certainly necessary, and in any case if we had time we could have deepened it further, we had, how to say, the cultural approach, because we are used to think in these terms, so I had no problem either to find a responsible person or to find who would do it operationally, in the arc of a weekend the thing was put in place. (ε)
		Coordination by the group allows for better emergency preparedness	We have set up a specific task force with regard to Breganze, we have a daily conference call, the whole

			management gathers for an update on the current status and this is something that is not an isolated case, i.e. η has organized itself in a structured way on all regions to have let's say local task forces that then converge to a global task force, then a central coordination in which statuses, updates from all regions and all sites are listened to (η).
	PREPARATION TO MITIGATE THE UNPREDICTABILITY OF THE EMERGENCY	Actions taken to ensure the continuity of activities in safety Task force and pre-existing risk plans adapted for the Covid-19 emergency	In reality we would never have stopped if the government's input had not arrived. We had already set up all the systems, possible procedures and the use of security systems on site to guarantee the safety of workers and employees, we had carried out sanitation in the offices in the plant, we had all equipped with masks, we had established precise rules for the canteen (η). We a coronavirus task force, at that time not yet circulating the name Covid-19, created it well before. This task force was enriched with further contributions because it was understood that the operational part, in the field, was the one that was penalized the most and so

			we focused a lot on this whole (ε).
	AGILITY	Rapid action to exploit the potential of certain projects during lockdown Need to adapt in an unfavourable context in order to react	We have also implemented, quickly, a service called Virtual Assistance, which is practically a sort of additional tool for remote telephone assistance that allows you to exchange video, chat, draw on video... try to repair machines remotely by seeing what actually happens on the other side.(ε) The theme is that you have to be content with solutions that are partial but which then give you the cue to continue, so woe betide you to say "ah, I can't do anything because I don't have this, I don't have that other", concentrate on what you have, use what you have! This is the thing that in an emergency, I feel like saying, works better.(ε)
	DIGITAL READINESS	Inadequate equipment slowed down the conversion to smart working	A different hardware equipment, therefore more mobile, would certainly have facilitated the entry into force of smart working (α)

		Adoption of the SW prior to Covid-19 facilitates the management of activities during the crisis	We already have the possibility to have smart working in the company, so that allowed us to lighten the load. (η)
	ROLE OF DIGITALIZATION	Use of SW allows you to work even during lockdown	The systems are supporting, so the access to the network from outside, the access to the programs to work from home, have worked very well so we are satisfied with what we have done.(α)
		Use of digital solutions to offer remote after-sales activities	In the after-sales part especially, of the indirect ones as a distribution service can be, digital connections allow us to work from home or remotely rather than in offices other than those normally used. (α)
		Recognised importance of digital technologies to respond to emergencies	Digital technologies, yes, absolutely. Without it, you wouldn't even be able to work today, without it the lockdown would be the desert. So, on the contrary, we have also seen the limits of our own IT infrastructures, VPNs that can't handle the load, the need to quickly expand systems, etc. So,

			digital technologies absolutely.(ε)
	ROLE OF SERVITIZATION	The offer of advanced services makes it possible to achieve revenue even during lockdown	We are also doing remote technical interventions for a fee, in the sense that especially in the software field it is possible to do many things remotely, installations etc., and so even in these days I was told that we are billing a little something just doing remote interventions, which customers appreciate a lot because they can basically use this time to carry on some activities. (ε)
		The offer of advanced services is also an advantage for the customer	We have found the system so that they can even do it from home, basically leaving the servers on in the office they connect, act as a bridge, and so we say that from evening to morning we have managed not to lose the opportunity to hold these courses, with an advantage both for us and for the customers because we use this lockdown time in a profitable way. (ε)
		Impact on FSO cushioned by the use of technology	In the agricultural sector, well, we are implementing the adoption of Google Glasses in the company and through our service we are giving the

			possibility - let me give you an example - to make Google Glasses available to a dealer who has a fail, a failure on the machine in the field (η).
THE NEW NORMAL	**POTENTIAL OF SOME QUICK&DIRTY SOLUTIONS IN THE BM OF THE FUTURE**	Smart working is also rated positively for the next normal Improved quick&dirty solutions and offers in the future too	Let's say that the almost obligatory smart working of everyone has also made us aware that a lot can be done in this sense, foreseeing that people can also organize themselves with this remote working and this teaches us that in the future we will also say what is called work-life balance (η). This online courses thing will have to be perfected, also because the idea would be not only to hold online courses, but to be able to offer courses on demand, in the sense that we record some kind of tutorials and then people listen to them, if they watch them as many times as they want (ε)
	INVESTMENT IN DIGITAL SERVICES AND TECHNOLOGIES	Short-term offer of advanced services to ensure greater competitive advantage	What we will be working on in the coming months, hopefully if we are allowed to do so, is to offer customers a digital platform where they can use what interests them most at that moment, profiling the customer and knowing exactly what they are buying, where

		Confirmation of the long-term opportunities offered by the adoption of digital technologies	they are going, what they are looking for, what they are most interested in, etc., so that we can also offer them tailor-made packages according to the customer's own tastes, so even maintenance packages, we can configure the machines, at least the simplest ones (ε) These can be fundamental tools, i.e. the use of Google Glasses has now been implemented in our plants in the United States in Jackson and allows us to give instructions in real time to the operator on the next steps, to give KPIs on timescales, to give real effectiveness and efficiency at the same time, on the entire production line on all the standard operations that on the assembly line are done by the operators (η).
	CHALLENGES RELATED TO SERVICES AND DIGITAL TECHNOLOGIES	Critical aspects of FSO and limitations of digital technologies with respect to part replacement activities	The FSO is reduced to the fact that someone is working and needs an intervention, otherwise even here, technology helps little: if a machine is stationary in a field and needs to replace a part, you can't do much digitally. (α)

		Advantages of digitisation also conditional on its adoption by suppliers and customers	But I can robotise this company as much as I want, I also have to robotise my suppliers, the conveyors, it's useless if I do it myself. Some operations, linked to bureaucracy, especially shipping operations, where a bill or invoice has to be signed, unfortunately have to be done on site and this is something I think it is worth thinking about.(α)

AGGREGATE DIMENSIONS	***SECOND ORDER THEMES***	***FIRST ORDER CONCEPTS***	***REPRESENTATIVE QUOTATIONS*** **(Company)**
RESILIENCE	***DIGITAL SERVITIZATION CHALLENGES***	The positive experience made with smart working practices during the pandemic poses spaces and future scenarios for a greater use of this tool. Smart working can only be applied to certain company departments, i.e. those that do not require the mandatory presence of human resources	"As far as the future is concerned, I believe that the adoption of the logic inherent in smart working will certainly, in my opinion, become an integral part of the way people work". (γ) "In this context of uncertainty, where we still don't really know what to do about redundancy payments and holidays, it is obvious that all the activities that generate value, which can... are managed in smart working, of

		for operational purposes. The main requirement to change course concerns the ability and willingness to face certain cultural and organizational changes. Technologies are an enabling factor, but the real change must take place culturally, starting from the value proposition to the client and continuing through an overall vision and sense of teamwork.	course. But I can't assemble the machines because I can't get the parts, it's clear that I can't...What do I do? I have to put myself in these conditions". (γ) "In this sense I believe that IMA can certainly face certain changes, also because there are a lot of enlightened people, let's call them that, in short, it is such a big reality that it cannot afford not to be there and no longer be a leader because it is not ready to face certain changes, but they are not simple, because cultural changes are difficult, they are the most difficult ones. It's not whether or not to adopt a technology, but it's how I adopt it, because I adopt it and how I change and restructure my entire organization, which until today has worked in one way, from tomorrow it must work in another". (ζ) "That's what you design behind it, technology comes next, it's an enabling factor, but real design comes first. I mean, what do I want to give the client? What do I want to achieve with the service I am designing? And then I choose the most suitable technology, I choose the tool, the medium and whatever else. And it's not so much those who then have to use it because if they are guided in the right way, if they

			have a certain type of input, in my opinion they don't have big problems. The problem always happens... everything has to start from the top. But from the top with a strong committment, with a vision... or a delegation, even a delegation, but it must be a total and clear delegation. That is: "I delegate you, and you all know that she or he is delegated and therefore what he says must be followed, full stop".... It's time to say: let's be a team! We put everyone's ideas on the table and then we look for the most interesting one, maybe it's none of them, but from the ten ideas that come on the table comes an eleventh that is the winning one". (ζ)
	INVESTMENTS IN DIGITAL SERVITIZATION	The investments made in teleservice logic have shown important benefits in pandemic management and in guaranteeing continuity of service to the customer.	"Considering these difficulties in moving technicians, there is a strong demand for teleservice activities, which for us was a new project that we have been implementing for two years now, with a fairly innovative solution, and now it is benefiting us in this way. We have been implementing it for two years now, we have been consolidating it...it is clear that this has enabled us to reach, to reap the full benefits, which are basically that of working more people on more than one machine, because we then have all the traceability of the user and so we are able to work with more hands on the same customer or on the same machine...and then we clearly speed up all the orders that

			were in the installation phase that had not yet set up the system". (γ) "The challenge, with regard to this logic of teleservice, the problem is often given by the customer, isn't it? Either they don't trust us, or they don't give us the right weight, or our pm tells him and he doesn't provide me with the connection...so let's say that customers now speed up and understand how important it is to have this kind of support". (γ)
		The pandemic has changed the customer's perception of teleservice tools and therefore there will be greater openness to the supplier company.	
		To make up for the difficulties due to the lack of mobility of technicians, the company uses remote assistance, while still managing the shipment of spare parts.	"So, in order to overcome the difficulties in sending our technicians, we try to give assistance remotely as much as possible, we try to be there, there is the presence of the salesmen even if maybe in smart working, there is the presence of the administration in smart working, the order management, the warehousemen, because of necessity, not full but in shifts, are present in the company to ship the goods and then any spare parts are shipped anyway. Probably we are not always able to maintain the service levels we normally have, this is due to external but internal logistics problems and obviously everything is a bit slowed down, but in short we try to give and guarantee all possible support to our

