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EXECUTIVE SUMMARY OF THE THESIS

Off to the future of creativity and innovation: what AI can – and cannot – do[1]

TESI MAGISTRALE IN MANAGEMENT ENGINEERING – INGEGNERIA GESTIONALE

AUTHOR: ALBERTO GEGRA

AUTHOR: FEDERICO MACCAGNOLA

ADVISOR: PROF. LUCA GRILLI

CO-ADVISOR: PROF. MATTIA PEDOTA

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1. Introduction

With his artwork "Théâtre D'opéra Spatial", Jason Allen won first prize in the 2022 Colorado State Fair art competition. The painting, however, was created by the generative algorithm Midjourney, sparking uproar and controversy on social media. Where is the line between art and science? Is there a difference? Can we even tell if the art was made by humans or by an algorithm? Art is a difficult thing to define and possibly harder to create but until recently, producing creative output was considered a distinctly human pursuit. Recent improvements in artificial intelligence (AI) have shifted the dial.

AI is among the technological outbreaks that are disrupting the competitive scenario of nearly every business field. The proliferation of big data from multiple sources (e.g., business processes, customers, social networks, markets), and the ever-increasing power of computers have settled the ground to bring AI to a tipping point (Ferràs-Hernández, 2018). AI comprises any technique that enables computers to replicate (and/or overperform) human behavior and decision-making to solve complex tasks which normally would require human capabilities such as reasoning, learning, planning, perception, and communication (Russel & Norvig, 2012). The application of AI allows humans to overcome the well-known barriers caused by their bounded rationality (Simon, 1997), clearly emphasized by the data-rich environment which characterizes markets today. Therefore, AI applications have grown exponentially, and the rapid evolution of the technology opens new opportunities to redesign data-driven business processes and even found AI-based companies (Osservatori Digital Innovation). The most recent developments have led both scholars and practitioners to debate the role of AI algorithms in creativity and innovation processes, thus reshaping entrepreneurship and competitiveness. Extant studies have pointed out

[1] The title of this thesis has been generated through an AI-powered copywriting tool (credits: copy.ai)

the capability of AI to have *(i)* a direct impact on creativity, through generative AI and knowledge recombination (Shneiderman, 2002, 2007) and *(ii)* an indirect impact by supporting data gathering, enabling data sharing, and freeing up humans from operating tasks (Dewett, 2003; Lubart, 2005; Siau, 1995). On one hand, the huge potential of these new tools makes them a potential game changer. On the other hand, it is equally true that a deeper understating of how to use them, how the human-machine relationship changes, and how such tools interact with the other components of the creative system is fundamental to maximizing AI contribution. With our work, we want to *(i)* elucidate in a structured way the impact of AI on creativity and innovation process, and *(ii)* investigate the new paradigms of human-AI interactions and their main determinants. Hence, we detailed the following two research questions:

RQ1: *How does the application of artificial intelligence change the phases and the determinants of the innovation process?*

RQ2: *How are humans' role and human-machine interactions changing in light of the application of artificial intelligence in the innovation process?*

To address these questions, our analysis consisted of a multiple case study approach based on semi-structured interviews with a pool of 8 AI-native startups in Italy.

2. Methodology

This work consists of two fundamental parts: the systematic literature review (SLR) and the multiple case study – i.e., the interviews with companies.

The SLR started with a search on Scopus through a query aimed at merging two key areas of research: *(i) Artificial Intelligence,* i.e. the technology to be applied, and *(ii) entrepreneurship, creativity, and innovation,* i.e. the application field. The result, a pool of 660 papers, was subjected to the screening phase according to their abstract first, then the whole article. In the end, 27 articles were considered eligible for our SLR. In addition, 6 papers from Google Scholar keywords research and 9 articles from snowballing (Greenhalgh & Peacock, 2005) were added to our sample because of their relevance and adherence to the topic. After a careful reading of all 42 articles by both authors, the results of the SLR have been synthetized into three clusters which grouped the findings based on the application area of AI: *(i) Process improvements, (ii) Decision-making,* and *(iii) Innovation and creativity.*

Bearing in mind the goal of analysis and the novelty of the topic, a multiple case study with semi-structured interviews was chosen as the best method to address our research questions (Yin, 1994). Starting from the Italian scenario, the rationale to build up the sample of interviewees was based on three drivers: *(i) structure of available information*, considering the kind of data – structured or unstructured – and their availability for companies purposes, *(ii) relevance of predictive capability* to provide an effective service, acting proactively to anticipate customers' needs and unpredictable events, and *(iii) role of human intuition* in creating a new and valuable solution to existing needs. Finance, healthcare, and content-making were the three sectors selected. This approach aimed at setting up a pool of startups that could provide a complementary view on the topic, pointing out different perspectives. In addition, a fourth category was added – AI solution providers – to complete the sample with a panoramic view of AI applications. For each company, a business expert (e.g., CEO, CPO) and a technical expert (e.g., CTO) were interviewed to integrate their perspective. The research design allowed for the generation of rich information and a deep understanding of the phenomenon of interest. The main findings have been analyzed through a structured coding procedure (Glaser & Strauss, 2017) starting from the transcription of every interview. The abstraction process, starting from first order codes, led to the identification of five main themes. After an in-depth analysis of each of them, we present a framework that summarizes and allows for a systemic view of the themes, highlighting their relationships. During the discussion of the results, key differences among the sectors included in our sample are highlighted, linking the results with the research design specifics.

