Università degli Studi di Padova

Department of Economics and Management

Master Program in Business Administration

DIGITAL STRATEGY IMPLEMENTATION IN PROCESS MANUFACTURING FIRMS:

THE SIRMAX CASE

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Firma

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EXECUTIVE SUMMARY

The cover of *The Economist* magazine, published in May 2017, was entitled “The world’s most valuable resource. Data and new rules of competition”: digital transformation topic has been debated for few years, and the attention has shifted also to competition related to technology, until in March 2018 the same magazine entitled a new copy “The battle for digital supremacy” referring to the challenge between the US and China. Many researches and magazines has emphasized the importance of digital transformation from a business point of view, but very recently the attention has been moving towards digital implementation in business firms. In fact, a research conducted by McKinsey published in October 2018 investigates some cornerstones to effectively implement digital strategy (Bender et al., 2018); a report published by the same consulting firm in September 2018 focuses on how organizational culture, guided by firms’ leaders, may accelerate data analytics usage to make better decisions (Díaz et al., 2018). Another survey conducted by McKinsey published in November 2018 highlights importance of IT and business infrastructures in digital transformations and that a lack of coordination between business and IT weakens the change (Blumberg et al., 2018).

Purpose of the thesis

The interest about digital technologies originated by my tour in Silicon Valley, California (US) to visit businesses and institutions in a territory where tech-firms are growing. After having tasted the flavor of technological development, all this raised a question, that is which effects of this kind of technologies are observed in a business environment. This led to the elaboration of the dissertation about how a prospected change might be implemented in business organizations. Moreover, the interest in a specific company led to study how a digital strategy may be implemented in process manufacturing firms.

What is studied

The thesis researches how digital strategy may be implemented in process manufacturing firms and finally investigates the SIRMAX case.

The macro argument is unpacked in three pillars in Chapter One, namely digital strategy and business model change, digital technologies and organizational modification, following the example of Butera in the article "I tre pilastri della quarta rivoluzione industriale" (Butera, 2018) which proposes technology, organization and work as critical aspects. In the article "Digital transformation: what is new if anything" (Lanzolla et al., 2018), institutions and strategy, business models and organizational innovation, individual career choices and capabilities are selected as cornerstones.

In Chapter Two a literature review about digital strategy implementation is conducted using different sources: journal articles, research reports, university researches and books. The importance of the strategy, the institutions and leadership in the change, the skills often required, and the required organizational change emerged from the analysis. Moreover, a literature review about technologies illustrated in one of the pillars of Chapter One is presented as well.

The investigation moves further in Chapter Three, with the examination of a case study about digital implementation in discrete manufacturing firm, published in the journal *Advances in Mechanical Engineering* (Zheng and Ming, 2017), chosen for the detail of the analysis. A distinction is made to distinguish between the concepts of discrete manufacturing and process manufacturing. After asking a digital implementation-expert consulting firm, two companies were selected for a benchmarking analysis: ASO Hydraulics & Pneumatics and Stevanato Group. The former illustrated technological and operational aspects of the implementation; the latter exhibited main strategical steps and organizational obstacles influencing the digital implementation.

The insights gained from literature review and benchmarking analysis are the basis to analyze the SIRMAX case in Chapter Four. The Italian process manufacturing firm producing polypropylene compound, has been growing in revenues over the last few years and has the objective to exploit digital potential to continue in its growth.

Main Findings

Once the macro topic of digital transformation has been divided in three pillars to have a clearer view of each, a literature review has been conducted to find out which has been the state-of-the-art in digital implementations over the last ten years. Even though digital implementation has started, a lack of skills, long-term vision and organizational change have been highlighted; the review has been conducted also to understand technologies' features and their known potential. Real cases of digital implementations have been analyzed, discussing some operational issues, strategical and organizational pitfalls. Insights gained in literature have been confirmed and deepened by the benchmarking analysis, outlining the lack of digital maturity about technological application, the importance of strategical formulation and the resistance to change in the organization.

A technological and strategic formulation to face the transformation in SIRMAX is added in Chapter Four. Besides technological aspects, long-term vision and corporate culture seems to be very important. Since there are many possible technological applications and the pace at which these innovate is very fast, the strategic value of the transformation is related to the technology selection and timing of the change. SIRMAX may benefit from a forward-looking and agile transformational approach, meaning being able to stay ahead of the curve despite changes can appear more frequently than in the past. These facets are then summarized in a roadmap for the digital strategy implementation in process manufacturing firm.

1. CHAPTER ONE

WHAT DIGITAL TRANSFORMATION IS

1.1 Introduction

Digital transformation has been differently defined by several authors or authorities. According to Westerman et al. (2011, p. 5), “digital transformation is the use of technology to radically improve the performance or richness of enterprises” (Westerman et al., 2011); Mazzone (2014, p. 8) wrote “digital transformation is the deliberate and ongoing digital evolution of a company, business model, idea process, or methodology, both strategically and tactically”. In the view of BMWi (2015, p. 3), the German Federal Ministry for Economic Affairs and Energy, digitization means networking of all sectors in the economy and in the society, together with the ability to collect relevant information, to analyze and translate information into actions; digital transformation describes the fundamental shift of the whole business world through the adoption of new technologies connected by the internet with a critical impact on society at large. Schallmo et al. (2017, p. 4) define digital transformation as a “framework that includes the networking of actors such as businesses and customers across all value-added chain segments and the application of new technologies. As such, digital transformation requires skills that involve the extraction and exchange of data as well as the analysis and conversion of that data into actionable information. This information should be used to calculate and evaluate options, to enable decisions and/or initiate activities. Digital transformation involves companies, business models, processes, relationships, products” (Schallmo et al., 2017).

Since digital transformation is such a huge topic, some documents select potential splits that could ease the analysis. Specifically, to identify the three pillars that will be considered as reference point in all the research, two articles recently published from two important journals have been considered.

These two reports present digital transformation divided in three key parts: in "I tre pilastri della quarta rivoluzione industriale" (Butera, 2018), technology, organization and work are proposed as critical aspects; while in the article "Digital transformation: what is new if anything" (Lanzolla et al., 2018), institutions and strategy, business models and organizational innovation, individual career choices and capabilities are identified as key elements.

Following this division, Chapter One is organized in three pillars, even though in a different mix that comprehends elements reported in the mentioned elaborations: digital strategy and business model change, related to new visions and value propositions; digital technologies and applications, concerned with significant technologies refined over the last few years; organizational change, associated to the impact of the transformation on people inside the organization.

1.2 Digital Strategy and Business Model Change

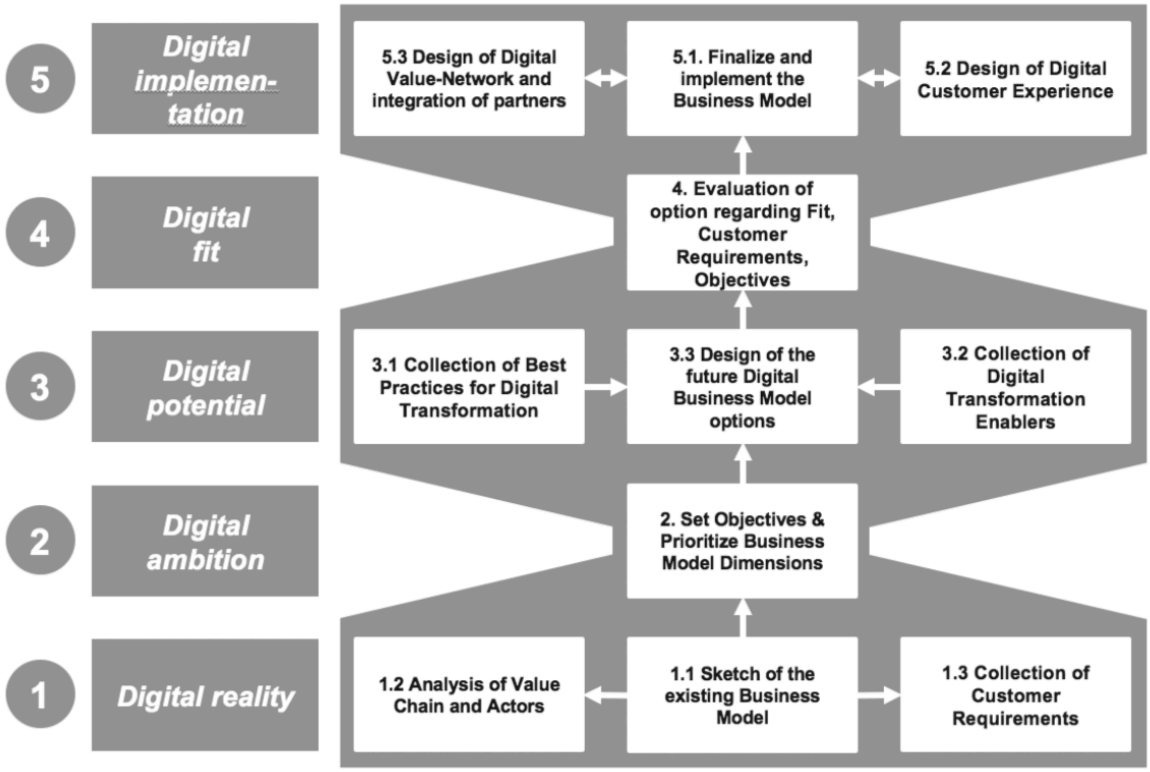
In this context, a business model is the basic logic by which benefits are provided to customers and partners; the value created allows differentiation from competitors, the strengthening of the customer relationship and the achievement of competitive advantage. Value may be captured by building complementary independent sides able to create an architecture from which value is generated from different sources, particularly in digital industries (Schallmo et al., 2017; Gandia and Parmentier, 2017). Forces driving businesses in general are the same that drive digital business, but the value concept for the latter is not fixed; there are more choice opportunities to expand the space or the dimension at which a firm operates (see The Case Box 1). Successful digital companies caught an opportunity building real value: many firms neglect choices of tomorrow's customers and what tomorrow's customers may value the most (Keen and Williams, 2013).

A feasible approach may be the one of a roadmap based on existing theories about business model innovation (Figure 1):

- Digital Reality: company's existing business model is outlined with a value-added analysis related to customers' requirements and other stakeholders;
- Digital Ambition: definition of the digital transformation objectives, in relation to time, finance, space and quality;

- Digital Potential: establishment of enablers and best practices for having a starting point to design a future digital business model combining business model elements;
- Digital Fit: analysis of the options for the design of a digital business model, to ensure that customers' requirements are fulfilled and business objectives are achieved;
- Digital Implementation: digital business model implementation by defining a framework formed by resources and capabilities to allow creation and integration of new options or changes in the existing model (Schallmo et al., 2017).

Figure 1: Roadmap for Digital Transformation



Source: "Digital transformation of business models – best practices, enablers and roadmap", (Schallmo et al., 2017).

Digital implementation is permitted by enablers, which allow to use applications or services for the business model digital transformation.

Those enablers may be grouped in four main categories:

- Digital Data: collection and the processing, as well as the analysis of data for facilitating and improving the decision-making and for having insights for the future;

- Automation: combination of classical intelligence and artificial intelligence that enables autonomous work, reducing errors, increasing speed and lowering costs;
- Digital Customer Access: mobile internet allows the client's direct access. This access must be transparent and must comprehend new services;
- Networking: interconnection of the whole value-added chain via high-speed broadband telecommunications, which permit a reduction in production times and innovation cycles (Schallmo et al., 2017).

The Case Box 1

The **NETFLIX** case

business model re-invention

A Business Model reinvention implies the re-thinking of the core business – and so the entire business itself: Netflix is a well-known example of continuous reinvention. The evolution and re-designing brought the company from being a DVDs renter, through streaming entertainment for a monthly subscription, to a company that now creates its own content. Obviously, reinvention requires a lot of commitment; it is not only about deciding the right investment or the good strategy, but also bring the change at a large scale, in the entire organization. A myriad of capabilities is required, but what is often missing is a comprehensive view of how an organization sets the right ambition, how to architect and put together the proper elements for the transformation, how to systematically undertake the change journey (Dahlström et al., 2017).

Source: "From disrupted to disruptor: Reinventing your business by transforming the core", (Dahlström et al., 2017).

1.2.1 Value Proposition, Processes, Technology and People

Thinking about a real core reinvention, the focus is on the value proposition, shaped and operated through a clear strategy, enabled by processes, technology and especially people. A digital reinvention should be built based on the value provided by means of products and services from company to customers. It is therefore important to identify and evaluate those assets that drive value creation in relation to customers' desires (Dahlström et al., 2017).

The Case Box 2

The **DELL** case

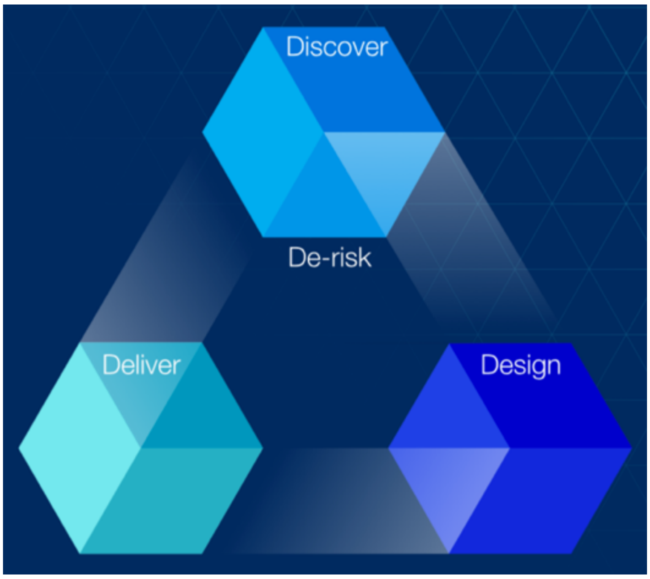
supply chain re-organization and client's services

Dell's strategy, based on direct sale to the final customer and the on-demand manufacturing, is characterized by disintermediation in retail supply chains. Two important trends of digital age are highlighted: the reorganization of industry value-chains and the critical role of services. Information Systems has been fundamental both to share knowledge and support business processes; this impact is demonstrated by cost reduction occurred (lower inventory), faster lead times (in logistics and production), financial optimization, customers' segmentation, product portfolio product portfolio, growth of sales (mainly internationally). In the Dell case, information systems and IT function had a prominent role to transform the business model. (Delmond et al., 2017).

Source: "How Information Systems Enable Digital Transformation: A Focus on Business Models and Value Co-Production", (Delmond et al., 2017).

Re-shaping processes and mechanisms, digitizing or automating supply chains and information-intensive processes, can increase the business speed and reduce costs (The Case Box 2). Technology and new skills are important to re-design processes, but establishing governance and decision rights is fundamental to provide accountability. Technology itself is clearly not enough: it might be dangerous to invest in technology if the implementation is not tailor-made for the characteristics of the company or the industry, and people may be the most important enablers in any transformation. (Dahlström et al., 2017).

Figure 2: The 4Ds of a digital transformation



Source: "From disrupted to disruptor: Reinventing your business by transforming the core", (Dahlström et al., 2017).

According Dahlström et al. (2017), there are four Ds in a systematic approach toward a reinvention for digital transformations, represented in Figure 2:

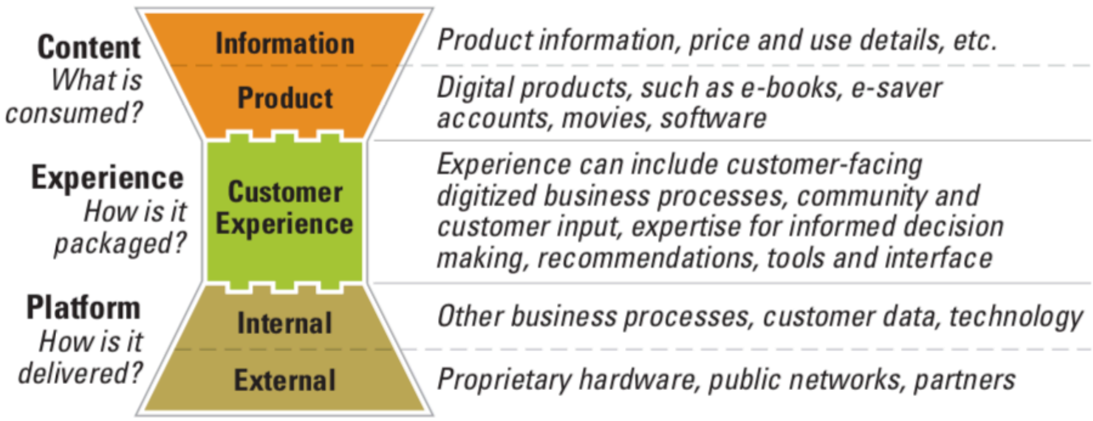
- Discover: shape digital ambition, strategy and business case based on insights;
- Design: prototype new capabilities and breakthrough journeys as part of the program;
- Deliver: activate an ecosystem to rapidly deliver at scale;
- De-Risk: structure the change program. Resources and commercial model to reduce operational and financial risk.

The scalability of a business model is related to the value perspective of shareholders, identifying strategic partners, gaining high level of detail on business models. Innovation creates ecosystems and sometimes a new entrant with a different value proposition may alter the value perception of the market (Lund and Nielsen, 2018; Dedehayir et al., 2017).

1.2.2 Content, Experience and Platform

Customers are demanding to interact with, enterprises should strengthen their digital business models and how they engage customers anytime and anywhere. The MIT Center for Information Systems Research did a two-year research through a survey involving 118 companies in different industries: data on content, experience and platform of interviewed companies (Figure 4) were collected; then, the analysis was shared with the interviewed executives to create success for companies' transformations (Weill and Woerner, 2013).

Figure 3: The Three Components of a Digital Business Model



Source: "Optimizing your Digital Business Model", (Weill and Woerner, 2013).

The Case Box 3

The **AMAZON** case

content, customer experience, platform

Considering Amazon's retail customer digital business model, the content (what is consumed) is formed by digital products like movies and software. Some products have changed the status quo: Amazon e-books outsold physical books for instance in 2011 for the first time. Customer experience at Amazon includes the website and the processes through which the customer gets in touch with the company or the product, like the shopping cart and options of payment, messaging and delivery alerts. At Amazon, internal platform is concerned with customer data, finance, human resources, merchandising (processes that do not touch the customer); external platforms comprehend computers, phones and everything that consumer uses for products purchasing, even logistics company partnerships (Weill and Woerner, 2013).

Source: "Optimizing Your Digital Business Model", (Weill and Woerner, 2013).

Controlling a stable platform raises competitiveness, because it triggers a family of derivatives: companies equipped with a product platform usually compete in economies of scope or scale. A platform is composed by layers of digital technologies, including devices, network and valuable content (Kazan et al., 2018; Parker et al., 2017).

The Case Box 4

The **THYSSENKRUPP** case

value from information stream

One division of ThyssenKrupp, a German industrial group, produces elevators and escalators. The installation, maintenance, repair and modernization services are offered to customers. Nevertheless, competitors began offering elevator maintenance service-packages, which entail high-margins. ThyssenKrupp created MAX, the Elevator Monitoring System to identify causes of failure in advance. A real-time information flow that provide key insights about the elevator's status is required, so sensors on elevators' components were installed. These changes allowed the company to have improvements on resources, maintenance planning and costs, as well as reduction in elevators' downtime. ThyssenKrupp considered information ignored before, used to provide value for the customer, therefore creating profit. Digital transformation is a continuous process: there are many opportunities to take advantage from digital actions (Schallmo et al., 2017).

Source: "Digital Transformation of Business Models – Best Practice, Enablers, and Roadmap", (Schallmo et al., 2017).

Weill and Vitale (2002) define the IT infrastructure as the union of four stable components:

- Hardware and basic software;

- Skills, methods, standards and computer specialists' experience;
- Shared services (intranet, network accesses, management of shared data);
- Standard applications shared by all in the company that are more and more extended to an increasing number of business processes based on best practices.

An example of a company case featured by the elements content, customer experience and platform is provided in The Case Box 3; while The Case Box 4 describes a firm exploiting value through a new source of value for customers concerned with information.

The Case Box 5

The **SALESFORCE** case

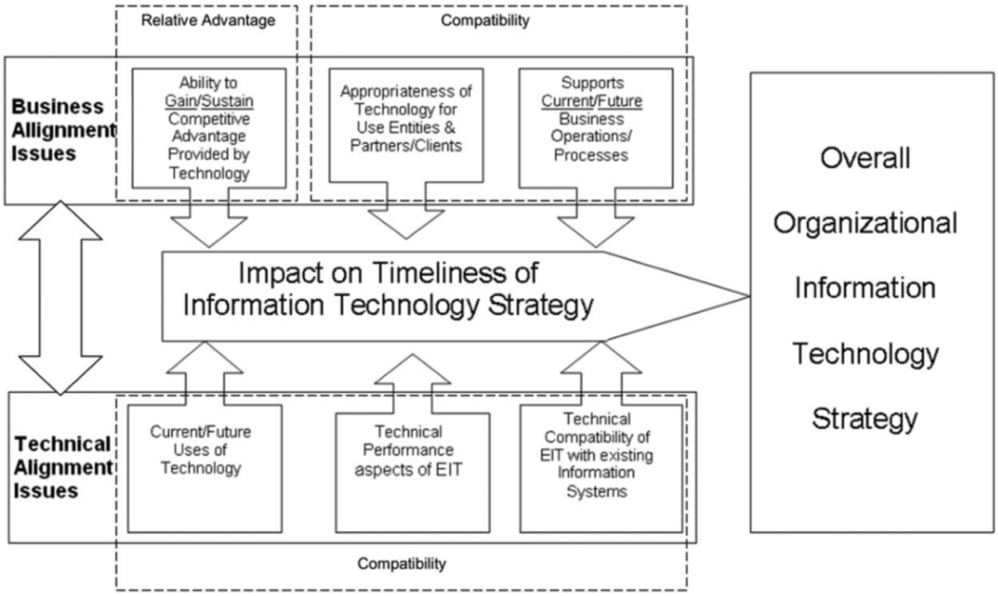
value co-creation with customers, partners, competitors, vendors

Salesforce provides IT solutions for business applications using a Clouding Computing model and relies heavily on partners. Salesforce's competitors may also be partners, like Oracle, Microsoft or SAP for the CRM offering. Salesforce is active in developing solutions through partnerships with various subjects: with customers, like the innovative solution of a module progressed with CISCO; with Consulting Partners, some installations are done by approved consulting partners supported Salesforce. Other partnerships are established with Independent Software Vendors: most applications requires a validation process that needs responses from Salesforce, the independent vendor and an integrator. Moreover, Salesforce counterattacks the risk of clients' contract non-renewal through strong customization. Another strategic key is the ecosystem created by Salesforce: markets are targeted globally through local teams and many partners (Delmond et al., 2017).

Source: "How Information Systems Enable Digital Transformation: A Focus on Business Models and Value Co-Production", (Delmond et al., 2017).

Lack of a clear vision and therefore lack of suitable capabilities are causes of not successful digitalization (Ross et al., 2017). An example of a complex company architecture is described in The Case Box 5, where different actors playing a part in an enlarged firm environment. The connection given by platforms is strategical, since allow to recognize data-centric strategies and to move towards new technologies starting from IoT and Cloud Computing. Indeed, competitive advantage is not concerned with single application of technology to produce benefits for a limited time, but a continuous effort for technologies' integration management (Parker et al., 2018; Cegielski et al., 2013) as illustrated in Figure 5, where business and technical issues alignment is described as crucial for firms' lasting development through new technologies' application.

