UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M.FANNO"

CORSO DI LAUREA MAGISTRALE IN ENTREPRENEURSHIP AND INNOVATION

TESI DI LAUREA

"HOW TECHNOLOGY BOOSTS STRATEGIC DECISION-MAKING. FROM THE ORIGINS TO THE COVID 19 RESILIENCY TEST"

RELATORE:

CH.MO PROF. DI MARIA ELEONORA

LAUREANDO: NICOLO' GOBBI

MATRICOLA N. 1238610

ANNO ACCADEMICO 2021 – 2022

Il candidato dichiara che il presente lavoro è originale e non è già stato sottoposto, in tutto o in parte, per il conseguimento di un titolo accademico in altre Università italiane o straniere.
Il candidato dichiara altresì che tutti i materiali utilizzati durante la preparazione dell'elaborato sono stati indicati nel testo e nella sezione "Riferimenti bibliografici" e che le eventuali citazioni testuali sono individuabili attraverso l'esplicito richiamo alla pubblicazione originale.

The candidate declares that the present work is original and has not already been submitted, totally or in part, for the purposes of attaining an academic degree in other Italian or foreign universities. The candidate also declares that all the materials used during the preparation of the thesis have been explicitly indicated in the text and in the section "Bibliographical references" and that any textual citations can be identified through an explicit reference to the original publication.

Firma dello studente

INDEX

INTRODUCTION

Nowadays, the world is constantly evolving from a technological point of view.

Firms constantly try to be one step ahead of their competitors but, generally, developing internal skills and competencies is not enough. Many companies have started to digitalize their processes, developing an "internal digital knowledge" that could be the base to build a durable competitive advantage.

In addition, the COVID-19 pandemic has forced many firms to accelerate the process of digital adoption to remain operative in the new reality: this acceleration involved both firms' production processes and the external environment where they operate.

Nowadays, more than ever, we live in a VUCA world (Volatile, Uncertainty, Complexity and Ambiguous), so firms must be adaptable and flexible to adjust their decisions to market dynamics.

The first chapter discusses traditional methods that firms generally used to strategically position themselves inside the market. The analysis is based on the description of the various environmental levels that impact the firm's strategy, from the macro-environment to the internal dynamics taking place inside every firm. Each level can be addressed using different approaches, each of them presenting specific straightness and weaknesses.

The second chapter presents a historical overview of DSS (Decision Support Systems) from the beginning (the 1950s) to the start of the new Millennium. The analysis focuses on DSS's different characteristics and their crucial role in decision-making. Finally, it describes different classification schemes based on their scope and functionalities.

The first part of the third chapter is about the Fourth Industrial Revolution, which is changing market conditions and opening new digital opportunities for companies. The focus then shifts to big data analytics and Artificial Intelligence, as the main digital breakthroughs that firms are learning to employ to accelerate decision-making and productivity. An analysis of the various big data and artificial intelligence categories, their main benefits, and the most common challenges completes the section.

The final chapter opens with a first part about the COVID-19 pandemic and its effect on firms and their operating environment. The second part contains a case study, developed through a qualitative approach, whose aim was to understand whether "already digital" firms (the ones that already used digital solutions before the pandemic) were better placed to face the challenges posed by the pandemic.

CHAPTER 1 Strategic positioning

The decision about the positioning of a firm could be considered the base of its strategy. It is the only way that permits a company to achieve and maintain a good market space. Porter (2001) names strategic positioning as a source of sustainable competitive advantage. An excellent strategic position is possible only if the firm can understand all the different aspects (internal and external) that could influence its results. According to Nzive Kasyoka (2011), the strategic positioning of an organization is a complex business operation, and managing this complexity increases overheads and requires more sophisticated management techniques, tools, and information. The primary benefits of strategic positioning are to gain market share dominance and keep margins as high as possible to maximize profits. Another benefit of strategic positioning derives from the organizational differences that can help a firm avoid the self-inflicted wound of hyper-competition by insulating a firm against competitive convergence enabled by the rapid diffusion of best practices (Porter, 2001). On the same line are (Ulrich and Lake, 1991) according to a solid strategic position, the organization is poised for ongoing success, sustainability, and distinct competitive advantage.

Different analysis was developed to understand these factors and to prevent possible unexpected situations. More methods could be used to obtain a clearer vision of the situation. Using different models is helpful for the firm to understand clearly all the levels of the environment that influence its strategy. It is possible to divide the environment into four different levels.

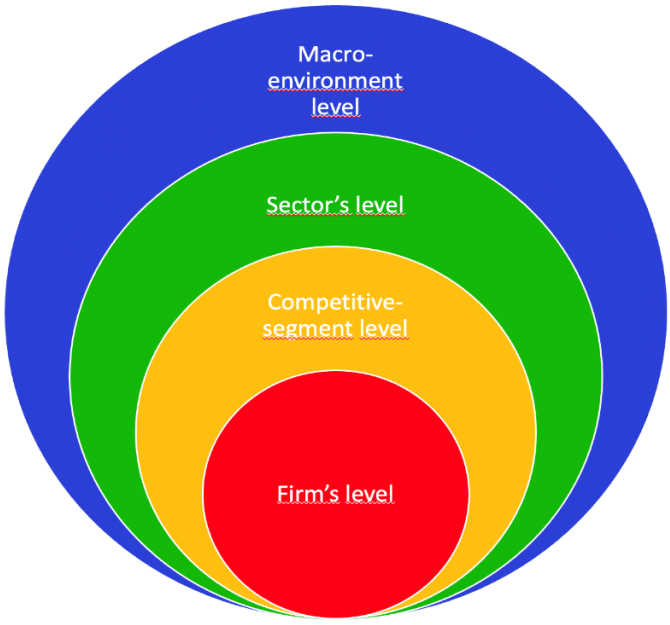

Figure 1.1, Four environmental level that impact on firm's strategy. SOURCE: Fundamentals of Strategy,2009, Gerry Johnson; Kevan Scholes; Richard Whittington, p. 26

- Macro-environment, which is composed of all those factors that, in a way or another, have an impact on organizations, production sectors, or markets.
- Production sector, or competitive space, which includes all those companies that produce the same goods or that offer the same services.
- Market segment and competitors with which the firm goes directly in touch.
- Its organization, composed of its manager and employees, takes the strategic decisions, invests its resources, and carries on the economic activity.

1.1 Macro-environments level

1.1.1Pestel analysis

The key instrument to analyze the macro-environments is the PESTEL analysis. It considers six environmental factors: political, economic, technological, social, ecologic, and legal. To decide the strategic positioning of a firm, the analysis considers market factors and nonmarket ones.

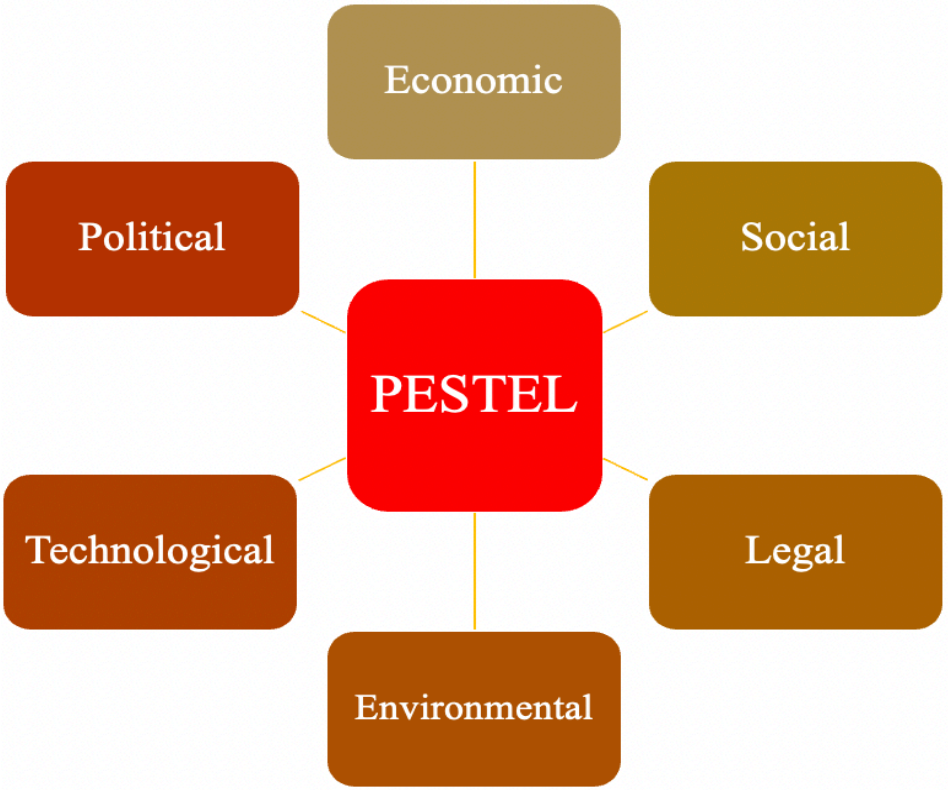

Figure 1.2 PESTEL analysis. SOURCE: Understanding the Marketing and Management of trails using PESTEL Analysis, 2018

- Political elements underline the role of the State and the political campaign on the macro-environments. A firm has to understand how much the State is directly involved in the economic activity. For example, the State will be more involved in issues regarding the interest of the national army rather than problems about the food industry. On the other side, the food industry must face another type of pressure. Even if private companies, in general, control the food industry, they must face pressures given by civil society for workers' rights or by fair trade activists. These pressures could force the food industry to explain the quality of their products to maintain a favorable social position. To achieve a complete vision about the impact of the political elements on its macro-environments, a firm has both to consider the direct involvement of the State the pressures of the civil society.
- Economic factors include an analysis of variables like exchange rates, interest rates, and different growth rates between countries. A pivotal concept to analyze the macroeconomics trends is to understand the economics cycles. Macroeconomics seasons don't last forever. Macroeconomics cycles could be divided into three different groups. Kitchin's cycle is the shorter one. It lasts, in general, three or four years. The time of this cycle is in connection with the necessity of the firms to rebuild the stocks of raw material and semifinished ones*. The second one is Juglar's cycle, and it lasts between seven and eleven years. The cycle is driven by an increase in investments in capital goods, like equipment and machinery. The end of the Juglar's cycles depends on the moment when capital goods became worn or obsolete. The Kuznets cycle is the longer one. It lasts between fifteen and twenty-five years. These cycles follow the cycle of life of investments in infrastructure like houses or transports. The combination of all the different cycles can show the entire cycle of economic growth. Managers must evaluate their position compared to the complete cycles of economic growth.
- Society factors can affect the level of demand and supply. The elements that managers have to consider are the demographic situation of customers and their distribution of wealth. For example, in the last twenty years, there's been an increase in the sales of luxury products while there's been a decrease in the consumption of goods of the middle classes. Moreover, even the culture of a population changes the customers' demand for some goods. The born-digital generation has, for example, different expectations about education and consumer products. Organizational networks represent another important social aspect. It consists of forming different communities formed by companies that

interact with one another more frequently than with other external subjects. Forming an excellent organizational network could help the firm increase its potential innovative capability, power, and efficiency.

- Technology factors like Internet, nanotechnologies, or new raw materials could offer new opportunities for some firms and a possible threat for others. There are five principal indicators to analyze the innovational activities; Research and Development's budget, patent activity, citation analysis to measure the impact of the innovation of the firm on the society, communication of new products, and their media coverage. Managers can use these indicators to understand if their market sector is rapidly changing or not.
- Ecological issues increased their value in the evaluation of the macro-environment in the last years. Managers must analyze possible "green solutions" to avoid pollution and wastes. Three different challenges must be considered about ecological issues of the macro-environment. Firstly, direct commitments to reduce the pollution, reducing at the minimum required the production on pollutants. Secondly, management of the product in an ecological sense considering the entire life cycle of products. Thirdly sustainable development, avoiding wasting of raw materials. This ability could also help the firm cut production costs and introduce a premium price thanks to introducing a "green" product.
- Legal aspects include different themes like jobs, workers' rights, taxation, norms on the property, and competition among firms. Every country has different specific rules, but it is possible to identify three models of capitalism with different formal and informal rules. The first model is based on liberal market economies and promotes competition among firms, hostile takeovers, corporate raiders, and the free negotiation of employment contracts. This model encourages radical innovations, and it is open to the entrance of foreign companies. The second one is based on coordinated market economies that encourage coordination among firms and frequently establish legal constraints against hostile takeovers. These types of economies promote continuous innovation and a long-term orientation. The last model includes the economies of developing markets, and it is characterized by the critical role of the State, which generally owns the most important firms. In general, the State encourages coordination among firms deciding their industrial policy and obstructing the entrance of foreign firms.

These factors have a different impact on the macro-environment of a firm. For that reason, it is essential to focus on critical factors of change. They represent all those macro-environment factors that, much probably, will have a higher impact on the production sectors, highly affecting the success or the failure of a firm's strategy.

1.1.2 Predictive analysis

Every strategic decision must involve previsions on future conditions and possible results. In general, three fundamental approaches are taken into consideration based on different levels of risk.

- The first approach is based on the prevision of a single future event. Managers should use this approach only when they are confident about the evolution of the future, limiting themselves to predict only one scenario.
- The second one is based on a prediction interval, which could be more helpful when firms have lower confidence about the future. In this case, it is possible to estimate a range of possible results, each with a different probability level.
- The last approach is focused on the prevision of more alternative futures, and in general, this model is used when the level of uncertainty is even higher. It is based on the construction of possible future situations all different from each other. The main difference is the fact that these possible futures are discontinuous. They can happen or not, creating opposite and completely different results.

1.1.3 Scenario analysis

Scenarios offer a range of possible alternatives about the possible changes of the macro-environment shortly, generally with a long-term perspective. Scenarios represent possible future alternatives of the environmental contest that firms might have to face. This analysis is generally used in very uncertain situations. Scenario's analysis is designed for a more distant future than the prevision for alternative futures. Therefore, there are no different grades of probabilities for every scenario.
Even if there are different ways to create a scenarios analysis, the process is generally structured in five different phases.

- Define the range of action of the analysis, deciding the reference framework and its time horizon.
- Identify the key factors of change, use PESTEL analysis to understand the most influential ones.
- Develop different "stories" for each scenario. Every key factor of change must be integrated with other elements to create stories that seem plausible and coherent.
- Identify the possible impact of each alternative scenario on the firm. Every company should change its weak strategies and develop emergency plans to face every possibility.
- Monitor the development during the time, ensuring the coherence of eventual changes with the scenario's expectations. In this final phase, managers have to be able to fix the prevision efficiently and appropriately.

Considering the high level of uncertainty of the scenario's construction method could be better to avoid selecting only three possible scenarios. The evaluation of three scenarios involves managers adopting three prospective: a positive one, a middle one, and a negative one. The main risk is to focus more on the intermediate option, leaving out the other two possibilities. For this reason, it is preferable to develop two or four scenarios, avoiding the risk of giving priority to the middle option.
In the end, it does not matter if the scenario does not happen; in that case, its real value will be given by the process of learning that will increase the knowledge about all the possible scenario's options.

1.2 Sector's level

A sector is defined as a group of firms that produce the same goods and offer the same services with common characteristics. Sectors are organized in different specific markets (or in market segments). A market includes all clients of a specific product or service which present common characteristics. The best model to understand the actual level and its evolutionary dynamics is Porter's five forces model.

1.2.1 Porter's five forces model

Market sectors could have a different attraction level, which could be measurable by the number of profits each firm could achieve. Porter's five forces model represents an excellent method to understand the attractive level of the sector. It is constituted by five different indices: the level of competition among competitors, the threat of new possible entrants, the threat of substitute products, the bargaining power of the customers, and the bargaining power of the suppliers.

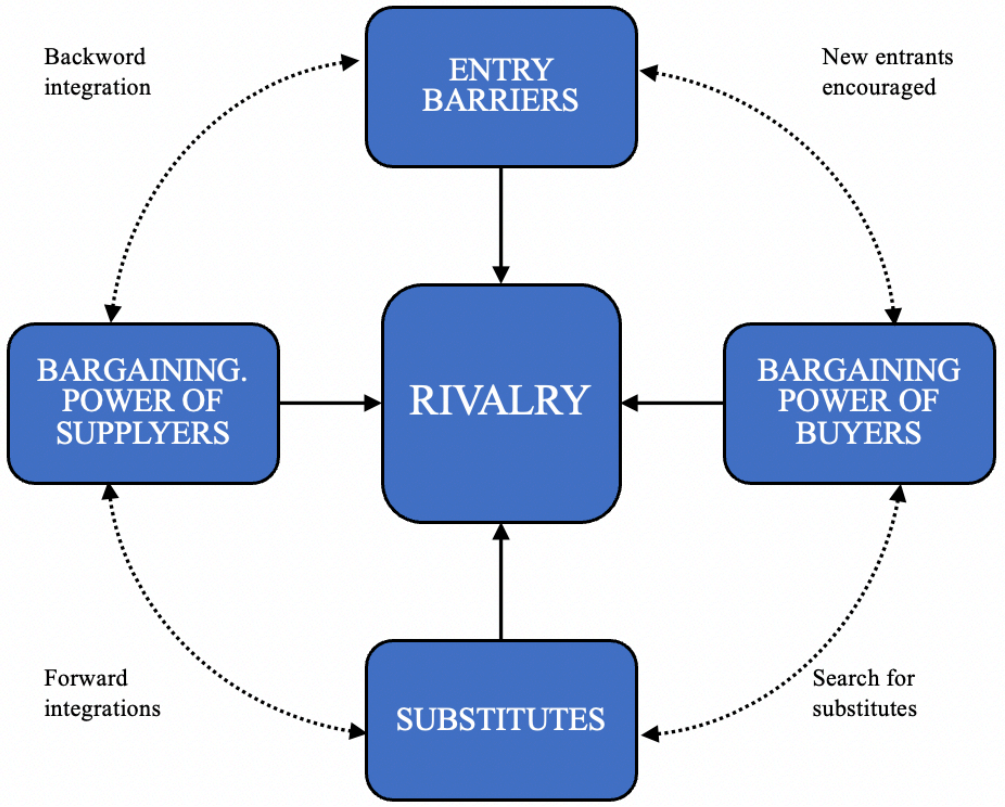

Figure 1.3 Porter's five forces model: key internal interdependencies. SOURCE: Rethinking and reinventing Michael Porter's five forces model Grundy, Tony, (2006)

- The level of competition among competitors is at the center of the model. Higher is the level of competition inside the sector, and worst is the situation in the sector. Rival contenders are those organizations that produce similar goods or services for the same type of customers. Five factors influence the level of competition (inside the sector or it). The first one is the number of competitors; when several firms of similar size compete, the risk of a higher level of competition increases. The second one is the index of growth of the sector. When a high index firm can grow with the market, while when the market is frozen, the level of competition increases. The amount of fixed costs is the third factor that can influence the competition among competitors. Indeed, sectors with high fixed costs generally present a higher competition level. The fourth factor is the level of barriers to exit from the sector. Higher will be the barriers, and higher will be

competition, especially in decline sectors. The last factor is the differentiation grade of goods. In the commodity sector, where products have a low level of differentiation, the competitive pressure is higher. Due to the low differentiation, clients can switch from a company to another one without problems.

- The threats of possible new entrants refer to the threat of new competitors substituting existing competitors in an industry. Higher is the threat lower could be the profits prospective. A sector with a high level of attractiveness has suitable barriers to entry that limit the threats of the entrance of new competitors. The five principal barriers to entry are economies of scale and experience, limited access at the offeror at the distribution channels, the expectation of retaliatory actions by competitors already present in the sector (for example, war prices or aggressive marketing campaigns), laws and norms applied by the public administration (like the protection of intellectual property through patents) and other advantages of the incumbents, like the technological or the geographical.
- The threat of substitute products includes those products that can satisfy the needs of the same category of customers even if they have a different production process. Frequently managers focus their attention only on direct competitors, forgetting about the threats about substitute products. Two possible aspects must be taken into consideration about substitute products. The first one is the relationship between price and services offered. A substitute product (or service) could remain a threat even if its price is too high. Indeed, what matters is not the price of the goods but the relationship between price and performance. The second one is the induced effects from firms that operate in other sectors. Moving managers to watch beyond the borders of the natural sector is the actual value of the concept of a substitute product.
- The bargaining power of customers refers to the pressure that customers can put on firms to obtain different advantages. If customers have high bargaining power, they could require lower prices, reducing the profit margins. Three possible conditions could increase the bargaining power of customers. A high concentration of clients permits the customer to impose their bargaining power on the suppliers, a low level of switching costs give the possibility to them to quickly substitute a supplier with another one, and even the threats of a possible upstream vertical integration could increase customers' power if they can supply themselves autonomously.

- The bargaining power of the suppliers refers to the pressure that suppliers can exercise on firms to obtain different advantages. Suppliers are those subjects that offer to the firm everything it needs to carry on its economic activity. The effectiveness of the bargaining power of the suppliers depends on different conditions. Firstly, if the number of suppliers is low, it limits the supply choices of a firm. Secondly, there are high switching costs; if the transition from a supplier to another one is very costly, the firm will be more addicted to its actual suppliers. Lastly, even the possible threat of competition by suppliers could increase their bargaining power. This is possible when the supplier can go directly to the final customer through a vertical integration downstream.

1.3 Competitive segment level

A sector could represent a much broader level of analysis to understand a firm's competition. For this reason, it could be helpful to divide the sector into different markets. The concept of strategic groups permits a better realization of which firm could be considered a competitor and which not. Even sector's clients could show different characteristics and, based on these differences, it is possible to find different market segments. These approaches could help the firm to understand the value creation process of its competitors. According to Nzive Kasyoka (2011), companies use strategic positioning when they consciously decide to expand their business into different market segments than they are in currently.

1.3.1 Strategic groups

Strategic groups are groups of companies inside the same sector and are featured by similar strategies and product characteristics. Two elements permit to distinguish a strategic group. The first is the firm activity area (like the type of products, the geographic area of its market, the distribution channels), and the second is its outflow of resources (marketing expenditures, vertical integration grate).
The identification of the strategic groups could be helpful for three reasons.

- Help the company to understand competitors' characteristics. Managers could focus only on direct competitors inside their strategic group, considering the high rivalry grade. It also helps the company find critical variables that differentiate the top performer firm from the low performer one.

- Analysis of the strategic opportunities. Strategic groups could help the company find strategic spaces with higher attractiveness inside the sector, which must be evaluated carefully.
- Analysis of mobility's barriers. For a firm could be challenging to move from a strategic group to another one. Strategic groups are usually characterized by mobility barriers, which obstacles firms' movement from one group to another. Firms positioned in a successful strategic group could be protected through mobility barriers and entry barriers obstacles to entrance external firms in a sector.

1.3.2 Market segments

Sectors could also be divided into smaller and more specific market partitions based on customers' needs, which are generally known as market segments. A market segment is composed of a group of customers who present similar needs and are different from the needs of other customers of the same sector. If a market segment is very small, it is generally named niche. The dominance in a market segment or a niche could be very profitable. Segmentation choices should be reflecting the organization's strategy, and the strategies based on market segments should be based on customers' needs.

- Differences and variations on customers' needs. A solid strategy of market segmentation could be produced, focusing on the needs of customers. Different needs could create different market segments. However, the criteria for the segmentation changed according to the reference market.
- The construction of a successful strategy is possible only if the firm can develop an efficient market segmentation, which helps the firm specialize in the most profitable market segments. This strategy is generally called the "strategy of niche." Being able to serve in a unique way a segment which the other competitors cannot cover in the same way is frequently the base for a solid profitable long-term strategy. Firms that operate in a specific niche should be established strong relations with the other subjects which operate in the niche that hardly can be replicated by competitors. Experience and relationships generally permit the firm to defend a dominant position in a particular market segment. On the other hand, focusing too much on a particular niche could lower the possibilities of a firm to compete in the entire sector. In the end, a good market

strategy should combine specialization with the capability to adapt to the dynamic needs of the customers of the entire sector.

1.4 Firm's level

The external environment is not the only factor able to influence the strategy of a firm. The internal differences in the resources and capabilities are equally significant in determining the strategic positioning of a firm. Firms are not all equal, and each one has specific resources and capabilities that could make a difference. In addition, internal capabilities are, in general, tough to be copied and imitated by other organizations. These concepts are summarized in the resource-based view approach (RBV), through which the competitive advantage and the higher performance of an organization are due to the different specific resources and capabilities.

1.4.1 Resources and capabilities

Resources and capabilities help an organization to survive in the long period and to develop a competitive advantage. Sustainable competitive advantage is the prolonged benefit of implementing some unique value-creating strategy not simultaneously being implemented by any current or potential competitor, along with the inability to duplicate the benefits of this strategy (Hoffman, 2000). Resources are the whole of all the assets of an organization. Capabilities represent through which those assets are used and exploited. What matters is not the total amount of resources and capabilities owned but how they are used and managed. The importance of competitive advantage and distinctive competencies as determinants of a firm's success and growth has increased tremendously in the last decade. This increase in importance is due to the belief that the fundamental basis of above-average performance, in the long run, is a sustainable competitive advantage (Porter, 1985). Every firm must achieve a threshold capability to compete in a specific market, reaching the same result as competitors. Threshold capabilities represent the minimum level for the firm to survive and continue its activity in the market. Finding and managing threshold capabilities could be difficult, especially in dynamic sectors where critical factors of success change frequently, and the level of competition is very high.

