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AI for innovators

An exploratory study on the application of Artificial Intelligence as a supportive tool in the innovation process

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Abstract

The technological evolution we are experiencing nowadays has impacted many businesses and industries. In this sense, one of the most influential technologies is certainly Artificial Intelligence, which especially in recent months has been at the centre of numerous debates.

The purpose of this research is to understand whether and how Artificial Intelligence can be used as a supporting tool in innovation processes, as well as what are the future perspectives in this regard.

Indeed, for quite some time now, AI has been used in the most innovative companies as a support in decision-making, to streamline and automate processes, or through the robotisation of activities that were previously carried out by human workers. However, it is unclear whether and to what extent it can also support organisations in long and complex innovation processes.

In order to get a more complete idea about this, a qualitative exploratory study was implemented. Several exponents from different companies and industries were interviewed by means of semi-structured interviews. The target market context was Sweden, considering the role that this country has and has always had in terms of innovation and cutting-edge companies.

The results of the study contribute to the theory and knowledge in the literature but also have more practical implications. Indeed, through this research, it has been shown how AI can be a crucial element in several directions when applied to different contexts of innovation. In fact, AI can have a direct impact on innovation drivers and barriers and along all stages of the innovation process, leading companies to achieve incremental but also more disruptive innovations. However, at the moment, we are only at the beginning of the path of AI adoption in innovation processes and this implies that companies will have to pay attention to the main opportunities and challenges in this regard, that have emerged during the primary and secondary data analysis phases.

Keywords: *Innovation, Innovation Drivers, Stages of Innovation, Innovation Models, Innovation Process, Artificial Intelligence, Industry 4.0 and Artificial Intelligence, Machine Learning, Deep Learning, Generative AI, Artificial Intelligence in Business, Artificial Intelligence and Innovation.*

Table of Contents

List of Tables

List of Figures

1. Introduction

1.1 Aim of the Research

Technology and innovation are two fundamental and interconnected concepts. Their impact on companies and on the business world has always been particularly significant. Indeed, both innovation and technology play a fundamental role in the dynamics of every firm, influencing their strategies and success. Nowadays, technological evolution is completely disrupting several industries and ways of doing business. A wide range of new technological tools is at the centre of companies' strategies and at the heart of the digitisation process we are experiencing with the fourth industrial revolution. One of the tools that have most attracted the attention of practitioners is Artificial Intelligence (AI). The business contexts in which this tool is applied have grown exponentially since the 1980s (Sestino & De Mauro, 2022), and the opportunities for future development are increasing dramatically. Especially with the advent of ChatGPT and other Generative AI tools, new possibilities and potential uses are emerging, also for innovation. This paper aims to explore this point in more detail, by answering the following Research Question (RQ):

RQ: "How can AI be a supportive tool in the innovation process?"

On the one hand, indeed, it is clear that Artificial Intelligence is being used to accelerate data analysis, increase efficiency, and automate numerous processes within companies that were previously carried out by employees (Xiong et al., 2020). On the other hand, however, there is still a need for further research on how this technological tool can be used in the different phases of the innovation process. Specifically, indeed, not many studies have analysed how companies' innovation models can be supported by Artificial Intelligence. Therefore, this paper aims to get a clearer picture of how innovation and Artificial Intelligence interact with each other, and particularly how the latter impacts the former being used as a supportive tool.

It is evident the potential significance that the results of this study could have. On the one hand, in fact, every company is doomed to die without innovation. Indeed, innovation (in processes, products, and so on) is the key for companies to align themselves with changing competitive scenarios and environments and build a competitive advantage over competitors (Goffin & Mitchell, 2017). On the other hand, the use of the latest technological tools could be the means to achieving relevant results, also in terms of innovation.

1.2 Research Methodology

In investigating the Research Question, an exploratory approach will be adopted. In more detail, both the current *status quo* and the potential future possibilities and challenges that could be faced in using AI as a support tool in innovation practices will be explored. Therefore, the analysis is conducted focusing on both the present and the future.

In more detail, for answering the RQ, both primary and secondary data will be considered. The latter will be collected through a Literature Review conducted in a systematic way, focusing on the concepts of Innovation, Artificial Intelligence, and its applications on business activities (with an emphasis on innovation). On the other hand, primary data will be obtained via qualitative research, which will be developed through a series of semi-structured interviews. The interviewees are selected among Innovation and Artificial Intelligence experts operating in different industries and companies in the Swedish market environment. As the GII 2022 (Global Innovation Index 2022) annual report shows, Sweden is second only to Switzerland in terms of innovation in the European context. Therefore, for this reason, Sweden is considered a relevant country to extract the sample of respondents. Moreover, the broad approach in selecting interviewees is considered to be in line with the exploratory nature of the research, which do not want to focus on a single case study but rather aims at considering the concept of innovation in different industries and from different angles. All collected data will be then analysed according to a thematic analysis, to obtain clear and concrete findings, which will be then discussed in the final section of this research.

1.3 Research Structure

This paper is divided into different sections. Section 2 will delve the present state of the art of the literature. Specifically, the concept of innovation will be explored in detail, analysing its meaning, main drivers and barriers, different degrees, and models. Subsequently, the concepts of Industry 4.0 and Artificial Intelligence will be deepened in the second part of the Literature Review. Regarding AI, also some concrete applications that this technology has had over time in the world of business and innovation will be presented. Subsequently, in Section 3, the methodology followed in the research will be explained in detail, with an in-depth examination of the Research Strategy, Research Design, and an overview of the Data Collection and Data Analysis methods. After that, in the Section 4 and Section 5, the results of this research will be presented and then discussed, trying to highlight the practical implications in terms of concrete applications, opportunities, and challenges that Artificial Intelligence can determine in relation to innovative processes. Finally, Section 6 will provide the main conclusions, limitations, and suggestions for future research.

2. Literature Review

Introduction

In this section, dedicated to the review of current literature, the following macro-topics will be explored: Innovation, Industry 4.0 and Artificial Intelligence, and its concrete applications. All the sections that will be analysed will provide a more complete and clearer view of the current theoretical framework. The information gathered will serve to highlight the most relevant aspects of the considered field of research, thus building the basis of the present analysis.

2.1 Innovation

2.1.1 The concept of Innovation

The role of Innovation

In today's dynamic and magmatic market environment, companies must always be ready to evolve as a response to continuous changes on the consumer side, as well as to be able to capitalise on the new various opportunities offered by new technologies in the market (Baregheh et al., 2009). In this sense, the ability to innovate is a fundamental aspect for companies, which without innovation would be doomed to extinction. Indeed, as pointed out by Zahra & Covin (1994, p.1), "*innovation is widely considered as the life blood of corporate survival and growth*". Consequently, it could be inferred that the role of innovation itself is crucial to create value and keep a competitive edge over other market players (Baregheh et al., 2009). Indeed, innovation is the key to building a competitive advantage, especially in an intensely turbulent and competitive environment (Neely & Hii, 1998), and it is often regarded as the natural growth engine for companies (B. Brown, 2010). Moreover, high levels of innovation have been proven to increase the likelihood of surviving market changes and the entry of new players (Cefis & Marsili, 2006). Therefore, if we consider the importance and the role that innovation plays in the life of companies, it is crucial to deepen this concept. In practice, in fact, it is not always clear what we are referring to when we speak of innovation. It is indeed a complex concept, which is often misunderstood or misused.

Definition of Innovation

Many confuse innovation with mere invention. In reality, however, although these two concepts are deeply related, there are substantial differences. Indeed, invention represents the first manifestation of a new idea or concept, usually in relation to a product or process. It is the generation of a new idea born of research or simple creativity (Carayannis, 2020). When this new idea is used for commercial

purposes, then we speak about innovation (Carayannis, 2020). However, it must be clarified that sometimes one can also speak of innovation by applying not-new ideas to different contexts (Goffin & Mitchell, 2017), so one does not necessarily have to deal with an invention to be able to speak of innovation.

Another mistake frequently made when discussing innovation in business contexts is associating this concept with the mere introduction of new products into the market (Goffin & Mitchell, 2017). However, in reality, innovation is a much more complex and richer concept that is more than just about new products. Therefore, understanding the true meaning of innovation and its implications is crucial for managers and employees to pursue it successfully. Consequently, it is worth analysing the different definitions that have followed one another over the decades, also following a multidisciplinary approach (Baregheh et al., 2009).

In fact, over time, innovation has been defined in different ways, depending on the discipline through which the concept is viewed. Indeed, definitions of innovation exist in the literature on human resources management, operations management, research and development, marketing, and business strategy (Baregheh et al., 2009). Each of these disciplines has tried to outline the main elements of this complex concept from its own perspective: sometimes there are overlaps between the different definitions, while at other times, some nuances and differences can be noted (Baregheh et al., 2009).

Following a more general approach, one could say that innovation is a concept related to change, since it often serves as a tool to influence a changing environment or to change an environment, be it internal or external (Damanpour, 1991). If one wanted to simplify the definition of this complex concept, therefore, one could say that innovation represents the introduction of something new (Goffin & Mitchell, 2017).

The Austrian economist Joseph Schumpeter was the first to attempt to define the concept of innovation, highlighting specific components that are still relevant today. In more detail, as reported by Porter (1990), Schumpeter saw innovation as: 1) The introduction of a new product to customers or at least an improved version of one previously introduced to the market and thus available to consumers. 2) The introduction of new production methods or the application of existing production methods to areas where they had not been applied before. 3) The creation of new markets. 4) The discovery of new sources of supply. 5) New forms of competition and new rules within an industry.

As can be seen, therefore, Schumpeter's vision of innovation goes far beyond the mere introduction of new products, but also extends to the discovery of new processes, markets, and so on.

Michael Porter, following Schumpeter, also defined the concept of innovation as "*both improvements in technology and better methods or ways of doing things. It can be manifested in product changes, process changes, new approaches to marketing, new forms of distribution, and new*

concepts of scope ... [innovation] results as much from organisational learning as from formal R&D" (Porter, 1990). As is evident, a particularly interesting aspect that emerges from Porter's definition is that innovation does not, as many believe, only originate in the R&D department. In fact, it can be linked to other company functions, such as marketing. Goffin and Mitchell (2017), in this regard, point out precisely how innovation influences a company's different functions. At the same time, good innovation management implies that all business functions contribute to stimulating and ensuring broad levels of innovation (Goffin & Mitchell, 2017). Moreover, like Schumpeter, Porter argues that innovation is not only related to introducing new products but can also concern internal business processes, new markets, and so on.

The element of novelty, when speaking of innovation, is also present in the definition of the OECD[1] innovation strategy, where innovation is defined as "*the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations*" (OECD, 2010). Research carried out by Baregheh et al. (2009) on 60 multidisciplinary definitions of the concept of innovation showed that the word *"new"* was used as many as 76 times. On average, therefore, more than once per definition. This is undoubtedly significant and makes it clear that the concept of newness is one of the most critical elements when speaking of innovation. Out of the 60 definitions analysed by Baregheh et al. (2009), some of the elements that emerge as the most frequently mentioned are the following, shown in Table 1:

Words used in the definition	Total number of occurrences	Number of occurrences in distinct definitions
New	76	42
Organisation	29	15
Product	40	33
Service	25	21
Process	23	21
Idea	22	18
Invention	12	8
Creativity	10	8
Change	10	9
Development	13	12
Technology	12	11

Table 1 - Words used in the definition of innovation - Adapted from Baregheh et al. (2009)

[1] Organisation for Economic Co-operation and Development.

In their analysis, Baregheh et al. (2009) categorised and highlighted six main elements that form the basis for a comprehensive definition of innovation. These elements, called *"attributes"*, are:

- Nature of the innovation, which refers to the form of the innovation. Specifically, it is something that can be completely *"new"* or improved.
- Type of innovation, which concerns the type of output that results from the innovation itself. We speak, as is also evident from the terms in Table 1, of product innovation (cited 40 times), service innovation (cited 25 times), process innovation (cited 23 times), and so on.
- Stages of innovation: these are all the steps one usually goes through to arrive at innovation. It usually starts with the generation of ideas and then leads to the commercialization of the innovation itself. In the following paragraphs, an analysis of the innovation models most frequently used by firms will be made to identify what the main stages have been over time.
- The social context in which innovation takes place. It concerns the set of people or environmental factors that influence the innovation itself in one way or another.
- Means of innovation: these are the resources needed to make innovation possible. They can be of different natures: technical, financial, creative, etc.
- Innovation goal: the result that organisations want to achieve through innovation.

In general, therefore, it is possible to conclude how difficult it is to frame the concept of innovation rigidly. However, by using some recurring elements in the definitions in the literature, Baregheh et al. (2009, p.11) arrived at the following definition: "*Innovation is the multi-stage process whereby organisations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace.*"

What needs to be reiterated, however, is that just like the marketplace in which companies operate, the concept of innovation itself is something magmatic, changing over time both in its nature and in its means, objectives, stages, and types. Therefore, it is a concept destined to evolve and change continuously, also depending on the perspective from which it is viewed (Baregheh et al., 2009). Nowadays, as will be analysed in more detail in the following paragraphs, in defining the concept of innovation, one must consider the ever-increasing intensity linked to the influence of technology and the technological tools adopted by companies.

2.1.2 Drivers of Innovation

Drivers' classification

Once framed the main elements that make up the complex concept of innovation, it is necessary to understand the main drivers that guide it. This, for the purposes of this study, will be crucial to investigate how AI can be applied to some of the drivers to stimulate innovation.

There are numerous classifications in the literature in relation to the drivers of innovation at an organisational level. Specifically, the classification taken into consideration for the aims of this paper is the one that divides the internal drivers of the organisation from the external ones.

On the one hand, the choices, objectives, strategies of the company, the corporate culture, the type of leadership, as well as the organisational structure are aspects that have a strong influence on the level of innovation and therefore depend on internal factors (Dani & Gandhi, 2021; Goffin & Mitchell, 2017). On the other hand, however, there are some aspects influencing innovation that come from the outside: specifically, the level of competition, changing consumer preferences, technological advances, as well as the environment in which one operates are all external factors that have a significant influence on the level of innovation (Goffin & Mitchell, 2017).

Throughout this section, all these drivers will be analysed in more detail to fully understand their significance.

Internal Drivers

Internal drivers are all those aspects that concern the internal configuration of the company, which therefore characterise and influence the levels of innovation based on several peculiarities typical of the company itself. Dani & Gandhi (2021) divide innovation drivers between the organisational and individual levels.

On the organisational level, all those drivers related to the managerial level are recalled. In fact, the organisational environment appears to have a significant impact on the level of creativity and, consequently, on the level of corporate innovation (Amabile, 2012; Anderson, 2012). The drivers identified at the organisational level are the following:

- Organisational Strategies and Intent: these are all the strategies needed to achieve the goals that enterprises set for themselves (Dani & Gandhi, 2021; Goffin & Mitchell, 2017). The enterprise chooses which strategies to implement in terms of resources and tools to be used in order to be able to achieve the goals in the short and long term (Dani & Gandhi, 2021).
- Organisational Culture: it refers to the beliefs of workers, to the values on which the enterprise is founded (Dani & Gandhi, 2021). Several studies over time have proven how corporate culture plays a crucial role in the innovative orientation of the company (McLean, 2005;

Mumford & Licuanan, 2004; Zopiatis & Theocharous, 2018). Dani & Gandhi (2021) highlight how corporate culture primarily enables employees to socialise and coordinate in their work (aspects that stimulate creativity and thus innovation). Goffin and Mitchell (2017) also recognise the importance of corporate culture for the purposes of innovation, including it as one of the key elements of the "Innovation Pentathlon Framework."

- Organisational Structure: a proper internal structure, as well as the right balance between hierarchy and flexibility, have a strong influence on the firm's level of innovation. Several studies, for example, have proven how the size of an enterprise dramatically influences the level of innovation performance (Gomes & Wojahn, 2017). Larger organisations certainly have more resources they can deploy in innovation processes. However, conversely, they are characterized by less flexibility and more formality and centralization of decisions (Dani & Gandhi, 2021). On the other hand, smaller firms founded on the flexible organisation of projects can handle greater complexity, thus supporting radical innovations (Damanpour, 1991).
- R&D Investments: they are a key measure and proxy of the innovation level of a given company (Anzola-Román et al., 2018). However, not every single resource deployed in R&D actually leads to the commercialization of an innovation (Goffin & Mitchell, 2017). Indeed, in some circumstances, firms face the failure of a project despite high R&D expenditures. Therefore, to say that greater investment in R&D necessarily leads to a higher level of innovation is incorrect. However, through R&D investment surely one can get an idea of how much the firm wants to invest in innovation and thus influence it (Goffin & Mitchell, 2017).
- Organisational Learning: it concerns the acquisition and use of new knowledge and skills that are shared among workers in the enterprise (Husain et al., 2016). Enterprises use exploitative and explorative learning to stimulate creativity and innovation (Dani & Gandhi, 2021).
- Organisational Support: numerous studies have proven that the application of innovation is also strongly influenced by the type of corporate support that is provided. Specifically, such support is provided through "*management strategies, policies, actions and the work environment, which is, in turn, idealized, inspired and stimulated by top management and organisational leaders*" (Dani & Gandhi, 2021, p.17).
- Business Processes and Practices: these are all the day-to-day operations that stimulate innovation (Crossan & Apaydin, 2010; Smart et al., 2009). Technical support, incentives, control structures, traineeships, and managerial coaching are all activities that influence the level of an organisation and increase its organisational performance (Dani & Gandhi, 2021).

However, nowadays, Artificial Intelligence and Machine Learning reduce human intervention and accelerate the generation of innovation in daily activities (Haefner et al., 2021).

As anticipated, then, there are a whole series of drivers that instead influence innovation from a more individual perspective (Dani & Gandhi, 2021). Indeed, while it is important to stimulate collaboration and many of the innovations are carried out in teams, at the same time the individual employees' attributes may be crucial to the firm's innovative goals (Goffin & Mitchell, 2017). Indeed, a firm's level of innovation also depends heavily on the ability of individuals to generate and implement new ideas that stimulate innovation (Dani & Gandhi, 2021). In more detail, the individual drivers of innovation according to Dani and Gandhi's study (2021), are:

- Creativity: this is obviously one of the key elements, one of the main drivers of innovation. Creativity, in fact, is a key driver especially at the beginning of the innovation cycle, during the idea generation and execution phases of the idea (Amabile, 2012). Several studies have proven how a work environment that stimulates creativity then leads to more significant outcomes in terms of innovation (de Vasconcellos et al., 2019; Yeh-Yun Lin & Liu, 2012).
- Employee motivation: concerns the level of commitment and dedication that each worker is willing to devote to his or her work (Dani & Gandhi, 2021). Motivation is key to encouraging workers to make courageous decisions, which therefore incentivize innovation. In fact, motivation plays a key role in generating new ideas, stimulating workers to find innovative solutions (Dani & Gandhi, 2021).
- Leadership: it plays a key role at every level of the organisation (Dani & Gandhi, 2021). Several studies have proven that there is a positive relationship between leadership and innovation (Berson et al., 2006; Lee et al., 2018; Tung & Yu, 2016). Specific characteristics of leaders allow constant support for workers, especially when in innovative processes one has to deal with a high degree of ambiguity (Shamir et al., 1993).

External Drivers

In addition to internal drivers, there are then a whole series of drivers that go outside the boundaries of the firm. They have been extensively analysed by Sheth and Ram (1987), and later taken up by Goffin and Mitchell (2017). Specifically, these are:

- Technological advances: new technologies can create new industries and new markets (Goffin & Mitchell, 2017). Every firm must be able to stay abreast of new technologies that continually emerge in the marketplace by aligning both its products and services and its internal production processes (Goffin & Mitchell, 2017). Technological evolution, as will be

analysed in more detail in the following sections of this paper, has been a driver that especially over the past has played a key role in the innovative processes of enterprises.

- Changing customer needs: the second external driver of innovation is the set of consumer preferences and needs, which are constantly changing (Goffin & Mitchell, 2017). Such changes can even lead to the disappearance of historical and traditional market segments, and companies must be able to adjust their assets based on what the market demands (Goffin & Mitchell, 2017).
- Competition: companies must always consider the strategies of competitors, which could sometimes be a stimulus for innovation. In fact, companies must always take into account possible innovations by other market players, and in this sense align themselves and follow any advancements if there are evolutions or innovations that put the company under pressure and in a position to have to innovate (Goffin & Mitchell, 2017).
- Changing Business Environment: decisions made by government agencies have always had a great influence on businesses, which sometimes have to innovate their products or processes based on new rules or regulations (Goffin & Mitchell, 2017). Therefore, this too, turns out to be an important driver of innovation in enterprises.

Figure 1 below summarises all the different drivers (internal and external) of innovation on which enterprises need to focus.

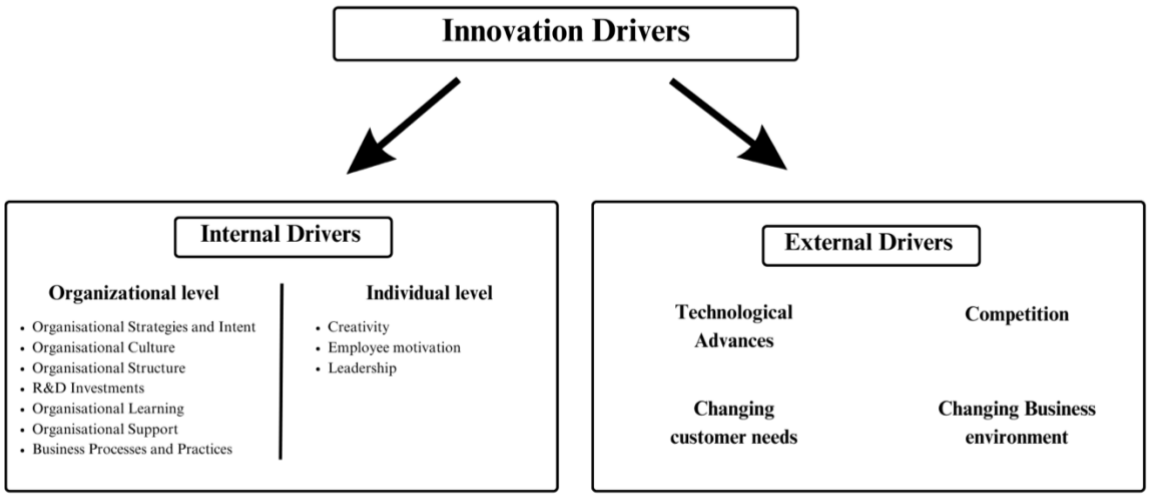

Figure 1 - Internal and External Drivers of Innovation - Adapted from Dani and Ghandi (2021); Goffin and Mitchell (2017)

2.1.3 Barriers to Innovation

Barriers' classification

Once the main drivers of innovation have been highlighted, it is also necessary to analyse what are the major barriers to innovation processes. For the purposes of this study, in fact, this is crucial to get a more complete picture and to investigate whether and how AI can be used as a tool that supports companies in overcoming or lowering these barriers, thus stimulating innovation.

The literature has highlighted several barriers to innovation, which often change depending on the market and type of enterprise. Barriers, like drivers, can also be classified according to an approach that looks both outside and inside the enterprise. This classification, initially proposed by Piatier (1984), has been taken up by a series of subsequent studies (Hadjimanolis, 1999; Madrid-guijarro et al., 2019). Categorizing the different barriers can become useful when considering that, based on their nature, the barriers themselves have a more or less pronounced impact on each of the different stages of the innovation process (Hadjimanolis, 1999). Both internal and external barriers will be explored in the following sections.

Internal Barriers

Internal barriers are divided into two main subcategories: resource-based and human nature-related (Hadjimanolis, 1999; Madrid-guijarro et al., 2019).

Barriers that fall into the resource-based category certainly include obstacles such as the absence of sufficient financial resources to be invested, or skills needed to support and stimulate innovation processes. Especially the fact that large investments are required to innovate is a barrier, in particular in the case of small businesses (Madrid-guijarro et al., 2019). Moreover, the uncertainty inherent to innovation itself exposes companies to a high risk of failure in the innovation process, and this often blocks financing innovative projects due to conflicts among investors (Bergemann & Hege, 2005). Risk and financial exposure are, in fact, closely linked: to innovate requires investments, but investing in innovative projects is particularly risky.

Added to this, then, are human-related barriers, associated with the attitude to risk and innovation present in firms both in employees and at the managerial level (Madrid-guijarro et al., 2019). In this, in fact, managers have a key role, since they must be able to promote a corporate culture that supports and stimulates innovation. Often, in fact, weak managerial support leads to a bottleneck of innovation. At the same time, innovation implies change, and change is often frowned upon by employees, who therefore develop a sense of inertia toward innovation due to a lack of support from managers (Madrid-guijarro et al., 2019). Such resistance from employees, then, may

also be present due to aspects such as poor communication or weak human resource practices (Zwick, 2002).

External Barriers

As anticipated, there are also barriers related to the external environment in which firms operate. Every company, in fact, in carrying out its business, comes into contact with several external entities, such as competitors, public institutions, and so on. Obviously, these contacts with third parties influence the firm's decisions, including those regarding innovation (Madrid-guijarro et al., 2019).

On the one hand, as seen in the drivers' section, competition and new regulations can stimulate firms to keep up with the times and innovate. However, at the same time, there can be negative input from the outside: a closed, traditional market environment with an absence of information flows can be a major obstacle to innovation. In fact, information about the external environment often stimulates innovation. Consequently, the absence of such information can become a strong hurdle (Hadjimanolis, 1999).

Also, the uncertainty of government policies or lack of government support and assistance are elements that have been identified as strong barriers to innovation (Piatier, 1984).

Figure 2 below briefly highlights all the main barriers to innovation set out in the previous sections.

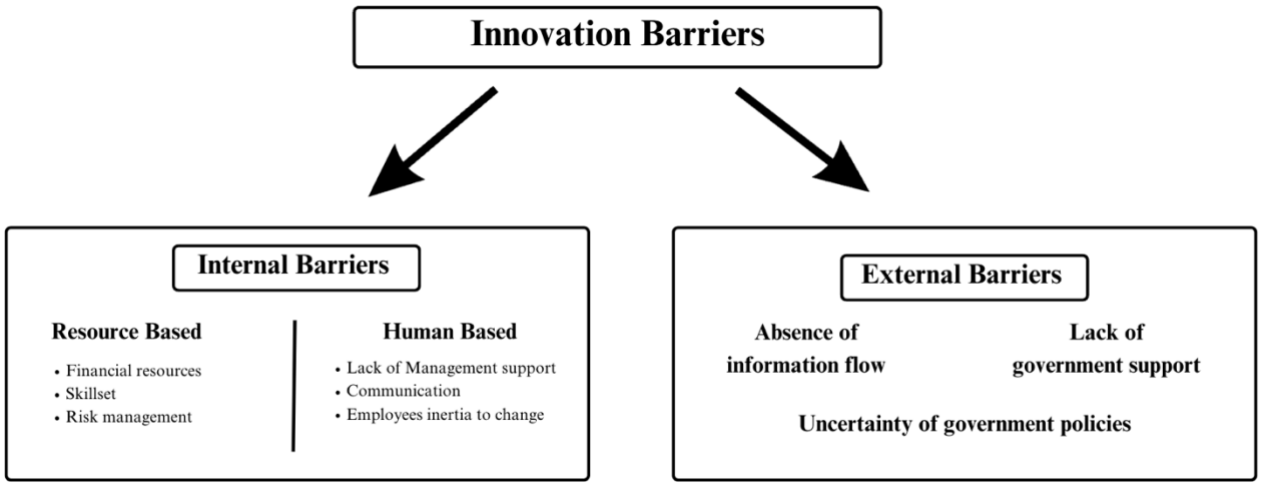

Figure 2 - Internal and External Barriers to Innovation

2.1.4 Different Degrees of Innovation

Another aspect worthy of attention relates to the different possible degrees of innovation. For the purpose of this research, indeed, it is considered appropriate to deepen this point in order to understand what is the impact that AI can have on them.

Nowadays, there are numerous classifications that are often conflicting and use different terms referring to the same degree of innovation. Often, in fact, some levels of innovation overlap and coincide for some researchers, while for others, it is found appropriate to distinguish them (Sandberg & Aarikka-Stenroos, 2014). For the purpose of this research, Goffin & Mitchell's (2017) classification was considered, which highlights three different degrees of innovation: incremental, breakthrough, and radical.

Incremental Innovations are nothing more than improvements to existing products, services, or processes. They target the consumers and core markets of the companies pursuing this type of innovation, with the goal of increasing market shares. Often, they arise as a result of simple market research through which consumer preferences are investigated (Goffin & Mitchell, 2017). This is the simplest degree of innovation, which leads firms to minor changes in products, services, and so on.

Breakthrough Innovations instead involve a more substantial change than incremental ones. For instance, this kind of innovation might lead to the satisfaction of previously unmet needs, or new categories of consumers (Goffin & Mitchell, 2017). Developing such innovations certainly represents a more complicated challenge for companies: as Deszca et al. (1999) highlight, "*traditional market research and development approaches [have] proved to be particularly ill-suited to breakthrough products*". This certainly means that also the market's acceptance process of a new product or service is more complex when it is a breakthrough innovation. Indeed, when it comes to breakthrough innovations, the time it takes for consumers to understand the real benefits of new products has to be considered: as such, the firm's growth in revenues may be slower and thus take longer (Goffin & Mitchell, 2017).

Finally, the most intense degree of innovation considered is the one of *Radical Innovations*, often defined as game changing. They are certainly much rarer and frequently involve the creation of completely new businesses or a complete redefinition of the competitive environment (Goffin & Mitchell, 2017). Managers often aspire to that level of innovation, but the success rate is significantly lower as they represent the most complex and the rarest degree to achieve (Sandberg & Aarikka-Stenroos, 2014). This is also due to the presence of higher innovation barriers when it comes to radical changes (Sandberg & Aarikka-Stenroos, 2014).