Figure 4: The Emerging Information Technology evaluation model



Source: "Evaluating Adoption of Emerging IT for Corporate IT Strategy: Developing a Model using a Qualitative Method" (Cegielski et al., 2013)

1.3 Digital Technologies and Applications

1.3.1 Connectivity and Smart Factory

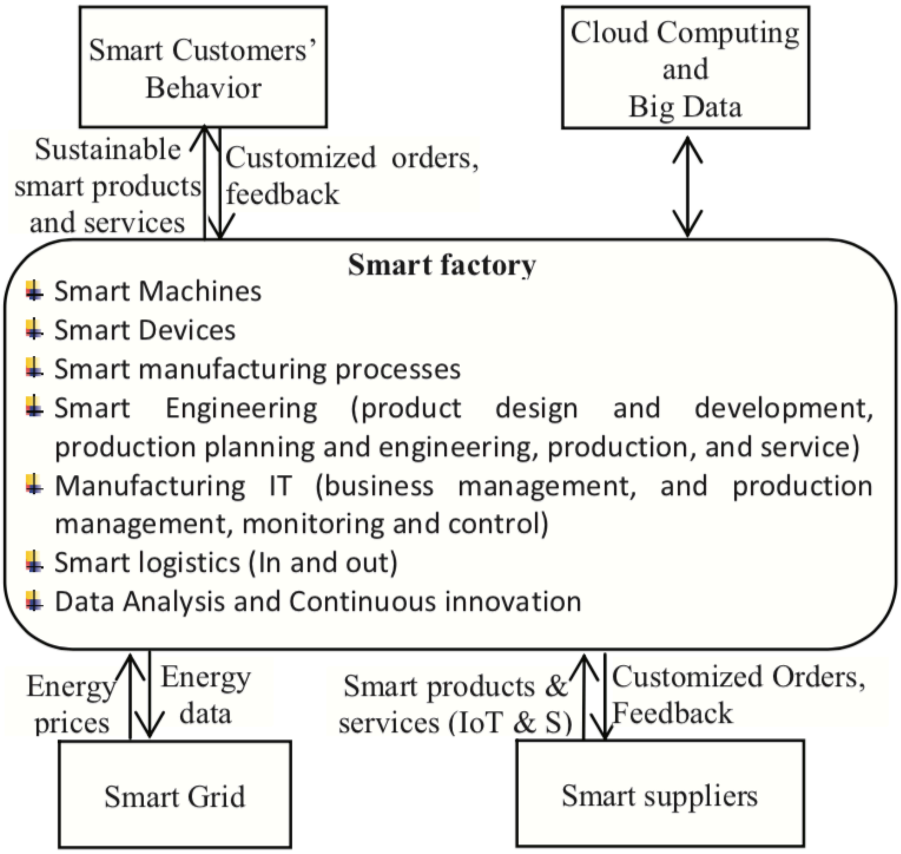
"Industry 4.0" has been a widely-used term since its diffusion in Germany after 2010, and it involves the utilization of communication networks to connect modern technologies in production processes. Industry 4.0 is based on intelligent, flexible and decentralized structures: integration of cyber-physical systems based on the Internet of Things, production and logistics (Odważny et al., 2018). The scopes of Industry 4.0 are:

- Facilitating the contact and cooperation between people and machines with systems that allow information and communication in real time;
- Production of individual items manufactured in small batches based on high efficiency;
- Allowing flexible and efficient, high-quality production process;
- Realizing a global network influencing business models and corporate structure.

Introducing devices that enable a flexible and dynamic system management, considering the customer's importance (Odważny et al., 2018).

Among those devices, there are smart wearables, portable microcomputers equipped with sensors that can be kept on the body: smart glasses, grooves, watches, trackers are some examples. Smart wearable enable hands-free information processing for employees in the workplace and are becoming important to motivate employees, acting like an assistant and not like a tool that replaces workers (Sun et al., 2018). The interconnection and the communication machine-human-machine is the fundament of digital factory and allow faster employees' decision making, reduction of confusion and shop floor monitoring. The exchange of data between different devices in real-time is the critical element of the smart factory concept. Furthermore, the relationship between smart factories and customers in industry 4.0 is enabled by smart products and services connected to the internet and provided to the customer (Sun et al., 2018; Shrouf et al., 2014).

Figure 5: Reference Architecture for IoT-based smart factory



Source: "Smart Factories in Industry 4.0: A Review of the Concept and of Energy Management Approached in Production Based on the Internet of Things Paradigm Optimizing your Digital Business Model", (Shrouf et al., 2014).

The architecture for an IoT-based smart factory is represented in Figure 6, where the manufacturing concept is related to computer usage and information gathering involvement:

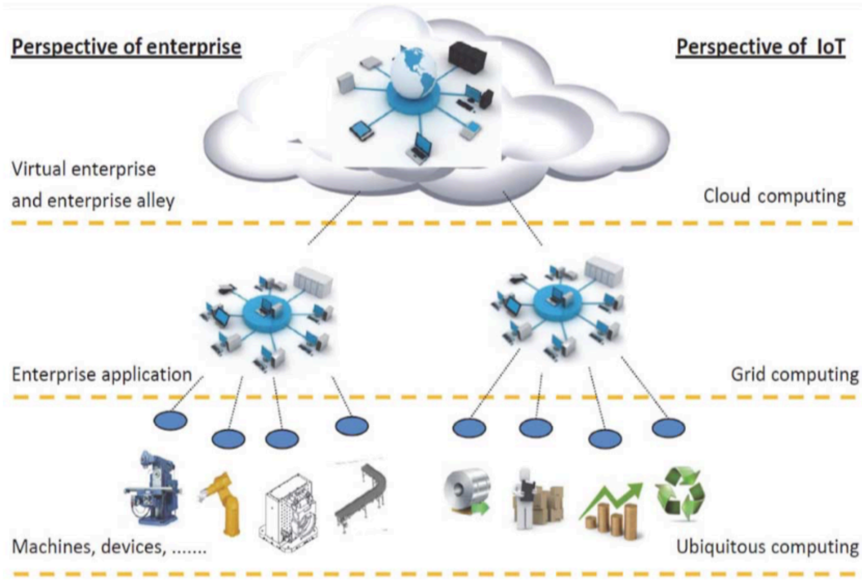
- Smart Machines: including machine communicating with other devices and humans;
- Smart Devices: connected devices such as field devices, mobile devices, operating devices, etc.;
- Smart Manufacturing Processes: dynamic and real-time process communication to managers; control for the manufacturing environments enabled by Internet of Things;
- Smart Engineering: product design and development. Smart engineering may require the use of data collected from the manufacturing process to plan future processes;
- Manufacturing IT: software applications, smart monitoring though sensors; data are integrated from Internet of Things into a smart production logic;
- Smart Logistics: includes tools and processes;
- Big Data and Cloud Computing Data: include algorithms and other applications that bring opportunities for improving future factories and manufacturing processes;
- Smart Suppliers: includes building solid relationships with suppliers, e.g. by increasing the sharing of information in real time;
- Smart Grid: smart infrastructures of the factory in field of energy supply (Shrouf et al., 2014).

A further analysis concerned with IoT architectures is addressed in chapter two, where a literature review is dedicated to major technologies available for manufacturing.

1.3.2 Internet of Things

Internet of Things considers the interconnection of all the entities of the physical world put in touch in a digital world. Industrial Internet of Things represents a different, industrial concept that aims to improve operational efficiency, but producing companies may benefit from it even by developing value-added application scenarios (Sun et al., 2018). The main goal is concerned with tracking processes and record valuable information translating data into knowledge, and eventually monetize the potential of data. Therefore, it is fundamental that companies align process activities and the goals set, creating a data-driven vision: IoT decentralizes analytics and the decision making; this is possible with different field devices that communicate one another (Pflaum and Michahelles, 2018; Rüßmann et al., 2015).

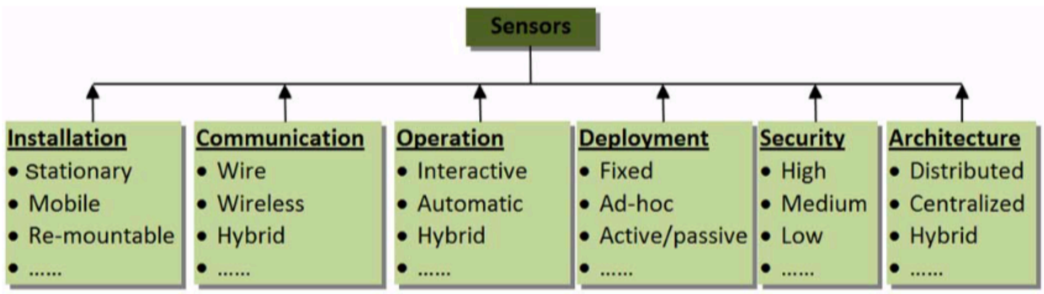
Figure 6: IoT for modern manufacturing



Source: "Internet of Things for Enterprise Systems of Modern Manufacturing", (Bi et al., 2014).

As shown in Figure 6, sensors are a critical point to acquire data, and sensors' implementation involves their installation, communication and operation. Sensors' deployment and security are critical to ensure a safe flow of data, while the architecture should be based on the process's features (Bi et al., 2014).

Figure 7: Classification of data acquisition system



Source: Internet of Things for Enterprise Systems of Modern Manufacturing, (Bi et al., 2014).

The integration of IoT within and enterprise system can address some challenges of a manufacturing company (Figure 5):

- Ubiquitous computing and grid computing can be applied to network manufacturing resources; what is connected (e.g. machines, devices, etc.) usually permits to collect data for quick decision making;
- Customers gain power through the electronic commerce because it allows them to compare products and vendors around the world;
- A networked environment supports the coordination of manufacturing, assembly and design among partners;
- The integration of information connects database, data acquisition and data monitoring. Online data acquisition systems serve for real-time control of machines and for providing feedbacks about changes at the high-level system planning and control (Bi et al., 2014).

1.3.3 Cloud Computing and Fog Computing

The Cloud Computing concept is emerging as a new paradigm of manufacturing and can be treated as a collaborative manufacturing service model. Manufacturing resources, meaning software and manufacturing capabilities, are connected in cloud platforms (Ren et al., 2015).

Nowadays, manufacturing firms have production plants in various world regions, even producing different parts of the final product in different places: coordination among manufacturing units is often fundamental to cope with customers' demand. Modern manufacturing strategies require agility and responsiveness: cloud-based multi-agent manufacturing architecture can be a solution to boost efficiency and revenues of those "distributed" manufacturing firms, through integration of different business units in one shared platform, allowing rapid exchange of information (Mishra et al., 2016).

The full value of cloud exerted in shared platforms is enabled by the development of the IT structure through an open Application Program Interface (API). API are set of rules that can be followed by software programs to communicate: it plays the role of interface between different programs and it is used to simplify programs' interaction. Traditional enterprises have two major issues when they move to cloud:

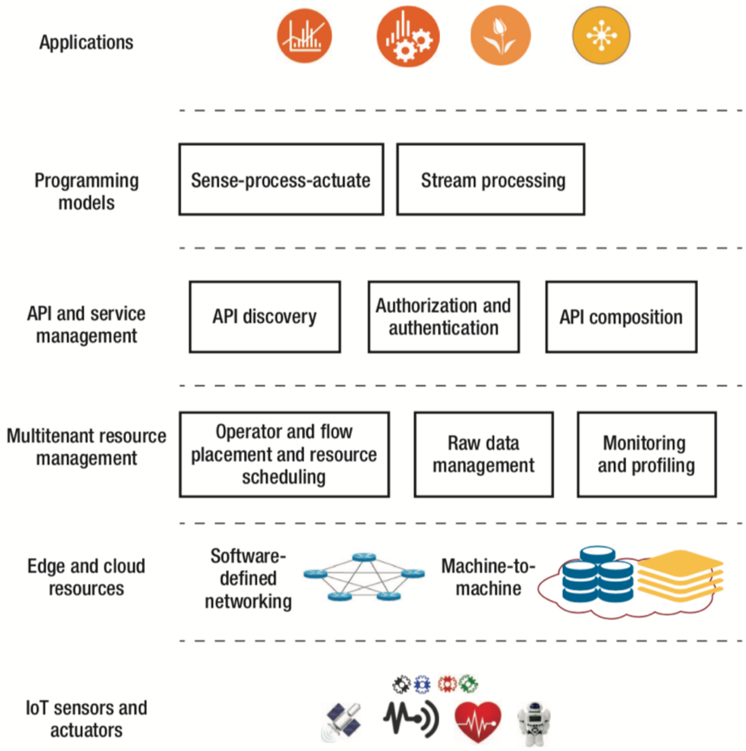
- Existing business applications were created by referring to traditional concept of IT, with the result of monolithic applications configured for few (static) data-centers. Just moving them into cloud will not give the dynamics needed;
- The typical technology workforce develops business applications in the traditional IT framework. Hence, many workers need to be upskilled for cloud (Mosqueira-Rey et al., 2018).

The cloud technology can be used also to adopt online services for businesses, using so-called Software-as-a-Service, described by Iranpour and Sharifian (2018, p. 81) as a "model [in which] users can access the application through the Internet by paying the cost of their usage without worrying about issues such as licensing and updating the software. The main goal of SaaS providers is to minimize the costs while enhancing customer satisfaction level" (Iranpour and Sharifian, 2018). This kind of business applications have become very popular for functions like sales, marketing, collaboration and communication (Bommadevara et al., 2016). To sum up, the cloud may be the key to enable the necessary standardization and automation. Indeed, with the cloud companies can:

- Reduce IT overhead costs by 30-40%;
- Optimize the IT asset usage scaling IT processes up and down;
- Improve the flexibility of IT function to embrace business needs, offering sophisticated solutions like machine-learning and big data services;
- Reduce IT incidents and increase the quality of services through self-healing nature of solutions (Bommadevara et al., 2016).

A huge quantity of data is stored in the cloud, but might be not necessary to keep everything there in some cases: for example, when a company need information at a lower level (e.g. at the plant level or for processes of some machines) the Fog Computing concept may be applicable. Dastjerdi and Buyya (2016, p. 113) define Fog Computing as "a distributed paradigm that provides cloud-like services to the network edge. It leverages cloud and edge resources along with its own infrastructure. Essentially, the technology deals with IoT data locally by utilizing clients or edge devices near users to carry out a substantial amount of storage, communication, control, configuration, and management" (Dastjerdi and Buyya, 2016).

Figure 8: Fog-Computing Architecture



Source: "Fog Computing: helping the Internet of Things Realize Its Potential", (Dastjerdi and Buyya, 2016).

Figure 7 shows a Fog-Computing architecture: sensors stream data into IoT networks and applications that run on devices placed at the edge of machines to process the information; after that, the obtained insights are translated into actions. In Fog environments, analytic tasks are pushed to cloud-based or edge-based (closer to the place where the information is needed) by resource management systems, and are mainly employed to minimize latency and throughput time (Dastjerdi and Buyya, 2016).

1.3.4 Augmented Reality and Virtual Reality

The smart factory concept and the IoT concept rely on the ability of manufacturing systems to be visualized in real-time or even in advance. While a Virtual Reality system immerges the user in a fully artificial digital environment, Augmented Reality systems overlap virtual objects in real-world environment. Devices may interact with reality and create systems in which the real-world encounters objects that does not exist but are perceived through different sensor modalities (Turner et al., 2016). According to a Goldman Sachs estimation, Augmented and Virtual Reality market is expected to grow up to $95 billion by 2025: the demand for technology currently comes from creative industries like gaming, live events, video entertainment and retail, but it might be applied in other industries as healthcare, military or real estate (Hall and Takahashi, 2017).

Augmented and Virtual Reality will change the way content is created and experienced in four main ways:

- Moving from observation to immersion: a replacement of rectilinear devices with technologies that allow new experience and immersion in other worlds;
- Reducing production costs in creative activities: the time and cost of iteration in the development of products can be reduced, and the quality of end-product improved;
- Lowering barrier to entry for new creators: smaller firms can be able to produce higher quality products at a lower cost, opening creative avenues for everyone;
- As a tool for empathy and cognitive enhancement: immersive technologies may enable a telepresence that evokes higher levels of empathy, despite suggestions that increasing digital media consumption reduce human feelings' involvement (Hall and Takahashi, 2017).

In the manufacturing industry companies try to enhance the product quality reducing product development cost: Virtual and Augmented Reality assistance can be useful for assembly planning and evaluation process in the production phase, through eyewear, stationary see-through or projected displays (Kroeker, 2010; Wang et al., 2013).

The Case Box 6

The **GE** case

augmented Reality for Industry

GE Aviation, as reported by Upskill, (provider of Augmented Reality platform "Skylight" for General Electric and Boeing), lost million dollars due to errors made at the key points during the assembly of its engines: this entails costs related to lost productivity, delays in testing, delays in deliveries and if errors are detected after engines are sent to the customer the cost increases exponentially. To solve the problem, GE Aviation started the deployment of Augmented Reality in its facility in Cincinnati through instructions step-by-step and images directly on the line of sight of the workers, that are alerted and corrected in real-time through smart glasses. "We believe that Skylight with glass has the potential to be a real game changer in terms of its ability to minimize errors, improve productivity quality, and increase mechanic efficiency" said Ted Robertson, manager of GE Aviation (Upskill report, 2018).

Source: "Upskill and GE, driving transformation across all of GE", (Upskill report, 2018).

Upskilling technologies can increase the abilities of the worker, resulting in a strong improvement of performance, greater worker satisfaction and higher safety (The Case Box 6): Wearable Augmented Reality devices are used by some companies, like GE, in manufacturing settings to boost worker's productivity by making them more efficient: General Electric experience shows that combinations of humans and machines entail better performances than either working alone (Abraham and Annunziata, 2017).

Often, current available video devices are heavy and sometimes cause discomfort and eye strain to the worker. For this reason, the shape and size of a pair of glasses seems to be a good deal: when the user needs instructions can focus in the small clip-on display for a short time, having a natural view of the environment for the rest of the time. However, Augmented Reality applications are in an exploratory stage: Augmented Reality systems should be integrated with a fast and stable internet system. Virtual Reality can be easily applied in creative industries and in gaming, whilst Augmented Reality is more likely to be implemented for marketing services and manufacturing operations (Ong et al., 2008).

1.3.5 Artificial Intelligence

Artificial Intelligence is more and more available in an increasing number of objects or devices and its application in business problem solving is growing. Deep-Learning techniques use "neural" frameworks, or better large-scale neural networks that can contain millions of neurons structured in layers. These systems are usually not programmed, they need to be "trained" through a huge amount of data, and it is not easy to collect them. AI models are not so able to distinguish from one circumstance to another; for this reason, the training stage can be time – and even money – consuming (Chui et al., 2018).

Some online translations and photo-tagging services are using AI for products' enhancements, but AI presents many issues for businesses: progress on those issues is likely to by crucial to realize AI's benefits and to safeguard people from risks:

- Encourage broader uptake of AI: broader adoption of AI, especially in small firms, might be important to sustain productivity growth;
- Address employment and income-distribution concerns: there might be workers whose skills are not aligned with AI and governments should re-think social support;
- Resolve ethical, legal and regulatory issues: there is an increasing call for algorithmic transparency, accountability and for privacy concern;

- Ensure the availability of training data: a huge amount of data is crucial for training AI; setting common data standard may help in this process;
- Deploy AI with government: improved planning and targeting can deliver more efficiency in government services, like healthcare or education (Bughin et al., 2017).

Adopting AI broadly across the organization is likely to have better and stronger results where soft skills and organizational flexibility enable new forms of collaboration, even between humans and machines (Ransbotham et al., 2017; Bughin et al., 2017).

1.3.6 Big Data Analytics

The share of produced and trackable data is growing and one of the main enabler is the IoT, but also new tools have been developed to catch data and translate them into insights. "Machine Learning", a term that is concerned with algorithms approaches and statistical methods has advanced to the forefront of analytics. Together, those developments reinforce each other and converge (Mohr and Hürtgen, 2018).

Research on big data has received a lot of attention over the last few years, but research on business value of big data remain scarce; business firms find difficulty in determining the value of data. The critical challenge is to find the best way for translating data into valuable insights for the business: not only to generate value, but also to justify the required investments. Moreover, the extensive use of Big Data Analytics across supply chain management systems may inspire inter-organizational learning between firms and their supply chain partners (Grover et al., 2018; Chen et al., 2015).

A survey conducted by McKinsey found that many companies are concentrating on data-centered businesses, but it is hard to see a significant financial impact: the right mix of strategy, organization and culture is needed, starting from some efforts:

- Focus on yourself first: before starting down the path for monetization, take time to set the own right foundations;
- Look outside for innovation: once firm's data and analytics foundations are in place, partnering with others externally to find new solutions that may enrich existing data;
- End-to-end transformation and business involvement: lack of partnerships between business and IT can slow down the impact on business (Gottlieb and Rifai, 2017).

1.3.7 Machine Learning and Deep Learning

Machine Learning concept is about the computers' ability to learn how to perform a task by studying and training with a large set of examples, so that the computer can perform same tasks with data never met before. First algorithms appeared around 1970s, but nowadays the increased computing power permits the use of Machine Learning to tackle complex problems, such as:

- Security algorithms to protect from cyber-attacks;
- Image analysis for identifying shapes, like face or fingerprint recognition;
- Deep learning to generate rules for data analytics or big data management;
- Object recognition and predictions from multisensory fusion and video streams;
- Pattern recognition to analyze codes (Louridas and Ebert, 2016).

Deep Learning is a new approach for artificial networks, neural nets through which a computer can learn to perform assignments by analyzing training examples. However, even when automated systems are almost perfect, they sometimes make mistakes that are shocking for a human being, "we call them stupid errors" said Salim Roukos (2017, p. 3), IBM fellow at IBM's Thomas J. Watson Research Center in New York (Monroe, 2017). Regarding smart manufacturing, Deep Learning offers advanced analytics and gives higher visibility of the operations (see The Case Box 7) to decision makers, as well as real-time performance measures and costs (Wang et al., 2018).

The Case Box 7

The **HITACHI** case

operators' movement recognition in the workshop

Hitachi is developing a technology to recognize movements of factory workers and to detect those movements deviating from standards, with the purpose of improving the quality of the product: a motion camera is used to detect worker's movements in a 3D shape, and those movements are the basis for Machine Learning to recognize the good or bad movement thanks to pieces of information combined together. The presence of an abnormal operation is judged by making a statistical comparison with a standard operation model (Irie et al., 2016).

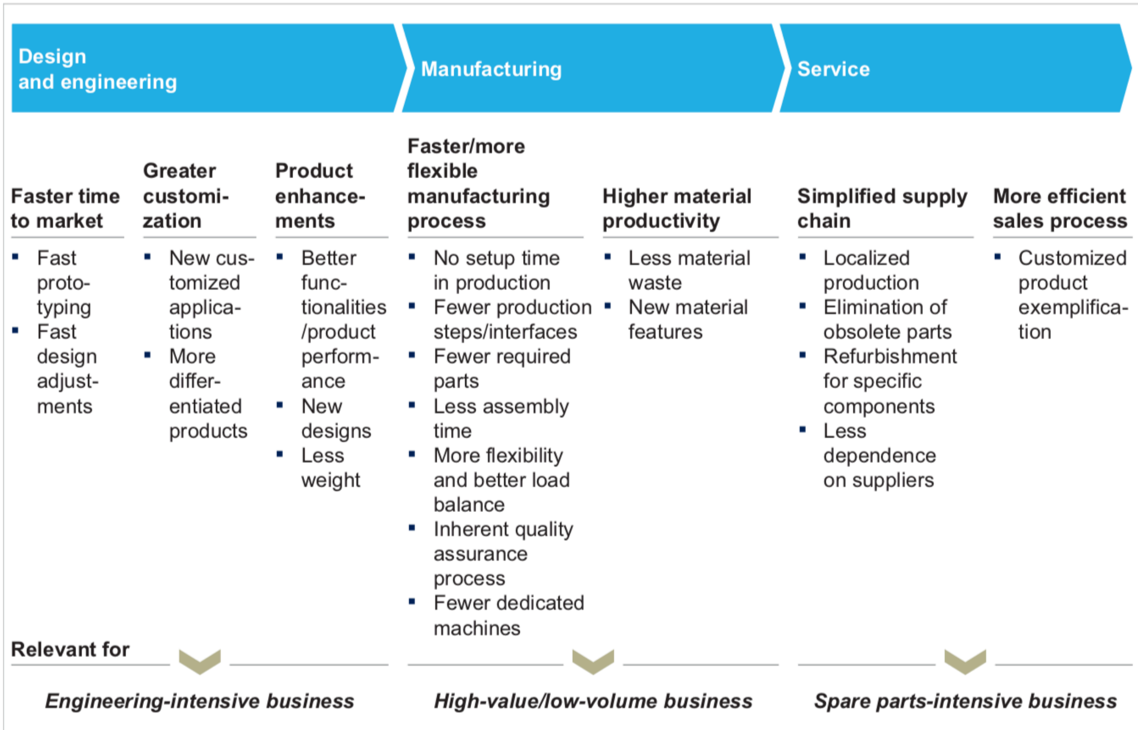
Source: "Utilization of AI in the Manufacturing Sector. Case Studies and Outlook for Linked Factories", (Irie et al., 2016).