However, reaching the threshold capabilities is not enough to achieve a competitive advantage. To obtain a competitive advantage, it is necessary to develop distinctive capabilities that make the firm unique.

There are four fundamental criteria to evaluate firm resources and capabilities, like value, rarity, inimitability, and organization, summarized by the VRIO model. Following the frameworks in resource-based view, to achieve a sustainable competitive advantage, the firm must possess resources that are valuable, rare, imperfectly imitable, and imperfectly substitutable or heterogeneous, imperfectly mobile, ex-ante limits to competition, and ex-post limits to competition. (Nzive Kasyoka, 2011)

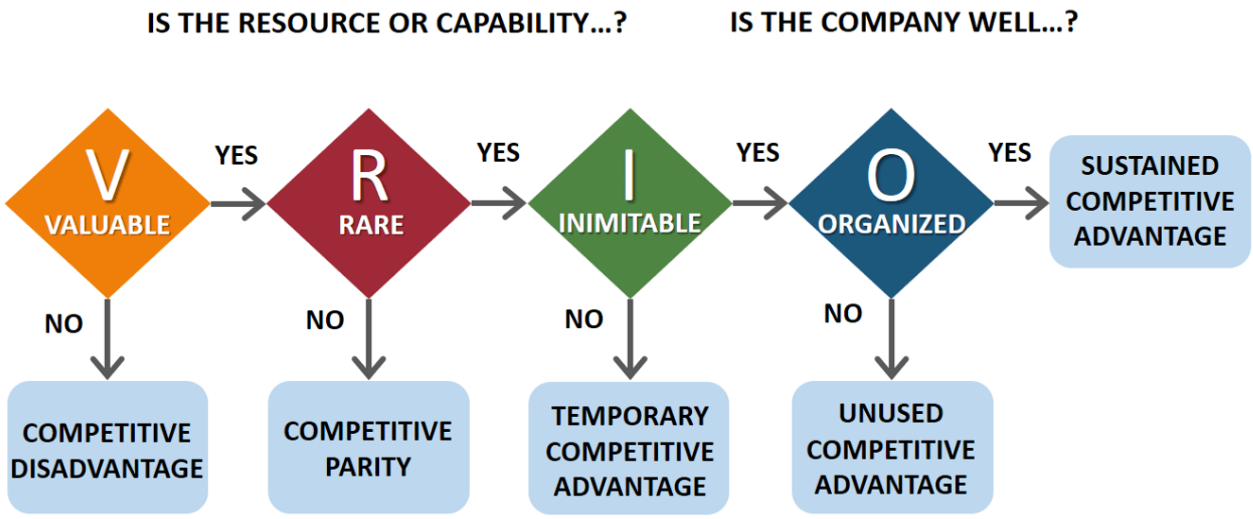

Figure 1.4 The VRIO model. SOURCE: VRIO: From Firm Resources to Competitive Advantage, Lars de Bruin, 2016

- Valuable resources allow the firm to create a product or service that the customers appreciate and help it face external threats. A valuable resource or capability permits one to exploit the opportunities and face potential threats. The resources or capabilities have to be able to create value for clients. What matters is not how the firm perceives the resource but how customers perceive the resource. Finally, managers have also to keep costs in line to achieve the expected profitability level.
- Rare resources and capabilities are owned exclusively by one or a few organizations. The internal vital resources and capabilities have not to be widely distributed among competitors. Patents could represent a critical advantage that helps the firm to protect its innovations.
- A sustainable competitive advantage is achievable only if the firm's essential resources and capabilities are inimitable by competitors. A resource or capability is inimitable

when complex, for example, through internal links or external interconnections. A firm's potential could be challenging to imitate when competitors cannot find the linkages that create the base for the competitive advantage; for example, there could be ambiguities on resources characteristics or difficulties in finding the fundamental relations that link company processes. According to Barney (1991), a firm is said to have a sustainable competitive advantage when it is implementing a value-creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy.

The possibility of owning rare and inimitable capabilities and offering a product that customers recognize is the basis for constructing a competitive advantage. However, the firm must be able also to organize, using suitable systems and organizing processes to sustain its potential. When a firm acquires individual-level knowledge resources (human capital) through selection, training or experience, and other learning activities, it must find a way to leverage those resources to the team level and eventually to the organizational level (DeNisi, 2000). If the firm is not able to do it, it could lose its potential competitive advantage. For this reason, a sound organizational system is fundamental to support the development of valuable, rare, and inimitable capabilities and resources.

1.4.2 The evaluation of firm potential

The VRIO analysis helps a firm to understand the level of its strong potential. In particular, it analyzes if a company owns resources and capabilities which are valuable, rare, inimitable and if the organization supports everything. Nevertheless, it is not the only model used to evaluate a firm's potential. Other valuable methods are the value chain, benchmarking, and SWOT analysis.

The value chain describes the different categories carried out inside an organization that contributes to creating a product or service. The main goal of the value chain is to move management to think about the organization like a whole of activities. These activities are divided into primary activities (logistics activities, operational activities, marketing activities, and services) and support activities (supply management, technology development, human resources management, and infrastructural activities). The value chain model could be an efficient instrument to understand the strategic positioning and analyze its internal resources and capabilities. However, a firm rarely carries out all its value chain activities internally, but it specializes in some roles and becomes an integral part of a more comprehensive value system.

Being part of a value system includes new challenges like the relationships with partners and identifying the profit pools, different levels of profit inside the different areas of the value system.

Benchmarking is an instrument used to compare organizations. It compares the company with competitors or other firms that perform the same activities or similar production functions. There are two benchmarking approaches. The first one is at a sector level, which compares a company's results with the result achieved by competitors of the same sector. The second one is best-in-class benchmarking, which compares a firm's capabilities and performances with the best one, no matter the sector where they operate. However, even if benchmarking could be considered an excellent way to understand how to achieve a similar performance level, it does not help the firm to move on and reach competitive advantage by developing its recourses and distinctive capabilities.

The SWOT analysis summarized its strengths, weaknesses, opportunities, and threats, which influence its strategy. The main goal of this analysis is to find the impact of a firm's strengths and weaknesses on the evolution of its strategies. The SWOT analysis becomes a more practical method when it has a cut comparison with principal competitors. It also does not include too many factors but only the key ones, excluding less significant ones. In any case, it is essential to remember that, even if SWOT analysis is a valuable instrument, firms do not have to over-reliance on it. The SWOT analysis is a simplistic model based on management's prejudices and cannot substitute a strategic analysis, which is considered more complex and objective.

1.4.3 Firm potential and dynamic capabilities

After evaluating the firm's potential, management should decide how to manage and develop these resources and capabilities. Even if these assets represent the base for long-term success, they cannot remain static, but they must evolve. The dynamic capabilities concept relates to the capability of a firm to renew, rebuild and reconfigure resources and capabilities to satisfy the needs of a dynamic environment. Today, an organization's sustainable competitive advantage should be built upon its corporate capabilities and constantly reinvented. According to the new resource-based view of the company, sustainable competitive advantage is achieved by continuously developing existing and creating new resources and capabilities in response to rapidly changing market conditions. (Nzive Kasyoka, 2011)

If a firm cannot do it, it could lose its competitive advantage since competitors will copy and imitate any potential positive factor.

There are three types of dynamic capabilities.

- The capability to perceive, find and explore new technologies and market opportunities, through an efficient R&D activity.
- The capability to take advantage of these new opportunities, realizing new products, services, processes, and activities.
- The capability to reconfigure and renewing organizational capabilities, technologies investments, and production processes to take the opportunity.

Summarizing, dynamic capabilities could help the firm to modify its operational capabilities to follow environmental changes.

Managers have different ways to create, amply, and update a firm's resources and capabilities; a company could develop its business growth internally, using its capabilities of creation and recombination, or externally, through acquisition transitions, alliances, or joint ventures. Another managerial option is to dismiss any activity that does not participate in the value creation process. Lastly, even the awareness-raising of the employee could help the firm to update its resources and capabilities. Education policies and staff development are crucial roles for education and to increase people's awareness about their contribution to the competitive advantage.

CHAPTER 2 Digital Support Systems

2.1 History and Development of Digital Support System

By the late 1970s, several companies had developed interactive information systems that utilize data and models to help managers solve semi-structured issues. These various systems take the name of Decision Support Systems (DSS). Ralph H. and Sprague Jr (2011) define DSS as "a class of information system that draws on transaction processing systems and interacts with the other parts of the overall information system to support the decision-making activities of managers and other knowledge workers in the organizations." From the beginning, it was recognized that DSS could be structured to support decision-makers at any organizational level. They could support operations, financial management, and strategic decision-making. During the years, many of the more interesting DSS have been targeted at middle and senior managers. DSS are also frequently designed for specific organization types, like hospitals, banks, or insurance companies. These systems are sometimes referred to as vertical market or industry-specific DSS.

2.1.1 Decision Support Systems Origins

Researchers and technologists of Information Systems have built and studied computerized Decision Support Systems (DSS) for approximately 40 years. The history of the implementation of these systems starts in the mid-1960s. In a specialized area like DSS, history is not linear. Different people perceived Decision Support Systems' field from various points and report different opinions of what happened and what mattered. During the technological progress, new computerized decision support applications were built and analyzed. Researchers used multiple structures to help them to develop and study these systems.

Before 1965, it was very costly to develop extensive information systems. At about this time, developing robust mainframe systems like IBM System 360 and others made it more practical and less costly than developing Management Information Systems (MIS) in large companies. These early MIS that were produced were focused on giving managers structured, periodic reports, and the information was mainly from accounting and transaction processing systems, but this type of system did not provide any interactive support to help managers in the decision-making process.

George Dantzig, Douglas Engelbart, and Jay Forrester did pioneering work that strongly influenced the viability of informatics decision support systems. In 1952, after becoming a research mathematician at the Rand Corporation, Dantzig started implementing linear programming on its experimental computers. In the mid-1960s, Engelbart and his colleagues created the first hypermedia groupware system named NLS (oNLine system). NLS helps the creation of digital libraries and the storage of electronic documents with the use of hypertext. On the other side, Forrester was involved in building the SAGE (Semi-Automatic Ground Environment) air defense system for North America, which was terminated in 1962. SAGE is probably the first example of computerized data-driven DSS.

In the last years of the 1960s, a new type of information system was developed, which became convenient, the model-oriented DSS or management decision systems. Ferguson and Jones (1969) reported a preliminary experimental study using a computer-aided decision system. Other two DSS pioneers, Peter Keen and Charles Stabell, claimed the decision support's concept evolved from "the theoretical studies of organizational decision making at the Carnegie Institute of Technology in the late 1950s and early '60s to the technical work on computer systems, primarily carried out at the Massachusetts Institute of Technology in the 1960s" (Keen and Scott Morton, 1978, preface).

During the late 1970s, different vendors, practitioners, and academics encouraged the construction of new computer-based Decision Support Systems (DSS). Their actions generated high expectations for DSS and generated much optimism about the prospects on decision making. Despite the initial excitement, the success rate of decision support applications had been initially unsatisfactory. Gorry and Scott-Morton (1971) were the first to use the decision support system term in the Sloan Management Review article. They argued that Management Information Systems mainly concentrate on structured decisions and proposed that the supporting information systems for semi-structured and unstructured decisions be maned "Decision Support Systems."

T.P. Gerrity, Jr. concentrates mainly on DSS design problems in a 1971 Sloan Management Review article entitled "The Design of Man-Machine Decision Systems: An Application to Portfolio Management." His works were structured to help investment managers in their ongoing management of a client's stock portfolio. Since Gerrity started his research on DSS for portfolio management, they have become very sophisticated and helpful.

John D.C. Little (1970) identified four conditions for designing models and systems to support management decision-making. His four criteria included: robustness, simplicity, ease of control, and completeness of relevant detail. These four factors are still relevant in evaluating

modern Decision Support Systems. By 1975, Little produced a DSS named "Branded" designed to support product, promotion, pricing, and advertising decisions. These results were the combination of its marketing and DSS studies.

In 1974 an influential text on MIS was published by Gordon Davis, a professor at the University of Minnesota. He defined a Management Information System as "an integrated, man/machine system for how to provide information to sustain the operations, management, and decision-making process in an organization. (p. 5)". Davis s framework includes computerized decision support systems in the innovational field of management information systems. DSS textbook of Peter G. W. Keen and Michael Scott Morton (1978) offers a behavioral orientation to DSS analysis, design, development, and evaluation. In 1980, Steven Alter's research results were published in a book titled "Decision Support Systems: Current Practice and Continuing Challenge." Alter's research expanded the management DSS framework and divided DSS into different categories, from extremely data-oriented to extremely model-oriented. His studies gave a company a descriptive foundation for identifying DSS. Bonczek, Holsapple, and Whinston (1981) developed a framework for understanding the problem of designing knowledge-oriented DSS. They found four critical factors that seemed to be familiar to all DSS:

- A language system (LS) that clarify all messages a specific DSS can accept.
- A presentation system (PS) for all messages that a DSS can emit.
- A knowledge system (KS) for all knowledge that a DSS owns.
- A problem-processing system (PPS) that is the “software engine” that proves to find and solve problems during the process of a specific DSS.

The book entitled "Building Effective Decision Support Systems," written by Ralph Sprague and Eric Carlson (1982), was an important milestone. It gave a practical description of the mothed that an organization has to follow to develop a DSS. In the mid-1980s, academic researchers built software to help group decision-making (cf., DeSanctis and Gallupe, 1987; Huber, 1984). From that moment, several studies have examined the impacts and the effects of Group Decision Support Systems (GDSS). In addition, several companies have started to sell GDSS and groupware.

The beginning of the 1990s was characterized by technological development with Executive Information Systems (EIS) evolution from a single-user model-driven decision to a support system and improved relational database products. The first EIS used default information screens and was kept by analysts for senior executives. The technological created the possibility

of producing new business intelligence, data warehousing, and Online Analytical Processing (OLAP) software, which expanded DSS capabilities (cf., Dhar and Stein, 1997). There was also a change from a mainframe-based data-driven DSS to a new client/server DSS in this period.
In 1995, the World Wide Web and data warehousing development started to influence several practitioners and academics interested in decision support technologies. Many firms buy enterprise resource planning (ERP) applications. In the mid-1990s, business intranets were built to help exchange information inside the company and permit direct connections between decision-makers. In 1996 the leading decision supported system incorporated ad hoc query and reporting tools and quantitative models. Powell (1997), talking about data warehousing, said that it "became the cornerstone of an integrated knowledge environment that provided a higher level of information sharing across an organization, enabling faster and better decision making."
In 1998 there was a general updating on the executive information systems thanks to the introduction of enterprise performance management and balanced scorecard systems
As the millennium advance, Web-based analytical applications and business intelligence solutions were upgraded by many vendors. The introduction of more sophisticated decision portals started a combination process with knowledge management, business intelligence, and communications-driven DSS through an integrated Web environment.
Database research has contributed to develop tools and research on managing and analyzing different data and documents. The development of new mathematical models by Management Science and Operations Research for use in model-driven DSS has provided clear evidence on the advantages of modeling in problem-solving.
The history of Decision Support Systems covered a relatively short amount of time, and the concepts and technologies are still changing. Many of the previous innovators and early developers are retiring, but their efforts and actions can be remembered to guide future innovation in this area. The development of the Internet and Web have helped the speeded-up decision process and have provided a new means of capturing and recording the development of knowledge in this research field. However, the DSS pioneers created particular and distinct streams of technology development, and their research serves as the base of much of today s work in computerized decision support.

2.2 DSS's conceptual perspective

The name of Decision Support System derives from the last years of the 1970s when several companies started to define DSS as the development of interactive information systems that used data and models to help managers analyze semi-structured problems. DSS is structured to

help the organization at any organizational level and in the different processes like operations, financial management, and strategic decision making. DSS could be targeted for middle and senior managers and often designed for specific organization types like hospitals, banks, or insurance companies. DSS could provide support to individuals as well as to groups. For instance, it could help a single person using only one computer or many people in a networked client-server or Web environment.

2.2.1 DSS' characteristics

Even if the term "Decision Support System" include many and different connotations, the research of Steven Alter (1980) found three common aspects of all DSS:

- DSS is explicitly structured to facilitate decision processes
- DSS should support rather than automate the decision-making process
- DSS should be able to respond quickly to the changing needs of decision-makers

In the same period, Keen (1980), following Alter's studies, developed a "characteristics" approach where he found some DSS common characteristics, which include:

- DSS is generally used to solve less well-structured, underspecified problems that top managers have to face.
- DSS tries to combine models or analytic techniques with traditional data access.
- DSS has features that permit it to be usable also by non-computer computers in an interactive way.
- DSS is flexible and adaptable to environmental changes and the different decision-making approaches of each user.

In addition, Clyde Holsapple and Andrew Whinston's work (1996) found some common characteristics that a DSS generally possesses, even if it could be considered general and abstract. They explained that a DSS must have a body of knowledge, a record-keeping capability that can present knowledge on various customized situations as well as in standardized ones, a capability for discovering the desired subset of stored knowledge for either presentation or for deriving new knowledge, and must be designed to directly interact with a

decision-maker helping the user to produce flexible choices and sequence of knowledge-management activities.

Other common characteristics of DSS are found in Adeleh Asemi Zavareh's paper entitled "The Role of Management Information System (MIS) and Decision Support System (DSS) for Manager's Decision-Making Process." The author finds some aspects that more recent DSS generally owns. In particular:

- DSS supports decision-makers primarily in semi-structured and unstructured situations, unifying the machining process with human decisions.
- The main scope of DSS is to improve the effectiveness of decision-making, so increasing the level of factors like accuracy, timeliness, and quality, instead of focusing on its efficiency and considering primary factors like cost of making the decision, including the charges for computer time.
- DSS has to be able to provide efficient support to individuals as well as to groups. Indeed, semi-structured problems involve several individuals from different departments and organizational levels who have to participate in decision-making.
- The most advanced DSS is equipped with a knowledge component, which should permit the possibility to find an efficient and effective solution to challenging and unexpected problems.
- DSS can handle a large amount of data thanks to their database. On the other side, DSS must also be able to solve problems where a small amount of data is required.
- DSS must be developed using a modular approach. In this way, different functions of a DSS are in different modules, which can be used for more purposes and different systems.
- DSS has a graphical orientation. Nowadays' DSS generally has a graphical orientation to facilitate the understanding of the actual situation.
- DSS support optimization thanks to a heuristic approach. A heuristic approach is constructive in very complicated and ambiguous situations. With a heuristic approach, DSS finds the "very good-but not necessarily the best- solution." Through this approach, the decision-maker has a higher flexibility level on taking his final decision.
- DSS can perform "what–if" and goal-seeking analysis, making possible changes in the actual situation and observing the expected results.

On the other side, there are many types of different DSS, and many terms are used to identify specific support systems like "business intelligence," "collaborative systems," "data mining," "data warehousing," "knowledge management," and "online analytical processing." What matters is that all these systems must support every management decision process, providing them the correct information to find possible solutions.

2.2.2 The role of the DSS in the process of decision making

DSS is usually developed to respond to the specific need of the individual and group managers. In recent years DSS has extended its support on the decision-making process. Uma (2009) has stated that a Decision Support System is an integrated set of computer tools allowing decision-makers and managers to interact directly with computers to obtain helpful information in making semi-structured and unstructured decisions.
Ralph H. Sprague, Jr (2004) finds some performance criteria to judge a DSS. Focusing on the manager's view, a DSS should possess specific performance requirements to help managers' decision-making. It is essential to underline that no specific DSS can possess all these requirements; indeed, performance criteria for any Specific DSS will also depend on the task, the organizational environment, and the decision-maker(s) involved. Three of the six criteria depend on the type of decision-making task managers and professionals face, the other three on the type of support needed.

1. DSS should support the decision-making process; notably, they must help take semi-structured and unstructured decisions, where managers generally have more problems.
2. DSS should help managers at all levels in the decision-making process, permitting an integration between the different managerial levels. Challenging problems are faced not only by top managers but also by middle and low ones. It's important that every member of the firm involved in the decision process can use DSS advantages. In addition, their choices must be integrated with other managers' decisions.
3. DSS should support but interdependent and independent decisions. The DSS development has increased DSS use by groups or several people in sequence to accommodate decisions. Keen and Hackathorn (1979) found three different decision types: independent, where the decision-maker has a full responsibility, sequential interdependent, where the decision-makers are part of a "process" of decisions, and

pooled interdependently, where the final decision is taken from the continuous interaction of decision-makers.

4. DSS should support managers in all phases of the decision process. Herbert Simon divides the decision process into three steps:
    - Intelligence, where decision-makers studied the environmental conditions and obtained first raw data
    - Design, where the problem is analyzed, understood and different solutions are developed and tested
    - Choice, where the decision-makers take the final decision.
5. DSS should support many decision processes and not be dependent on anyone. In other words, a DSS is supposed to be independent and be able to help the user with more tasks.
6. DSS should be simple to use. DSS could be used by different managers with different knowledge and technological capabilities. For this reason, DSS should be flexible and user-friendly. These features, which are essential DSS aspects, are sometimes underscored on a DSS evaluation.

DSS permits improving and speeding up the processes by which people make and communicate decisions, offering information and knowledge to the managers. On the other side, managers must consider which types of information are needed to support their information activity. For example, some managers want detailed data while others want summarized ones. Some managers want tables and numbers, but the majority prefer a lot of charts and graphs.

Generally, an Information System can permit business transaction information. Managers could understand better many business operations and be able to solve different performance issues. The information must be timely and current in all those situations, and any analysis must be accurate, relevant, and complete.

A more specific DSS must present specific and complete information in an appropriate format, which remains easy to understand and manage. For instance, Nokhbatolfoghahaayee et al. (2010) have introduced a Fuzzy Decision Support System (FDSS) with an innovative decision-making process, which can be applied to handle crisis conditions in any large-scale system with different criteria. The FDSS receives both functional variables of the system and fault signals primarily and then makes proper decisions to make up and fix the distorted situation and the affected factors of the network according to its database established through experience gathered from managers and decision models that are specifically developed. These decisions

are expressed in the form of some scenarios with different results, which are determined by some specific developed fuzzy multi-criteria decision-making methods, enabling the manager to select the best one according to his discretion.
The information achievable from a DSS could derive from different resources, like transaction data, business models, or external sources. DSS generally use these historical internal and external data for possible quantitative analysis and developing possible future scenarios, offering the decision-makers the possibility of predicting the effects of a particular operation and its financial results.

2.3 DSS's categories and classification

Even if DSS could have common characteristics, it is possible to identify various types of DSS, which could help decision-makers take different decisions. DSS could also have a different scope. Some are useful for manipulating extensive databases; some help managers apply checklists and rules; others use mathematical models extensively. Having a different scope, DSS could also have a different objective. Particular DSS focus on data, some on models, and others on communication. DSS can "take on many different forms and be used in many different ways" (Alter, 1980, p. 71).
DSS could be used not only by decision-makers but also by intermediaries like marketing analysts or financial analysis.
Different examples could explain the different possible use of DSS. Airlines companies use DSS for different operations, like pricing and route selection. DSS could also be used by firms for corporate planning and forecasting. Specialists usually use DSS that focus on financial and simulation models. DSS can help on the monitoring costs and revenues activity. DSS is also commonly used for investment evaluation and support systems. Transportation companies use DSS to schedule trucks, airplanes, and ships. DSS generally supports quality upgrading and control decisions. Big companies like Walmart use DSS to manage a large amount of data and make sales prevision. It is possible to find DSS that help track and manage stock portfolios or suggest gifts on the Internet.

2.3.1 Alter taxonomy and subsequent ones

A possible classification of DSS was initially proposed by Steven Alter in 1977. Alter ended his research in 1980. He categorized DSS in terms of the standard operations that such systems can execute. These operations extend along a single dimension, are range from extremely data-

oriented to extremely model-oriented. Alter conducted a study on 56 DSS that he classified into seven different types of DSS.

- Data analysis systems help managers with data manipulation through computerized tools specialized in an operation and setting or more general tasks and operators. Some examples could be monitoring of budget analysis and variance and investment opportunities' analysis. The majority of data warehouse applications would be divided into data analysis systems.
- Analysis information systems that give access to decision-oriented databases and small models. Examples include sales forecasting based on a marketing database, competitor analysis, and product planning and analysis.
- Accounting, financial, and mathematical models that calculate the possible actions' effects. Examples include estimating the profitability level of a new product or service or analyzing operational plans using a goal-seeking capability. These types of models could be used as a "What if?" or sensitivity analysis.
- Representational models that evaluate the actions' effects are based on simulation models that feature causal relationships and accounting definitions. Possible examples are a market response model, risk analysis models, and production simulations.
- Optimization models that give guidelines for action to develop the best solutions with a series of restrictions. Examples like scheduling systems, resource allocation, and material usage optimization.
- Suggestion models that offer a specific suggested decision for enough structured or well-known operation through a logical process. Examples include insurance renewal rate calculation, an optimal bond-bidding model, a log-cutting DSS, and credit scoring.