			customers". (ζ) "Certainly, the solutions we are putting in place to deal with the pandemic will continue to apply in the future. Evolution and awareness raising for what could be the risks of contagion have also been seen, where progressively day after day there were always small improvements...a system has now been put in place to measure the temperature for those accessing the various buildings. In other words, these are all things that can perhaps become an integral part of the processes tomorrow, right? These were things that have been put in place with great effort and commitment, and clearly going to improve even by collecting feedback from the people involved... So with that something has certainly taught us... Surely all the experiences made will also be taken into account in future developments, no matter what, no?". (γ)
		The solutions undertaken during the pandemic have brought positive lessons, which are also applicable for the future.	
		Augmented reality will be a tool that can offer various post-pandemic benefits, even the most	"I believe that in the near future, the implementation of truly technical and technological solutions that allow more and more remote assistance and, I was thinking just the other day, maybe it's the right time to find a real use case for augmented reality. It's always been, we've all been around it, it's the one that

		reluctant customers or companies will adopt this logic, which can greatly improve remote assistance. The must-have for the company in the coming years will be the connection of its machines, so as to have a constant channel, offer remote assistance, analyze data and have information in real time.	makes the wow effect at trade fairs, but in the end, in practical use, we've never found the use that tells us: okay, cost-benefits, it's a relationship that works. Now it could be the keystone, where this kind of technology really takes hold because in my opinion for a long time... or it won't be possible, for a while, or even afterwards it will tend to limit this thing. Other solutions will have to be found, even for a fee, of remote assistance for a fee, clearly with tools and technologies that allow it in the most efficient way possible". (ζ) With reference to the most promising technologies or those to be adopted in the near future, I believe that certainly the first and indispensable one is to have the machines connected. This makes it possible to have a constant channel, the flow of information and to be able to act and see the machine, what is happening remotely, as well as putting the customer in a position to have data and information analysis in real time. (ζ)
AREAS OF IMPACT OF THE CRISIS	**Impacts of the Crisis on the Service BUSINESS (short term)**	The company has carried out field service activities at international level,	"So, in order to overcome the difficulties encountered with FSOs, we started to organise the business so that ... we could

		through local branches and at national level with Italian technicians.	send technicians from our branches from countries where there was no such problem. So on an international level we operate with local branches basically, while in Italy we manage it with Italian technicians". (γ)
		FSO's activities are those in which the effects of the pandemic are greater, as they are completely inhibited due to mobility regulations.	"Yes, well, the technician isn't going anywhere at the moment, of course. Even if he wanted to, he can't, and in any case we couldn't guarantee the necessary safety conditions for those who had to leave, so we as a company can't do that". (ζ)
		The company's production capacity is heavily penalised due to the lack of spare parts supply, mainly due to supplier downtime.	"As for the production capacity we are travelling at, well it's hard to say, but it's clear that you've had a big reduction. That is, to date, with this blockade you are blocking everything...zero... Because in fact, it's true that I can work as a company that maybe works in the food sector, but it's also true that whoever makes me the parts to assemble on the machines...eh! That is, they are stationary. Because in theory you should go back in the supply chain and say "OK, you do (...) but the supplier A, B, C then does the parts for me". (γ)
			"The parts of the machines are

		In relation to (custom) mechanical parts, the impacts were greater, as their complexity is greater and requires the collaboration of partners.	made to design, all modernly structured companies no longer do these things at home but rely on qualified partners to do it, for flexibility needs and to reduce investments in machinery...and so I assemble. So it's true that I can have the part of the business, but I miss the parts to design...The problem occurs when I receive a request for a particular design, therefore customizable, then I get into trouble". (γ)
	CRISIS IMPACTS ON THE CHAIN SUPPLY (mid-long term)	The strategies of the past, aimed at streamlining warehouses, have proved counterproductive in the presence of pandemics such as Covid-19	"Following the adoption of past strategies, we are prone to not having a warehouse and we have said it well, I avoid filling up my warehouse, on these components that are long lead time I put them in my house, those short lead time I make them on demand, that is I make small batches (?) with my supply chain and maybe I buy 5, I buy 10 when I need them, because I know that in two days they come to me. So we're in trouble about that now... We answer on the emergency parts, but on the parts we say "high turnover" we have problems, because the people who supply them to me are still in the middle of it". (γ)
		As a solution implemented to deal with the pandemic, the company wants to improve the management of local warehouses in order to unblock the flow of	"To deal with the problems posed by the current pandemic, let's say that we are trying to progressively use the resources of the local branches trying to understand how to use the local warehouses and understand

		spare parts...	where the parts are". (γ)
	UNCERTITUDE GENERATED BY CRISIS (short-term)	In the early stages of the pandemic the company is going through a period of great uncertainty, it is still necessary to determine how the redundancy fund will be managed and the granting of leave for employees.	"There is still uncertainty arising from the issue of the ATECO codes, everything needs to be defined, everything needs to be clarified ... Yesterday everything was not yet clear, we had foreseen the closure, but today and tomorrow... also because the union is involved. It is a question of what the President will decide on how to move. In the end, you can say "I'm closing, I'll close in August and then leave again afterwards". We are also considering how to deal with the issue of the redundancy fund rather than the granting of holidays for employees: to scale up the residual holidays accumulated in previous years until they are exhausted, to scale up the paid annual leave (PAR) of previous years...eeehm....to say the employees who will explicitly request it, and then you can go so far as to suspend workers with the ordinary redundancy fund (CIDO)". (γ)
		In the early stages of the pandemic, the company expressed many difficulties in finding personal protective equipment.	"Another problem that came up after the outbreak of the pandemic concerns the retrieval of PPE, for us it was not easy because even in the company it was not easy to retrieve it. To say, I personally tried to buy on Amazon and nothing, on Ebay...and so here too we have to find channels to get the PPE...because in any case it is

			important to protect others. The company hasn't given them to me, now it has been structured, for about two weeks, and they are given to people who may be at risk, right? In the sense that maybe you live in an office with more people, then". (γ)

AGGREGATE DIMENSIONS	*SECOND ORDER THEMES*	*FIRST ORDER CONCEPTS*	*REPRESENTATIVE QUOTATIONS* *(Company)*
AREAS OF IMPACT OF THE CRISIS	**IMPACT ON THE SUPPLY CHAIN**	The blockage of the installations also led to the suspension of the activities of realities that mainly offered maintenance and repairs	"Please also keep in mind that, in our sector, many companies that carry out repair and maintenance activities are also installers. So the failure of the installation activity leads many companies to suspend their activities". (β)
		In the context of the health emergency, the benefits of Lean are likely to become barriers to services.	"Then, perhaps the habit of these years of having centralised, highly efficient logistics structures, which guarantee extremely rapid reactivity times, has somehow led to having to work with zero warehouses. So in less than 24 hours you had the material available". (β)
		Ignorance emerged of the importance of its own and suitable customer-side equipment and reflections on possible centralisation of	"From the point of view of risk management, one thing you value a lot if I am the client is the importance of having your own equipment, which is something we have been working on successfully for a few years. In my opinion this

		stocks with doubts linked to the consequences created by the health emergency	situation will give us an additional boost to the client's propensity to keep any spare parts". (δ)
		The convenience of having some dislocated activities has also led to problems due to the lockdown phase shift.	" The distribution of the activities helped us but also created problems. Knowing to do certain things only in one part of the world clearly prevents the completion of the whole. Knowing that those things can be done anywhere in the world would have significantly reduced the effects of the lack of parts and spare parts. Not so much spare parts, because there is a different reasoning. More of noble parts that are used to complete the systems". (θ)
	IMPACTS ON THE COMPANY ORGANIZATION	The impact on service growth was significantly negative	"At the service level we had forecast growth of +5% (confidential), now if all goes well we will probably close with -5% over the previous year. But between +/-5% we are talking about 4/5 million economic result on service alone". (δ)
		Crisis as an opportunity to focus on internal staff training and e-learning solutions for clients	"The situation also lends itself to doing things that are typically late or suffering, specifically the development of tutorials and documentation (especially the company one, in which we have invested heavily and are running... so not so much the one for the final customer, but rather the documentation for the testing service, of all the contents functional to the fact that Salvagnini can perform those

			operations correctly). So we were able to give more space to this activity... As far as training activities are concerned, we are working above all - hoping that this situation will not evolve disruptively - on the development of "e-learning" contents, in any case for the training of our clients remotely". (δ)
		A good IT infrastructure, combined with quick & dirty solutions, has made it possible to keep the company up and running at all times.	"All production colleagues are now at home on forced leave and we have also opened a redundancy fund procedure. However, the positive thing that I was able to detect is that all these rather recent all-in-one computers have been found to be compatible with this setup. Our IT has activated VPNs for everyone, so in record time, within a day, we were able to "transfer the workforce" from the offices to their homes while basically maintaining operations. It's a "reaction" solution, it's not a medium-long term strategy, and now I'm struggling to quantify it, but even from the impressions of our customers I can say that we've maintained our usual operations". (δ)
		Internationality seems to be a resilient element	"Because the organizational model, for example, already thought or predicted situations of complications, since we have, in any case, the need to operate worldwide and therefore often also be subjected to crisis situations due to wars, for example". (θ)

	IMPACTS ON FIELD SERVICE	Part of the operations were lost due to the inability of staff to go to the workplace	"We have physiologically lost some of our capacity due to the impossibility of going to the workplace. We have, of course, brought all the resources that it was possible to bring into smart working" (β)
		Drastic drop in Field Service with important differences between Italy and the rest of the world: completely stationary and at 30%.	"The national FS is completely stationary. Globally it can be estimated at a fair 30% compared to normal conditions" (δ)
		Internal demand for spare parts has increased for anti-crisis stocks	"Italian branches have requested more spare parts" (δ)
	UNCERTAINTY	A deficient planning of the country system led to a lack of security	"Now to think that a company has hundreds of masks, or hundreds of suits, gloves and everything you would need to operate safely is difficult. That, in my opinion, is one of the major critical points of the Italian system, we have not planned to make it available especially for those critical sectors. So anyone who has to go and do repairs, maintenance in a hospital, perhaps on a kitchen or a distribution trolley, has to take risks that are greater than what would be legal, to guarantee the service. Allowing the structure itself to stand, but in general this is what we see: it is the individual who makes up for the shortcomings of the overall organization". (β)