1.3.8 Additive Manufacturing

Additive manufacturing may be defined as the process of making a product layer by layer using a machine instead of using traditional techniques: 3D scanners can capture the reality, they turn atoms into bits (Bromberg and Kelly, 2017; Anderson, 2012).

A virtual illustration can be built starting from a real object, with the help of software to correct the model, since they capture many points in the tridimensional plane and those are then “shaped” together. This technology was once employed only for prototyping, but the use of Additive manufacturing for creating spare parts, tooling and small products is increasing. Several materials can already be deployed to make many things, like steel or aluminum, alloys or plastics, ceramics, paper, glass, wood and cement. Although 3D Printing is still in an expansion phase, it is likely to completely change how products are designed or built, but also distributed, sold or serviced (Bromberg and Kelly, 2017).

Figure 9: Additive Manufacturing offers significant benefits



Source: Additive manufacturing: A long-term game changer for manufacturers, (Bromberg and Kelly, 2017).

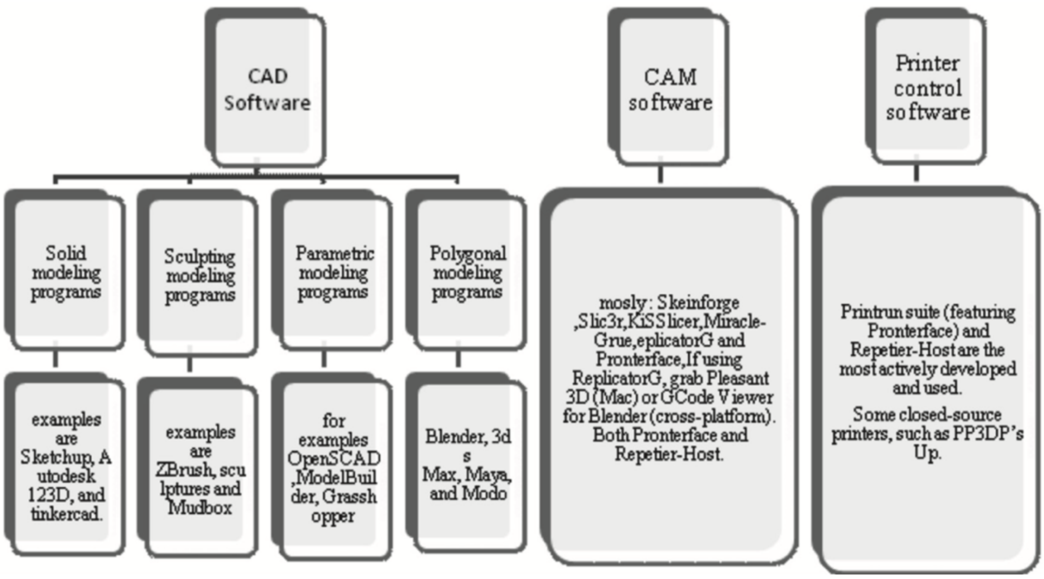
As shown in Figure 8, Additive manufacturing can generate benefits for the product itself, for a more flexible and faster manufacturing process and a more efficient sales process, considering to be to a greater or lesser degree more independent from suppliers. Nonetheless, even if this technology implies cost-effective process for small production batches, the investment related to 3D Printers for large-scale production is still a strong issue for manufacturing companies (Chalabyan et al., 2017).

Among the numerous techniques, two are the most used for consumer level Additive Manufacturing:

- Fused Deposition Modelling (FDM): layer-by-layer material adding, extruding semi-liquid plastic in a defined layout;
- Stereo Lithography (SLA): layer-by-layer material adding, using an ultra-violet light source to have effects on a given resin (Kamran and Sexena, 2016).

In 3D Printing technologies, the first steps are CAD (Computer Aided Design) converted in a second step into Stereo-Lithographic file for example. The file breaks down the surface into a representation of the 3D model used for the slicing algorithm. An integration between hardware and software is essential in developing a digital model and creating a real object Additive Manufacturing affects operations strategy for many industries where it aims to increase operational efficiency. Automakers like BWM or Honda are working for the 3D creation of industrial tools and end-use parts in their factories, especially metal, composite plastic and carbon-fiber materials (Kamran and Sexena, 2016; D'Aveni, 2015).

Figure 10: Software hierarchy used in 3D printing



Source: "A Comprehensive Study on 3D Printing Technology", (Kamran and Saxena, 2016).

There are three kinds of software used to prototype physical objects represented in Figure 11: the CAD (Computer Aided Design), the CAM (Computer Aided Manufacturing) and the Printer Control Software to communicate precisely with the printer for its every single movement (Kamran and Saxena, 2016).

1.3.9 Cybersecurity

All kinds of organizations have fallen victim of cybersecurity attacks over the last few years: although a great attention about cybersecurity has been focused on credit card stealing, attacks to cyber infrastructure are even more important but they are not so glamour, according to cybersecurity expert Stuart E. Madnick, director of MIT's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity, where academic researchers, companies and government experts collaborate. Madnick (2017, p. 23) said "if you don't address the managerial, organizational, and strategic aspects of cybersecurity, you're missing the most important parts. A lot of people are working on developing better hardware and software, and that's good. But that's only a piece of the puzzle". Between 50% and 80% of cyberattacks are unintentionally enabled by insiders, typically through phishing in e-mails (Mangelsdorf, 2017). The US Government has identified Cybersecurity as one of the most important issues related to economical and security challenges for the United States. Cyber risk needs to be treated not as an IT problem, but as a risk-management issue, and companies must address the cyber risk in the business context (Poppensieker and Riemenschnitter, 2018). According to the Security Research Report by Akamai, one of the largest distributed computing platforms in the world, collaboration and data sharing are fundamental topics in security. It is therefore important to create collaborations against hackers and hacker systems: alliances with other companies and with government agencies, because the private and the public sectors need to act and think together to address the cybersecurity challenge (Esteves et al., 2017).

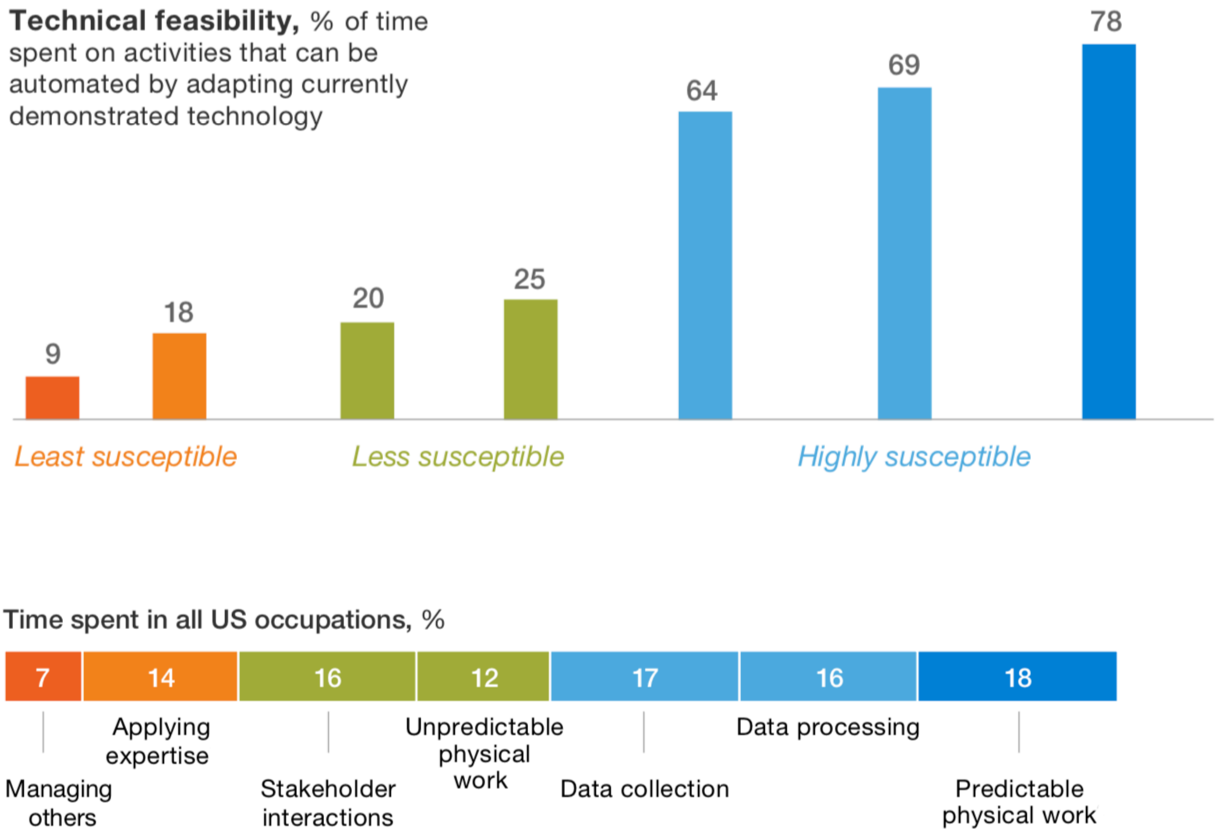
1.4 Organizational Change

1.4.1 Automation Impact

The digitalization has effected many sides of the labor market, entire fields have been penetrated by connectivity in their core parts. Often, structural changes in employment opportunities manifest due to the rapid work digitalization, but also the speed at which those change happen is not banal. Some acclaimed studies predict that in few years more than 45% of US jobs will be threatened by machines, computer or robot replacement, while other studies suggest that the digitalization has not enough potential to replace the human labor (Eichhorst et al., 2017). Technology has also the potential to create disparities caused by mechanisms for vast automation and the depletion of industrial professions, since undertakings that cannot be replaced by technology and automation, are often supplemented by them. Technological unemployment may generate distributional issues and personal axiology issue: several hand-operated and low-income occupations protected in the past may decrease over time. Developments in information and communication have made easier for companies to track and supervise processes and employees (Nica, 2016). Automation has maybe the potential to partly transform sectors, such as finance or healthcare, that involve some share of knowledge work. Technical feasibility is one of the necessary preconditions for the automation of an activity, together with the cost of developing the hardware and the software. In some sectors, such as healthcare and education, the importance of human interaction is evident: there is potential for automation in healthcare sector, but it is lower for professionals exerting daily activities that require expertise and direct contact with people (Chui et al., 2016).

Some activities will be more susceptible than others to automation, like predictable physical work or data processing, while applying expertise and manage other people seem to be skills that is difficult to replace using machines; those activities involved with human interactions are less likely to be easily substituted, as shown in Figure 9.

Figure 11: Analysing work activities rather than occupations is the most accurate way to examine the technical feasibility of automation



Source: "Where machines could replace humans and where they can't (yet)", (Chui et al., 2016).

This perspective helps to rethink workers' engagement with their own work and how digital platforms can connect people and projects. Top managers may be more able to think about how to enhance and allocate activities among workers and machines. Among economists, there is a wide agreement that technological change has brought a change in skills demand and growing inequality in the labor market. Technological change has different impacts, evident in the declining employment in routine task-intensive production and clerical occupations, both in the manufacturing and even non-manufacturing sector (Chui et al., 2016; Autor et al., 2015).

1.4.2 People and Talent Management

The answer to the technological change may depend on the ability of corporate leaders to split multifaceted jobs into discrete tasks, making distinction between those that can be automated and those better performed by humans. Leaders can benefit from a different approach of people management by spending few time on appraisals and more on the development and professional growth of their reports: it is not just allocating effectively talented people, it is more about freeing workers to focus on the most essential parts of their roles. (De Smet et al., 2016). In this context, digital platforms discussed in first pillar may help to define rules and how the work should be done, coordinating activities and decreasing interaction costs. Technical capabilities are required, as well as a robust understanding of employees' attitudes, performances, experiences. Over the last years, a growth in virtual team adoption has been registered: members of these teams are geographically dispersed, work independently to reach common goals, and communicate through electronical media. (De Smet et al., 2016; Dulebohn and Hoch, 2017). Business growth often requires new talents for those teams; detailed assessment to gather talent is very important, as well as attracting skilled resources.

Figure 12: GCTCI variables

Source: "The Global Talent Competitiveness Index 2018", (Lanvin and Evans, 2018).

A model for talent acquisition is provided by the Global Cities Talent Competitiveness Index communicates, illustrated in Figure 10: attracting talent is not enough, information flow rapidly and it is maybe more difficult to retain skilled employees, that today live and work in a global world (Lanvin and Evans, 2018).

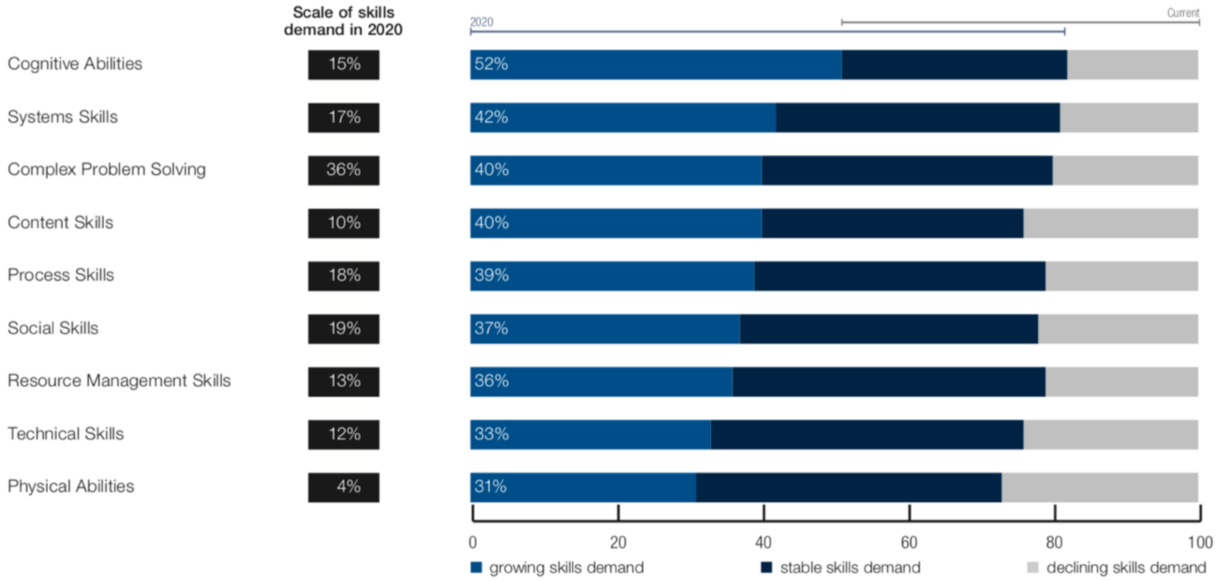
1.4.3 Education and Skills

According to Vivarelli (2014), it is important to look at the qualitative effect of those changes in the companies' needs of human capital characteristics. Empirical research show that, depending on the degree of flexibility and the institutional system, there has been an increase in wage differentials between skilled and unskilled workers in many developed countries. Advanced industrial technologies lead not only to a greater utilization of higher-qualification employees, but also workers able in cross-section analysis (Vivarelli, 2014).

The growing amount of data triggers the need of new workforce capable of analyzing them in business frameworks. Notably, data analysis in cybersecurity is strongly and increasingly demanded, as well as in healthcare, retail or transportation sectors (Hajkowicz et al., 2016). Beyond data analysis, interpretation of data and complex decisions making are important: with so many options today, something like the "paradox of choice" may appear, a phenomenon in which too many choices overwhelm or demotivate the decision-maker (Hajkowicz et al., 2016).

Several former technical activities are expected to transform and show a new demand for creative and interpersonal skills. Social skills, like persuasion or emotional intelligence, are likely to register a higher demand across industries than narrow technical skills. Overall, respondents of the survey conducted by the World Economic Forum anticipate the higher degree of cognitive abilities, such as creativity, logical reasoning and problem sensitivity (Leopold et al., 2016). This fact boosts the hypothesis that recent changes have - to a greater or lesser degree - a significant impact on skill requirements in various job families; there is a real potential for re-skilling and up-skilling talent from varied academic backgrounds (Leopold et al., 2016). As represented in Figure 12, physical abilities and technical skills are those for which demand is growing less, whilst cognitive abilities and systems skills demand is increasing.

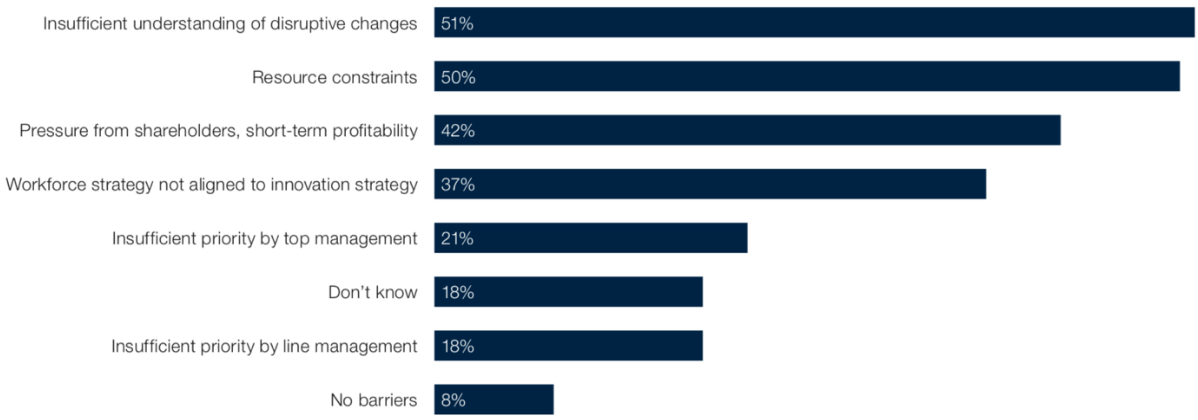
Figure 13: Change in demand for core work-related skills, 2015-2020, all industries



Source: "Future of Jobs Survey", World Economic Forum (Leopold et al., 2016).

Reponses to the Future Jobs Survey show that business leaders are aware of those priorities to have updated workers for future growth, but they have been slow in acting.

Figure 14: Significance of barriers to change, industries overall



Source: "Future of Jobs Survey", World Economic Forum (Leopold et al., 2016).

As Figure 13 shows, the most significant perceived barriers for a decisive impact include a lack of understanding and anticipation of disruptive changes ahead, but also resources constraints, short-term profitability pressure and a workforce strategy not aligned to a proper innovation strategy (Leopold et al., 2016).

1.4.4 Organizational Culture

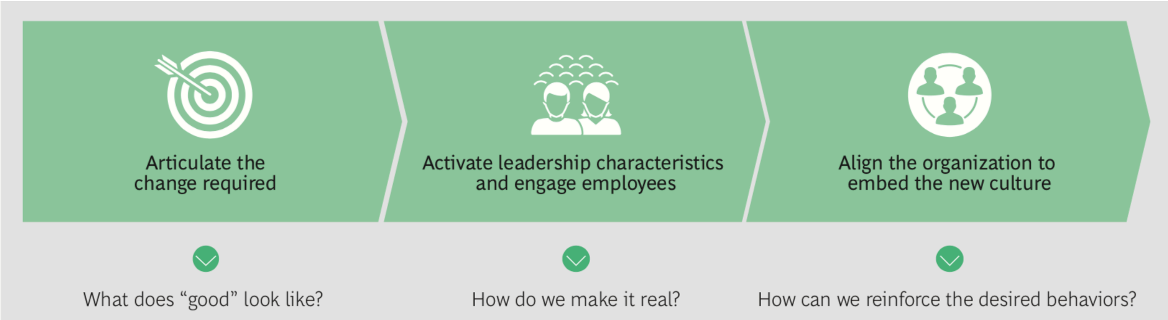
Having a huge budget, a great enthusiasm and a lot of energy to start a digital transformation might not be enough; the trap here is to not really understand what a digital transformation is. As explained by Rob Roy (2018, p. 2), Chief Digital Officer at Sprint Corporation, an American telecommunication company: “digital transformation isn’t about digitizing a channel or simply doing more things digitally. It’s a much broader scope than that. We’re now working with each area in the business to help everyone think and act digitally for the things they control” (Seitz, 2018).

Data in this case are used to take out and examine the most valuable activities and how to improve them; the trickiest part here is probably to discern meaningful information from meaningless ones. Corporate culture shifts inevitably from conservative operations to cross-functional teamwork: not only a shift in the structure of flows or tasks, but also a variation that influences employees’ mindset by opening them to new ways of interacting and engaging with each other, increasing company’s agility and dynamism. Digitally mature organizations encourage to experiment, accepting the risk of failure, and leaders need to nurture a corporate culture if they want to reach digital maturity (Seitz, 2018; Kane et al., 2017).

Getting an organization to embrace risk is something more than just consider risk as acceptable: when organizations’ cost for experiments is too low, then the organization’s exposure to risk may be higher because experimentation means learning. Risk taking, agility and collaborations boost the idea of dynamic active organizations that test and innovate a lot. By ignoring culture, an organization risks digital transformation failure. According to a research assessment of roughly 40 digital transformations conducted by BCG, the proportion of companies reporting strong financial performance was five time lower among companies that neglected culture compared to those focused on it, through actions shown in Figure 15 (Hemerling et al., 2018; Kane et al., 2016).

Since digital organizations for their intrinsic features move faster than traditional ones, decision making processes are faster, employees are more empowered to make judgments and the reputation of being a digital leader attracts talents: millennials are fascinated by digital companies more than traditional ones because of their promise of a collaborative, creative and work-autonomous environment (Hemerling et al., 2018).

Figure 15: How Do Companies Embed a Digital Culture?



Source: "It's not a digital transformation without a digital culture", (Hamerling et al., 2018).

1.4.5 C-Level Responsibility

According to a Harvard Business Review statistical research, companies are more likely to pursue the path of digital reinvention when there is commitment from their leaders (Bughin and Catlin, 2017). Although the digital transformation is ideally driven by disruptive technologies, it is maybe even more shaped from the top. CEOs have a very active role and responsibility in taking decisions and in selecting the approach towards a huge change: they are the engine of a metamorphosis, architects and boosters of future digital strategy. Michael Porter of the Harvard Business School argues that the world of smart connected devices represents a revolutionary change in the fundamental dynamics of competition; John Chambers of Cisco Systems predicts that 40% of present business will fail in the next ten years, while 70% will digitally transform themselves to a greater or lesser degree but only 30% will succeed. C-Level employees perceive therefore the necessity to embrace or get into this wave in the best possible way. Digital transformation is then forcing CEOs to re-think companies' processes, management practices and information handling. New talents are recruited for roles like the Chief Digital Officer, the person with the knowledge and the budget to carry the company during digital development (Bughin and Catlin, 2017; Siebel, 2017).