Alter's taxation helps managers distinguish different DSS types, reducing confusion and creating a clear classification. Alter taxation was not the only DSS classification. For instance, Donovan and Madnick (1977) divided DSS into institutional DSS or ad hoc DSS. Institutional DSS provides managers support on everyday decisions, which have to be taken frequently. This type of DSS is generally already inside the decision process. Ad hoc DSS provides support for unexpected problems that are not anticipated and could also happen just once.

Hackathorn and Keen (1981) identified three different DSS categories interrelated to each other; Personal DSS, Organizational DSS, and Group DSS. These three categories are based on who is the actual user of the DSS.

Holsapple and Whinston (1996) identified five specific types of DSS. The first type of DSS that they found was a dynamic group of DSS, called text-oriented DSS, which helps the decision makers electronically keep track of textually represented knowledge that could affect decisions. The other four types of DSS were database-oriented DSS, spreadsheet-oriented DSS, solver-oriented DSS, and rule-oriented DSS. These last four types of DSS were similar to the Alter categories.

2.3.2 A more recent Decision Support System classification

Alter's DSS classification represents a significant milestone, helping decision-makers identify the type of DSS that can help them make critical decisions. However, a more exhaustive classification than Alter's taxonomy is needed due to the evolution of DSS during the time. In order to categorize the most common DSS currently in use, Power (2001) divides DSS into five principal categories that are interrelated with three secondary categories. The five primary categories are characterized by the term "driven," which refers to the dominant functionality of this aspect in the Decision Support System.

The five significant dimensions are data-driven DSS, model-driven DSS, knowledge-driven DSS, document-driven DSS, communication-driven, and group DSS.

Dominant DSS Component	User Groups: Internal, External	Purpose: General, Specific	Enabling Technology
Communications **Communications-driven DSS**	Internal teams, now expanding	Conduct a meeting Bulletin board Help users collaborate	Web or Client/Server
Database **Data-driven DSS**	Managers, staff, now suppliers	Query a Data Warehouse	Main Frame, Client/Server, Web
Document base **Document-driven DSS**	Specialists and user group is expanding	Search Web pages Find documents	Web
Knowledge base **Knowledge-driven DSS**	Internal users, now customers	Management advice Choose products	Client/Server, Web
Models **Model-driven DSS**	Managers and staff, now customers	Crew scheduling Decision analysis	Stand-alone PC

Table 2.1 Relationship between dominant DSS component and secondary dimension of DSS. SOURCE: Powell, R. DM Review: A 10 Year Journey, DM Review, February 2001, last accessed March 10, 2001.

- Data-driven DSS is the first type of DSS, which is focused on the analysis of large amounts of structured data. Data-Driven DSS provides the highest level of functionality and decision support linked to analyzing extensive collections of historical data (Power, 2021). It is structured using a data warehouse product and a report and query product. Examples of data-driven DSS could be file drawer and management reporting systems or Executive Information System (EIS), which are developed for senior management. One of the first data-driven DSS was developed using an APL-based software package. It was built from 1970-1974 by Richard Klaas and Charles Weiss at American Airlines (Alter, 1980).

  The first EIS was developed in the late 1970s by Northwest Industries and Lockheed, but the primary growth of EIS corresponded with the development of vendor-supplied EIS software in the mid-1980s. In that period became easier to create an EIS with the capabilities for data importation, screen design, and access to news services.

  Business Intelligence (BI) system could also be an example of data-driven DSS. The term BI is a popularized term coined by Howard Dresner of the Gartner Group in 1989. It describes concepts methods to improve business decision-making using fact-based support systems (Power 2021). BI is sometimes used equally with briefing books, report

and query tools, and executive information systems. A business intelligence system could be described as "a data-driven DSS that primarily supports querying of a historical database and production of periodic summary reports." (Power, 2008).

Generally, data-driven DSS gives the access and the possibility to understand a large amount of internal and external data. In particular, data warehouse systems that permit data management by computerized tools tailored to a particular task and setting or by more standard tools and operators provide additional functionality.

- Model-driven DSS is focused on the management of financial, optimization, and/or simulation models. It permits to manipulation of different models to help decision-makers analyze a situation. In works with limited data and parameters provided by decision-makers and are not necessarily an extensive database for model-driven DSS. On the contrary, sometimes, a specific analysis is necessary to extract valuable data from large databases.

  The first model-oriented DSS was developed in 1969 by Ferguson and Jones. Model-driven DSS was called in different ways during the time; it was called model-oriented DSS by Alter (1980), computationally-oriented DSS by Bonczek, Holsapple, and Whinston (1981), and later spreadsheet-oriented and solver-oriented DSS by Holsapple and Whinston (1996). The first commercial tool for building model-driven DSS was built in the late 1970s by Gerald R. Wagner and his students at the Texas university, and it was called IFPS (Interactive Financial Planning System). Dan Bricklin and Bob Frankston co-develop in 1978 the software program VisiCalc, a calculator which made possible the development of many model-oriented, personal DSS for managers' use. In 1987, Frontline Systems, founded by Dan Fylstra, marketed the first optimization solver add-in for Microsoft Excel.

- Knowledge-driven DSS has the scope to suggest or recommend specific actions to managers. This DSS category is still evolving and could be compared with Alter's category "Suggestion DSS." These DSS are person-computer systems with specialized problem-solving. These DSS are "expertise" in a specific field with the capabilities to understand and solve these particular problems. A connective notion is "data mining." Data mining is defined as the process of sifting through significant amounts of data to create data content relationships. Tools used for developing these systems are also called Intelligent Decision Support methods (cf., Dhar and Stein, 1997). Data mining tools could be equally useful both for data-driven DSS and knowledge-driven DSS.

In 1965 the DENDRAL expert system was created by a Stanford University research team led by Edward Feigenbaum. The DENDRAL system was able to help physicians diagnose blood diseases through a set of clinical symptoms. It could be considered the first rudimental type of knowledge-driven DSS. Higher interest in using these technologies in the DSS field was created by Bonczek, Holsapple, and Whinston's (1981) book. The increasing connection between expert systems technologies to relational databases has raised the diffusion and use of knowledge-driven DSS in the last years.

- Document-driven DSS is a new type of DSS. It helps managers to manage unstructured documents. A document-driven DSS uses computer storage and processing technologies to provide document retrieval and analysis. Examples of documents that could be available by a documented driver are catalogs, and corporate historical documents, like minutes of meetings and correspondence. For instance, a search engine is a primary decision-aiding tool connected with a document-driven DSS.

  The precursors of this DSS type is the article of Vannevar Bush (1945) named "As We May Think." In his article, Bush wrote, "Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and to coin one at random, memex will do." Bush's memex is a much broader vision than that of today's document-driven DSS. In 1978 was written the first article on this DSS category, Swanson and Culnan (1978). The explosion of the World Wide Web technologies has increased data availability and facilitated document-driven DSS development in the last years. Some authors call document-driven DSS Knowledge management system.

- Communication-driven DSS includes all the communication technologies which help decision makers' collaboration and communication. Communication technologies are the main factor of the system, and it includes groupware video conferencing and computer-based bulletin boards.

  This type of DSS could be called GDSS (Group Decision Support System), which identified this DSS category in the past. In particular, the term GDSS derives from the early 1980s, when academic researchers built a new software category to support group decision-making.

  The pioneered work of Engelbart in 1962 entitled "Augmenting Human Intellect: A Conceptual Framework" represents the base for future studies about communication-driven DSS. However, the first empirical study in this research area was done by Joyner and Tunstall in 1970, which tested their Conference Coordinator computer software. At

the end of the 1980s, DeSanctis and Gallup (1987) divide this DSS category into two groups. The first group of GDSS includes systems with the scope to reduce communication problems like voting mechanisms or large screens to display ideas. This first group could be identified as communication-driven DSS. The second group was more similar to model-driven group DSS, providing problem-structuring techniques, such as planning and modeling tools. In addition, from that period, companies start to commercialize both communication-driven DSS and model-driven group DSS. Nowadays, the Internet growth has increased the level of communication-driven DSS with the possibility to develop synchronous communication-driven DSS.

On the other side, Power classification identified three secondary dimensions of DSS. These three dimensions are inter-organizational or Intraorganizational DSS, function-specific or general-purpose DSS, and web-based DSS.

- Interorganizational DSS could be considered a recent DSS category, strictly connected with the rapid growth of the public Internet. The prefix "inter" is used to identify a DSS which is used not only inside the firm but also outside of it, to connect companies each other or provide access at firm intranet to authorized stakeholders, like crucial customers and suppliers, giving them the possibilities to have direct access to company's specific DSS capabilities. For instance, companies could decide to make data-driven DSS available to suppliers or a model-driven DSS available to customers to have some advice on developing a specific product. Despite interorganizational DSS growth, the majority of DSS remain intraorganizational DSS. The prefix "intra" is used to identify a DSS that is used within a specific organization. Intra organizational DSS is developed for an individual inside a firm or by managers in a company.
- Function-specific DSS are developed to support a specific function or operation inside the company. A function-specific DSS can be purchased from the outside or developed inside the company through the specification of general-purpose DSS. General-purpose DSS, which helps the creation of function-specific DSS, is named "DSS generators." DSS can be divided by their purpose. General-purpose DSS helps the firm support them in more general operations like project management, decision analysis, or business planning. Function-specific DSS helps the firm in more recurring specific tasks, which generally repeat during the time. Function-specific DSS can be model-driven, data-driven, knowledge-driven DSS, based on its dominant component. An example of

function-specific DSS is a budgeting system that can cover only one specific function that is regularly repeated.

- Web-based DSS relies on the fact that DSS can be improved using Web technologies. Web-based DSS began approximately in 1995 when the Worldwide Web and global Internet developed a technology platform for further increasing the capabilities and deployment of computerized decision support. In November 1995, Power, Bhargava, and Quek submitted the Decision Support Systems Research page for inclusion in ISWorld with the scope to provide a first interaction between the Web-based materials and the decision support systems. From that moment, there was a constant increase in interaction between DSS and web technologies. A web-based DSS could be defined as "a computerized system that delivers decision support information or decision support tools to a manager or decision support analyst using a "thin-client" Web browser like Netscape Navigator or Internet Explorer (Power, 2000)". Web-based DSS could help the company's intranet from one side, creating a connection among a large group of managers who can coordinate with each other. On the other side, Web-based DSS could also develop interorganizational DSS giving the possibility to the company to have direct contact with suppliers and key customers. Some DSS was developed using web and internet technologies while other DSS continues to be built traditionally, without Web influence.

CHAPTER 3 From the 4th Industrial Revolution to the Artificial Intelligence

3.1 4th Industrial Revolution

The scientific term "Industry 4.0" was first introducing in Germany in 2011 at the Hanover fair, where it was used to describe the transformation process in the global chains of value creation. Industry 4.0 could be described "as a golden age of machine industrial production, organized on the basis of digital technologies and fully automatized" (Brynjolfsson and McAfee 2014). Before the fourth industrial revolution event it is possible to distinguish three past "waves": the agrarian revolution, the transition to industry, and the transition to society that is based on knowledge. The term "industrial revolution" was used to describe rapid and step like character of changes that happened between 18–19th centuries in England and later spread in other Europe countries. The first author to introduce this concept was the French economist Jérôme-Adolphe Blanqui in 1830s.

3.1.1 A Brief Overview of previous industrial revolutions and Introduction of Industry 4.0

The First Industrial Revolution, started in England in the late 18th–early 19th century: England's leadership position in external exchange thanks to colonies and accumulation of capital transform the society, making trade and industry its new basis. Subsequently it arrived in France and Belgium in 1830s–1860s, in Germany in 1850–1873, and in Russia in early 20th century.

The Second Industrial Revolution was based on electrification and organization of transporter production in the 20th century, with the introduction of new products, like cars. In early 20th century West countries started to base their industrial economic systems on new technologies and dynamic economic growth. The key role in the Second Industrial Revolution belonged to massive changes in energy's sector: steam was replaced by electricity. New communication methods were developed thanks to these new industrialization conditions, and some innovations, like the telegraphy became very popular. From the second half of the 19th century, companies started to develop advertising campaigns. The Second Industrial Revolution changed and simplified the Western people's life. A scientific approach was required to develop new technologies and to control production and organization of labor. In 1913, H. Ford F. Taylor created a new model and applied the first assembly line at his plant. The Second Industrial Revolution in late 19th century led to rapid industrialization process in the "second

wave" countries. The main role in the development of Second Industrial Revolution was played by British and French.

The Third Industrial Revolution began in the second half of the 20th century. It was based the transition from minerals to renewable sources of energy, with the creation of computers in production, automatization, and transition to digital additive production (Kupriyanovsky et al. 2016). "The economist" divide the industry 3.0 in three principals: the shift of profit center to development and design, the labor efficiency growth, and the replacement of business' traditional centralized models by distributed structures and horizontal interaction. The Third Industrial Revolution included a complex and profound transformations of systems, structures, relations, and technologies, which modify the sense, mechanisms, and content of people's organizing production, exchange, consumption, training, communication, and leisure. New technologies, like machines, equipment, and devices were developed using new scientific solutions. This period was characterized by the creation of machines that generate new types of energy, like electric, and hybrid and computer products' production became feasible.

The Fourth Industrial Revolution begin in the 21st century, in Western countries in 2011 as a project (initiative) based on increase competitiveness level of the processing industry (Lu et al. 2016). Germany could be seen as the leader transition phase which drive to the concept of "Industry 4.0". It is based on ì new technologies' development like Internet of Things (IoT) or robototronics. It planned that every physical object or "thing", like machine, component, or final product embodied built-in digital technology that permits to interact with external objects and humans. The main sense of systemic transformations in industry is about the formation of an entire automatized production. In this way it is possible to combine a "cyber physical system" in industry processes. The introduction of these new technologies permit to firms to be more flexible and to adapt to new customer's needs. Indeed, the main purpose is to develop systems which allow to change production processes in case of necessity.

3.1.2 Differences between the Fourth Industrial Revolution and previous ones

The fourth industrial revolution is expected to be an unprecedented engine on the development of the economy. Even if some common features permit to define the transition to "Industry 4.0" like a new industrial revolution, there are also some differences between this new revolution and the previous ones. Popkova, Regulina, and Bogoviz (2019) find some differences between the fourth industrial revolution and the previous ones:

- The main difference between the fourth industrial revolution and the previous ones is the total elimination of humans from the production process. Even if previous industrial

revolutions permit a reduction of human participation, this new revolution will lead to human's elimination from the production system, with a creation of a "machine to machine" interaction. This fact also allows a full elimination of mistakes caused by the "human factor". The number of workers needed to maintain the same level of production exponentially drops, with the digital business that reaches a marginal cost of production that tends towards zero. On the same line also is a report by McKinsey & Company which found that half of all existing work activities would be automated by currently existing technologies, enabling companies to save billions of dollars and to create new types of jobs. (Manyika et al. 2017).

- The second difference is the different impacts on all business processes of an industrial company. Thanks to the capabilities of artificial intelligence for deep change, this revolution affects all those processes, optimizing all components of the production and distribution systems. For instance, when arrived an order from a customer is possible to develop a complete solution (project, draft, etc.) using only machines and without human participation.
- The third difference is the possibility to reduce the negative social externalities that generally go with an industrial revolution. In previous industrial revolutions indeed the increasing level of productivity was related to negative externalities like the reduction of population's living standards of the territories on which the industrial companies were located and to the negative influence of production on these companies' employees. The increasing automatization' level gives the possibility for a remote administration by humans eliminating negative social consequences.
- The fourth difference is the key role taken by industrial patents. During the previous industrial revolution, the main idea was to hide the technologies to avoid the possibility to be copied by competitors. now all information will be available on the Internet and will become generally accessible. However, the patents' introduction help owners to protect their rights, bereaving the rivals of the legal possibility to use them, despite awareness of all details.
- The last difference is about the rate of change of the direction of specialization of industrial production. The other industrial revolutions create also initial complications making the production system more stuck. This fact didn't happen during the Fourth Industrial Revolution. Indeed, humans do not participate in the production process and high mobility is achieved due to the possibility for quick re-orientation of machines.

The Fourth Industrial Revolution change the type of technological mode through industrial innovations and systemic transformations in industry, with big changes in logistics. In addition, this revolution could help to increase the harmonization and integration of many disciplines. For instance, the biological world can interact with digital fabrication technologies. The possibility to use new technologies permits to reduce the distance between inventors and markets. For example, innovations like 3D printing allow inventors and entrepreneurs to establish small companies with lower start-up costs. The exponential increase of new technologies and the development of artificial intelligence could cause an economic disruption in the next years.

3.1.3 Opportunities and Challenges of Fourth Industrial Revolution

This dramatic change could be a threat to many kinds of works, but also create new jobs opportunities for economic growth. For instance, new economic businesses, like Instagram or WhatsApp, for example, did not require much capital to start and became a top business in the Fourth Industrial Revolution. In addition, the Fourth industrial revolution will combine different scientific and technical disciplines. But it will not be only a simple combination. It will permit the creation of new markets and d new growth opportunities for each participant.
Robots will continue to enter more and more inside people's life. They help us to cook, play music, record TV programs, etc. Robots could improve the quality of people's lives, helping them at home but also creating new jobs or improving the conditions of already existing ones.
Lastly, the Internet of Things (IoT) permits advanced connectivity of devices, systems, and services that go beyond machine-to-machine (M2M) communications and cover a variety of protocols, domains, and applications. (Holler, et al. 2014). The advance of the internet and its usage on personal computers and mobile devices permits a high and fast interconnection between people from different countries all around the world. "By 2010, the number of computers on the Internet had surpassed the number of people on the earth." (Gershenfeld and Vasseur, 2014)
The book titled The Fourth Industrial Revolution by Klaus Schwab (2018) theorizes a strategic role of this revolution about inequality. The author believes that the fourth industrial revolution will generate great benefits and challenges, in equal measure. This fact is supported by the so-called ‘platform effect’, where digitally driven organizations create networks that match buyers and sellers of a wide variety of products and services and thereby enjoy increasing returns to scale.

On the other side, the fourth industrial revolution could be considered both exciting and scary. It could bring different advantages and opportunities but also many kay challenges. Schwab (2015) explains that the answer to this technological revolution must be "integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academic and civil society." All the value chain has to participate in the technological revolution embodied it among all the supply process. All these actors must be involved in this process and understand the higher value and long-term gains in efficiency and productivity. If the firm will not be able to do it the risk is to slow down the productivity level through the formation of bottlenecks inside the supply chain process.

Moreover, the revolution could create new markets but also disrupt already existing ones. In this way, the revolution could yield greater inequality, and low-skilled and low-wage jobs will be replaced by computers and digitization with a possible increase in social tensions.

A possible challenge of the fourth industrial revolution from the demand side could be the capacity to find people who can create new ideas and innovations. (Brynjolfsson, McAfee, and Spence 2014) theorized that in the future, talent, more than capital, will represent the critical factor of production. Other possible threats are cybersecurity and hacking, raised during the Fourth industrial revolution, when our lives become extensively connected to various devices, like personal computers and smartphones. (Xu, M. David, Hi Kim, 2018), explain how nowadays more than ever companies need to achieve greater cybersecurity, mapping their networks, assessing the risk and critical factors relating to security.

Lastly, another challenge for a firm that already operates in the market could be the entrance into the market of new digital firms. Netflix is competing with traditional television. Taxis must compete against Uber and Lyft. These companies offered a similar product offered to customers in a new different way.

In sum, there is no doubt about the fourth industrial revolution's potential, which can permit people to improve every aspect of their life. However, challenges like inequality, cyber security, the difficulties in the research of possible entrepreneurs, and the possible entrance of more digital competitors are challenges that people and firms can't ignore if they want to reach the maximum level of benefit from the revolution.

3.2 VUCA environment

Nowadays, we lived in a world that has a rate of change completely different from the past. The internet diffusion with the possibility to have a continuous interaction among people around the

world and the Fourth industrial revolution explosion has increased the speed through which the world changed. In "The World is Flat" Thomas Friedman writes "there is something different about the flattening of the world that is going to be qualitatively different from other such profound changes: the speed and breadth with which it is taking hold. This flattening process is happening at warp speed and directly or indirectly touching a lot more people on the planet at once. The faster and broader this transition to a new era, the more likely is the potential of disruption.". Companies who failed to adapt to these new dynamic conditions could be face difficulties especially on lack of leadership, flexibility, and imagination not because they are not smart or ready but because the speed of change is overwhelming them. This rapid change is creating a new dynamic environment that takes the name of the "VUCA" environment. The VUCA acronym stands for Volatile, Uncertain, Complex, and Ambiguous. It was used for the first time by the military after the Cold War to describe a new type of war. Nowadays the acronym has acquired an economic meaning and reflects the consequences of the high mobility of people and goods as well as the evolving technical interconnectivity. It is by economic leaders to describe the chaotic, turbulent, and rapidly changing business environment that has become the "new normal." California Management Review (Vol. 61, 2018) describes VUCA as "both an outcome of disruptive innovation and a driver of it".

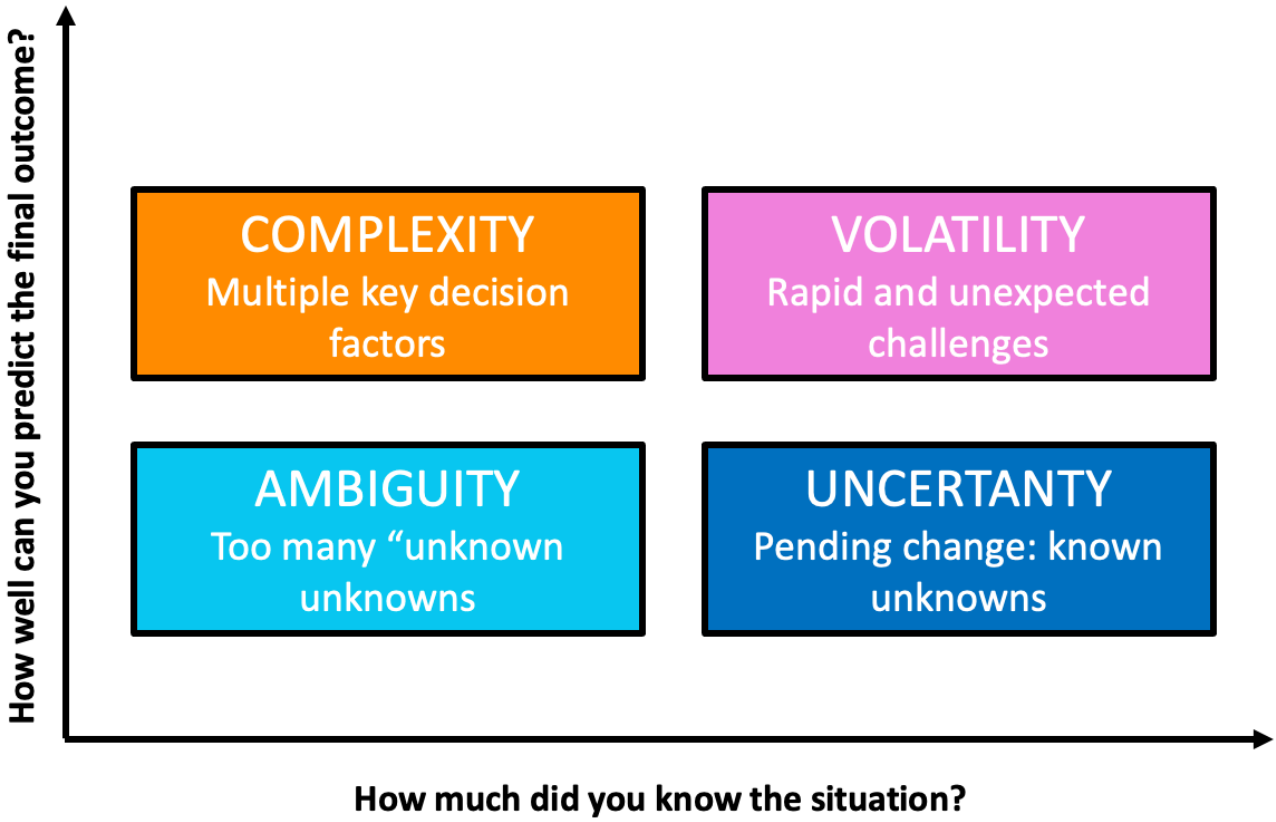

Figure 3.1 VUCA environment. SOURCE: Lorena Ignazzi, 2020, Il ruolo del Marketing in situazioni complesse

To understand and face well VUCA environment leaders must identify the unique challenges presented by volatility, uncertainty, complexity, and ambiguity. Indeed, if VUCA is seen as general, unavoidable, and unsolvable, leaders will take no action and fail to solve an actual problem. Each of these aspects requires its own separate and unique responses. For this reason, each component of VUCA will be analyzed separately, to fully understand their challenges and possible solutions.