Considering the risk that can arise from managing more complex levels of innovation, managers should try to find some sort of balance among the three degrees of innovation, allocating

different percentages of their innovation budget between less risky and riskier innovations. This balance is often referred to as the *"golden ratio"*, and it usually changes according to business objectives (Goffin & Mitchell, 2017).

A tool often used for investment allocation between incremental, breakthrough, and radical innovation is the innovation ambition matrix. It graphically represents the strategic positioning that the company wants to take on innovation, highlighting the choices in terms of degree, intensity, and size of innovation (Nagji & Tuff, 2012).

2.1.5 Different Innovation models

A historical overview

From a more practical point of view, it is then crucial to understand the main models used by firms to pursue innovation. For the sake of this study, indeed, identifying the different stages of the innovation process is fundamental in order to understand how AI can be used as a supporting tool in each of them. Over the years, there has been a gradual evolution in this area: the literature has presented a set of different innovation models that have followed one another over the decades and have gradually been enriched, reflecting the increasing importance of innovation in the business world (Barbieri & Álvares, 2016). Specifically, by *"innovation model"*, the researcher refers to a set of principles, rules and practices that guide innovation and its processes (Barbieri & Álvares, 2016).

Roy Rothwell has been a leading researcher in the field of innovation management for many years, and in one of his papers, he set out his theories regarding the shift from simple, linear models to more complex, interactive models (Rothwell, 1994).

Specifically, Rothwell (1994) identified five main generations of models that have followed one another over time as a response to the increasing complexity and accelerating growth of industrial technological change. Since Rothwell's studies, later authors (Berkhout et al., 2006; Boehm & Fredericks, 2010; Shavinina, 2003; Tidd, 2006), have also taken up these theories, modifying some aspects. Despite some differences present in the literature in relation to the names of the different generations or the number of different models, it is possible to notice a set of recurring themes and commonalities (Barbieri & Álvares, 2016).

The first generation, dating from the 1950s – Mid-1960s (Rothwell, 1994), is given by the *"technology push"* model, so-called by most authors (Berkhout et al., 2006; Boehm & Fredericks, 2010; Rothwell, 1994). This model is based on the use of R&D and scientific knowledge to achieve innovation (Barbieri & Álvares, 2016). The assumption on which this model is based is that the greater the input in terms of R&D investment, the greater the amount of new products and/or

innovations (Rothwell, 1994). If one wanted to summarise this model graphically, one could do so through the following Figure 3:

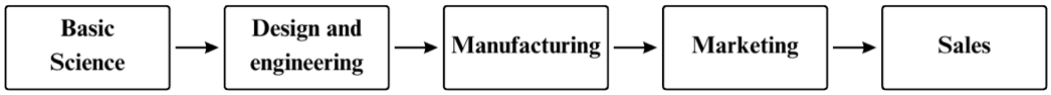

Figure 3 - First Generation of Innovation Models - Adapted from Rothwell (1994)

The second generation, developed between the Mid-1960s and 1970s, turns out to have a diametrically opposed starting point to that of the first generation of innovation processes. In fact, if with the latter we speak of technology push, with the second we speak of *"market pull"*, *"need pull"*, or *"demand pull"* (Berkhout et al., 2006; Boehm & Fredericks, 2010; Rothwell, 1994). According to this model, the R&D department had a simple reactive role in the innovation process: in fact, its task was to respond to the needs or demands of the market, which was the real resource of ideas (Rothwell, 1994). Consequently, the final output of the innovation process was also fundamentally derived from what the market demanded (Boehm & Fredericks, 2010). It is possible to represent graphically the second generation of innovative models as in Figure 4 below:

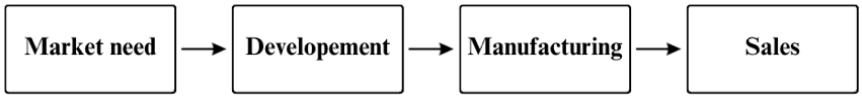

Figure 4 - Second Generation of Innovation Models - Adapted from Rothwell (1994)

The first and the second generation were joined by Tidd (2006), who called these two models *"linear"*, considering their typical linear succession of functional activities, as also visible from Figures 3 and 4 above.

The limitations of these two approaches (technology push and market pull), soon became clear: they saw innovation as a simple matching process according to which innovation was the result of simple research or market need (Tidd, 2006). In reality, however, both cases represent extreme and atypical situations of more frequent dual interaction between technological abilities on the one hand and market needs on the other (Barbieri & Álvares, 2016; Rothwell, 1994).

It is precisely this interaction that gives rise to the third generation of innovation models, known as coupling models (Rothwell, 1994). The third generation, indeed, represents a partial evolution of the first two: while on the one hand, the structure of the model continues to be linear from a certain point of view, the transition along the sequence of different stages is no longer one-way. In fact, there is a greater level of interaction and feedback between the different stages (Barbieri

& Álvares, 2016), as can also be seen from the arrows throughout the process represented in Figure 5 below.

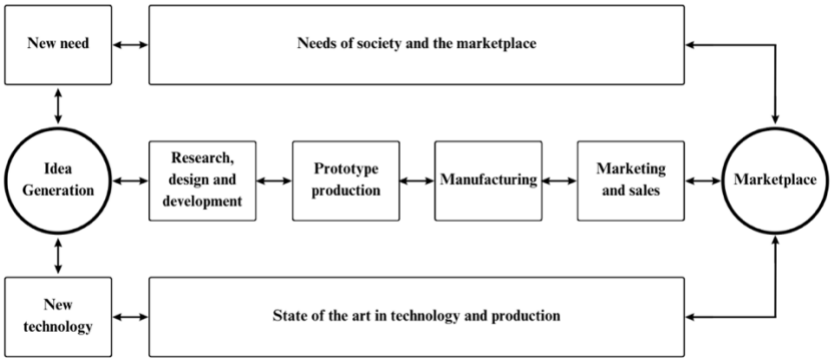

Figure 5 - Third Generation of Innovation Models - Adapted from Rothwell (1994)

The different stages of this model are thus distinct, but compared to the previous generations of models there is a strong interdependence and thus a higher level of interaction (Rothwell, 1994). Consequently, the entire innovation process can be thought of as a network of communications between the world inside and outside the company (Rothwell, 1994), as a confluence to the different internal stages of technology and market needs (Boehm & Fredericks, 2010).

Later, in the 1980s, many American and European companies recognised the power and competitive capabilities of Japanese firms (Barbieri & Álvares, 2016). In those years, characterized by the efficiency of the Japanese Just in time (JIT) model, it was understood that in Japan the two key drivers of innovation processes were integration and parallel development (Rothwell, 1994). Specifically, in fact, the goal of this fourth-generation model (also known precisely as the *"integrated model"*), was to integrate suppliers into innovation development processes and at the same time to integrate the activities of different departments (Rothwell, 1994). As a result, work was based on cross-functional teams, with simultaneous rather than sequential organisation of tasks (Rothwell, 1994). An example of such a model can be represented in Figure 6 below:

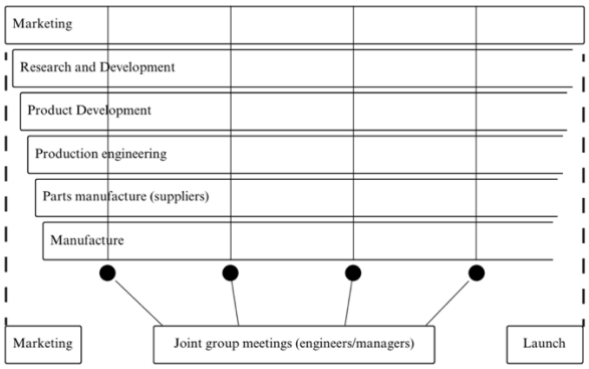

Figure 6 - Fourth Generation of Innovation Models - Adapted from Rothwell (1994)

The fifth generation of innovation models proposed by Rothwell (1994) was developed in a historical context in which technological evolution was becoming more evident and faster (Rothwell, 1994). Innovation was seen as a multi-actor process, requiring a high level of flexibility and integration (both *intra* and *inter* firms) (Barbieri & Álvares, 2016; Tidd, 2006): this approach was certainly facilitated by the strong technological evolution typical of that time, which greatly stimulated also networking (Tidd, 2006).

As anticipated, Rothwell's studies were then taken up over the following years, and this resulted in some contradictions and deepening (Rothwell, 1994). Marinova and Phillimore (2003), for example, pointed out that there was an even earlier generation than the first one identified by Rothwell. This was in fact the black box model, according to which firms, even in their innovation processes, were a kind of box: it did not matter what happened inside it, but only the resources used and the results obtained (Marinova & Phillimore, 2003). Moreover, again Marinova & Phillimore (2003), as well as Boehm & Fredericks (2010) also added a sixth generation of innovation models. It is subject to different visions, but it basically represents an evolution of the fifth in terms of network exploitation and the companies' openness to the outside world and to the new technologies.

Modern innovation practices and models

The previous section highlighted the main developments that, from a theoretical point of view, have occurred historically over the past decades when it comes to innovation models. As described, different generations have followed one another. At the same time, however, it is also appropriate to further investigate the current situation. Indeed, in this section of the paper, the most current models and practices that characterize business innovation processes nowadays will be analysed. Specifically, in this paragraph, the Design Thinking model, as well as the Stage-Gate Process (which has evolved into the Triple-A system in recent years), will be explored.

Design Thinking

As pointed out by Bason and Austin (2019), the Design Thinking model can be developed in different ways, and therefore take on different meanings. First and foremost, as the name itself suggests, it is a way of thinking. Specifically, then, through this way of thinking, we get to transform and innovate (Tschimmel, 2012). In line with this, the Design Thinking model describes "*processes, methods, and tools for creating human-centred products, services, solutions, and experiences*" (Bason & Austin, 2019). It is also defined as a "*design-based approach to solving human problems*", and is increasingly used in the field of innovation (Nakata & Hwang, 2020). In general, therefore, what it is possible to infer is that there is no unique definition for the Design Thinking concept (*IDEO Design Thinking*).

One of the key features of this model is the connection between the so-called "Designer" and the people (users) for whom the innovation is created (Liedtka, 2018). The centrality of the designer is also evident from Carlgren's definition of Design Thinking, arguing that it is a "*multidisciplinary, human-centred innovation approach inspired by designers*" (Carlgren et al., 2016). Another characteristic of the model that can be easily derived from this definition, as well as from the previous ones, is precisely the centrality of the human being, another fundamental aspect of the model (Nakata & Hwang, 2020). In addition, Design Thinking differs in two other aspects: abductive reasoning and learning by failing. On the one hand, in fact, an inductive or deductive type of reasoning is common in other innovative models; in Design Thinking, on the other hand, through an abductive approach without limits or constraints, one can imagine every possibility (Nakata & Hwang, 2020). Moreover, failure turns out to be a fundamental aspect, seen as an opportunity to learn and eventually arrive at effective solutions (Nakata & Hwang, 2020).

But how is this model put into practice? There are several differing views on this in the literature. Some of the leading researchers (Gruber et al., 2015; Liedtka, 2018) identify three main phases of the model. In the first stage, "*customer discovery*" (Liedtka, 2018), the importance of the designer is crucial. More specifically, he or she aims to understand what is really important to customers and what their preferences and needs are (Liedtka, 2018; Nakata & Hwang, 2020). Under traditional approaches, data are collected through interviews, focus groups, surveys, and so on, and then analysed by an expert who, however, is often biased and influenced. With design thinking, on the other hand, designers are brought inside the customer's experience (empathizing) and, through this, are able to capture unspoken needs and hidden preferences (Liedtka, 2018). Next, the collected data are reordered, understood, and analysed. From these, problems and needs are highlighted, and innovators look for potential solutions through the second macro-phase that characterises the model, which is called "*Idea Generation*" (Liedtka, 2018; Nakata & Hwang, 2020). In this phase, potential solutions can be discussed through visual and interactive brainstorming sessions (Nakata & Hwang, 2020). After that, there are discussions, interactions, and evaluations regarding what emerges (Liedtka, 2018). Such interactions among participants are essential, as they allow for sharing complementary visions and different perspectives due to different skills and expertise (Carlgren et al., 2016). Eventually, some of the emerged and analysed ideas are selected to be tested: "*Testing Experience*" is the last phase of the Design Thinking process (Liedtka, 2018; Nakata & Hwang, 2020). In this phase, ideas are tested iteratively, through a loop that consists of continuous creation and testing of prototypes and artifacts (Nakata & Hwang, 2020). From the feedback gathered, then, the necessary modifications emerge to create a prototype closer to the needs of the customers: this process goes on until they are completely satisfied (Liedtka, 2018).

Also IDEO, one of the leading practitioners of the model (*IDEO Design Thinking*), identifies more or less the same three phases previously discussed. In more detail, the approach proposed by IDEO and its CEO and president, Tim Brown, is the so-called 3I model (Inspiration, Ideation, Implementation). These three steps correspond to the Customer discovery, Idea Generation, and Testing Experience phases exposed above, respectively (T. Brown & Wyatt, 2010; *IDEO Design Thinking*).

Another popular approach often utilized to implement Design Thinking practices is the Double Diamond model (Tschimmel, 2012). Developed by the Design Council in 2004, it is a model based on a dynamic convergence-divergence process that is divided into two macro-phases, represented precisely by the two diamonds. Each of these two stages, which in some studies are referred to as the *"problem domain"* and *"solution domain"* (Kakatkar et al., 2020), are divided into two other phases. Accordingly, this model is based on four steps, the so-called 4 Ds: Discover, Define, Develop, Deliver (Design Council, 2019; Tschimmel, 2012). The first diamond, consisting of the first two Ds, aims to understand what the problem is: initially, there is a broader approach, and a set of potential unmet needs of consumers or other stakeholders are considered. In the second phase (Define), all the insights initially collected are filtered, reduced, and selected: this, indeed, is the first phase of convergence (Kakatkar et al., 2020; Tschimmel, 2012). This phase covers the initial part of idea generation as well, which then is implemented in the third step (divergent phase of Development), in which potential solutions to the chosen problem are developed through typical Design Thinking practices such as brainstorming or prototyping. Finally, in the last Deliver phase, the final concept is tested, produced, and commercialised. The final solution is the one identified as the best one for the problem considered (Design Council, 2019; Kakatkar et al., 2020; Tschimmel, 2012).

Although Design Thinking is often used by companies and organisations as one of the main methodologies for innovation, some criticisms have arisen over time. One of the most important criticisms, as highlighted by Iskander (2018), is that the final solutions that are tested are not necessarily the best. More precisely, indeed, the *"feasible solutions"* are those considered best by the people who have decision-making power within the organisation. This implies that in the various stages that make up the Design Thinking, the designer is placed at the centre of the process (Iskander, 2018). In this sense, those with power within the company are sometimes above the people they serve (end users and consumers) (Iskander, 2018). Despite this, Design Thinking remains one of the most widely used innovative approaches in today's industrial landscape.

Stage-Gate Process and Triple-A System

When it comes to the creation, development, and launch of new products, one of the best known and most influential models is certainly Cooper's Stage-Gate Process (Cooper, 2008). It is an *"idea-to-launch"* process that nowadays is often used to turn ideas into successful new products (Edgett, 2015). Business adoption of this model has grown over the years and is continuing to grow now (Edgett, 2015). In its simplest form, Stage-Gate consists of a series of stages in which all the steps necessary to gather information, analyse data, and implement innovative strategies are implemented (Cooper, 2008). These steps are all followed by gates in which go/kill decisions are made as to whether or not to continue investing in a particular project (Cooper, 2008). Typically, in a traditional Stage-Gate Process, there are five main steps, preceded by a substantial Idea Generation phase (Cooper, 2008; Edgett, 2015).

Specifically, then, as pointed out by Cooper (2008) and Edgett (2015), the different stages of the model are the following ones:

- Idea Generation. Initially, it is necessary to identify what are the different opportunities that the market offers, thus generating new potential ideas.
- Stage 1 - Scoping. The first stage is to research the basic information of the project, which will serve as a starting point.
- Stage 2 - Build the Business Case. In the second stage, the level of investigation is deepened, including primary research. Usually, this leads to the creation of a Business Case aimed at defining the product, justifying the project, and proposing a plan for development.
- Stage 3 - Development. Consists of the detailed design and development of the product and the operations required to do so.
- Stage 4 - Testing and Validation. Consists of doing tests to evaluate and validate the product itself.
- Stage 5 - Launch. This stage initiates the large-scale production of the product and its sale in the market.

Before each Stage, as anticipated, every innovative project must pass through a Gate, which serves as a *"quality-control checkpoint"* (Edgett, 2015). Since each Stage has a different objective, functionality, and cost, this will also apply to the Gates (Edgett, 2015). If in fact Gate 1 will consist of the simple screening and selection of the most promising ideas, Gate 3 for example will involve the elimination of those projects that are not deemed worthy of a major investment to develop the product itself (Edgett, 2015). Figure 7 below shows the traditional Stage-Gate process.

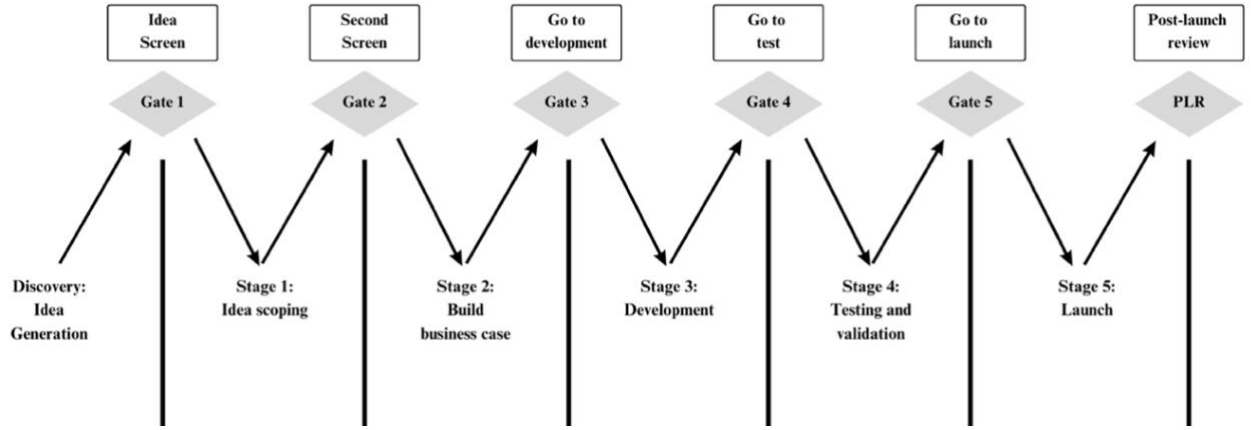

Figure 7 - Stage-Gate Process - Adapted from Cooper (2001)

Apparently, as it is represented, the Stage-Gate model might appear to be a completely linear process, as are those of the first and second generations identified by Rothwell (Rothwell, 1994). Indeed, this turns out to be one of the main criticisms to the model, to which Cooper, the author of Stage-Gate himself, responded. In fact, within each stage there are actually many iterations, loops and back-and-forth before proceeding (Cooper, 2008). Many activities are implemented in parallel, while others even overlap (Cooper, 2008). In this sense, then, Stage-Gate represents a next level from past models, which moreover continues to evolve over time. Cooper (2008), in fact, defines it as a dynamic model that adapts to new business needs and market demands. Indeed, if in the past the Stage-Gate process was a fully functional model, based on the work of individual functions at each stage, nowadays it represents a cross-functional process, which therefore includes all business functions (Cooper, 2008).

Moreover, Cooper himself, laid the foundation for the evolutions that in the present and future will characterize such an *"idea-to-launch"* system (Cooper, 2014). In detail, in one of his more recent studies, he has evolved the Stage-Gate Process through the *"Triple A system"*: in fact, Cooper (2014) has devised a Stage-Gate that is more Adaptive and flexible, Agile, and Accelerated.

Thus, on the one hand, the next generation of idea-to-launch systems will be more flexible and able to adapt and evolve throughout the process (Cooper, 2014). The product will be less defined before entering the development stage, and through build-test-revise iterations will then be adapted to new information that is obtained along the process itself (Cooper, 2014). In addition, the new model will incorporate elements typical of Agile Development, the rapid development system employed by the software industry (Cooper, 2014). These new system will allow rapid movement from one step in the process to another, making the process itself more streamlined and eliminating all the waste in terms of time and resources often caused by excessive bureaucracy (Cooper, 2014).

Finally, the future generation of Stage-Gate processes will be Accelerated: cross-functional teams will devote themselves entirely to the project to speed the product to market as much as possible

(Cooper, 2014). Often some activities within individual stages will be overlapping, and sometimes the stages themselves will overlap: the notion of *"stage"* will thus be less relevant, and the boundaries between one stage and another will be blurred (Cooper, 2014). The new model, therefore, would take the form depicted in Figure 8 below.

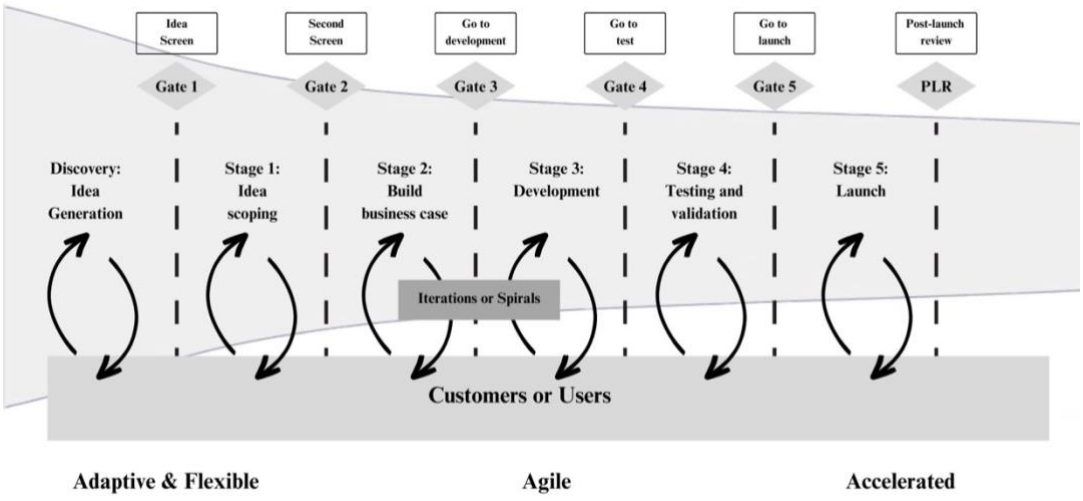

Figure 8 - The new Stage-Gate Process: the Triple-A System - Adapted from Cooper (2014)

2.2 Industry 4.0 and Artificial Intelligence

2.2.1 Industry 4.0

General overview

Over time, as production techniques have evolved and human knowledge has expanded, there has been a series of industrial revolutions that tend to reflect the major technological advances that have occurred historically. Starting with the first industrial revolution, which began in the second half of the 1700s and was characterized by mechanization and the steam engine, we then moved with the internal combustion engine and the intensive use of electricity to the second industrial revolution, which began in 1900 (Lasi et al., 2014; M. Xu et al., 2018). As a result of continuous changes and technological advances, the implementation of the third industrial revolution, characterized by the evolution of information technology and the digitisation of business processes, then began in 1960 (M. Xu et al., 2018). Now, starting in the early years of the 21st century, the business world is experiencing a further massive digital transformation, which is more commonly known as the fourth industrial revolution, or Industry 4.0 (Ghobakhloo, 2020).

Specifically, the fourth industrial revolution represents a period of digital transition and evolution that as anticipated had already begun with the third revolution (Magd et al., 2022; M. Xu

et al., 2018). With the fourth industrial revolution, however, the use of advanced technology tools in the business world is gradually intensifying (Magd et al., 2022) and the boundaries between the physical, digital, and biological spheres are becoming increasingly blurred (M. Xu et al., 2018).

With Industry 4.0, in more detail, there is a push toward the adoption of automation and integration processes in the digitisation process of industries, expanding the application of tools such as Internet of Things (IoT), smart factory, Artificial Intelligence, and many more (Magd et al., 2022). Thus, the combination of the Internet and future-oriented technologies in the context of *"smart"* machines seems to be the basis of the fourth industrial revolution (Lasi et al., 2014).

Industry 4.0 future opportunities

Many studies have reiterated how the fourth industrial revolution will bring great innovation to the future of business (M. Xu et al., 2018) and great changes for workers, but also for society as a whole (Ross & Maynard, 2021). Work and its meaning are bound to change, and a new balance will have to be sought between the benefits of new technologies and the new kind of contribution that is required of employees themselves (Ross & Maynard, 2021). Specifically, thanks to the study by Xu et al. (2018), some of the main future opportunities in relation to Industry 4.0 have been highlighted:

- Lower barriers between inventors and markets: the fourth industrial revolution is intended to reduce barriers between the market and inventors by leveraging technologies such as 3D printing to prototype (Anderson, 2012).
- Integration of different technics and domains: innovative technologies will integrate scientific and technical disciplines in a variety of ways. Such integration will go beyond mere combination because it will create new markets and new opportunities for growth.
- Improved quality of our lives: in many ways, because of the strides that will be made in robotics, customized robots will be able to create new jobs as well as improve the quality of existing jobs.
- Connected life (internet): the Internet of Things will bring advanced connectivity between different devices and systems, going to stimulate the automation of different processes in various fields.
- A more active role for Artificial Intelligence (AI): Artificial Intelligence traditionally has been used to rationally solve complex problems. On the one hand, this will likely lead to the disappearance of a set of jobs. However, at the same time, the ever-increasing trends regarding Artificial Intelligence will cause new opportunities to emerge.

It thus emerges that in the context of Industry 4.0, among the different technologies employed, Artificial Intelligence will play an undoubtedly fundamental role, going to disrupt and redefine the

way of thinking and doing business (Peres et al., 2020). Considering its centrality for the present study, the concept of Artificial Intelligence will be explored in more detail in the following section, to understand the role it plays in business contexts.

2.2.2 Artificial Intelligence

Introduction

The concept of Artificial Intelligence is particularly broad and complex, and over the years it has undergone rapid development. The concrete fields of application and the interest that has been generated over the years have grown significantly over time. As evident from Figure 9 below, there has been a sharp increase in the number of searches on Google for the term *"Artificial Intelligence"* over the past decade, showing a growing interest around it.

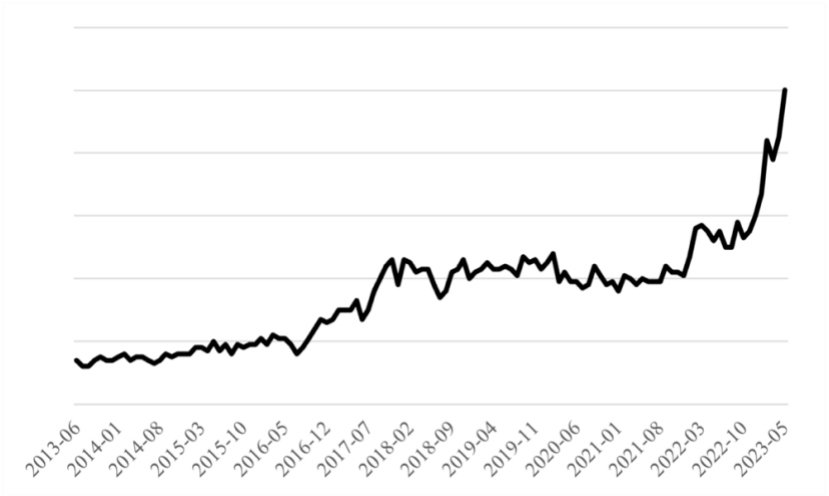

Figure 9 - Google Search for Artificial Intelligence in the last ten years - Adapted from Google Trends

However, before understanding and exploring its various applications in the practical field, it is therefore appropriate to delve into and understand its many different shades in more detail. This will be the goal of the following sections.

Origins and concept of Artificial Intelligence

The birth of Artificial Intelligence (intended both as a term and as a branch of study) is traced by many to the summer of 1956, when during a conference at Dartmouth College John McCarthy and other scientists were discussing how to create machines that could simulate human intelligence (Boobier, 2018). However, it is Alan Turing who is often seen as the true pioneer of Artificial Intelligence: indeed, in his paper *"Computing Machinery and Intelligence"* (1950), the British mathematician tried to figure out whether machines could be capable of thinking (Boobier, 2018).

Over the years that followed, Artificial Intelligence became a real branch of study that has evolved considerably. There are numerous studies that have tried to frame its main features, and various definitions that have followed over the years. Russell (2010) points out that historically, many of the definitions related to Artificial Intelligence refer to a similarity between machines and human beings. In fact, often over the decades, different scholars have defined as *"intelligent"* those machines capable of replicating the way of thinking or acting typical of human beings (Russell, 2010). In line with this view, the following definition is relevant: AI is seen as "*the use of computer programming to mimic human thought and actions to create human-like responses through machine learning, logic, perception, and reasoning*" (Magd et al., 2022).

Another particularly significant definition is that provided by Helmold & Terry (2021), who define AI as a "*wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence*."

In general, then, Artificial Intelligence tools differ from ordinary computers precisely by being, in a sense, *"intelligent"*. On the one hand, classical calculators have always been able to give answers to problems precisely because they are trained to do so (Fogel, 2022). While calculators are capable of solving problems solely because someone has been able to solve them before, Artificial Intelligence aims not only to provide the solution to problems, but also to figure out exactly how to solve new problems (Fogel, 2022). In order to do this, the algorithms on which Artificial Intelligence is founded are based on a reiterative approach of monitoring and understanding (Vishalakshi & Mangai, 2022).