CEOs' excessive caution and fear of unknown may slow down or obstacle the success of the transformation; at the same time, the company should not make the mistake of entering too many digital projects, which could make it lose focus on strategic ones. Lack of talent and lack of discipline are possible shortcomings that need to be fixed to not waste the effort made: leading companies are building out ecosystem relationship-management capabilities, also framing teams dedicated to partners' management and communities' development (Siebel, 2017; Arora et al., 2017).

1.5 Conclusions

After reporting different definitions of what digital transformation is, this macro argument has been broken down in three important pillars that will be considered in all the following chapters. In fact, digital strategy, new digital technologies, and organizational impacts will be considered in benchmark analysis of Chapter Three and in the SIRMAX case investigated in Chapter Four.

The main concepts of Chapter One are going to be closely studied and analyzed in Chapter Two, which describes a literature review on digital strategy implementation and new technologies available for manufacturing purposes.

2. CHAPTER TWO

LITERATURE REVIEW: DIGITAL APPLICATIONS AND MANAGERIAL IMPLICATIONS

2.1 Introduction

In Chapter Two a literature review is presented, to gain knowledge on what has been studied and which conclusions have been reached about digital strategy implementation and recent technological applications over the last ten years. Insights acquired from the literature analysis are examined to obtain a theoretical formulation of what has happened recently. The literature review will also be used as a basis for further comparison with results of real benchmark cases analysis provided in Chapter Three. The union of those different perspectives will then be useful to get a broader picture on digital implementation and to investigate the SIRMAX case in Chapter Four.

2.2 Methodology

The research has begun with a broad collection of documents about digital implementation and industry 4.0 applications. The aim of this crossed research was to find common points in about the same topic, analyzing from various sources in the following order:

- Scientific or academic journal articles;
- Consulting firms research reports;
- Research report analysis published by top universities or business schools;
- Chapters of books concerned with digital transformation.

The documents have been selected among elaborations completed over the last ten years, from 2008 to 2018, except for some definitions or captions useful for a better understanding of the topic. Further paragraphs of Chapter Two are concerned with literature review of digital technologies, taking into consideration those ones described in Chapter One. In every table of Chapter Two, documents are reported from the most recent on the top of the table to the oldest on the bottom of the table and are journal articles or research reports. The research has been conducted using different databases:

- "EBSCO Business Source Complete", a database by EBSCO international covering themes of management, finance, accounting, administration and international economics;
- "Web of Science", multidisciplinary database that offers the possibility to search by choosing topics, authors, quotes;
- "Portale AIRE (Accesso Integrato Risorse Elettroniche)", a useful platform for getting information from Università degli Studi di Padova library system. This database allows multidisciplinary research to simultaneously investigate different areas, with a focus on the social sciences and engineering fields. The AIRE portal is a useful instrument to search both in Web of Science and SCOPUS (Elsevier API) databases.

A further spotlight of the analysis has been on manufacturing process and production characteristics, gathering information about new technologies available for business firms' usage.

The themes that have been studied researching on the mentioned databases are:

- Digital Transformation;
- Industry 4.0;
- Digital Culture;
- Augmented Reality;
- Automated Robots;
- Smart Manufacture;
- Artificial Intelligence;
- Manufacturing Processes;
- Big Data Analytics;
- Internet of Things;
- Machine Learning;
- Cloud Computing and Fog Computing;
- Application Program Interfaces;

- Deep Learning;
- SaaS (Software as a Service).

In the EBSCO Business Source Complete database, the selection scheme for academic articles has been performed as follows:

- Boolean/Phrases search mode, often using the operator “AND”;
- Limiting the results for “Full Text” and “Scholarly (Peer Reviewed) Journals;
- Publication date range was chosen for the last ten years of publications;
- Selected language selected was “English”;
- Document type was “Article” and the type of publication was “Academic Journal”;
- PDF Full Text was selected before starting every research.

When the initial query did not yield any result, SmartText Searching software helped in finding results based on keywords. In Web of Science database, the investigation was often focused on technical topics, selecting the citation index “Science Citation Index Expanded (SCI-EXPANDED)”.

On the AIRE database, the research has been carried out as “ricerca semplice” in multi-disciplinary setting, focused on management and engineering articles, considering only results concerning the last ten years. The results found in database investigations were filtered by checking the title and/or the abstract of the article: in case of useful articles concerning with the macro argument, the entire document was screened before selecting it.

The research has been conducted also consulting libraries of economics science and industrial engineering departments at Università degli Studi di Padova.

2.3 First Literature Screening and Ranking: Digital Transformation and Implementation

In this paragraph, documents’ distinction is done among journal articles, consulting firms research reports, universities and schools reports or surveys and books’ chapters. The research about digital implementation has been conducted to discover main theoretical findings and some operational results, by using query “*digital transformation*”, finding 67 results in EBSCO Business Source Complete and 21 results in AIRE database, limiting the period between 2008 and 2018 in both cases. The query "*industry 4.0*", imposing the limits reported at the beginning of this chapter, generated 28 results in EBSCO database and 29 results in AIRE database.

Table 1 shows the ranking based on the type of publication, that is related to the source: Journal Article is related to academic journals, followed by four research reports related to consulting firms; the subsequent three reports come from universities or schools, while the last two rows are related to books' review. This work allowed to find common points among different sources, then reported in the conclusions of this chapter.

Table 1: Literature Review about Digital Transformation, different sources cross-screening

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR	CONTENT	MAIN FINDINGS
Strategic Change: Briefings in Entrepreneurial Finance	Loonam, J. Eaves, S. Kumar, V. Parry, G.	Journal Article	*Towards digital transformation: Lessons learned from traditional organizations*	2018	10 case studies review from literature: analysis of approaches organizations have taken to implement digital technologies.	4 key perspectives found to implement a digital business model: strategic- centric, customer-centric, organization-centric, and technology-centric perspective.
Information and Organization	Hinings, B. Gegenhuber, T. Greenwood, R.	Journal Article	*Digital innovation and transformation: An institutional perspective*	2018	Three types of novel institutional arrangements for digital transformation: digital organizations, digital institutional infrastructures, and digital institutional building blocks.	Implementing digital innovations have grave impact on the identity, autonomy and boundaries of occupations. Organizations should adopt novel digital institutional arrangements that are radical.
Optical Switching and Networking	Mata, J. de Miguel, I. Durán, R. J. Merayo, N. Singh, S. K. Jukan, A. Chamania, M.	Journal Article	*Artificial intelligence (AI) methods in optical networks: A comprehensive survey*	2018	Review of AI techniques' application to improve performance of optical communication systems and networks. Summary of opportunities and challenges: AI is expected to play a key role in the future.	AI techniques' ability to find optimal or near-optimal solutions in highly complex scenarios: current optical communication networks need to face physical limitations imposed by noise and nonlinear distortions.
MIS Quarterly Executive	Sebastian, I. M. Ross, J. W. Beath, C. Mocker, M. Moloney, K. G. Fonstad, N. O.	Journal Article	*How Big Old Companies Navigate Digital Transformation*	2017	25 companies- study that were embarking on digital transformation journeys.	New structures and processes that empower people to experiment technologies and deliver integrated products to customers. Two identified stategies: customer engagement and digitized solutions.
International Journal of Production Research	Liao, Y. Deschamps, F. Rocha Loures, E. Perin Ramos, L. F.	Journal Article	*Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal*	2017	Study investigating the academic progresses in Industry 4.0. Systematic literature review to analyse the academic articles about Industry 4.0 published online until June 2016.	This analysis highlights the huge gap between Industry 4.0 laboratory experiments (95.1%) and industrial applications (4.9%).
International Journal of Production Research	Moeuf, A. Pellerin, R. Lamouri, S. Tamayo-Giraldo, S. Barbaray, R.	Journal Article	*The industrial management of SMEs in the era of Industry 4.0*	2017	Results show that SMEs do not exploit all the resources for implementing Industry 4.0	Industry 4.0 in SMEs mostly related to production processes, current capabilities improvement and flexibility. The least expensive and least revolutionary technologies are the most exploited in SMEs.
Computers in Industry	Büyüközkan, G. Göçer, F.	Journal Article	*Digital Supply Chain: Literature review and a proposed framework for future research*	2017	Identification of key limitations in Digital Supply Chain. Summary prior academic and industrial research, knowledge gaps, weaknesses of some methods.	First of all define a digitalization strategy. Then focus on three areas: digital organization, digital operations, digital products&services. Customer experience is a futher critical point.

Procedia CIRP	Goerzig, D. Bauernhansl, T.	Journal Article	*Enterprise architectures for the digital transformation in small and medium-sized enterprises*	2017	Identification of the first steps aiming at the development of a method for the holistic planning of the digital transformation in mechanical engineering SMEs.	Currently used approaches are not sufficient for SMEs in mechanical engineering: main challenges are high complexity of the approaches and the infeasibility for the fast development of new solutions.
Procedia Manufacturing	von Leipzig, T. Gamp, M. Manz, D. Schöttle, K. Ohlhausen, P. Oosthuizen, G. Palm, D. von Leipzig, K.	Journal Article	*Initialising customer-orientated digital transformation in enterprises*	2017	Model development for initialising digital transformation in enterprises. Model based on continuous improvement successfully validated in the German service sector.	Approach focused on customer contact points by which customer satisfaction can be quickly and effectively influenced.
Multinational Business Review	Strange, R. Zucchella, A.	Journal Article	*Industry 4.0, global value chains and international business*	2017	Review of several sources about new digital technologies to consider how those might lead to new configurations involving suppliers, firms and customers.	New technologies wide availability will have significant impact on business models, organization of production, customer relationship.
Strategy & Leadership	Berman, S. J.	Journal Article	*Digital transformation: opportunities to create new business models*	2012	Companies with a cohesive plan for integrating digital technologies in operations and reshaping value proposition can successfully transform their business models.	Enhancing products and services for a better customer experience; finding new revenue streams. Reshaping value proposition; creating new digital capabilities; leverage information across the organization.
PWC	Curran, C. Garrett, D. Puthiyamadam, T.	Research Report	*A decade of digital. Keeping pace with transformation*	2017	2,216 business and technology executives surveyed in late 2016: towards a connection between organizations that have more comprehensive digital strategies and those that achieve stronger financial performance.	The survey reveals a shortage of relevant skills, scarce for many emerging technologies. Commitment needed to educate executives, train workforce, create a collaborative environment.
Deloitte Insights	Mittal, A. Slaughter, A. Bansal, V.	Research Report	*From bytes to barrels. The digital transformation in upstream oil and gas*	2017	Digital Operations Transformation (DOT) model, a framework that explains the digital journey through 10 stages of evolution, with cybersecurity and digital culture at the core.	Adopting digital technologies is not enough. A company should promote cross-discipline, cross-company workflows; implement systemic changes in work- forces and cultivate digital culture, with a long-run digital strategy.
BCG	Küpper, D. Heidemann, A. Ströhle, J. Spindelndreier, D. Knizek, C.	Research Report	*When Lean Meets Industry 4.0*	2017	Company's solutions testing in specific parts of the plant. Leaders can validate the approach and showcase the opportunities for value creation. Mobile app development to make data available to plant personnel allowing comparisons with industry benchmarks.	BCG suggests that lean tools are essential for unlocking the potential of Industry 4.0 , preventing the automation of waste and reducing costs.

McKinsey Global Institute Intelligence Review	Manyika, J. Chui, M. Bisson, P. Woetzel, J. Dobbs, R. Bughin, J. Aharon, D.	Research Report	*The Internet of Things: Mapping Value Beyond the Hype*	2015	IoT can change how companies manage physiscal assets, how consumers attend to their health, how cities operate. Coordination, investments and talents are required.	Businesses can improve operations gathering insights from data and need to invest in capabilities, culture and processes. Governments will have to ensure new systems' safety and data protection.
MIT Sloan Management Review	Kane, G. C. Palmer, D. Phillips, A. N. Kiron, D. Buckley, N.	Research Report / Survey	*Achieving Digital maturity. Adapting Your Company to a Changing World*	2017	Survey of more than 3,500 business executives, managers, and analysts from organizations around the world in 2016. Insights captured from individuals in 117 countries and 29 industries.	Company's leaders must stress the importance of digital maturity. Need to build a supportive culture of risk taking and experimentation, making organization a talent magnet.
TAG Innovation School	Researchers of the Master in Digital Transformation for the Made in Italy	Survey	*La Digital Transformation e le PMI italiane nel 2017*	2017	More than 500 SMEs interviewed. Focus on: 1. Cultural approach of SMEs; 2. Present situation comparing with digital transformations already in place; 3. Future scenarios and future SMEs' choices.	65% of the interviewed SMEs focus on corporate culture, followed by digital strategies (61%) and need for new technologies (35%). Large investments in R&D (46%) and production (40%). Marketing Specialist (60%), Data Analyst (50%) and Digital Officer (32%) are considered key figures of the SMEs' future.
Harvard Business Review	Iansiti, M. Lakhani, K. R.	Report	*Digital Ubiquity. How Connections, Sensors, and Data Are Revolutionizing Business*	2014	General Electric case: digitization of previously analog machine and service operations, organizational tasks, managerial processes.	Connection of existing assets across companies and examination of new value creation. Software usage to extend the boundaries. Institutions should ensure that connections are transparent.
Book publisher: Edizioni Università Trieste	Venier, F.	Book, ch.2 (2.5)	*Transformazione Digitale e Capacità Organizzativa. Le Aziende Italiane e la Sfida del Cambiamento*	2017	Analisys of digital technology, skills organizational processes and business models to create value for stakeholders and sustain the organizational change.	Digital Transformation related not only to investments in information systems: capacity of changing processes, organizational structures and human capital skills development, using also shared platforms.
Book publisher: Springer	Bounfour, A.	Book, ch.5	*Digital Futures, Digital Transformation*	2016	Key building blocks identification about digital emerging production system: 1. the multiplicity of value creation spaces; 2. the acceleration of links; 3. space and time in activities' coordination; 4. society vis-à-vis the organization.	In the digital economy value is created and deployed by multiple channels, by individual and collective experience. Companies' boundaries are broken: cloud applications, crowdsourcing, open innovation solutions, etc.

Source: Author's elaboration

Digital strategy is included as one of the critical points of digital transformation, with a focus on organization, operations, digital products and services brought to market, but also on the customer experience, as well as having a technology-centric perspective able to change the business model paradigm.

Nevertheless, the lack of substantial empirical field studies limits research, but the success digital implementation is likely to depend on a lot of variables, different for industries and markets (Eaves and Parry, 2018).

Beyond articles of academic journals, interesting surveys enhance the basis for having a literature review that comprehends different points of view: "to become a digital leader, a company should consider making a change in its physical world by modernizing its core assets", a suggestion coming from Mittal et al. (2017, p. 5). Not only a modernization of assets, but also integration between industry 4.0 tools and lean management techniques proposed by Küpper et al. (2017), which focuses on the integration of transparent big data analytics and the effectiveness of lean instruments that promote continuous improvement (Küpper et al. 2017).

According to Bounfour (2016, p. 54), is emerging a new mode of production involving key digital element "whose boundaries and guiding principles are yet to be determined", value production will extend its domain to multiple spaces. Furthermore, an "organizational liquidity" facilitated by virtual reality, cloud applications and open innovation solutions make the business organizations malleable, changing their shapes at a higher speed (Bounfour, 2016).

The survey conducted by PWC and reported in "A decade of digital. Keeping pace with transformation" by Curran et al. (2017), describes today's technology investments as tomorrow's building blocks, but unfortunately few resources are employed in digital innovation: among 2.216 executives interviewed, 80% says identifying opportunities to digitize their enterprise is critical to innovate, but only 43% of executives declared to have a dedicated team for digital innovation. However, Internet of Things and Artificial Intelligence were perceived as the most disruptive technologies (Curran et al. 2017).

2.4 Articles Review: Connectivity and Smart Factories

The research for this first subtopic has been conducted using the queries "*Automated Robots*", "*Smart Manufacture*", "*Connectivity*" AND "*Smart*" AND "*Manufacturing*", "*Smart*" AND "*Manufacturing*", for period 2008-2018, using the same specifications mentioned in paragraph 2.1 for the EBSCO Business Source Complete database. Reviewed documents related to Connectivity and Smart Factories are reported in Table 2.

It is not only the financial investment or the technology availability: smart concepts implementation requires resources, organized processes and competent staff. One of the advantages is process standardization, which on the one hand keeps the production process stable, while on the other hand permits a good degree of agility (Odważny et al., 2018).

This process enhancement is allowed by collecting data and providing them in real time to those who should take quick decisions (Shrouf et al., 2014). Smart devices, like smart glasses, or indoor localization services are instrument through which the integration between humans and machines is effective in smart manufacturing. However, given different ages and types of machines it is not easy to find the right solutions for each factory system composed by many processes (Sun et al., 2018). Negahban and Smith (2014), found that there has been a shift from manufacturing design to manufacturing operations planning and scheduling. A significant increase has been registered in integration of simulation with artificial neural networks, looking at better insights for operations understanding, as well as efficiency enhancement (Negahban and Smith 2014).
The growth of electronic business has generated important challenges in the Intelligent Transportation Systems of freight: capabilities' improvement and solutions for dynamic formulations to identify profitable sets. This change is expected to bring freight's transportation vehicles to interact in industrial value chains and logistics (Crainic et al. 2009).

Table 2: documents reviewed for Connectivity and Smart Manufacturing

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
Scientific Journal of Logistics	Odwazny, F. Szymanska, O. Cyplik, P.	Journal Article	*Smart Factory: The Requirements for Implementation of the Industry4.0 Solutions in FMCG Environment - Case Study*	2018
Scientific Journal of Logistics	Sun, J. Gao, M. Wang, O. Jiang, M. Zhang, X.	Journal Article	*Smart services for enhancing personal competence in industrie 4.0 digital factory*	2018
Proceedings of the IEEE	Shrouf, F. Ordieres, J. Miragliotta, G.	Journal Article	*Smart Factories in Industry 4.0: a Review of the Concept and of Energy Management Approached in Production Based on the Internet of Things Paradigm*	2014
Journal of Manufacturing Systems	Negahban, A. Smith, J. S.	Journal Article	*Simulation for manufacturing system design and operation: Literature review and analysis*	2014
Transportation Research, Part C: Emerging Technologies	Crainic, G. T. Gendreau, M. Potvin, J.-Y.	Journal Article	*Intelligent freight-transportation systems: Assessment and the contribution of operations research*	2009

Source: Author's elaboration

2.5 Articles Review: Internet of Things

Algorithms improve communication between devices through internet connection; smart manufacturing is built and sustained by the internet that make machines communicate to each other. Machines, working parts and workers together allow the industry 4.0 (Sun et al., 2018). Therefore, the focus is moving a bit from business processes to data-driven services. There are plenty of IoT applications, but the key insight stated by Pflaum and Gölzer (2018, p. 88) relies on the fact that "the source of innovation does not lie in a single technology; it is the fusion of different technologies that drives innovative IoT solutions" (Pflaum and Gölzer, 2018). Smart machines monitor their status constantly to prevent maintenance costs; smart vehicles like Automated Guided Vehicles, autonomous robots moving physical materials in the factory, coordinate production and supplies. Furthermore, in case of a driven-vehicle, there is still a risk of an information overload: an appropriated design of information system should not be neglected (Lu et al., 2014).

The application of internet-designed machines or at least the employment of sensors is needed in the factory to permit machines to communicate among them and field devices to interact with centralized controllers, enabling decentralized real-time responses (Rüßmann et al., 2015). Therefore, emerging IoT infrastructures can effectively support information systems anytime, anywhere; mutual interactions are supported by ubiquitous computing and could computing: IoT brings advantages and new opportunities, even though IoT application in enterprises systems is at its early stage (Bi et al., 2014). The lack of real-time status information slows down and worsen manufacturing processes because it is very tricky to identify runtime production exceptions or take dynamic decisions (Zhang et al., 2015).

Table 3 reports the reviewed documents for this topic.

Table 3: documents reviewed for Internet of Things

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
IEEE Pervasive Computing	Pflaum, A. A. Michahelles, F.	Journal Article	*The IoT and Digital Transformation: Toward the Data-Driven Enterprise*	2018
Scientific Journal of Logistics	Sun, J. Gao, M. Wang, O. Jiang, M. Zhang, X.	Journal Article	*Smart services for enhancing personal competence in industrie 4.0 digital factory*	2018
International Journal of Computer Integrated Manufacturing	Zhang, Y. Zhang, G. Wang, J. Sun, S. Si, S. Yang, T.	Journal Article	*Real-time information capturing and integration framework of the internet of manufacturing things*	2015
BCG	Rußmann, M. Lorenz, M. Gerbert, P. Waldner, M. Justus, J. Engel, P. Harnisch, M.	Research Report	*Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*	2015
IEEE Transactions of Industrial Informatics	Bi, Z. Xu, L. D. Wang, C.	Journal Article	*Internet of Things for Enterprise Systems of Modern Manufacturing*	2014
IEEE Internet of Things Journa	Lu, N. Cheng, N. Zhang, N. Shen, X. Mark, J.W.	Journal Article	*Connected vehicles: Solutions and challenges*	2014

Source: Author's elaboration

2.6 Articles Review: Cloud and Fog Computing

Large equipment manufacturing industry needs to adjust a system of collaborative operations to change and adapt to cloud services logic, solving the issue of resources coordination. The research is at an infant stage, but an objective difficulty may be observed in achieving a synergy effect in the factory organization (Yang et al., 2014).

Sophisticated techniques are adopted to enhance the responsiveness of manufacturing systems in coping with customers' demand fluctuations through distributed manufacturing (Mishra et al., 2016). Cloud computing and connections among devices and machines are allowed by the usage of Application Program Interfaces, that permit to create new dynamics in business models of organizations (Mosqueira-Rey et al., 2018). Cloud manufacturing is a quite new area of research and has the potential to transform the concept about how enterprises do business: cloud manufacturing customers have access to engineering design, simulation, assembling, production or testing services. It is therefore fundamental to have the necessary ability to adapt for future changes brought about by cloud computing (Ren et al., 2015; Ivanov, 2012).

In Table 4 Cloud Computing and Fog Computing documents are reported.

Table 4: documents reviewed for Cloud Computing and Fog Computing

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
Information and Software Technology	Mosqueira-Rey, E., Alonso-Rios, D., Moret-Bonillo, V., Fernandez-Varela I., Alvarez-Estevez, D.	Journal Article	*A systematic approach to API usability: Taxonomy-derived criteria and a case study*	2018
International Journal of Production Research	Mishra, N. Singh, A. Kumari, S. Govindan, K. Imran, S.	Journal Article	*Cloud-based multi-agent architecture for effective planning and scheduling of distributed manufacturing*	2016
Enterprise Information Systems	Ren, L. Zhang, L. Tao, F. Zhao, C. Chai, X. Zhao, X.	Journal Article	*Cloud manufacturing: from concept to practice*	2015
International Journal of Production Research	Yang, X. Shi, G. Zhang, Z.	Journal Article	*Collaboration of large equipment complete service under cloud manufacturing mode*	2014
Journal of Manufacturing Technology Management	Ivanov, D.	Journal Article	*The Inter-Disciplinary Modelling of Supply Chains in the Context of Collaborative Multi-Structural Cyber-Physical Networks*	2012

Source: Author’s elaboration

2.7 Articles Review: Augmented and Virtual Reality

Future Augmented Reality technology will be one of the main user interface instruments via which workers will communicate with the world: a new mixed physical-virtual world where humans are immersed, by means of see-through displays or interactive surfaces. A great challenge in this sense is about developing a complete infrastructure of technologies, security and privacy infrastructures to guarantee a safe usage (Kroeker, 2010).