		The need for less bureaucracy is evident	"If you are in a system that allows you to act in time and you have a bureaucracy that can somehow slow you down, the sooner you start the better, and so here is the advantage of having this kind of solution. So if you are in a system that allows you to act in time and you have a bureaucracy that can somehow slow you down, the sooner you start the better, and so here is the advantage of having this type of solution. (δ)
		An uncertain role of the institutions, which has led to regulatory gaps and management difficulties, is underlined.	"Because in the ATECO codes in the first draft we weren't there, Confindustria wrote a nice letter saying "you can't think of keeping installations and maintenance open, and not keep distribution or production of electrical and plumbing equipment open". Consequently, in the second draft, we were there, we were both the producers of electrical and plumbing equipment. It's true that if my bedside table light bulb burns, I can wait 15 days, but if you burn a medium-voltage cabin in the hospital, it's not like I'm waiting to get out...".
		Trade union dynamics can protect workers and slow down realities that risk closure	"FIOM has blocked us. FIOM denied us because they didn't feel they had the responsibility that those technicians could take risks. So, in this way, however, the food chain, the medical chain and everything else stops. The risk if the companies are closed a little longer is that all the small ones

			will die". (δ)
	IMPACTS ON SALES	During phase 1, as far as aftersales are concerned, the domestic and foreign markets travelled at two speeds: the first was stationary, while the other continued to demand	"An important part, which is the Italian one, is gradually coming to a standstill, so also from the point of view of after sales at the moment it is abroad that continues to request, while in Italy we are at the level of communications to update the situation in general and not on specific or technical requests. (β)
		The health emergency led to a significant and sudden drop in turnover	"Now the turnover is at -70, today is Friday, it's the last Friday of the month, historically it's always very low, because of course our customer may wait for Monday or Tuesday, that is wait for the next month for a speech about currency, so I expect the next days frankly like -80, that's it. So, it's obvious that in this situation that, what do you want, there are all the problems of a company that... what do you want, I'm on the board of the Electrical Materials Federation, so I'm in daily contact with my colleagues who are represented on the board, the situation is similar for everyone, there are those who can shine because they have a privileged channel".

RESILIENCE	**SMART WORKING**	Difficulties in combining monitoring and smart working to ensure that a certain level of productivity is maintained	"On knowledge no one was ready. monitoring. I, for example, could no longer monitor directly and I asked myself whether it made sense to set up a project to tell people "if you have time, work on these instances here". What could be improved is a kind of monitoring with KPIs planned as activities and on which we could then do some monitoring on people, so that we could then say "efficient to the maximum". Because if we were to go on like this for a few months with smartworking at 8 hours a day, but knowing that people can do something else, the company would then have no revenue. It only has costs. The technicians have made themselves available for training activities, for example, but we have said that those are hours in which they invest in themselves. So I would ask myself the question of monitoring" (δ)
	INVESTMENTS IN DIGITAL TECHNOLOGIES	Advanced IT enables rapid responses and reactive change	"Fortunately, our IT part has evolved and therefore there has been reactivity, both in terms of provision, of VPNs, dedicated bands". (β)
		The health crisis pushes towards more efficient software development	"Well, the elaboration of some daily reports, which we always take for granted in terms of monitoring and data synthesis, is perhaps more expensive than we expected. So even here, investing in some software development that allows us to obtain the same data with less effort and time

			would justify it". (β)
	INVESTMENTS IN DIGITAL SERVITIZATION	Condition monitoring as a basis for the future of services	"It is useful because it is all information that allows you to make assessments and estimates. The problem is when you see a machine in distress, that you see that it needs maintenance soon, but now you can't do anything about it. In this sense, condition monitoring is a bit of a hard nut to crack for the future: clearly, if you can't send the technician you still have a problem, but it still allows you to have the situation under control without asking anyone for anything". (δ)
		IoT tools can provide a stronger competitive advantage in meeting customer needs than other more "typical" solutions such as marketing investments.	"I quote you 2. One relates to a very important Spanish chain, one to a German group that distributes products in our sector. In both cases, let's say, the real layout of the IoT tools was the winning key to competition, regardless of economic conditions, service level or product reliability. These are very recent stories, in the end having concreteness and flexibility on these issues pays much more than having marketing structures, which then maybe get lost and don't lead to the things that customers want to see". (β)

		The use of augmented reality as the key to telephone support in remote support	"At the level of telephone support, we have seen that the use of augmented reality and Acty is giving a boost. The customers who were always asking for the technician, they made up their minds and started to change, while we were giving remote support. And we were able to get machines back up and running where we needed a technician, so again digitisation and AR have great strategic potential for the future. (δ)
		IoT as added value for real-time activity tracking	"IOT: the added value, trivially, is to know that at this moment in the world this is the scenario, obviously as far as the machines that are under IOT are concerned. Lately we have had several installation requests, and here we come back to the subject of being connected and the goodness of the solution that does not involve installation hardware, nothing physical, so we were able to continue the installation even in these days at a distance". (δ)

Appendix A2: Coding collection of interviews, grounded theory Phase 2

Grounded Theory Phase 2

AGGREGATE DIMENSIONS	***SECOND ORDER THEMES***	***FIRST ORDER CONCEPTS***	***REPRESENTATIVE QUOTATIONS (Company)***
ELEMENTS OF UNPREDICTABILITY AND EXOGENEITY	**UNCERTAINTY DICTATED BY THE NATIONAL POLITICAL CONTEXT**	Disorientation linked to the continuous evolution and heterogeneity of national and international provisions	New indications were constantly coming from the government and consequently they were difficult to follow, there was always uncertainty (F).
		Inadequacy of the ATECO system to guarantee the continuity of the necessary dies during lockdown	Much thought has been given to ATECO codes: this could be re-evaluated because it has been demonstrated that this classification is not representative of today's supply chains, some sectors that could be stopped have worked while others have been blocked. (O)
	VARIABILITY OF THE SCENARIO ACCORDING TO THE BUSINESS TO WHICH IT BELONGS	The business suffers from dependence with the sectors most affected	At the level of opportunities we still don't know how it will go, we are linked to sectors (HoReCa, automotive...) that will be strongly affected (O).
		Advantage of providing the hospital-	Among the various products that we produce, there are compressors that go specifically to hospitals and in this business there is

		healthcare sector	clearly an important demand, which is an advantage from this point of view (F)
		Enormous losses due to unprotected ATECO membership	For the atheist code speech, we had to stay closed, so April we stayed closed and the blockade was 100% (C)
IMPACT ON BM AL RESTART	**IMPACT ON REVENUES AND COSTS**	Loss of most orders and expectations of recovery only in the long term	The clients I know, I can say with confidence that they will wait until the end of the year before returning to investing. Who is now willing to make an investment? I am talking about an investment of a few tens of millions. I think the only possible one is "let's wait and see what can happen". [...] In this period here we have missed a fundamental moment for orders. (C)
		Late payments and increased warehouse costs	(Clients) have rationed orders and take home what is functional and needed at the moment or in other cases you enter a payment backlog regime (they do not pay on time and our administration reacts by blocking other orders). This second situation is critical because it results in a double loss: both because you do not ship and because stock and working

			capital increase. (O)
	NEW ORGANIZATION OF ACTIVITIES AND WORK	Recourse alternatively to holidays and CIG for those who do not adopt the SW Continuity of activities thanks to SW	Previously, people wanted to take their holidays, now that there was the possibility of having more weeks of redundancy pay, since it is obviously cheaper for the company in terms of costs, for the summer when the situation is expected to be a little static, priority is given to cash, while maintaining the obligatory holiday weeks (C). With the exception of those who are in the office because they support the production we are all at home in smart working(O)
	IMPACT ON THE SUPPLY CHAIN	Found collaborations in the supply chain Blocking the supply chain poses a threat to the procurement and sale of products	We left with that letter from the prefect and we saw that our suppliers were very cooperative and helped us to leave(F) The durable good must be produced and sold, but for this to be possible we have to acquire something from the supply chain, we have to produce it and then transport it to our

			customers.(C)
	IMPACT ON THE RANGE OF SERVICES OFFERED	Blocking of FS interventions at customer sites	As some customers who no longer wanted us on the site told us we do not allow suppliers to enter and therefore you can't do anything else to them. (F)
		Continuation of remote assistance services	We have estimated the impact on FS at around 90%. Then with regard to maintenance contracts...well in our case we can't move, so 100%, we could only give a service, so the services worked for 20%(C)
		Continuation of spare parts services	Spare parts also worked at the end of April. They had a restart during lockdown, because someone had asked for spare parts (C).
REACTION AND RESILIENCE FACTORS	**ROLE OF SERVITISATION**	Limited impact and structure of the services in relation to the overall offer	It is difficult today to understand the price of services... We are structuring ourselves to separate the services, but at the moment within the cost of the machine there is also the service. You could probably say around 20% of the average cost of a plant, of a line. (C)
		The offer of advanced services provides a competitive	In the service we had a tool

		advantage	that we needed a lot: we connected the compressors from the customer's home (IoT) and monitored remotely. This technology will be something we will focus on and sell more in the future.(F)
	ROLE OF DIGITALISATION	The use of technology makes it possible to guarantee the continuity of activities	Smart working and the digital transformation of back-end processes will be especially important for the sales & marketing department (O).
		The use of technoloogies allows to reduce some costs	Once you adapt, you discover that you can travel less and reduce costs and this is no small thing. Suppose you can do the same things without travelling, you have a deadly impact on costs(F)
		Potential of an e-commerce channel not fully exploited	For e-commerce, we have had it for 5 years for spare parts, but it has never gone off the rails, in the sense that our customers really like human contact (C).
	DIGITAL READINESS	Adoption of digital solutions for process management	The offer is digitalised, the customer's order is made and managed through ERP, in detail SAP, which is then divided into phases by the simulator, which manages the load according to each department, according to the workflow is managed by processes (C).
		Evaluation of opportunities to	

		use the SW before Covid-19	From a prospective point of view we approached companies to understand how to adapt to work from home but we had not implemented structures (F).
		Problems related to inadequate hardware and software equipment	In the beginning there were no PCs for everyone and it was also a reason to be unhappy for some who were not essential because they didn't have a PC (C).
	AGILITY	Ability to easily adopt smart working allows reopening with full functionality	We left again, also going to close the lay-off fund, so we are here all or remotely, there is no one on holiday or laid off.(F)
		Attempts to modify the product offer to respond to the emergency	We are thinking about products that could be born on the basis of technologies that we have at home, and they go in the direction of making sanitation equipment. (O)
	ROLE OF THE GROUP'S CULTURE AND STRATEGY	Difficulty in adopting the SW due to incompatibility with the corporate culture	Smart working was almost non-existent before, because in any case the value of the company and its creed requires a presence at the headquarters (C).
		Group pressure to adopt the SW prior to the Covid-19 emergency	They hammered us into using Teams even before Covid-19, as if they already knew a pandemic would happen. Even before that we had the same "pressures" to use Skype, then replaced by Teams for