3.2.1 Volatility

The "V" in the VUCA acronym stands for volatility. A volatile situation can be defined as one that is unstable or unpredictable. (Sullivan, 2012 January 16) described volatility as a situation where the nature, speed, and volume of change that is not in a predictable pattern. Volatility's concept relates to turbulence and dynamicity, factors that are increasing their magnitude in the last years. Volatility represents the common definition of VUCA generally used in the business press: relatively unstable change. The situation has not to be complex or involve a lack of knowledge. The main problem is that experience and best practices no longer provide solid indicators for identifying solutions for the present, or the future. Leaders who have to face a volatile situation struggle due to the lack of certainties about the future.
How volatility can be countered? Different solutions were developed to help managers to face volatile
situations.

- Lawrence, (2013) theorized that volatility can be countered by vision due to the vital role that vision has to face turbulent moments. A leader able to maintain a clear vision about where they want their firm will be in the next future can face a volatile environment and possible threats like new competitors or economic downturns, for instance, taking business decisions to counter the turbulence while keeping the organization's vision in mind. Bob Johansen (2007) proposes a positive reading of VUCA, where the volatility is countered by vision. Codreanu (2017) defines vision as the capability to identify key priorities that matter most. In that way leaders will be able to know the activities that are essential for firm

interest, fueling a sense of community and communion that is required for any organization to have.

- Bennett and Lemoine (2014) show how when a volatile situation is expected a possible solution could be to develop an agile mentality. This method could be costly and consist, for instance, of stockpiling resources. Possess of more raw materials, employing more talented people could be the key to handling volatility periods facing unstable and unpredictable conditions.

3.2.2 Uncertainty

The "U" in the VUCA acronym stands for uncertainty. Uncertainty is used to describe a situation with a lack of knowledge, not as to cause and effect but rather about whether a certain event is significant enough to constitute a meaningful cause. The main problem of an uncertain environment is the difficulties on makes forecasting and developing a more standardized decision-making process. In addition, the dynamic conditions of an uncertain environment lowered the possibility of taking actual decisions using experience. (Sullivan,2012)
Two possible solutions were developed to permit the firm to face an uncertain situation.

- Lawrence, (2013) theorized that uncertainty can be countered with understanding. It can be defined as the ability of a leader to stop, listen, and understand the situation. To understand the situation in a VUCA environment, leaders must take some time, learn to look, and listen beyond their functional areas. To do it, it is necessary to communicate with all levels of employees in the organization and to develop and demonstrate teamwork and collaboration skills. Understanding is the solution even on VUCA positive model by Bob Johansen (2007). Leaders must develop regular communication inside the firm, giving advice and listening to the needs of employees. They have to imitate the behavior they want to see by others, and give trust to them, delegating tasks creating a collaborative environment.
- Bennett and Lemoine (2014) theorized that uncertainty situations can be solved by dedicating and investing more resources on "boundary-spanning" activities. This fact includes moving beyond existing networks, data sources, and analysis processes to obtain information from different partners having a more extensive view.

3.2.3. Complexity

The “C” in VUCA stands for complexity. A complex situation is characterized by many interconnected parts. Leaders must face many difficult-to-understand factors, both inside and outside the organization, that characterize a problem. These factors could create difficulties during the decision-making process, creating bottlenecks and congestions situations. The main problem of a complex situation is to don’t be able to understand and clearly define a firm’s challenges.

Additionally, this level of complexity has risen due to the ease of accessibility to big data that will continue to increase their key role in the decision process at an ever-quickening pace. (Patrick Hollingworth, 2016)

Two solutions were theorized to the countered complex situations:

- Lawrence, (2013) supposed that complexity con is faced by clarity, through a process of making sense of the chaos. Leaders who can manage chaotic situations can make better, more informed business decisions. To achieve clarity over complicatedness Morrieux and Tollman (2014) suggest understanding the effect that employees have on total performance, encouraging cooperation rather than competition among them. In addition, the authors underline the importance to react quickly to a complex world and avoiding complicatedness, understanding people's performance needs, and making them concern organizational behavior. Therefore, understanding the context of employee behavior can help leaders to bring clarity over what works and what does not.
- Bennett and Lemoine (2014) theorized that the most straightforward option for a firm to address complexity is to simplify the situation using a structure that mirrors that of the environment. The idea is based on the research of Heugens & Lander (2009) which prove that organization that adapts themselves to match’ environmental change performs at higher levels, while firms that maintain past structures and processes in the face of a changing business environment are less effective.

3.2.4 Ambiguity

The “A” in the VUCA acronym stands for Ambiguity. It can be defined as the lack of clarity about the meaning of an event. Sullivan (2012) describe ambiguity as “causes and the ‘who, what, where, how, and why’ behind the things that are happening (that) are unclear and hard to ascertain.”

Col. Eric G. Kail (2010) defines ambiguity as the “inability to accurately conceptualize threats and opportunities before they become lethal.” Ambiguous situations are characterized by difficulties in understanding cause-and-effect relationships. Ambiguity is rendered by the

inability to provide “yes/no” solutions. Many alternatives could be valid. It depends on how, where, or when, certain events take place.
Different solutions were developed to face ambiguous situations.

- Lawrence, (2013) theorized that ambiguity could be countered through agility. An agile method help leader to communicate with employees across the organization, finding new solutions quickly (Kinsinger and Walch, 2012). Agility is about withstanding difficulties by changing flexibly and swiftly. More complex firms must face more difficulties to remain agile and flexible. In particular, a firm with hierarchical structures, well-established routines can remain stuck and paralyzed by the analysis. The signals that allow the existence of such stumbling blocks are: “silo mentality, conflicting departmental priorities and goals, slow response times, processes becoming disconnected from the customer or ether, duplication of effort, lengthy decision making, political behavior, and lack of accountability” (Linda Holbeche, 2015).
- Bennett and Lemoine (2014) suggest that a possible solution to an ambiguous situation could be experimentation. To respond to ambiguous circumstances firm could adopt a mindset of experimentation. For instance, if the potential impact of a new product with new features is ambiguous, the firm could initially try to add new features to existing products and analyze customers’ reactions.

3.2.5 Final thoughts

The volatility, uncertainty, complexity, and ambiguity inherent in today’s business world could be considered the “new normal”, and it is profoundly transformed not only how organizations do business, but how leaders lead. Globalization has created opportunities with one hand as it has introduced threats with the other. To face these new threats, leaders require to develop more strategic, complex, and critical-thinking skills. They need to adapt to this new dynamic environment, becoming more flexible, and using firm resources, like managers' capabilities and big data analysis, countering volatility, uncertainty, complexity, and ambiguity different optimal course of action based on the situation.

3.3 Big Data Analytics

In a world that is more dynamic than ever, where decisions must be taken quickly and with flexibility, a firm must obtain more and more information from different sources to make the right choices timely and without critical doubts. For this reason, in today’s technology and knowledge-driven society, data is considered to be the most critical resource of an organization.

World Economic Forum declared data as a new class of economic asset, like currency or gold (The World Economic Forum, 2012). Even if capturing the potential of data analytics is not an easy task, there are some successful examples like Google or Amazon which based their enterprise on data analytics. Most of this data explosion is originating through Transactional data, Machine data, and social data and leads us into a new world of data known as Big Data. (Kaiser J. Giri, 2014). Since Big Data and Analytics is a relatively new and evolving phrase, there is no uniform definition. For this reason, big data could be defined in different ways, from different points of view.

Mills et al (2014) define big data as "a term that is used to describe data that is high volume, high velocity, and/or high variety; requires new technologies and techniques to capture, store, and analyze it; and is used to enhance decision making, provide insight and discovery, and support and optimize processes."

Ward and Backer (2013) after analyzing different definitions from multiple sources define big data as "a term describing the storage and analysis of large and/or complex data sets using a series of techniques including, but not limited to NoSQL, MapReduce, and machine learning".

The National Institute of Standards and Technology, USA, defines big data as a "zone" "where the data volume, acquisition velocity, or data representation limits the ability to perform effective analysis using traditional relational approaches or requires the use of significant scaling (more nodes) for efficient processing."

Guntur (2015) defines big data analytics as "data that is too large, complex, and dynamic in a way that it is impractical for any conventional hardware and/or software tools and systems to manage and process in a timely manner and scalable fashion".

In any case, big data derives from multiple sources, and, using different technologies, a firm can collect information and value from data that would be previously considered dead. The total value of big data and its market size is constantly growing every year. In 2011 its value was 7.6 billion U.S. Dollars. In 2022 it's expected to reach the staggering level of 70 billion U.S. Dollars with a total of 920 percent increase (Statista, 2021).

Multiple sources provide different types of data that have different characteristics. There are three types of data: structured, semi-structured, and unstructured (Kaiser J. Giri, 2014).

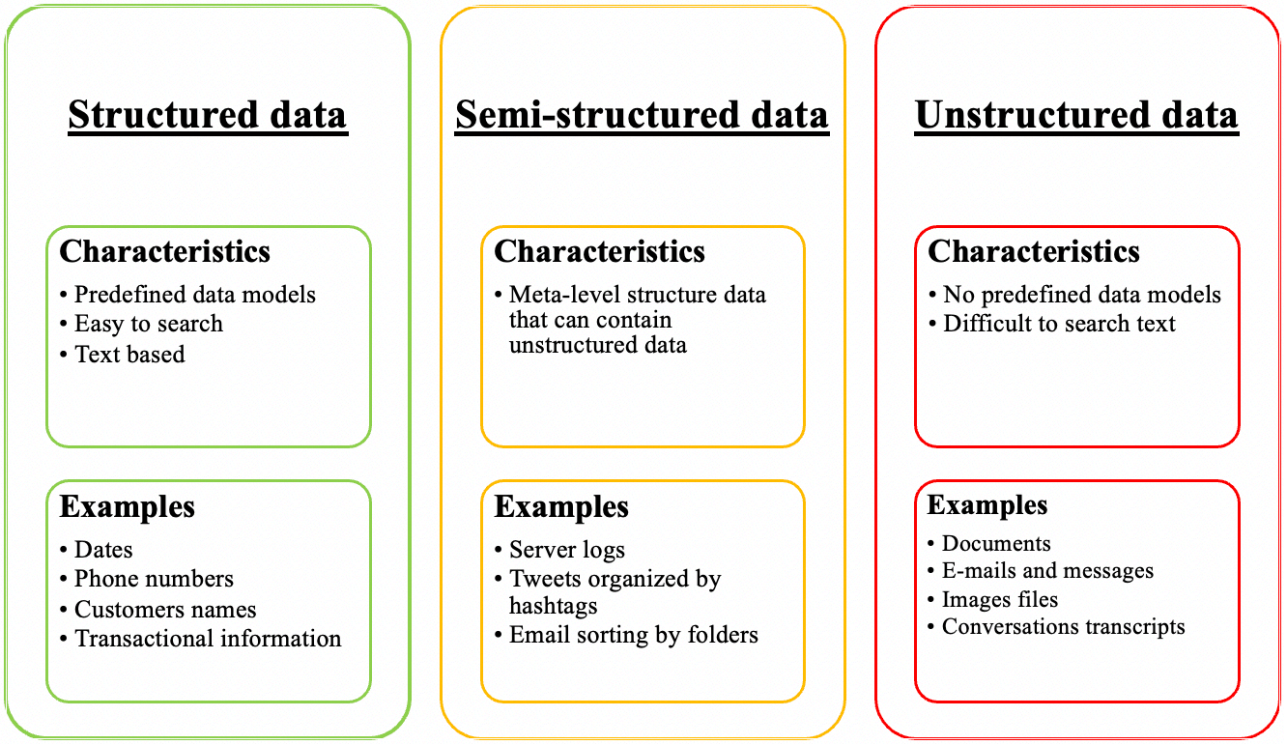

Figure 3.2 Different types of data. SOURCE: Lucille Crombez, 2021. Structured, semi-structured and unstructured data: what makes them different?

- Structured data: Data that can be easily categorized and analyzed like numbers and words. They are generated through network sensors in electronic devices for instance smartphones, global positioning system (GPS) devices, etc. Structured data also include transaction data, sales figures, and account balances. This type describes data that is inside a standard database, generally groups in lines and columns. The data configuration and consistency permit it to respond to simple questions to obtain usable information, based on an organization's parameters and operational interests.
- Semi-structured data: It is a form of structured data that hasn't got a precise scheme. The data is inherently self-describing and possesses tags to apply hierarchies of records and fields inside the data. Some examples could be social media feeds and weblogs.
- Unstructured data: It includes more complex information, like customer reviews from commercial websites, comments on social networking sites and photos, and other multimedia. These data are difficult to be separated into different categories or analyzed numerically. Indeed, this type of data includes formats that cannot easily be categorized into tables for analysis or querying. Possible examples include images, audio, and video files.

3.3.1 ‘V’s model of Big Data

To understand the characteristics of big data during the time were developed a model which describes big data characteristics with five ‘V’s. The first model was developed by Laney D.in 2001, where the emerging characteristics of big data were defined with three V’s (Volume, Velocity, and Variety). In 2011, IDC define a new but similar model which include the introduction of a fourth ‘V’ (Value). Finally, in 2012 a fifth ‘V’ was included in the model (Veracity). The five ‘V’ model is the most common model to describe and categorize big data.

- Volume means, with the generation and collection of large amounts of data, data scale becomes increasingly big (Giri et al, 2014). In 2013 was estimated by the International Data Corporation as 4.4 Zettabytes (ZB) (Zetta = 10^21). It is doubling every 2 years and it is estimated that this trend will continue over the years (V Rajaraman,2016). This exponential growth is due principally to the explosion of machine-generated data and from the high human engagement on social networks. Such a huge number of volumes of data can introduce different problems like scalability and uncertainty (for instance a database tool may not be able to accommodate infinitely large datasets). Many data analysis techniques are not structured to support these large-scale databases and can fall short when trying to scan and understand the data at scale (Hariri et al,2019).
- Variety refers to the different forms of data in a dataset including structured data, semi-structured data, and unstructured data (Hariri et al. 2019). In the past, the majority of data were structured (in the 1960s, the predominant data types were numbers and text), while nowadays the 80 percent of the world’s data is unstructured and needs specific database technologies to be processed. For this reason, analyzing unstructured and semi-structured data can be challenging, and the problem could become higher when data under observation comes from heterogeneous sources with a variety of data types and representations. Therefore, several data preprocessing techniques, like data cleaning, data integrating, and data transforming are used to remove these problems from data (Han J, 2011).
- Velocity means the rapid generation of data. The velocity of data in terms of the frequency of its generation and delivery is also an important aspect of big data. Every Internet of Things (IoT) device constantly produces huge amounts of sensor data. For instance, medical devices delay may result in patient injury or death (Jain A, 2017). For this reason, now it’s almost possible to analyze key data at the same time when they are generated.

Velocity, Variety, and Volume can be represented in a 3D graph, where volume's axis represents the growth of data size, velocity's axis represents speed's increase in which the data must be processed, and variety's axis show the increase in various types of data. (University of North Carolina, 2014)

- Veracity represents the quality of the data. Big data could be inconsistent, noisy, ambiguous, or incomplete. Data veracity classified different data like good, bad, or undefined. The increasing amount of big data produces in every moment creates a much more difficult task for companies. Indeed, due to the increasingly different sources and variety of data, accuracy and trust become more difficult to verify in big data analytics. For instance, programs that involve automated decision-making must verify previously the accuracy of data, to avoid process mistakes.
- Value represents the context and usefulness of data for decision-making. It is important to remember that not all data has value. One of the main tasks of a data analyst is to understand if data are important and therefore have value for the decision process of a firm. Indeed, if the firm owns a large amount of data but they are not able to use it efficiently to improve the business strategies, it is useless (Giri et al, 2014). For this reason, "value" could be considered the most important 'V' of big data.

3.3.2 Different types of data analytics

From a taxonomical view, data analytics could be divided into three different types, based on their different function.

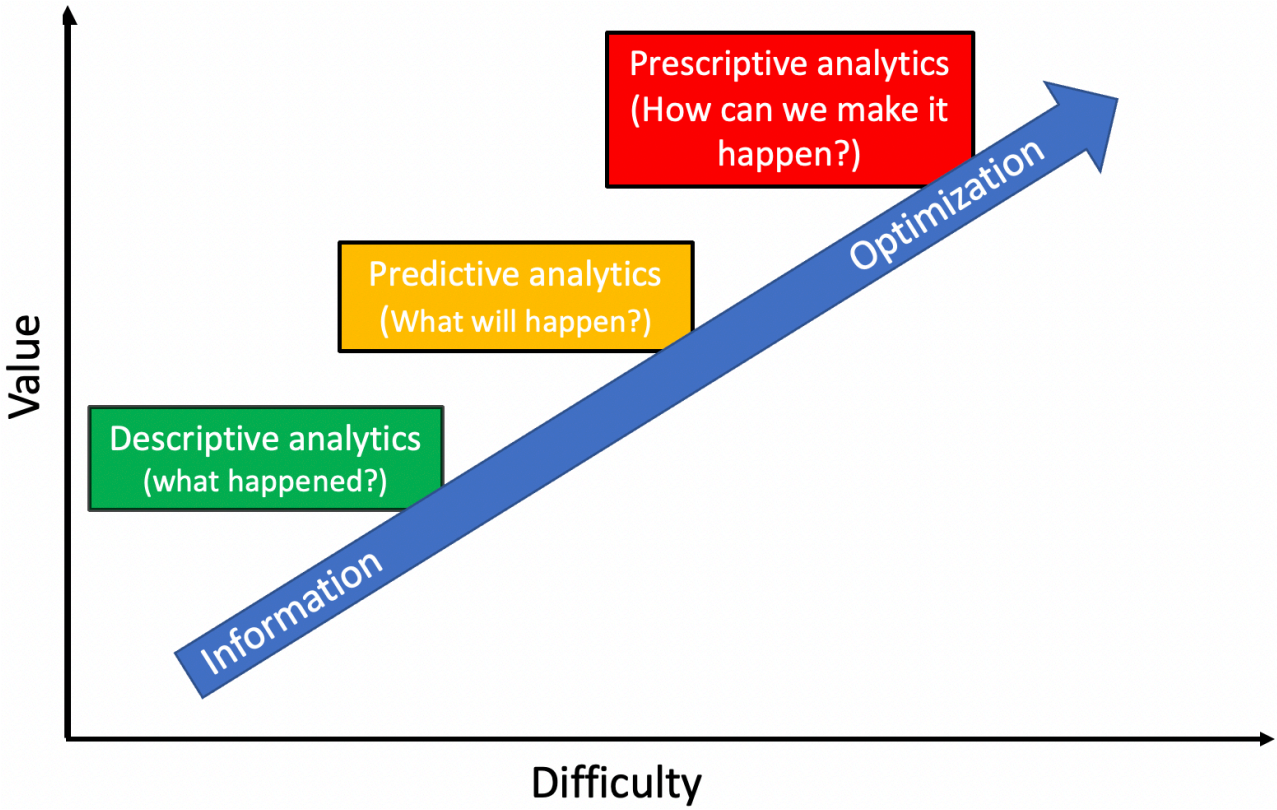

Figure 3.3 Three types of data analytics. SOURCE: Alison Krumm, Cortell Intelligent Business Solutions, 2017, Comments Off on predictive analytics big data warehousing meetup

- Descriptive analytics looks at historical data to find the reasons behind past success or failure. It tries to answer questions like "what is the attrition rate in the last six months?" or "How many customers do I have lost?". This essentially tells what happened in the past and presents it in an easily understandable form. Some examples of descriptive analytics are management report which gives historical information about sales, customers, operations, finance and tries to find correlations between the various variables.
- Predictive analytics extrapolates from available data and gives information about what could happen in the future. Predictive analytics to develop their model use statistical methods, neural networks, and machine learning algorithms. The main objective is to turn data into available information. It can answer a question like "Why has the attrition rate increased in the last six months?" or "which customers gives to the firm the higher value?". Broadly speaking, predictive analysis can be even applied in e-commerce for a product recommendations, price management, and predictive search (Jasmine Zakir et al, 2015). The predictive analysis could be particularly helpful even to understand previously customers' needs and preferences. Through data mining and machine learning processes, it is possible to extract information from existing data sets to

determine patterns and predict future outcomes and trends. It is possible to identify the steps needed to apply machine learning or data mining algorithms for knowledge discovery tasks (G. Bharadwaja Kumar,2015).

  - Understanding: The first step is understanding the specific need. A firm must have a specific vision about the application domain, relevant prior knowledge, and main objectives.
  - Selection of data set: The firm should select a precise target data set on which one needs to perform data analysis to extract useful information.
  - Data cleaning: Data must be available, relevant, adequate, and clean. This is a very important pre-processing phase because the result would be dependent on the quality of selected data.
  - Data transformation: It is the process of reduction of effective variables with the selection of only use one to depict data more efficiently based on the goal of the task.
  - Selection and Application of data mining algorithm: In this phase, it is selected an appropriate method for looking for patterns from the data. Based on the method selected it is decided then the consequent model and parameters.
  - Pattern evaluation: A firm needs to constantly evaluate the mined patterns and relationships. If the patterns evaluated are not useful, then the firm must reevaluate the choices of the previous steps.
  - Consolidation: The knowledge discovered must be represented to the user in a simple and easy-to-understand format. Mostly, firms use visualization techniques to make users understand and interpret information in an easy way.

- Prescriptive analytics: Prescriptive analytics try to go beyond predicting the future result by giving advice about the possible actions to benefit from the predictions and showing to the decision-maker the possible result of each decision option. Prescriptive analytics not only predict what will happen and when it will happen but also explain the reason and provides recommendations on how to act to take advantage of the situation. In other words, the analysis tries to explain what to do in a specific market environment to achieve the desired result. It tries to answer questions like “Which customers should I target to retain?” or “What can we offer even before the customer realizes their need?”.

3.3.3 Big data benefit and challenges

Thomas H. Davenport was the first to observe in his Harvard Business Review article, published in January 2006, ("Competing on Analytics") how organizations that compete on their analytical capabilities considerably outperformed their competitors in the marketplace. Nowadays, the payoff and the economic advantage from joining the big-data and advanced analytics management revolution is no longer in doubt. When companies successfully fit data and analytics deep into their operations, they can increase productivity and achieve profit gains that are 5 to 6 percent higher than competitors (Mckinsey Quarterly, 2013).

Big data can create value and give benefit to the firm in several ways:

- Creating transparency. Giving the possibility to share big data analytics result with firm stakeholders can help the firm to create value. For instance, in manufacturing products, integrating data from R&D and manufacturing units permit engineers to cut time and improve the quality of their work.
- Enabling experimentation to discover needs and improve performance. More data are collected by the organization more information will be available about the firm's performance. Using data is possible to analyze variability in performance and to make controlled experiments to evaluate possible improvements on a firm's production process.
- Segmenting population. Big data permits companies to create specific segmentation. This enables the firms to offer personalized services to meet customers' needs. Using big data analytics marketing firms can develop a real-time micro-segmentation o of customers to target different promotions and advertising.
- Supporting or replacing human decision-making with automated algorithms. Big data analytics can assist firms during the decision-making process, giving constant information about the situation and minimizing risks. The possibility to analyze the entire dataset from customers and employees gives the firm a high knowledge level that could be exploited in the decision-making process.
- Innovation of business model, products, and services. Big data enables companies to create a new business model or improve existing ones. They also allow firms to develop new products and new services, like after-sales offers that could increase brand awareness and its level of loyalty.

On the other side, capturing the potential of data analytics it's not a soo easy task. First of all, it is dangerous to fully trust the results obtained from big data analytics. Often it is assumed

that big data collected include all data points relevant to the problem. This is far from true as data collected can seldom be all data.

In addition, other potential challenges could spot firms to achieve the desired results.

- Big data talent shortage. This could be considered the main challenge of big data analytics. A significant constrain on realizing data is the lack of high skilled people in statistics and machine learning. Talent is an important asset the firm and for the growth of new technology but unlikely, there are not too many already skilled people.
- Data policies. The increasing amount of data that firms own could create some problems about the privacy and security of sensitive data. This data must be collected but also protected and controlled to maintain customers' privacy. Another issue related to big data is to determine who really "owns" these data. Indeed, many data could be copied perfectly and easily combined with other data, so the same data can be used simultaneously by more people. All of these are unique characteristics compared to traditional physical assets.
- Big data complexity. To capture the whole value from big data, firms have to deploy new technologies and techniques. The use of unstructured data like video, comments, and images are more difficult to analyze and sometimes could appear unclear how the data should be interpreted.
- Designing of filters. Not all data generated from different sources are important. Selecting and extrapolating valuable data could be a challenge. When companies integrate information from multiple data sources they must verify if the interest of the stakeholder from which derive the information is aligned with the company's interests.
- Industry structure. Not all sectors have the same benefit from big data analytics. Sectors with a relative lack of competitive intensity and performance transparency, competing in industries where profit pools are concentrated, are likely to receive less benefit from big data. For this reason, organization leaders and policymakers have to consider the possible evolution of the industry in a big data world. Specifically, they must define how to optimize the value creation at the level of individual firms, sectors, and total economies.