Augmented Reality and Virtual Reality are immersive technologies, and despite suggestions that can generate a shortage of empathy, is the way humans interact with changing content and new learning opportunities are created (Hall and Takahashi, 2017; Iordache and Pribeanu, 2009). Virtual reality may help in enhancing a continuous improvement process, directly carried out by groups of workers and engineers; the usage of pertinent human Virtual Reality interfaces may enable the immediate availability of information within the manufacturing environment (Aurich et al., 2009). Augmented Reality has been used for assisted assembly planning, deploying a 3D manipulation of virtual objects (Wang et al. 2013). In Table 5 Augmented and Virtual Reality documents are reported.

Table 5: documents reviewed for Augmented Reality and Virtual Reality

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
McKinsey & Company	Hall, S. Takahashi, R.	Research Report	*Augmented and virtual reality: The promise and peril of immersive technologies*	2017
IEEE Transactions on Human-Machine Systems	Turner, C.J. Hutabarat, W. Oyekan, J. Tiwari, A.	Journal Article	*Discrete Event Simulation and Virtual Reality Use in Industry: New Opportunities and Future Trends*	2016
International Journal of Production Research	Wang, Z. B. Ng, L. X. Ong, S. K.	Journal Article	*Assembly planning and evaluation in an augmented reality environment*	2013
Communications of the ACM	Kroeker K. L.	Journal Article	*Mainstreaming augmented reality*	2010
Informatica Economica	Iordache, D. D. Pribeanu, C.	Journal Article	*A Comparison of Quantitative and Qualitative Data from a Formative Usability Evaluation of an Augmented Reality Learning Scenario*	2009
International Journal of Production Research	Aurich, J.C. Ostermayer, D. Wagenknecht, C. H.	Journal Article	*Improvement of manufacturing processes with virtual reality-based CIP workshops*	2009
International Journal of Production Research	Wadhwa, S. Mishra, M. Chan, F. T. S.	Journal Article	*Organizing a virtual manufacturing enterprise: an analytic network process based approach for enterprise flexibility*	2009

Source: Author’s elaboration

2.8 Articles Review: Artificial Intelligence

Tech giants like Google, Amazon or Apple are investing a lot in technologies known with the name of "Artificial Intelligence"; in the automotive industry, big players like Toyota, Tesla and BMW are spending resources in robotics and machine learning for driverless cars. Industrial firms like ABB, Bosch or General Electric are investing as well but more internally, to develop specific technologies for their businesses. According to McKinsey Global Institute discussion, in a survey involving more than 3000 firms, 41% reported one of the biggest barriers for AI adoption is the uncertain return on investment, while 26% declare a lack of relevant AI solutions in the market (Bughin et al., 2017). Even small businesses can see benefits' generation from Artificial Intelligence application in their risky decision-making (Fish and Ruby, 2009).

The complication, as mentioned in chapter one, is that a large data set may be difficult to gather for many businesses. One-shot learning could be a technique that allows AI model to learn about a subject when a small number of training-examples is given. Rapid manufacturing adoption is allowed by computer-aided system to guide workers in optimum selection of production requirements. Further improvements for a more robust rapid manufacturing system in the future will be concerned with cost analysis modules, capable of make calculations for economic-batch and single components (Chui et al., 2018; Munguìa et al. 2010). When innovative breakthroughs happen, nobody believes in their success in advance but the development of algorithms can be an opportunity offered by Big Data collection: the challenge is about having data and techniques to analyze them, keeping in mind that a computer is not able to create disruptive innovations, to select the right technology, make acquisitions or to manage people (Makridakis 2018; Jankel, 2015).

The reviewed documents related to Artificial Intelligence are reported in Table 6.

Table 6: documents reviewed for Artificial Intelligence

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
McKinsey Quarterly	Chui, M. Manyika , J. Miremadi, M.	Research Report	*What AI can and can't do (yet) for your business*	2018
Foresight	Makridakis, S.	Journal Article	*Forecasting the Impact of Artificial Intelligence*	2018
MIT Sloan Management Review	Ransbotham, S. Kiron, D. Gerbert, P. Reeves, M.	Journal Article	*Reshaping Business with Artificial Intelligence*	2017
McKinsey Global Institute	Bughin, J. Hazan, E. Ramaswamy, S. Chui, M. Allas, T. Dahlstrom, P. Henke, N. Trench, M.	Research Report	*Artificial Intelligence. The next Digital Frontier?*	2017
Communications of the ACM	Kroeker, K. L.	Journal Article	*A new Benchmark for Artificial Intelligence*	2011
International Journal of Production Research	Munguia, J. Lloveras, J. Llorens, S. Laoui, T.	Journal Article	*Development of an AI-based Rapid Manufacturing Advice System*	2010
International Journal of Entrepreneurship	Fish, K. Ruby, P.	Journal Article	*An Artificial IntelligenceForeign Market screening method for Small Businesses*	2009

Source: Author's elaboration

2.9 Articles Review: Big Data Analytics

The ultimate success of Big Data analytics is related to value creation for the business firm, in most of the cases by creating advantage over competitors. Many enterprises failed in making investments in this field: investments should look not only at data infrastructure, but also at strategic positioning and competent analysts. It is not just a matter of having data, it is about formulating the appropriate data platforms integrating diverse kinds of information (Grover et al., 2018). According to the McKinsey Global survey, 41% of respondents say that primary goal of their data analysis activities is to generate new revenues and they have begun just over the two previous years; considering that most of those respondents are in energy, materials, financial services and high tech industries (Gottlieb and Rifai 2017). According to Chen et al. (2015, p. 13-14), big data analytics can bring support to the top management at organizational level, improving asset productivity and business growth. One of the major challenges is related to the handling of data-sets: the main issue is to predict problems, due to the unstructured data-sets generated by poor classification results (Kumar et al. 2016).

The increasing awareness about the value generation potential of Big Data analytics is pushing illuminated business organizations to include the figure of Chief Data Officer in their organization. It would be a key leader in providing a three-dimensional support to the organization: collaborating on internal business processes and externally focusing on external stakeholders; managing data starting from company's traditional data; bringing evolution towards Big Data development (Lee et al., 2014).

Insights-based value creation models can be arranged in three main categories:

- Top-line use cases, may enhance customer-facing activities, like pricing or promotion optimization to drive growth;
- Bottom-line cases, employing data-driven insights to optimize internal processes, like predictive maintenance and supply chain optimization;
- New business model cases, moving beyond optimizing processes, by enlarging the offerings portfolio of the company (Mohr and Hürtgen 2018).

In Table 7, reviewed elaborations regarding Big Data Analytics are reported.

Table 7: documents reviewed for Big Data Analytics

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
Journal of Management Information Systems	Grover, V. Chiang, R. H. L. Liang, T.-P. Zhang, D.	Journal Article	*Creating Strategic Business Value from Big Data Analytics: A Research Framework*	2018
Digital McKinsey	Mohr, N. Hurtgen, H.	Research Report	*Achieving business impact with data*	2018
McKinsey Global Survey	Gottlieb, J. Rifai, K.	Research Report	*Fueling Growth through Data Monetization*	2017
International Journal of Production Research	Kumar, A. Shankar, R. Choudhary, A. Thakur, L. S.	Journal Article	*A big data MapReduce framework for fault diagnosis in cloud-based manufacturing*	2016
Journal of Management Information Systems	Chen, D. Q. Preston, D. S. Swink, M.	Journal Article	*How the Use of Big Data Analytics Affects Value Creation in Supply Chain Management*	2015
MIS Quarterly	Lee, Y. Madnick, S. Wang, R. Wang, F. Zhang, H.	Journal Article	*A Cubic Framework for the Chief Data Officer: Succeeding in a World of Big Data*	2014

Source: Author's elaboration

2.10 Articles Review: Machine Learning and Deep Learning

Machine Learning is a supervised training for computers, to make them learn how to solve problems, to fix future new troubles. Different tools have been brought about by Machine Learning, and most of them are open source tools, like numerical or statistical tools, easy to be accessed (Louridas and Ebert 2016). The deep learning models' performance rely on the dataset's quality: the effectiveness is much higher with well-defined tasks, and multi-sensors has been used to earn data at different stage of the product's life. However, one of the critical challenges is still concerned with non-structured and unbalanced data (Wang et al., 2018). The sample size of data is a feature that is related to their reliability, and when you have small datasets the characteristics of the entire population are not well-described by the information gained. Those predictive analytics are not only a hot topic for academics, but also for industries' practitioners: the ability to predict customer behavior in advance, for example, has consequences in product innovation, production or distribution (Li et al. 2013; Waller and Fawcett, 2013).

In some cases, like the one reported by The Case Box 7, it is not easy to have huge amounts of data and human knowledge can be used to execute optimization: in Hitachi case, work movements were investigated on-site and those elements were taken as prior knowledge. There are two types of Machine Learning:

- *Unsupervised Machine Learning*: involving only normal operation samples and so the standard operation model can be estimated as a probability distribution;
- *Supervised Machine Learning*: regarding training of normal operation samples and of abnormal operation samples, to help the system make the correct judgment, even though is difficult to collect abnormal operation samples (Irie et al., 2016).

Algorithms used in Machine Learning approaches have usually a low classification accuracy for an application to real-time monitoring in manufacturing processes.

Documents related to Machine and Deep Learning are grouped in Table 8.

Table 8: documents reviewed for Machine Learning and Deep Learning

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
Journal of Manufacturing Systems	Wang, J. Ma, Y. Zhang, L. Gao, R. X. Wu, D.	Journal Article	*Deep learning for smart manufacturing: Methods and applications*	2018
Communications of the ACM	Monroe, D.	Journal Article	*Deep learning takes on translation*	2017
IEEE Computer Society	Louridas, P. Ebert, C.	Journal Article	*Machine Learning*	2016
Hitachi Review	Irie, N. Nagayoshi, H. Koyama, H.	Company Report	*Utilization of AI in the Manufacturing Sector. Case Studies and Outlook for Linked Factories*	2016
IIE Transactions	Bastani , K. Rao, P. K. Kong, Z. (J.)	Journal Article	*An online sparse estimation-based classification approach for real-time monitoring in advanced manufacturing processes from heterogeneous sensor data*	2016
International Journal of Production Research	Li, D.-C. Huang, W.-T. Chen, C.-C. Chang, C.-J.	Journal Article	*Employing virtual samples to build early high-dimensional manufacturing models*	2013
Journal of Business Logistics	Waller, M. A. Fawcett, S. E.	Journal Article	*Click Here for a Data Scientist: Big Data, Predictive Analytics, and Theory Development in the Era of a Maker Movement Supply Chain*	2013
International Journal of Production Research	Shah , P. Gosavi, A. Nagi, R.	Journal Article	*A machine learning approach to optimise the usage of recycled material in a remanufacturing environment*	2010

Source: Author’s elaboration

2.11 Articles Review: Additive Manufacturing

Markets for Additive Manufacturing could see an increase in importance for sectors or industries in which there are small production outputs, high product complexity, a high demand for tailored products customized to customers’ needs and when it is appropriate to build some objects on-the-field (Weller et al., 2015).

Designers do not always answer with the same accuracy, that is often decisive to get the desired product or functional mechanism, but it is different from one 3D printer to another (Gardan, 2016).

Despite the great potential and hope placed on 3D Printing, near-term expectations may be overblown, according to the MIT Sloan Managements Review Research. Indeed, there are profound differences in processes because materials are diverse: for example, plastic Additive Manufacturing is completely different from metal Additive Manufacturing. Other limits can be related to flexibility, because a 3D Printer that should build very different products should be configured and checked every time; it might turn out to be more convenient to have several machines to make different products, unmasking the myth of replacing mass manufacturing with mass customization (Bonnín Roca et al., 2017).

The investment for the procurement of a 3D printer can be an issue: today's price of a 3D printer is lower than the price of six months ago, but the cost of the materials remains high (Mavri, 2015).

3D Printing industrialization is characterized by the limitations that occur when a technology and applications are at a preliminary stage and are yet applied for every function. Looking at operations management, for instance, some aspects have gained scarce attention or have not been analyzed yet, but approaches for preventive maintenance, process design or capacity and resource planning should be subject to change (Long et al., 2017; Niaki and Nonino, 2017).

Table 9 represents studied documents concerned with Additive Manufacturing.

Table 9: documents reviewed for Additive Manufacturing

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
MIT Sloan Management Review	Bonnín Roca, J. Vaishnav, P. Mendonça, J. Morgan, M. G.	Journal Article	*Getting Past the Hype About 3-D Printing*	2017
International Journal of Production Research	Long, Y. Pan, J. Zhang, Q. Hao, Y.	Journal Article	*3D printing technology and its impact on Chinese manufacturing*	2017
International Journal of Production Research	Niaki, M. K. Nonino, F.	Journal Article	*Additive manufacturing management: a review and future research agenda*	2017
International Journal of Production Research	Gardan, J.	Journal Article	*Additive manufacturing technologies: state of the art and trends*	2016
MIT International Journal of Mechanical Engineering	Kamran, M. Saxena, A.	Journal Article	*A Comprehensive Study on 3D Printing Technology*	2016
Knowledge and Process Management	Mavri, M.	Journal Article	*Redesigning a Production Chain Based on 3D Printing Technology*	2015
International Journal of Production Economics	Weller, C. Kleer, R. Piller, F. T.	Journal Article	*Economic implications of 3D printing: Market structure models in light of additive manufacturing revisited*	2015

Source: Author's elaboration

2.12 Articles Review: Cybersecurity

The increasing digitalization of businesses boosts the risk of cyberattacks through the internet connection with the world outside a company. Organizations in telecommunications, healthcare, logistics and many other industries have been held hostages of attacks in the United States, Canada and Europe. In 2018 "Meltdown" and "Spectre" cyberattacks were exposed among the biggest cyber-threats showing vulnerabilities in both software and hardware (Poppensieker and Riemenschnitter, 2018). Countermeasures must help in ensuring information systems' confidentiality, their availability and integrity by preventing asset losses. It is important to think about security planning, taking into consideration a budget for countermeasures (Rees et al., 2011). "Typically, just knowing where to go and what to do is enough to cause major disruptions" said expert Samy Kamkar (2016, p. 18), former hacker who attacked MySpace social network in 2005 (Kugler, 2016). Cybersecurity is a key component for a successful Industry 4.0 implementation, a hard challenge for government authorities and for private business firms (Ghobakhloo, 2018).

In Table 10 are reported the reviewed documents about cybersecurity.

Table 10: documents reviewed for Cybersecurity

SOURCE	AUTHORS	TYPE OF PUBBLICATION	TITLE	YEAR
Akamai Security Research	Einav, Y. Yuzifovich, Y.	Company Report	*[state of the internet] / security. Career Insights Report*	2018
McKinsey & Company	Poppensieker, T. Riemenschnitter, R.	Research Report	*A new posture for cybersecurity in a networked world*	2018
Journal of Manufacturing Technology Management	Ghobakhloo, M.	Journal Article	*The future of manufacturing industry: a strategic roadmap toward Industry 4.0*	2018
MIT Sloan Management Review	Mangelsdorf, M. E.	Journal Article	*What Executives Get Wrong About Cybersecurity*	2017
MIT Sloan management Review	Esteves, J. Ramalho, E. De Haro, G.	Journal Article	*To Improve Cybersecurity, Think Like a Hacker*	2017
Communications of the ACM	Kugler, L.	Journal Article	*How a Supervillain (or a Hacker in His Basement) Could Destroy the Internet*	2016
Decision Support Systems	Rees, L. P. Deane, J. K. Rakes, T.R. Baker, W. H.	Journal Article	*Decision support for Cybersecurity risk planning*	2011

Source: Author's elaboration

2.13 Conclusions

Reviewed documents show that digital implementation process comprehends a bundle of approaches, organizational challenges, business changes and new technologies' adoption. Organizations should re-define their structure enhancing collaboration and support for workers, to better embrace the change. Moreover, in this process not only company's own culture may be affected by digital impact, but also products and services for the customer should be re-considered from a digital point of view, even if it involves risk-taking and different modes to create value.

Institutions are likely to have an important role in facilitating the application of new technologies both for companies and for individuals: this means providing not only monetary incentives, but also promoting the utilization of new technologies and approaches.

The focus is often on productivity and efficiency, but also end-to-end digital integration deserves paying attention, in order to take into consideration privacy issues.

Leaders and professionals should radically inspire other figures in the organization, worrying about creating a supportive culture, being magnets for talents and raising awareness about the importance of change. Literature highlights the importance of leadership in moments of change. The ownership and executives of an organization should provide a supportive environment, pushing the alignment of every employee and sharing reasons backing the choices made.

Having a solid digital strategy is important to successfully face the changes ahead, without having too many priorities. This base may help to successfully implement a transformation, in which technological aspects should be integrated with organizational requirements to better take advantage from this change. According to Bounfour (2016) there is an acceleration of links that speeds up the change, activated by an innovative engine that shrinks functional and geographical distances.

Next chapter focuses on three real cases of digital strategy implementation, in discrete and in process manufacturing, proposing also a distinction related to technical aspects.

The first case is reviewed from an article of the journal *Advances in Mechanical Engineering*, while other two cases have been investigated through visits and interviews.

3. CHAPTER THREE

BENCHMARKING ANALYSIS

3.1 Introduction

After a literature review on digital strategy implementation and applicable technologies, this chapter has the aim of studying real cases of digital technologies implementation. The literature research led to an article of the journal *Advances in Mechanical Engineering* (2017), chosen for the level of detail in documenting the implementation. The paper concentrates on implementation in a discrete manufacturing firm of the automotive industry in China, and a further distinction between discrete and process manufacturing firms is addressed afterwards.

Once the distinction in made, the chapter shifts on two real benchmark cases. The benchmarks were chosen after an initial reasoning with a digital implementation-expert consulting firm, that suggested two complementary process manufacturing firms to examine. ASO Hydraulics & Pneumatics benchmark has given useful insights for technological instruments' application, while the Stevanato Group benchmark has been fruitful to earn strategical insights and organizational hints for a digital implementation.

Furthermore, some quick case studies are added in the form of The Case Box, as did in Chapter One.

The integration of results from literature review and benchmark analysis is functional for the SIRMAX case investigation reported in Chapter Four.

3.2 Digital Strategy Implementation in Discrete Manufacturing Firms: A Case Study in Automobile Industry

This paragraph illustrates an example about digital technologies' implementation in process manufacturing firms, found using the databases described in Chapter Two. The research brought to the article "Construction of cyber-physical system-integrated smart manufacturing workshops: A case study in automobile industry" (Zheng and Ming, 2017). The elaboration analyzes in detail the needs and improvements brought about by digital implementation in discrete manufacturing. It can be taken as a reference point to make a comparison between discrete and process manufacturing operations.

The research conducted by Zheng and Ming (2017) treats the integration of advanced sensing technologies in robotics, internet of things and internet of information. The researchers collaborated with manufacturing companies from different industries.

3.2.1 A case study in Automotive Industry

The case study in automotive industry that Zhang and Ming (2017) present in their elaboration is related to a company named "Company S", specialized manufacturer of Body-In-White (BIW) components in China. The researchers call "subsystems" those arrangements that combine digital technologies for operational needs. These subsystems are summarized in Table 11, together with associated issues and solutions that are used, or that are suggested, to deal with arisen troubles.

Among the issues faced by the company, one was related to welding, gluing and conveying activities performed manually, with a consequent loss of efficiency and higher risks for operators. The solution was the introduction of automated robots controlled through a PLC industrial computer. Computer visual simulation was used to fix high work-in-process problems, since it plans the logistic routine and give real-time feedbacks. Other problems are related to the Real-Time Monitoring System of Production Process and the Digital Logistics Tracking System. In the former system, multiple sensors and monitoring stations were deployed; in the latter, bar codes, QR codes and RFID technology were used for logistic tracking.

To improve the reliability of workshop's operations, an automatic fault diagnosis warning system has been developed through a mix of WLAN and LAN systems to reduce communication complexity and have real-time alerts. In this case, an escalation problem-solving logic has been set: problems are signaled at on-site equipment, then at workshop level (if not previously solved), and to remote diagnosis if the problem persists.

Integrated information systems in workshop level can combine originally isolated systems to provide a workshop visualization, sharing of real-time integrated data, more efficient connection and communication (Zheng and Ming, 2017).

Table 11: Workshop issues and solutions in automotive industry case study

Subsystem	Issue	Adopted/Proposed Solution
Automatic Loading and Unloading Systems	Manual operations for welding, gluing and conveying	Automated robots used for former manual tasks
Leveled and Balanced Mixed of Production Flow	High Work-In-Process and bottlenecks	Workshop's ogistic routine optimized through computer virtual simulation
Real-Time Monitoring System of Production Process	Lack of process data monitoring	Real-time data acquisition, transmission, storage, display and control
Digital Logistics Tracking System	Lack of control system for materials' tracking	Bar code, QR code, RFID technology
Automatic Fault Diagnosis and Warning	Troubles for having a reliable communication system	Connected systems and escalation problem-solving logic

Source: "Construction of cyber-physical system-integrated smart manufacturing workshops: A case study in automobile industry", (Zheng and Ming, 2017).

3.2.2 Results

There is still a gap from strategies' formulation and implementation at the operational level. This research provides a description of how improvements may be accelerated employing technologies that allow to tackle issues in discrete manufacturing dynamics. However, some insights might be useful for process manufacturing firms' logics and might be applied in a continuous flow workshop that might need data monitoring and warning in case of error. In the next paragraph the differences between discrete and process manufacturing firms are highlighted; then a comparison of insights gained from the examined paper and the other two benchmarks is presented in the conclusions of Chapter Three. Those insights will be important to support the analysis presented in Chapter Four.

3.3 Discrete Manufacturing VS Process Manufacturing

There are two main types of manufacturing process and there are differences between them. Discrete manufacturing relates more on the assembly of different components to

create a single identifiable product; while process manufacturing is concerned with continuous flow of materials, like in food, pharmaceutical, petrochemical engineering and metallurgy industries, as described by Wang et al. (2002, p. 413).
Those differences are relevant on examining a digital strategy implementation, mainly for technological aspects of applications, both hardware and software, that might be applied at operational level.

> "There exist large differences between discrete and process manufacturing industries in the production and business processes. The end products are made by material cutting and component assemblies in the discrete manufacturing industries. The production processes are divided into discrete stages, where the work-in-process can be deferred in buffers between stages, whereas in the process industries, the raw materials continuously flow through a set of pipelined equipment until they are transformed into end products and by-products. For instance, the final products of petrochemical industries are obtained through various chemical reactions such as splitting, combination, distillation and fraction. These production processes run continuously and the material flows cannot be interrupted before completion" (Wang et al., 2002).

Different characteristics are present at the level of formulations and bill of materials, as the latter can be multi-level or single-level. Three practical arguments may rise:

- Multi-Level vs Single Level: process-oriented firms with a deep bill of materials need to deal with a capacitated material requirements planning;
- WIP Lot-sizing vs Raw Material Lot-sizing: in many cases the same method is used interchangeably between WIP and Raw Material lot-sizing, but this can lead to inappropriate lot-sizing solutions;
- Multi-Plant vs Single Plant: several process-oriented companies have interlinked networks of plants and dependence in raw materials among them. This creates a greater complexity in planning for raw material transfers (Schuster et al., 2000).