The three levels of Artificial Intelligence: ANI, AGI, and ASI

After having defined such a complex concept, another issue that is worthy of consideration is that there also are different levels of Artificial Intelligence that have been identified by the literature over the years. This classification has been carried out according to how much Artificial Intelligence tools may achieve the capability of emulation of human intelligence. Specifically, the literature identifies three different levels of Artificial Intelligence:

- Artificial Narrow Intelligence (ANI): this is the basic level of Artificial Intelligence. ANI turns out to be specialised in a single area, in a single sphere, or in specific contexts (Goertzel, 2014; Soviany, 2018; Strelkova, 2017). A concrete example of this type of Artificial Intelligence may be AlphaGo, the machine that in 2016 was able to beat the world chess champion (C. Zhang & Lu, 2021), or face recognition devices (Saghiri et al., 2022).
- Artificial General Intelligence (AGI): this is a more advanced level of Artificial Intelligence, at the same level as human intelligence (Strelkova, 2017). AGI is related to the ability to

achieve a broader range of goals and to perform a wide range of tasks, in different contexts and environments (Goertzel, 2014).

- Artificial Super Intelligence (ASI): represents a level of intelligence superior to that of humans in every respect and in every domain, "*including scientific creativity, general wisdom and social skills*" (Bostrom, 2006). Specifically, then, in one of his more recent studies, Bostrom (2014) specified that there are three main types of ASI: 1) Speed ASI, which refers to a machine that is faster than a human being; 2) Collective ASI, which instead relates to the ability to make decisions similar to those that a group of humans would arrive at; 3) Quality ASI, which instead would arrive at solutions that humans could not arrive at.

The Drivers of Artificial Intelligence

As anticipated in previous sections, the concept of Artificial Intelligence has been a subject of extensive debate over the years, considering its being magmatic and constantly evolving. Once the main definitions of this complex concept have been outlined, and the different intensities of AI have been analysed, it is important to understand also what are the drivers on which AI is based. C. Zhang & Lu (2021) identified Algorithms and Big Data as the main enablers of Artificial Intelligence.

Algorithms, in fact, are a crucial building block of computer science. They are essential to the work of computers: algorithms are implemented by different programs, and perform the processing of data and other calculations (Hill, 2016). Therefore, as is easy to understand, there can be no AI without there being an underlying algorithm. Algorithms are what makes Artificial Intelligence possible (Chi-Hsien & Nagasawa, 2019).

Another building block of Artificial Intelligence is undoubtedly Big Data. The available database is of fundamental importance for training Artificial Intelligence algorithms (Kreutzer & Sirrenberg, 2020). With the implementation and diffusion of IoT (Internet of Things), the amount of data generated has increased exponentially and therefore we have come to speak of Big Data (C. Zhang & Lu, 2021). In more detail Big Data have been defined by Kreutzer & Sirrenberg (2020) according to the following criteria:

- Volume, which refers to the breadth and depth of the data set considered.
- Velocity, which refers to the speed with which data is created, updated, analysed, and deleted. Nowadays, many Artificial Intelligence tools rely on real-time data.
- Variety, which refers to the number of internal and external data sources as well as the number of different data formats that need to be considered in different AI applications.
- Veracity, which refers to the quality of available data and sources in terms of absence of errors, coverage of all relevant fields, validity of data over time, and absence of contradictions.

- Value, which refers to the relevance of the data to a specific application.

Ultimately, therefore, the presence of big data that has the characteristics listed above is essential for the development of Artificial Intelligence tools and technologies (C. Zhang & Lu, 2021).

Different subsets of Artificial Intelligence

Once the concept of Artificial Intelligence has been defined and its two main pillars (Algorithms and Big Data) analysed, it is necessary to delve into some of the main branches of AI. As anticipated, AI studies machines with the ability to perform tasks that require the intelligence typical of humans (Helmold & Terry, 2021). As these activities are many, so are the subfields of AI, which are therefore worthy of analysis: in doing so, the researcher wants to give the reader a clearer and more complete picture of the actual implementations of AI technologies.

Specifically, in this section of the present research, the concepts of Machine Learning, Deep Learning, Computer Vision, and Natural Language Processes (NPL) will be explored. They represent, in fact, some of the main subfields of Artificial Intelligence. From a practical point of view, indeed, AI develops in various forms, with different objectives, inputs, and outputs. All of the aforementioned technologies are based on mechanisms and algorithms that are partly different, but at the same time interdependent: many of the Natural Language Processes and Computer Vision technologies, for instance, often use Machine Learning and Deep Learning mechanisms to improve themselves (Shinde & Shah, 2018).

Machine Learning

Machine Learning is often defined as a subfield of Artificial Intelligence (Shinde & Shah, 2018). Specifically, Machine Learning is based on the use of an algorithm that improves the performance and capabilities of the machine, which learns from the data used as input (Nilsson, 1982). In more detail, then, Machine Learning is a software that is able to learn how to perform and tackle a given task without being explicitly programmed for it (Campbell et al., 2020). Looking at the different types of learning methods, four main categories can be identified:

- Supervised Learning: this is when the data used to train the machine are labelled. Supervised learning, therefore, considers data sets that have a specific mapping of input and output data (C. Zhang & Lu, 2021). The aim is to obtain a mathematical function that best approximates this mapping. In fact, the main objective of supervised learning is to be as close as possible to the result that an expert or an *"accepted source of truth"* might arrive at in predicting a given output (Verganti et al., 2020). Given its characteristics, this type of Machine Learning could be applied, for example, to train a model on past sales data and predict future sales (Kakatkar

et al., 2020). Another typical example proposed by Verganti et al. (2020), is that of a model that, by analysing photos of cats and dogs, can tell when seeing another photo whether it is a dog or a cat based on past analysis.

- Unsupervised Learning: compared to supervised learning models, which teach the machine to recognise known outcomes, the aim of unsupervised learning algorithms is to discover insights *"with few preconceptions or assumptions"* (Verganti et al., 2020). Therefore, in this type of learning, the output data is not labelled and the approach in identifying patterns from the data themselves is more exploratory (Kakatkar et al., 2020). For this reason, when it comes to unsupervised learning, clustering techniques are often used to discover commonalities and/or anomalies in the data (Kakatkar et al., 2020; C. Zhang & Lu, 2021). In a certain sense, therefore, the aim of unsupervised learning algorithms is to cluster data in a "natural" way, according to variables that might escape the observer or not seem obvious to him/her. In the example of cat and dog photos, unsupervised learning algorithms could find different groupings, e.g. dividing photos between cats and dogs, or between indoor and outdoor photos, or photos taken during the day or at night and so on (Verganti et al., 2020).
- Semi-supervised learning consists of mixing supervised learning and unsupervised learning. Indeed, both labelled and unlabelled data are used and mixed in the learning process (C. Zhang & Lu, 2021).
- Reinforcement Learning *"is a method of obtaining rewards by interacting with the environment, judging the quality of actions by reward levels, and then training the model"*. These types of models are usually trained by means of a trial-and-error approach, in order to find the action that yields the highest return (C. Zhang & Lu, 2021). In general, such models may even be more effective than supervised and unsupervised learning models, as they have a greater impact: they do not start with data and a clear, labelled vision of the outcome (as in supervised learning), nor are they based on the search for a pattern or an anomaly (as in unsupervised learning). Such systems, in fact, only require a starting point and a performance function: *"the system starts somewhere and probes the space around the starting point, using as a guide whether it has improved or worsened the performance of the algorithm. The key trade-off is whether to spend more time exploring the contextual complexity beyond the current understanding or exploiting the model built so far to drive decisions and actions"*. (Verganti et al., 2020, p7).

Deep Learning

Deep Learning is another subfield of Artificial Intelligence that is rapidly expanding nowadays. More specifically, as the name suggests, it is another learning method and is often referred to as a subset of Machine Learning (Shinde & Shah, 2018). Compared to Machine Learning, Deep Learning differs in the fact that it requires less human intervention (*What Is Artificial Intelligence (AI) ?*, n.d.), but especially because it is based on Neural Network architectures (Shinde & Shah, 2018). For this reason, Deep Learning is often addressed as Deep Neural Networks (Shinde & Shah, 2018; C. Zhang & Lu, 2021).

Specifically, Neural Networks are also a sub-branch of Machine Learning and mimic the functioning and structure of the human brain through a set of algorithms (Kavlakoglu, 2020). They consist of node layers, and more specifically of an input layer, one or more hidden layers, and an output layer. These nodes are interconnected and each of them is associated with a weight and a threshold. If the output of a single node is greater than its threshold value, then data are sent to the next layer of the network; if, on the other hand, the threshold value is not exceeded, then no data are sent to the next layers of the network (Kavlakoglu, 2020).

The word *"Deep"* in Deep Learning refers to the number and depth of layers in the network itself. Specifically, if there are more than three levels, then the Neural Network under analysis can be considered a Deep Learning algorithm. Therefore, apart from the input and output layers, two or more hidden layers (Kavlakoglu, 2020) must be present for one to be able to speak of Deep Learning.

Natural Language Processing (NLP)

Natural Language Process (NLP) is a field of AI that makes machines capable of understanding and processing language (both written and spoken) typical of humans and in a similar way to humans (Gruetzemacher, 2022; *What Is Natural Language Processing?*, n.d.).

C. Zhang & Lu (2021) define NPL as a technology that enables communication with computers: NPL tools are able to recognise words and texts, which are then interpreted by machines. Specifically, NPL is the subject of computational linguistic: indeed, it is an interdisciplinary subject, which is part of AI on the one hand and human linguistic on the other (Chowdhary, 2020; Nadkarni et al., 2011). In more detail, then, computational linguistic is divided into the two categories of *"language generation*" and *"language analysis"*. The latter is then further divided into more specific sub-branches (Chowdhary, 2020).

Since its origins, NPL has evolved considerably and is acquiring more and more capabilities. Among the main activities of NPL, there are: *"natural language translation, information retrieval, information extraction, text summarisation, question answering, topic modelling, and the recent one*

on opinion mining" (Chowdhary, 2020), as well as speech recognition (speech-to-text), sentiment analysis (attempt to extract qualitative insights from texts), text generation and so on (*What Is Natural Language Processing?*, n.d.).

Thanks to the possibilities of NPL, there are now many concrete applications of this technology: it is present in chatbots, text summarisation tools, many translators and so on (*What Is Natural Language Processing?*, n.d.). Among the most recent and most famous technologies that use Natural Language Process models is certainly ChatGPT (Gruetzemacher, 2022), which will be discussed in more detail in one of the following sections, devoted to the new tools of Generative AI.

Computer vision

Computer Vision is defined as *"an interdisciplinary scientific field"* that *"involves using computers to gain a detailed understanding of visual data, which is a similar approach to that of human visual systems"* (S. Xu et al., 2021, p.1). Indeed, the goal of this branch of AI is to train machines to recognise and understand the world through its vision, just as humans do (C. Zhang & Lu, 2021). Thanks to Computer Vision systems, machines can derive meaningful information from images, videos, or other types of input, and then give recommendations or other kinds of output based on the understanding of the input examined (*What Is Computer Vision?*, n.d.).

Shinde & Shah (2018) pointed out that many of the concrete applications of Computer Vision make use of Machine Learning and Deep Learning algorithms and techniques. This aspect is also highlighted by IBM (*What Is Computer Vision?*, n.d.), according to which the two main technologies used by computer vision systems are Deep Learning and Convolutional Neural Network (CNN). On the one hand, it is easy to see how a lot of data is needed to train a computer to recognise certain objects: thanks to the typical algorithms of Machine Learning and Deep Learning, machines can train themselves to recognise an image, for example. On the other hand, thanks to CNN, Computer Vision technologies can *"break"* images into several pixels, assign each pixel a label and on the basis of the label assigned, make predictions about what the object being observed is (*What Is Computer Vision?*, n.d.; C. Zhang & Lu, 2021).

Among the more concrete applications that can be mentioned in the field of Computer Vision are image classification, facial recognition, object detection and object tracking (Shinde & Shah, 2018; *What Is Computer Vision?*, n.d.).

The new era of Artificial Intelligence: Generative AI

According to a BCG article, we are currently experiencing a period of generational change in Artificial Intelligence. In fact, the so-called "Generative AI" (*Generative AI*, n.d.) is at the heart of

many debates. Specifically, Generative AI refers to Artificial Intelligence models that usually make use of the typical mechanisms of deep learning and that, as the name itself implies, are capable of "generating" high-quality texts, images, codes, videos or other content (*Generative AI*, n.d.; *What Is ChatGPT, DALL-E, and Generative AI?*, 2023; Martineau, 2023). More in detail, Generative AI models use *"raw data"* to generate outputs that are *"statistically probable"* (Martineau, 2023).

The rapid evolution that such models have been experiencing in recent months is mainly due to the launch of ChatGPT, which marked the first real inflection point in the public adoption of AI: thanks to this, more and more people started to understand the real transformative and creative potential of Generative AI models (Daugherty et al., 2023). The growth of such models is set to become increasingly intense, and it is estimated that by 2025, Generative AI will have a 30% share of the overall AI market (*Generative AI*, n.d.).

Generative AI models, as anticipated, differ based on the type of output they are able to produce and the mechanisms underlying their operation. Below are just a few of the main Generative AI models on the market today:

- GPT Models: GPT stands for *"Generative Pretrained Transformer"* (*Generative AI*, n.d.). These models launched by OpenAI, the American AI research and deployment company (*OpenAI Website*, n.d.), have evolved rapidly over the years. GPT-3 is the model on which ChatGPT-3 is based. As mentioned above, in more detail, it is the Generative AI tool that consecrated the deployment of AI in the public domain (Daugherty et al., 2023). Specifically, GPT-3 is defined as an *"autoregressive model pre-trained on a large corpus of text to generate high-quality natural language text"* (*Generative AI*, n.d.). This model thus mainly performs language tasks. On the other hand, GPT-4 represents the latest version of the GPT models and is a *"multimodal model"* that accepts as input not only text but also images and produces mainly output in the form of text (*Generative AI*, n.d.). Thanks to GPT-4, the functionality and reliability of GPT models have been significantly improved (*OpenAI Website*, n.d.).
- DALL-E: it is an AI system also created by OpenAI. This model is able to generate realistic images from text input (*OpenAI Website*, n.d.).
- Stable Diffusion: this is a text-to-image model, which therefore, in a similar way to DALL-E, is able to generate images from a written description. Specifically, this model uses a so-called *"diffusion"* system, thanks to which it gradually improves the output produced, so that it reflects in detail the description provided (*Generative AI*, n.d.).

- Midjourney: this is also an image generation model that uses written descriptions as input (‘Huge “Foundation Models” Are Turbo-Charging AI Progress’, n.d.). In terms of potential uses, therefore, it is a similar tool to DALL-E and Stable Diffusion.

As already anticipated, those mentioned above are only some of the main models of Generative AI on the market today. Many new Generative AI tools are being created, launched, and improved all the time. All major tech companies are developing their own Generative AI tools in order to keep up with the times and adapt to technological evolution.

2.3 Artificial Intelligence in the Business World

2.3.1 General overview and future growth

Once defined the concept of Artificial Intelligence and framed some of its main characteristics, it is important to give a more concrete measure of the actual impact this technology can have at the enterprise level.

The contribution that Artificial Intelligence has made so far has mainly regarded the manufacturing industry, reducing the amount of human error, increasing production efficiency, and reducing waste and losses (Magd et al., 2022). Considering the growth that AI is having in its applications, it is estimated that by 2030 such technologies will contribute $15.7 trillion in value globally (Magd et al., 2022). In some European states, the growth in the use of Artificial Intelligence appears to be particularly significant: in Germany, this rate is estimated at between 4% and 32%, and in the UK even between 14% and 45% (Loucks et al., 2021). Consequently, investments by companies are also particularly growing: in 2021, investments for AI-enabled companies increased by 115% compared to the previous year (Magd et al., 2022).

In the following paragraphs, it will be analysed in more detail how AI technologies are being deployed concretely at the business level.

2.3.2 The application of Artificial Intelligence in business activities: opportunities and challenges

Over time, several studies have delved into the concrete applications of Artificial Intelligence in different business processes, as well as the implications that arise from this.

From the research of Sestino & De Mauro (2022), it emerged that some of the main areas of use in the business context involve decision-making and automation processes. Indeed, Artificial Intelligence has been used in decision support systems for several decades already, proving its great ability to extract and create information from raw data (Turban, 1988).

Furthermore, as anticipated in previous sections of this paper, the implementation of Artificial Intelligence tools and technologies has led to a strong increase in efficiency within organisations. In fact, through the process of robotisation and automation of various business activities (including, for example, financial and bureaucratic activities), many companies have been able to eliminate the waste of resources and time. In fact, through the use of machine learning, internal processes can improve in quality and speed, increasing the ability of companies to adapt to the magmatic competitive environment (Davenport, 2018). The positive impact Artificial Intelligence has had in companies has also been seen in the improvement of emotional involvement by employees and consumers due to interaction with *"human-like"* technologies, such as chatbots (Davenport, 2018). The contribution of Artificial Intelligence could also be significant in improving corporate digital security and cyber security systems by immediately detecting potential intrusions or threats (Davenport, 2018; Magd et al., 2022).

Artificial Intelligence, however, is not only used to optimize internal processes: it often plays a key role in improving many external processes as well (Davenport, 2018). Many of the leading companies in the digital transition and evolution (such as Google, Netflix, and Amazon), have used Artificial Intelligence for external practices such as online operations, sales, marketing, and customer engagement (Davenport, 2018). In line with this, in fact, due to its abilities to analyse and interpret data, Artificial Intelligence is often used in mining processes, with the goal of identifying meaningful insights into consumer behaviour (Davenport, 2018), as well as opportunities, trends, and interesting patterns that can positively impact businesses (H. Zhang et al., 2020). Precisely from the analysis of huge amounts of past data, Artificial Intelligence can help in anticipating the future (Sestino & De Mauro, 2022). More specifically, in fact, concrete applications in this regard include: forecasting future sales (Castillo et al., 2017), risk evaluation (D. Zhang et al., 2010), or analysis of sentiments and opinions generated by consumers with the aim of extracting additional information (Rambocas & Pacheco, 2018). Moreover, nowadays, thanks to the evolution and spread of new models of Generative AI, the opportunities for the use of Artificial Intelligence in different industries are growing considerably ('The New AI', 2023).

On the one hand, it is clear that there are many possible concrete applications and numerous opportunities related to the use of AI in business contexts. However, at the same time, it is also necessary to delve into some of the critical issues that emerge in this regard. Several articles, indeed, highlight some main threats or challenges regarding the adoption of AI as a support tool in different business processes. Among them, in an article published in McKinsey Review, it was pointed out that there may be several difficulties with regard to data management. In fact, it is pointed out that *"ingesting, sorting, linking, and properly using data has become increasingly difficult as the amount*

of unstructured data being ingested from sources such as the web, social media, mobile devices, sensors, and the Internet of Things has increased" (Cheatham et al., 2019). Several problems therefore arise with regard to the management of data and their potential use. Managing the sensible data of consumers, in full respect of privacy, could therefore be very complex. Linked to this problem, there is still precarious and totally immature regulation. At the moment, the European Commission is working as early as 2021 on a regulation concerning the use of AI and data protection, identifying different risk levels on the basis of which different AI tools can be accepted or not. Specifically, this legislation is better known as the AI Act (The AI Act, 2021). However, there are still many points to be defined, and it is certainly not easy to work on the regulation of something that is constantly evolving.

Another aspect that needs to be considered concerns the potential presence of bias. In fact, even though it is often believed that AI cannot make mistakes as a machine, in reality, if the data on which the algorithm is driven or the people writing the algorithm themselves are biased, then this bias will also be present in the results (PwC, 2022). When AI is applied in decision-making processes, it is easy to see how basing such decisions on biased data or unreliable outputs can expose companies to make bad strategic choices. In this regard, an article in The Economist reported the testimony of Sam Bowman, Professor at New York University: in more detail, he argued how he sees the possibility of *"AI that police AI"* in the future. In fact, according to Professor Bowman, secondary models of AI will check the main models and see whether or not the outputs obtained are acceptable ('The New AI', 2023).

Finally, one must also consider the set of consequences that Artificial Intelligence will also have in the world of work. According to a recent study by Goldman Sachs, the changes triggered by technological advances in AI could lead to the automation (and thus replacement) of up to 300 million full-time jobs (Goldman Sachs, 2023). This aspect is also referred to in the April 2023 edition of The Economist: it is very likely that, as in the past other technologies did, AI will replace old jobs and create new ones ('How to Worry Wisely about AI', 2023).

2.3.3 The application of Artificial Intelligence to Innovation Practices

As seen from the previous sections, the existing literature related to the application of Artificial Intelligence is vast and covers numerous areas and business processes. However, for the purposes of this paper, it is of critical importance to delve into the current state of the art regarding the use that has been made (or could potentially be made) of AI technologies in innovation processes.

Indeed, as the study by Kakatkar et al. (2020) shows, "*AI can play an important role in the innovation process, from the exploration of problems to the selection of solutions. [...] AI can*

substantially drive innovation analytics." However, several AI concrete applications in innovation processes are still not entirely clear. The few examples in the literature refer to the exploitation of AI in the idea generation phase, with an approach of support by AI technologies during the creative process (Maiden et al., 2023). In fact, for about 30 years already, some digital tools have been used primarily to stimulate human creativity (Maiden et al., 2023). However, now, more modern co-creative AI tools are making room for new opportunities, given the reasoning capabilities that characterise AI machines (Maiden et al., 2023). As anticipated in the preceding sections, creativity is one of the most important drivers when it comes to Innovation (Dani & Gandhi, 2021), and so this is certainly an aspect that deserves to be explored.

Furthermore, Bouschery et al. (2023), argue how especially transformer-based language models could create interesting opportunities for AI-augmented innovation processes. Indeed, the capabilities of translating, summarizing texts, extracting information and insights, or generating creative outputs could play a key role in business innovation (Bouschery et al., 2023). They, in fact, could be used (again in the idea creation phase) to generate ideas for patents applications or to predict trends about future consumer needs. A clear (as well as very current) example of this could be OpenAI's Generative Pretrained Transformer (GPT-3) (Bouschery et al., 2023).

Evidence of further applications of Artificial Intelligence in innovation then concerns the use of this technology in the implementation of Design Thinking practices (Verganti et al., 2020). In more detail, although through their own research Verganti et al. (2020) have demonstrated how the use of AI tools in design practices can help create value, still many questions remain unanswered. Indeed, as Verganti et al. (2020) rightly clarify, the design phase (and even more the idea generation phase), is just at the beginning of the innovation process, which is difficult to fully understand.

Therefore, much remains to be explored: how can Artificial Intelligence also be applied to the later stages of innovation processes? Can AI lower barriers of innovation or boost the main drivers? How can it support innovation along the whole process? Can it be just a supporting tool, or is there the potential for innovation to also be automated in the future and fully AI based? How far can the creativity of AI go in terms of degrees of innovation? Can it be used only for incremental innovation, or does it have the potential to be able to generate radical innovation? What are the future potential developments? What are the main challenges to the adoption of AI within the innovation processes?

These are just some of the points on which, as is evident from the current literature, there is still much clarity to be gained: through the present study, many of these crucial aspects will be further investigated.

3. Methodology

Introduction

This part of the research will describe the methodological approach chosen in order to answer the Research Question. Specifically, the rationale behind the selected approach will be highlighted, emphasising the importance of a methodology that is functional to the topic under analysis. Initially, in the first part of this section of the thesis, the Research Strategy will be explained to clarify how the research was implemented. Next, the Research Design will be analysed. Subsequently, the methodology chosen for the Data Collection as well as the Data Analysis phase, will be explored in more detail. This section of the thesis will then be concluded with a reflection regarding the quality of the research, highlighting how the main quality criteria were met.

3.1 Research Strategy

One of the key aspects to clarify when conducting research is undoubtedly the definition of a Research Strategy that is consistent and in line with the Research Question to be answered. Indeed, the function of the Research Strategy is to guide the choices one makes in terms of data collection and data analysis methodology. These choices, imply then different kinds of relationships that may be present between the theory and the research itself (Bell et al., 2019): therefore, it is evident how the choice of the most appropriate Research Strategy is crucial.

Since the goal of this research is to understand how Artificial Intelligence can support innovation, also looking at potential and future developments, the data needed to answer the RQ of this paper are qualitative. Accordingly, qualitative research has been conducted: this Research Strategy has been considered more appropriate than other research methodologies, such as quantitative or mixed research. While quantitative research is indeed based on the analysis of purely numerical data (Easterby-Smith et al., 2012), through qualitative research, *"words rather than numbers"* are prioritized in both data collection and analysis (Bell et al., 2019). In this sense, for the sake of this research *"words"* were considered, and collected data were interpreted and analysed in depth in order to highlight each significant element that emerged. In fact, considering the interpretive approach that distinguishes qualitative research, it was possible to emphasise the real point of view of the respondents rather than that of the researcher. This does not usually happen in quantitative research, where instead it is the researcher himself who is placed at the centre of the research process (Bell et al., 2019). In fact, in quantitative studies is the researcher that, based on existing theories, formulates hypotheses that must be tested empirically, so following a deductive approach. In the

specific case of this paper, on the other hand, an inductive approach has been followed: the level of novelty that characterises the object of the research led the researcher to adopt a strategy that is exploratory in nature, and that aims precisely at creating new theories without formulating hypotheses *a priori*. This broad and explorative approach followed in conducting the research is typical of qualitative research, which often implies a broader analysis of the entire contexts against a more focused investigation typical of the quantitative research (Bryman, 2016). Indeed, qualitative research tends to have an exploratory and holistic nature (Lofland et al., 2022) and that is one of the reasons why it was considered as the perfect Research Strategy for the present study.

Obviously, this had significant implications with regard to the relationship between theory and research: the former, in fact, has been generated and developed because of the latter (Bell et al., 2019). Indeed, after having collected observations and results, a series of inferences have been drawn from them. These have been useful in building the theory that has been used to answer the Research Question of the present paper.

Specifically, as explained in more detail in the following sections, in order to obtain the primary data needed to answer the Research Question of the present paper, a series of semi-structured qualitative interviews have been conducted. Through this data collection methodology, entirely in line with the selected research strategy, it has been possible to have a data base to analyse and from which to then develop the relevant theory.

3.2 Research Design

A proper Research Design is critical to effectively guide the execution of a given research strategy and subsequent data analysis (Bell et al., 2019). As anticipated in the previous section, for the purposes of this paper, qualitative research was considered the most appropriate. Accordingly, it is fundamental to identify a Research Design that is in line with the type of Research Strategy selected. In fact, there are different types of Research Design, which are also more or less suitable for different types of Research Question.

As anticipated, the goal of this paper is to understand the real potential of Artificial Intelligence when used as a tool to support innovation. Accordingly, the Research Design of this paper has been formed from a set of qualitative interviews. The aim is to understand the current state of the use of such technologies in innovation processes, as well as potential future applications and opportunities, challenges and barriers. In doing so, a holistic approach has been followed, considering not a single neither a multiple case-study, but instead investigating how AI can support innovation from different perspectives and in different industries and companies. The nature and the exploratory

design of the research, therefore, are completely in line with a methodology based on semi-structured interviews, which has been the basic tool for primary data collection (as explained in more detail in the next section).

Once the data and testimonies of different companies and experts have been collected, a comparative approach has been followed, to highlight similarities and diversities in the use of AI, as well as convergent and/or shared ideas about the role that these technologies, which are undergoing strong development today, will play in the future.

3.3 Research Methods

3.3.1 Data collection

To answer the Research Question of this paper, both primary and secondary data have been considered. The secondary data, collected through a Literature Review, were used to get a clear picture of the current literature on Innovation and Artificial Intelligence topics. On the other hand, primary data were gathered through a series of semi-structured interviews. The following sections will elaborate on these aspects and provide a more detailed explanation of the data collection methodology used for the purpose of this research.

Secondary Data

As anticipated, the secondary data used for the present research were collected through a Literature Review, presented in the previous section of this paper. As pointed out by Bryman and Bell (2011), this process provided a solid theoretical foundation for the purposes of this research. Specifically, the approach followed in conducting the Literature Review was a systematic one: this greatly reduced the possibility of developing biases over the course of the research and allowed the researcher to follow clear steps in collecting and analysing the current literature (Bryman & Bell, 2011). In fact, after conducting an initial scanning of scientific and managerial articles and papers related to the topic of the thesis to have an overview of current theory, calls for research and still unclear aspects were taken into consideration. In this way, it was possible to identify a gap in the literature, which made it possible to give a clearer and more specific direction to the research, highlighting a specific Research Question.

As a result, subsequently, the boundaries of the literature review itself were delineated. The three macro-topics relevant to the subject of the research were identified: Innovation, Artificial Intelligence and its applications in the business world. Next, the search for relevant literature was continued using keywords such as: *Innovation, Innovation Drivers, Stages of Innovation, Innovation*

Models, Innovation Process, Artificial Intelligence, Industry 4.0 and Artificial Intelligence, Machine Learning, Deep Learning, Generative AI, Artificial Intelligence in Business, Artificial Intelligence and Innovation.

Specifically, the main research tools used for this purpose were Google Scholar and Scopus. During the search, a set of filters was used by which peer-reviewed articles, textbooks, and other reliable sources were considered for the purpose of preserving the quality of the research. All materials considered were published in English. In addition, mainly data and research after 2010 were considered so as to draw on more recent information and theories in line with the current scenario. Considering the rapid evolution that Artificial Intelligence tools have undergone in recent years, materials prior to 2010 may be outdated and consequently no longer valid and applicable in current business contexts. In this regard, however, some exceptions have been made, citing older sources. Especially in defining the concept of innovation and some of the concepts related to AI, milestones in the literature have been cited to provide a deeper and more complete understanding of the topics covered. In these cases, therefore, some older sources were utilised. In this way, it was also possible to delve into the evolution that some concepts have had over time.