Finally, big data analytics has the potential to transform economies, increasing both firms' productivity and customer surplus (McKinsey Quarterly,2011). The possibility to manage a huge amount of data can help the firm to solve many problems. It could be useful to create more

transparency, improve internal performances, segment the population, support the management in the decision-making process, and even create a new product, services, or business model.
At the same time, firms cannot undervalue the main challenges presented by big data. The low number of highly skilled people with big data maintain people's privacy, the complexity of unstructured data, and the difficulties in selecting valuable data are challenges that cannot be undervalued if companies would achieve the target initially set.

3.4 Artificial Intelligence

3.4.1 From analytics to artificial intelligence

Companies have spent the last decades to build new capabilities for analytics, and for other instruments that help them in the decision process. However, in the last years, they are started to explore and exploit even Artificial Intelligence (AI). AI could be considered as the straightforward extension of firm analytical capabilities. It could be seen as the natural evolutionary outgrowth of analytics, the next step that a firm could do to achieve a competitive advantage against its competitors.
This process that leads companies from analytics to artificial intelligence is described in Davenport (2013, 2018) studies, which divide the analytics process into four different eras.

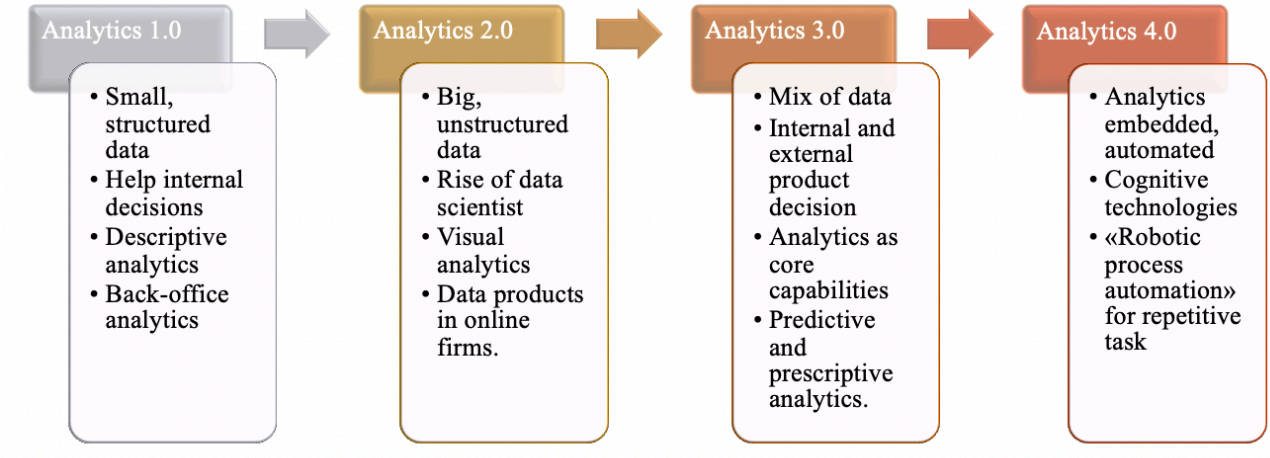

Figure 3.4. The four eras of Analytics. SOURCE: Thomas H. Davenport (2018) From analytics to artificial intelligence, Journal of Business Analytics, Vol 1 NO. 2, 73-80

- Analytics 1.0. The era of artisanal descriptive analytics (business intelligence). This phase characterized business analytics for many years, and the main value was given by

the support that analytics given to the firm in the internal processes, like the internal decision-making process.

- Analytics 2.0. The era of big data analytics, with the development and explosion of social networks and new data management platforms. The scope of data analytics changed and it became “data products” built around data and analytics for use by customers. It isn’t based anymore on the internal use of the firm but to collect and analyze data that are coming from the outside.
- Analytics 3.0. The era of data economy analytics, where even more traditional companies adopt analytics, and their start to adapt to analytics their business model. Big companies develop data and analytics-based products, while analytical activities are increasingly “industrialized.” To achieve success in analytics 3.0. a firm needs to make investments, be coordinated, and adapt its business.
- Analytics 4.0. The era of artificial intelligence, or cognitive technologies. It is widely adopted by big enterprises and now even midsize companies are increasingly utilizing AI. Deloitte's (2017) survey finds that 80% of midsize companies intend to increase their annual AI investments, implementing cloud-based AI like data science and machine learning platforms. Analytics 4.0. have both common aspects and differences from the first three eras. As the previous phases to develop the full potential of AI firm needs data big data processing and statistical methods. On the contrary, the amount of skills, and investment is different between this era and the previous ones. To understand AI technologies like the automated machine learning process, people must develop capabilities that go beyond the traditional analytics skillset. Machine learning and data mining are at the base of many approaches to artificial intelligence.

3.4.2 Different types of AI

It could be useful for companies to divide AI through the business needs that they want to satisfy instead of the technology there are based on. AI can support three important business needs: automating business processes, gaining insight through data analysis, and engaging with customers and employees (Davenport, 2018).

- Process automation. The automation of digital and physical tasks is the most common type of AI. It uses robotic process automation technologies (RPA), which act like humans and obtain information from multiple systems. RPA is the most common and cheaper cognitive technology and generally permits an easier and quicker return on investments. RPA can conduct different tasks, for instance:

- It can transfer and record data that derive from multiple data sources.
- Substitute lost credit or ATM cards, reaching different systems and updating records.
- Read and analyze many documents and extract provisions using natural language processing.

- Cognitive insight. It used algorithms to evaluate patterns in vast volumes of data and to find useful information. Cognitive insight uses machine learning and has different characteristics from traditional analytics. They are usually much more data-intensive and detailed, the models typically are trained on some part of the data set. Cognitive insight applications are generally used to increase performance on jobs only machines can do, so they are not seen as a threat for the possible substitution of human works. Cognitive insights could consider, thanks to the use of machine learning, as "analytics on steroids" (Davenport, 2018). It could be used for different tasks, such as:
  - Predict customers' behavior.
  - Identify and simultaneously detect credit fraud.
  - Offer to the client personalized ads.
  - Give insurers more specific and detailed actuarial models.
- Cognitive engagement. They are projects that involve employees and customers through instruments like natural language processing chatbots, intelligent agents, and machine learning. The idea for the future is to allow customers to have direct contact with cognitive agents, without the interaction of employees.

Figure 3.5 Cognitive engagement idea. SOURCE: Chrobis, clever technology, making a difference.

At the moment, this is the last type of cognitive technology where companies invest. This fact is due to the actual immaturity of the technology which is perceived as "not ready yet". Cognitive engagement technologies could cover different duties, such as:

- AI agents that offer continuous customers service, asking to most common questions and helping them to solve different issues.
- Internal sites develop to answer employee questions.
- Giving support to retailers, offering them personalized products and sales.
- Health treatment recommendation systems that help providers to develop personalized care plans that consider individual patients' health status.

When companies became more familiar with AI technologies breaking down the doubts about their efficiency, can start to combine the different cognitive technologies to reach the maximum benefit from AI.

3.4.3. Benefits and challenges of AI

AI can bring many benefits to the firm, from increasing the performance of products and services or even helping the firm to create new products to the possibility to optimize internal or external business processes (Deloitte, 2018). Indeed, different AI applications could be helpful for the company. Each of these applications can be considered as an extension of the one previously undertaken with analytics (Davenport, 2018a).

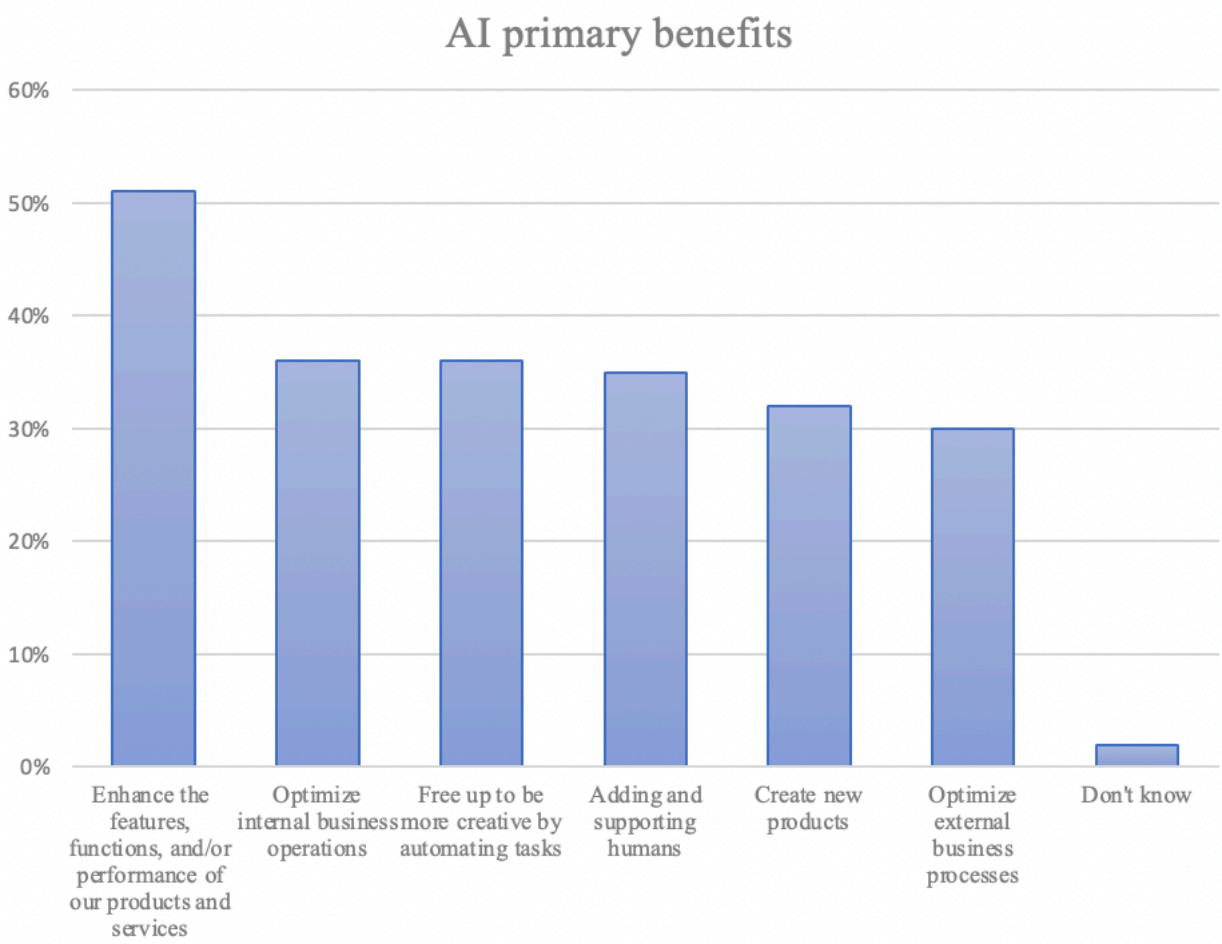

Figure 3.6 AI primary benefits. SOURCE: The 2017 Deloitte State of Cognitive Survey

- Enhance the features, functions, and/or performance of our products and services. The main benefit that AI is expected to produce is the improvement of actual products and services. In particular, companies would improve their product features making them "smarter". Organizations can use AI to improve almost any product or service (Davenport 2018a). AI takes the activity to make predictive or prescriptive analytics and bring it to a new level increasing automation and sophistication. Nowadays it is possible to generate new products, testing new features and opportunities accelerating the process development.
- Optimizing internal business operations. Applying machine learning is possible to improve already achieved using analytics. AI could help the firm to optimize the supply chain using the best one and maximize investment returns (Deloitte, 2017). The quality of the decision-making process and its speed could increase permitting the company to adapt to a dynamic environment. In addition, AI can help the firm to face possible cybersecurity problems, identifying possible new threats and quickly responding to them.

- Free up to be more creative by automating tasks. Many organizations have difficulties hiring high skilled analysts and data scientists. The introduction of automated machine learning (Davenport, 2018b) could help the firm to overpass this challenge. Automated machine learning systems can evaluate different algorithms and choose the best one. In addition, analysts and data scientists can avoid spending a huge amount of time doing basic tasks, focusing on the most challenging ones, and becoming more productive.
- Adding and supporting humans. Companies can use cognitive technologies even to support human judgment. AI using unstructured data can improve decision-making quality, finding new solutions and opportunities. Analytics capabilities have reinforced human capabilities in the last years, but cognitive capabilities can improve these advantages making human choices even smarter and faster.
- Developing new products and services. Cognitive technologies enable a firm to develop even new products and services. Products like Alexa or Google Home are goods developed with cognitive capabilities. They permit the company to give to every customer a personalized product that is able through its voice recognition capabilities, to identify the owner of the product and who is currently speaking. This "personalized" product permits the firm to adapt to different customers' needs (For example answering different types of questions) increasing brand awareness and the loyalty of each customer.
- Optimizing external business operations. Born-digital companies have reached a top-level performance applying analytics in the last years and now AI to external business processes. AI can improve sales operations, sales and marketing campaigns, and customers engagement. For instance, it can be used in the social media area to verify the impact of marketing campaigns or to forecast the sales level of a new product.

Although cognitive technologies seem to have initial success with an increasing number of firms that are starting to invest in them, there are some challenges and obstacles that could preclude some firms to achieve the desired results.

AI is a relatively new argument therefore sometimes companies are not able to face unexpected situations. Deloitte survey (2017) identifies the key challenges with cognitive technologies that organization address.

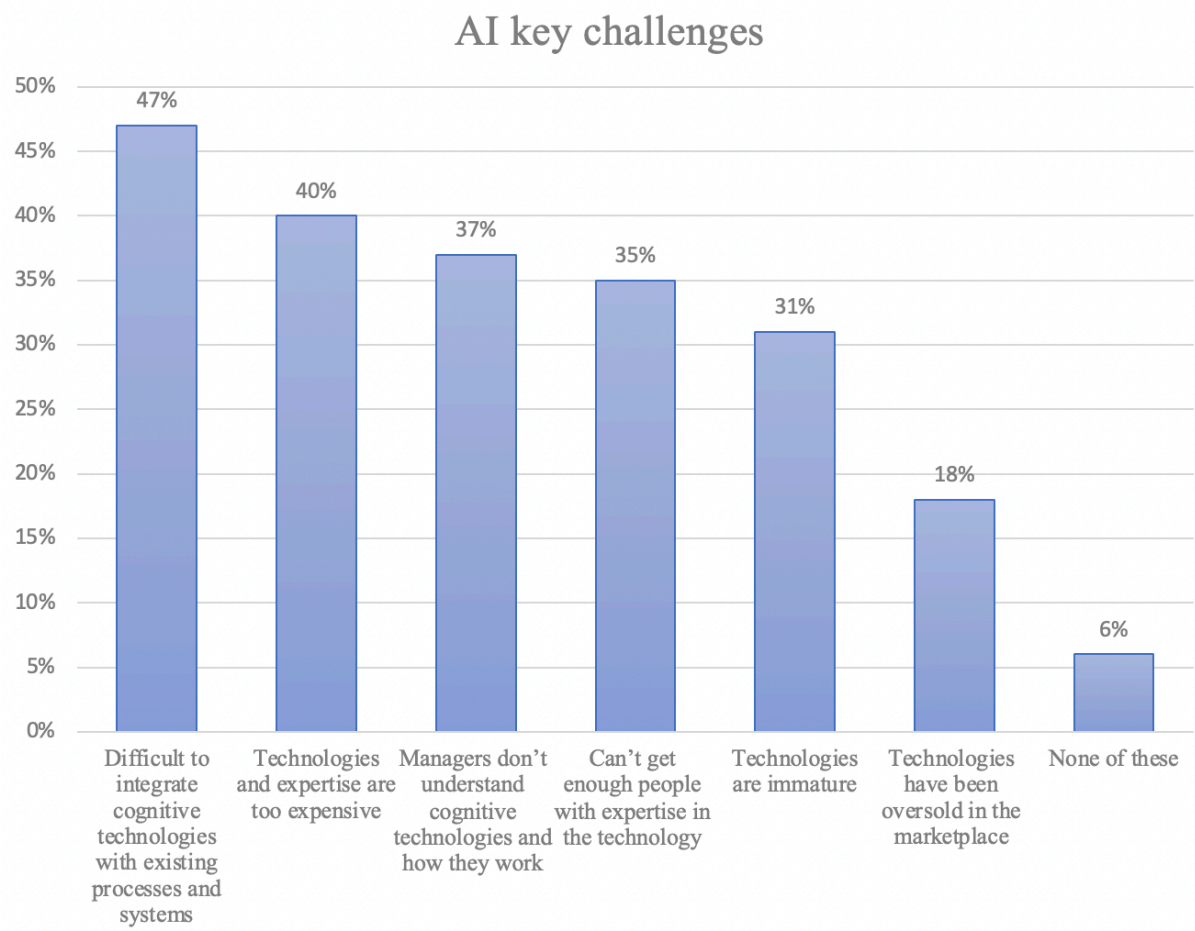

Figure 3.7 AI key challenges. SOURCE: The 2017 Deloitte State of Cognitive Survey

- Difficult to integrate cognitive technologies with existing processes and systems. The main challenge that firms face is to integrate new cognitive technologies with the already existing operating system. This will require cognitive capabilities that function as modular components. Only when the system is restructured organizations can fully take advantage of AI technologies.
- Technologies and expertise are too expensive. This issue was cited most by companies that employ physical robots and must make huge investments to make them fit with the actual organization process. In addition, the low number of AI expertise permits them to require a high wage that firm must bear to be able to use AI efficiently.
- Lack of human resources. Another issue is the low number of high skilled workers on AI. The difficulties to hire data analysts and experts. There are not enough people who can make other businesses understand the advantage and technological progress which AI technologies represent. In other words, we can say that there are not enough people who know how to operate machines that think and learn by themselves. (Robert Adixon, 2019).

- Technologies are immature. Some people still perceived AI as immature, so they typically decide to postpone the implementation of new cognitive technologies. Indeed, some people don't feel comfortable because they don't understand clearly how the decision was made. Sometimes people didn't trust AI results. The only solution is to demonstrate through experimentation that AI technologies work.

3.4.4 Final thoughts

We are still in the early phases of the cognitive computing era. These technologies have the potential to completely transform work. The impact of the new era of analytics 4.0 has all the requirements to be more disruptive than the previous ones. Companies that will move faster through this new era could create a large gap between them and the other ones. Davenport (2018) support the idea that companies that are adopting AI in moderation now and have aggressive implementation plans for the future, will find themselves as well positioned to reap benefits as those that have embraced analytics early on. In addition, the possibility to apply cognitive technologies in different contexts like marketing, health care, financial services, and education will permit to high skilled workers to focus on more challenging tasks, becoming more productive.

To conclude, although firms that invest in new AI technologies must face new challenges, like difficulties in acquiring strategic human resources or the constriction to adapt to new different technologies, the possible benefit that cognitive technologies could bring to the firm is undoubtedly higher, with companies that could increase their automation's level, their employees' productivity, optimize their internal and external business processes, and provide highly personalized offers to any customer.

CHAPTER 4 Covid-19 pandemic and qualitative analysis

4.1 COVID-19 scenario and firm "Digital" reaction

COVID-19 changed the life of all of us. Nowadays it's normal, or even mandatory to go out with a mask, keeping a safe distance and avoiding close contact with unknown. On the other side, from an economic point of view, COVID-19 could be described like a "global society shock". Lockdowns all over the world stop the production in many sectors with a concrete risk of a high increase in unemployment. The effect on the global economy has been significant, with a report of Eurostat (2020) show a decrease of Eurozone GDP by 3,8 points in the first quarter, with similar effects even in the US and UK economies. However, from another prospective, COVID-19 could be also seen as "the game-changer that is leading to unprecedented changes and transformation of businesses across the globe by requiring new operational, production, and service processes" (Andy Ohemeng Asare,2020). While many companies are worried about the immediate impact on their stakeholders, others have gone further, trying to adapt their business to the "new normal". These firms started to adopt agility strategies, artificial intelligence (AI) technologies and data analytics capabilities to partially overcame virus threat and find possible business markets.

4.1.1 Firm's digitalization process

Over the last years, it is commonly agreed that our economy is becoming more digital. The economist (2017) said that nowadays 'the world's most valuable resource is no longer oil, but data' (p. 7). COVID-19 has amplified a trend that was already present in the market. For example, the pandemic has forced many jobs to be performed remotely, accelerating the adoption and the implementation of many digital projects to facilitate remote working. For instance, in this contest Zoom became one of the most used application to generate virtual meetings, recording them and giving the possibilities to share the screen to discuss about the different arguments. One of the best strategies to respond to the environmental changes is to transform your business model with the support of digital technologies. This process affects even some firms with a low level of digitalization which start a process to "standing up analytics capabilities in a matter of weeks to inform business responses to COVID-19 challenges and prepare for the future" (Henke, Puri and Saleh, 2020). For instance, many restaurants must rethink to their business model, adopting new delivery services to partially continue their activity. In this contest digitalization has helped them do develop this new service, with the

online purchases and home delivery which have an unprecedent rise. In fact, data-driven decisions and analytics capabilities are particularly valuable to organizations in terms of fostering process innovation (Wu, Lou and Hitt, 2019). From a managerial perspective, Asare, A. O., Addo, P. C., Sarpong, E. O., & Kotei, D. (2020), find some particular capabilities which leaders and managers must develop to build good dynamic strategy.

- Consciousness, to predict possible rapidly changes in the market, identifying opportunities and threats. To do so, managers must deeply understand the causes of events and behaviors.
- Accessibility, like the possibility to quickly discover relevant data and information, to develop, through descriptive, predictive, and prescriptive analytics possible future scenarios and be ready for any possible event. Information must be accessible at all organizational levels, especially if the firm adopt an open innovation strategy.
- Decisiveness, define like the management ability to take determined decision based on data and information achieved. "In the long run, managers that can make swift decisions are better able to lead their organization to detect threats and or seize market opportunities."
- Speed, define like the ability to move quick and exploit new market opportunities. During the COVID-19 period many companies are switching from their traditional product to produce high demand products.
- Flexibility, as the ability to modify its range of service offers. Organizations should consistently try new methods and processes that work efficiently and effectively to promote innovation rather than being comfortable and reliant on old ways of doing thing. In this way artificial intelligence (AI) could help managers to be more proactive.

In a very dynamic environment, the importance on analytics and of AI technologies has increased due to its problem solving and predictive prowess and to face unexpected tasks. This fact is supported by a McKinsey survey (2020) which show that companies, to be able to satisfy then new demand increase in the last year both digital and technological investments, deciding to cut resources from other parts of the business.

In this new environment "managers can no longer see digital technologies as a supporting function; but should instead be part of a company's business innovations. In order to shift this paradigm, managers need to reconstruct their existing mindsets." (Open Innov. Technol. Mark. Complex. 2020). In effect, in the last two years there was a mindset transformation. The

technology role became much more significant, and a McKinsey survey (2020) show nowadays that only 10% of respondents use technology primary as a source of savings, while it was the main reason in 2017. Technology is now use mainly as a way to make competitive advantage (38%), to modernize and achieve new technological capabilities (30%) or to refocus the entire business around it (19%). This mindset shift was mainly taken by company which already present decline revenues before the pandemic. Over a half increased their focus on digital or make some significant changes to their initial strategy. Managers of these companies try to take advantages from the pandemic, directing their resources into possible new business opportunity. This phenomenon is generally called "disaster entrepreneurship" (Prijono, Moin, Putri, Journal of Open Innovation, Vol. 6, 104, 2020).

On the other side, the McKinsey analytics survey of 2021 show that even the highest performing companies start to make bolder investments in technology to maintain their economic advantage from their direct competitors. This move helps firms to maintain an economic outperformance level and to develop technology endowment's individual capabilities. Due to different motivations, many companies start a process of implementing their technological level; the best one to maintain the role in the business and to remain at the top of it, the worst one to change the actual negative situation and to find new spaces or market opportunities.