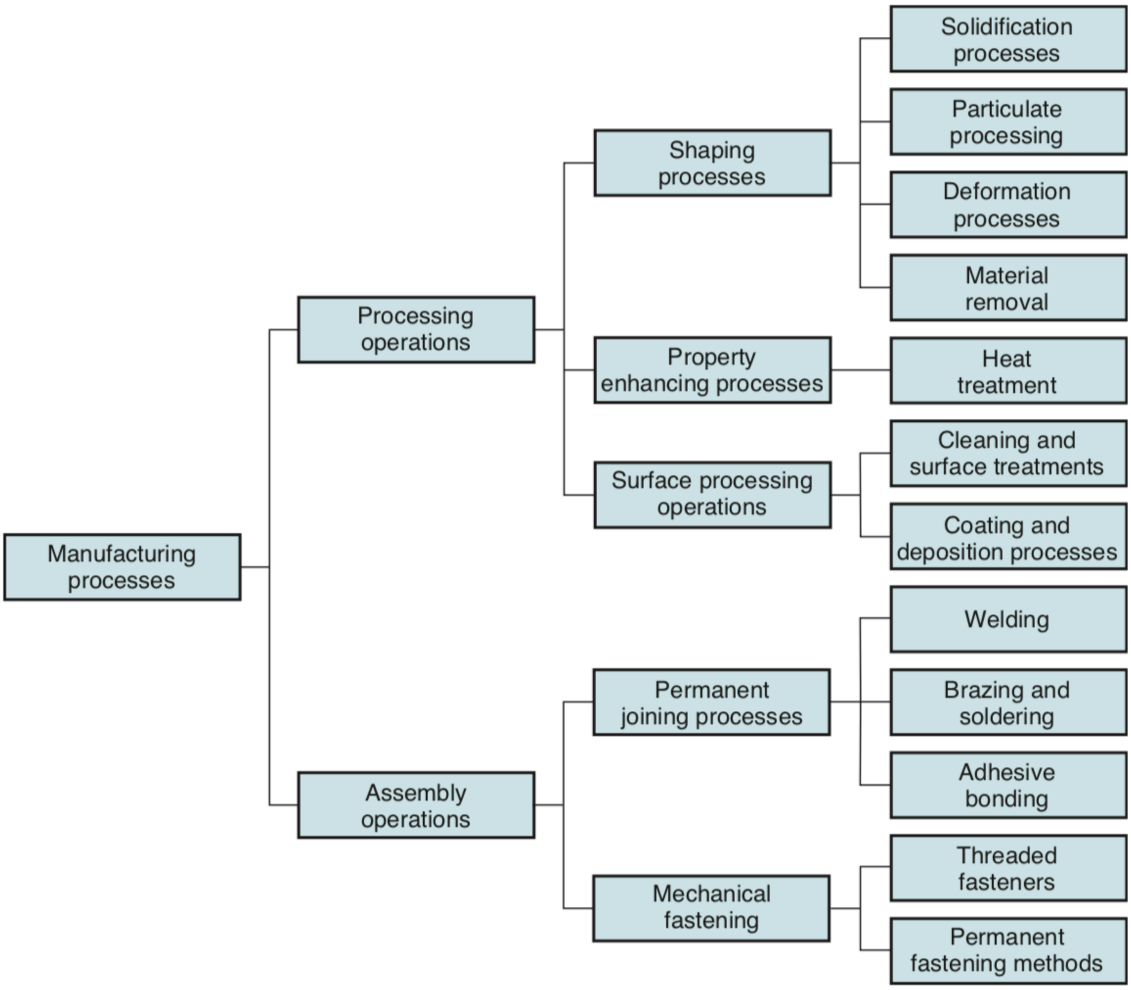
Process-oriented industries have often refused traditional Materials Requirements Planning (MRP) logic and substituted it with different methods guided by the process structure to schedule calculations (Schuster et al., 2000).

A metal printing is a discrete stage, while the metal sheet in the metal printing comes from a continuous process item for instance. Several discrete components are made by continuous or semi-continuous elements, like the extruded ones. Groover (2010) provides a classification of manufacturing processes, represented in Figure 17.

Processing operations use energy, including mechanical, thermal, electrical and chemical, to adjust the shape or physical properties of a product adding some sort of value to the product itself, performing a necessary sequence to achieve the appropriate design specifications (Groover, 2010). There are three main types of processing operations:

- Shaping operations: operations that apply heat or mechanical force to affect the geometry of the work material. The starting material can be a liquid, a powder, a ductile solid (like metal) or a solid that is modified in its shape.
- Property-enhancing operations: operations performed to enhance the work material's mechanical or physical properties, usually not changing the materials' shape. This process is performed involving heat treatments.
- Surface processing: operations concerned with cleaning, chemical and mechanical processes to remove something from the product; operations concerned with surface treatments (Groover, 2010).

Figure 16: Classification of manufacturing processes



Source: Fundamentals of Modern Manufacturing. Materials, Processes and Systems, (Groover, 2010).

Some dynamics, like in the case of a buffer between stages, are possible in discrete manufacturing but not in process manufacturing, due to continuous flow of materials of the latter. Process manufacturing firms, for the nature of their process, need to monitor operations related to the modification of shape or surface and property-enhancing processes. Although the robot automation seems more suitable for discrete manufacturing firms, there are technologies able to satisfy needs present in both discrete and process manufacturing operations. These are the need of real-time data collection, a system concerned with warning alerts, and a tool for remote maintenance.

In Paragraph 3.4 and Paragraph 3.5, two process manufacturing firms are analyzed as benchmarks to figure out their issues and the proposed or adopted solutions.

3.4 Digging Deeper: Implementation in ASO Hydraulics & Pneumatics

ASO Hydraulics and Pneumatics is a company of the ASO Group and has been selected after the suggestion of a digital implementation-expert consulting firm. The core business of the company is related to pipes (one type) and bars (6 types) made of steel. The firm produces 90 tons/day of finished product and performances are measured by OEE (Overall Equipment Effectiveness).

Figure 17: ASO H&P benchmark dimension overview

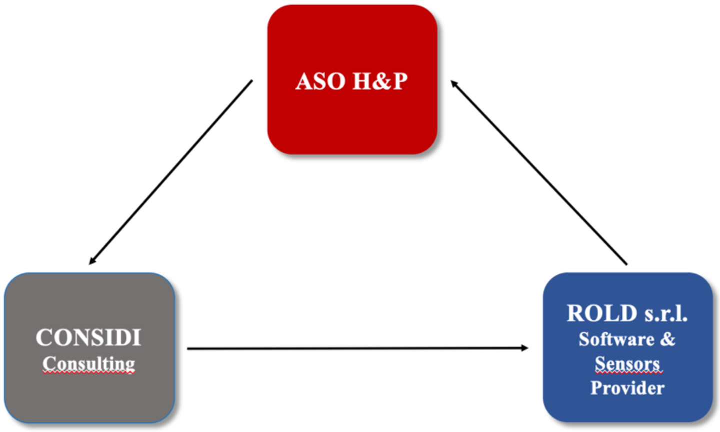
ASO HOLDING SRL					
	2013	2014	2015	2016	2017
(in Million)					
SALES	159. 577. 727 €	240. 171. 542 €	212. 754. 104 €	203. 320. 068 €	250. 764. 106 €
SALES GROWTH	-18,94%	33,56%	-12,89%	-4,64%	18,92%
EBITDA	14. 740. 727 €	30. 302. 328 €	13. 358. 883 €	15. 938. 879 €	23. 996. 856 €
EBITDA MARGIN	8,33	11,83	5,93	7,43	9,11
NFP	23. 172. 378 €	53. 505. 624 €	34. 012. 319 €	28. 936. 047 €	30. 006. 157 €
No WORKERS	306	301	318	322	340

Source: Analisi Informatizzata delle Aziende Italiane.

ASO H&P has chosen to adopt digital solutions in process manufacturing operations characterized by a continuous flow. A company's dimension overview is provided in Figure 18.

The company is implementing a system to monitor the OEE in real-time and to consequently check the machines' status. The analysis and data gathering has been performed in collaboration with CONSIDI consulting, Italian firm specialized in digital implementation. Figure 19 shows the collaboration involving three firms: CONSIDI consulting provided service to ASO H&P and had built the connection between ASO H&P and Rold s.r.l., a company specialized in sensors and software platforms for manufacturing plants.

Figure 18: ASO H&P case

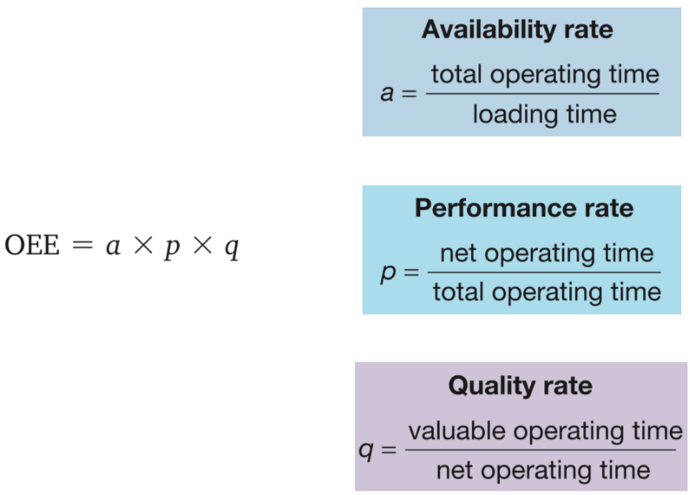


Source: Author's elaboration

3.4.1 Issue presentation

The issues that made the company look ahead and bring some changes were mainly concerned about the manual and late calculation of the OEE: a weekly calculation from data of the production process written by operators in papers and reported in an Excel file only the following week. Figure 20 provides insights about Overall Equipment Effectiveness formula: it measures availability rate, as the time in which the machine is available for producing; the performance rate, to measure the machine's usage; the quality rate that measures the proportion of compliant products produced.

Figure 19: Overall Equipment Effectiveness



Source: Operations Management, (Slack et al., 2013).

The first step was the implementation of the ERP system Microsoft Dynamics AX (from January 1st, 2018) that allowed to accelerate a lot the flow of process data almost real-time, but still the machines' stop causes were manually reported by operators. This implied not even having statistics about machines stops available to be analyzed.
The possibility to see in real-time the slowing down of a machine, is likely to shorten the duration of a stop.

3.4.2 Methodology

An interview with Simone Grossule, member of the Quality Assurance and KAIZEN team for continuous improvement in ASO H&P, has been conducted to understand what brought about the idea process' digitalization, which problems made the company invest in new technologies and the steps about how the operators or managers reacted facing the change. The day in which the interview was performed was also dedicated to train plant operators and the two plant managers Andrea Pellini, Process Manager and Application Expert, and Enrico Rodatis, Product and Quality Manager. Two different lectures because using the software platform operators and managers have different access possibilities, design alerts and add new options, while operators have only access to interact with the machine edge panel, mainly to insert the causes of the stops. A tour in the manufacturing plant was allowed by the company and this helped to better fit in understanding which problems the company had.

3.4.3 The interview and the factory experience

The interview with Simone Grossule, member of the Quality Assurance and KAIZEN team for continuous improvement, was made during a tour in the factory that helped to dive into the ASO H&P real plant's manufacturing process.
A large part of the organization is focused on the process and having higher efficiency in the process means having higher profits most of the times: this is the case of ASO H&P that needed real-time monitoring of the process. Hence, they wanted technology support to have an improved knowledge of their processes:

> "We are at the mercy of what happens, especially when issues come from machines' stops or breakdowns and we do not realize it on time. We aim to have better knowledge of our processes to reach higher savings. Having unequivocal data permits an objective reporting that does not depend on the operator's meticulousness" (Grossule, 2018).

There were two reasons why the process slowed down: the knowledge of the process and the personal attention of the operator that may influence – and it does – the machine performance, because sometimes operators do not signal stops. Data needed to be manually listed from pieces of paper into an excel file once a week for the OEE calculation: managers required an agile method to gain real-time and updated information. Hence, digital tools have been employed to reduce errors, to empower workers' accountability, and to earn more reliable information. The main goals of ASO H&P were:

- OEE real-time calculation;
- Prompt alert signaling;
- Creating and storing big data from process.

A brief example of a sensor-system installed for having process data available and make the process more efficient, is described in The Case Box 8.

The Case Box 8

The **STANLEY BLACK & DECKER** case

IoT deployment in workshop

The company needed a real-time transparency of the OEE and line productivity to reduce the changeover time. With the help of hardware components, Wi-Fi infrastructure, plant-wide Ethernet provided by CISCO, but also software components and Real-Time Location System (RTLS) provided by AeroScout, Stanley Black & Decker fully connected its production lines. Status alerts are immediately visible and employees' efficiency is therefore enhanced. This technology allowed:

- 24% increase in the OEE;
- First-Time pass defects per million opportunities (DPMO) reduced by 16%;
- throughput time increase around 10%;
- inventory costs reduction around 10% (Cisco Public Information).

Source: " Leading Tools Manufacturer Transforms Operations with IoT", (Cisco Public Information, 2014).

The lack of real-time OEE calculation data has been solved through sensors' deployment that allows data gathering and visualization of updated information on edge-machine panels. Among the issues and proposed or adopted solutions for the ASO H&P case, the development of a central platform for the pivotal monitoring of data has been important to have a big picture of the plant updated in real-time. Through this platform, different alarms have been set, together with the option to check the real-time performance and past trend of a single machine. When a stop is not justified by the fulfillment of causality, an alarm is triggered: managers can decide time thresholds after which the alarm call another senior operator when an issue is not solved within set time limit. Alarms are sent through wearable smartwatches gear S3 worn by the demanded workers. The lack of finished product tracking may be solved with integration of information collected through the ERP and the platform software. This information need to be stored, and the company has decided to store them in internal servers, even if a cloud solution could be a safer method. Another objective in perspective is related to the usage of data for predictive maintenance, even though the firm is at an early stage on this point.
These issues and related adopted or proposed solutions are reported in Table 12.

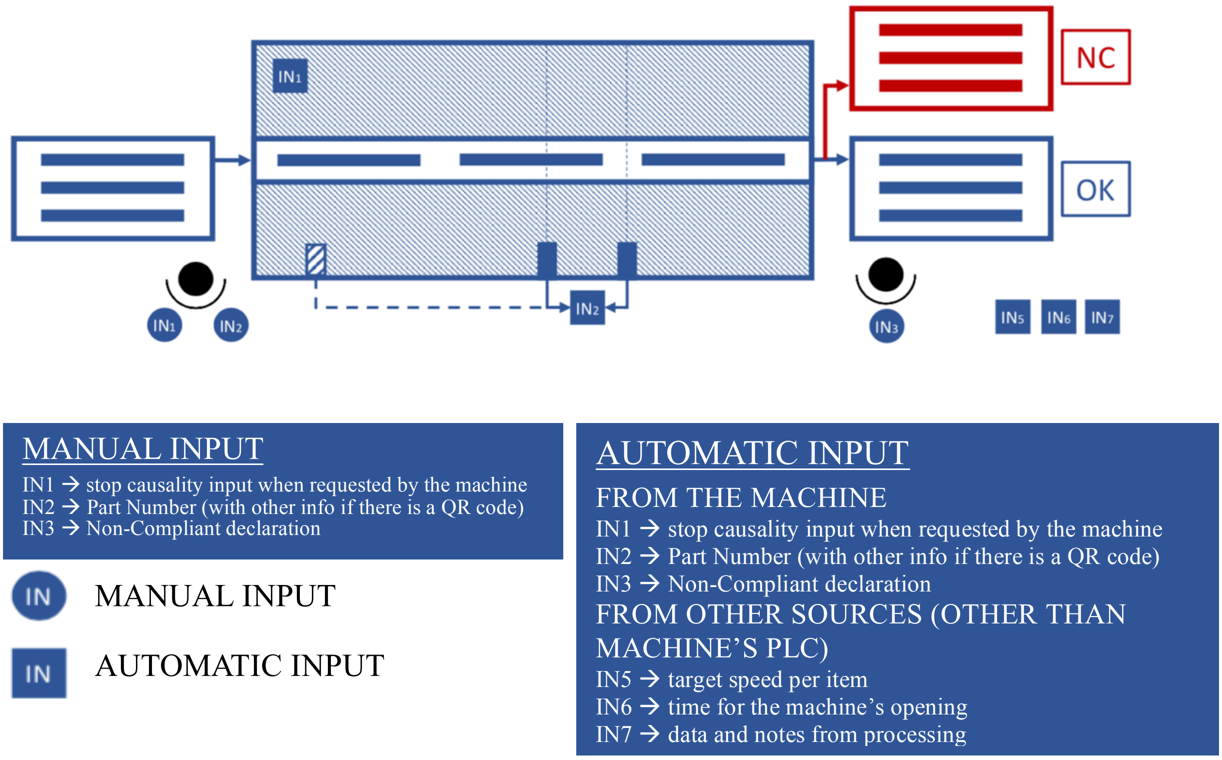
Table 12: Workshop issues and adopted/proposed solutions in the ASO H&P case

Subsystem	**Issue**	**Adopted/Proposed Solution**
Real-Time Process Information and Machines' Performance	Lack updated OEE calculation	Sensors' and edge.machine monitors' installation
Central Display Monitoring of Information and Warning System	Absence of a system for central data monitoring of data	Software development for information visibility
Real-Time Logistics Information	Lack of materials' tracking	Integration of software platform data and ERP's information
Data Storage and Availability	Need for data storage	Internal servers to store data collected through the software platform
Predictive Maintenance	Absence of a system for predictive maintenance	Data fcollection to practice predictive maintenance

Source: Author's elaboration.

The logic scheme regarding the manual and automatic inputs of the information flow after the implementation of the platform, is represented in Figure 21. The representation in relative to one pilot machine, in which manual inputs may be entered before and after the passage of the bar by operators using edge-machine panel, while automatic inputs are generated by the machine itself and included in the platform as well.

Figure 20: Logic Scheme: Information Flow



Source: "Presentazione scenari di implementazione per Rold", (CONSIDI consulting, 2018).

> "The initial idea and the feeling about necessity for a change came both for the management and from the ownership of the company. Both believed that the process needed to be integrated with an information technology system to have clearer view of what happened and more efficiency in the process" (Simone Grossule, 2018).

Digital strategy was defined internally between ownership and management to answer common questions, to smooth the process after solving stops and therefore having a better understanding of the process. A higher transparency throughout the process has an immediate effect in front of the client, that has been proved also during customers' visits in the plant, in a situation in which they looked at the data in real-time directly showed by monitors in the offices of ASO H&P. The long-term goal is to use sensors and technology even in the relationship with the supplier: for example, the ability to track a quality problem and connect it directly to a raw material batch may fasten the feedbacks flow towards suppliers. Therefore, the digital changes that affected ASO H&P involved aspect that are both internal and external from the company.

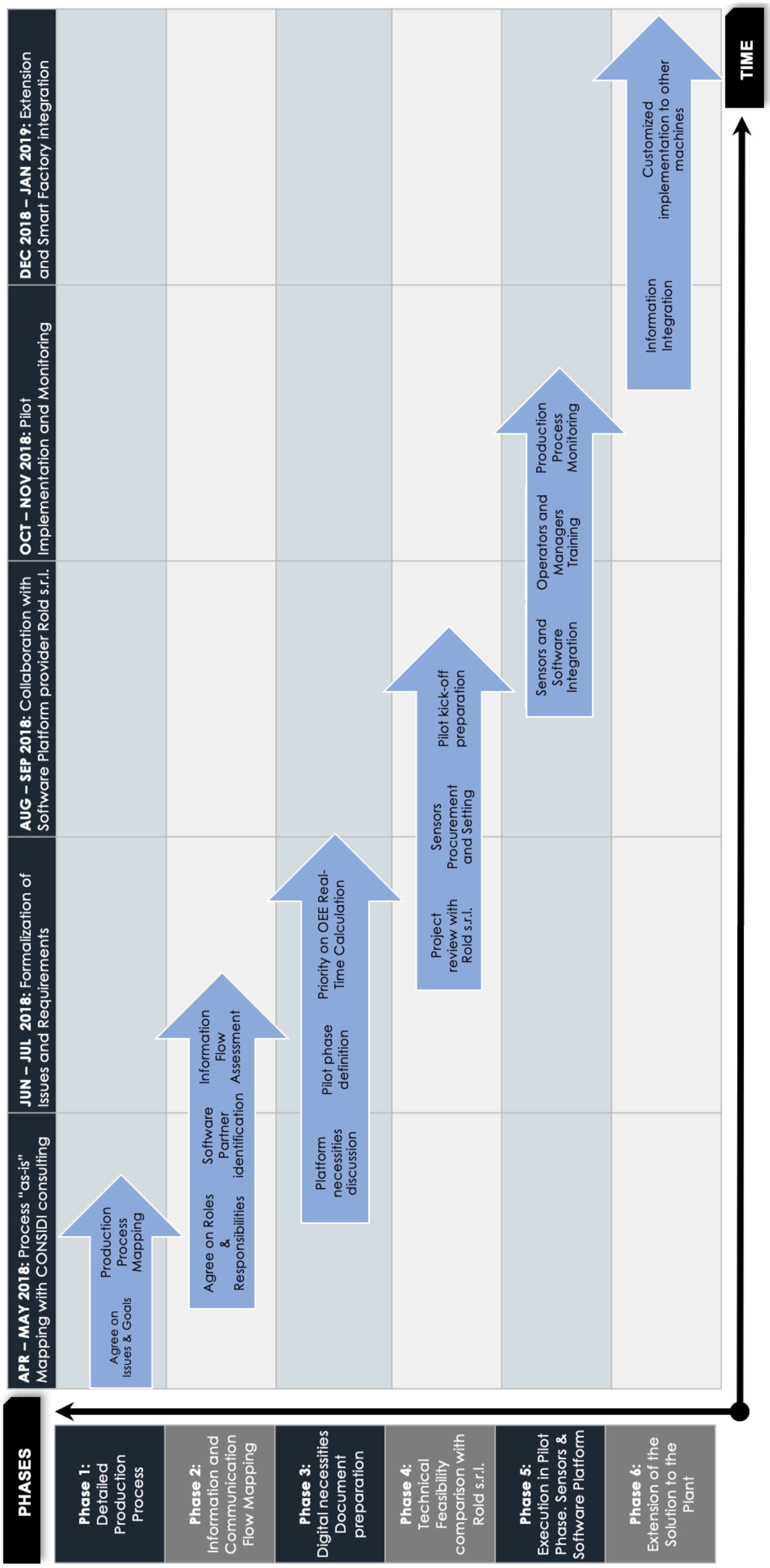
3.4.4 From Digital Strategy to Implementation

The implementation occurred in ASO H&P followed different steps. Phases between strategy initial definition and subsequent changes along the way towards the concrete implementation, in a process where people from different companies worked together to build an architecture suitable for ASO H&P's main requirements. The GANTT of the project is represented in Figure 22:

- *Detailed Production Process Study*: the first phase was concerned with the deep analysis of the process in every single step, internally by ASO H&P for mapping every critical or sensible point;
- *Information and Communication Flow Mapping*: managers analyzed each step of the process, checking them also physically in the plant to verify the validity of the conducted study;
- *Digital Necessities Document Preparation*: according to internal requirements, internal analysis and on-field verification, ASO H&P's necessities were organized in a document;
- *Technical Feasibility comparison with Rold s.r.l.*: ASO H&P managers and software's provider company checked the plan's feasibility. Some specifications remained, some parts instead changed: they ended up with a modified document.
- *Execution in Pilot Phase, Sensors Installation and Platform Starting Up*: after the installation of the hardware in form of sensors, a pilot phase to test the functioning of edge-machine panel and the central control panel was in place.

  Very important phase for adjustments and first real impressions about the new hardware-software architecture.
- *Extension of the Solution to the Plant*: after a pilot phase, the solution was extended to the machines of the plant, connecting installed sensors with the software platform to have every step of the process reported in real-time.

Figure 21: Actions and Timing for Smart Platform implementation in ASO H&P



Source: Author's elaboration.