For what concerns articles and papers found through the search, first and foremost, the abstract was read in detail, so as to have an immediate overview of the research and an idea of its relevance and relevance in relation to the present work. The articles deemed most relevant were then later explored and analysed more carefully, deriving from them the theoretical framework on which this research has been developed.

Primary Data

Methodology chosen

As anticipated, to investigate the object of this research and answer the Research Question, primary data were collected. Obviously, the methodology used to obtain such data was chosen based on the type of information needed to answer the Research Question, as well as considering the selected Research Strategy and Research Design. In fact, there are different Research Methods associated with different Research Designs, and different Research Designs more or less suitable for different Research Strategies (Bell et al., 2019). Consequently, to ensure high research quality standards, all these factors must be aligned with each other. Specifically, Bell et al. (2019), identify the following main research methods associated with qualitative research: 1) ethnography/participant observation; 2) focus groups; 3) language-based approaches to qualitative data collection, such as speech and conversation analysis; 4) qualitative collection and analysis of texts and documents; 5) qualitative interviews.

When it comes to the present research, qualitative interviews were the Data Collection method selected. In more detail, considering that the present study aims at understanding how AI could be support innovation, a series of individual interviews have been implemented with different experts, both in the field of innovation and in the field of Artificial Intelligence. In this way it was possible to delve and deepen the main points highlighted. Indeed, compared to other Data Collection methodologies typical of qualitative research, interviews allow for a thorough understanding of the interviewee's point of view, going into their thoughts through questions and clarifications (Bryman & Bell, 2011).

Bell et al. (2019), then identify different types of qualitative interviews: in the case of the present research, data have been collected through semi-structured qualitative interviews. Compared to structured interviews, they differ for their great level of flexibility. Of course, this represents one of the main advantages associated with this type of Data Collection methodology, as well as one of the reasons why this method was chosen. In fact, thanks to the characteristics and structure of semi-structured interviews, there is the possibility to range between different topics, having great flexibility in conducting the research and leaving the interviewees the opportunity to highlight all the points they consider important (Bell et al., 2019). In fact, "rambling" is often encouraged during this type of interview precisely because it allows interviewees to bring out insights that perhaps relate indirectly to the research topic but still turn out to be significant (Bryman & Bell, 2011). In addition, the greater flexibility that distinguishes semi-structured interviews from structured interviews allowed the researcher to ask follow-up questions to clarify certain points or to elaborate on unexpected insights deemed interesting, which often emerge in research of an exploratory nature such as the present.

At the same time, however, compared to an unstructured interview, semi-structured interviews turn out to be partially more focused. In unstructured interviews, in fact, the researcher does not have any kind of reference and the interview often resembles a conversation (Burgess, 1984). On the other hand, although semi-structured interviews do not follow a rigid script of predetermined questions, they still rely on the interview guide. Thanks to this, in fact, while still allowing ample freedom to the interviewee and thus high levels of flexibility, it has been possible to identify a set of topics and potential questions that have formed the skeleton of the interview itself (Bell et al., 2019). This, for the purposes of the present research, was a key aspect to direct the interviews toward those aspects deemed most important in order to answer the Research Question. In more detail, the interview guide of the present research is reported in Appendix B.

Conducting Interviews

Each interviewee was contacted via email: after briefly introducing the research topic, the interviewee's availability to schedule a meeting was requested. Most of the invitation requests were sent in the period between the 20th of February and the 15th of April 2023, considering the deadlines related to the thesis project. The text sent via email can be found in Appendix A.

Prior to conducting the interviews, as anticipated, an interview guide was drafted and served as the starting point for each interview. This guide was then adapted from case to case based on the background and potential contribution each interviewee could provide.

In general, some personal information about the interviewer and the purpose of the interview was reiterated before each interview. The field of research was explained in more detail to clarify any doubts the interviewee might have had before the interview began. Next, some information was given about the estimated duration of the interview, which was usually in the range of 35 to 65 minutes. The variable length of the interviews was mainly due to the different time availability that the interviewees had. A more detailed picture of the duration of each individual interview was given in the following section on the reference sample.

With full respect for privacy, before each interview, permission was finally sought to make an audio recording of the interviewees' responses. In this way, it was possible to realise a detailed transcription of the responses, which, as explained in the following sections, provided the basis for analysing the findings of the interviews themselves. This, moreover, made it possible to focus more on facial expressions and all nonverbal language cues during the interviews, since it was possible to replay the responses and thus it was not necessary to take detailed notes during the interviews.

This whole set of premises was collected in Section B.1 of the Interview Guide, found in Appendix B of this paper. As evident then from section B.2 of Appendix B, a gradual approach was followed for the questions, which moved from general to more specific questions. In fact, after a series of introductory questions about the interviewee and his or her experiences and background, the researcher moved on to more focused questions that covered more specific aspects relevant to the research. In this way, the flow of questions was smoother, and the interviewees gradually immersed themselves in the topic, feeling comfortable during the interview itself. On the other hand, in fact, as Bell et al. (2019) pointed out, the risk of starting with too specific questions right away is to stress the interviewee and thus unconsciously reduce his or her willingness to respond freely and share information. Indeed, starting with questions about the role and experience of the respondent in relation to AI and then delving into more detail about its use in innovation processes was helpful for gradually getting into the core topic of this research.

In any case, the questions in the Interview Guide formed only the skeleton of the interviews. In fact, in each of them, several follow-up questions were asked, both to clarify and verify the interviewee's thinking and to deepen his or her beliefs and views. Finally, the interviews were conducted in real time, either face-to-face or remotely based on the availability of the researcher and interviewees. In the latter case, the video conferencing tools used were Zoom or Google Meet.

Sample

One of the models used for the composition of the reference sample was purposive sampling (Bell et al., 2019). Accordingly, interviewees were selected based on a set of criteria and considering their suitability for the present research. In this way, in fact, only interviewees who had the potential to provide interesting insights to answer the Research Question were chosen. Specifically, considering the purpose of the present research, the two main criteria taken into consideration to delineate the target interviewees were: 1) knowledge and/or direct experience of the world of innovation and innovation processes; 2) knowledge and/or experience of Artificial Intelligence technologies.

To obtain data as heterogeneous and generalizable as possible, people from companies of different sizes and belonging to different industries were interviewed. In this way, a broader and more general view of the potential that Artificial Intelligence tools have in different business scenarios was obtained. For the purpose of this thesis, focusing on a single industry would have been counterproductive: the more general approach taken led to the creation of insights that disregarded the sector and instead looked at innovation practices in a broader sense.

The reference context from which the sample of respondents was drawn is Sweden. This choice was made for two reasons:

- *In primis*, according to the GII 2022 annual report (Global Innovation Index 2022), in 2022 Sweden was the second largest economy in Europe in terms of innovation and the third largest in the world. The Global Innovation Index, specifically, sorts the world's economies based on their innovative capabilities, using about 80 different indicators for this purpose (GII Website). Considering the subject of the research, therefore, the choice of Sweden was purposeful given by the strong expertise that Swedish companies have in terms of innovation. In addition, being a country that is strongly at the forefront of technology, it was possible to find many experts in Artificial Intelligence.
- *In secundis*, the convenience sampling approach (Bell et al., 2019) was applied: respondents were also chosen based on the possibility and feasibility of reaching them. In order to simplify reaching the target interviewees, First to Know Scandinavia's extensive network and, specifically, Per Östling's numerous contacts were exploited. After identifying the starting

group of interviewees, the snowball technique was then applied, leveraging the interviewees' network to reach other potential experts in line with the research topic.

In this way, the choice of respondents was the result of a combination of different scientific methodologies (purposive sampling, convenience sampling, and snowball sampling). This made it possible to identify the most suitable respondents to be included in the sample for the purpose of this study.

Below, in Table 2, is reported a summary with some information about the sample and the different interviews conducted. The names of the interviewees have not been reported to respect the wish of some of them to remain anonymous.

Respondents	Date	Role	Company	Interview length	Meeting location
Respondent 1	09/03/2023	Mechanical Engineer	Yovinn & Smart Eye	55 minutes	First to Know Scandinavia
Respondent 2	13/03/2023	Technology Executive & ISV Developer	IBM Nordics	35 minutes	IBM Gothenburg
Respondent 3	13/03/2023	Project Manager	Lindholmen Science Park	47 minutes	Zoom
Respondent 4	14/03/2023	Innovation Leader	Ericsson & Ericsson Garage	41 minutes	Ericsson Garage Gothenburg
Respondent 5	21/03/2023	Mechanical Engineer	AI Sweden	45 minutes	Zoom
Respondent 6	13/04/2023	Senior Technical Lead & Data Engineer	AI Sweden & Volvo Cars	44 minutes	Zoom
Respondent 7	14/04/2023	Service Designer & Podcaster	SKF Group	65 minutes	Zoom
Respondent 8	17/04/2023	Chief Digital Officier & Board Member	Real Estate Manager and Developer company[2]	45 minutes	Zoom
Respondent 9	02/05/2023	Creative director	Boid	42 minutes	Google Meet
Respondent 10	02/05/2023	Development Leader Digital Services	Göteborgs Stad	51 minutes	Zoom

Table 2 - Summary of Interviews

[2] The interviewee specifically requested to keep the name of the company anonymous.

3.3.2 Data Analysis

As anticipated in the previous sections, all interviews conducted for the purposes of this research were recorded. In this way, it was possible to create transcripts of the responses, to obtain a more complete collection of data than could have been obtained by simply taking notes during the interviews themselves. To facilitate the transcription process, Avrio (an online software that provides a first-draft transcript based on the interview recording) was used. This first raw draft was then revised and corrected, both to familiarise with data gathered and to simplify the analysis process.

On the one hand, these practices allowed the researcher to have a more complete and extensive database from which to start. On the other, of course, it involved a great deal of time as well as a truly significant final amount of data to examine. This is one of the most common problems affecting qualitative research (Bell et al., 2019). In total, in fact, more than 65 pages of transcripts were produced. Thus, considering the large amount of data available, it has been essential to outline a clear Data Analysis method on how to analyse the data collected, so being efficient and effective.

There are several commonly accepted guidelines in the literature regarding the analysis of qualitative data. However, several Data Analysis methodologies have developed from these guidelines, which are more or less appropriate based on the specific characteristics of the data collected and the objectives of the research. Obviously, therefore, the most appropriate methodology must be chosen on a case-by-case basis.

The methodology selected for the purpose of the present research was that of thematic analysis. This approach was chosen based on its flexibility and adaptability. Indeed, in more detail it consists of searching for recurring themes among the different interviews, but different procedures can be used to do so (Bell et al., 2019). Specifically, the main steps that were followed for the present research are:

- Partitioning the transcripts into first-order concepts: these are labels assigned to discrete phenomena. They have been defined as "*theory building blocks*" (Bell et al., 2019). In more detail, first-order concepts emerged through the coding process: specifically, this involved examining interview transcripts and assigning labels to the parts that seemed to have particular relevance or to the most salient points from a theoretical perspective. In other words, the data were broken down into small parts, which were given names. Specifically, the open coding practice has been used for this purpose (Bell et al., 2019).
- Grouping first-order concepts into second-order themes: specifically, a second-order theme can contain one or more first-order concept and thus represents a higher level of abstraction than first-order concepts (Bell et al., 2019; Gioia et al., 2013). In the specific case of this research, twelve second-order themes were highlighted.

- Identification of aggregated dimensions: from second-order themes pertaining to the same topic, four aggregated dimensions were identified. They then formed the basis for comparison with the theory that emerged from the Literature Review, as well as the starting point for structuring the Empirical Findings and Discussion chapters.

To facilitate these steps, also ensuring adequate quality in the execution of Data Analysis, the NVivo software was used. Thanks to this tool, it was possible to visualise concepts and themes belonging to the same aggregated dimension, thus facilitating comparisons between the different interviews. To arrive at the generation of a formal theory, indeed, it is necessary to consider data from contrasting contexts (Bell et al., 2019). This appears to be in line with the design of the present research, which therefore involved the analysis of multiple firms and contexts, in order to have a broad view of the real potential of AI if used as a supportive tool in the innovation process along different industries and companies.

3.4 Research Quality criteria

A key aspect to consider when conducting research concerns meeting specific quality criteria. In general, the most important criteria to consider during research are reliability, replicability, and validity (Bell et al., 2019). However, appropriate differentiations must be made between qualitative and quantitative research. In fact, what has emerged from several studies is that the meaning of these criteria must be modified and adapted to the specific characteristics of the research, thus differentiating the valence and meaning that these criteria have in quantitative and qualitative research. In the specific case of qualitative research, scholars have often debated the relevance of these traditional criteria (Bell et al., 2019). In fact, several alternative criteria have been proposed over the years: in particular, Guba & Lincoln (1985, 1994) proposed trustworthiness and authenticity as alternatives to reliability and validity. For the purpose of this research, this new classification of quality criteria was considered, as it was deemed more in line with the present qualitative research. Therefore, it is appropriate to further explore these concepts, based on Guba & Lincoln (1985, 1994) studies. On the one hand, trustworthiness is composed of four sub-criteria:

- Credibility: credibility of the results involves ensuring that the research is conducted according to the *"canons of good practice"*: in other words, the research should be representative of the real world, showing that the researcher has understood the phenomena studied. For the purposes of this paper, all the formal standards necessary to achieve high credibility were, of course, adhered to: typical research procedures were followed in a scientific and professional manner, so as to avoid any kind of alteration of what the real world is or any kind of bias that might distort reality.

- Transferability: qualitative researchers are stimulated to produce results that can be extended and generalised to other contexts. This, however, is often complex regarding qualitative research, which usually analyses a specific context in depth. In the case of the present research, however, a more holistic approach was used. In fact, different aspects related to the concept of innovation (drivers, stages, degrees), in different time horizons (present and future opportunities and challenges), and in different companies and industrial realities were explored in depth, going to understand how on this framework Artificial Intelligence technology can be used and exploited. In this way, the results obtained can be considered partially transferable to different contexts and therefore more generalisable than those that would have been obtained through a single case-study or with a more focused approach.
- Dependability: usually implies the adoption of an auditing approach. All the different steps and stages of the research process are recorded so that they are accessible and verifiable. This increases the transparency of the research, and usually peers act as auditors. This should preferably be done during the research (and thus not only at the end). In the specific case of this work, all interviews were recorded to realise transcripts that were then analysed in more detail, and in order to be able to further check the data obtained. In addition, periodic follow-ups and frequent update meetings were conducted with the two supervisors of this paper, from both Luiss Guido Carli (Rome, Italy) and the University of Gothenburg (Gothenburg, Sweden). In this way, it was possible to have continuous suggestions, guidance, and clarification.
- Confirmability: consists of ensuring that one is acting in good faith. At every stage of this research, the highest possible level of transparency has always been preserved: the results obtained correspond to the reality of the facts and there were neither alterations at the Data Collection stage nor biased interpretations at the Data Analysis stage.

The second key variable mentioned by Lincoln and Guba (1985) and Guba and Lincoln (1994) is then authenticity. It consists of avoiding bias in the respondents, allowing them to have a broad view of the topic under analysis. As explained in the previous sections, the field of this research was presented in two circumstances: first via email and then later before the interviews. On this latter occasion, it was left room to the interviewees to ask for further clarification if needed, so that misunderstandings and/or biases were avoided before the interview began.

4. Empirical Findings

Introduction

In this section of the paper, the researcher will present the empirical data obtained through the qualitative interviews conducted. The data collected have been reorganised and reported in this section so that the reader can clearly follow the main points of the research. In detail, in fact, the empirical findings of the present study have been divided by topic to bring out the views of the respondents on the various points covered during the interviews. These, of course, were developed from the current Literature, as well as based on the specific data needed to answer the Research Question. The main points analysed during the interviews are: AI and drivers of innovation; AI and barriers to innovation; AI in different phases of the innovation process; AI and different degrees of innovation; AI, opportunities and future developments; Challenges of AI adoption as a supportive tool.

4.1 AI and Drivers of Innovation

Several drivers of innovation were identified from the interviews. Findings that emerged in this regard change from one company to another, based on the different contexts in which companies operate and on the interviewees' direct experiences at work. In general, the main drivers highlighted during the interviews are:

- New market opportunities and new disruptive ways of doing business.
- Fear of missing out and fear of being left behind (competition).
- Technology evolution.
- Strategic intent: efficiency and customer value.
- R&D Investments.

Respondent 1 highlighted how, based on his experience in innovation, he has dealt especially with the first three main drivers. Specifically, in fact, it emerged how the ever-changing world and social environment in which businesses operate opens great opportunities in terms of innovation: "*Our society is not going to be the same in 10 years from now, and so there is an innovation opportunity there.*" In other words, businesses are forced to innovate in order to keep up with the times and align with new societal and consumer needs. In this, according to the interviewees, the role of Artificial Intelligence can certainly help companies to identify new market opportunities, and thus begin the innovation process.

Also the answers provided by Respondent 2 were in line with this: he pointed out that the ease with which businesses today often arrive at new solutions also thanks to the presence of AI, which opens up new opportunities and innovative ways of conducting business: "*there are a lot of people that can create solutions and that can disrupt an old business like, Airbnb or Uber or Bolt or whatever. They can disrupt an old business because it's so easy to create new solutions today.*" Obviously, then, it emerged how important it is for businesses to keep up with the times. Related to this is the second of the drivers highlighted above, which is precisely the fear of being left behind the competition, of not being able to keep up with the latest market developments. This fear, therefore, acts as a *stimulus* for firms, which therefore feel pressured to innovate. The role of competition, then, proves to be crucial, and this is clearly reiterated by Respondent 6, who as visible from Table 2 given in the previous chapter, works at Volvo Cars: "*if Tesla hasn't existed, I don't think that we have talked about AI in our vehicles.*"

Finally, technology (and therefore AI in the specific case under analysis), represents a driver of innovation in its own: "*I think that these waves of AI, like the one we're experiencing now with generative AI, and mostly with ChatGPT, [...] force everyone to prioritize innovation because it makes it so clear that the world will look a lot different in 10 years*" (Respondent 1). This point was also made by Respondent 7, who emphasised that having a new technology available in the market is itself a driver for business innovation. However, what emerged from Respondent 7 is that although the presence of new technology tools such as AI is certainly an incentive for companies to innovate, they first definitely need to learn how to use such technology and not adopt it outright. The topic of how knowledge is crucial to apply and exploit AI will then be taken up in subsequent sections of the findings.

Then there are a whole series of drivers that are related to the Strategic Intent of enterprises. These are in fact goals or metrics that are considered by companies as building blocks on which to innovate. The main driver of internal innovation is the goal of improved profitability for firms: in fact, these firms, according to what is especially evident from Interview 4, Interview 5 and Interview 6, aim to look for innovative solutions that are cost saving, that improve efficiency and productivity. Respondent 6 then clarifies that such investments in R&D in order to improve efficiency are in the DNA of the company itself. In the innovative choices of companies, however, also the desire to ensure better products and services for consumers takes a marked centrality. Indeed, as Respondent 4 pointed out, "*a lot of things that are done to make ourselves more efficient, but a lot is also done to provide more value to our customers.*" In this sense, AI has often been used in the business contexts analysed to counter inefficiencies and improve internal processes and/or services offered. This aspect will be explored in more detail in the following sections.

4.2 AI and Barriers to Innovation

In addition to the drivers of innovation, the interviews also delved into the various aspects that, in the experience of the interviewees, have hindered innovation itself. Again, the goal was to understand whether AI can act as a tool to support overcoming or lowering such obstacles.

The barriers highlighted by interviewees are many and differ from industry to industry. Taking an innovative project through to commercialization (or more in general implementation, if it is an internal innovation), is certainly complex, and this was reiterated frequently during interviews: *"the important thing to note is that there are a thousand ways for innovation to die, but only one way to succeed"* (Respondent 5).

Specifically, however, among the barriers to innovation mentioned by respondents, surely one of the main ones has to do with investment. The amount of money needed to innovate is significant, and the current macroeconomic environment sometimes hinders even business districts that have historically excelled in their level of innovation. Respondent 2, for example, pointed out how the fall of the Silicon Valley Bank could have big repercussions on the level of innovation investment.

Obviously then, employees' limited knowledge of innovation or the use of technological tools in innovative contexts can be another major limitation for companies wishing to implement innovation strategies (Interview 2 and Interview 3). For both investments and limited knowledge, however, interviewees did not indicate any specific ways in which AI can be used to help companies overcome these barriers.

Another barrier worthy of attention, highlighted primarily by Respondent 3 and Respondent 7, is the ability that firms have to manage the risk associated with innovation itself. Risk, in fact, is one of the main stoppers when it comes to innovation within a company: often, firms have internal systems that do not tolerate high levels of risk, and because of this they sometimes stop innovation. According to Respondent 7, AI can be helpful to mitigate this problem: often, innovation stalls because doubts related to the riskiness of the project emerge between different stages of the innovation process. In this, AI can be used as a tool to support the creation of explanatory texts about the project. On the use of AI's communicative capabilities, additional insights also emerged, which will be examined in more detail in the section on the different stages of the innovation process.

Often, as a consequence of the risk associated with innovation, another barrier then follows: many companies, in fact, in response to risk adopt a *"defensive perspective"* (Interview 3), which therefore obstructs innovation in itself. In line with this, in fact, other elements mentioned are *"conservative thinking,"* a *"refusal to change,"* and the *"traditional thinking"* typical of some industries. All these aspects emerged throughout most of the interviews, being in fact highlighted by

Respondent 1, Respondent 5, Respondent 6, and Respondent 8. Also Respondent 10 highlighted how the presence of that kind of mindsets could seriously hinder innovation. Many workers, especially the older ones, are not keyed on innovation and prefer to maintain what they have.

Artificial Intelligence can be used to face these barriers as well. Indeed, as Respondent 1 argued, the problem lies in demonstrating the value of new technologies and change, and thanks to AI it is becoming easier and easier to prove the usefulness of certain tools. In line with all these aspects, then, Respondent 5 pointed out that improvement is definitely not possible when there is a refusal to change, and in this AI can be instrumental: *"what AI provides is another method for change."*

4.3 AI on the different stages of the innovation process

To understand in detail the use and applications of Artificial Intelligence as a support tool along the innovation process, individual respondents were first asked to explain the different stages of the process in the companies they are working for. The responses obtained were largely different from each other for two main reasons:

- Companies are different from each other and adapt their innovation processes to the needs of the business.
- Some of the companies considered (specifically IBM, Lindholmen Science Park, and AI Sweden) collaborate with external partners, sometimes making their contribution only in some of the innovation phases.

Therefore, it was deemed appropriate to present the individual cases separately in the following sections, so as to provide the reader with a more detailed view of each case considered. In this way, moreover, it is also possible to have a clearer picture of what are the main differences and what, instead, the most evident similarities in terms of the application of AI to the different stages of the innovation process.

4.3.1 Interview 1 – Yovinn, SmartEye, and personal AI-driven projects

Respondent 1, in addition to working for Yovinn (an innovative company) and SmartEye (an AI-based company), is currently working privately on a project that aims to be applied for recycling and circularity purposes. Indeed, he has built software that can automatically index random pieces using Artificial Intelligence technologies.

The innovative process typically followed by Respondent 1 is given by the Double Diamond model. The first part of the process is based on an open-minded approach that leads the respondent

to research a problem, an opportunity. The second step in this first diamond is then to identify a single and more specific problem that needs to be solved. Done this, the process moves into the second diamond, where in the first phase the vision is again broadened to seek a *"concrete proof of concept"*, that is a potential solution to the identified problem. One then chooses, in the second phase of the second diamond, the solution that is deemed optimal for the problem initially identified.

Respondent 1, analysing the different phases of the process itself, emphasised the importance of testing the identified solution, *"I do some kind of prototype. They can look very very different, but it is important to be able to test the idea and to get some real-world feedback."* Respondent 1 argues that the essential aspect of making prototypes is to get feedback from people, and therefore it is not necessary to make a very thorough product before testing it, but one can simply make a quick rendering of the product itself. At this stage of design and prototype making, according to Respondent 1, generative AI can potentially be very helpful: *"if you would use Midjourney or one of those generative AI to create images that looks like a description of a product, you can ask people: would you buy it? That's an example of a very quick prototype: you don't build a product, you just like invent a product on a screen. So, it's just enough for someone to understand what it is and can react to it, basically."* In his experience, for example, Respondent 1 said he often made some fake landing pages or fake websites that looked like finished products but actually were not, just to understand how customers interacted with them: *"The idea is to not overthink the prototype, to focus on what answers do we want and how do we get those answers with the minimal amount of work."* Then, starting from the results obtained, an iterative process aimed at improving the prototype and finding the best version starts.

In general, as emerged in the Interview 1, the innovation process could be supported by the use of AI at other stages as well: *"You could just start by asking ChatGPT. You can have a discussion with it, asking for instance to describe different types of ways the problem could be solved."* In this sense, then, generative AI could be used as a tool to support idea research from the very beginning. To this end, Respondent 1 said that he had tried using ChatGPT, asking to be interviewed by it about his project. After explaining how the software created works and what its main features are, Respondent 1 asked ChatGPT to provide a summary of the project itself, and the output was surprising: *"ChatGPT added that in my project there is also the possibility to add a variable light source. So, when we take the pictures, there will be a variety of different light sources, and so the shadows will fall differently. I mean, it's something I of course have thought about, but I didn't mention it. It came up with it on its own. I mean, ChatGPT was like: if you have to build such a machine, then this would be like a natural feature to have."* Respondent 1 thus pointed out that ChatGPT can certainly be a tool to stimulate creativity on the one hand, but also to lead the innovator

not to forget basic features that are, however, demanded by the market. Often, in fact, according to the interviewee's thinking, innovative people are at the extremes, being *"out of the box."* A tool like ChatGPT, which is a statistical model, indeed provides as a response a set of words that combined are as close as possible to common knowledge. In line with this, Respondent 1 believes that tools such as ChatGPT can be particularly useful in communication during all stages of the innovation process, which is certainly something that should not be underestimated: *"it's all about communication. If I'm not able to communicate what my idea is and how it can help people, nothing will happen. And if you're in an organisation, if you can't communicate the benefits, then you won't pass the next step."* Whether one wants to communicate their idea to consumers or internally within the enterprise to move a project forward, AI is able to adapt to its interlocutor and effectively summarise an idea that would otherwise be difficult to summarise. This, then, in addition to helping at the marketing stage of the product by making consumers understand its characteristics and potential, could also be useful along all stages of the internal process.

An aspect worthy of attention, is that the uses of ChatGPT mentioned above, are related to the project that Respondent 1 is following individually. In the business contexts in which the Respondent operates, however, the adoption of such tools is still complex: *"we're starting to look at GPT potential, we're looking for it, but it's nothing that we use today."*

4.3.2 Interview 2 – IBM Nordic

Respondent 2 works at IBM Nordic as a Technology Executive and ISV & Developer Relations. Specifically, he has the role of establishing and strengthening IBM's relationship with leading Nordic start-ups, scaleups, and ISVs. Thus, on the one hand, he works internally on IBM's processes; on the other hand, instead, he interacts with a range of external companies. This dual perspective has led Respondent 2 to interface with different innovation processes over the course of his experience. Indeed, on the one hand, IBM has its own internal innovation process, which often follows the typical principles and mechanisms of design thinking according to what emerges from the interview. On the other hand, however, the interviewee says that when he works with start-ups and scale-up companies, he does so as an accelerator or incubator point of view. In this sense, the innovation processes are the most varied.

However, considering that mainly Respondent 2 works with scale-up companies, he tends to take over when companies have already undertaken the early stages of the innovation process: *"Here at IBM we have been working with more with scale apps than start-ups. So, they have done something, when we have been working with them: they have done their MVP (minimum viable product), they have done their stuff."* In this process, Respondent 2 highlighted how the main use of AI is in trying

to figure out if the companies under consideration have an idea that is unique or not: *"We can use AI to figure out if the company has a solution that is unique. We use AI to see other stuff inside the companies, as well as IP rights, patents and so on. So, we use AI, for instance, to see if their solutions violate some patents. Because if you have your solution and somebody else has a patent, you cannot do what you are thinking of doing."* According to the findings, then, the usefulness of AI lies mainly in mapping competitors' strategies to understand whether solutions and ideas identified in the business innovation process are usable or whether they are already being adopted by other players in the market. Many companies then, according to Respondent 2, are starting to use AI right from the ideation stage. In this, according to the interviewee's point of view, creativity could be boosted if one has a good AI tool. In fact, AI could make suggestions and confirm the validity of an idea, as well as map competitors' ideas and products. In general, Respondent 2 highlighted how in his view in the future AI will be able to provide a solution to problems automatically: *"you maybe will use text and you will say: well, do this and this. And it will automatic built solution for you, without code. You will say: well, find a solution using these data."* Moreover, according to the interviewee, AI will be applied more and more in all stages of the process, which nowadays is still often not done: *"So of course, AI can be used in the innovation process and in all processes, actually. But we are not there yet. We and nor still using AI in all steps. In some steps, yes. But not in all steps."*

4.3.3 Interview 3 – Lindholmen Science Park

Respondent 3 is employed at Lindholmen Science Park and works as a project manager and innovation leader in a project that aims to spread digitisation across the broad tourism industry. Specifically, as clarified by the Respondent 3 himself, *"digitisation"* means *"big data and machine learning strategies, intelligent visualizations and new business opportunities."* Their approach to innovation, in more detail, was defined as a linear and traditional funnel, which starts with finding new opportunities and challenges, or problems to solve: *"we're vacuuming the whole area for challenges, problems.*" When something that has potential and can involute numerous stakeholders is found, then usually it becomes a project. A series workshops or meeting opportunities are then set up, where the purpose of the project itself is more clearly defined. Once the plan of action has been identified, all the players involved collaborate to find a solution to the problem itself. At this stage, digital twin technology is often used to test potential solutions and study their concrete effects. Specifically, at different stages of this process, machine learning is sometimes used to gain more meaningful insights from the data collected.