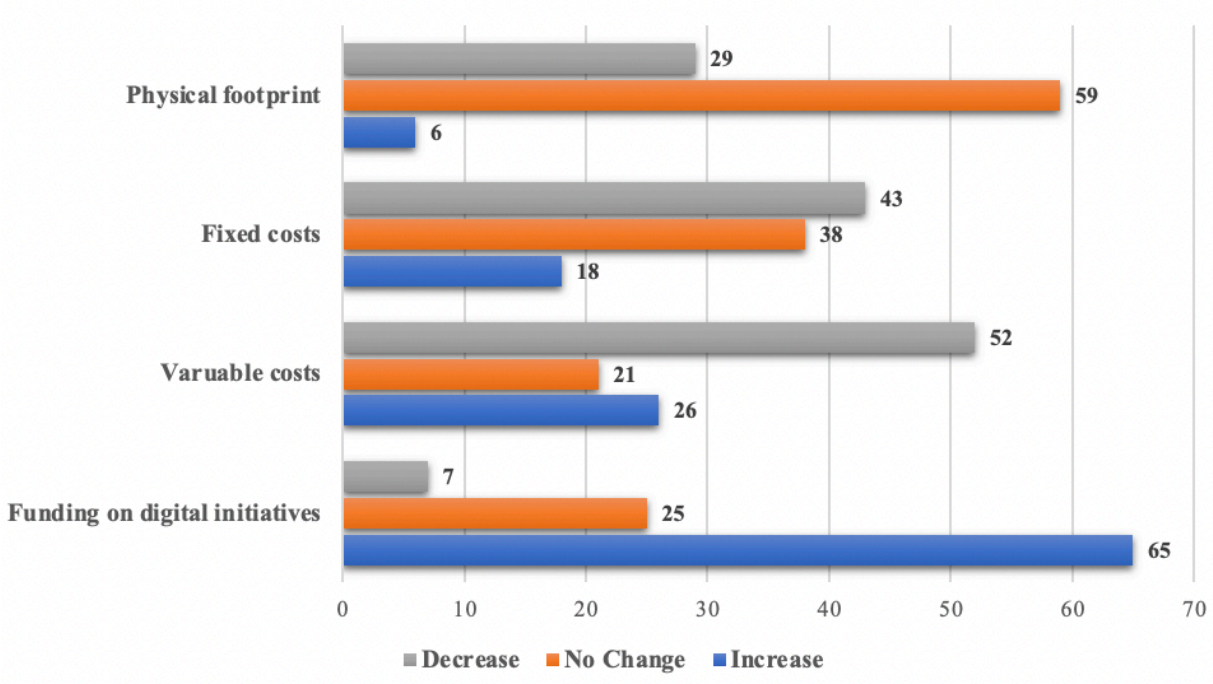

Figure 4.1 Investments during the pandemic. SOURCE: McKinsey Digital, The new digital edge: Rethinking strategy for the postpandemic era. (2021)

Nowadays even the role of technology itself has changed, with a more strategic view. More than a half of the companies now look at technology as a strategic way to differentiate

themselves from competitors. In particular, top decile performers use more aggressive differentiation strategies to differentiate themselves, achieving bigger economic results (McKinsey and Company, 2021)

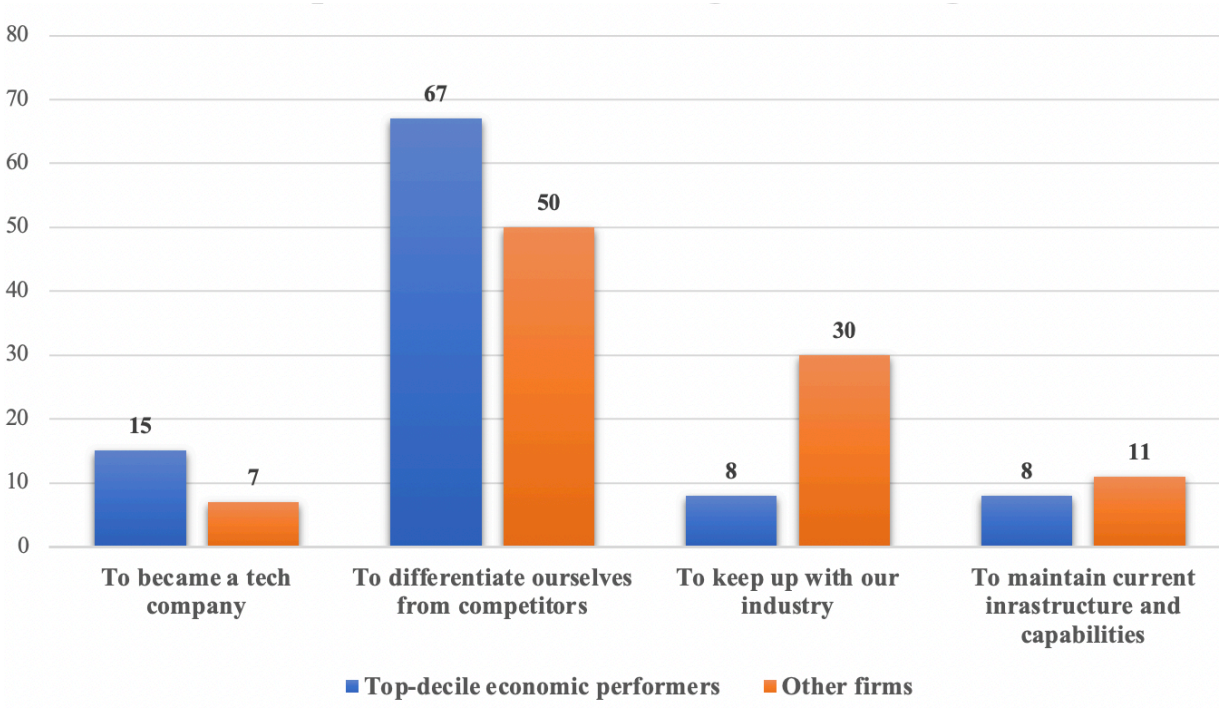

Figure 4.2 Scope of investments in digital technologies, SOURCE: McKinsey Digital, The new digital edge: Rethinking strategy for the postpandemic era. (2021)

However, firms cannot create or implement new analytics capabilities without a clear view about the internal and external environment. In a McKinsey & Analytics article, Henke, Puri and Saleh (2020) underline the importance to align your analytics analysis with your business priority. In particular, they find that only the 30% of the firms align their analytics with the company strategy. Firms that are able to align the analytics strategy with their mission could find before competitors new analytics driven solutions that enable them to face COVID-19 challenges. They show that firms that use AI efficiently are nearly four times more likely than others to align these strategies. The high level of misalignment between analytics and firm's strategy could be explained by the effect that many industries have not already study a clear process of digitalization in a very short period of time. Many respondents of the McKinsey & Company survey (2021) recognize the fact that many companies' business model is becoming obsolete and in the next two years they must build new digital businesses. In particular only the 11% percent of the respondents think that their business model will remain viable without any changes. This "need of change" is mainly due to the pandemic effect, which creates new

vulnerabilities and opportunities especially in the profit structure, in the manual value chain operation and in the operational cost structure (McKinsey & Company survey (2021)).

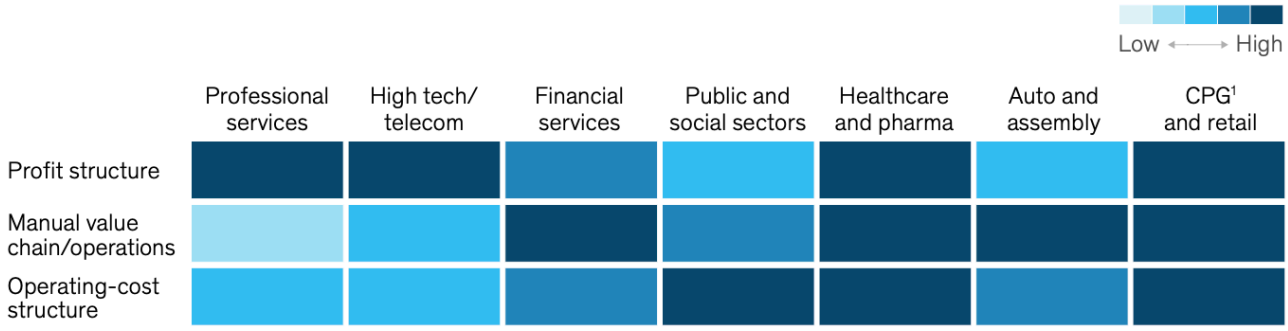

Figure 4.3 Business model future changes due to the pandemic effects. SOURCE: McKinsey Digital, The new digital edge: Rethinking strategy for the postpandemic era. (2021).

Although digital transformation could help companies to create new business models or important changes in the present ones, firm's digitalization does not necessary mean that company has to completely abandoned their previous business model. A good example could be represented by many television networks which were strongly influenced by digitalization and by streaming success. They continue to produce on their current TV channels, but they also open a streaming platform where it's possible to watch different production and past TV show. This fact permits to the television network from one side to continue to satisfy the "old" loyal customer, from the other to acquire new "digital" customer and face the possible threats given by the birth of new exclusive streaming platform (Netflix, Amazon Video, Infinity, etc.). Through a digitalization process, firms should pursue a business model ambidexterity. In this view, firm need to maintain their actual market position, exploiting possible new opportunities from it but at the same time they have to try to expand, exploring totally new business models to provide new value proposition in emerging markets.

4.1.2 COVID-19, VUCA world and Agile strategy

COVID-19 create a very dynamic environment. We already lived in a VUCA environment, where factors like volatility, uncertainty, complexity, and ambiguity represent the "new normal" that every firm must face. COVID-19 has empowered the existing situation. Scharmer (2020), say that COVID-19 has become one of the most effective and impactful teachers of our VUCA time. COVID-19 went quickly from a localized outbreak to a global pandemic (CIFS, 2020). This tiny agent, about 0.000125 millimeters, became able to put the world in check.

Volatility, uncertainty, complexity, and ambiguity are now the norm, not just risks, for every company in every business.

For this reason, firm must adopt new methods to adapt themselves to this new market conditions. Firms have to take quick decisions to not remain freeze and surpass by its competitors. Agility and ability to change became key capabilities to face continues threat and opportunities. The need for speed and dynamic changes which were already increasing, accelerated even more during the pandemic. To survive in a volatile complex, uncertain and ambiguous world like the actual one companies need to become more agile than ever, dividing their employees in high performance teams where developer, data analysis, testers can collaborate and interact each other. Handscomb, Mahadevan, Schor in a McKinsey research (2020), shows that agile companies have outperformed others in adapting to COVID-19. Agile organizations must change their processes, decentralizing their technology and delegating to the business unit different operations. For this reason, human capital represents a key component to develop a good agile strategy. In addition to be align with firm proposition they must have the competences and the capabilities to decide what to do in every situation adapting themselves to the different circumstances. In addition, we already seen as one of the main challenges of data analytics and AI the difficulties on finding high skilled employees. The pandemic could change these conditions permitting to the firms to find and hire very talented workers in the market which lost their jobs. Hiring in a period when other firms don't do it, can give the possibility for the firm to acquire a strategical advantage among the competitors with the possibility to significantly increase the human resources' level.

For instance, McKinsey & Company survey (2021) show that top performers are more likely to fill the talent gaps through hiring.

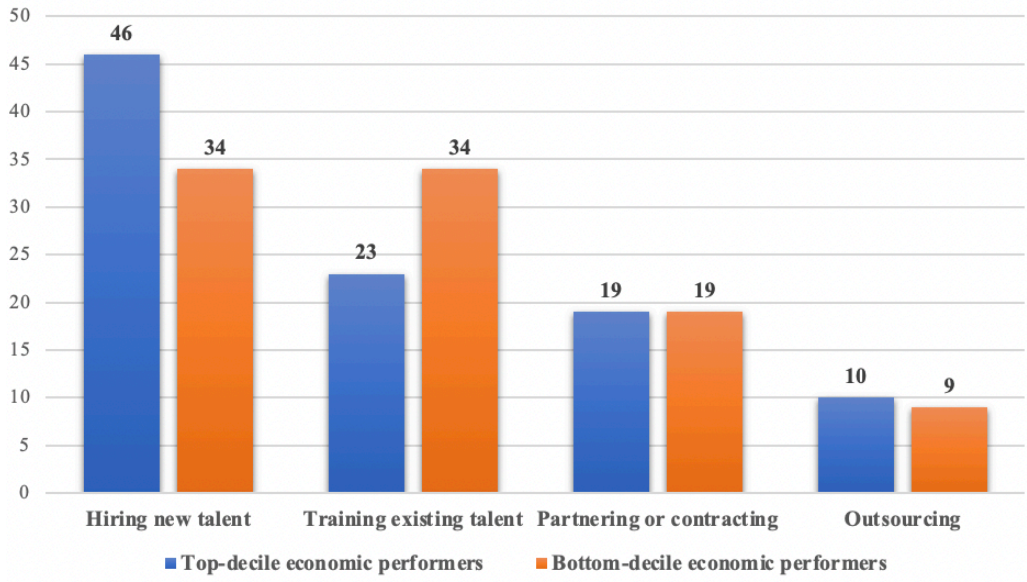

Figure 4.4 Human resources management: different approaches. SOURCE: McKinsey Digital, The new digital edge: Rethinking strategy for the postpandemic era. (2021)

The acquisition of new talented human resources is crucial for companies to cover the talent gaps in technology. This process of hiring must be done among all the chain, starting from the board to the frontline. Better managed firms may have also been able to capitalize easily on the range of policy support measures available. In addition (Lamorgese et al, 2021), show that better managed firms in Italy have a lower decline in expected sales during the pandemic period. This fact could be related to the board ability to support its employees enhancing them even during the teleworking period. These methods could increase the loyalty of the employees raising their firm's awareness. In this way it will be possible to delegate some decision to the frontline employees, making sure that they will decide basing on company's interests. In an agile strategy, it is important be not only to acquire new talent people, but also to train and develop the capabilities of your actual employees. They must be ready for any possible change in the market, moving them to a more agile way of working. The agile transformation indeed, it's a good moment to learn different jobs and new skills. Capabilities could be built through journeys, combining more theorical lessons with real world application cases. Training your employees on analytics could also help them to understand the importance and the potential of the analytics and of the AI. The McKinsey & Company survey (2021) show that top companies are more likely to invest in training to develop the potential talent through new digital training methods. These types of training include virtual learning opportunities, on site courses and the possibility to have on the job training returning to the office. In particular, more digitalized and highly potential incumbent firms have the possibility to respond quicker to the pandemic crisis and acquire the best human resources in the market. From this point of view the possible

reallocation due to the COVID-19 pandemic could give a benefit for the total productivity level but much remains to be learned and it is associated with several concerns. What happened for sure is the fact that the pandemic crisis has accelerated the automation. For this reason, the low skilled and low wages workers were impacted much harder with a "substitute" effect. Many jobs became obsolete thanks to the labor savings automation. At the same time even the next generation of workers could be harmed by the pandemic effects. Due to the COVID-19, many students lost the possibility to go to school and the introduction of the remote learning couldn't totally cover the problem, especially for students with low-income households. "These interruptions to learning and work will likely set back human capital accumulation—with such effects spread unevenly across generations, genders, and income levels, and with adverse implications for longer-run productivity" (Group of Twenty, June 2021).

4.2 Digital firms' reaction against COVID-19 pandemic: a qualitative analysis

4.2.1 Company selection and methodology

After a historical analysis that underlines the central role of Artificial Intelligence (AI) as the main character of the new Analytics era (Davenport, 2017), it could be interesting to analyze how firms that already used AI as a source of competitive advantage faced the pandemic threats. In particular, the main objective of the qualitative analysis is to understand if these firms were able to face quicker and more efficiently the pandemic threat and which advantages they were able to exploit through the use of AI.

To this aim, Paolo Inì's thesis (2019), "Artificial Intelligence in Italian manufacturing: growth potentials and criticalities" has been used as a starting point. In the final chapter, he interviews different firms that were already confident with the usage of AI, investigating main challenges and opportunities.

The analysis included three different Italian manufacturing companies:

- SPEA Spa: The company is located in Volpiano (TO) and was founded in 1975. It is the global leader in test equipment for electronics, semiconductors, MEMS, and sensor industries. These circuits are then used in different automotive, consumer, industrial, medical, and military sectors.

- BELLINI Spa: It is a firm placed in Zanica (BG) which started its history in 1943, and now it is managed by Stefano, Marco, and Andrea Bellini. They produce and sell industrial fluids, in particular lubricants for metalworking products.

- UNOX: The company is located in Cadoneghe (PD) and started its production in 1990. Nowadays, it produces high-quality personalized ovens, and in general, it provides services to all food cooking businesses.

Company	SPEA Spa	Bellini Spa	UNOX
Headquarter	Volpiano (TO)	Zanica (BG)	Cadoneghe (PD)
Sector	Production of automatic test equipment	Production and sale of industrial fluids	Production and sale of professional ovens
Number of employees	Over 900	56	Over 600
Target Market	Multinational, through company's branches	National	Multinational, through company's branches

Table 4.1 Companies selected for the qualitative analysis

The companies are selected from a *Champion companies'* sample, including 500 companies with a turnover between 20 and 120 million that in the darkest years of the crisis - between 2010 and 2016 - instead of going into trouble, have begun to grow to produce profits and jobs. This sample discovered that only five companies *(BELLINI Spa, UNOX, SEA Vision, SPEA Spa,* and *PROCEMSA Spa)* were familiar with and used AI in their production processes. Based on their availability, three of five companies (except *PROCEMSA Spa and SEA Vision*) were considered to take part in the qualitative analysis.

Firms were initially contacted via e-mail, introducing myself, asking for collaboration, and giving them a general explanation of the aim of my thesis.

Secondly, after positive feedback, we planned a remote interview (It was impossible to make it face-to-face due to the COVID-19 situation), asking them a series of prearranged questions.

Under the supervision of Professor Di Maria, I realized a selection of general questions to understand the actual level of AI of the companies and how they are facing the current COVID-

19 pandemic. However, questions remained only a guideline, and the main objective was giving freedom of speech to the respondents, trying to make them feel as comfortable as possible.

The key questions are the following ones:

- Briefly description of the activity of the company, its products, and its market segments.
- Briefly description about how there are actually use AI, how it works, and in which area of the company.
- Which results were reached through AI, and which are the main benefits that AI provides?
- How it was initially faced COVID-19 pandemic (first wave), and which role were played by AI and digital technologies to face the main challenges given from it.
- What key factors did the firm try to safeguard during the pandemic? (Ex. The maintenance of the production level, safeguard of client relationships, safeguard of supplies relationship)
- Which role do you predict AI could have in managing pandemic problems? Do you foresee to maintain these solutions even in a post-pandemic future?
- Being a digital firm, do you think it was much easier to adapt and carry on the productive activity even during the new pandemic situation?

4.2.2 Qualitative research

The aim of the qualitative research is to understand if companies which can be considered "already digital" were able to adapt quickly to the "new normal" environment. The COVID-19 pandemic has blocked many productive activities, especially at the beginning, when firms could not carry on their businesses and were forced to freeze or to adapt to new market conditions.

4.2.2.1 SPEA Spa

The qualitative analysis started with the interview with SPEA Spa with Mr. Tamburini (Financed Research Manager of R&D Department), considered one of the main experts about the company's digital technologies.

First of all, he made an incipit specifying how SPEA is not a company that directly used Artificial Intelligence in their production process. The primary role of SPEA is to test and develop circuits and components that their clients use to develop different types of cognitive technologies. SPEA plays a vital role in producing new digital technologies testing many products in every production phase, from the beginning, testing microchips and single components, to the end with the finished product. Therefore, even if SPEA does not directly use AI technologies, it plays a crucial role in developing technologies that are useful for their clients to develop AI technologies. For this reason, SPEA could undoubtedly be considered as a completely digital company, in which any process or test is digitalized.

SPEA does not test only components of "actual" machines, but it allows its client to test new components and verify their performance. Therefore, one main challenge is to adapt the tester to these new solutions, finding new ways and methods to test these innovative products efficiently. He explained how each device, system, or card must be tested, and the testing phase is an essential part of every digital product, from the silicon wafer to the final product. Each phase has a precise test, and SPEA is present in each of these.

Nowadays, SPEA counts more than 900 employees with some foreign branches with the scope to facilitate sales processes. However, the design, production, and planning phases are done in Volpiano (TO), where the company headquarters is set. Its customer portfolio is generally spread worldwide, especially in North America and Europe, counting global digital companies, like Apple.

Figure 4.5 SPEA testing process. SOURCE: https://www.spea.com/it/

Digital technologies are involved in every phase of the production process, and they are fundamental to produce in this market sector. Mr. Tamburini underlined how the market sector where SPEA operates has wide growth margins. It permits the firm to make high innovation jumps with a high-profit margin but avoids the possibility of focusing on specific process details that are generally increasingly relevant when the market sector becomes more mature and become crucial to make a little step against competitors.

COVID 19 did not stop the firm's productivity; on the contrary, its targeted market is increased during the pandemic phase. People have started asking for more digital devices, like tablets or personal computers, so the number of requests to test digital solutions has increased.

SPEA made extensive use of their digital solutions already owned inside the company to keep the productivity to high levels and to satisfy the increasing demand.

One of the main effects of the pandemic on the company is to increase even more the digitalization level. Mr. Tamburini explained it with an example "there is no paper anymore, in a few months the number of sheets in every desk is dropped, and digital signatures have substitutes paper ones."

In addition, COVID-19 allowed the firm to implement digital solutions already present and available by the company but were not used. SPEA is a family-run business, founded and managed by Luciano Bonaria. Despite the company's growth in the last thirty years, he continued to control many firm's processes directly, even if it became more challenging due to the increasing number of tasks and employees. COVID-19 pandemic has forced to digitalize many firm processes and decision meetings, permitting SPEA to overcome this managerial bottleneck.

About SPEA digital situation, Mr. Tamburini said, "What is clear is the fact that we were ready to use the digital solution inside the company. Maybe we were lazy and more familiar with a traditional model, but we had everything available and ready to be used when it was the moment."

SPEA agrees with the idea of have been capable to remain productive thanks to their actual digitalization level. The possibility of continuing to produce every day without any stop is strictly connected with their ability to adapt quickly and efficiently using the digital technologies already available inside the company. To describe company's vision in this particular moment, Mr. Tamburini cited the words of the company's chairmen, which explain that "the World is here, and it is always ready to acquire products. What is important is selling what the World wants to buy. So, where there are crises or problems, you do not have to be scared or resigned, but you have to be able to satisfy these needs and sell what the World wants to buy". From this point of view, digital technologies were crucial not only to do not stop the production process but even to increase their production levels.
Even if SPEA was prepared to face the pandemic initially, it has empowered its systems, and now it could be able even to address a more critical situation.

The crucial aspect that SPEA decided to safeguard during the pandemic was jobs security. The company decided to not lay off any employees. While many companies used social safety nets to lay off some of their workers, they decided to carry on the activity, not using this opportunity. The management decided to give a signal to all SPEA's employees to keep morale up. On the contrary, the company has decided to hire and increase its organic.

From customs and suppliers' point of view, no particular action was needed. The only aspect that was important for SPEA's suppliers (which are little firm that operate in the area) was SPEA's decision to continue their productive activity without any stops, permitting them to continue their businesses.

The increasing level of the demand was only a positive factor, and it did not represent a problem at all for SPEA. The company covered all test requests arriving worldwide without any delay, even during the most critical periods.

Mr. Tamburini is sure that these innovations and implementations in digital technologies will remain even in a post-pandemic future. Employees were forced to change from a traditional method and cannot be lazy anymore. This new "more digital" method gives the company more opportunities and possibilities and it will be used even in the post-COVID-19. On the other side, Mr. Tamburini underlined how some aspects will be done like in the pre-pandemic era to "enjoy the taste of things like were done before," starting to travel worldwide to your customers again, to organize in the presence meetings, and carry on the different projects.

4.2.2.2 Bellini Spa

The interview regarding Bellini Spa was done with Mr. Andrea Locatelli, who could be considered one of the company's foremost experts in Artificial Intelligence implementation. Bellini studies, develops, produces, and markets fluids to support industrial processes; in particular, it is specialized in lubricants.

The company is set in Zanica (BG), where all the production phases are developed using an internal lab owned and managed by the firm itself. The company is an SME, and nowadays it counts 56 employees, everyone specialized on different tasks and with different responsibilities.

Figure 4.6 Bellini's R&D Department. SOURCE: https://www.bellini-lubrificanti.it/ricerca-sviluppo/

Bellini Spa could be considered an actual digital firm. For instance, the company own an extensive database with data collection in 2016. At the end of 2019, the company considered this database to understand data analysis possibilities and potential. They introduced a Business Intelligence software, Power BI, which can analyze software by replacing managers on more standardized tasks. In this way, managers are relieved from extended excel analysis, and they have only to make supervisory work.

In addition, from a system production level, IoT helps the company collect any data that previously were not considered, permitting the firm to take action in specific situations.

From the AI perspective, Bellini Spa will introduce text analytics, which will analyze and interpret different digital documents finding the information needed by the firm even if it is written with different layouts and types. However, this solution is not ready yet. The significant difficulties about the firm's embrace of AI technologies are similar to those that already emerged in Paolo Inì's thesis. In particular:

- Firstly, AI technologies still have significant costs; Mr. Locatelli said that "we will have to wait some years still" before the AI can support the company at a sustainable cost.
- Secondly, it is not easy for the company to find personnel with the skills necessary to manage these technologies. There are not enough experts who are able to carry on AI projects yet.