ASO H&P reported no need for additional talents to implement this kind of change: new workers in the phase of preparation and digital technologies' implementation were not hired, since the firm had previously hired new and qualified workers before the ERP implementation, as reported the by the Quality Assurance and KAIZEN team member Simone Grossule.

3.4.5 Investment and Expected Benefits

The sensors' installation and the software implementation, including consulting services, entailed an overall investment between 30.000 and 40.000 €. This investment comprised both the pilot phase and the extension of the solution to the plant in Oppeano, Verona. ASO H&P expects to register process improvements, through detection of machines' breakdowns or errors in materials' manufacturing along the production line, as well as a more reliable reporting system through a software platform. To mention an example that often occurred, process managers and/or operators were not capable to detect defects on bars in initial phases, before the chromium plating phase: the result was a waste of bars and of some quantity of chromium, being the batch composed by bars with fissures. Developments on real-time controlling of the process and the alerting system should allow ASO H&P to reduce this kind of phenomenon.

In addition, performance data at the machine's edge should increase ownership of the job of operators, since they have an additional tool to monitor the process.

In perspective, the management of the company aims to gain reliable data even about energy consumption, to have prompt alerts also in cases of abnormal high peaks of energy usage.

3.4.6 Results

In the short period, ASO H&P expects to have higher awareness of the process and a strong readiness to fix problems at production level. The digital boost given to the production process is not only for having some advantage in the short run, but also a first step to earn better knowledge of the process. The management believes that this initial investment will increase production efficiency and will create savings to be invested even in other enhancing-solutions.

The company are not hiring new talents to bring digital knowledge, but plans to train current workers in the future.

The KAIZEN team member Simone Grossule declared he would have changed the initial phase in which the strategy design was made only internally, building the path with digital experts to have a clearer understanding of digital potential and feasible actions. In one of the last considerations Grossule mentioned also the discrete manufacturing orientation of the platform and the need to marginally change its features for process manufacturing needs.

3.5 Stevanato Group: Digital Architecture and Long-Term Approach

In this section, an investigation about digital systems and IT architecture beneath various technologies' implementation in Stevanato Group is presented. Those aspects brought the choice of Stevanato Group, suggested by digital implementation-expert consulting firm. The company offers its customers integrated solutions for pharma & healthcare, as reported in the official website. Since 1949 they produce small containers and vials for medicines; the company develops also systems for smart industrial solutions internally and often deploys its products in own plants.

Figure 22: Stevanato Group benchmark dimension overview

STEVANATO GROUP SPA					
	2013	2014	2015	2016	2017
(in Million)					
SALES	241. 449. 000 €	286. 537. 000 €	338. 432. 000 €	444. 635. 000 €	476. 066. 000 €
SALES GROWTH	17,16%	15,74%	15,33%	23,89%	6,60%
EBITDA	60. 378. 000 €	73. 459. 000 €	84. 387. 000 €	100. 799. 000 €	102. 988. 000 €
EBITDA MARGIN	24,62	25,13	24,35	21,97	21,19
NFP	37. 785. 000 €	62. 864. 000 €	80. 679. 000 €	169. 329. 000 €	191. 985. 000 €
No WORKERS	1818	2053	2158	3012	3113

Source: Analisi Informatizzata delle Aziende Italiane.

Stevanato Group has two divisions: Pharmaceutical Systems and Engineering Systems. Some of the production is concerned with discrete manufacturing, while other sections are related to creation of small containers in glass or in plastic, characterized by process manufacturing logics as continuous production. As in the benchmark case of ASO H&P, an overview of the Stevanato Group's dimension is provided in Figure 23.

3.5.1 Issue Presentation

In the late '90s Stevanato was one of the many companies transforming glass for pharmaceutical use in the world, and its aim was to become one of the most important players in the market. Stevanato Group's goal was related to growth, and today Stevanato is one of the top 5-6 companies producing packaging for medicines.

The project is evolving year after year, but the initial intent was to grow with a solid structure, laying the foundation for a sustainable growth. This point is critical in a benchmarking analysis and gives another perspective, different from the one of ASO H&P. Stevanato Group believed that an IT or digital architecture was a necessary condition in early 2000s. Today, the focus is still on information gathering and on making the best use of them. To build a solid structure, the company completely changed the organization more than once, with the help of new managers to operate with new vision and mission towards new objectives. One of the main goals was related to the integration of processes and people: the company believes that a successful transformation is characterized by changes involving people and processes. For these reasons, new platforms were established to enable connections among plants that are placed around the world: Italy, Mexico, Romania, US, Slovakia, China, Brazil, Denmark and Germany.

The organization changed as a result of Stevanato Group transforming from a small-medium enterprise to a large company, and the resistance to change is not easy to handle in this process.

3.5.2 Methodology

To gather information about the approaches and strategy adopted by Stevanato Goup, an interview with Nicola Gianese, digital manager of the company, was conducted in Stevanato headquarter in Piombino Dese (PD), Italy. Nicola Gianese is an information technology expert, that had organizational management roles in the past.

The interview aimed to gain a clearer view about what Stevanato Group has been doing over the years to consolidate its digital position and broaden its purpose of becoming a large company, but still very integrated and connected.

Various aspects were touched during the interview: technological, strategical aspects, as well as organizational aspects. Furthermore, initiatives are brought about for having contamination with many subjects: among company's plants, with other partners, other companies or start-up and with the university.
During the interview, Nicola Gianese showed some technologies they are using or testing in their plants. Directly from his office in Pimobino Dese, it was possible to virtually move to buildings of the firm placed in other countries.

3.5.3 Long-Term Strategy and Information as Driving Engine

The ownership involvement has been critical, since the support and the approach embraced by the people at the apex of the company were fundamental to reach the goal of sustainable growth. The adjective "sustainable" here is important because the company decided to go for a very long-term strategy. Investments were made in a fertile ground, since the board understood that investing in better digital solutions would have meant spending less in the future for the company. Stevanato Group, according to Nicola Gianese, is below the average amount internationally spent in IT:

> "We knew we wanted to grow, so we tried to feed the organization with the right proteins, carbs, everything we need. The concept was always to jump the gun. If I act based on what we need today and not tomorrow, I will spend much more, because every time there is a need I have to start from scratch instead of having the solution ready. That means higher costs and higher timing" (Nicola Gianese, 2018).

The Group's management and ownership believed in a very long term project in IT infrastructure, meaning the capacity of having a good IT architecture.
Information is centralized in two cages, one in Padova and one in Bologna, synchronized in business continuity (see also The Case Box 9), using a 10 Gigabit connection provided by Telecom Italia. Stevanato Group built this basement of IT architecture together with Telecom: it was a challenge for both. The 10 Gigabit connection allowed to bring machine data in data centers, starting using cloud. Artefacts

> "We preferred to leave mission critical applications to specialized providers, while we keep the corporate intelligence internally. It is like when you want to cross the Atlantic Ocean with a sailboat: you can make it still struggling a lot, but if you have a solid vessel and a prepared crew it is easier to cross the Atlantic Ocean" (Nicola Gianese, 2018).

The company is trying to bring the ERP in cloud as well. The ERP produces plenty of data, but many times the information provided is not very useful. According to Gianese, Stevanato tries to select the kind of information that make a user reactive and information that make a user proactive (see The Case Box 10). Hence, the selection and the synthesis of useful information is one of the goals for Stevanato Group's organization.

The Case Box 9

The **BORMIOLI ROCCO** case

business continuity solution in Bormioli Rocco

The company Bormioli Rocco produces glass packaging for pharmaceutical products and tableware in various plants. The company has a complex organization and a wide presence in the world, that is why it needed a business continuity solution: Bormioli Rocco is process manufacturing company, with a continuous flow of production and the ownership wanted reliable and innovative technologies to support the business. In 2015, together with the technological partner Var Group, Bormioli Rocco built a project to ensure business continuity, operations, information availability and storage. They re-organized a data-center with a solution provided by IBM and they have now same data available among plants placed several kilometres one from another (Var Group Public Website, 2016).

Source: "Casi di Successo", (Var Group Public Website, 2016).

In Stevanato Group some technologies have been implemented after a wide codification of the space in plants: with an online application, they can have a 180° image representation of internal space in plants around the world, and it is very fast to jump from a plant in China to another plant in Mexico to monitor the situation, mainly the status of some internal assets in mapped buildings through low-range Bluetooth beacons and Wi-Fi antennas. They are also able to use a technology of augmented reality in shared monitors, through which they can also write shapes or arrows, to show for example an operator working in Brazil how to fix a machine problem from Italy. To identify people authorized to enter critical areas, maintaining respect for personal privacy, Stevanato uses bracelets that may be activated only by users themselves and that communicate the information about the worker's heart rate, keeping in mind that there is one possibility out of twenty-five million that two people have the same heart rate.

The Case Box 10

The JOHN DEERE case

staying ahead with information services

John Deere is aware of potential digital entrants that may extract value from sensors, data, artificial intelligence to boost farming productivity beyond previous limits. The company is therefore creating a data-driven service to cluster soil samples examined to help farmers enhance crop yields. Sensors in tractors gather data for predictive maintenance; sprinkler systems are concerned with weather; and an open-software platform permits third parties design new apps for servicing farmers. Samuel R. Allen, the company's CEO, told shareholders recently, "Precision agriculture may evolve to a point that farmers will be able to monitor, manage, and measure the status of virtually every plant in the field." The aim of John Deere is to actively participate in data-driven agriculture and differentiate traditional products and services at the same time (Bughin et al., 2018).

Source: "Why digital strategies fail", (Bughin et al., 2018).

3.5.4 Open Innovation and Contamination

This embedded connection allowed to have higher employees' accountability, wherever they are working: there is a headquarter for several reasons, but the innovation is open and has no space barriers. Before launching a mock-up or a pilot, Stevanato Group does a small research about where to begin the pilot. For instance, if they understand that the best choice is to launch the mock-up in China, they do it in China first, then in Brazil maybe or in Denmark and the Italian headquarter only as fourth or fifth. The company adopts this approach to boost people's motivation:

> "We tend to provide technologies to give anyone the possibility to make a "knit" activity. Our vials experts, for instance, are in Italy or in Slovakia, and it may happen that an employee helps another from Slovakia to Brazil, without interacting with the headquarter. A "knit" structure to promote as-sistance and co-working". (Nicola Gianese, 2018).

The concept of innovation and contamination is not only concerned with plants internally, but also externally with different collaborations. Following the example of ASO H&P,

Table 13 offers a review of issues and solutions adopted or proposed in the case of Stevanato Group.

Table 13: Strategical/operational issues and adopted/proposed solutions in the Stevanato Group case

Subsystem	Issue	Adopted/Proposed Solution
Long-Term Strategy	Need of a strategy for sustainable growth	Long-term strategy shared by ownership and management
IT Infrastructure as Enabler of Smart Connections	Lack of an infrastructure to connect spots and share information rapidly	IT infrastructure building employing a 10 Gb high speed optical fiber
Data Centers in Hybrid-Cloud	Absence of a safe way to store data	Two data centers establishment with a specialized partner
Assets and People Localization through Codification	Need of monitoring internal places. Assets and people recognition	Set of technology applications
Remote Maintenance Real-Time Development	Need of an agile method to overcome geographical barriers	Augmented reality in tablets and monitors
Open Innovation and Contamination	Need for solutions' development and open innovation	A high-speed IT infrastructure and corporate culture

Source: Author’s elaboration

3.5.5 Organizational Challenge

Nicola Gianese believes that making a digital transformation is extremely hard. Although it may seem odd, many times the resistance to change come from new graduates or younger people. Making a transformation is tricky and the resistance lays more on people’s rejection of going out from their comfort zone than workers’ refusal to adopt new technologies. It happened in Stevanato Group that experienced workers, whom have rooted firm’s values, well accepted the adoption of new approaches to improve their condition or company’s performance, while this aspect is less strong in young employees. According to Nicola Gianese, there is a high inertia even from people who have high education or who have recently graduated: people tend to have pre-established schemes and they do not want to exit them.

To realize a transformation, people should be ready to re-invent not only processes, but to re-invent themselves and the way they work: in Stevanato Group, experienced workers seem to be those more passionate and willing to change than youngers, maybe for their knowledge of the tasks and the sense of belonging to the firm.

3.5.6 Results

Stevanato Group began its digital journey some years ago and is still working to keep the pace of innovation in a competitive market, where the company wants to be among the best world's players. Building a solid structure and having a long-term strategy seems to pay in making investments in new technologies and in adopting new approaches in the organization. Nevertheless, new sources of value, like information, have been found along the route. Further efforts are planned and Stevanato Group is already working on perspective, trying to anticipate what will happen remembering that resistance to change in a transformation is a critical issue.

3.6 What do we learn from Digital Implementation in Discrete Manufacturing case, ASO H&P and Stevanato Group cases?

ASO H&P, and partly Stevanato Group, are companies characterized by continuous flow process operations, where the physical transformation of raw materials is essential and there is no screwing or assembly of parts. The discrete manufacturing benchmark and the two process manufacturing benchmarks have developed a central platform to govern the process, having a clearer understanding of what is happening. Transparency and traceability of raw materials in the line are important for quality control.

In process manufacturing, a stop in the production process flow is an inauspicious event since it entails a waste of time and money. In some sectors, audit inspection for production quality is very strict: customers often visit the supplier's plant to check that production process runs smoothly and there are no mistakes. A unique platform allows the central supervision of the line composed by different machines that do not communicate to each other. The platform helps in centrally mapping the process and in localizing the problem both in a central panel and in edge-machine panels. An instantaneous warning system to signal anomalies and the capacity of storing data to interpret useful information is another key tool to help process improvement, common in discrete and process manufacturing.

ASO H&P's management decided to store data in the plant's internal physical servers, transferring information directly from the platform to the internal server. Stevanato Group, instead, decided to store data in third-party owned data centers, leaving the task to a specialized player. This solution might entail the advantage of relying in a partner equipped with more advanced skills, to avoid the risk of losing all data after unexpected failures to internal servers.
All these elements may be employed to formulate a roadmap for digital strategy implementation's, which includes specific key points to design a successful digital transformation or at least to attempt avoiding pitfalls.

3.7 Conclusions

Considering insights gained in the Chapter Two, this chapter allows to collect intuitions from real cases. The research conducted by Zheng and Ming about digital implementation in a discrete manufacturing company offers some hints applicable to process manufacturing's needs and real-time monitoring system of the production process is an example: both in discrete and process manufacturing process, data gathering is needed to have clearer vision and control of what happens in some critical steps, as confirmed by the implementation of sensor and related software platform in ASO H&P.
The function of IT infrastructure as enabler of smart connections emerges in the Stevanato Group case: the purpose of those systems is to have a centralized control where information flows into, through connected devices and the support of a software system. In the two process manufacturing benchmark cases, data have been stored using different solutions: indeed, in ASO H&P data is stored in internal servers; Stevanato Group has chosen third-party data centers.

On the one hand, ASO H&P benchmark has given practical insights useful for the operational part of the digital implementation. On the other hand, Stevanato Group analysis has provided inspiration for understanding how to properly approach a digital transformation from the origins, the strategic considerations to make before starting the implementation and organizational challenges to face.

Insights gained from literature in Chapter Two and from benchmarking analysis done in Chapter Three are going to be considered later in Chapter Four.

4. CHAPTER FOUR

DIGITAL STRATEGY IN PROCESS MANUFACTURING: THE SIRMAX CASE

4.1 Introduction

SIRMAX is a multinational player producing engineering plastic compounds and resins for many industries: home appliances, automotive, electrical furniture and power tools household. Regarding the geographical localization, the company has three plants in Italy, two in Poland, one in Brazil and one in Indiana, United States. SIRMAX does not only produces in Europe, North America and Latin America, but it has recently entered the Asian market with a strategic joint venture agreement with the Indian Autotech, a plastic producer and supplier for automotive industry in India. Moreover, the Italian company has sales offices in areas close to Milan, Barcelona, Frankfurt and Strasbourg cities.
The SIRMAX's business concentrates on the extrusion of polypropylene and other raw materials, like carbonate calcium or glass fiber to obtain polypropylene compound. SIRMAX has been often labelled as "pocket multinational company": indeed, the company's main strengths are its flexibility and readiness in answering to clients' requests, together with the ability to produce with high quality standards. The talent of the company lies in the chemical skills that allow the procurement phase and the production process to be efficient, having knowledge to create high-quality finished product.

Over the last few years, the company has experienced a dimensional growth that stimulates evaluation of new digital opportunities. For this reason, SIRMAX case has been chosen to analyze how a digital strategy implementation may be performed in a process manufacturing firm. Figure 24 offers an overview about SIRMAX's dimension improvements recently occurred.

Figure 23: Sirmax dimension overview

SIRMAX SPA					
	2013	2014	2015	2016	2017
(in Million)					
SALES	147. 899. 053 €	157. 449. 405 €	172. 865. 642 €	215. 549. 273 €	257. 027. 671 €
SALES GROWTH	4,74%	6,07%	8,92%	19,80%	16,14%
EBITDA	10. 518. 097 €	10. 396. 973 €	13. 936. 226 €	20. 431. 909 €	25. 599. 683 €
EBITDA MARGIN	7,09	6,58	8,04	9,45	9,92
NFP	35. 232. 353 €	31. 320. 863 €	43. 669. 045 €	48. 863. 706 €	41. 521. 031 €
No WORKERS	178	187	200	309	346

Source: Analisi Informatizzata delle Aziende Italiane.

In this chapter, some key points of the implementation of a digital strategy for process manufacturing firms, gained from benchmark cases, are going to be highlighted.

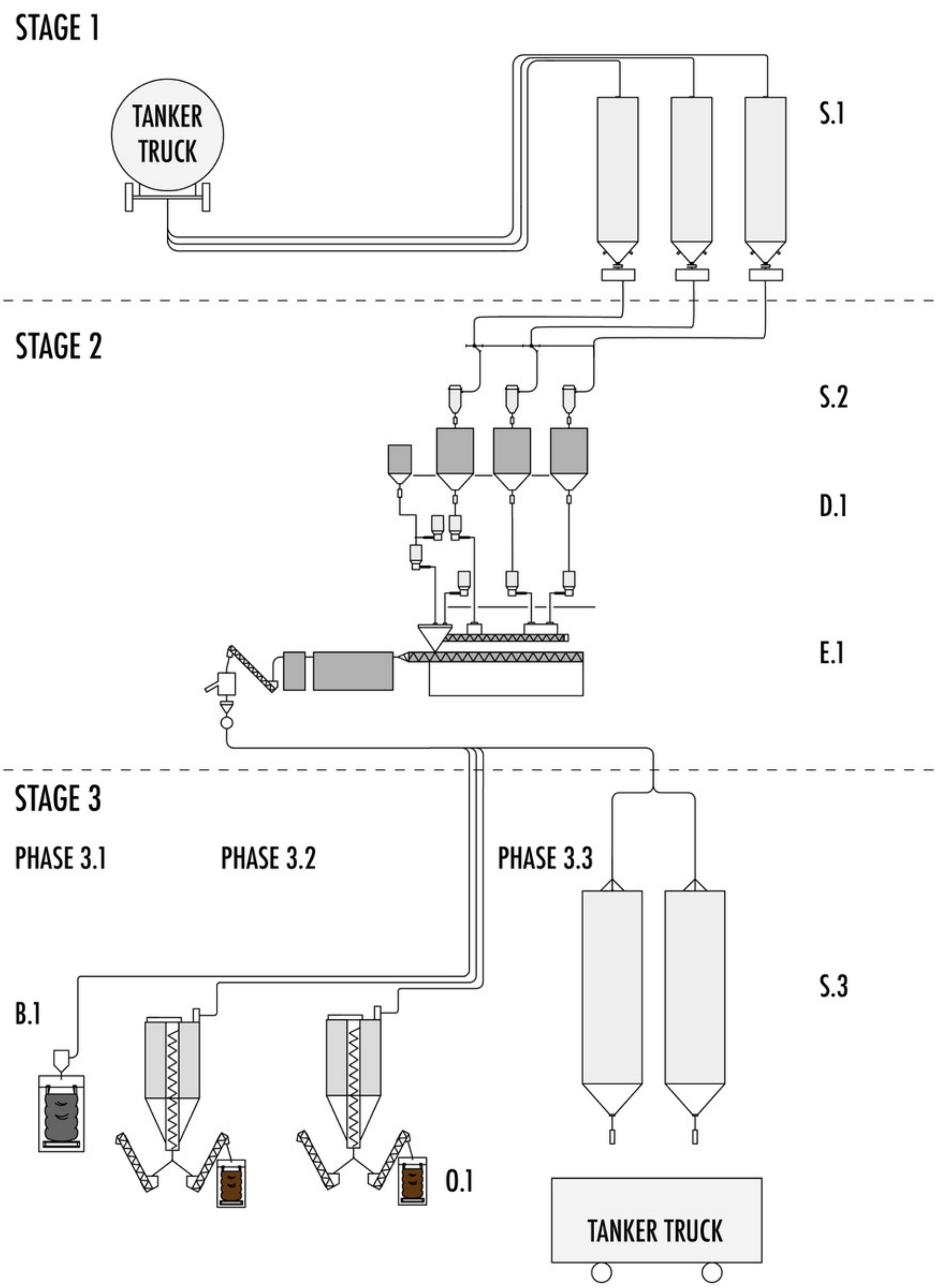
4.2 Issues Presentation and Methodology

The operational side is a critical aspect of SIRMAX and this chapter is focused also on steps and benefits that may be expected in implementing some technologies. Indeed, the production process's efficiency and the quality of finished products are among main competitive advantages of the firm. Operations are strategically important for SIRMAX and for this reason the company have been creating a team dedicated to continuous improvement, investing in human resources and robust training for them. The challenge is not only to invest in people, but also to exploit technologies to reinforce success factors or to create new ones, as reported in Chapter One's pillars.

Focusing on how the SIRMAX's plant is generally organized, we consider the headquarter plant based in Cittadella, where the process is replicated as in other production plants around the world. Raw materials arrive in trucks, in bulk or in pallets, and are stored in storage areas or in silos until they are called to enter the extrusion phase: through air-operated pipes system, raw materials (polypropylene, calcium carbonate, fibers, etc.) are moved into small silos connected to dispensers, that have the task to measure the quantity of raw materials before they enter the extruder. Materials then enter the extruder, a huge machine that mixes materials together at a high temperature, to obtain granules of finished product. Granules are stored in big bags weighing 1000-1400 kilograms or in "octabins", large octagonal bins weighing around 1000 kilograms. Finished product that must be loaded directly on tanker trucks, instead, is sent in silos properly equipped. The described scheme, shown in Figure 25, is logically divided in three stages:

- STAGE 1: a tanker truck carrying raw materials uses air-operated pipes system to push materials in external silos (S.1) designed for raw materials collection (some materials may arrive in pallets via truck and stored in silos as well);
- STAGE 2: through air-operated pipes system, raw materials are sent in the three-level stage, named STAGE 2 in Figure 27, where materials enter first small silos in the upper level, then pass through dispensers (D.1) governing the needed quantity, and therefore materials move inside the extruder (E.1) where they are mixed together at a higher temperature;
- STAGE 3: Air-operated pipes system allow once again materials to flow in STAGE 3, where finished product is stored in different phases: PHASE 1 represents finished product stored in big bags (B.1), while PHASE 2 shows the mechanism to fill octabins (O.1). Both big bags and octabins are therefore stored in finished product warehouse. In PHASE 3 is shown finished products, that is polypropylene compound, in external silos (S.3) where are ready to be injected into tanker trucks, again via air-operated pipes system. This scheme is important to understand the points in which SIRMAX needs to gather data, starting from OEE calculation data of extruders.