			the group's own suggestion (F).
		Dependence on the foreign market poses a threat in the event of border closures	Do you consider that C does 90% of its work abroad, so if until last year it was good to work abroad, now with the borders closed, everything we produce and the potential turnover we already have at home, how do we transport it? This is the threat (C)
	CHALLENGES RELATED TO THE ADOPTION OF THE SW	Difficulties in assessing the performance of smart working workers	The company has targeted smart working only for some figures, maybe for product development...also because in my opinion it works for those who work by objective (C)
		Use of smart working depends on hardware and software equipment	It is not true that I can give you the laptop, because underneath you need an infrastructure both software and hardware that is not so portable, so this is the difficulty: it is not enough to give you the tool to make you work from home (C).
		Lack of IP policies to implement smart working	As the company becomes more and more technological, there are areas that are equipped to work from home, but there are others for which, although necessary, it is not possible to have a computer at home, and it is only said
		Intrinsic limits of smart working with respect to	

		production activities and communication difficulties	that you can also get there for the protection of intellectual areas (C). Communication with employees, talking to them remotely is not the same. Keep in mind that we have about 200 workers and you cannot send them emails. (F)
THE NEW NORMAL	**RETHINKING THE SUPPLY CHAIN**	Need to redesign the supply chain to cope with new crises	Surely procurement policies with closer supply chains will be evaluated to compensate for lockdown risks. (O)
	CRITICALITIES WITH RESPECT TO DIGITALIZATION AND SERVITIZATION	Need to ensure cybersecurity to be ready for a "digital emergency Lack of IP policies to exploit the potential of 3D printing for spare parts Need to digitise all processes	We thought about security in relation to the digital world, that whole world of cyber security. The next pandemic could be on systems, not on people, and even that could be very dangerous (F) 3D printing, yes, can be interesting but it is not the solution until the customer also has the opportunity to produce the piece through a rightly recognised intellectual property policy (C). Some processes need to be reviewed, especially those that require the interaction of different people (e.g. issuing a document that needs to be reviewed by the legal department, signed by the manager do other steps) because it is an inefficient

	SECOND ORDER THEMES	*FIRST ORDER CONCEPTS*	*REPRESENTATIVE QUOTATIONS*
			process made of emails coming and going. (O)
	IMPORTANCE OF INVESTING IN DIGITAL TECHNOLOGIES	Digital technologies will improve your operations and those of the customer. Acknowledged advantages of smart working	Normally a production plant was visited every 2 weeks to see how it was doing and to hold meetings, in the future all this will be skipped and replaced by digital methods: alternative solutions will be needed to visit the production processes. Installing webcams to view processes can be an idea and this will have a number of impacts.(O) Smart working was seen very badly by us before the crisis and during the crisis we saw that it is a tool that can make its contribution (F).
	IMPORTANCE OF INVESTMENTS IN SERVICES	The crisis confirms the opportunities offered by servitization	As far as services are concerned, the situation has not led us to introduce new ones, in case it has confirmed that we are moving in the right direction, because it is a path we started more than a year ago (C).

RESILIENCE	**IMMEDIATE REACTIONS TO THE CRISIS**	The quick and easy adoption and the positive impact of video call tools have led to a rethink on their use in the post-crisis period.	"One interesting thing that we didn't use before, because we were more inclined to travel and face-to-face with the customer, are the video call tools. I think this will have to be reviewed by us, because we have noticed that a lot of things can be handled in this way. Skype and Microsoft Teams are tools that have proved to be really useful and we are particularly satisfied. (G)
		The adoption of quick & dirty measures to deal with the pandemic has resulted in an enhancement of video call tools, transferring employee training entirely to digital channels and increasing the implementation of smart working.	"With regard to the quick & dirty strategies employed, I would say that in order to reconcile the company's needs with the provisions of the various regulatory provisions, we have increased the use of smart working, involving the majority of clerical staff at headquarters. We have also enhanced the videoconferencing tool for virtual meetings and transferred staff training completely to digital channels...Certainly, the cultural factor and continuous training of our employees has also made a difference and allowed us to continue our business on a regular basis". (D)
			"As far as internal problems are concerned, we have certainly had to deal with a problem that was in many ways unexpected, and to do so extremely quickly.

		The company was able to react to the emergency and implement the necessary solutions in a short time, creating a task force from the outset and adopting smart working logic, all of which was possible thanks to previous investments.	I am thinking, for example, of the implementation of the company task force, the strengthening of smart working on the basis of the project we had been implementing for some time and the organizational measures of working life and the reconfiguration of common spaces". (D)
	DIGITAL READINESS	The completeness of the company's IT equipment has made it possible to react very quickly, ensuring operations and promoting the introduction of security procedures.	"We are already SAP customers, Microsoft and whatever else, so we already have our VPN so I can connect to the ERP from anywhere in the world, all I need is a connection. So from this point of view, we have become operational in a very short period of time. In putting the security procedures in place here too, we decided quite quickly: on 4/5 May we already had all the workstations in the Plexiglas-covered open-space, so we had already established all the procedures. (G)
		The digital projects undertaken in the pre-pandemic period formed the basis for the development of innovative solutions.	"With regard to the subject of technological equipment, I must say that we could count on a series of well-developed projects, which were then developed and formed the basis for creating new and innovative solutions. Certainly, the cultural factor and the ongoing

			training of our employees also made a difference and enabled us to continue our activities on a regular basis". (D)
		Digital technologies played a crucial role in managing the crisis, minimizing its effects, making the relationship with customers and suppliers immediate, leading to the emergence of new solutions.	"With regard to the role that technologies will play in the management of future pandemics, I believe that they have played a crucial role in the continuation of the company's activities, minimizing negative impacts. Allowing anyone to work anywhere in the world without problems and making the relationship with customers and suppliers easier and more immediate. In addition, this period was also propitious for developing new solutions that can also be evaluated at the end of the emergency phase. In this way, the company will increasingly move in the direction of becoming a true "intelligent factory". (D)
		Those already digitised have suffered significantly less impact than those doing business in the traditional way, reacting better and faster.	"Surely there will be some changes, I see it more on the consumers because the restaurants and installers who were a bit more technological I see that they are living this phase better in the sense that here the Digital divide is felt, i.e. the restaurant that had the delivery that had the website of the Facebook page where the chef continued to communicate with his own page i.e. those who were already connected and is doing better than the

			traditional ones that were waiting for customers in the room those who closed everything closed enough and do not remember them anymore. And the same is true for retailers but also for the salesman, who was familiar with the use of devices and technologies, and who, let's say, had less impact at the time. The others have been knocked out at home and are waiting for things to pass while they can't even work anymore". (I)
	DIGITAL SERVITIZATION CHALLENGES	The crisis will reduce customers' resistance to sharing data from the installed base with a view to service, guaranteeing greater access to their company network. For the future of services, it is important to invest to find solutions that respond to the problems related to the mobility of technicians, expressed by the pandemic.	"Some customers don't allow us access to their network, so our system remains closed and they only let us in when they have a problem, so the current pandemic can help us to reverse this trend, to make them understand that it is good for them to open up more. Even though this is the result of all the IT security issues and they don't want outsiders accessing their networks. (G) "The main challenge for services will surely be to be able to minimize visits to clients, while ensuring a high level of service. Especially me, who follow the commercial sales part, also in the service, I have to make sure that I don't lose contact with the customer and the fact, maybe, that I can't visit him regularly doesn't help. So this is a bit of a challenge". (H)

	INVESTMENTS IN SERVITIZATION	The strategies of the past, aimed at streamlining warehouses, have proved counterproductive in the presence of pandemics such as Covid-19 Investments will continue to be made to inform the design of products and make them better suited to the customer's needs, becoming the basis for providing services.	"Well, these were all things that we already had largely in place: our systems are all supervised and therefore nothing has changed for us. They were already part of our technical baggage, no surprise there. All our machines can be connected to a proprietary network of our own, with software that fully supervises them, which we can access to check the operating conditions. It's clear that everything can be improved and we have improvement and implementation plans for this too, but they already existed pre-Covid-19, it was all already part of our development initiatives". (G) "We will certainly continue to push on tools about the use and analysis of data, so that we can better respond to customer requests. So yes, more use will be made of the data". (H)
	INTERNATIONALISATION STRATEGY	Having an international sales and service structure helps to cushion the impacts of the pandemic. The pandemic has not changed the	"Then our organization is fortunately very widespread, we have twenty commercial service organizations around the world, so we have service centres on the continent and we have managed with them". (G) "Well, we are already well structured, with offices all over the world and we already have our own opening plans, for

		investment plans for opening foreign offices and subsidiaries, which have proven effective in limiting the impacts of the pandemic. The internationalization strategy adopted by the company has generated positive impacts, ensuring proximity to the customer and ensuring supply management.	which we will continue. Then, also following our business model, so producing in every continent for that specific market, at this stage we also had a hand". (G) "Still from the point of view of problems external to our organization, from an international point of view, our internationalization strategy based on proximity to our customers in the most relevant markets for our sector, has allowed us to better manage the supply side as well, regularly continuing our activity all over the world". (D)
AREAS OF IMPACT OF THE CRISIS	**IMPACTS OF THE CRISIS ON SERVICE BUSINESS (SHORT-TERM)**	Product delivery services have not been interrupted, to the detriment of installations that have stopped instead. With the reopenings, FSO's activities are resumed normally, in compliance with the regulations. Due to lockdowns, after-sales activities, interventions and visits have had negative impacts; where possible,	"Then it's clear that many machines we couldn't install even though we delivered them, because people couldn't move around. (G) "Now, with the return to normality, fortunately FSO's activities are gradually resuming. So, everyone is now giving us access to their production sites to make plant visits, set up installations and so on". (G) "The only impact we have partly felt is the fact that we also produce glass forming machinery, machines for the visual inspection of filled containers and assembly and packaging lines for medical