The pandemic was considered a boost for digitalization. The company had already started a digitalization process before COVID-19, but it was mainly focused on the production and logistic departments. Other projects were under development (like the dematerialization of paper), but there was no practical decision to carry them on. This lack of decision was principally due to two reasons:

- Bellini Spa sells oil and lubricants, so it was not the primary necessity. (It was more important to produce more pounds in less time than process paper)
- The company has a forty-year history. So, the older employees were not too many confident with the use of digital technologies.

During the pandemic outbreak became necessary to bring the older employees closer to the digital and informatic world through internal courses organized by the company. Bellini Spa has had the good fortune of hiring young people in the last seven years. It permitted the company to close relatively quickly the digital gap. Indeed, the newly hired employees learned the job from the older ones and successfully explained how to exploit the fully digital instruments' potential. It became a giving and receiving mechanism, making the collaboration even more fruitful.
The company created customized satellite software networks that could interact with each other. The company created document management software, analysis management software, production scheduler, and logistic scheduler, producing and actively participating in the software production.

In the beginning, Bellini Spa employees rejected the digital change; they were afraid of not being able to use them efficiently, be replaced in the next future, or to see their job wholly transformed.
The company established internal tutors and sponsors to convince these employees. The creation of these new networks helped the firm, especially during the second COVID-19 wave, to have a more efficient smart working, which became crucial to maintaining the offices' productivity.
During the first pandemic waves, the company faced significant problems.

- The major problem was the short timing from the COVID-19 outbreak to the lockdown. The company was not ready yet to work in intelligent conditions. This low level of time prevents the company from organizing more efficiently.
- The second challenge was about the hardware topic. Not all the employees owned a laptop or digital devices that could support them in the company's tasks.
- The third problem was about “digital illiterate” workers. The issues became even bigger to the need to train them in remote conditions. At this scope, the company selected three digitally skilled employees to assist the other employees, making them able to work.
- Another challenge was related to the difficulties of organizing meetings in person, which were necessary in some cases. (Difficulties in establishing the date, be warned on not overcrowding the company, working in a closed-door situation to avoid the spread of the virus).

- The last difficulty was a more technical one. The company has not a good broadband coverage, and they still do not have optical fiber.

Despite these problems, the company was able to continue its productive activity (the company was included in the Ateco codes as an "essential firm" that allowed to this continue to produce), but the rest of the world was "frozen." This fact did not prevent Bellini Spa from continuing to carry on its activities even if there was a forty percent reduction of the production level during these four months.

During the second wave, the only problem was to relate efficiently with other companies. The world was not frozen anymore, so even if Bellini Spa improved its "internal" connection, the major challenge was maintaining a continuous speech among the company and the external stakeholders. However, the activities are going on nowadays, and the situation is getting better and better.

Mr. Locatelli explained how, in his opinion, Bellini Spa's success is also due to its high digital level. This feature helped the company even before the COVID-19 pandemic, and every improvement (disruptive or incremental) was digital. "In the ninety percent of the case, when there is an issue that must be solved, we intervene in the digital process." The significant benefit of having increased the digital level of the company is the possibility to "use" people on more personalized and challenging tasks, reducing the time they spend on the more standardized ones. Moving before competitors on the digital solution was always a crucial advantage. COVID-19 pandemic has only increased the possible advantage to be already ahead from the digital point of view.

All the new digital solutions developed by the company will remain functional even in a post-pandemic future. Anything will through away, and COVID-19 boosted the engagement of such solutions that the company already planned before the pandemic.

The only factor that will come to the previous stage is the physical return to work. The firm is an SME, which makes all the production processes of its product internally, so it needs its employees in the building to be more flexible and coordinate, constantly sharing problems and solutions.

During the pandemic spread, the essential thing that the company tried to safeguard was its employees' "psychological" aspect. The management tries to reassure the employees by establishing company policy to guarantee their security and permit them to remain focused on

their work. The company produced a web called "all people meetings" with all the operators and Marco Bellini (owner of the company), which shared the company's information and what could happen in the following months. "There was a "we stick together" mentality to keep the firm afloat."

During the first wave, the company used social safety nets using redundancy funds, but only during the period when the production was reduced by forty percent. After these critical four months, the company started to grow again. It summed up again the employees who were lay-off, and on the contrary, it hired six or seven new employees at permanent contract in the subsequent months.

4.2.2.3 UNOX

The qualitative analysis about UNOX has been done through an interview with Mr. Mario Cammarota –Research Manager of the company – which has a relevant role in AI implementation.

The company is set in Cadoneghe (PD), and it counts more than 600 employees, of which around 200 are in Italy, where the company is focused on the Operation and Innovation areas.

The company produces professional ovens, which other companies in their production process use. Every company which sells cooked food can potentially be a UNOX client to large chains like McDonald's, Subway, or supermarkets through more minor activities like canteens, hotels, and gourmet restaurants. From the geographical point of view, UNOX sells its products worldwide (ninety percent of its turnover is made abroad), especially in Europe, the United States, and Asia.

UNOX makes "smart ovens" that already have well-developed digital content. This fact is fundamental to producing top-performance ovens. UNOX sells professional ovens with different needs, from the performance and reliability aspects. UNOX ovens can work 24 a day, and it must last years, especially with customers who work with many different machines, like supermarket chains; it is essential to give him a top-level machines, which also provides the possibility to get access to their performance data.

Figure 4.7 UNOX production process. SOURCE: https://www.unox.com/it_it/

UNOX has already used Artificial Intelligence for many years, especially in the Research area and IT area. Mr. Cammarota highlighted two main benefits which UNOX obtained using AI technologies and that he saw during his works every day:

- Firstly, the significant benefit concerning the quality of its products. The AI use permitted the company to improve the level of its products, which became more performing and gave a higher value to the customers.
- The second one is about the production process perspective. The possibility of structuring the production process based on the internal AI developed, helped the company made the process flow in the best possible way to achieve a higher production quality, without any re-elaboration.

The company moved quickly to hire high skill digital employees, trained them, and developed their competence even more. "In a technical department of seventy or eighty employees, twenty of them are working on the software area, both from the backhand and front hand side and even from the technological development point of view, implementing Artificial Intelligence solutions like mass envision and voice control." Mr. Cammarota did not find any problem anymore about implementing and using AI technologies inside the company, neither from the human capital perspective (UNOX hired many born-digital employees) nor from the cost

perspective (he described the AI as a commodity, thanks to the accessibilities to AI libraries of big companies, like Google and Microsoft).

During the COVID-19, UNOX was able to minimize the closing time of the firm. People who cannot worked in the lockdown period have been lay off, while the other employees have continued to work, especially software employees which were capable of working in these "new" conditions and developing new software.

The closing time was minimized from the productivity point of view, but the productivity level was reduced only to satisfy core activities that remained open in every pandemic phase, like supermarkets or hospitals.

In any case, the production slowdown decreased the turnover level of the company in 2020, even if it remains positive and equal to four percentage points higher than in 2019. The companies returned to high production in 2021 with the terms of turnover that increase by thirty percent than in the previous year. From this aspect, UNOX was able to limit the damages well, avoiding losses, and carried on a process of continuous growth.

According to Mr. Cammarota, one of the main reasons UNOX's ability to limit the pandemic damages was having "sown well" before the pandemic. In addition, UNOX has a commercial property based on subsidiaries spread around the world, which helped the company be available for their customers to avoid travels that were impossible during the COVID lockdown.

UNOX was "ready" to face the COVID 19 problems. The high literacy digitalization level permitted the company to adapt to use quickly new solutions, like Microsoft Teams, which were crucial to organize online meetings. Moreover, making innovative goods with high digital content helped the company sold products easily. On the other side, the absence of customers, which were forced to block their product system during the lockdown, obviously directly affects UNOX too, which was forced to slow down.

UNOX did not use training courses for its employees. The company started working in new conditions immediately before it became legally necessary. The company already had all the instruments to manage smart working from the IT perspective. “We were ready, and we did not need to make formation courses, the average age is very young in the company, and we are almost everyone born-digital.”

UNOX wants to maintain the “structural” digital solutions implemented during the pandemic. Many practices are becoming part of the company, and they will continue to be used even in a post-pandemic scenario. The company will continue to use smart working in some

circumstances, avoiding unnecessary travels and organizing meetings with people worldwide. Unlike other companies, Mr. Cammarota explained that UNOX will not go back from smart working. On the contrary, it will be consolidated and improved, becoming a daily solution even more.

The company did not take any different solutions during the pandemic. They were ready from the beginning so that they could adapt both in the first period and in the next one. “There have been no “milestones” that were implemented during the pandemic. The instruments were already present in January 2020, and we became capable of using them better and better, in a gradual process to adapt more and more to utilize specific instruments improving every day.”

During the pandemic breakthrough, there were many aspects that the company tried to safeguard, from keeping the relationship with customers and suppliers, to reassure its employees about their health security.

From the management side, the company tried to be focused on all these details. The most important thing was to give the employees a sense of security. They were divided into different rooms; the company got herself facemasks that were difficult to find, provided temperature gauges and installed hand sanitizing gel spots. Everything concerning employee health safety has been implemented effectively and efficiently. In addition, UNOX employees were constantly informed about the evolution of the pandemic situation, giving an interpretation of the possible future scenarios. The company organized daily meetings, shared information, and advised them about every possible change.

Another important aspect has been to reassure UNOX customers, especially those the company could continue to produce, like supermarkets or hospitals.

Equally relevant was the ability to keep the factor open, carrying on, even in the darkest periods, R&D activities, which were also improved in the lockdown period.

4.1.3 Comparative Analysis Based on Davenport and VUCA model

After the case-by-case analysis of the various methods that each firm adopted in facing COVID-19, it is possible to compare the result of each interview to identify the common aspects and the different ones.

Every firm operates in a different sector, which was crucial to explain their different reactions during the COVID-19 outbreak. Even though every firm had to face different challenges and opportunities, some significant common characteristics united them.

First of all, it could be helpful to identify the similar elements that emerged from every interview:

- Every firm was considered an “already digital” company. Everyone already possessed internal “technological” capabilities and exploited them to achieve a competitive advantage in its sector. In addition, every firm empowered its technological level during the COVID-19 pandemic as the primary resource to face the pandemic crisis.

- Each firm continued to produce even during the lockdown period (the most critical one). The digitalization level of these firms helped them to surpass their internal challenges. SPEA could increase its level of productivity and timely satisfy the demand’s increasing level. Bellini Spa and UNOX did not close a day too. Their level of productivity was forcibly, directly or indirectly, reduced due to State restrictions, but they continued their productive activity without interruptions.

- All the firm sees their technological level as the primary source to carry on their activity without interruptions. This permits each of them to be ready-made and to adapt quickly to a new dynamic that requires technological knowledge and skills.

- One of the major problems that every firm tried to face during the initial phase of the pandemic was to safeguard its employees' health safety. This action did not concern only the physical one but also the psychological one. Each company organized daily meetings, giving employees information about what could happen in the following months and the possible firm strategy to face the difficulties.

- All the firms did not fire any employee during the pandemic. Bellini Spa and UNOX used social safety nets using redundancy funds in the most critical moment, but in the end, they were reinstated. In addition, both SPEA and Bellini Spa increased their organic, by hiring new workers.

- Every company agrees that almost any new digital solution implemented will remain functional even in the post-pandemic era.

In short, what emerges from these companies' common factors is the focus on the "preservation" of their internal resources. Being digitalized helped them to continue their operations without too many problems. This permitted them to focus on other issues, like employee's health status, also considering the psychological side. In addition, the possibility of maintaining a good production level helped them not only to safeguard jobs of existing workers (no one was fired) but also to hire new ones with new competencies in order to improve competitiveness even during the pandemic periods.

The qualitative analysis has highlighted not only common points but also significant differences among firms' structures and their consequent strategies in facing the COVID-19 pandemic.

- First of all, these three companies operate in different market sectors. This aspect was crucial, especially in the first period, when only some specific companies were authorized to produce. All the firms were available to continue to operate but at different speeds. SPEA (which operates in the digital technology's tester sector) continued to produce, and it had paradoxically to satisfy higher demand. On the contrary, Bellini Spa (which operates in the oils and lubricants sector) and UNOX (which operates in the professional ovens sector) were "legally" forced to reduce their production.

- Secondly, not each firm had to put the same effort to upgrade its digitalization level. Bellini Spa had significant problems in the first period, and it became necessary to develop new important digital solutions. SPEA already owned the internal competencies inside the firm, but it was not necessary to use them and change the traditional approach until the COVID outbreak. UNOX was ready, and it did not implement any new digital solutions because it already had all the instruments to manage smart working.

- Thirdly, workers' "digital knowledge" was not uniform among these firm prior to the pandemic. UNOX presents a young workforce where almost everyone is born-digital. This helped the company to easily accept the adoption of digital methods, fully exploiting the benefits of digital instruments. On the contrary, Bellini trained its old employees that initially rejected the digital changes. For this reason, the company named an internal tutor to make people understand the advantages of these solutions.

- Lastly, there was an essential difference in the firm's approach to smart working. SPEA and Bellini used it only as a temporary solution, and it took some time before this

method became fully efficient. When the State reduced the level of restrictions, both firms ceased to use smart working. On the contrary, UNOX decided to prolong it even when conditions permitted a return to the office. UNOX will maintain this method even in the post-COVID-19, adopting a hybrid solution.

The various strategies employed by each firm to face the pandemic required different levels of investments and produced different results. In addition, working in different sectors, each company faced different challenges and conditions. UNOX was "more ready" to face this new dynamic environment, and the presence of a high level of internal digital knowledge was probably the main reason they decided to later carry on the smart working. SPEA had the major advantages from the COVID-19 outbreak, and it was able to adopt smart working and digital solutions quickly. However, the management decided to ask employees to come back to the office in Volpiano as soon as possible, in order not to lose the experiential advantages and positive synergies given by working in presence. Bellini Spa implemented the most relevant digital innovations over that period, investing both in new disruptive and incremental innovations, and in training its employees to spread the digital knowledge even among less confident ones.

Company	SPEA Spa	Bellini Spa	UNOX
Key challenges	• Safeguarding employees' security • Satisfying the increasing level of the demand	• Safeguarding employees' security and psychological aspects • Increasing firm digitalization to remain productive	• Safeguarding employees' security • Safeguarding firm's production as much as possible
Solutions implemented	• Organization of daily meetings and temporary use of smart working. • Recruitment of new skilled employees	• Organization of "all people meetings" • Creation of customize software networks that could interact with each other	• Organization of daily meetings and permanent use of smart working • Use of internal digital technologies already present in the firm
Main achievements	Productivity raised and the company was able to satisfy the high demand, taking full advantage from the favourable circumstances.	Successful implementation of new customize software networks, increasing firm's digitalization and overcoming employees initial doubts	The company was able to limit the damages well, avoiding losses and carry on a process of continuous growth.
Main Issues	There were no significant problems, indeed the sector in which the company operates has even benefited from the pandemic situation	The firm faced difficulties on adapting its employees to the new normal and on working in totally online conditions.	The firm had no evident issue during the pandemic, having "sown well" before the Covid-19 outbreak

Table 4.2 How target companies faced the pandemic: key aspects and solutions

At this point, it is possible to apply Davenport's model concerning the different analytical eras (2017) to the cases just examined, in order to understand more precisely what the level of digitization of each company is and whether it has represented a key variable to effectively face an environment with particularly marked VUCA conditions.

SPEA, despite having a high technological knowledge and an extremely digitized environment, has not yet implemented artificial intelligence solutions. The company can be placed in roughly the third analytical era of Davenport's model, managing to effectively use different types of data and develop new test models to conduct evaluations efficiently. The pandemic effect was lower than in the other cases, also because the sector in which the company operates has even benefited from it. In addition, the good level of digitalization, the ability to organize through daily meetings and the high flexibility in developing new test models for innovative products enabled SPEA to adapt quickly to the new situation and to take full advantage of the favorable circumstances.

Unlike SPEA, both Bellini Spa and UNOX have been directly affected by the effects of COVID, given the sector in which they operate; however, their level of digital readiness and the difficulties encountered were different.

Using the Davenport Model (2017), we can see how Bellini Spa is in a transition phase between the analytical era 3.0 and that 4.0. The company already uses a database of data collected since 2016 to analyze and study results and possible alternative solutions. The company also plans to introduce artificial intelligence solutions, such as a text analyzer, in order to prevent its employees from spending time performing standardized tasks and have them focus more on performing high-value-added operations. However, such tools have not yet been implemented due to high costs and a lack of qualified personnel. The company found it more difficult to deal with such an extreme VUCA environment, especially in the first period, where a strong phase of innovation and implementation of new digital tools was necessary. Their subsequent introduction, however, has allowed them to face the consequences of the subsequent pandemic phases more efficiently, and probably by now the company is ready to take the last step towards the Analytical 4.0 era.

UNOX is the company among those of the sample that has most developed artificial intelligence solutions, which they even describe as a commodity. The ability to move in advance has allowed the company's human capital to develop a strong knowledge of digital solutions. Based on the Davenport model (2017) the company is already fully in the 4.0 analytical era. Artificial

intelligence is used both in the research area and in the IT area and is the same product that is defined as "intelligent", able to directly collect data about its performance and identify any operating problems. When the company faced an extreme VUCA environment, it did not encounter any major problems. The tools to deal with the pandemic crisis were already present and the company began to operate with remote working even before it became legally mandatory.

To sum up, from the comparative analysis we can identify a sort of correlation between the level of digitization, measured through the analytical eras of the Davenport model (2017), and the efficiency in the response to VUCA conditions: the company that had the highest level of digitization had to manage fewer criticalities.

To conclude, what emerged from the qualitative analysis is that being already digital before the pandemic brought many advantages to these companies. Each of them considered this as the crucial aspect that enabled them to adapt quickly to a different environment without shutting down production. Even if they operate in different sectors, this created a competitive gap between them and their competitors. Preparing themselves before the crisis permitted them to climb from the middle of the mountain and not from the bottom. However, being a digital firm did not eliminate all pandemic issues. Firms were unable to foresee such a critical event, and it took some time to organize the productive activity. In any case, each company has expressed its decision to continue to follow the “digital way.” Everyone showed their intention to continually improve from a technological point of view, maintaining a leading role in their sectors in a world where digitalization is becoming more and more a crucial resource.

CONCLUSION

Nowadays, firms must be dynamic and flexible. In some critical circumstances, they even need to produce with a just-in-time method. To this aim, a traditional strategic positioning method could not be so effective anymore. Some firms may invest a considerable amount of time analyzing the actual environment and making scenario analysis to decide when and how to enter in a new market segment. However, the high environmental volatility risks to completely change the market conditions in a very short time.

Instead, firms need to be agile, supporting the traditional methods with digital instruments, to automatize the repetitive tasks of productive processes. The development of Decision Support Systems over the last fifty years has helped firms in making decisions, by facilitating internal communications or accelerating some productive processes. However, nowadays, even more sophisticated solutions are needed.

Indeed, we currently live in a VUCA environment, and the COVID-19 pandemic has been just one of many factors that strengthened VUCA conditions. Despite this, COVID-19 has been largely the most powerful one because it not only affected the external environment, making such conditions even more unstable, but also had a direct effect on companies. Many of them were forced to block their productive activity, and in 2020 more than 70'000 Italian firms left the market. (Banca d'Italia, Relazione annuale sul 2020)

In this context, an increasing necessity of big data analytics and artificial intelligence solutions implementation emerged, setting the stage for the development of new innovative strategies, like open innovation. Today, this kind of solution is becoming very popular: in 2021, 81 percent of big Italian companies declared to have used an open innovation method. (Politecnico di Milano, 2021)

In so doing, such firms try to boost their digitalization level, which has indeed become not just an opportunity, but also an evident necessity. The pandemic has furtherly increased the productivity gap between digital and non-digital firms. The qualitative analysis conducted in this thesis has highlighted how "already digital" firms could exploit and reinforce their existing digital knowledge, which has been a key element to keep up during the pandemic.

Possible future studies could employ a quantitative analysis of digital firms' reaction to COVID-19, reinforcing the present results. On the other side, it could be interesting to analyze both already-digital firms and non-digital ones to make a direct comparison, considering the different solutions implemented by each category.

REFERENCES

ALISON KRUMM, 2017 Cortell Intelligent Business Solutions, Comments Off on predictive analytics big data warehousing meetup-5-638. Available on < http://www.cortell.co.za/real-life-fopm-organisational-outlook/predictive-analytics-big-data-warehousing-meetup-5-638/>

ALTER, S. 1977, *"A Taxonomy of Decision Support Systems," Sloan Management Review Vol. 19, Fasc. 1,* Available on <https://www.proquest.com/openview/a0802c3359352285b4a9d3ea056df90b/1?pqorigsite=gscholar&cbl=35193>

ALTER, S.L. 1980, *Decision Support Systems: Current Practice and Continuing Challenge Reading, version 2.8*. Available on < http://dssresources.com/history/dsshistoryv28.html>

ANDREW J. HOFFMAN, 2000, Competitive Environmental Strategy: A Guide to The Changing Business Landscape. Available on: <https://books.google.it/books?hl=it&lr=&id=6gxwmh6JTIsC&oi=fnd&pg=PP15&dq=ANDREW+J.+HOFFMAN,+2000,+Competitive+Environmental+Strategy:+A+Guide+to+The+Changing+Business+Landscape.&ots=ruKD-f3Kxp&sig=6V9a-9zUJhYjyweKoY0fMGmV6pc#v=onepage&q=ANDREW%20J.%20HOFFMAN%2C%202000%2C%20Competitive%20Environmental%20Strategy%3A%20A%20Guide%20to%20The%20Changing%20Business%20Landscape.&f=false>

ANDREA LAMORGESE, ANDREA LINARELLO, MEGHA PATNAIK, FABIANO SCHIVARDI, March 2021, Management practices and resilience to shocks: Evidence from COVID-19. Available on < https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3816875>

ANJAR PRIYONO, ABDUL MOIN AND VERA NUR AINI OKTAVIANI PUTRI, Oct 2020. Identifying Digital Transformation Paths in the Business Model of SMEs during the COVID-19 Pandemic, *J. Open Innov. Technol. Mark. Complex. 2020, 6, 104*. Available on < https://www.mdpi.com/2199-8531/6/4/104>

ASARE, A. O., ADDO, P. C., SARPONG, E. O., & KOTEI, D. 2020, COVID-19: Optimizing Business Performance through Agile Business Intel- ligence and Data Analytics. *Open Journal of Business and Management, 8, 2071-2080.* Available on < https://www.scirp.org/journal/paperinformation.aspx?paperid=102660>

ASEFEH ASEMI, ALI SAFARI, ADELEH ASEMI ZAVAREH, 2011, The Role of Management Information System (MIS) and Decision Support System (DSS) for Manager's Decision Making Process. *International Journal of Business and Management Vol. 6, No. 7* Available on < https://www.ccsenet.org/journal/index.php/ijbm/article/view/8940>

AURA CODREANU, 2016, A VUCA Action Framework for A VUCA Environment. Leadership Challenges and Solutions, *Journal of Defense Resources Management, Vol. 7, Issue 2, 31-38*. Available on
< http://www.jodrm.eu/issues/volume7_issue2/03_codreanu_vol7_issue2.pdf>

BANCA D'ITALIA, 2021, Relazione annuale sul 2020 in sintesi. Available on < https://www.bancaditalia.it/pubblicazioni/relazione-annuale/2020/sintesi/index.html >

BELLINI SPA < https://www.bellini-lubrificanti.it/ricerca-sviluppo/ >

BUSH, V. 1945, "As We May Think", *The Atlantic Monthly Vol 1 pp. 1-13*. Available on < http://org.noemalab.eu/sections/stuff/download/as_we_may_think.pdf>

BOB JOHANSEN, 2007, Get There Early, Berrett-Koehler Publishers. *World Business Academy Volume 21, Issue 6* Available on < https://worldbusiness.org/wp-content/uploads/2013/07/vp082207-1.pdf>

BONCZEK, R. H., C.W. HOLSAPPLE, AND A.B. WHINSTON. 1981, Foundations of Decision Support Systems. *1st Edition,* Available on < https://www.elsevier.com/books/foundations-of-decision-support-systems/bonczek/978-0-12-113050-3 >

CARLA C. J. M. MILLAR, OLAF GROTH, AND JOHN F. MAHON, 2018, , Management Innovation in a VUCA World: Challenges and Recommendations, *California Review Management 61(1):5-14*. Available on < https://journals.sagepub.com/doi/abs/10.1177/0008125618805111>

CHRISTOPHER HANDSCOMB, DEEPAK MAHADEVAN, LARS SCHOR. June 25, 2020, An operating model for the next normal: Lessons from agile organizations in the crisis, *McKinsey&Company*. Available on < https://www.mckinsey.com/business-functions/people-and-organizational-performance/our-insights/an-operating-model-for-the-next-normal-lessons-from-agile-organizations-in-the-crisis>

D. J. POWER, 2021, A Brief History of Decision Support Systems*, DSSResources.COM, version 4.0*. Available on < https://dssresources.com/history/dsshistory.html>