From the interview it also emerged how ChatGPT is used in personal processes by Respondent 3, but not as a business tool: *"I would say ChatGPT is fantastic when it comes to my innovation*

process. In my daily work, I use it sometimes to help me figure out good formulations in applications and so on." In internal processes, in fact, from what emerges from Interview 3, AI is not currently used as a support tool: "*in our projects, we have decided not to use Artificial Intelligence in that scope [...] since the data has not been good enough."*

4.3.4 Interview 4 – Ericsson and Ericsson Garage

Respondent 4, as anticipated in Table 2 reported in the previous chapter, is an innovation leader at Ericsson and Ericsson Garage (Ericsson's innovation hub). The respondent's statements revealed how the innovation process changes between Ericsson and Ericsson Garage. Specifically, in fact, the model adopted in the Garage appears to be a bit more flexible: *"I don't think we have strict main steps."* Respondent 4, however, makes it clear that there is usually a lot of work at the early stages of the innovation process: *"we work in the early parts of the innovation funnels, generating ideas, finding ideas, new ideas, and then we try to figure out what ideas could be interesting to take a little bit further."* At this stage, third parties, companies or potential partners who might be interested in the idea are usually contacted to be included in the project, and in order to discuss and see if there might be common benefits in collaborating.

After an initial phase of idea generation, then, those that are deemed most interesting and may have potential go on to be deepened and turned into an actual project, to which resources and time are devoted. At a certain point, however, there comes a time when it becomes necessary to turn to Ericsson Global: *"[...] if you want to come to a point that this should be scaled up, you need to invest more money. At Ericsson Garage we have some financial resources too, but at a certain point you have to pitch it into Ericsson global to have more resources and more money."* At this point things become more structured: *"There are quite clear gate stages in Ericsson global. But before that, we don't really stage or have clear phases in what we're doing here."*

According to Respondent 4, AI has great potential when used as a tool for innovation especially in the first stages of the process. Indeed, the interview revealed how AI can have the potential to identify problems and propose possible new solutions, as well as in having new ideas and thus in stimulating the creative process. In this, according to the interviewee, AI has an edge: *"trying to find a solution to a problem is what was so difficult with innovation. That's because we know what we know, and we often also know what we recently have experienced, the short-term memory, where do we start to search for the solution. I think an AI could be more open minded than we can be. [...] Innovation is very much about connecting dots, right? Connecting things that already exists in a new way. That's the most of what innovation is. I guess that AI bots could be as good as many people and become better than us to actually do that, because AI could look at so many more dots than we can."*

What is interesting to point out, however, is that although the respondent is firmly convinced of the applicability of AI in innovation processes, at the same time it emerged from the interview how he has not yet experienced it directly in business projects. What emerges is that companies, according to Respondent 4's view, still do not adopt AI as a supporting tool at all stages of the process, but that we are currently at an *"inflection point."* This means that between now and the next few years, according to Respondent's vision, AI will be an increasingly widespread tool in companies' innovation processes.

4.3.5 Interview 5 – AI Sweden

Respondent 5 works at AI Sweden, where he oversees several projects and collaborates with different partners in order to facilitate the experimentation of AI in different uses and industries. Specifically, then, Respondent 5 was interviewed to understand whether and how the different companies and partners he works with have used or are using AI as a tool to support innovation.

In his experience, Respondent 5 came into contact with several companies that use AI for problem identification. A concrete example the Respondent provided concerns a company working in the automotive industry: *"It's a company working on developing self-driving software for autonomous cars or autonomous vehicles. They're using AI to highlight where their current software is insufficient. So, in a sense, they're using it to find problems that they can then try to solve. In a certain way, that becomes an early phase of the innovation process."* This, however, is not the only example highlighted by the interviewee. In fact, another particularly interesting case involves a group of scientists and researchers who were studying the movement of Gilmores, birds that live near the beaches of Gotland Island (an island in the Baltic Sea). Machine learning technologies were used for this purpose, thanks to which they discovered unexpected trends and insights that they were actually not even looking for: *"the secondary information they got that they didn't see from the beginning was that they can actually more or less live measure the amount of fish available in the sea, where that fish is, and how large amount of fish there is."* All this was simply because the AI noticed a pattern between the weight of the birds as they departed and returned to the beach, as well as the duration of their flight. All of these were identified by the AI as proxies for the location and size of the shoal of fish.

Through these two examples, then, Respondent 5 reiterated how through the use of Artificial Intelligence it is possible to find problems, patterns, trends, or insights that *"from a machine learning perspective, become self-evident that they exist even though we didn't know they existed."* From these, then, a process of innovation could begin.

In general, then, according to Respondent 5, *"AI opens to new possibilities,"* and a current concrete case is ChatGPT. Respondent stated he used it as a support tool in one of the projects at AI Sweden, and noted how it was particularly helpful in making suggestions to stimulate brainstorming sessions and to expand their vision. In this sense, therefore, Respondent 5 argues how AI can greatly enhance human creativity, and this is certainly relevant in innovation processes.

Then, according to the respondent's claim, AI also has the potential to be applied in the later stages of the innovation process, such as to design a new product. In support of this, the interviewee said he has noticed that some companies are leveraging AI to simplify processes that have traditionally been complex, and design is certainly among them. Ultimately, then, the impact of AI on innovation processes can certainly be very significant: *"AI, and ChatGPT today are changing the innovation ecosystem. It's pushing players out. It's bringing in new players. So, it's a big disruptive tumble of steel."* Especially in traditional industries, where things have been done for so long always in a certain way, *"AI is a good candidate for driving innovation."*

4.3.6 Interview 6 – Volvo Cars and AI Sweden

Respondent 6 works both at Volvo Cars and at AI Sweden. At Volvo Cars he has the role of data engineer in a part of the organisation that supports the R&D department. On the other hand, at AI Sweden, he manages, administers, and develops the implementation of the Lab Infrastructure. Due to this dual job position, his experience in the AI field is particularly relevant, with the use of object recognition, classification, and machine learning tools primarily in his employment at Volvo Cars.

Precisely in the automotive company, Respondent 6 argued how there is a very fast innovation process, consisting mainly of two macro-phases: idea generation and proof of concept creation. Often, therefore, the stage of creating a business case is skipped, as given the technicality of the role, they go straight to finding a solution to the problem: *"as technicians, we go to straight to solve the problem."*

The first phase, however, again consists of generating new ideas, which usually, in Respondent 6's experience, arise subsequent to the identification of an innovative idea or problem. In this, Respondent 6 highlighted how AI can be helpful: *"(AI can be helpful) by finding gaps both in what we are missing to be able to support our ideas, but also to find gaps in the product. [...] you can scan patents and find a gap, you can write your own patent and AI might actually be writing the patent for you."* Although the interviewee calls AI still immature to be able to drive innovation in all its phases, one application that is therefore identified is the ability to identify *"hidden dependencies"* among a vast amount of data.

However, this is not the only potential use Respondent 6 recognised for AI. In fact, the interviewee strongly argues how it has the potential to also support further stages of the innovation process, such as that of designing a possible solution to the identified problem. In more detail, in his experience at Volvo Cars, Respondent 6 said that AI is used to identify what is the best possible design for the structure of specific car components to improve their durability over time. This is a clear example of how AI cannot only identify problems and generate new ideas about them, but also identify potential optimal solutions to those problems.

Subsequently, then, according to what emerged from the interview, prototypes of the product are usually made, and even at this stage the respondent argued that AI can be used as a support tool. Respondent 6 did not provide any kind of concrete examples in this regard about his work experience, but he certainly recognised the potential that Generative AI tools have in this regard. The respondent referred specifically to stable diffusion models, AI technologies capable of generating images from text. In this sense, in fact, one would only need to enter as input an accurate description of the product one has in mind to obtain a graphical representation of it through the use of AI. In this regard, however, Respondent 6 specified how to a large extent such tools can only be used to get a digital approximation of the new product, because many of these AI tools are not yet as accurate as it would serve to be used in the enterprises. Applications of this kind, however, will become more and more accurate and can lead to large reductions in design and prototyping costs, going a long way toward speeding up processes. For these reasons, in fact, Respondent 6 believes that such technology will be used more and more in every industry: *"I think that it'll come more and more, because it's quicker, designing it directly more or less as you enter the numbers. And it'll be cost saving in the product in the end."*

Finally, what emerged according to Respondent 6's statements is that one of the biggest difficulties in the innovation process is convincing the people who have the decision-making power to push a particular innovation project forward. In this, certainly, AI can be helpful. The tool mentioned also in this case by the respondent is ChatGPT, which could be used to make pitches and presentations of innovative projects *"more selling."* Therefore, Respondent 6 also recognised the capabilities that some AI tools have regarding facilitation in internal communication processes.

4.3.7 Interview 7 – SKF

Respondent 7 works for SKF as a service designer with a focus on innovative projects and innovation processes. Over the years and through his experience, the interviewee claimed to have been involved in several data-driven projects that would have benefited from the use of tools such as Generative AI and advanced machine learning systems. In fact, today, according to the interviewee, there have been

so many changes in different aspects because of the access one has to these new tools. In addition, the interviewee is also a Podcast Host, and because of his experience, he produces content regarding the application of modern technologies in the world of design. Specifically, therefore, he delves into the intersection that is present between design and AI and robotics in general.

In the interviewee's experience, innovation processes usually begin with the identification of a problem to be solved. There is then a subsequent generation of potential ideas on how to solve that problem. From there, we then move to an *"implementation and funding"* phase, where the idea identified as potentially best for solving the problem itself is implemented. Obviously, in this, it is necessary to have sufficient economic resources available to support the innovation process itself.

Respondent 7's focus, however, is directed primarily at the first stage of the process. In fact, according to the interviewee's view, when it comes to innovation, it is precisely the problem that must be placed at the centre of the entire process: a good idea regarding an innovative product or service is not valuable if it is not connected to an actual and well-defined problem worth solving. AI can certainly be applied in the definition process of the problem itself, according to the interviewee: *"you can use some capabilities of generative AI, [...] to do some sort of analysis, to try to get a good understanding of the problem from the perspective of people and process."* The essential aspect within an organisation, then, is not only to identify the problem through analysis and research, but also then to get it understood by all the people working on it. In this, Respondent 7 believes that AI can help a lot. Specifically, according to the interview, AI could play a key role in improving the level of clarity of communication throughout the different steps of the innovation process: *"I think the communication within the innovation chain is absolutely the cost of that [...] People are quite bad at writing and communicating, the levels are quite different. So generative AI or AI in general can serve as an evener that makes it less unequal between different people at a company and makes it so that managers can more easily understand what the innovation teams are doing."*

Even in the implementation phase, and specifically with regard to the design phase, the interviewee recognised the potential that could be linked to the use of tools to support Generative AI, such as Midjourney: *"you can ask Midjourney to solve that problem [...] maybe you could create a better sketch, but you would have to be so precise. You would have to be so exact in how you prompt Midjourney."* What emerges, then, from the respondent's testimony is that to use the tools currently available, one must be particularly precise. However, Respondent 7 acknowledges the possibility that these tools can enhance the capabilities of those who use them: *"I can see situations where I would benefit from that [...] but you have to look at these tools as augmenting the capabilities of the people that are using them."*

Ultimately, then, Respondent 7 argues how AI can certainly support innovation: *"AI can support innovators for sure in what we can create, in what's possible to create."*

4.3.8 Interview 8 – Real Estate Company

Respondent 8 is the Chief Digital Officer (CDO) of one of the largest real estate companies in all of Scandinavia (which in this section will be called RECompany for brevity). Specifically, the interviewee is primarily responsible for the company's digital development. At the same time, he serves on the boards of several coworking companies that have been acquired by RECompany. These include an innovation lab in which digitisation and the use of AI are stimulated. The experience in the field of Artificial Intelligence has been gained as well along the previous positions held by Respondent 8 in other companies: *"I've been building five AIs in the previous company I've been working for [...] One is extremely good. It's generating a lot of millions, I would say."* In addition, the interviewee has been to Silicon Valley several times, also as a beta tester of ChatGPT: *"I've been using ChatGPT since last summer, because I've been a beta tester. I've been in Silicon Valley many times. I have some friends there who wanted me to test this really early."*

As a result of that experience, the interviewee says that since late 2022 they have been doing innovative experiments within RECompany, precisely through the use of ChatGPT and other Artificial Intelligence tools. Specifically, in fact, the interviewee stated the following: *"we started to do experiments with this (ChatGPT) in November, maybe October, in order to connect data, and ask how we should push financially, how we should change the company in different ways."* Based on the results obtained through these very experiments, ChatGPT was described by Respondent 8 as a *"really smart colleague at work."*

More concretely, what emerged from the interview is that there are different innovation processes within the company. Regarding the construction of new properties, they usually start by doing studies that test the feasibility of the project itself, through the creation and analysis of business cases. In contrast, for situations where there are out-of-the-ordinary and completely new ideas, the innovation process that is usually followed is different. Specifically, in these circumstances, RECompany uses an app, where any worker who has an idea can share it with colleagues and start a discussion about it. If it then proves to have potential, financial resources are provided to further explore and develop that idea, including for the purpose of testing it. At this stage, a proof of concept is usually developed to see if indeed the idea actually works.

According to the interviewee, the uses that can be made of AI in all these different steps are many. Artificial Intelligence tools, for example, can be used right from the start as support in the generation phase of new ideas or again to find problems in business or needs among consumers.

ChatGPT was also used by RECompany to find out whether the ideas considered had already been developed by someone: *"What you can do is ask ChatGPT: I have an idea. Is it anybody else who has done this before? There you can have a really good one, because then you have a huge database. We have actually tried it."*

Another potential use that could be made of AI according to Respondent 8's vision would be to employ it to validate the ideas themselves, separating those that have actual potential value to the company from those that would not bring any added value: *"I think AI can be applied to see what kind of ideas look good or bad. Like: okay, we have an idea here, and in that area we run this business expensive, so it must be some money we can save."* In this sense, according to the interviewee, AI could be employed to prioritize the immense flow of ideas that one has especially within large companies. In some of his experiences, indeed, Respondent 8 stated that he had to manage fifty to a hundred new ideas every day, coming from different parts of the organisation. Therefore, having an AI to select the best ones would be a way to save money and time.

In the internal processes, however, before using ChatGPT as a support tool to make decisions along the steps of the innovation process, Respondent 8 argued how RECompany creates its own dataset. On this, one does advanced analytics for then asking ChatGPT what strategy to implement based on the analysis done: *"what we do is that we take the data we have, and we do advanced analytics on that kind of data. Then we ask a normal question to ChatGPT. Like: should we do this or that way?"* If companies do not have data, this procedure cannot be put into practice: according to the interviewee, ChatGPT is useful if you know what to ask, and to know what to ask, you need to have analysed your company's internal data. A similar point was made regarding the use of Midjourney or similar tools at the design stage: *"when it comes to design, it's excellent to start with Midjourney or similar tools I think. In the real estate business, for instance, I can say: okay, give me a fancy house or whatever. The tricky thing here, I think, is to write the right question."* And to ask the right questions, you must have meaningful data. Therefore, the *conditio sine qua non* for doing this is to have internal data to do this. According to what emerged from the interview, thus, this represents one of the major critical points regarding the use of AI as a support tool in innovation processes, and one of the main reasons why AI is not yet used at every stage of the innovation process. Given its centrality, this point will be taken up in the next section on Challenges.

4.3.9 Interview 9 – Boid

Respondent 9 works as a creative director at Boid, a product design studio located in the city of Gothenburg. His background as an Industrial Design Engineer and the many experiences he has had during his working career have led the interviewee to develop a range of practical and theoretical

knowledge regarding the concepts of innovation and Artificial Intelligence. With specific regard to the latter, the interviewee points out that within Boid it is used in its more traditional forms, such as machine learning. This type of AI has been, over the years, an integral part of various projects and a tool through which they have tried to provide a practical solution to the problems that the company had to solve for its clients. On the other hand, however, Respondent 9 has repeatedly pointed out that especially in recent months, particular attention is also being paid to the so-called *"more modern"* AI tools, such as ChatGPT, Midjourney and stable diffusion models in general. In detail, these are not tools that are fully integrated into internal processes, at least not in an official way; however, what emerges is that these tools are available to workers in their premium versions, and are therefore exploited as support in more and more activities.

Within the company, innovative processes change depending on the type of project and the needs of individual customers. However, according to the interviewee, it tends to start almost always with a *"user research"* phase, where one tries to understand exactly what the customers' problem is by means of interviews, observations and other data collection and analysis tools. Also in this, the tools used may vary depending on the type of user to be analysed. This phase emerges as particularly complex in some circumstances: it is not always easy to collect data, especially with certain categories of users. To succumb to such problems, the interviewee claimed to have used chatbots, which were asked to imagine that they were a certain category of users: *"we had asked to chat bots like: can you imagine that you are this user, and you are faced with the situation, what could be the possible pain points, for example. And sometimes it's been really weird and sometimes it's been pretty good."* The results of such use were therefore varied, with situations in which the AI responses were strange, and other situations in which good cues were obtained. On this point, the interviewee insisted: *"we are designers, we're used to working with users, so we can imagine a lot of things. And when we do interviews, a lot of it is just to verify. But sometimes we also see something that we didn't expect. And that is when we can really ideate. I think that could be possible with AI as well, to imagine situations and come up with scenarios where, we could look at that sort of description and just realize: ah, this could be a thing."*

After this first phase, the innovation process typically continues with an idea generation phase, which usually takes the form of workshops in which several of Boid's employees work together to identify potential solutions. So far, the interviewee claimed that AI has not yet been employed in this phase, except to obtain suggestions for minor problems. In these circumstances, however, the interviewee pointed out that the ability of tools such as ChatGPT to make good and quick suggestions has certainly helped. According to the interview, in fact, AI was used to generate project suggestions.

However, as claimed by the interviewee, the real use has been in the next step, which consists of the product design phase. In this regard, the interviewee gave several examples: *"We have also used it in the innovation process when it comes to actually industrial design. For example, when we design a vehicle in a stable diffusion, you can use this image-to-image algorithm or a model where you input an image. So basically, we input the frame of the vehicle we're developing: this is where the lights go, this is the general layout of it, the size of it. And then we can choose, to vary that to certain degrees together with a prompt. So, we can get a number of suggestions of variations of the lights, of the different placement of things. And this works really well if it's something of known like a vehicle."*

Finally, another aspect that was emphasised by the interviewee is the use that is made especially of ChatGPT in order to make texts and/or speeches more professional, so as to communicate more effectively both with customers and within the company. This, which in the past was a skill that the interviewee claimed he had to acquire over time, is now an activity that can be done more effectively and faster using AI tools.

4.3.10 Interview 10 – Göteborgs Stad

Respondent 10 performs the role of Development Leader Digital Services at the municipality of Gothenburg, in a department called *"Democracy and Citizen Services"*. In the work he does, the aim is to try to involve citizens as much as possible, making them part of the projects. Specifically, then, the interviewee deals with projects that have to do with the sphere of digitalisation. During the interview, it emerged that for the time being, AI tools have not been officially integrated into innovation activities, given the many problems that exist in this regard, especially in terms of regulation. However, during his work activities, Respondent 10 has used modern AI tools such as ChatGPT, widely recognising their potential in several respects.

Focusing more on the innovation process, the respondent pointed out that the process followed tends to be the one on the *Innovationsguiden website*. This model consists of a service design process, which follows a step-by-step methodology. It is made available to Swedish companies, individuals and institutions that want to innovate.

The first step is to collect data to define what the underlying problem is. In this, the interviewee argued how AI can be crucial in helping to collect the necessary data. The second step is then based on the analysis of this data: *"the next step is to analyse and evaluate, look at the data. So really researching the information also there. And AI can help you a lot more than you can do."* So, even at this stage, AI could be used as a support tool, leading to better results. The third step is to try to exploit the insights gained from the previous steps by focusing on the problem and/or project with

real potential. At this point, we move to an idea generation phase, where participants exchange their respective visions of the project. In this phase, the interviewee emphasised how important the support of AI can be: the example given by the interviewee concerns the use of ChatGPT to obtain suggestions of various kinds. Asking simple questions or asking for suggestions could stimulate the idea generation process.

Once a set of ideas has been identified, the next step is to test them. In this sense, the interviewee makes it clear that it is necessary to develop a prototype, physical or virtual, from which data on user reaction and interaction can be obtained. While AI cannot make physical prototypes (especially depending on the type of project), it has great potential for making virtual prototypes. Furthermore, the capabilities of AI can be used not only in the realisation of a prototype, but also to analyse and evaluate the data obtained during testing. The example given in this regard by the interviewee is significant: if one wanted to build a cycle route, it is obvious that it would not be cost-sustainable to build a physical prototype. In this sense, however, AI could help by providing insights into tracks built in the past: *"it can understand how 50,000 asphalted roads have performed previously in racetracks, in bike tracks, in mountains, in coal weather and all that. And it can give you the steps that you need to build on, how to build and what the result usually is."*

Respondent 10, then, also recognised the great capabilities AI has in terms of communication: the respondent pointed out that we often have to deal with language barriers. AI is able to break down these barriers by adapting to the interlocutor to whom the message is addressed.

4.4 AI and different degrees of Innovation

Another interesting aspect that was sought to be investigated during the interviews concerns the impact that the use of Artificial Intelligence as a supporting tool in the innovation process could have in terms of degrees of innovation. In this regard, respondents were somewhat contrasting in their statements.

Respondent 1 pointed out that in his opinion AI can definitely be employed with regard to incremental innovations. In fact, according to the respondent, AI has great potential in this regard and could go as far as automating incremental innovations: *"we can train AI to see when the public start behaving in a certain way, and then it's time for looking for innovations within this field or whatever."*

Also, in Respondent 1's use of ChatGPT for his own innovation project, after explaining the features of the software he created, the AI added incremental features: *"In my project, when ChatGPT added features to my invention without me, it was incremental innovation. It was like: all right, why don't you just add this other simple feature? Since it's trained [...] to respond with the most likely*

answer, it is going to provide the answer that most people are most likely to accept. It'll always be like middle of the road. I think that leads itself to these very simple incremental innovations."

Similar experience was that of Respondent 7. The latter, specifically, highlights how, through the use of AI, he was able to implement *"incremental improvement"* in his daily workflow.

Respondent 4, on the other hand, believes that companies will undertake a gradual process of integrating AI into the various internal stages of the innovation process, first going incremental. Then later, the use of AI will grow to lead to more disruptive innovations. Of different opinion is Respondent 6, who essentially argues that there will be an opposite process: as soon as companies become aware of the potential of AI as a tool to innovate, it will lead to many disruptive innovations: *"I think, in the beginning it will be extremely disruptive. We've seen that with traditional machine learning, in the beginning, we found lots of unknown dependencies. But later on, when you have found those, it'd be harder and harder to find another. But you can always tweak it and find some improvements. So, I think in the beginning it'll be lots of disruptive findings."*

Respondent 2, on the other hand, believes that AI can lead directly to both levels of innovation: either to *"small innovations,"* as defined by the respondent himself, or to give insights never seen before: *"AI can create insights that you haven't seen before. With these new insights, you can be much more disruptive or whatever [...] AI now can do something that you had never seen before."* In this sense, then, AI could also be applied to achieve innovations that are not simply improvements to existing products, but innovations that change the market more substantially with new products provided to consumers. In this sense, a key aspect is obviously the data set related to consumer behaviour to discover hidden needs or new trends. In this sense, Respondent 1 also pointed out that AI will be able to play a key role: *"I'm sure that you could add user behaviour data to see like in which way the user move, and I'm pretty sure it'll be able to discover maybe not completely hidden, but like emerging needs."* As evident, then, AI can be applied in identifying new trends and emerging needs, but it is important to note how according to this statement by Respondent 1, there are some doubts about AI's capabilities in identifying *"completely hidden needs."* Also in line with this view is the example given by Respondent 8, who argued that when Apple decided to launch the iPad, no one knew there was a need for it. That was a completely hidden need and that was a strong innovation in that field: *"It was an innovation and I think that is something that an AI can never answer in a good way because it was something totally new. The AI didn't know about it because it was a new invention. So, you need to be really good at business analytics. You need to know your customers and other things. And I think in that perspective, it's kind of hard with that."*

In a way, interviewee 9 is also in line with this: while AI can certainly lead to incremental innovations, the situation is more complex with regard to disruptive innovations. Indeed, it is difficult

for AI to make suggestions on aspects that it does not know about. The example given by the interviewee regarding the applications of AI in the field of design is certainly significant: "*If it is something that doesn't exist at the moment we get really strange results [...] because the models are trained on things they know... they are very good with cars, not very good with things that don't exist: how do you push it to do something that doesn't exist? He's also very good at combining things [...] but if you ask it to design a new creature that has new properties, I think it's much more challenging."*

4.5 AI, opportunities and future developments

Several insights emerged during the interviews regarding future developments of Artificial Intelligence and its application as a supporting tool in innovation processes. All interviewees argued how the potential for growth of this technological tool is evident, both in terms of concrete uses and applications and in terms of the refinement of Artificial Intelligence models.

"I think is going to be a very explosive field," said Respondent 1, highlighting the importance of there being effective development of such technology, considering that it will be able to help solve numerous problems not only at the business level but in general for the well-being of the society. Such development will make AI an increasingly sophisticated and intelligent technology over the years, as argued by Respondent 2. This will lead AI to play a *"significant role"* in revolutionizing the way we do business and innovation (Respondent 4). This also emerges from the words of Respondent 3, who argues that *"AI and the solutions that are coming will change the landscape a lot."* However, AI will not only play a crucial role in ensuring new solutions or in the final product, but real growth will also occur in the application of AI as support in internal innovation and production processes: *"I think we will see more and more AI, and especially maybe not so much in the end product, but in supporting system that supports you creating the products"* (Respondent 6). Development and growth, on the one hand, will certainly lead to increased productivity and faster innovation processes (Respondent 9), but on the other hand the hype related to AI itself may also lead to some issues: according to Respondent 7, in fact, it may also increase the level of distraction of AI users. The hype around new tools such as ChatGPT is very high, and according to Respondent 7 it will be difficult for those involved in innovation processes to identify which tool is genuinely useful among the many that will be available to us. Such growth on several fronts will certainly be helped by a gradual lowering of the cost of accessibility to such tools, according to Respondent 3.

This cost decrease, then, certainly could be further facilitated by two key aspects that emerged in the interviews: cloud computing and open sourcing. Specifically, according to interview 1, *"from an innovation point of view, cloud computing makes it easier to start small and scale if necessary,*

because you don't have to buy the physical computer. [...] this is good for innovation, the ability to scale and not having to invest millions in big computers right away. You can scale in a gradual way." Many of the major players in the tech industry, then, could play an essential role in sharing open-source libraries such as TensorFlow, used specifically by Interviewee 1 in building the Artificial Intelligence needed for his project: *"The open source part of AI is incredible and a great enabler of innovation. [...] Google, Amazon web services and even Microsoft Azure are the big players [...] I think everybody uses one of the different libraries, because that makes it really easy to develop new innovative projects. [...] The motivation for them to offer these open source libraries is that it then comes back to them: people can first try out their ideas and then, when they want to scale them, they come back to Google to use their web services."*

The future development that emerged most insistently during the interviews, however, is that related to the implementation of complex systems composed of AI tools that collaborate with each other. This aspect emerges from several statements made mainly by Interviewee 2, Interviewee 4, and Interviewee 8. Specifically, having an *"AI network"* (Respondent 4) would represent an opportunity on several levels: first, as highlighted by Respondent 2, one cannot take an AI output as good a priori. In this sense, having multiple AIs checking up on each other might provide a safer solution: *"I think the biggest opportunity I see is to have an AI that actually takes care of the AI. [...] You can't think that managing AI is the truth. So who is going to find out that sometimes the output is fake news? It's another AI."* With this goal in mind, IBM Nordic has developed trustworthy AI software. Specifically, thanks to that tool, it does several checks on the datasets used and the different AI models used. In addition, collaboration between different AIs could greatly benefit the innovation process. In this regard, the example provided by respondent 8 is significant: *"Most people, when they have an idea, they go to a friend and talk to him about the idea. And then you start to discuss: that is exactly what you need to have an AI as well. Everyone has his/her experience in his/her life, and there can be different perspectives. That's why we can't just ask one AI, we need to have several AIs who discuss the questions. Then it can be really, really powerful. And then you can use it for innovation."*

This aspect was explored in depth during the interviews, to understand the extent to which such AI networks may go in the future to replace the presence of humans. In this, too, the interviewees were fairly aligned. While it emerged that AI will be increasingly used in more and more phases of business processes, *"AI in itself, just as a little magic toy, is not enough"* (Respondent 3). From one point of view, then, AI will have more and more autonomy, as well as more independence in collaborating with other AIs and making decisions. Such autonomy, however, will never be total. In fact, according to the respondents, the presence of *"human eye"* will always be required (Respondent

2), considering that one can never be totally certain of the outputs produced by the AI (Respondent 4). Respondent 6 argues that in fact such outputs will have to be supervised or tested by humans in order to understand whether they can be usable or not. Skipping this step, as reiterated in Respondent 2 and Respondent 5, could expose companies to enormous risks and dangers.

4.6 Challenges of using AI as a supportive tool in the innovation process

Another aspect that was explored throughout the interviews concerns the main future challenges and potential difficulties that, firms specifically, will have to overcome to effectively exploit the potential of Artificial Intelligence. Indeed, according to the interviews, *"there are so many problems for a big company that aren't for the individual"* (Respondent 7). In more detail, among the problems that emerged most frequently were: the mindset of companies, skillset and knowledge of employees, presence of adequate tools and resources, presence of appropriate data sets, and issues related to legislation and regulations as well as ethics and the use of consumer data.