		these activities have been digitized and carried out remotely.	devices, and because we could not move due to lockdown, we were unable to carry out service or after-sales visits and interventions in our customers' production sites. However, we have made up for this wherever possible by carrying out these activities remotely with digital systems". (D)
	IMPACT OF THE CRISIS ON PRODUCTION ***(MID-LONG TERM)***	The main threat concerns a contraction of business in the medium to long term. The negative impact of the crisis on production will produce its effects in the medium-long term.	"Here, too, there's a nice speech to make. In my opinion, normality, as it was understood before, is hard to see, in short, it also depends a little bit on contagions and their course. At a business level, I don't know if business can be reduced in the medium-long term, it's something I fear. We will have to see how the sectors in which we operate will react". (H) "Surely we will have repercussions in the future because there will probably be fewer new openings and fewer renewals, and of course we are assessing the impact on the medium term... In other words, let's say that those who work on medium-long term projects do well to evaluate the current situation, but, rightly so, many people are betting on the fact that sooner or later things will start up again, hopefully as before". (I)
	IMPACTS OF CRISIS ON VALUE CREATION *(MID-LONG TERM)*	To make up for the drop in sales related to the core business, the company plans to expand its offer	"In order to manage the drop in orders that we would have in the future, we would have to adjust the company's production capacity... There are

		with the development of complementary products. By offering a durable capital goods, the order portfolio has not been affected in the short term and will therefore suffer negative impacts in the medium to long term.	flexibility tools such as the redundancy fund that we had access to during the two weeks of July and we have been open since last Wednesday... In short, there are the tools to do this in order to try to reduce the impact, so in the meantime we are setting up, let's say, strategies to expand the range of products, let's say complementary products, and probably in the coming months we will set up an expansion of the offer in order to try to make up for the lack of sales of our core product, which are the kitchens that will certainly sell less with a GDP that falls around the world". (I) "Well, on value capture, rather than on our revenue model, we sell an instrumental good and our portfolio for now does not seem to have been delayed, postponed a bit, but ours is an instrumental good so we do not have an immediate pulse, that is, what it sells at the restaurant, I do not know the water or the wine is immediate, we do not, the restaurant buys a kitchen every ten twenty years as a durable instrumental good. We will have the impact at the end of the year/next year when we say that the new openings or renewals will decrease so we will have a decrease". (I)
	IMPACT OF THE CRISIS ON THE SUPPLY CHAIN	The local-for-local business model has significantly	"We had few problems with the supply chains. Also take into account that our business

	(MID-LONG TERM)	reduced supply chain impacts. The threat posed by the pandemic affects the supply chain, which could change substantially if certain sectors fail.	model is local-for-local, so basically if we produce in Italy, the bulk of the supply chain is in the same country, although some components may also come from Europe. In the USA, it's almost the same thing". (G) "On the subject of new normal, I believe that attention will have to be paid to changes in supply chains. The risk is that other sectors may not be able to cope and therefore change the current chain, which is a real threat".

AGGREGATE DIMENSIONS	*SECOND ORDER THEMES*	*FIRST ORDER CONCEPTS*	*REPRESENTATIVE QUOTATIONS (COMPANY)*
AREAS OF IMPACT OF THE CRISIS	**UNCERTITUDE**	The lockdown has generated great uncertainty on the management of staff effort, considering whether to use the latter at full or reduced capacity.	"There is an internal debate about 100% reopening. We will probably work with 50% of the staff present the first week and the second week with the other 50% and so on". (N)
		There is a framework of uncertainty linked to the expectation of confirmations related to bonuses and applications for financial incentives, such as the Calenda plan	"As far as digitisation is concerned, I am also expecting confirmation of a few additional bonuses from a financial point of view, which we will perhaps see more of towards the end of the situation. I certainly imagine and hope that there will be incentives to use it further than the Calenda plan presented in the last government. That seems to be promising something on this government, we will see. We also expect help from this point of view". (R)
		The emergency has a dual connotation: threat to turnover and opportunities for new business.	"Clearly, there is a threat to turnover in the sense that nobody at the moment, but not just us, I believe that on a planetary level it knows how to estimate or predict what could be a relapse on the market of what has been and what is a parenthesis - because I want to hope that the Covid-19's was - it is clear that

			precisely because of a concept of resilience this type of disaster is also a stimulus to suggest what could be new business, new ideas on the market, so a threat to turnover is certainly an opportunity to think about new business. ” (R)
	IMPACT ON FIELD SERVICE	The installation of meters has highlighted the limits created by the health emergency which does not allow the mobility necessary for operators to perform an important function of the company.	"What has brought the availability is certainly the question of installations, because if I send a meter to England today, there is no one to pick it up and install it because of the lockdown situation. So, if we look at what happened in Italy, where it is clear that the massive installation because of the lockdown has been stopped, by virtue of it the hope is always that it will be a parenthesis and that there will be a reopening and that the market will resume and everything will start all over again, even pulling". (R)
		The drop in sales, marked by problems in the installation network due to the inability of meter installers to operate, was partially covered by the sale of stockpiles	"It is clear that at the time of lockdown, some customers still managed to keep the rules and gas distributors also managed to keep the installation activity active and sell our products in stock or ask us for them, but it is clear that there has been a downturn in recent months, because everything has been closed, so there were no installers to install the meters either. What was expected, however, is that the situation will now return to normal quickly because

			everything is now reopening, and so the installation activities are also reopening". (R)
	IMPACT **ON OPERATIONS**	The impact appears to have occurred only on Italian sites, quantitatively between 5% and 10% on an annual basis.	"Okay, then let's go. Indicatively the impact on the production sites was only on the Italian sites because at the beginning the Ateco code that they could continue to produce were the ones we were not part of, so we can say that indicatively the percentage impact on an annual basis, whatever, closed two/three weeks, so we can consider it between 5 and 10% at the level of Italian production sites". (R)
		There is a greater loss of administrative operations than production: 50% for "White collars" and between 5 and 10% for production.	"The percentage impact on an annual basis between 5 and 10% at the level of Italian production sites. As far as the loss of operations is concerned, we made about, I would say, 4 weeks in which we were working at approximately 50%, I am talking about white collars because, as I said, the plant has all gone ahead and so in recent weeks I have talked to those who worked and Smart Working, but we have taken advantage where possible of holidays, after which from May we left almost 100% and we have made a couple of days

			of redundancy that were the last two Fridays and we do not expect a reduction in operations in the coming months". (R)
		The crisis has a greater impact on medium-long term cash flow dynamics	"If I have lost admit even the 20 - that I haven't lost it - 20% of the receipts are not the ones that cause me problems now I will have the problem in June when now that I haven't billed much less and I won't find the bank receipts, then I have prepared enough liquidity to keep up June-July-August, as a structure, so if I miss them I'll make it clear €300,000 per month that I foresee, I must have one million ready. That's what I did before and I didn't do now". (L)

		The rethinking of the spaces (meetings in person 2 m away, reorganization of the canteen and changing rooms) had an impact both from an organizational and cost point of view	"I would say it was easy. It's clear that you've changed the way you are in the office, I know. Today we travel with these objects (mask), so we have just reopened and avoided having meetings in presence, so, even though we were in the office, we used to have meetings at a distance, then, progressively, we took measures, so today we have meetings in presence with a distance that is, let's say, between 1.5 and 2 meters and, wearing the mask for the whole duration, as well as the sanitation of the rooms, as well as the management of the canteen that was more operational: there is a paradigm shift compared to the past. The introduction of the impact, let's say, has had more of an impact on the common spaces, because then the operators, typically because of the way our production is structured, are very far from each other, so it is clear that the paradigm has changed, it is clear that today's world in the office in production is different from yesterday's world. That being said, I think it is a little bit the personal experience that is different and so to say if the reopening was easy for the company my point of view has been handled in an absolutely excellent way, in the sense that a whole series of measures have been defined and shared with all the people these measures. Today

			everyone respects these security measures: frankly, coming to the office is my choice. I could be in Smart Working 50% of my time, but I am in the office all week, but it also feels good in the sense that I also feel safe in the interaction. So I think the company has handled it well. It's clear that managing the changing rooms in a different way and common spaces in a different way has an impact. It has an impact both from an organizational point of view and from a cost point of view, because today if you go around the company you find staff and before there were two police shifts, now it's cleaning. In the sense that there are people around the company and they continue to clean railings, bathrooms, all the spaces that can be with us and all the common areas: here there is certainly an impact from a marginal point of view, in the sense that if we compare it to what has been outside what is outside these are absolutely small things we adapt we go around with the mask we continue our operations as before". (R)
	IMPACT ON THE SUPPLY CHAIN	The crisis has led to an increase in the demand for spare parts to make preventive stock, while the service part aimed at maintenance has	"As we are a key sector for the livelihood of the population there has been a peak demand where we have provided more spare parts and services. Spare parts performed better than other segments. Another maintenance-related service part that needed the mobility

		suffered as a result	of technicians was more impacted. Just as line upgrades are being postponed. It is a mix of activities that go better and worse". (N)
		Difficulties have emerged in the supply chain due to the tightening of logistical complexities both in and out of the goods, which have led some companies to build up stock	"We tried to resist strenuously before the three weeks the plant closed down, fighting against everything and everyone, in the sense that, little by little, suppliers were beginning to have difficulty acquiring components. We have plants that are supplied from Italy and so we found ourselves in a condition where there were borders that were blocked to us trying to deliver until it became impossible to resist because they blocked our Ateco code and therefore default and we had to stop these flows, so these were the difficulties with the outside world there were some effects in which some supply chains increased demand so they tried to make stock. There have been some supply chains that have increased the demand therefore tended to try to have material at home in case of a potential lockdown also in certain other countries and therefore I had tried to follow the trend of demand so for the outside world the difficulty was mainly that on the one hand to have a supplier tap around the world and around Italy that was struggling to deliver in fact for us to deliver meant moving

			goods when for us it was objectively more difficult to find slots in air transport when it was necessary to move on trucks. In fact I think that's what almost all the companies that export have experienced". (SIT)
		No particular discontinuities in the relationship with customers are noted	"In reality, talking about restart or reopening is not correct because from the point of view of operations, if the offices & White Collar has had a continuity, it has had a reduction in operations but this operation has never gone to zero and we have never stopped, so just to clarify, it was only three weeks of closure. If we reason in terms of production a similar argument in the sense that our production has never stopped and there have been Italian plants that have had a closure for a limited number of weeks, but in the rest of the world instead went ahead. So strictly speaking we cannot talk about reopening because there has never been a closure, if not a week. Today I would say that we have an operation - I don't know 100% June with all the staff on duty if all the staff of both the Italian plants and the