DAN ANDREWS, ANDREW CHARLTON, ANGUS MOORE, 2021, COVID-19, productivity, and reallocation: Timely evidence from three OECD countries, *OECD Economics Department Working Papers No. 1676*. Available on <https://www.oecd-ilibrary.org/economics/covid-19-productivity-and-reallocation-timely-evidence-from-three-oecd-countries_d2c4b89c-en>

DANIEL J. POWER, 2002, Decision Support Systems: Concepts and Resources for Managers *Faculty Book Gallery. 67.* Available on <https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1066&context=facbook>

DANIEL POWER, 2008, Understanding data-driven decision support systems, *Information Systems Management Volume 25, - Issue 2*. Available on < https://www.tandfonline.com/doi/abs/10.1080/10580530801941124>

DAVE ULRICH AND DALE LAKE, 1991, Organizational capability: creating competitive advantage, *Academy of Management Perspectives, Vol. 5, No. 1*. Available on <https://journals.aom.org/doi/10.5465/ame.1991.4274728>

DAVIS, G. 2000, Information Systems: Conceptual Foundations, Structure, : Looking Backward and Forward.. *The International Federation for Information Processing, vol 41 pp 61-82. Springer, Boston.* Available on < https://doi.org/10.1007/978-0-387-35505-4_5 >

DENISI, A. S., & KLUGER, A. N. 2000. Feedback effectiveness: Can 360-degreee appraisals be improved? *The Academy of Management Executive Vol. 14, No. 1, pp 129-139*. Available on <https://www.jstor.org/stable/4165614>

DESANCTIS, G. AND R. B. GALLUPE. 1987, "A Foundation for the Study of Group Decision Support Systems," *Management Science. Volume 33, Issue 5 May 1987 Pages 547-686* Available on < https://pubsonline.informs.org/doi/abs/10.1287/mnsc.33.5.589>

DHAR, V., & STEIN, R. 1997, Intelligent Decision Support Methods: The Science of Knowledge Work. *Upper Saddle River, NJ: Prentice Hall*. Available on < https://dl.acm.org/doi/book/10.5555/249195 >

DONOVAN, J.J. AND S.E. MADNICK. 1977, "Institutional and Ad Hoc DSS and Their Effective Use", *ACM SIGMIS Database: the DATABASE for Advances in Information Systems Volume 8 Issue 3 pp 79–88*.
Available on <https://dl.acm.org/doi/abs/10.1145/1017583.1017599>

E. BRYNJOLFSSON, A MCAFEE, 2014, The second machine age Work, progress, and prosperity in a time of brilliant technologies. *W W Norton & Co.* Available on < https://psycnet.apa.org/record/2014-07087-000 >

ELENA G. POPKOVA, YULIA V. RAGULINA, ALEKSEI V. BOGOVIZ, 2019, Industry 4.0: Industrial Revolution of the 21st Century *Studies in Systems, Decision and Control, Vol 169*. Available on < https://static.s123-cdn-static-c.com/uploads/1259807/normal_5e88204229a10.pdf>

ENGELBART, D.C. 1962, "Augmenting Human Intellect: A Conceptual Framework, Air Force Office of Scientific Research, *Vol 49, pp (638)-1024 SRI Project No. 3578.* Available on < https://apps.dtic.mil/sti/pdfs/AD0289565.pdf>

ERIK BRYNJOLFSSON, ANDREW MCAFEE AND MICHAEL SPENCE, 2014, New World Order: Labor, Capital, and Ideas in the Power Law Economy, *COUNCIL ON FOREIGN RELATIONS, PUBLISHER OF FOREIGN AFFAIRS.* Available on < https://www.philadelphiafed.org/-/media/frbp/assets/events/2015/the-economy/2015-philadelphia-fed-policy-forum/brynjolfsson-new-world-order.pdf>

FERGUSON, R. L. AND C. H. JONES, 1969, "A Computer Aided Decision System," *Management Science Vol 15, No 10, pp. 461-583*. Available on < https://pubsonline.informs.org/doi/abs/10.1287/mnsc.15.10.b550>

G. BHARADWAJA KUMAR, March 2015, An Encyclopedic Overview of 'Big Data' Analytics, *International Journal of Applied Engineering Research. Volume 10, Number 3, pp. 5681-5705* Available on <https://www.researchgate.net/profile/Vijayabharadwaj-Guntur/publication/280721972_An_Encyclopedic_Overview_of_'Big_Data'_Analytics/links/55c2d0ae08aea2d9bdbff28d/An-Encyclopedic-Overview-of-Big-Data-Analytics.pdf >

GANTZ J, REINSEL D. 2011, Extracting value from chaos. *IDC review*. Available on < http://www.kushima.org/wp-content/uploads/2013/05/DigitalUniverse2011.pdf>

GEORGE MARTIN, NZIVE KASYOKA, October 2011, The Use of Strategic Positioning to Achieve Sustainable Competitive Advantage at Safaricom Limited. Available on < http://erepository.uonbi.ac.ke/bitstream/handle/11295/5819/Kasyoka_The%20use%20of%20strategic%20positioning%20to%20achieve%20sustainable%20competitive%20advantage%20at%20Safaricom%20Limited.pdf?sequence=1 >

GERRITY, T. P. 1971, Jr., Design of Man-Machine Decision Systems: An Application to Portfolio *Management. Sloan Management Review Vol. 12, Fasc. 2, 59*. Available on < https://www.proquest.com/openview/743aedcf997c602cb503229a9f3bef3a/1?pq-origsite=gscholar&cbl=35193 >

GERRY JOHNSON; KEVAN SCHOLES; RICHARD WHITTINGTON, 2009, Fundamentals of Strategy.

GERSHENFELD, N., & VASSEUR, J.P. 2014, As Objects Go Online: The Promise (And Pitfalls) of the Internet of Things, *Foreign Affairs*. Available on < https://www.foreignaffairs.com/articles/2014-02-12/objects-go-online >

GORRY, A. AND M.S. SCOTT-MORTON, 1971, A Framework for Information Systems, *Sloan Management Review 510-71*. Available on <https://dspace.mit.edu/bitstream/handle/1721.1/47936/frameworkformana00gorr.pdf >

GROUP OF TWENTY, June 2021, Boosting Productivity in The Aftermath of Covid-19. Available on < https://www.imf.org/external/np/g20/pdf/2021/061021.pdf >

GRUNDY TONY, 2006, Rethinking and reinventing Michael Porter's five forces model, *Strategic Change Vol. 15 (5) pp.213-229*. Available on <https://www.ftms.edu.my/images/Document/MOD001074%20-%20Strategic%20Management%20Analysis/WK5_SR_MOD001074_Grundy_2006.pdf >

H. HARIRI, ERIK M. FREDERICKS AND KATE M. BOWERS, 2019, Uncertainty in big data analytics: survey, opportunities, and challenges*, Journal of Big Data volume 6*. Available on < https://journalofbigdata.springeropen.com/articles/10.1186/s40537-019-0206-3 >

H. J. WATSON, 2014 Tutorial: Big data analytics: Concepts, technologies, and applications, *Communication of the Association for Information Systems, Vol.34, Article 65.* Available on < https://aisel.aisnet.org/cais/vol34/iss1/65/ >

HACKATHORN, R.D. AND P.G.W. KEEN, 1981, Organizational Strategies for Personal Computing in Decision Support Systems, *MIS Quarterly Vol. 5, No. 3, pp. 21-27*. Available on < https://www.jstor.org/stable/249288 >

HENKE, N., A. PURI AND T. SALEH. May 2020, Accelerating Analytics to Navigate COVID-19 and the Next Normal. *McKinsey & Company*. Available on < https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/accelerating-analytics-to-navigate-covid-19-and-the-next-normal >

HODA NOKHBATOLFOGHAHAAYEE, MOHAMMAD BAGHER MENHAJ, MASOUD SHAFIEE, 2010, Fuzzy decision support system for crisis management with a new structure for decision making, *Expert Systems with Applications Vol. 37(5) pp.3545-3552*. Available on <https://www.researchgate.net/publication/223625289_Fuzzy_decision_support_system_for_crisis_management_with_a_new_structure_for_decision_making >

HOLLY FOSHER, 2018 Understanding the Marketing and Management of trails using PESTEL Analysis, *Master thesis*. Available on <https://scholars.unh.edu/cgi/viewcontent.cgi?article=2182&context=thesis>

HOLSAPPLE, C. AND A. WHINSTON, 1996, Decision Support Systems: A Knowledge-Based Approach, Minneapolis/St. Paul. Journal of Computer Sciences and Applications, *Vol. 1 No. 3, 46-54.*

INI' PAOLO, 2019, Artificial Intelligence in Italian Manufacturing: Growth Potentials and Criticalities. Available on <http://tesi.cab.unipd.it/63435/1/In%C3%AC_Paolo.pdf>

J. S. WARD AND A. BAKER, 2013 A Survey of Big Data Definitions,. Available on < https://arxiv.org/abs/1309.5821 >

JAIN A. 2016, The 5 Vs of big data. *IBM Watson Health Perspectives*. Available on < https://www.ibm.com/blogs/watson-health/the-5-vs-of-big-data/ >

JAMES MANYIKA, JAANA REMES, JAN MISCHKE, MEKALA KRISHNAN, 2017, The productivity puzzle: a closer look at the United States*, McKinsey Global Institute* Available on <https://www.mckinsey.com/~/media/mckinsey/featured%20insights/employment%20and%20growth/new%20insights%20into%20the%20slowdown%20in%20us%20productivity%20growth/mgi-the-productivity-puzzle-discussion-paper.pdf >

JAMES MANYIKA, MICHAEL CHUI, BRAD BROWN, JACQUES BUGHIN, RICHARD DOBBS, CHARLES ROXBURGH, AND ANGELA HUNG BYERS, 201, Big data, the next frontier for innovation, competition and productivity, *Mckinsey Global institute*. Available on < https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/big-data-the-next-frontier-for-innovation >

JASMINE ZAKIR, TOM SEYMOUR, KRISTI BERG, 2015, Big Data Analytics, *Issues in Information Systems Vol 16, Issue II, pp. 81-90*. Available on < https://iacis.org/iis/2015/2_iis_2015_81-90.pdf >

JAY BARNEY, 1991, Firm Resources and Sustained Competitive Advantage*, journal of Management; Vol. 17(1), pp 99-120* Available on < https://journals.sagepub.com/doi/abs/10.1177/014920639101700108>.

JEFF GALVIN, LAURA LABERGE, EVAN WILLIAMS. May 2021, The new digital edge: Rethinking strategy for the postpandemic era, *McKinsey Digital.* Available on < https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-new-digital-edge-rethinking-strategy-for-the-postpandemic-era >

JOYNER, R. AND K. TUNSTALL, 1970, "Computer Augmented Organizational Problem Solving," *Management Science Vol. 17, No. 4*, pp. 212-225 Available on < https://www.jstor.org/stable/2629371 >

KAIL, E. 2011, Leading effectively in a VUCA environment: A is for ambiguity. *HBR Blog Network*. Available on < https://hbr.org/2011/01/leading-effectively-in-a-vuca-1 >

KAISER J. GIRI, TOWSEEF A. LONE, 2014, Big Data -Overview and Challenges, *International Journal of Advanced Research in Computer Science and Software Engineering. Volume 4, Issue 6, pp 525-529* Available on <https://www.researchgate.net/profile/Kaiser-Giri/publication/287294077_Big_Data_-

Overview_and_Challenges/links/56751e7508ae125516e3f384/Big-Data-Overview-and-Challenges.pdf >

KARTHIK RAMACHANDRAN, VARUN DHIR, PAVEL KRUMKACHEV, 2018, Cloud helps accelerate midsize companies' AI adoption. *Deloitte Insights*. Available on <https://www2.deloitte.com/us/en/insights/industry/technology/ai-adoption-mid-size-companies.html >

KEEN, P. G. W. AND HACKATHORN, R. D. 1979, "Decision Support Systems and Personal Computing," *Department of Decision Sciences, The Wharton School, The University of Pennsylvania CISR No. 47 Sloan WP No. 1088-79*. Available on <https://dspace.mit.edu/bitstream/handle/1721.1/47213/decisionsupports00keen.pdf?sequence=1&origin=publication_detail >

KEEN, P. G. W. AND M. S. SCOTT MORTON, 1978, Decision Support Systems: An Organizational Perspective. *DSS News, Vol. 2, No. 10* Available on < https://dssresources.com/dsswisdom/password/page15.html >

KEEN, PETER G. W. 1980, "MIS Research: Reference Disciplines and Cumulative Tradition", *in E. McLean, Proceedings of the First International Conference on Information Systems . ICIS 1980 Proceedings. 9.*. Available on < https://core.ac.uk/download/pdf/301363927.pdf >

KLAUS SCHWAB, 2015, The Fourth Industrial Revolution: What It Means and How to Respond. *World Economic Forum, Foreign Affairs* Available on <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/ >

KLAUS SCHWAB, 2017, The Fourth Industrial Revolution. Available on <https://books.google.it/books?hl=it&lr=&id=ST_FDAAAQBAJ&oi=fnd&pg=PR7&dq=KLAUS+SCHWAB,+2017,+The+Fourth+Industrial+Revolution.&ots=DUjvaSwvUM&sig=TyplzG09A7XLxyOyhJIUbc3qD5c#v=onepage&q=KLAUS%20SCHWAB%2C%202017%2C%20The%20Fourth%20Industrial%20Revolution.&f=false >

KIMBERLY MLITZ, 2021, Forecast revenue big data market worldwide 2011-2027, *Statista*. Available on <https://www.statista.com/statistics/254266/global-big-data-market-forecast/ >

KIRK LAWRENCE, 2013, Developing Leaders in a VUCA Environment, *UNC Executive Development 2013.* Available on <https://www.cfmt.it/sites/default/files/af/materiali/Developing-leaders-in-a-vuca-environment.pdf>

KUPRIYANOVSKY, V. P., KUPRIYANOVSKAYA, Y. V., SINYAGOV, S. A., DOBRYNIN, A. P., & CHERNYKH, K. Y. 2016, Digital economy—various paths to effective application of technologies, *Vol 169*. Available on < https://link.springer.com/chapter/10.1007/978-3-319-94310-7_2 >

LANEY D. 3D, 2001, data management: controlling data volume, velocity and variety. META Group Res Note, *Vol 6*.

LARS DE BRUIN, 2016 VRIO: From Firm Resources to Competitive Advantage. Available on <https://www.business-to-you.com/vrio-from-firm-resources-to-competitive-advantage/ >

LAURA LABERGE, CLAYTON O'TOOLE, JEREMY SCHNEIDER, KATE SMAJE, Oct 2020, How COVID-19 has pushed companies over the technology tipping point—and transformed business forever, *McKinsey and Company*. Available on < https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever >

LINDA HOLBECHE, 2015, The Agile Organization, Kogan Page. Available on <https://books.google.it/books?hl=it&lr=&id=vba6CQAAQBAJ&oi=fnd&pg=PP1&dq=LINDA+HOLBECHE,+2015,+The+Agile+Organization,+Kogan+Page.&ots=-J7fsapCPj&sig=K_IKFVv26llPDDrUaCB7EjgGNHo#v=onepage&q=LINDA%20HOLBECHE%2C%202015%2C%20The%20Agile%20Organization%2C%20Kogan%20Page.&f=false >

LITTLE, J. D. C. 1970, "Models and Managers: The Concept of a Decision Calculus". *Management Science Vol. 16, No. 8, pp. 466-485*. Available on <https://www.jstor.org/stable/2628654 >

LITTLE, J. D. C. 1975, Brandaid, an On-Line Marketing Mix Model, Part 2: Implementation, Calibration and Case Study, *Operations Research Vol. 23, No. 4, pp. 656-673.* Available on <https://www.jstor.org/stable/169848 >

LORENA IGNAZZI, 2020, Il ruolo del Marketing in situazioni complesse, *Agile Marketing*. Available on < https://www.agilemarketingitalia.com/vuca-marketing-agile-mondo/ >

LUCILLE CROMBEZ, 2021, Structured, semi-structured and unstructured data: what makes them different? Available on < https://2os.io/structured-semi-structured-and-unstructured-data/>

LU, Y., MORRIS, K. C., & FRECHETTE, 2016, S. Current standards landscape for smart manufacturing systems, *Report Number 8107*. Available on <https://www.nist.gov/publications/current-standards-landscape-smart-manufacturing-systems >

MIN XU, JEANNE M. DAVID, SUK HI KIM, 2018, The Fourth Industrial Revolution: Opportunities and Challenges, *International Journal of Financial Research Vol 9, No 2.* Available on < https://www.sciedupress.com/journal/index.php/ijfr/article/view/13194/0 >

N. BENNETT AND J. LEMOINE, (January/February 2014), "What VUCA Really Means for You," *Harvard Business Review*. Available on < https://hbr.org/2014/01/what-vuca-really-means-for-you >

PATRICK HOLLINGWORTH, 2016, The Light and Fast Organisation: A new way of dealing with uncertainty, John Wiley & Sons. Available on < https://books.google.it/books?hl=it&lr=&id=rlVwCwAAQBAJ&oi=fnd&pg=PR1&dq=PATRICK+HOLLINGWORTH,+2016,+The+Light+and+Fast+Organisation:+A+new+way+of+dealing+with+uncertainty,+John+Wiley+%26+Sons&ots=k5hUnyGv2m&sig=4qaDm-xf8Qm8lyu_8rFu8PHYEAc&redir_esc=y#v=onepage&q=PATRICK%20HOLLINGWORTH%2C%202016%2C%20The%20Light%20and%20Fast%20Organisation%3A%20A%20new%20way%20of%20dealing%20with%20uncertainty%2C%20John%20Wiley%20%26%20Sons&f=false >

POLITECNICO DI MILANO, 30 November 2021Osservatori Startup Intelligence e Digital Transformation Academy convention “Startup e imprese nella trasformazione digitale: open innovation per accelerare la ripresa”

PORTER, M. E. 1980. Competitive strategy: Techniques for analyzing industries and competitors. *New York: FreePress.* Available on < https://www.hbs.edu/faculty/Pages/item.aspx?num=195 >

POWELL, R. February 2001: A 10 Year Journey, *DM Review*.

POWER, D. J. 2000, A History of Microcomputer Spreadsheets, *International Scientific Journal of* M*anagement Information Systems, Vol. 9 (4), pp 09-14.* Available on < https://www.researchgate.net/publication/280096970_Spreadsheets_-How_It_Started >

POWER, D. J. 2001, Supporting Decision-Makers: An Expanded Framework, In Harriger*, A. (Editor), e- Proceedings Informing Science Conference pp. 431-436.* Available on < https://proceedings.informingscience.org/IS2001Proceedings/pdf/PowerEBKSupp.pdf >

PURSEY P. M. A. R. HEUGENS AND MICHEL W. LANDER, 2009, Structure! Agency! (And Other Quarrels): A Meta-Analysis of Institutional Theories of Organization, *Academy of Management Journal Vol. 52, No. 1.* Available on < https://journals.aom.org/doi/abs/10.5465/amj.2009.36461835 >

PRIYONO A., MOIN A., PUTRI, V.N.A.O. 2020, Identifying Digital Transformation Paths in the Business Model of SMEs during the COVID-19 Pandemic *J. Open Innov. Technol. Mark. Complex Vol. 6, 104.* Available on < https://www.mdpi.com/2199-8531/6/4/104 >

QUENTIN JADOUL, ANDRÉ NASCIMENTO, OLLI SALO, AND RENATO WILLI, 2020, Agility in the time of COVID-19: Changing your operating model in an age of turbulence Can organizations be transformed while employees are working remotely? Four real-life stories suggest that they can, *Mckinsey&Company*. Available on <https://www.mckinsey.com/business-functions/people-and-organizational-performance/our-insights/agility-in-the-time-of-covid-19-changing-your-operating-model-in-an-age-of-turbulence >

RALPH H. SPRAGUE JR. 1980, A Framework for the Development of Decision Support Systems, *MIS Quarterly, Management Information Systems Research Center, Vol. 4, No 4, pp. 1-26.* Available on < https://www.jstor.org/stable/248957 >

ROBERT ADIXON, 2019, Artificial Intelligence Opportunities & Challenges in Businesses *Towards Data Science*. Available on < https://towardsdatascience.com/artificial-intelligence-opportunities-challenges-in-businesses-ede2e96ae935 >

SCHARMER, O. March 16, 2020, Eight emerging lessons: From coronavirus to climate action. *Medium*. Available on < https://medium.com/presencing-in- stitute-blog/eight-emerging-lessons-from-coronavirus-to-climate-action- 683c39c10e8.>

SHAN SUTHAHARAN, 2014, Big Data Classification: Problems and Challenges in Network Intrusion Prediction with Machine Learning, *Performance Evaluation Review, vol. 41(4), pp. 70-73,* Available on <https://libres.uncg.edu/ir/uncg/f/S_Suthaharan_Big_2014.pdf >

SIMON BLACKBURN, JEFF GALVIN, LAURA LABERGE, AND EVAN WILLIAMS, October 2021, , Strategy for a digital world, A winning digital strategy requires new twists to familiar moves, *Mckinsey Quarterly* Available on <https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/strategy-for-a-digital-world >

SPEA SPA, Available on < https://www.spea.com/it/ >

SPRAGUE, R. H., JR. AND E. D. CARLSON. 1982, Building Effective Decision Support Systems, *Computers and Standards, Vol. 1, Issues 2–3, September 1982, Page 190*. Available on < https://doi.org/10.1016/0167-8051(82)90033-X >

STEFAN BIESDORF, DAVID COURT, AND PAUL WILLMOTT, 2013, Big data: What's your plan?, *Mckinsey Quarterly* Available on <https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/big-data-whats-your-plan >

SULLIVAN, J. 16 January 2012. VUCA: The new normal for talent management and workforce planning. Available on < https://www.ere.net/vuca-the-new-normal-for-talent-management-and-workforce-planning/ >

SULLIVAN, J. 22 October 2012, Talent strategies for a turbulent VUCA world—shifting to an adaptive approach. Available on < https://www.ere.net/talent-strategies-for-a-turbulent-vuca-world-shifting-to-an-adaptive-approach/ >

SWANSON, E. B. AND M. J. CULNAN, Dec. 1978, "Document-Based Systems for Management Planning and Control: A Classification, Survey, and Assessment", *MIS Quarterly, Management Information Systems Research Center, University of Minnesota, Vol. 2, No. 4, pp. 31-46*. Available on <https://www.jstor.org/stable/248903 >

THANOS PAPADOPOULOSA, KONSTANTINOS N. BALTASB, MARIA ELISAVET BALTAC, 2020, The use of digital technologies by small and medium enterprises during T COVID-19: Implications for theory and practice, *International Journal of Information Management Vol. 55.* Available on < https://af.booksc.eu/book/82645760/c18a81 >

THE ECONOMIST: New York, NY, USA, 6th May 2017, The world's most valuable resource is no longer oil, but data. Available on <https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data >

THE WORLD ECONOMIC FORUM, 2012, "Big Data, Big Impact: New Possibilities for International Development", Switzerland. Available on < https://www.weforum.org/reports/big-data-big-impact-new-possibilities-international-development >

THOMAS H. DAVENPORT, 2006, Competing on Analytics, *Harvard Business Review*. Available on < https://hbr.org/2006/01/competing-on-analytics >

THOMAS H. DAVENPORT, 2018, From analytics to artificial intelligence, *Journal of Business Analytics, Vol. 1, NO. 2, 73-80.* Available on <https://www.researchgate.net/publication/329079285_From_analytics_to_artificial_intelligence >

THOMAS H. DAVENPORT, 2018, What's Your Cognitive Strategy*?, MIT Sloan Management Review*. Available on < https://sloanreview.mit.edu/article/whats-your-cognitive-strategy/ >

THOMAS H. DAVENPORT, JEFF LOUCKS, DAVID SCHATSKY. 2017, Bullish on the business value of cognitive Leaders in cognitive and AI weigh in on what's working and what's next, *The 2017 Deloitte State of Cognitive Survey*, *pp 1-13*. Available on <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/deloitte-analytics/us-da-2017-deloitte-state-of-cognitive-survey.pdf >

THOMAS L. FRIEDMAN, 2005, The World Is Flat: A Brief History of the Twenty-first Century, *Farrar, Straus and Giroux.*. Available on < https://psycnet.apa.org/record/2005-13366-000 >

UMA, V.D. 2009, Role of Decision Support System for Decision-Making Process in Global Business Environment. Available on <https://eziniearticles.com/?Role-of-Decision-Support-System-For-Decision-Making-Process-in-Global-Business-Environment&id=2315787 >

UNOX Company. Available on <https://www.unox.com/it_it/>

YVES MORIEUX, PETER TOLLMAN, 2014, Six Simple Rules. How to Manage Complexity without Getting Complicated, *Harvard Business Review Press, Boston, Massachusetts*.

V RAJARAMAN, 2016, Big Data Analytics, *General Article, vol 21, pp 695-716*. Available on <https://link.springer.com/article/10.1007/s12045-016-0376-7 >

WU, L., L. HITT AND B. LOU 2020, 'Data analytics, innovation, and firm productivity', *Management Science, Vol 66, pp. 1783– 2290*. Available on