Respondent 3 highlighted that currently in many companies there is no approach aimed at using AI in different processes, including innovative ones. This, as also highlighted by Respondent 2, Respondent 6, and Respondent 7, especially leads companies and industries that have always worked in a traditional way to develop inertia toward innovations such as AI. In this regard, Respondent 2 provides a clear example: *"If you take a look at healthcare, they are just on the beginning of their journey for AI because they are working very conservative."* Furthermore, because of this closed mindset, it is problematic in such industries to use AI as a tool in innovation processes. This closure, as highlighted by Respondent 6, sometimes also stems from the fear of being replaced by these new tools. This, however, again according to Respondent 6, is inevitable. There will indeed be a shift in skills and knowledge, with new roles displacing old ones: *"it's a new technology: it demands new competence and new organisational parts."* Respondent 9 also touched on this, arguing that AI will perform tasks that were previously performed by human workers: this, however, in the respondent's view, will lead to two main effects: 1) there will be easier accessibility to more and more skills, as some tasks previously performed by specialised workers can be performed by AI; 2) there will be a transition that will see humans adapt to the new situation and perform new tasks.

Precisely in this regard, however, it often emerges during the interviews how slow this transition will be, due to the low skills and knowledge that still exist about AI. According to Respondent 10, the real major barrier to the adoption of AI is precisely the lack of appropriate knowledge and competencies. As Respondent 3 argued, then, AI itself is still something immature, completely magmatic, and therefore difficult to understand. In order to effectively deploy AI as a

support tool in innovation processes, it would be necessary to develop knowledge that is currently not present in many companies: *"the knowledge is not there: how do you set up this? What infrastructure should you have? What frameworks should you have? What processes should you utilize? How does this fit in with your current processes?"* (Respondent 5).

However, fostering AI education and the acquisition of the necessary skills requires resources in terms of money and time, which businesses often do not have. In this regard, in fact, Respondent 6 argued how despite increasing accessibility to AI tools, huge investments are required to be able to integrate this technology into business processes, which are therefore often postponed.

Other critical issues that hinder the adoption of AI tools in innovation processes and in internal processes in general certainly include the still fragmented and immature regulation (Respondent 6). This point is also touched on clearly by Respondent 7. The latter, specifically, pointed out how considering that the use of Midjourney or other similar tools appears to be still unregulated, this represents a strong disincentive for companies: *"what is the status of intellectual property of an innovation that has been heavily based on these tools? There are so many legal issues in using Midjourney to create a new product for your company. I would discourage that right now, before the legal frameworks for this area are set up: I would absolutely not use Midjourney, because you actually don't own the sketches."*

Respondent 2, Respondent 3, and Respondent 5 were also of the same opinion. The latter, specifically, clarified how nowadays there are protocols and standards in place to ensure the safety and reliability of codes and software through testing and other procedures. However, the same is not true for machine learning algorithms, for which regulation in this regard is not yet fully complete and exhaustive: *"the verification parts and the process parts are not mature yet, and that makes AI as a tool for innovation, I would say, scary or difficult to implement"* (Respondent 5).

Tied to the lack of regulation are a set of additional issues such as the protection of business and consumer data. Respondent 1, in highlighting how AI can be applied for the purposes of discovering hidden or emergent needs in consumers, raised some concerns at the same time, *"then you come down to all these ethics, like: who owns the data? Is it ethical? What user data can you use?"* Similarly, Respondent 4 argues that tools such as ChatGPT cannot currently be used for analysis on Ericsson's internal and consumer data. In fact, this would expose the company and customers to great risk, considering how there is no clarity on how the data itself is handled: *"the problem is to understand what we can discuss and share with ChatGPT, with Microsoft and so on since they are behind there. So, it's about information security. That is a huge hinder, I think."* Using these tools would mean integrating them into companies' innovation processes, but this is still not possible considering the lack of clarity on information security.

On the subject of data, then, several interviewees emphasised that if one wants to exploit the potential of AI in internal processes, it is necessary to have an appropriate data set, in line with the company's objectives. Data, then, according to the interviews, is a fundamental requirement for AI to be used in innovation processes: *"the first thing is [...] to collect data. So, without data, you cannot run anything. You can go out and maybe steal data, but then that is not accurate. So, you must have data about your stuff, and then you can run AI on that data"* (Respondent 2). Without data, then, AI cannot be used. However, having access to databases that are accurate is not always a given and indeed often one of the biggest obstacles to overcome. Respondent 3 argued how in some of the projects he led it was expressly chosen not to use AI because the data available were not appropriate: *"people think that they can buy an AI in some kind of black box, and it will just jump out like a magician and sold things. But if you don't have the right data sets, it doesn't really matter. [...] in our projects, we have decided not to use Artificial Intelligence as a tool for innovation since the data has not been good enough."* Respondent 6 also stresses the importance of having the right data, and of the same opinion is Respondent 8. The latter, highlights how *"the problem most companies have is that they don't have data, their own data in the right way. It's easy to ask questions to an open AI, but then you don't have the company data on that. And that is the trickiest part."* Open AI and other similar tools can certainly be used because they are based on large data sets, and useful as support at different stages of the innovation process, but there are limitations in this: first, as anticipated, many interviewees expressed their concerns about information security. Second, then, others have also wondered about potential bias or the reliability that the data on which ChatGPT or similar tools are based might have. In this regard, in fact, apparent mismatches often arise, which therefore make some ChatGPT responses not usable in some business or market contexts. A funny but at the same time eye-opening example in this regard is the one provided by Respondent 6: *"I asked to ChatGPT: where do Santa Live? And it says North Pole. But that's not what we're thinking here in northern Europe: Santa Lives in Finland for us. So you can see that it has been trained on English American data and stuff [...] So, it is extremely important that you understand the bias in the data. You can still use it (ChatGPT), but if you don't understand that it has a bias, then you have a problem."* The importance of recognising bias in the data was also highlighted by Respondent 2, who argued that the importance of continuous checks on both AI inputs is critical to then be able to get reliable and usable outputs in innovation processes and in all business processes.

To overcome these problems and to be able to fully exploit the potential of AI, therefore, each company should have its own Artificial Intelligence systems with its own data sets (Respondent 8).

5. Discussion

Introduction

In this section of the thesis, a discussion of the data obtained through the present research will be reported. To this end, for each of the macro-themes that emerged during the analysis, the researcher will frame a comparison between the results of the interviews, reported in the previous chapter, and the previous studies, presented in the Literature Review section. In this way, it will be possible to highlight any points of contrast or in common between literature and research findings, so as to have a clearer and more complete view on the potential of Artificial Intelligence as a tool in the innovation processes. Specifically, thanks to this analysis, it will be possible to answer the Research Question.

This section will be divided into paragraphs, following an order similar to that of the topics covered during the interviews, as well as that used for presenting the data in the previous section on Empirical Findings. This disposition will help the reader to focus on the main points of the present research and will serve to provide a holistic framework on innovation and how AI can be used in this as a supporting tool. In more detail, this framework is based on the analysis of the data collected: the 449 initial codes were firstly divided into first-order concepts, as anticipated in the Methodology section. These were then grouped into second-order themes, which were finally merged into aggregated dimensions. Figure 10 below shows the results of this analysis.

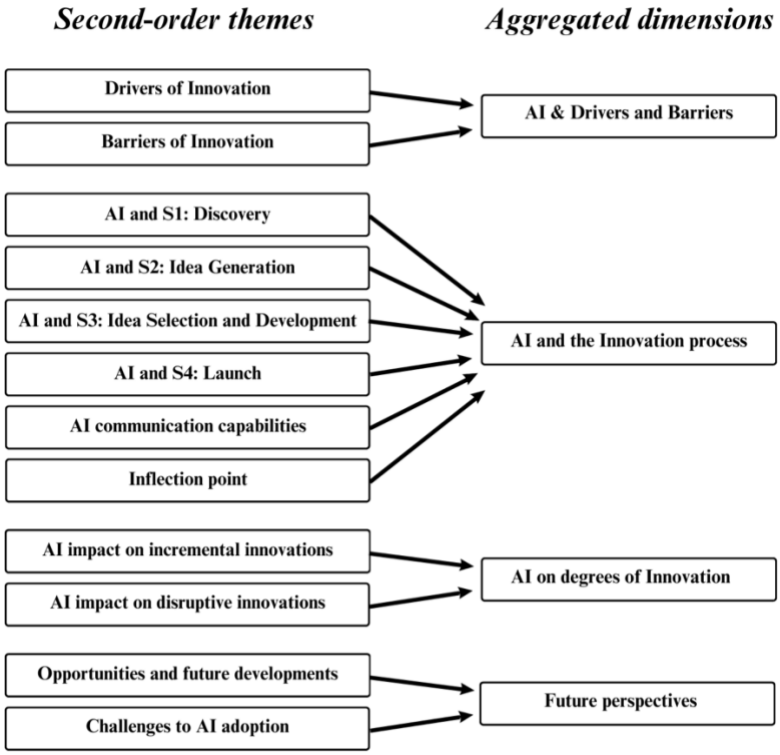

Figure 10 - Thematic Analysis

5.1 AI & Drivers and Barriers to Innovation

5.1.1 AI and Drivers of Innovation

As widely anticipated, one of the first aspects considered in this research concerns the drivers of Innovation. There are numerous studies in the literature in this regard, which have identified various drivers, both internal and external to the enterprise. During the interviews, this aspect was sought to be explored in more detail and the respondents were asked to highlight the main drivers of innovation that characterise the companies they work for. In more detail, this was used to understand if and how AI could play a role in stimulating innovation, going to facilitate the presence of these drivers or enhancing them.

As reported in section 4.1 of the Findings, there were five main drivers that emerged during the interviews. To have a more immediate match with the literature, they were divided between internal and external during the analysis.

Specifically, previous literature and interview findings appear to be particularly aligned with regard to the external drivers of innovation. Indeed, new market opportunities and needs, competition and fear of being left behind, as well as technology evolution, are the main external drivers that emerged during the interviews, and they correspond exactly to three of the four external drivers identified by Goffin and Mitchell (2017). As the Empirical Findings revealed, in relation to these drivers, companies could benefit from using AI as a supporting tool. Indeed, it was reiterated by several Respondents how AI could be adopted to scan both consumers and competitors' data. This would facilitate procedures for finding new market opportunities, new (especially emerging) consumer needs, and new competitors' strategies. This point, in fact, would be crucial in order not to be left behind by competitors and to be always aligned with new market needs. Consequently, it could be inferred that AI is a tool that drives companies to innovate, considering how access to competitor and market information is greatly facilitated and enhanced.

AI, then, represents an important technological evolution, and for this reason it is itself a driver of innovation: in fact, according to the findings, it will be one of the main drivers that will require companies to innovate, thus leading to a paradigm shift.

The fourth and final external driver identified in the literature has to do with government agencies and regulation and market policies, which sometimes, as pointed out by Goffin and Mitchell (2017), drive firms to innovate. During the interviews conducted, however, this aspect emerged not so much as a driver of innovation, but as a major challenge in adopting AI as a tool to support business processes. Consequently, this point will be explored in more detail in the last section of this chapter.

Two main internal drivers were then also identified during the interviews. In the literature, there is a subclassification between organisational level and individual level (Dani & Gandhi, 2021).

In this specific case, however, both drivers mentioned by the interviewees fall under the organisational level. Specifically, in fact, the interviewees emphasised the importance of Strategic Intent, as well as investment in R&D. Respondent 4, Respondent 5 and Respondent 6 highlighted these two aspects, focusing on how innovation is often the result of the company's desire to provide greater value to customers or to make processes more productive. In this sense, AI can certainly be useful and provides several efficiency-enhancing solutions. In addition, it could also be used to foster communication between different employees and divisions of a company, clarifying the strategies the firms want to pursue. Being aligned is crucial, especially when it comes to innovative projects. Section 5.2 will set out some reflections regarding the AI's function as a communication enabler, as this certainly represents an aspect that could support all stages of the process.

The interviewees then argued how creativity is also strongly stimulated by the presence of AI: although not explicitly mentioned as a driver by the interviewees, it represents one of the internal drivers being part of the individual level (Dani & Gandhi, 2021).

5.1.2 AI and Barriers to Innovation

Through the interviews also the potential barriers to innovation that emerged in the experience of the interviewees were identified. Again, as with the drivers, the goal was to understand whether these barriers to innovation can be overcome or lowered through the use of Artificial Intelligence.

Specifically, the literature identifies both internal and external barriers to innovation (Piatier, 1984). To facilitate the comparison and understanding of the main elements, in this section, the interview findings will be discussed following the same classification.

Internal barriers cited in the literature include high investment, the set of skills required to be able to innovate, and risk management policies. Moreover, added to these are a lack of support from top management, poor communication, and the inertia of workers to change (Hadjimanolis, 1999; Madrid-guijarro et al., 2019). Among all of these, respondents focused mainly on a few. First, the need for large investments required to innovate was mentioned, specifying how the macroeconomic environment does not help in this regard (Respondent 2 cited the example of the failure of Silicon Valley Bank). Still, another barrier highlighted by respondents is the limited knowledge and ability of employees to perform in innovative projects. On these barriers, specifically, interviewees did not comment on the possibility of using AI. However, considering how this technology is being applied in more and more contexts and areas, including the financial one, the researcher believes that the decision-making capabilities of AI highlighted in the literature could be exploited (Sestino & De Mauro, 2022). In fact, for instance, AI could potentially support in identifying and choosing what are the most convenient forms of financing and investment for different businesses.

Among the internal barriers that emerged during the interviews, there is also the high risk of failure related to the innovation itself. Risk management is one of the problems that, according to what was mainly highlighted by Respondent 3 and Respondent 7, often causes a stop of the innovation process, which is therefore abandoned. This, as found in the literature, is also due to the fact that the uncertainty associated with the success of such projects often gives rise to conflicts within the company or among financiers (Bergemann & Hege, 2005). Such conflicts, according to Respondent 7, are exacerbated by a low level of clarity about the project and, thus, a lack of clarity in communication. This represents another of the internal barriers highlighted by Madrid-guijarro et al. (2019). In this, AI could be a useful tool to create greater clarity in internal communication processes and thus avoid all those situations in which process-related uncertainty grows solely due to ineffective communication. In addition, because of AI's ability to predict future trends and patterns based on historical data, the risk of a project could be assessed by comparing it to similar past projects. This would exploit the risk-evaluation capabilities of AI cited in the literature by D. Zhang et al. (2010). Finally, the last internal barrier highlighted by interviewees was workers' inertia to change. This, too, could be reduced by the presence of AI. In fact, usually, opposition to innovation is due to the fact that workers do not recognise the value of change itself: this, thanks to AI becomes easier. In fact, Artificial Intelligence and especially tools such as ChatGPT and Midjourney are nowadays within everybody's reach. Everyone, therefore, can check their potential and understand how they are a viable method of change and innovation (Respondent 5). Therefore, the possibility to personally test the real potential of these tools increase the employees' attitude toward innovation and change. This, in a certain way, is also supported by the literature: the study conducted by Davenport (2018) shows that in work contexts in which it is possible to interact with *"human-like"* technological and AI tools, employees feel more emotionally involved, and therefore this could help to overcome the employees' inertia to change.

When it comes, instead, to the external barriers cited in the literature, it is possible to mention: the absence of information flow, the absence of support from government agencies, and policy and regulatory uncertainty (Hadjimanolis, 1999; Madrid-guijarro et al., 2019). Among these, respondents mainly highlighted government policy uncertainty and regulatory immaturity as major challenges to the use of AI within enterprises. Considering that, as anticipated, AI itself represents a strong innovation, these issues could still be considered as barriers to innovation, as is the case in the literature. However, these points will be explored further in Section 5.4 of the Discussion, which is devoted precisely to the future opportunities and challenges of using AI as a support tool in business processes of innovation (and not only).

5.1.3 General considerations on Drivers and Barriers

From the analysis of primary and secondary data regarding barriers and drivers of innovation emerges that, sometimes, drivers can become barriers if not stimulated. In addition, the reverse can also happen. The role of government entities, for example, could be both a driver (if there are policies that stimulate business innovation) and a barrier (if government choices block or hinder innovation). Similarly, the firm's Strategic Intent can be a strong driver but, at the same time, a major barrier to innovation if it is not communicated effectively or if there are misalignments between different parts of the firm. In general, then, it could be seen that the line between drivers and barriers to innovation is quite blurred. It all depends on the perspective from which one looks at the same element.

However, what is important to highlight in this section is that AI turns out to stimulate innovation both by going to facilitate the presence of some drivers and by going to lower or counteract the presence of some barriers. This, for the aim of the research, can be considered as a meaningful result.

5.2 AI on different stages of the Innovation process

5.2.1 Innovation Process: a new comprehensive model

Several innovation processes can be found in the Literature. In section 2.1.5 of the Literature Review, the five generations of innovation models identified by Rothwell (1994) were explored in depth.

In addition, some of the most currently used models were highlighted, such as Design Thinking in its various forms, as well as traditional Stage-Gate process and its more modern evolution (Triple-A System). All these models, then, are usually modified and adapted to the concrete case by different companies. During the interviews, in fact, it emerged how each company has its own process, developed according to the specific needs of its business and the context in which it operates. A careful analysis of the models identified (both in literature and through the interviews), showed how they differ from each other for a series of reasons: 1) the different phases are named differently even though they sometimes match, as is often the case in the many reported versions of Design Thinking; 2) some processes incorporate several phases into one, while others have a more evident subdivision; 3) the boundaries between one phase and another are sometimes sharper and sometimes more blurred; 4) some innovation processes skip some steps; 5) some processes are more linear, while others are more flexible.

However, despite the diversity among the models, some commonalities have been identified for all innovation processes through a detailed analysis. From these commonalities, the researcher

has brought together, under four macro stages, all the different steps of the main innovation processes[3] analysed in the course of this research. This new model created by the researcher has been reported in the following Table 3:

Innovation Model	S1: Discovery	S2: Idea generation	S3: Idea Selection and Development (Design, Prototyping and Testing)			S4: Launch	
1st Generation (Rothwell, 1994)	Basic Science		Design and engineering		Manufacturing	Marketing	Sales
2nd Generation (Rothwell, 1994)	Market need		Development		Manufacturing	Sales	
3rd Generation (Rothwell, 1994)	New need or new technology	Idea generation	Research, design and development		Prototype production	Marketing	Sales
Design thinking (Liedtka, 2018)	Customer discovery	Idea generation	Idea selection		Prototype and testing	Marketing	Sales
Design thinking (IDEO, 2010)	Inspiration	Ideation	Implementation			/	
Double diamond (Design Council, 2004)	Discover and Define (1st diamond)	Ideation (2nd diamond)	Develop (2nd diamond)			Deliver (2nd diamond)	
Stage-Gate and Triple-A system	Discovery	Idea generation	Scoping and Build the Business case	Development	Testing and validation	Launch	
Respondent 1 (Double diamond)	New problem or new opportunity	Idea generation	Idea selection and Development			Sales	
Respondent 3	New problem or new opportunity	Idea generation	Solution finding through workshops and third parties' involvement		Testing and validation	/	
Respondent 4	New opportunities	Idea generation	Implementation through third parties' involvement			/	
Respondent 5	New problem or new opportunity	Idea generation	Design and implementation			/	
Respondent 6	New problem or new idea	Idea generation	Idea selection and Design		Prototype and testing	/	
Respondent 7	Problem finding	Idea generation	Idea selection	Implementation and funding		/	
Respondent 8	New problem or new idea	Idea generation	Funding and Idea development	Prototype and testing		/	
Respondent 9	User research	Idea Generation	Design and Prototyping			/	
Respondent 10	Discovery, Research and focus	Idea Generation	Idea Development and testing			/	

Table 3 - Innovation Process: a new comprehensive model

[3] Some of the processes mentioned throughout the research have not been reported in Table 3. In detail, the last generations of Rothwell (1994) have not been listed because they are particularly similar to the earlier ones in terms of the stages of the innovation process. The major changes regard a more flexible and cross-cultural approach, but in general the macro-stages are always the same. Moreover, there is no model with regard to the Respondent 2 interview. This, as is evident from the Empirical Findings, is due to the fact that he works primarily as an accelerator or incubator with start-ups or scale-ups in later stages of the process. For this reason, it would not have made sense to report it in the Table 3.

The model reported above, thus, is a holistic and aggregated version of all the most important stages of the different innovation processes. Specifically, the four stages (S) identified are: Discovery, Idea Generation, Idea Selection and Development, and Launch.

This framework, created from the analysis of primary and secondary data of this research, will form the backbone of this section. Indeed, in the following paragraphs, the real and potential uses of AI in each of the four stages have been analysed.

Stage 1: Discovery

The first macro-phase often consists of research and identification of inputs from which the innovation process then starts. These inputs, as emerges both from the literature and from the interviews, can be either internal problems within the company (such as inefficiencies in processes), or external to the company (new opportunities in the market or new problems to be solved). As Respondent 7 pointed out, an innovation that does not start with the identification of a problem worth solving is an innovation for its own sake. Therefore, it is evident that this preliminary stage of the innovation process is extremely important.

In this phase of the innovation process, especially in some models (see, for example, design thinking and double diamond), an open-minded and broad approach is used, where a large group of potential unmet needs or problems are considered (Kakatkar et al., 2020; Tschimmel, 2012). At this stage, even when it is complex to contact consumers to interview them and gain insights, AI can be used to make simulations. In fact, Respondent 9 revealed that in his company chatbots were sometimes asked to pretend to be a certain category of consumers to highlight potential points of criticism.

In general, according to what several Respondents have highlighted, it is possible to say that AI emerges as a tool that can certainly be useful in both gathering but especially in analysing data. Indeed, Respondent 2, as reported in section 4.4, pointed out that through the use of AI, it is possible to gain insights never seen before. The statements of Respondent 5 were also significant in this regard, with the example of researchers studying the movements of the Gilmores. Through machine learning, they arrived at insights that they had never thought existed and for which they were not directly investigating. In this, AI thus shows its great potential.

Similarly, AI can be useful internally to companies to highlight problems or inefficiencies in processes and products, as argued by Respondent 6. In fact, AI is capable of noticing gaps in products from which a subsequent innovation process leading to higher value for customers can then be launched. Also significant in this regard is the other example provided by Respondent 5, who pointed out that some companies are using AI to scan their products and software to identify points of

inefficiency. What emerged in the interviews, therefore, confirms and enriches with a series of more concrete examples what has been emphasised by previous studies, such as that of Kakatar et al. (2020): they, in fact, argued how AI can be applied at different stages of the innovation process, including problem exploration.

In this, one aspect that is certainly important is to clearly define the problem you want to solve or the unmet need you want to satisfy. Once identified, in fact, it is necessary to communicate it clearly to the rest of the company so that in the subsequent stages of the process everyone has the common goal clear in mind. The problem of communication comes up several times during the interviews, but in relation to the clarification of the initial problem it was particularly emphasised by Respondent 7. In order to be able to move forward in the innovation process, according to the respondent, first of all one has to clearly define and communicate what the problem is that one wants to solve. This must be done from the perspective of people and business processes. In this, according to interviewee 7, especially generative AI can be of great help through the creation of texts and/or summaries that focus on the most important elements of the problem to be solved.

Stage 2: Idea Generation

Once the starting point has been identified, usually all innovation processes move on to an idea generation phase. Specifically, then, in the literature as well as in the interviewees' statements, this phase is implemented according to different approaches. Among the most frequently used methodologies are brainstorming sessions and workshops. In general, regardless of the method utilised, the objective of this phase is to arrive at a set of potential ideas that can solve the identified problem or close the gap in the market. According to Respondent 4, this is precisely the most complex step when innovating: finding a solution to the identified problem is often difficult because, as humans, what we know is usually limited to what we have recently experienced. AI, on the other hand, has a much deeper capacity for storing and analysing data, and is often more open-minded than a human being in making suggestions or looking for a potential solution.

Creativity is also seen as one of the main bottlenecks in the innovation process by Respondent 5, who argued that AI can achieve better results in less time. The level of creative capabilities of humans could also be much more intense according to the evidence of Respondent 2, Respondent 6 and Respondent 8. Tools such as ChatGPT, for instance, can be an excellent starting point in the idea generation process, providing *"food for thoughts"* (Respondent 5) for brainstorming sessions, thus widening the range of potential solutions. This tool was often mentioned by the interviewees in this regard: Respondent 1, for example, used it to be interviewed about his innovative project. This, as emerged from the Empirical Findings of the research, led to a final summary with all the main

characteristics of the project itself, to which ChatGPT autonomously added basic features that had not been mentioned by the respondent. This is certainly a concrete proof of how such tools, nowadays, can support this phase of the innovation process, boosting human creativity but at the same time preventing innovators from forgetting the basic features that are often required by the market for specific products.

A confirmation of how useful AI can be in this phase can also be found in the literature: Bouschery et al. (2023), as well as Maiden et al. (2023), argue how the application of AI and tools such as ChatGPT can support the innovation process in the creation phase of new ideas and with the stimulation of human creativity.

Stage 3: Idea Selection and Development

After having identified a set of potential solutions to the problem, it is necessary to choose the idea that might be most suitable. This Idea Selection phase represents the beginning of the second diamond in the Double Diamond model (Design Council, 2019; Tschimmel, 2012), as well as the first part of the Implementation phase in the Design Thinking model (*IDEO Design Thinking*). In general, however, it emerged from the interviews that regardless of which specific innovation model is used, once the idea generation phase is over, it is necessary to focus on one or a few ideas that can then be developed more concretely. In more detail, AI has the potential to be used in choosing the best idea or design. Respondent 2, for instance, argued that thanks to AI, it is possible to understand whether an idea is unique and therefore implementable, simply by using algorithms to check whether someone has already registered a patent on that idea.

Furthermore, especially in large companies, the use of AI could lead to great savings in resources and time. Respondent 8, in fact, pointed out that in his work experiences, he often had to manage a flow of fifty to one hundred new ideas per day: as it is easy to understand, in such situations, having the analysis and selection capabilities of an AI would be an indispensable element. In these scenarios, therefore, such a tool could be used to identify potentially interesting ideas, based on the characteristics of the company and/or the target consumers it addresses.

Usually then, according to what emerges from the analysis of the models in the literature as well as from the interviews, after having identified one or a few ideas that are worthy of being implemented, the object of the innovation has to be designed. In fact, the goal is to give a more concrete shape to the project, and especially if it is a product innovation, an attempt is made to make a sketch of the idea's implementation. As Respondent 1 argued, the idea of this second part of Stage 3, which the researcher has called “Development”, is to obtain a proxy of the final innovation, so that its validity can be tested. To this end, therefore, even a rough draft of the final product may be

sufficient, since in any case it allows to understand what needs to be improved. In this too, both from the literature and from the interviews, it is possible to see how AI can play a supporting role. Indeed, whereas Verganti et al. (2020) demonstrated how the use of AI tools in design practices can help create value, also many interviewees highlighted current and potential uses of Artificial Intelligence in this regard. Respondent 1, for example, argued that when it comes to design, it could be an excellent starting step to ask image generation tools such as Midjourney to create a graphical draft of the product to be tested. Respondent 8 was also completely in line with this view, emphasising the potential of stable diffusion *"text to image"* tools, which thus realise the graphic visualisation of a simple textual description. In this regard, however, it has been clarified that it is necessary to know how to prompt these tools and what kind of input text to use in order to generate an image that is realistic and in line with the ideas behind it. Respondent 7 and Respondent 6 also recognised the potential of AI in this regard. In more detail, Respondent 6 provided a concrete example: at Volvo Cars, an AI is employed to identify the best possible design for specific car components once certain parameters have been set. At the moment, this technology is being used, for example, to improve the durability of some of these components as much as possible. Furthermore, Respondent 9 also pointed out that in the design phase it can be helpful to use *"image to image"* tools: once the initial design of the product has been prompted, a series of suggestions on how to improve the design itself can be obtained through such AI tools.

These tools, however, in the view of some interviewees are still imperfect and can therefore only be applied as a support and to get a rough idea. What is certain, however, is that they will be used more and more, as they will considerably reduce the costs and time required to obtain and select a new product design, thereby greatly facilitating the processes.

In the testing phase, then, AI could certainly be useful to analyse the responses and data obtained as feedback and consequently make appropriate improvements to the prototype realised. In this sense, Respondent 10 expressly emphasised how, thanks to the capabilities of AI, it is possible to analyse really large datasets: in the design and prototyping phase, it is therefore also possible to gain valuable insights into past projects, so that it is possible to understand which strategy is to be implemented for the new ones.

Stage 4: Launch

Once the innovative idea has been selected, as outlined in the previous section, it is developed and tested in order to obtain feedback and make appropriate modifications and improvements. At this point, once the innovation has been optimised, it is brought into the company (if internal) or into the market (if consumer-oriented). Especially if externally oriented, the most disruptive innovations (and

thus especially breakthroughs or radical innovations) may need time to be understood and accepted by the market. Indeed, according to previous studies (Deszca et al., 1999; Goffin & Mitchell, 2017), it may take time for consumers to recognise the actual value of an innovative product or service.

However, based on what was argued during the interviews, the adoption of a new innovation could be facilitated by AI. In fact, as widely anticipated, many of the interviewees recognised the great communication capabilities of Generative Artificial Intelligence, which is flexible and adaptive depending on the interlocutor to whom it has to address the message. Especially Respondent 1, indeed, highlighted how AI can be helpful thanks to this ability. From the Empirical Findings of the research, in fact, it emerges that along the innovation process, there are several commercialisation stages: just as it is important to convince consumers to adopt the final innovation, it is also important to convince the various workers involved in the project itself. In this, then, AI could be exploited to produce texts defined as *"more selling"* by Respondent 6, thus enabling faster and easier adoption of the innovation.