			Italian foreign branch offices come". (R)
RESILIENCE	**SMART WORKING**	Evolution of the smart working product offer and the need to equip itself with more platforms	"A boost also of requests for tools of this kind because then we know that there are also some limits of Teams which is very good and is not a perfect tool as any collaboration tool. Eh has some very strong limits towards the outside world that we then saw and this suggested us to focus on another tool with a series of initiatives that together we are carrying out in order to provide the company with more powerful tools for communication towards the outside world. So with customers and suppliers, in short, the whole world outside the company. And precisely for this reason we are now installing other products that are those of Cisco in this case that should give a better experience because we all imagine that they are far away in times when we could travel a lot and meet customers in foreign plants as well as in the divisions, so waiting for everything to return to normal, we must pay a lot of attention in everything that supports Smart Working"(R)

		Presence of tools and smart working use and training programme has greatly helped remote migration	"Of course, as far as the IT area is concerned, I would say he supported us on the sudden extension of Smart Working, even though we already had a Smart Working programme and had already promoted and carried out it at pilot level during the year: it started last year and clearly for this project the technological support part was particularly important, so we still had a good part of the services on cloud and we still had an Office 365 package with important collaboration tools such as Microsoft Teams and we did extensive training to all White Collar employees in Italy. This made it possible to benefit immediately from an extension; clearly, it was not trivial to manage it, but we already knew that we had a substrate ready to activate this service". (R)
		The health emergency has laid bare the Smart Working tool, highlighting its positive and negative aspects such as improved flexibility and overworking.	"Here, I would like to add something that I may have said before, that is that in this parenthesis an intensive use of Smart Working has certainly been made, I think it is truly unique and has shown the advantages, but clearly also some limits that were linked to the relational aspects in the sense that when it comes to creating new relationships it is really important to manage, it is clear that the meeting in attendance or a fair in attendance are always at very different times because precisely the relational trust clarifies it with these aspects

			and in any case we are pursuing It was already planned to have a 20% so a day and a half a week, I don't know after Covid-19, when we will return to normal if it will be a day or if we really decide to increase it, I don't know. I don't know, I think that what this period has shown us is that it is feasible and that the activity goes on even if a main counterpoint is overworking because if you have a chat with some company staff, everyone agrees to say that everyone is much more concentrated and less detached and here comes everything that happened and that there was a recommendation from the human resources office to say please respect the breaks and try not to overwork because you have the computer near you, there in the house and there is the mobile phone, so what was typically done in the office, now the risk is done at home. ” (R)
	DIGITAL CULTURE	Strong preference for offline modes of training over online modes	"No, it doesn't seem to me in the sense that the planned formations have been postponed because we preferred to do them in presence because today the training actively requires interaction and there is a whole part that is not only in the minutes, but presence certainly helps so we decided to postpone the formations just to allow this interaction: the

			technical training on the tools fortunately we had anticipated it by six and a half months and then the others were already quite practical and were operational, then those who found themselves catapulted in the use of the tools actually did an accelerated gym and developed what they probably had left behind. (R)
		Sensitivity towards digital stimulates research and development, sometimes leading to new patents	"We have recently made a patent concerning a virtual assistant to help our technicians and customer operators using a QR Code. (N)
		A strong awareness of the cruciality of digital means that digital investments are independent from crises.	"They are independent of the crisis, they are part of a long-term project. We invest 60 million euros in R&D every year and there are certainly IoT solutions, factory robotization, digital twins, 3D printing...". (N)
	INVESTMENTS IN DIGITAL TECHNOLOGIES	The health emergency has accelerated the process of migration from offline to online with a major overhaul of the contact/meetings	"Yes, for safety's sake, at least in the short term, we're trying to find ways to succeed later, around June, which is resuming, I think I'll resume normally, to give the right space to everyone together, but this has enriched me because with that excuse I was able to analyze a little bit the positions and then as I said the representatives who came to the company weekly for the meeting now I do it all with zoom and then I avoided a lot of expenses because you have to come sleep at night for tomorrow to find them 46

			hours together. I put the giant screens in the office to do something, but you never adapt. No, no certainly the time for physical meetings here is over, I'll organize one or two events a year where I'll have them come with their wives. On the other hand there has been a change because I I had planned to do some regional interventions in which I would take 5 or 10 clients, I would have a meeting with them and then the next day I would go to the university for a lesson on the territory and then I felt like doing something, now I'm looking for it, I've already got in touch, here we have the faculty here in Pordenone of design and multimedia and I got in touch with them to organize a platform so that I can do those clients as a university of remote lessons or remote interventions so I will also do these meetings with, instead of going to the place where I was supposed to leave three of us, instead now I will do everything in telematic mode. ” (L)
		The appropriate technological equipment guarantees agility and serenity in the approach to solving a problem	"Smartphones and laptops, so much so that we were very quick to implement remote working: out of 5000 employees, 3500 work remotely, the others are technicians or workers who cannot work from home. the problem was the lockdown that stopped all the

			technicians. We did it remotely, supporting the local technicians who were perhaps not very well prepared with our central technicians. The support can be done with smartglass, a simple remote support for direct interventions on the machines or even a telephone or documentation support". (N)
	INVESTMENTS IN DIGITAL SERVICES	A rethinking of participation in digital trade fairs is underway due to augmented reality	"What I could say is that as far as the communication part of digital trade fairs is concerned the social media part has already started to communicate and was started a couple of months ago so it was an activity that is continuing. As far as the communication part with the client is concerned, for us fairs are important, they are incredibly important, and they are usually allocated in the first part of the year, what we have managed to do we have managed to do. The others have been cancelled in some cases, in others postponed, but with still an extremely low percentage of participation, so we will probably go, but no longer as exhibitors. We are thinking about alternative forms for the next one, because we do not expect the hope that next year from January when the trade fair tour starts again everything will be normal and they were already thinking about ways of communication within the digital fair rather than we are replacing some of the experiences within the

			products through the physical experience and the displayed object. These virtual augmented reality projects have been carried out the same way we have. They are stationary and in case we start again with the holidays we can on the one hand put them inside and they can be tools that can also be used outside the fair but what we are seeing at the moment is that the contact has started physically not in Italy but went to customers for face to face meetings, I repeat, with the constraints of before, so the mask, the distances, but I'm also doing a tour around the world where there is this problem"(R)
		The implementation of augmented reality is marginal and its potential is not grasped.	"I did not mention it among the main projects of digitisation because it is small but it is - a project linked to the use of augmented reality for the management of relations between the internal customer base of the assistance both in foreign plants and colleagues who are in other locations around the world, on the other hand, that of being able to have any interaction tool with external customers, I take on a supplier because in any case there are requirements for quality tests, rather than interventions perhaps to understand a technical problem that can be

			facilitated in the resolution" (SIT).
	OPPORTUNITY	The health emergency has opened up new opportunities for business diversification	"I am now working on the machines for one day to sterilise the environments to be offered directly to my customers, so I hope that in 10-15 days I will have them ready. The ones to sanitize the environments I had thought of sanitizing mine, then I saw that the demand is high, so I am thinking of producing these machines that I don't think will give me the large volume of business that I need to regulate myself with the residue, but, at least, we do a continuous service to the customer and then, since I make the products for cleaning, etc., the sanitizers, etc., I will try to enlarge that slice of products, so...". (L)
		The health emergency has provided an opportunity to anticipate and focus on certain activities, such as training	"With site technicians and staff who can't work remotely, we have taken advantage of the training they have to do annually and have concentrated it now. (N)
		The context of crisis and emergency has allowed the construction of new social bridges and the extension of its network of	"I already see positives in what you and I are doing, for example: with this excuse I got in touch with many people to understand what was happening. I have also made a lot of new contacts that also help me open my mind. Think

		knowledge	about how now there is a focus on old people and hospitality with social awareness, with private and public health discourse. Heavy public intervention while hospitality is addressed to the private sector. Now we understand the importance of welfare and union". (L)
		The emergency has led to a review of the modus operandi concerning the projects, as well as greater clarity of the critical skills needed to bring them ashore.	"There is also a profound overhaul in the way we now go about structuring projects and taking our product vision forward in the first instance. But, to tend towards it, I think it also applies to projects that do not focus on the product and that therefore helps to see all the aspects even in a phase of choosing a budget for a term or for the review, apart from designing - if I understand the question - this is what you are doing and in this project tool one of the things we are going to see are the Critical Skills so what are the skills that must be present that if they are not there must be acquired before we can release a project. This is it". (R)
		Distance selling and customer proximity can represent the future	"Distance selling will be a point to process. Pima we have to understand the real limitation that there will be in a few months to understand if it will be a real need. We sell spare parts online: the customer logs in, enters the system code and sees a 3D representation and chooses the part. This is growing

			exponentially and we think more in the future. Then there are customer proximity operations but they are independent of the crisis, they are part of a medium-long term plan". (N)
		Liquidity and loyal customers as resilience factors that significantly reduce the risk of insolvency	"Fortunately, I had a lot of liquidity so for a few months I was able to hold my own without even blinking an eye and then I didn't have such a strong influence on clients because I had a good relationship with them and companies are loyal, so they warned me if there were any problems. Please note that I had a 15% insolvency and I was warned in advance, so it's nothing" (L)
		The supplier fleet and, more generally, the system of collaborations, has seen renegotiations and reshapes	"Especially the larger ones demand renegotiations, just as we do with some suppliers. It's clear that we can't do much more than that, or else some people will end up with their legs in the air, so there must be consistent behaviour both upstream and downstream". (N)