Figure 24: Sirmax's production process flow scheme



Source: Author's elaboration

Materials' flow has not clear traceability and visibility along the process; some process data are not collected and some others are manually collected. Moreover, central display would be desirable for managers and for the global operations director. The company is seeking methods for gathering process data in real-time, to have a higher knowledge and control of the process, as well as systems for gaining insights from collected data.

The analysis of SIRMAX's present situation has been conducted shoulder to shoulder with Alberto Alfonsi, Global Operations Director in SIRMAX since 2004. He is an engineer with more than 30 years of experience as a technical specialist, product manager and plant director. Several meetings have been made with Alberto Alfonsi during a seven-months period, from May 2018 to November 2018.

> "We want to gain higher knowledge about our production process, as its efficiency is the basis of our success. Real-time monitoring is essential to do this: we need to have updated information to promptly know how we can improve our process" (Alberto Alfonsi, 2018).

The situation of the company's operations was evaluated considering which technologies might have a positive impact on SIRMAX's production process and figuring out how to effectively employ them.
According to SIRMAX's needs and benchmark analysis done in Chapter Three, the research focuses on technical and organizational issues. The following paragraphs will present applicable technologies and expected benefits for SIRMAX. The focus will be then moved to critical points of digital strategy and organizational change in Paragraph

4.3 Applicable Technologies and Expected Benefits for SIRMAX

This paragraph concentrates on the digital technologies and applications pillar described in Chapter One. Inspired by the benchmark cases and The Case Boxes examined in previous chapters, some solutions are proposed to cope with SIRMAX's operational priorities and then summarized in Table 14, as did for the benchmarks in Chapter Three.
Each issue has been compared to those issues presented in Chapter Three, to propose solutions for SIRMAX reported as follows.

Real-Time Process Data Gathering. The lack of real-time process data to monitor the performance of the production line can be addressed deploying workshop sensors on machines, starting from ensuring the possibility of a real-time OEE calculation. In fact, the

OEE real-time calculation can be a starting point, but then many other process data could be collected to have higher monitoring of the process. Precise aggregate data may be collected through a shared platform to do statistical or timely analysis.
This updated monitoring of the production process allows improvements, both in discrete and in process manufacturing firms, as described by Zheng and Ming (2017) and in ASO H&P case, even if the application of sensors follows peculiarities of the process.

Central Data Monitoring System. Starting form what Alberto Alfonsi has said, it is possible to report that a SIRMAX's issue is the absence of a unique central monitoring system to visualize materials' flows.

> "It may happen that a batch of finished product is stored in the wrong silo because there has been lack of tracking along our internal process, and the batch is therefore wasted. Our machines are provided by different suppliers and usually do not communicate to each other. We would like to have a central government panel from which we can control the flow of materials and the status of all lines in our plants" (Alberto Alfonsi, 2018)

This problem may be addressed implementing a software platform that allows traceability of inputs from their entrance in the process, their processing, until they exit the process in form of outputs and are stored in the demanded warehouse. ASO H&P implemented software traceability with this aim, and this visibility is useful also for SIRMAX to associate finished product's characteristics to exact events in time and get back to what happened in that moment.

Storage of Data. The lack of a reliable system to store data, from which information can be available at any moment, is something that the company consider important to implement.

> "We cannot risk losing our data subsequently to an internet or electronic shut-down. We need a reliable storage system where data are available and shared for our needs. We also need a system that alerts us when something wrong happens or when materials do not follow the right path" (Alberto Alfonsi, 2018).

This fact can be solved though cloud storage: storing capacity is needed and it should be considered together with the risk of losing huge amounts of data. ASO H&P chose to store data in internal servers, while Stevanato stores data in specialized partner's data centers; the latter solution is likely to be more expensive, but it entails less risks and reliability of a skilled partner. Nevertheless, given the importance of availably of data and information for SIRMAX, a safer method might be a better solution.

Warning and Fault Diagnosis. The application of a warning systems is described to detect stops in both Zheng and Ming's elaboration (2017) and in the ASO H&P case. In ASO H&P case, a warning alert is sent to the demanded operator through edge-machine monitor and smartwatch: when the problem is not solved within a time limit, the operator's supervisor is warned, and so on until the problem is fixed. After solving the problem, operators should insert the cause of the stop in edge-machine's touch-screen monitor. A similar system should be linked to a centralized shared platform that may be used also in SIRMAX to promptly signal a stop or other problems in the production line.

Warehouse Inventory Management. Warehouse inventory requires a lot of time to be completed in SIRMAX, where the cycle counting is made through SAP ERP.

> "The inventory of stocks is an issue that takes us a lot of time to be addressed. We need a faster and more reliable way to get to know what we have in stock, like shooting a picture of our warehouses when we need it" (Alberto Alfonsi, 2018).

Zheng and Ming (2017) propose a system composed by bar codes, QR codes and RFID technology (Radio Frequency Identification) to check the presence of products in the warehouse through code reader or RFID antenna. This solution might be adopted in SIRMAX as well, to speed up the inventory of big bags and octabins when they are stored in warehouse.

Remote Maintenance and Assistance. In a multinational company composed by human resources and assets placed in different parts of the world, remote assistance may be useful to better exploit resources' potential. Stevanato Group acted to enable people connectivity and audio/video communication using tablets/monitors and augmented reality for effective real-time teaching and learning, virtually decreasing the physical distance. In this sense, augmented reality may be used also in other ways: for example, as reported in The Case Box 6, smart glasses in the workshop are used by GE's operators to have real-time information freeing their hands to work. Those solutions can be used with the support of a fast and reliable internet connection, and may be convenient for SIRMAX to deploy them, reducing the distance among plants.

Table 14: SIRMAX's operational issues and proposed solutions

Subsystem	**Issue**	**Proposed Solution**
Real-Time Process Data Gathering	Lack of real-time process data	Deployment of sensors to gather real-time data
Central Data Monitoring System	Absence of a unique central monitoring system to treace materials' flows	Software platform development
Storage of Data	Lack of a reliable storage system for data	Cloud solutions to reduce risks and increase information's availability
Warning and Fault Diagnosis	Lack of real-time warning system	Alerting system with escalation logics
Warehouse Inventory Management	Faster inventory of stocks	Bar code, QR code and RFID technology
Remote Maintenance and Assistance	Need for remote maintenance system	Tablets, smart glasses empowered by augmented reality

Source: Author's elaboration

In the cases examined in previous chapters, companies experienced issues like those SIRMAX faces today. The proposed solutions rely therefore on real cases of implemented technologies that generated results in terms of efficiency.

Digital implementation in process manufacturing firms is not only a technological issue: technology applications are an important element of a wider structure, highlighted in next paragraphs, that comprehends also strategical and organizational details.

4.4 A focus on digital strategy's critical points

The benchmarking analysis of Chapter Three treats real cases of technologies' implementation, narrowing the examination from implementation in discrete manufacturing, through separation between discrete and process manufacturing, to implementation in process manufacturing firms. Furthermore, from the Stevanato Group experience, the importance of having a very a long-term strategy view emerges. This implies the construction of a solid IT infrastructure to create a lasting basis for digital implementation. It is a long-term process that requires years to produce benefits. Initial investments are critical for future success - and future cost - of the next technological applications. From Stevanato Group case, we learn that digital strategy should look ahead to where the firm wants to be positioned after some years, trying to anticipate future needs.

Data storage, data availability and data reliability, are critical to gain advantage from the infrastructure. This should allow the functioning of a platform where not only data can flow, but also people and machines can be connected and recognized in a common system. For example, Stevanato Group acquired companies that wanted to keep the ERP software they already had in place and it was different from Stevanato's one: a common platform permitted Stevanato to overcome this problem. In this framework, people and machines are connected through sensors, while spaces and assets are codified.

As confirmed by ASO H&P, real-time information about process data is central in process manufacturing firms, and it is provided by the joint contribute of hardware installation for data gathering and software platform for information visibility.

Technological aspects confirm to be important, as digital strategy implementation did in the Stevanato Group case. Organizational issues, related to people and their approach to important changes in the firm, are another critical point of the change.

Digital Strategy implementation should therefore consider those aspects described in the three pillars of Chapter One and deepened in Chapter Two and Chapter Three.

4.5 A Digital Strategy Implementation Roadmap for Process Manufacturing Firms

The proposed digital strategy implementation roadmap for process manufacturing firms has been obtained from the three main sources: the three pillars described in Chapter One, literature review results reported in Chapter Two and real benchmark cases analyzed in Chapter Three.

The starting point refers to first pillar presented in Chapter One, is the digital strategy development: a long-term strategy should anticipate future needs, as learnt from Stevanato Group case, by clearly expressing goals, vision and related benefits (Mittal et al., 2017). Business model may be affected by a new strategy, different modes of production, and software platforms may change company's boundaries (Bounfour, 2016; Iansiti and Lakhani, 2014). The other cornerstone is related to organizational culture and the approach towards change, since firms risk failing in the transformation by ignoring culture (Díaz et al., 2018; Goran et al., 2017; Hemerling et al., 2018; Seitz, 2018; Kane et al., 2016). Considering these two points, represented on the top and the bottom of the sequential roadmap, other five steps related to the second pillar are illustrated in Figure 27:

- *IT-Business Infrastructure Building*: when the strategy's goals are clear, an operational backbone to support digital platforms is needed: IT infrastructure and business priorities should converge towards the same direction, aligned with the objectives of the overall strategy, in a continuous effort to integrate teams and technologies as they develop (Sebastian et al., 2017; Cegielski et al., 2013). Moreover, in Stevanato Group the IT infrastructure with fiber connection at 10 Gb was one of the first bets of the company's digital journey. This structure works also as a basis for smart connections and to allow data flows (Shrouf et al., 2014). IT and business together comes out to form the solid baseline for technological implementation to reach business goals.
- *Codification and Smart Connectivity*: the benchmark of Stevanato Group has provided a method for mapping spaces and assets by codifying them through Bluetooth beacons, used as presence sensors, capable of creating smart connections of buildings' rooms. Cyber-physical systems are allowed by IoT technologies, creating connections at the administrative and operational level (Odważny et al., 2018; Sun et al., 2018; Shrouf et al., 2014; Iansiti and Lakhani, 2014). For example, workers may be guided for maintenance assistance intervention in real-time, thanks to the fundamental contribution of IT infrastructure. Connectivity refers also to human resources: they can be placed in a site and enabled to contribute in another physical place at the same

time. Enhanced connectivity allows to break the concept of inequality between headquarter and subsidiaries at the operational level (Figure 26), like in the Stevanato case.

Figure 25: Networking building among plants, Sirmax's case

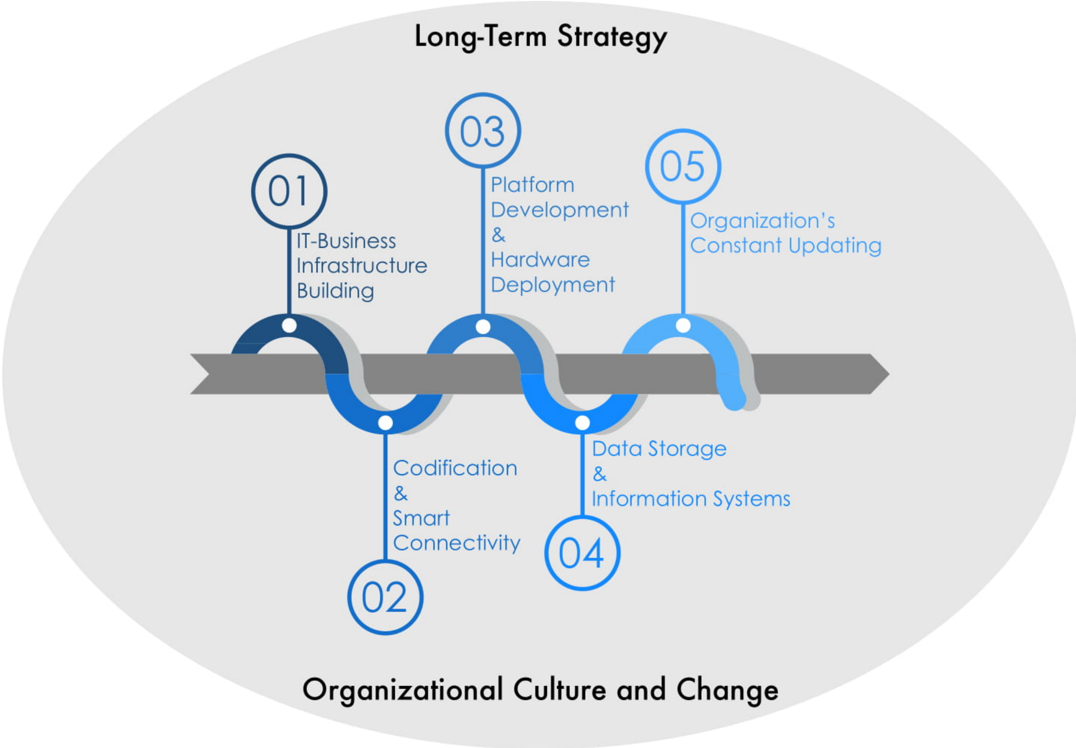
Source: Author's elaboration

- *Platform Development and Hardware Deployment*: in the Zheng and Ming digital implementation case (2017) and in the ASO H&P case, a central digital platform to visualize information has been developed, gaining advantage from real-time data acquisition that is important for both discrete and process manufacturing. This development finds confirmation even in The Case Box 3, 6 and 10, namely the Amazon, GE and John Deere cases, in which data are handled in platforms: a set of digital processes and data infrastructure that enable technologies' diffusion and that work across the entire enterprise (Weill and Woerner, 2013; Iansiti and Lakhani, 2014; Venier, 2017). Hardware deployment in workplace is the critical passage to permit data flow into platforms, thanks to sensors' application to machines: sensors gather process data then routed into platforms. In ASO H&P sensors were functional for picking up data from workshop machines, a crucial point for process manufacturing firms as demonstrated by benchmark analysis. Sensors are orientated towards real-time support for people and machines in carrying their tasks (Zheng and Ming, 2017; Odważny et al., 2018).

- *Data Storage and Information Systems*: once the sensors are in place and data are reliably gathered in a shared platform, process information should be safely stored, even relying on a specialized partner, as in case of Stevanato Group. Zheng and Ming (2017) suggest that when information come from many parts, an integration system of information might be adopted to take advantage of big data analytics: analytics systems should permit to exploit real-time information (Berman, 2012; Manyika et al., 2015). Specifically, information analytics are important to create insights for decision making (Kumar et al., 2016; Chen et al., 2015) as described in the case of DELL, The Case Box 2.
- *Organization's Constant Updating*: digital transformation in process manufacturing firms emerges from benchmark cases as a long-lasting journey, with the consequent difficulty for firms to stay updated and keep pace with innovation. For instance, Stevanato Group's digital strategy was 15-year long, and it is likely to last even more; ASO H&P intends to continue the implementation of digital technologies and to earn experience for future improvements.

Moreover, as highlighted in the pillars analyzed in literature, further attention should be paid to the creation of a collaborative environment provided by business leaders with the aim of aligning all employees (Curran et al., 2017; Gottlieb et al., 2017; Bender et al., 2018; De Smet et al., 2016), to a supportive firm's culture (Kane et al., 2017; Dulebohn and Hoch, 2017; Seitz, 2018), to the procurement of adequate talents and skills updating (Lanvin and Evans, 2018; Hajkowicz et al., 2016; Leopold et al., 2016). Lastly, the structure made by people and technologies should be maintained and nurtured with constant effort and investments (Sebastian et al., 2017; Strange and Zucchella, 2017), keeping in mind that resistance to change is present in the implementation of a digital transformation of process manufacturing firms. Roadmap road map road map.

Figure 26: Digital Strategy Implementation Roadmap for Process Manufacturing Firms



Source: Author's elaboration

SIRMAX is a company that is trying to digitally evolve not for survival reasons, but for a growth objective. Going digital involves different aspect of a business firm, as described in the three pillars of Chapter One. The benchmarking analysis provided in Chapter Three confirms this vision, treating operational and organizational issues. The main driver boosting SIRMAX's strategy may be identified as digital for growth, racing a challenge in which the company is quite new and a change is therefore needed.

> "SIRMAX has been growing over the last few years and we do not want the trend to be reversed. We need to combine investments in technologies and investments in people, we need to organize our growth. Digital change might be an opportunity for us to improve and we wish to find the right alchemy to exploit at best its potential" (Alberto Alfonsi, 2018).

As highlighted in the Stevanato Group case, resistance to change is likely to be an obstacle, as well as individual, group or organizational impediments: these may be generated by fears about the change generating uncertainty, even related to exiting the routine or comfort zone. Group norms and logics may be affected and the relationship inside teams can change accordingly; the alteration of powers' balance might generate conflicts in the environment provided by the existing firm's culture.

The organizational change moves the firm from a known state towards an unknown one, with the need of understanding the related steps. Regarding this concept, Lewin proposed a three-step model: change is a temporary state of instability in organization. The phases are related to unfreezing the organization from the status quo, making the change desired, refreezing the organization in a desired state (Hussain et al., 2018). It is not easy to unfreeze the organization from resistance to change, and another model provided by Kotter concentrates on how to manage the change. The guiding team should stimulate the sense of urgency to lead a transformation, developing a long-term strategy and communicating the vision in the organization saying why some things should change and how the organization may benefit from the change. The head of the organization should also use broad actions and generate short-term wins for workers. The model proposes also to consolidate gains and an evolving culture (Kotter, 2012). Corporate culture confirms to be a critical aspect also by being the central finding of a McKinsey survey on global executives, in which culture is found to be the most important barrier obstructing digital effectiveness. Moreover, non-digital culture is negatively correlated with economic performance (Goran et al., 2017). Culture is likely to be influenced by the approach brought about by leaders, who should adopt a long-term strategy to affect the cultural aspects of a company: organizational culture could be slow to change. Technological change, instead, might be evolutionary, thus gradual or incremental, even though results generated by technology's deployment are likely to be revolutionary, broadly focused and quite rapid (Davison and Ou, 2017).

Leaders are important to set a sense of urgency and an agile long-term strategy (Bughin and Catlin, 2017), defining "agility" as the firm's ability to deal with changes that rise suddenly in the business environment (Lu and Ramamurthy, 2011). Executives should be able to stimulate every step of the change acting with transparency, enhancing trust of employees and raising their involvement, motivating commitment and working with them to overcome obstacles (Hussain et al., 2017).

The roadmap in Figure 27 selects some technologies that might be useful in the SIRMAX's case, outlining some steps for digital implementation (considering that the length of the digital wave is unknown).

SIRMAX should work on the ability of selecting valuable applications for its business, among the ones emerged during the literature review, adopting an innovative approach. Innovation could be practiced both internally and externally through new partners, evaluating several development possibilities. Indeed, as suggested by Stevanato benchmark, an agile orientation can boost the firm's progress, incorporating or anticipating possible changes. This helps in handling the today's transformation speed, that seems to occur at a faster pace than past ones, implying that new solutions arise frequently from many outer sources.

The sense of urgency that should be stimulated by SIRMAX's leaders could be promoted by organizing events with digital experts to raise employees' awareness, or by triggering internal contests rewarding best ideas to innovate the company. The change might be inspired from internal and external stimuli.

In the roadmap, the proposed infrastructure allows the rapid implementation of the most appropriate applications, while the organizational culture comprehends the required knowledge for a smart selection of digital opportunities. In addition to this, the timing of the implementation becomes important to avoid being left behind in an environment that quickly evolves, especially for a company that intends to grow. Falling behind today might be more dangerous than it was yesterday. Other things being equal, the later the digital implementation, the higher the risk to hoard a gap that may be decisive for growth. Thus, the elements included in the roadmap may help in exploiting advantages brought from digital implementation, projecting the company to the next level.

4.6 Conclusions

From the case analysis, it comes out that digital strategy implementation is a huge challenge, which requires preparation and alignment in the organization. The wide argument of digital transformation has been center of attention of many researches over the last few years, but shifting the focus on digital strategy implementation requires the consideration of different aspects. These aspects have been specifically analyzed for a digital implementation in process manufacturing firms.

The first step to approach this issue, as illustrated in Chapter One, has been related to the analysis of the two articles "I tre pilastri della quarta rivoluzione industriale" (Butera, 2018) and "Digital transformation: what is new if anything" (Lanzolla et al., 2018). The examination of these articles led to the definition of three pillars for the investigation of the macro argument of digital transformation: the cornerstones “Digital Strategy and Business Model Change”, “Digital Technologies and Applications” and “Organizational Change” are then reflected along the thesis.

The literature review described in Chapter Two concentrated on digital implementation studies performed over the last ten years, using different sources from journal articles, research reports realized by consulting firms and universities to books. Results showed that the focus was not on only on technological application, but also on digital strategy and organizational challenges. Furthermore, to have a picture of advancements recently applied, the research about technologies and applications has been deepened analyzing several journal articles.
Once the literature view has been analyzed, the research concentrated on real cases of digital strategy implementation to check how a digital change has been performed. For this purpose, a case study published in the journal *Advances in Mechanical Engineering* (Zheng and Ming, 2017) has been chosen for the level of detail of the implementation’s description. The document relates to a discrete manufacturing firm case; for this reason, a distinction between discrete and process manufacturing followed. After having consulted an industry digital implementation-expert consulting firm, the benchmarking examination concerning with process manufacturing firms has been conducted on ASO Hydraulics and Pneumatics and Stevanato Group. The former company has an operational-process oriented approach, while the latter is more focused on digital strategy and organizational issues; the integration between the two benchmarks permitted to have a vast reference point on those aspects prospected in the pillars of Chapter One.

Literature insights and analysis of real benchmarks led to the proposal of the digital strategy implementation roadmap for process manufacturing firms, suitable for the SIRMAX case examined in Chapter Four. SIRMAX is a company that has experienced a quite stable revenues growth over the last few years and has the goal to continue in the future, as stated by the Global Operations Director Alberto Alfonsi. For this purpose, the two benchmarks helped to gain technological and operational insights in the case of ASO H&P, as well as strategic and organizational hints from the Stevanato Group case, that have been useful to have a full picture to propose a transformational map. Indeed, following the pillars identified at the beginning of this dissertation, SIRMAX's needs has been recognized to be not only technological or operational, but also strategical and organizational. The digital implementation implies a transformation, and the management of this change is an important pitfall that should not be underestimated. In fact, resistance to change may appear and it is likely to weaken the implementation, as in the Stevanato Group case. For this reason, the leadership of the company could be crucial in unfreezing the organization from the present situation setting a long-term strategy. Stevanato Group set a long-term strategy that is still evolving, communicating the new vision and allowing broad actions and short-term wins, boosting motivation in the organization and moving towards a new equilibrium.

SIRMAX is an international company which is growing while expanding its activities: the digital implementation may be a critical opportunity to jump further. It may be time for the firm to digitally evolve its processes and business. The organization's leadership should exert a crucial role in pushing the change by working on culture, employees and awareness about the transformation's fast rhythm.

There are two main implications for a firm like SIRMAX: the technological selection and the timing for change. In a moment where technological stimuli occur frequently there are many possibilities to innovate, more than in the past. The attention shifts to the selection of the best applications for a specific company, which is why a firm like SIRMAX needs the knowledge to make choices strategical for its future. The timing aspect should also be evaluated: the later the digital implementation, the higher the risk related to accumulate operational and organizational delay. The high pace of innovation implies less time than in the past to catch up with advancements. SIRMAX should focus on technological selection and timing, to sustain its growth. This might be a necessary condition to keep up with future changes.

There have been changes in business history and disruption is not a new phenomenon. Organizations had to adapt to new technologies even in the past. What is new is the speed of change, the pace that characterizes the digital change and the related strategy's implementation in business firms. Therefore, the ability to learn quickly and develop in advance seems to be a fundamental requisite now and for future transformations, starting from the digital one.

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