5.2.2 General considerations about AI in the different stages of the innovation process

From the previous sections, therefore, it emerged that both according to the literature and the interviewees, AI can be used as a supporting tool in the different stages of the innovation process. However, while the opportunities related to AI in innovation contexts are evident, it is worth reflecting on the actual use that companies currently make of it. What emerged from the interviews, in fact, is that most companies are just starting their journey towards adopting AI in their innovation processes.

Respondent 1 pointed out that he has so far used tools such as ChatGPT for his own individual innovation project, and that they are also starting to explore its potential in the companies where he works. However, at the moment, these tools are not yet fully integrated into the innovation processes of these companies. Respondent 2 also emphasised how he sees the possibility of using AI in every step of the innovation process but recognised that many companies still do not do so or do so only partially, thus not extending the use of AI in every step. Respondent 3 argued how, due to the lack of an adequate data set, it is often not possible to use AI in the innovation processes and projects in which he works. However, he recognised its strong potential, highlighting how tools such as ChatGPT enhance his personal innovation processes. Respondent 4 also recognised how the use of Generative AI can lead to numerous benefits also at the corporate level. At the moment, however, these are tools around which there is no clear regulation, and it is therefore difficult to use them within the company. Respondent 5 is also of the same opinion. At the same time, however, Respondent 4 pointed out that in the near future, these problems are likely to be solved: according to him, we are currently at an

"inflection point", and thanks to recent rapid developments, AI will be used more and more from now on, also as a support tool in innovation processes. Respondent 6 is also of the same opinion: he is firmly convinced of the potential of such tools and therefore argued that they will be increasingly incorporated into business processes. However, many of these technologies are immature and this makes adoption difficult, especially for large companies. Respondents 7 and 8 are also in the same line of thought. Respondent 9 works in a company which has started using these tools in the innovation process, even though AI technologies are not fully and formally integrated in their internal activities. Finally, Respondent 10 recognised several potential applications, but highlighted how at the moment most of the tools have been used just at an individual level.

To conclude, therefore, it could be said that many of the new AI tools, such as ChatGPT and Midjourney, certainly have the potential to be used as support tools at different stages of the innovation process. However, the process of embedding and integrating these tools into the innovation processes of companies is only at the beginning. In the coming months and years, there will be a strong development in this regard, and this will certainly have serious implications for managers, regulators, consumers and all stakeholders who may be affected by this sudden growth.

5.3 AI and degrees of Innovation

The previous sections have clarified the role that AI could play both in regard to drivers and barriers and in relation to different steps in the innovation process. However, another aspect that was explored through this research concerns the impact that such use could potentially have in terms of degrees of innovation. In this way, it was possible to understand what kind of outcomes companies that use AI in their innovation processes could aspire to.

In this sense, as pointed out in section 2.1.4 of the Literature Review, previous studies have identified three main degrees of innovation. Indeed, they are referred to as incremental, breakthrough, and radical (Goffin & Mitchell, 2017). In the Empirical Findings that emerged during the interviews, however, while there is a distinction between incremental innovation and more disruptive innovation, no clear distinction was made between breakthrough and radical innovation. However, from the statements of the interviewees and the specific definitions in the literature, it is possible to deduce some considerations in this regard.

First, it is evident how AI will definitely have an impact in both the short and long term as far as incremental innovations are concerned. Current AI tools, such as ChatGPT, are already proving their potential in this regard, demonstrating strong creative and supporting capabilities. What

happened in the project of Respondent 1 is a clear example of this: ChatGPT, after the description of the project itself, was able to suggest incremental features that could improve the software created.

Likewise, however, because of the ability to create new insights never seen before (an aspect recognised by several respondents), it is possible to leverage Artificial Intelligence for more disruptive innovations. These, in fact, as the literature points out, often start precisely from the discovery of unmet needs that are identified and met by companies (Goffin & Mitchell, 2017). In case such unmet needs are not completely hidden but partly emerge from consumer data themselves, they could be identified by AI and initiate a disruptive innovation process. However, it is worth noting that, to be applied in this sense, consumer needs must be at least emerging. Respondent 1, indeed, raises some doubts regarding the use of AI in identifying needs that are completely hidden. In this regard, the example of the iPad provided by Respondent 8 is also particularly significant. The iPad was a completely revolutionary product that was not even known to be needed. In these situations, according to Respondent 8, AI could not be useful, as these are completely new contexts or inventions often given by a completely latent (or even non-existent) need about which AI could know nothing. For these more radical innovations, therefore, which represent the highest degree of innovation to be achieved (Sandberg & Aarikka-Stenroos, 2014) and often involve a complete redefinition of the competitive context (Goffin & Mitchell, 2017), AI does not turn out to be able to be of particular help. Therefore, at least in the initial phase of problem and/or opportunity identification, it is possible to conclude that AI could lead to incremental and breakthrough innovations, but hardly to radical innovations. This has been highlighted also by Respondent 9, who stated how AI has a very great potential if applied to innovate something that already exists, while it leads to weird results if used to create something which does not exist yet. This is because AI is trained on real data and on existing things. Another aspect to consider when talking about disruptive innovations (thus both breakthrough and radical), is that these are often not immediately understood by consumers (Deszca et al., 1999). Therefore, to make customers understand the actual value of the innovation itself, it might be useful to take advantage of the flexible communication capabilities of AI and Natural Language Process tools, which can adapt based on the stakeholder with whom they interact. This point was many times underlined by the majority of the respondents.

5.4 Future perspectives

5.4.1 AI, opportunities and future developments

In the course of this research, future opportunities and potential scenarios concerning the application of AI were also explored. Indeed, as anticipated in the previous sections, the aim of the study was to

understand not only the current situation, but also potential future implications that AI could have in terms of innovation. An aspect that certainly emerges from both the literature and the interviews is the great growth associated with such technologies. Several studies and research have in fact highlighted how investments in AI have more than doubled in recent years, highlighting that this is a market destined to develop exponentially in the short and long term (Loucks et al., 2021; Magd et al., 2022). This growth is fully recognised by all interviewees, who argued that Artificial Intelligence will certainly play an increasingly prominent role in business dynamics. AI developments, according to the interviewees, will concern several dimensions: firstly, there will be an improvement of these technologies (Respondent 2). Secondly, they will be used more and more frequently, in more contexts and by a higher number of enterprises. This will lead to a massive change in the various business contexts, with AI becoming increasingly decisive in this respect (Respondents 3, 4 and 6).

This growth, as the interviews revealed, will lead to a strong increase in productivity (Respondent 9) and optimisation of business processes, as also emphasised in the literature (Davenport, 2018).

This diffusion will then be facilitated by the presence of open-source libraries, as highlighted by Respondent 1. This will certainly lead to a strong increase in the level of accessibility to these technologies, with the possibility for anyone to use the open-source resources made available by the main players in the tech industry. In this regard, another clear example provided by Respondent 1 is cloud computing, defined as a great *"enabler"* of innovation. In this sense, in fact, even small companies will be able to use the virtual spaces offered by Google, Amazon and so on to test their ideas. This will have a big impact on costs, reducing them drastically and thus allowing the development of new applications of AI. In this way, in fact, small realities will be able to scale up gradually, without necessarily having to sustain large investments in software and hardware from the beginning.

The growth of AI then, according to some respondents, will lead to the establishment and implementation of increasingly complex systems composed of different AI tools. Collaboration between different types of AI could both stimulate the level of creativity (Respondent 8) and make the final outputs more reliable. Indeed, as Respondent 2 made clear, some companies (including IBM Nordic itself) are starting to use AI tools to control other AI tools. In this way, in fact, it is possible to have greater confidence in the reliability of the data used, the algorithms and the answers obtained. In line with this is the testimony of Professor Bowman, reported in The Economist ('The New AI', 2023). In any case, however, it has been made clear that control intervention by human beings will always be required: while AI will in part be able to acquire greater autonomy and human presence

will be less required in various contexts, it would be too dangerous to leave machines to act completely on their own.

5.4.2 Challenges to the AI adoption

Several articles in the final part of section 2.3.1 highlighted some critical issues that might slow down the adoption of AI, as well as some challenges that need to be overcome by companies in different dimensions. Many of these challenges were also highlighted by the interviewees. Firstly, according to the interviews, the adoption of new AI tools is more difficult for enterprises than for individuals. This is especially accentuated if the companies under consideration are large. Indeed, there are a series of problems and responsibilities that companies obviously have to consider, which are not present for individuals. To facilitate the reading and analysis of the main points that emerged, these barriers to the adoption of AI have been divided into three main sub-sections: organisational change, data and regulation.

Organisational change

From the interviews and articles in the literature, it appears that at the corporate level, AI will generate a shift in skills and knowledge. The business world will be transformed, and this will entail several changes in terms of the distribution and roles of workers. This is in line with what emerged from different articles reported in the Literature Review section (Goldman Sachs, 2023; 'How to Worry Wisely about AI', 2023). In fact, as Goldman Sachs' recent report shows (2023), around 300 million workers will be replaced in the near future by AI due to its ability to automate and streamline processes. This, as Respondent 6 points out, will lead to a change in required skills and new organisational parts. Companies, therefore, will have to adapt their structures and roles to these new technologies, investing heavily in training their workers and changing their mindset. It is precisely this last point that was emphasised by Respondents 2, 3, 6, 7, and 10, who argued that especially the more traditional sectors show an inertia to change and technological adaptation, and this will certainly slow down the adoption of AI in several industries and consequently the possibility of exploiting its full potential. In order to promote the use of AI, therefore, it would be necessary to encourage a change in corporate culture towards new technologies. Moreover, employees should be trained to cope with the transition in the best possible way and fully understand the potential of these tools. This, however, would require an investment of resources that companies often do not have, according to several interviewees.

Data

Data, as has emerged several times throughout this research, are one of the key elements when it comes to Artificial Intelligence. Without data, in fact, the algorithms that underpin such technologies could not be driven (Kreutzer & Sirrenberg, 2020). The acquisition of an appropriate data set is the first step to be able to build or use an AI in various innovative processes, and this is also evident from the interviews (Respondent 2 and Respondent 3). Without data, in fact, it is not possible to use any kind of AI.

However, obtaining an appropriate dataset is by no means straightforward. As Respondent 3 argued, often along the projects he managed, it was chosen not to use AI tools precisely because it was not possible to construct an appropriate dataset. This, therefore, represents a major obstacle to the use and deployment of AI, as also reiterated by Respondents 6 and 8. Using datasets outside the enterprise, or AI trained on datasets outside the enterprise, could in fact lead to outputs that are not applicable to the specific context or even biased. This aspect is also underlined by the PwC report mentioned in the Literature Review of this research. A major risk that companies may face when using external AI tools, such as ChatGPT, is indeed the fact that there may be bias in the data on which the answers are based. For this reason, many of the interviewees emphasise that it is necessary to be careful and not to blindly trust the results obtained through the use of such resources.

In this sense, therefore, the best thing would be for each company to be able to collect data in relation to its business, to build its own AI to train on that data, and thus to use it in the various internal processes. However, as is clear, this is certainly not an easy path.

Regulation

The last major barrier is the presence of a still particularly fragile regulation, which exposes companies and individuals to various risks. As mentioned in the Literature Review, the so-called AI Act is currently being developed in the European context, but it is subject to constant changes due to the evolution of AI itself. Many points still remain to be defined, and this unstable situation is certainly not helpful for the adoption of AI by businesses. This aspect also emerged in the interviews: many of the Respondents, in fact, emphasised that the lack of clarity especially on the regulation of new tools such as ChatGPT and Midjourney is a major obstacle.

In addition, due to the presence of fragile regulation, many Respondents also highlighted the critical issues that could arise in the management of data and privacy, both of consumers and of the company itself. Inserting sensitive and internal company data for analysis via tools such as ChatGPT could in fact be particularly risky. In this sense, therefore, the lack of clarity on information security represents a major barrier to the use of these new Generative AI tools.

6. Conclusion

Introduction

In this section of the thesis, the author will present a brief restatement of the research problem and objectives. Then, the main points that emerged in this research will be highlighted in order to address the Research Question. Next, reflections on the Theoretical and Managerial implications that this study might have will be given, as well as the limitations of the present study and some suggestions for future research.

6.1 Final considerations

6.1.1 Restatement of the Research problem

The technological evolution we are experiencing is completely disrupting the way we do business. Among the technological tools that are experiencing a major development, Artificial Intelligence is certainly playing a key role and is attracting the attention of researchers and practitioners. Some companies have already started to adopt such tools in several internal processes, such as decision-making processes, automation of certain production steps that were previously carried out by human workers, and so on. However, the strong development that Artificial Intelligence is knowing, especially in recent months, opens the gates to new opportunities. The launch of Generative AI tools such as ChatGPT and Midjourney is causing much discussion in many respects and the potential of Artificial Intelligence has now become public knowledge.

Everyone is now beginning to recognise and appreciate the value of AI, and for this reason, it was deemed appropriate to explore further potential applications of this technology. Specifically, the aim of this research was to understand if and how AI could be used as a supporting tool in the different stages of the innovation process. In fact, while numerous studies have clarified how AI can be applied to make certain internal processes more efficient or to automate certain business phases, little has been written about the use of this technology in terms of innovation. Some previous studies, in fact, have clarified how AI can be applied to stimulate creativity, and in recent months some research has been done on the application of generative AI tools (such as ChatGPT), especially in the early stages of the innovation process such as idea creation. However, the innovation process itself is not limited to the creation of new ideas, but is long and complex, and differs from company to company. Furthermore, nothing has been found in the literature about the relationship between AI tools and Drivers and Barriers to innovation, as well as the impact AI can have in terms of innovation levels. Nor is it clear what the current situation is, how companies are actually using these tools at the

moment, and consequently what future developments and challenges might be in this regard. All these aspects have been explored in depth in the course of this research, with the ultimate aim of arriving at a more complete picture of the current scenario, as well as an outlook on the future situation.

6.1.2 Addressing the Research Question

Before proceeding with the analysis of the primary data, collected by means of semi-structured qualitative interviews, the concepts of Innovation and Artificial Intelligence were analysed individually from the literature. This made it possible to make the necessary clarifications and definitions of these complex and articulated concepts, before delving into them in detail. The theoretical frameworks found in the literature were then utilised to investigate how AI can be used in the field of innovation. Specifically, numerous theories inherent to the concept of innovation were examined in depth, so as to use a holistic approach that allows all the various aspects related to innovation processes to be embraced.

First, the drivers and barriers of innovation were studied, and from what emerged during the analysis, AI can be used both to enhance the former and to lower or help to overcome the latter. More specifically, AI can be exploited to map competitors and market evolutions, both of which are drivers of innovation, thus keeping companies constantly up-to-date with the competitive environment in which they operate and aligned with new trends and consumer needs. Moreover, AI is itself one of the main technologies in the modern landscape, and since technological evolution is a driver of innovation, one could point out how the sudden development of AI could lead to an increasingly widespread use of this technology by firms. This, therefore, would in itself imply business innovation. Finally, it emerged how AI could also be used to improve communication processes, aligning the different divisions on corporate Strategic Intent, another driver of innovation.

As far as barriers to innovation are concerned, AI could be applied mainly to reduce the risks associated with the uncertainty of innovation itself. Indeed, AI tools could both improve clarity in communication and thus reduce uncertainty about the value of the project. Moreover, thanks to its capabilities of analysing past data and predicting future data, AI could be used to calculate the riskiness of an innovative project based on similar projects carried out in the past.

In addition to drivers and barriers, the main innovation models found in the literature and emerging from the interviews were then studied. This analysis revealed that, despite the many points of difference between the different approaches, the macro-phases of the process are always the same. From all models, therefore, a single, comprehensive model was created, consisting of four steps: Discovery, Idea Generation, Idea Selection and Development, and Launch.

From the literature and interviewees' testimonies, it was seen how AI can be applied to each of these stages:

- In the Discovery phase, AI can certainly be used to identify patterns on data inside or outside the enterprise that humans would not be able to highlight.
- In the Idea Generation phase, AI and especially the new Generative AI tools can be used to stimulate creativity and broaden the often too closed human vision.
- In the Idea Selection phase, AI can be used to choose from a group of ideas or projects those with the greatest potential; even in the subsequent step, that the researcher called Development, AI can be used to make prototypes or to identify the best design given certain requirements; furthermore, even in testing prototypes and consumers' interaction with them, AI can be useful in order to analyse the insights gained.
- In the Launch phase, especially in case of more disruptive innovations, AI can be crucial in helping people to understand the true value of the innovation, by tailoring texts to the specific interlocutor. In this, but in general throughout the innovation process, the great communication capabilities of AI have emerged.

Once the current and potential applications of AI in the different stages of the innovation process were highlighted, an attempt was made to understand what the impacts of using such tools in the final innovation might be. In theory, in fact, different degrees of innovation are reported. In this regard, through this research, it was highlighted that AI can certainly play a fundamental role in incremental innovations, participating directly in the innovation process by adding features that improve the product. However, thanks to the possibility of discovering insights and patterns never seen before, AI opens even more disruptive innovative opportunities. AI, in fact, according to the interviews, can at least highlight emergent needs or emerging patterns from the data: some doubt remains as to its ability to lead to more radical innovations.

Looking to the future, then, this research found that we are currently in the midst of an inflection point: companies are only at the beginning of their journey to adopt AI in their innovation processes. The rapid development of this technology will lead more and more firms to integrate it into internal business processes in the coming years, with the potential creation of complex AI systems. Such adoption, however, is currently hindered by a number of issues. Among these, during the research, the inertia to change on the part of workers, the difficulty in both creating and eliminating data set biases, as well as a still uncertain and immature regulation, with consequent perplexities regarding information security and privacy management, emerged as potential barriers to the adoption of AI in innovative processes.

Ultimately, then, if one wants to summarise schematically the main findings of this research, it is possible to conclude that: 1) AI can stimulate business innovation, with a direct effect on certain innovation drivers and barriers; 2) AI can be applied as a supportive tool at all stages of the innovation process, leading to process improvement and human skill enhancement; 3) the effects of AI can lead to incremental innovations, but partially also to more disruptive innovations; 4) nowadays, most companies are only at the beginning of the journey of adopting and integrating these tools into the innovation process; in this sense, some difficulties and numerous challenges have to be faced, but certainly the application of AI will grow exponentially on several fronts and dimensions.

6.2 Research implications

6.2.1 Theoretical implications

This research could have numerous implications from a theoretical point of view. In fact, the aim of this study was precisely to take a broad and holistic approach, considering many aspects related to innovation in order to understand the different potential uses and effects that Artificial Intelligence could have on it.

In this sense, this research makes a strong contribution to the existing theory, which is still scarce and needs to be developed in this field. Compared to previous studies, in fact, several aspects that had not yet been addressed in the literature, or that had been covered very briefly, have been explored in depth. In fact, this study not only investigated the potential that AI could have in the early stages of the innovation process, but also considered the concept of innovation in its entirety, investigating the relationship between AI and innovation drivers and barriers, and between AI and degrees of innovation. Furthermore, by analysing current literature and primary data collected through the interviews, this study provides the literature with an omni-comprehensive theoretical model of the main stages of innovation that comprise all different innovation models used by companies interviewed and present in the literature. Thanks to this, the main steps of the innovation process were clarified, and the results of this research showed that AI has the potential to be applied to each of them.

Moreover, several industries and different companies were considered, and also this point has led to more generalizable insights, considering the broad perspective taken. The goal of this study, indeed, was more to consider innovation and all its shades than focusing on just a single industry or company through a case-study. Finally, not only the current situation was considered, but the present research delved also into the future possible developments and challenges, so enriching the final results of the study.

All these aspects certainly represent a strong contribution to the literature, as they led to new insights that fill a gap in the current literature.

6.2.2 Managerial implications

The results of this research also have implications from a more concrete point of view, which can direct managers and practitioners to take action based on the findings.

Thanks to this study, in fact, the many potentialities that Artificial Intelligence could have if applied to business innovation processes have been highlighted. This, therefore, sets a clear direction for companies, which must begin this process of integrating AI tools into internal processes if they do not want to be left behind.

In this sense, this analysis has investigated what might be the main challenges to be overcome regarding the adoption of AI in internal processes. In this regard, several practical implications emerged. Companies and managers must try to create a culture that is innovation and technology oriented, stimulating employee training in order to increase their knowledge and lower the inertia to change.

Furthermore, various investments must be made, both in terms of developing internal AI systems and in terms of creating and managing reliable datasets related to the company's specific business. Only in this way, companies will be able to fully exploit the full potential of Artificial Intelligence in internal processes, including those related to innovation.

6.3 Limitations and Future Research

The present research has a few limitations mainly related to the type of methodology and sample used. First, it should be pointed out that, as is typically the case in qualitative research, it is often not possible to fully generalise the results obtained. The broad approach used did not restrict the study to a single company, as this could have limited the exploratory character of the research. Indeed, different aspects related to the concept of innovation (drivers, stages, degrees) were considered, with different time horizons (present and future) and considering many firms of different sizes and from different industries. This allowed to partially generalise the results of this research.

On the other hand, however, there might be two main limitations in this respect: firstly, all respondents work mainly in the Swedish market context; secondly, the number of respondents could be further expanded. Especially in relation to this last point, the time constraints related to deadlines for the thesis work certainly had an influence.

Furthermore, another major limitation of this work is the fact that companies are currently only at the beginning of the process of adopting AI in innovative models. While this gives greater insights, as the fact that we currently are in an inflection point, it would be interesting for future research to understand how this technology can actually impact the final results of the process also in quantitative terms. In order to do so, however, it would be necessary to consider a company that is already using AI in the whole innovation process, and compare the results obtained against the ones achieved before AI. This could be a cue for future research, through which the concrete effects of the full adoption of AI in the various dimensions of innovation could be further investigated. To this end, experiments and/or workshops could also be conducted. A potential idea for future experimental research could be to compare the results obtained by two almost identical teams working on the same innovation project, with the only difference being that one of the two teams has access to and uses AI tools at different stages, while the other does not.

Moreover, starting from the theoretical frameworks identified through this research, it might be interesting to explore in more detail some of the following points, which have been dealt with more broadly in this research: what are the advantages of using AI in communication processes? What are the main advantages and disadvantages of applying Generative AI? What regulations are necessary for the use of such tools? What jobs in detail could be replaced by Artificial Intelligence? All these could represent some of the possible hints for future research on the use of AI in innovation processes and beyond. The evolution of such technological tools, in fact, opens an infinite number of possibilities in this regard, also considering how this technological tool is and will be constantly evolving.

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Appendix A – E-mail to potential interviewees

This appendix provides the text that was used to contact potential respondents through e-mail.

Dear Mr./Mrs. X,

I am Mauro Campus, a Master's student in Innovation and Industrial Management at the University of Gothenburg.

This semester I am writing my Master's thesis in cooperation with First to Know Scandinavia and, more specifically, with the help of Per Östling. My Master's thesis regards the application of Artificial Intelligence to innovation processes and the different stages of innovation within a company. In more detail, I would like to investigate better how Artificial Intelligence can be used as a tool to support, foster, and stimulate innovation, also understanding what the main opportunities and challenges in the future are.

I would be very grateful if we could arrange an interview in the next few days, in order to ask you some questions on this topic. Would you be available? Please let me know when it would be most convenient for you.

Thank you in advance.

Kind Regards,
Mauro Campus

Appendix B – Interview Guide

B.1 Premises

A series of premises with different scopes will be made during each interview before asking questions about the research object. These premises are set out below:

- Presentation of myself and explanation of why I am conducting this research. To this end, the following is an outline to follow at the beginning of the interview.
  "First of all, I wanted to thank you for your availability and for accepting the invitation to this interview. As I anticipated you by e-mail, my name is Mauro Campus and I am a Double Degree student attending the second year of the Master's degree program at the University of Gothenburg".
- Better explain the broad topic and clarify the field of research to get interviewees more into the topic itself. Ask the interviewees if they need further clarification on this or if they need to ask anything.
- Explain the structure of the interview: it starts with preliminary questions on the interviewee, then continues with general questions on the topic under analysis, and then goes into more detail on certain aspects. Explain that the expected duration of the interview is approximately between 40 and 60 minutes, but that there are no actual time limitations other than those related to the interviewee's availability.
- Ask permission to record the interview. Explain that the recording will not be shared and will be used to realize the transcript to analyse the answers better.

B.2 Interview Questions

The following table shows the questions that will serve as the basis for the interview. From these, there will be room to investigate further insights or observations that have emerged during the interview. Questions shown in italics are potential follow-up questions regarding aspects that the researcher would like to explore further. They have been adapted based on the specific case and the respondent's experience in this regard.

Topics	Questions
Introduction of the Interviewee	1) Could you please tell me your name and what your role is in the company/institution you work in?
	2) What is your experience with AI?

and about AI experience	3) What kinds of AI does your company/institution use, and how?
AI, drivers, and barriers	4) A: What do you think are the most important drivers of innovation within your company/institution? B: How can AI foster the level of innovation by intensifying some of these drivers?
	5) A: What are, in your opinion, the main barriers to innovation? B: How can AI help your company/institution to overcome them?
AI in different phases of innovation	6) A: What are the main steps of the innovation process of your company/institution? B: How do you apply AI / can AI be applied to all of these steps?
	How can AI impact the idea-generation phase?
	How can AI impact the design phase?
	How can AI impact the prototyping and testing phase?
AI and different degrees of innovation	7) How do you think AI can impact the degree of innovation in term of results?
	Do you think that AI is able to discover hidden needs?
	Do you think that AI can be applied for the automatization of incremental innovations?
	Do you think that AI can create breakthrough or radical innovations?
AI future opportunities and challenges	8) What do you think are the main future opportunities related to the application of AI in the innovation processes?
	9) What are the main challenges or barriers to the use of AI in innovation processes?
Conclusive Question	10) Is there something more that I would have asked or something else you would like to add?

Table 4 - Interview Questions

Executive Summary

1. Introduction

Technology and innovation are two interconnected concepts, and their impact on companies has always been significant, determining their strategies and success. Nowadays, technological evolution is disrupting the ways of doing business: a wide range of new technological tools is at the heart of the digitisation process we are experiencing with the fourth industrial revolution. One of the tools that have attracted the attention of practitioners is Artificial Intelligence (AI): the business contexts in which this tool is applied have grown exponentially, and nowadays, especially with ChatGPT and other Generative AI tools, new possibilities and uses are emerging, also for innovation. Therefore, this paper aims to explore this point further, by answering the following Research Question (RQ):

RQ: "How can AI be a supportive tool in the innovation process?"

Indeed, if on the one hand it is clear that AI is being used to accelerate and automate some processes, there is still a need for further research in terms of applications in the innovation process: not many studies have analysed how companies' innovation models can be supported by AI. Therefore, this paper aims to get a clearer picture of how innovation and AI interact with each other, and particularly of how the latter impacts the former being used as a supportive tool. It is evident the potential significance that the results of this study could have: on the one hand, every company is doomed to die without innovation; on the other hand, the use of the latest technological tools could be the means to achieving relevant results, also in terms of innovation. In investigating the RQ, an exploratory approach will be adopted, looking into both the current *status quo* and the potential future possibilities and challenges. Both primary and secondary data will be considered: the latter will be collected through a Literature Review, while the former will be obtained via qualitative research, developed through semi-structured interviews. All collected data will be then analysed through a thematic analysis. The main findings will be then discussed in the final section of this research.

2. Literature Review

This section, dedicated to the review of current literature, served to highlight the most relevant aspects of the considered field of research, to build the basis of the present analysis.

2.1 Innovation

In today's dynamic and magmatic market environment, companies must always be ready to evolve as a response to continuous changes from the external environment, and in this sense the ability to innovate is fundamental. Innovation is crucial to create value and keep a competitive advantage over

other market players (Baregheh et al., 2009), especially in a turbulent and competitive environment (Neely & Hii, 1998). Therefore, if we consider the importance and the role that innovation plays in the life of companies, it is fundamental to deepen this concept, which is often misunderstood or misused. Schumpeter was the first to define the concept of innovation, highlighting specific components that are still relevant today. According to his definition, innovation goes far beyond the mere introduction of new products, but also extends to the discovery of new processes, markets, and so on. Many definitions that followed took up Schumpeter's point of view, enriching and modifying it. A study conducted by Baregheh et al. (2009) highlighted some of the most recurring terms. From these, Baregheh et al. (2009) formulated the following definition: "*Innovation is the multi-stage process whereby organisations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace.*"

Once framed the main elements that make up the complex concept of innovation, it is necessary to understand the main drivers and barriers. This, for the purposes of this study, will be crucial to investigate how AI can be applied to enhance the drivers and to lower or overcome the barriers, so stimulating innovation. For both drivers and barriers, there are several classifications in the literature. Dani & Gandhi (2021) have divided innovation drivers between external and internal, and the latter have been further categorised between organisational and individual levels. With regard to barriers of innovation, on the other hand, one of the most relevant classifications is that proposed by Piatier (1984): according to this study, also barriers can be divided between external and internal, and in more detail internal barriers can be resource-based and human nature-related.

Another aspect worthy of attention when it comes to innovation, relates to its different possible levels of intensity: in this regard, Goffin & Mitchell (2017) highlight three different degrees of innovation. *Incremental Innovations* are improvements to existing products, services, or processes, and represent the simplest degree of innovation. *Breakthrough Innovations* instead involve a more substantial change than incremental ones: in this case, the time it takes for consumers to understand the benefits of new products must be considered. *Radical Innovations*, often defined as game changing. They are certainly much rarer and frequently involve the creation of completely new businesses or a complete redefinition of the competitive environment (Goffin & Mitchell, 2017). Managers often aspire to that level of innovation, but the success rate is significantly lower as they represent the most complex and the rarest degree to achieve (Sandberg & Aarikka-Stenroos, 2014).