Appendix A3: Coding collection of interviews, grounded theory Focus Group

Grounded Theory Focus Group

AGGREGATE DIMENSIONS	SECOND ORDER THEMES	FIRST ORDER CONCEPTS	REPRESENTATIVE QUOTATIONS (Company)
THE ROLE OF PROCUREMENT IN A RESILIENT SUPPLY CHAIN	**PRODUCTION AND PRODUCTIVE SYSTEMS**	Going towards full Lean manufacturing	"We are still studying Lean and we are not applying it yet, precisely because we want to apply it to the new shed that is being built, so we started with the layout of the shed with Lean consultants before moving on to the total management phase. " (BER)
		Lean as a working mentality before applying to manufacturing	"it's clear that finding people who are willing to give you two or three or five pieces when they want you and at the precise day and time is not easy, then I'm telling you that we are way off track and we have to apply Lean in terms of the sense of principles to be applied in the company towards the working mentality. As far as the supply chain is concerned, it has to be something softer and therefore more stocked than a tighter Lean" (BER)
		Efforts are made to be Lean	"we cannot say that we fully adhere to Lean technology, from an organizational point of view, in particular, even though we have been trying for a long time." (θ)
		Shifting from	"While we used to work on an absolute just-in-time basis, now there is a tendency to anticipate purchases of raw parts

		stockpiling to Lean manufacturing	more and more, so as to give workshops a little more peace of mind when orders are placed. So it is moving towards light stockpiling from Lean." (θ)
		Stockpiling is still a key for some types of goods	"Basically, we try to be and tend to be Lean, although, let's say, for certain types of goods we have to do some stocking first, but we tend to be there. Our production is a production that, although the model is both a just-in-time production and a made to stock production. " (IDY)

		Hybrid solutions between stockpiling and Lean manufacturing can easily respond to real time variations	"Salvagnini does not use any production model among those we say universally recognized, so we say assembly-to-ordeR, make-to-stock, make-to-order, engineer-to-order, etc. A momentary integration with a Just-in-sequence concept that is a bit more advanced than Just-in-time, because it integrates our suppliers within the operational production plan and intercepts any variation in real time and we go to manage the sequence of the codes on delivery, closes the delivery on time, because the sequences can change according to the product configuration. The stocks are managed in a diversified way by product, so something just-in-time, something just-in-sequence, we use all the part related to the kanban, security and reorder points, and then the classic MRP, Material Requirement Planning. " (SAL)
		Production unit won't produce as planned	"we have made a calculation and the production unit will not be able to get out the number of machines needed to recover. " (BER)
		Lack of skilled workforce has an impact	"The problem is that to make industrial machines you need a skilled workforce. " (BER)

		Lockdown as an opportunity to assemble complex machines	"We completed some assemblies that could also be done at a stop, when some assemblies, such as electromechanical ones, would be postponed to this summer. " (IDY)
		New shifts to avoid assembly	"In production, we have shifts slipped from 6 hours using a couple of hours a day, almost until August, in the Covid-19 lay-off box to avoid any kind of assembly in the common areas. " (SAL)
	SUPPLY BASE AS A KEY STARTEGIC FACTOR	Italian sourcing	"sourcing is mainly Italian, even if there is a little something abroad. " (BER)
		Local sourcing abroad and global sourcing are mixed	"No, our sourcing we say is 80%, as far as direct purchases are concerned, so for the operation of the plant, local, for our plant in Spain. As far as services and possible investments linked to the plants are concerned, on the other hand, we use them around the world, so this is the situation here. " (IDY)
		Global sourcing with an autonomous and independent pattern	"Sourcing is a function that operates on paper at a global level, but deals globally with suppliers of contracts across the various production sites. We make use of the factories' contracts and each one makes its own warehouse. In this sense they are decentralised hubs, since there is only a framework contract from which to draw, but each production unit is autonomous and independent in the

			procurement of materials from these strategic suppliers. ” (SAL)
		Renegotiations of payments	“It is likely to be necessary to negotiate sufficiently long payment terms.” (IDY)
		Renegotiations of financing and suppliers payments	“we have renegotiated all financing, therefore, both with the main suppliers and with any credit institutions we have renegotiated the terms of repayment of the loans in terms of payment, extending the deadlines, partly by using state subsidies, partly by making ad personam agreements with individual suppliers.” (IDY)
		Historical suppliers integration and involvement in designing products	“We have a number of historical suppliers with whom the relationship is integrated, in fact we do co-design activities, so for us the switch from one supplier to another is always very expensive and difficult to do, if not in conditions of absolute necessity. The fact that these suppliers are loyal suppliers and the company is loyal to them.” (SAL)

		Successful integrations lead to strong bonds and collaborations	"The company comes to them by granting advance payments or the purchase of goods that they keep from them and that we then collect over time: this happened, for example, in the lockdown when someone's closure, even from a financial point of view, marked them quite a bit. " (SAL)
		Loyalty first	"we normally deal with historical suppliers. " (BER)
		Relatively vast loyal suppliers portfolio to mitigate risk and rely on strong collaborations	"It is an integrated relationship for the strategic ones, because without them we would not be able to produce, therefore it is integrated and certainly collaborative, in the sense that we establish alliances with strategic suppliers, even if we always try to have alternatives, so never have a single supplier. " (IDY)
		Suppliers diversification paid off	"we have not lost any suppliers, but these suppliers have in some cases had heavy delays that have been partially compensated for by some, others have a little march on us at the moment ." (IDY)

		Strong suppliers guarantee some resilience	Let's say that eighty per cent of these investments were made with three to four main suppliers, so there were also some important relationships that were a little outside the Covid-19's contingent situation. To date there have been no cancellations, but clearly we have asked suppliers to help us out by saying that where there was no financing or direct payments, we have asked them to pay discounts, etc., in return for any delays in supplies. ” (IDY)
POST-DISRUPTION MANAGEMENT FOR A RESILIENT SUPPLY CHAIN	**SAFETY**	Crisis put security on the spot	“Covid-19 protocol I have found it at best to our possibilities, at least we think we manage it properly and so we continue to do so. Now we also have a security consultant. ” (BER)
		The pandemic require many precautions	“I have also arranged for the use of glasses and top glasses, for extra protection. We disinfect once a week the company, the cars, every car when they are serviced. ” (BER)
		Uncertainty drove more attention to safety	“not knowing what would happen, to manage a slow restart, so all the constraints we had said in the protocol on the safety conditions to be applied within the production departments, including spacing, re-entry at set times, somehow pushed us to make a slow re-entry. ” (SAL)

		Covid-19 task force to face to the crisis	"there is a permanent task force alongside the geb i.e. the executive board group that meets almost regularly to assess the time to time consequences and problems that various restrictions in various parts of the world can create for our business. the project involved the same top managers as θ, but, for the moment, the activity has been temporarily put aside, but it does not mean that the planned activities do not go ahead, but simply do not have an executive to report to, until we are out of this situation. " (θ)
	ANTECEDENTS OF RISK MANAGEMENT TO LEVERAGE IN A POST-DISRUPTION MANAGEMENT PERSPECTIVE	Education and its potential is recognised by the institution of an internal academy	"As far as training is concerned, on the other hand, we have an institution within θ that we do not define as a product, but rather as a service, called θ Academy, which is responsible for the training of all staff: continuous training for all internal staff who are also involved, on the one hand, in the recruitment of special professionals and, on the other, in the recruitment of emerging professionals from universities ." (θ).
		United to share technology know how and costs	"There are some companies that have privileged relations with us, even partner sharing, or are in a network of companies with us and therefore provide technology to support vertical applications in

			the steel industry. ” (θ)
		Networking for reaching more and mitigating risks	“In our case, in particular, we have joined a project that we have partly supported with MISE funding that allows us to develop together with three other business partners completely different from θ a manufacturing platform that we share that has been assigned in terms of development to a local software house, which, in turn, guarantees perfect transparency of intent to all three stakeholders, in this case the three partners. We have set up a network of companies: it is a well-defined legal entity.” (θ)
THE ROLE OF TECHNOLOGY IN A RESILIENT SUPPLY CHAIN	**IOT AS A POWERFUL TOOL FOR RESILIENCE**	Remote conditioning to stay close to the customers	“On the other hand, from the post-starter point of view, the visibility of some critical equipment at a distance has changed, with, as I said, an asset management project that allows us to see vital parameters of some suppliers' machines, we speak of machines as whole systems, in order to guarantee maximum reactivity in assistance .” (θ).
		Covid-19 accelerated remote projects	“remote control or those projects that have undergone a sudden boost more important than others.” (θ)

		Remote Installation helped not to lose clients	thanks to the 4.0 technology we have been adapting our machines since 2018 for remote connection and therefore, not having the possibility to travel for Covid-19 reasons to many countries around the world, at least we were able to do remote installation, which helped us. ” (BER)
	IT AND ITS BASIC APPLICATION	Traditional remote assistance is a safe back up plan	“if not directly with another help via Skype, or remotely, when we connect, and then remotely with a Skype call directly with the assistant's mobile phone to see together how, let's say, to carry out the test. We have seen that so far this has been more than enough .” (BER)
		Information systems have been tested properly	“On the positive side there were several things, in the sense that, starting from the information systems with which we would have had to stop a plant in order to do a test, this allowed us to implement all the tests (IDY) at that time, being unable to do anything else. ”
		Blockchain remains unexplored and digital culture needs to be reinforced	“No, we did not opt for blockchain solutions. On the other hand, as far as digital staff training is concerned, let's say it has two gears: we have a conventional part that is probably still a few steps ahead in the use of the instrumentation and tools that the market makes available, but the change is still not

			adequate, while there is a part of the company that deals more intensively with high technology. ” (θ)
		Dematerialization of the office is occurring	“Even from the point of view of production sites we do not have, for example, anyone in the company has a desktop computer, but we have mobile laptop computers, because regardless of the Covid-19, there is a dematerialization of the office concept and it is an obsolete concept .” (IDY).
		Information sharing is still traditional	“Typically by e-mail. We then have a software that notifies the supplier directly. ” (BER)
		Communications tools are still ordinary	“even remotely, we have the possibility to check what is happening with the production data for the other platforms. For ordinary communication and meetings the Microsoft teams demo etc. etc. and a bit sharepoint. These are the tools we use.” (IDY)
		Transparency is taken into consideration	“placing of a node for each building site at the same time as each building site is opened, as a consequence the building site itself becomes a protuberance of θ, so from this point of view nothing has changed. ” (θ)
		Sticking to tradition	we continue to use our information system, a system called sharing purchasing.” (θ)

		Sharing information is not given too enough importance	“Sharing information with suppliers is done in the traditional way through applications set up in our traditional management system .” (SAL)
		Investments on platforms are believed to belong to more complex structures	“We are not, let's say, yet a company that has a structure, a complexity, that allows us to make investments on platforms, or something like that, our main supplier district is close to the plant, so we don't need to digitize that part of the supply chain procurement.” (IDY)
		Covid-19 has accelerated digital transformation	“technology investment plan, especially in digital transformation, which was already very clear before Covid-19 and continues to be so. Let's say rather that it has accelerated. ” (θ)
		Investments in technology are kept unaltered	“The technology investment plan has not changed.” (SAL)

Appendix B1: Interview protocol Phase 1 cluster

1. ***Role of the interviewee***

Briefly describe your role within the company.