Once framed all the previously mentioned features and aspects related to the concept of innovation, an overview of historical models and more modern practices of innovation has been provided. In this way, it was possible to identify the different stages of the innovation process to understand how AI can be used as a supporting tool in each of them. From a historical point of view, Rothwell has identified five generations of innovation models (Rothwell, 1994), and later authors

(Berkhout et al., 2006; Boehm & Fredericks, 2010; Shavinina, 2003; Tidd, 2006) have taken up these theories. The first and second generations are the so-called *"linear models"* (Tidd, 2006): the first generation is called *"technology push"*, and has as initial input R&D investment; the second generation, instead, is *"market/need/demand pull"* (Berkhout et al., 2006; Boehm & Fredericks, 2010; Rothwell, 1994), meaning that has the objective to reactively respond to the needs of the market (Rothwell, 1994). The third generation represents an evolution of the first two: the sequence of different stages is no longer one-way, but there is a greater level of interaction and feedback between the different phases (Barbieri & Álvares, 2016). The fourth and fifth generations then emphasised the cross-functionality and the flexibility of the models (Barbieri & Álvares, 2016; Tidd, 2006).

When it comes to the more modern practices, some of the main models worthy of attention are Design Thinking and Stage-gate process. *Design Thinking* has been defined as a *"multidisciplinary, human-centred innovation approach inspired by designers"* (Carlgren et al., 2016). There are several differing views in the literature on how to put this model in practice: some of the leading researchers (Gruber et al., 2015; Liedtka, 2018) identified three main phases: 1) customer discovery; 2) idea generation; 3) testing experience. The same phases are called differently by other models, such as the 3I, in which the three phases are: 1) inspiration; 2) ideation; 3) implementation (T. Brown & Wyatt, 2010; *IDEO Design Thinking*). Another practice that uses a Design Thinking approach, is the Double Diamond model (Design Council, 2019; Tschimmel, 2012).

When it comes instead to the creation, development, and launch of new products, one of the best-known models is the Stage-Gate Process (Cooper, 2008). It is an *"idea-to-launch"* model in which there is an initial phase of idea generation, after which there are five steps: 1) scoping; 2) build the business case; 3) development; 4) testing and validation; 5) launch. (Cooper, 2008). These steps are all followed by gates in which go/kill decisions are made as to whether or not to continue investing in a particular project (Cooper, 2008). One of the main critiques against this model is its being linear: Cooper, the inventor of the model itself, for this reason, has proposed a new more Adaptive, Agile and Accelerated model, called the *"Triple A system"* (Cooper, 2014).

2.2 Industry 4.0 and Artificial Intelligence

Over time, as production techniques have evolved and human knowledge has expanded, there has been a series of industrial revolutions. Nowadays, the business world is experiencing a massive digital transformation, which is more commonly known as the fourth industrial revolution, or Industry 4.0 (Ghobakhloo, 2020). As a consequence, several industries are adopting an automatization and digitalisation approach, expanding the application of tools such as Artificial Intelligence (Magd et al., 2022): considering its importance for this research, this concept is worthy to be further explored.

AI is a particularly broad and complex concept, and over the years it has undergone rapid development. The birth of Artificial Intelligence is traced by many to 1956: since then, AI has evolved considerably. Numerous studies have tried to frame its main features, and various definitions have been reported. Among them, one of the most relevant is that provided by Helmold & Terry (2021), who define AI as a "*wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence*."

In line with this definition, different levels of AI have been identified based on its capabilities to emulate human intelligence. Accordingly, it is possible to mention three different levels (Bostrom, 2006; Goertzel, 2014; Soviany, 2018; Strelkova, 2017). *Artificial Narrow Intelligence,* which is the basic level of AI and is specialized in a single area or in specific contexts. *Artificial General Intelligence,* which can achieve a broader range of goals and perform a wide range of tasks, in different contexts and environments, and it is at the same level as human intelligence. *Artificial Super Intelligence,* which represents a level of intelligence superior to that of humans in every domain.

Once AI has been defined, is important is to understand also what are its main enablers: C. Zhang & Lu (2021) identified two main drivers of Artificial Intelligence. On the one hand, *Algorithms* are essential to the work of computers and are what makes Artificial Intelligence possible (Chi-Hsien & Nagasawa, 2019). On the other hand, another building block of Artificial Intelligence is represented by *Big Data*, which are fundamental for training Artificial Intelligence algorithms (Kreutzer & Sirrenberg, 2020): without data with specific characteristics, it would be not possible to train AI.

As anticipated, then, AI is a branch of computer science that studies machines with the ability to perform tasks that require human intelligence (Helmold & Terry, 2021). As these tasks are many, so are the subfields of AI. *Machine Learning* is certainly one of them: it is based on the use of an algorithm that improves the performance and capabilities of the machine, which learns from the data used as input (Nilsson, 1982), performing and tackling a given task without being explicitly programmed for it (Campbell et al., 2020). Then, *Deep Learning* is another subfield of AI, specifically a subset of Machine Learning. Compared to it, Deep Learning differs in the fact that it requires less human intervention (*What Is Artificial Intelligence (AI) ?*, n.d.) and because it is based on Neural Network architectures (Shinde & Shah, 2018). *Natural Language Process (NLP)* is another field of AI that makes machines capable of understanding and processing language typical of humans and in a similar way to humans (Gruetzemacher, 2022; *What Is Natural Language Processing?*, n.d.). ChatGPT is one of the most recent and famous technologies that use NPL models (Gruetzemacher, 2022). *Computer Vision* is another sub-branch of AI that has the goal to train machines to recognise and understand the world through its vision, just as humans do (C. Zhang & Lu, 2021).

As evident, thus, AI has various applications and is a constantly evolving field. Nowadays we are experiencing a generational change in AI, due to the so-called "Generative AI" (*Generative AI,*

n.d.). Specifically, it refers to AI models that are capable of "generating" high-quality texts, images, or other content (*Generative AI*, n.d.; *What Is ChatGPT, DALL-E, and Generative AI?*, 2023; Martineau, 2023). The evolution that such models have been experiencing in recent months is due to the launch of ChatGPT, which marked the first inflection point in the public adoption of AI: thanks to this, many people started to understand the transformative and creative potential of Generative AI models (Daugherty et al., 2023). Among the main Generative AI tools, it is possible to mention GPT Models (on which ChatGPT is based), text-to-image models (such as Midjourney) and many others.

2.3 Artificial Intelligence in the Business World

Once defined the concept of AI, it is important to deepen the impact this technology can have on companies. Nowadays, AI is applied in an increasing number of contexts: Sestino & De Mauro (2022) highlight that some of the main uses concern decision-making and automation processes, leading to increases in efficiency. The positive impact AI has had can be seen also in the increased involvement of employees due to interaction with *"human-like"* technologies, such as chatbots (Davenport, 2018). Many of the leading companies in the digital transition have used AI also for some external practices such as online operations, sales, marketing, and customer engagement (Davenport, 2018). In fact, AI is often used in mining processes, to identify insights into consumer behaviour (Davenport, 2018), opportunities, trends, and interesting patterns (H. Zhang et al., 2020). Moreover, thanks to the models of Generative AI, the opportunities are growing considerably ('The New AI', 2023).

If on the one hand, there are several possibilities, at the same time it is also necessary to delve into some of the critical issues. In an article published in McKinsey Review, it was pointed out that there may be several difficulties regarding data management (Cheatham et al., 2019). Indeed, managing sensible data of consumers in full respect of privacy could be complex. Linked to this problem, there is a still precarious and immature regulation: still many points must be defined. Another aspect that needs to be considered concerns the potential presence of bias. In fact, even though it is often believed that AI cannot make mistakes as a machine, if the data on which the algorithm is trained are biased, then this bias will also be present in the results (PwC, 2022): basing decisions on biased data or unreliable outputs can expose companies to make bad strategic choices. Finally, one must also consider the set of consequences that AI will also have in the world of job, going to replace several workers due to the automation of several processes (Goldman Sachs, 2023).

For the purpose of this research, then, it is important to delve into the concrete applications that AI can have in terms of innovation. Indeed, as Kakatkar et al. (2020) show, "*AI can play an important role in the innovation process, from the exploration of problems to the selection of solutions.*" Indeed, some digital tools have been used to stimulate human creativity (Maiden et al., 2023), which is one of the key elements when it comes to innovation. Bouschery et al. (2023), argue

how especially transformer-based language models could create interesting opportunities for AI-augmented innovation processes, by summarizing texts, extracting information and insights, or generating creative outputs. Moreover, evidence of further applications of AI in innovation concerns the use of this technology in the implementation of Design Thinking practices (Verganti et al., 2020). However, in all these cases many questions remain unanswered. Idea generation, design and all these activities are just at the beginning of the innovation process, which is difficult complex and much longer. Therefore, much remains to be explored: how can AI also be applied to the later stages of innovation processes? Can AI lower barriers to innovation or boost the main drivers? How far can the creativity of AI go in terms of degrees of innovation? What are the future potential developments and challenges? All these crucial aspects will be further investigated in this study.

3. Methodology

This part of the research will describe the methodological approach chosen to answer the RQ, highlighting the rationale behind the selected approach.

3.1 Research Strategy & Research Design

Since the goal of this research is to understand how Artificial Intelligence can support innovation, also looking at potential and future developments, the data needed to answer the RQ of this paper are qualitative. Accordingly, qualitative research has been conducted, following an inductive approach. Indeed, the level of novelty that characterises the object of the research led the researcher to adopt a strategy that is exploratory in nature, and that aims precisely at creating new theories without formulating hypotheses *a priori*. This implies a specific relationship between theory and research: the former, in fact, has been developed because of the latter (Bell et al., 2019). Indeed, a series of inferences have been drawn from data collected, to build the theory needed to answer the RQ.

The Research Design of this study has been given by a set of qualitative interviews. Since the aim is to understand the current state of the use of such technologies in innovation processes, as well as potential future applications, challenges and barriers, a holistic approach has been adopted. Due to this broad perspective not a single nor a multiple case study were considered, but instead how AI can support innovation from different perspectives and in different industries and companies was investigated. In that way, it was possible to obtain more generalisable results.

3.2 Research Methods

3.2.1 Data collection

To answer the RQ of this paper, both primary and secondary data have been considered. Secondary data used for the present research were collected through a Literature Review conducted in a

systematic way. After an initial scanning of scientific and managerial articles and papers related to the topic of the thesis to have an overview of current theory, calls for research and still unclear aspects were taken into consideration. In this way, it was possible to identify a gap in the literature, which made it possible to give a clearer direction to the research. As a result, the three macro-topics relevant to the subject under analysis were identified: Innovation, Artificial Intelligence and its applications in the business world. Based on that, the search for relevant literature was continued through Google Scholar and Scopus. Only reliable sources and mainly data and research after 2010 were considered to draw on more recent information and theories in line with the current scenario. In this regard, just some exceptions have been made, citing older sources and milestones in the literature to provide a deeper understanding of the topics covered. The abstract of the papers found was first read, and then the articles deemed most relevant were later explored and analysed more carefully.

Primary data, on the other hand, have been collected through semi-structured qualitative interviews. This choice was taken considering the great level of flexibility that this kind of interview has: indeed, thanks to the characteristics of semi-structured interviews, there is the possibility to range between different topics, leaving the interviewees the opportunity to highlight all the points they consider important (Bell et al., 2019). This allowed the researcher to ask follow-up questions to clarify or to elaborate on unexpected insights deemed interesting, which often emerge in research of an exploratory nature such as the present. At the same time, although semi-structured interviews do not follow a rigid script of questions, an interview guide was used. Thanks to this, it has been possible to identify a set of topics that have formed the skeleton of the interview itself (Bell et al., 2019).

Each interviewee was contacted via email. Prior to conducting the interviews some personal information about the interviewer and the purpose of the interview was reiterated to clarify any doubts the interviewee might have had. Permission was sought to make an audio recording of the interviewees' responses to realise a detailed transcription of the responses, then used in the Data Analysis. Purposive sampling, convenience sampling and snowball technique were used in selecting the sample. Specifically, considering the purpose of the research, the two criteria used to delineate the sample were: 1) knowledge and/or direct experience of the world of innovation and innovation processes; 2) knowledge and/or experience of AI technologies. To obtain data as generalisable as possible, 10 respondents from companies of different sizes and different industries were interviewed. In this way, a broader view of the potential that AI has in different business scenarios was obtained.

3.2.2 Data Analysis

As anticipated in the previous section, all interviews were recorded to create transcripts of the responses. To facilitate this process, Avrio (an online software that provides a first-draft transcript) was used. This first raw draft was then revised and corrected, both to familiarise with data gathered

and to simplify the analysis process. The methodology selected for analysing the large dataset obtained was that of thematic analysis. Specifically, the different steps that were followed for the present research are: 1) Partitioning the transcripts into first-order concepts; 2) Grouping first-order concepts into second-order themes; 3) Identification of aggregated dimensions. To facilitate these steps, also ensuring adequate quality in the execution of Data Analysis, the NVivo software was used: thanks to this tool, it was possible to visualise concepts and themes belonging to the same aggregated dimension, thus facilitating comparisons between the different interviews.

3.3 Reliability and Validity of the Research

A key aspect to consider when conducting research concerns meeting specific quality criteria: trustworthiness and authenticity, proposed by Guba & Lincoln (1985, 1994) for qualitative research were considered. In this way, each step of this study was done ensuring a high standard of quality.

4. Empirical Findings and Discussion

In this section, the main data obtained will be reported. For each of the macro-themes that emerged during the analysis, the researcher will frame a comparison between the Respondents (R) testimonies and the previous studies, presented in the Literature Review section. In this way, it will be possible to highlight any points of contrast or in common between literature and research findings. Specifically, thanks to this discussion, it will be possible to answer the RQ.

4.1 AI & Drivers and Barriers to Innovation

4.1.1 AI and Drivers of Innovation

One of the first aspects considered concerns the drivers of Innovation. During the interviews, five main drivers emerged, and to have a more immediate match with the literature, they were divided between internal and external during the analysis. When it comes to external drivers, previous studies and interview findings appear to be particularly aligned: new market opportunities and needs, competition, and technology evolution are the main external drivers that emerged during the interviews, and they correspond exactly to three of the four external drivers identified by Goffin and Mitchell (2017). In relation to these drivers, companies could benefit from using AI as a supporting tool: indeed, it was reiterated by several Respondents how AI could be adopted to scan both consumer and competitors' data, so facilitating procedures for finding new market opportunities, new (especially emerging) consumer needs, and new competitors' strategies. In this sense, therefore AI could be considered as a tool that drives companies to innovate. AI, moreover, also represents an important technological evolution, and for this reason, it is itself a driver of innovation. Two main internal drivers were then also identified during the interviews, and both of them, according to the

classification proposed by Dani & Gandhi (2021), fall under the organisational level. Specifically, in fact, the interviewees emphasised the importance of Strategic Intent, as well as investment in R&D. Especially when it comes to the former, R4, R5 and R6 underlined that AI can be applied to foster communication between different employees and divisions of a company, clarifying at every level the strategies the firms want to pursue.

4.1.2 AI and Barriers to Innovation

Through this research also the barriers to innovation were identified. Among the barriers cited in the literature (Hadjimanolis, 1999; Madrid-guijarro et al., 2019), respondents focused mainly on a few. First, the need for large investments required to innovate was mentioned, specifying how the macroeconomic environment does not help in this regard (R2 cited the example of the failure of Silicon Valley Bank). Considering that AI is being applied in more and more contexts, including the financial one, the researcher believes that the decision-making capabilities of AI highlighted in the literature could be exploited (Sestino & De Mauro, 2022), supporting firms in identifying what are the most convenient forms of financing and investment. Moreover, also the high risk of failure related to the innovation itself was highlighted: especially according to R3 and R7, it often causes a stop of the innovation process. In risk and uncertainty management, as emerged from the interviews, AI could be helpful to create greater clarity in internal communication processes, thus avoiding all those situations in which process-related uncertainty is due to ineffective communication. In addition, because of AI's ability to predict future trends and patterns based on historical data, the risk of a project could be assessed by comparing it to similar past projects. The last barrier internal highlighted by interviewees was workers' inertia to change: this, too, could be reduced by the presence of AI. In fact, usually, opposition to innovation is because workers do not recognise the value of change itself: this, thanks to AI becomes easier. In fact, especially tools such as ChatGPT are nowadays within everybody's reach: everyone can check their potential and understand how they are a viable method to innovate (R5).

4.2 AI on different stages of the Innovation process

4.2.1 Innovation Process: a new comprehensive model

Several innovation processes can be found in the literature and have been highlighted by interviewees. In fact, it emerged how each company has its own process, developed according to its specific needs. A careful analysis of the models identified showed how they differ from each other for several reasons. However, despite their diversity, various commonalities have been identified for all innovation processes, and consequently a new holistic and aggregated model was created by the researcher, based on the main recurrent steps. This new framework is composed of four main Stages

(Discovery, Idea Generation, Idea Selection and Development, and Launch), and will form the backbone of this section, so as to see the current and potential uses of AI in each of the four stages.

The first macro-phase (*Discovery*) often consists of research and identification of inputs from which the innovation process then starts. These inputs, as emerge both from the literature and interviews, can be either internal or external to the company. In this phase of the innovation process, usually, an open-minded approach is used, where a large group of potential unmet needs or problems are considered (Kakatkar et al., 2020; Tschimmel, 2012). At this stage, AI can be used in several ways: R9, for instance, revealed that in his company chatbots were asked to pretend to be a certain category of consumers to highlight potential points of criticism. R2, on the other hand, pointed out that by using AI it is possible to gain insights never seen before. R5, moreover, provided an example in which through machine learning it was possible to arrive at insights for which researchers were not directly investigating. Finally, R6 stated that AI can notice gaps in products from which a subsequent innovation process can start. All these points enrich Kakatar et al. (2020) theories, according to which AI can be applied in the problem exploration phase.

From what emerged from the analysis, the second macro-phase (*Idea Generation*) has the objective to arrive at a set of potential ideas that can solve the problem identified in the previous stage. According to R4, this is precisely the most complex step when innovating: as humans, what we know is often limited to what we have recently experienced. AI, on the other hand, has a deeper capacity for storing and analysing data, and is more open-minded than humans in looking for a potential solution. This point was reiterated by several interviewees: R2, 6, and 8 underlined how AI can increase human levels of creativity. Tools such as ChatGPT, for instance, can be a starting point in the idea generation process, providing *"food for thoughts"* (R5) for brainstorming sessions, and widening the range of potential solutions. Also in R1's experience ChatGPT was helpful in that, autonomously adding basic features to his software.

With the third macro-stage (*Idea Selection and Development*), firms first choose the idea that might be most suitable. This phase has been highlighted both in the literature (Design Council, 2019; *IDEO Design Thinking*, n.d.; Tschimmel, 2012) and by the respondents. Indeed, once the idea generation phase is over, it is necessary to focus on one or a few ideas that can then be developed more concretely. In more detail, AI has the potential to be used in choosing the best idea or design. R2, for instance, argued that thanks to AI it is possible to understand whether an idea is unique and therefore implementable. Furthermore, especially in large companies, the use of AI could lead to saving resources and time: R8 pointed out that when a big flow of ideas has to be managed, AI could be used to identify potentially interesting ideas, based on the characteristics of the company and/or the target consumers it addresses. Once one or a few ideas that are worthy of being implemented have been identified, the object of the innovation has to be designed: also in this AI could support

companies. R1 and R8, for example, argued that when it comes to design, it could be an excellent starting step to ask *"text to image"* generation tools such as Midjourney to create a graphical draft of the product to be tested. In this regard, however, it has been clarified that it is necessary to know how to prompt these tools to generate an image that is realistic and in line with the ideas behind it. R7 and R6 also recognised the potential of AI in this regard: the latter provided the example of Volvo Cars, in which AI is employed to identify the best possible design for certain car components. Also R9 also pointed out that in the design phase it can be helpful to use *"image to image"* AI tools: the initial design of the product can be used as a prompt in order to obtain a series of suggestions on how to improve the design itself. Finally, once a digital prototype has been obtained, AI could certainly be useful to analyse data obtained as feedback, consequently developing possible improvements (R10).

The fourth stage (*Launch*) consists of adopting the innovation itself, both inside the firm and externally (if consumer-oriented). Especially in the latter case, the most disruptive innovations may need time to be understood and accepted by the market. Indeed, according to previous studies (Deszca et al., 1999; Goffin & Mitchell, 2017), it may take time for consumers to recognise the actual value of an innovative product or service. However, based on the interviews, the adoption of innovation could be facilitated by AI. In fact, many of the respondents recognised the great communication capabilities of Generative AI, which is flexible and adaptive depending on the interlocutor to whom it has to address the message. In this sense, AI could be exploited to produce texts defined as *"more selling"* (R6), thus enabling faster and easier adoption of the innovation.

4.2.2 General considerations about AI in the different stages of the innovation process

From the previous section it emerged that both according to the literature and the interviewees, AI can be used as a supporting tool in the different stages of the innovation process. However, all interviewees highlighted that most companies are just starting their journey towards adopting AI in their innovation models. Indeed, as underlined by several respondents, many firms are still just partially using AI tools and not in all the innovation stages: even though AI tools certainly have the potential to be used to support different stages of innovation, the process of embedding and integrating these tools into the companies' innovation processes is only at the beginning. R4 highlighted how we are currently at an *"inflection point"*, meaning that in the coming months and years, there will be a strong development in this regard, and this will have serious implications for managers, regulators, consumers, and all stakeholders who may be affected by this sudden growth.

4.3 AI and degrees of Innovation

Another aspect that was explored through this research concerns the impact that such use could have in terms of degrees of innovation, which as highlighted in the literature, are incremental,

breakthrough, and radical (Goffin & Mitchell, 2017). In the Empirical Findings, just a distinction between incremental innovation and more disruptive innovation was made, but from the statements of the interviewees, it is possible to deduce some considerations in this regard. First, it is evident how AI will have an impact in terms of incremental innovations. Current AI tools, such as ChatGPT, are already proving their potential in this regard, demonstrating strong creative and supporting capabilities. R1 gave a clear example of this: ChatGPT, after the description of the project itself, was able to suggest incremental features that could improve the software created.

Likewise, however, because of the ability to create new insights never seen before (an aspect recognised by several respondents), it is possible to leverage AI for more disruptive innovations. In this sense, however, as emerged from interviews 1, 8 and 9, AI can be applied to highlight emergent needs, but not in completely new contexts or for inventions often given by a latent (or even non-existent) need about which AI could know nothing. For this reason, at least in the initial phase of problem and/or opportunity identification, it is possible to conclude that AI could lead to incremental and breakthrough innovations, but hardly to radical innovations. On the other hand, for both breakthrough and radical innovations companies may take advantage of the flexible communication capabilities of AI, which can adapt based on the stakeholder with whom they interact. This point, underlined by most of the respondents is crucial: indeed, Deszca et al. (1999) highlighted that it is can be difficult to make customers understand disruptive innovations. Thanks to AI, it can be easier.

4.4 Future perspectives

4.4.1 AI, opportunities and future developments

Future opportunities and potential scenarios concerning the application of AI were also explored. An aspect that emerged from both the literature and the interviews is the great growth associated with such technologies. AI developments, according to the interviewees, will concern several dimensions: firstly, there will be an improvement of these technologies (R2). Secondly, they will be used more and more frequently, in more contexts and by a higher number of enterprises. This will lead to a massive change in the various business contexts, with AI becoming increasingly decisive in this respect (R3, 4 and 6). This growth, as the interviews revealed, will lead to a strong increase in productivity (R9) and optimisation of business processes (Davenport, 2018). As highlighted by R1, this diffusion will be facilitated by open-source libraries, as well as by cloud computing, thanks to which the accessibility to AI will increase also for small companies.

The growth of AI then, will lead to the implementation of increasingly complex systems composed of different AI tools: collaboration between different types of AI could both stimulate the level of creativity (R8) and make the final outputs more reliable. Indeed, as R2 made clear, some companies (including IBM Nordic itself) are starting to use AI tools to control other AI tools, so

increasing the reliability of data used and answers obtained. In line with this is the testimony of Professor Bowman ('The New AI', 2023). In any case, it has been clarified that human control will always be required: it would be too dangerous to leave machines to act completely on their own.

4.4.2 Challenges to the AI adoption

Many challenges to the AI adoption were highlighted both in the literature and by the respondents. First, it appeared that at the corporate level, AI will generate a shift in skills and knowledge. The business world will be transformed, and this will entail several changes in terms of the distribution and roles of workers. As R6 points out, AI will lead to a change in required skills and new organisational parts, and companies will have to adapt their structures and roles to these new technologies, training their workers and changing their mindset. This last point was emphasised by R2, 3, 6, 7, and 10, who argued that especially the more traditional sectors show an inertia to change and technological adaptation, slowing down the adoption of AI. Secondly, the importance of data has been reiterated by several interviewees: without data, in fact, it is not possible to use any kind of AI. In this sense, however, obtaining an appropriate dataset is by no means straightforward. As R3 argued, along the projects he managed it was often chosen not to use AI tools because it was not possible to construct an appropriate dataset. This, therefore, represents a major obstacle to the use of AI, as also reiterated by Respondents 6 and 8. On the other hand, using datasets outside the enterprise is risky, since it could lead to outputs that are not applicable to the specific context or are biased. Finally, another major challenge is related to the particularly fragile regulation, which exposes companies and individuals to various risks. In this regard, many of the respondents emphasised that the lack of clarity on the regulation of new tools such as ChatGPT and Midjourney is a major obstacle and exposes companies to difficulties in managing data and privacy.

5. Conclusion

In this section of the thesis, the author will highlight the main points that emerged during this research, so to address the Research Question. Next, reflections on the implications that this study might have will be given, as well as the limitations and some suggestions for future research.

5.1 Final considerations: addressing the Research Question

As anticipated, the technological evolution we are experiencing and the strong development that Artificial Intelligence is knowing have opened new opportunities for firms. In line with this, the aim of this research was to understand how AI could be used as a supporting tool in the different stages of the innovation process, by looking both at the current situation and at future potential developments. In fact, while several studies have clarified how AI can be applied to make internal

processes more efficient or to automate some business phases, little has been written on the use of this technology in innovation. Consequently, several aspects have been explored to address the RQ.

First, the drivers and barriers of innovation were studied: in this regard, it emerged that AI can be used both to enhance the former and to lower the latter. More specifically, AI can be exploited to map competitors and market evolutions, both of which are drivers of innovation; moreover, AI is one of the main technologies in the modern landscape, and since technological evolution is a driver of innovation itself, this makes AI driving innovation; finally, it emerged how AI could also be used to improve communication processes, aligning the different divisions on corporate Strategic Intent, another driver of innovation. As far as barriers to innovation are concerned, AI could be applied mainly to reduce the risks associated with innovation uncertainty, improving clarity in communication. Moreover, thanks to its capabilities of analysing past data and predicting future developments, AI could be used to calculate the riskiness of an innovative project. In addition to drivers and barriers, the main innovation models found in the literature and emerging from the interviews were then studied. This analysis revealed that, despite the many points of difference between the different approaches, the macro-phases of the process are always the same. From all models, therefore, a single comprehensive model was created, consisting of four steps. In detail, it was seen that AI can be applied to each of these stages: 1) in the Discovery phase, it can be used to identify patterns in data that humans would not be able to highlight. 2) In the Idea Generation phase, AI and especially the new Generative AI tools can be used to stimulate creativity and broaden the human vision. 3) In the Idea Selection phase, AI can be used to choose from a group of ideas or projects those with the greatest potential; even in the subsequent step (Development) AI can be used to make prototypes or to identify the best design given certain requirements; furthermore, even in testing prototypes, AI can be exploited to analyse the data gathered. 4) In the Launch phase, especially in case of more disruptive innovations, AI can be crucial in helping customers to understand the true value of the innovation, by tailoring texts to the specific interlocutor. In this, but in general throughout the innovation process, the great communication capabilities of AI have emerged. Being applied as a supporting tool, it was then highlighted that AI can certainly play a fundamental role in terms of incremental innovations, participating directly in the innovation process by adding features that improve the product. However, thanks to the possibility of discovering insights and patterns never seen before, AI causes also more disruptive innovations. Looking to the future, then, this research found that we are currently at an inflection point: companies are only at the beginning of their journey to adopt AI in their innovation processes. The rapid development of this technology will lead more and more firms to integrate it into internal business processes in the coming years, with the potential creation of complex AI systems. Such adoption, however, is currently hindered by several issues. Among these, the inertia to change on the part of workers, the difficulty in both creating and

eliminating data set biases, as well as a still uncertain and immature regulation, emerged as potential challenges to the adoption of AI in innovative processes.

5.2 Research implications

This research has numerous implications from both a theoretical and managerial point of view. First, the research makes a strong contribution to the existing theory, which is still scarce and needs to be developed in this field. Compared to previous studies, in fact, several aspects that had not yet been addressed or that had been covered very briefly have been explored in depth. Moreover, from a managerial perspective, a clear direction for companies has been set: the many potentialities that AI could have if applied to business innovation processes have been highlighted, also investigating what might be the main challenges to be overcome. Therefore, managers should consider the results of this research as a starting and inspiring point on which develop their future strategies to the AI adoption on the innovation process.

5.3 Limitations and Future Research

The present research has a few limitations mainly related to the type of methodology and sample used: indeed, all respondents were selected from the Swedish market context, and the size of the sample could be expanded. Furthermore, another major limitation of this work is the fact that companies are currently only at the beginning of the process of AI adoption in the innovative process. While this gives greater insights, it would be interesting for future research to understand how this technology can actually impact the final results of the process in more quantitative terms. To this end, experiments and/or workshops could also be conducted. Moreover, starting from the theoretical frameworks identified through this research, it might be interesting to explore in more detail some "side points" such as the advantages of using AI in communication processes or what kinds of jobs could be replaced by AI. Considering the evolution of such technological tools, in fact, there is an infinite number of possibilities in this regard for future research.

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AI for innovators

An exploratory study on the application of Artificial Intelligence as a supportive tool in the innovation process