2. ***General impact on business***

2.1. What is the overall impact on business of the measures put in place to tackle the pandemic?

2.2. Are you recording a loss of operations due to staff reductions, holidays, smart working activation, in office processes? How are service activities impacted, compared to other areas of activity?

3. ***Impact on field service operations (FSO)***

3.1. What is the overall impact on field service operations (FSO) due to the measures put in place to tackle the pandemic? In which ambit/process did you find the greatest impact?

3.2. What are the most relevant problems you have faced in emergency and emergency conditions?

3.3. What are the only practical solutions adopted, actions taken or in progress to address the above problems?

3.4. How well have the needs of FSOs been understood and identified in the plans, procedures and task forces to which the task of managing the emergency has been delegated?

3.5. To what extent are these solutions, having been implemented in emergency conditions, presumably sub-optimal, and therefore far from being able to guarantee sustainability, efficiency and effectiveness in solving the problem, even over longer time horizons (for example, if this emergency was - as in some pessimistic scenarios - destined to last for many months)?

4. Critical factors that have hindered the development and/or implementation of optimal solutions.

In relation to point 3.5 above, which factors - in your perception - have hindered the development of optimal solutions? Please refer to the following categories to formulate a detailed answer:

a) Lack of knowledge: We had no knowledge/we were neither informed nor prepared about the problems we had to face or the solutions to be undertaken;

b) Lack of an ORGANIZATIONAL REFERENCE MODEL TO REFERRED TO INCREASE CRISIS MANAGEMENT RESPONSIBILITIES. We did not have a reference model for crisis management, which could be activated quickly and to which we could delegate every decision, with specific responsibilities and resources.

c) LACK OF OPERATING CAPACITIES, RESOURCES AND INFRASTRUCTURES ON WHICH TO IMPLEMENT OPTIMAL SOLUTIONS. We did not have the operational resources, skills and infrastructure to quickly implement the solutions identified as optimal, so we turned back - aware of the difficulties and risks - to practical solutions that were certainly not optimal and perfectible, but could be implemented in a short time. In particular, the limits and shortcomings in question are mainly attributable to:

c.1 operators' skills (e.g. knowing how to use smart working or remote assistance solutions)

c.2 support tools and procedures (e.g. lack of technologies and platforms for smart working or remote assistance with adequate number of licenses, laptop equipment for all technicians, etc.).

c.3 cultural factors (e.g. perception by the workforce of what is right to do/how to behave in these situations, without any kind of taxation/regulation having to be imposed/negotiated between employer and employee/your representatives)

c.4 factors of a legal-normative nature (e.g. the responsibility of management and over-relevant top management who have imposed or requested a certain type of solution)

c.5 lack of committment and priorities

5*. Role of digital technologies*

5.1. How much in the near future do you think your organization will need to boost the adoption of digital technologies (e.g. remote condition monitoring, remote intervention, smart working, workflow management systems, etc.), also as a tool to contain the impact of new and possible crises of this magnitude, or the continuation of this pandemic?

5.2. In particular, which technologies are in your opinion the most promising?

Appendix B2: Interview protocol Phase 2 cluster

1. Role of the interviewee and company characteristics

1.1. Briefly describe your role within the company.

1.2. What is the technological equipment of your company? (ERP system, cloud and SAAS systems, laptop and smartphone equipment for employees, workflow tools, sales force and CRM management tools, field service management tools, ...).

1.3. How do you rate the digital readiness of your company (modernity of the solutions adopted and sharing a digital culture in the company)?

1.4. What is currently your company's share of turnover represented by services (total after-sales including field service and maintenance contracts) (%), and what scope for expansion in services not yet exploited do you think there is for you?

1.5. You believe that the Covid-19 crisis is predominantly for your company:

- an opportunity
- a threat

1.6.As far as the resolution of the crisis and return to normality is concerned, you think rather:

- optimistic
- pessimistic

2. General business impact of the crisis (during, Quick & Dirty phase)

What has been the impact of the crisis on the main areas of the business model? In particular: [if possible respond by providing an order of magnitude % of phenomena; respond where applicable].

- What was the % impact on the activities of the production sites?
- What was the % impact on revenues and customer orders for products?
- What was the % impact on revenues and customer orders for after-sales services (spare parts)?
- What was the % impact on field service activities (maintenance and interventions at the customer's premises)?
- What was the % impact on revenues and customer orders for maintenance contracts (mid or full service contracts)?
- What was the level of loss of operations (% reduction in staff, holidays, CIG, ...)?
- How much did you use smart working, for the different types of work (% on the type of employees)?
- What training activities were implemented during the crisis period?

- What were the main problems that emerged when dealing with the crisis and what interventions have you implemented to address them? In particular:
    - On the internal side (e.g. organizational skills and equipment, procedures and material equipment, infrastructure and software,...)
    - On the external side (e.g. government regulations and provisions, local or supralocal institutions, other environmental variables, international outlet markets, international supply chains, ...).
- What were you ready for and what were you unprepared for?
- In particular, how has your digital readiness affected the crisis? (previous technological choices - adaptation of IT infrastructure and cloud migration of archives, documents, applications and office automation tools, and adaptation of devices and infrastructure - which were immediately used and tested).
- What was the role of services in supporting sales during the crisis?

3. Situation at the reopening immediately after the crisis ("Restart" phase)

3.1. How was the restart (Phase 2, Restart) for your company? In particular:

- When did you reopen?
- What degree of operation do you have TODAY with regard to the areas mentioned in question 2.1 (production sites, orders and sales of products, spare parts, field services and service contracts)?
- What is the situation in your channels (distributors and logistics)?
- What is the situation of your customers? (how did the crisis impact on purchasing behaviour, communication and customer relations, customer segmentation)
- What kind of adjustment phase do you expect (gradual increase, rebound, market reduction, ...)? (distinguish between orders / orders permanently lost and postponed)
- Do you foresee intermittent reopening / closing phases? If so, what solutions do you have in mind?
- Are there any problems resulting from international lockdowns?
- What capacity adjustment challenges (in products and services) do you have in mind?
- Have you thought about offering specific products and services for this restart phase?
- Have you started using technological solutions not previously used? If yes, which

ones?

- What organizational adjustments have you made in this phase?
- How much recourse to smart working (in % of the type of employees) do you have TODAY?
- Which innovative projects or others "in the drawer" were taken up or relaunched during the crisis?

4. ***Situation after the crisis (Adapt phase or "the new normal")***

4.1. What will the "new normal" be and what changes are required from your company to adapt to it? In particular:

- What opportunities and threats does the future present to you (e.g. market contraction, default of suppliers and partners, distributors, infrastructure and legal conditions, new mobility, ...)?
- Do you have plans to increase the use of smart working (digital transformation of back-end processes, new tools for collaboration and sharing of work content, training and cultural change from control to responsibility...)? If yes, which ones?
- Do you have plans to restructure your supply chain (e.g. re-treating relationships with partners, opening branches / offices, greater autonomy for branch offices)?
- Do you have plans to change your sales network? (articulation and type of resources and skills; strengthening of service sales capacity; strengthening of distant selling)
- Do you have plans to modify your field service network? (articulation and dislocation, type of resources and skills)
- Do you have investment plans for digital solutions concerning the product/service system (e.g. factory robotization, IIOT and IOT solutions, retrofitting of distributed products, Remote Condition Monitoring, Augmented Reality, Digital Twins, Cloud platforms, 3D printing, ...)?
- Which of these (and other) technologies are most promising for you?
- Do you have plans to introduce new products / enter new markets?
- Do you have plans to introduce new service solutions for your customers (e.g. full service product packages, advanced maintenance contracts, predictive maintenance, pay-per-use or renting solutions, facilitated purchasing solutions, risk sharing or full-risk contracts)?

- Do you have plans to invest in digital solutions that relate to communication and customer and market relations? (BtoB ecommerce, digital trade fairs, BtoB social presence,...).
- Hiring programmes or development of new skills and/or resources? If yes, which ones?
- Do you have plans to use data and usage analysis to inform the design of products and make them increasingly tailored to customer needs and to be the basis for service delivery?

Appendix B3: Interview protocol focusing on procurement, disruption management and blockchain

1. ***Role of the interviewee***

Briefly describe your role within the company.

2. ***Focus on Procurement***

2.1. What role does procurement play for you and how have its horizons and strategic objectives changed following Covid-19?

2.2. Is procurement integrated with the other divisions or does it play a separate role?

2.3. Do you enact a Lean or Stockpiling approach?

2.4. Do you use global sourcing or local sourcing? Do you have long or short SC?

2.5. Did procurement go through centralised hubs or decentralised systems?

2.6.What kind of relationship exists between you and suppliers (basic, collaboration, interdependent, integrated)? How is your supplier base characterized (flexible, loyal)?

2.7.How have relations with suppliers changed since Covid-19? Have contractual renegotiations been requested? Have any of them been lost due to closure of activities?

2.8. What were the KPIs related to the supply chain and how did you intervene in the light of the Covid-19 crisis?

3. ***Focus on Post-disruption management***

3.1. What choices have been made about the Covid-19 crisis? By whom and how were they measured and addressed? Is there any business continuity or disruption recovery planning in place? Can you describe it?

3.2. What decisions have been taken on future prevention following the end of the emergency?

3.3. Have you started collaborating with third parties or built new partnerships?

3.4. What were the key factors influencing post-disruption management?

3.5. In case of not having one, have you taken into consideration the use of ERP systems to improve quality and dissemination of information?

3.6. Have you developed a new integrated system for SC?

4. Focus on Technology and Blockchain Technology

4.1. What technological solutions have been chosen to respond to the crisis and how has the technology investment plan changed?

4.2. How do you share information between you and your suppliers?

4.3. Are there supply chain-specific tools and new applications?

4.4. How do you rate digital staff training? Have you opted for Blockchain solutions?

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