3. Systematic literature review

The extant literature is characterized by a high degree of heterogeneity, resulting in a broad and complex investigative framework. To facilitate and guide the literature review, we grouped the findings of papers according to three different

levels describing the impact of AI on entrepreneurial activity.

3.1. Process improvements

The first area of impact that emerges from the literature is how the entrepreneur can benefit from the operational advantages and the opportunities that AI enables in terms of job automation and performance enhancement, "to do more with less" (Autor, 2015). According to a 2017 McKinsey report, about half of the tasks performed by workers can be potentially automated. However, "for most occupations, partial automation is more likely than full automation, and the technologies will provide new opportunities for job creation" (Holford, 2019). In particular, concerning non-routine tasks, the human component is still an essential element of differentiation (Davenport & Ronanki, 2018; van der Zande et al., 2018). One of the main reasons behind the inability of machines in performing such tasks is their lack of explainability, which makes it difficult to fully codify the dynamics which regulate emotional-based activities (Ferràs-Hernández, 2018). With the advance of AI, humans are called to upskill to higher-order and sophisticated activities, where they still have a comparative advantage over machines (Jaiswal et al., 2022). On the other side, AI can impact most intermediate stages of the value chain, where computers can outperform human management since the required skills are connected to big data processing and analytical optimization (Choudhury et al., 2020; Peter Stone et al., 2016). AI assumes a performance-enhancing role where the company operates in a deterministic context with well-defined data, processes, and goals. Optimal results are obtained through a win-win setup that combines machine speed, precision, and scalability with human intuition and relational skills (Wilson & Daugherty, 2018).

3.2. Decision making

The distinctive features of AI make it a natural enhancer of decision-making, one of the critical success factors that allow for outperforming competitors (Blenko et al., 2010). Human decision-making is limited by the bounded rationality of decision-makers, whose cognitive constraints affect the decision process in every stage, from the data collection to the alternative evaluations and the actual decisions (Simon, 1997). In this scenario, AI stands out as a tool to address the computational limitations of humans. Being based on statistical models, AI can provide "unbiased output, free of social or affective contingence, able to consistently integrate empirical evidence and weigh them optimally, and not constrained by cognitive resource limitations" (Blattberg & Hoch, 1990). The most useful features that AI offers to improve the accuracy of companies' decisions are clustering of a dataset, patterns recognition, and simulation analysis, all of them aimed at leveraging data as a core asset and source of competitive advantages (Agrawal et al., 2019; Eriksson et al., 2020; Vincent, 2021). Algorithms allow more informed decisions to be undertaken thanks to the reduction of uncertainty, a crucial barrier that prevents managers from taking the right decision. That said, it appears clear that AI can perform at its best when dealing with analytic decision-making, i.e., a data-rich environment and a well-defined decision setting (Vincent, 2021). On the other side, criticisms of AI raise when debating about their actual capability to support decisions when dealing with ill-structured problems, with an unclear multi-objective goal, in absence of past decisions and contexts of data scarcity (Obschonka and Audretsch, 2020; Vincent, 2021). Hence, the extant literature agrees on considering a hybrid decision system as the best paradigm to support decision-making, leveraging the complementarity between humans and algorithms. The former for intuitive and ill-structured decisions and the latter for analytic decision-making (Denhardt & Dugan, 1978; Friedman et al., 1985; Hammond et al., 1987). In the era of algorithm-powered decisions, "AI will not overtake managers, but managers who use AI will overtake managers who don't" (Brynjolfsson & McAfee, 2017).

3.3. Innovation and creativity

Creative capabilities represent one of the very first drivers of growth, survival, and success of a company (Anderson et al., 2014). With the recent progress in AI, algorithms are said to be not only performance enhancers and a support tool for decision-making but even enablers of innovation (Amabile, 1997; Cockburn et al., 2018; Eriksson et al., 2020). The two main contributions to creativity and innovation refer to different features of AI: knowledge recombination and generativity (Schiavone et al., 2022). The former refers to AI's

capability to combine data from multiple sources to find new opportunities to innovate. AI data analysis empowers the innovation process by proposing ideas for product and service improvements based on recent trends in markets, social media, and patents issue, and exploring plenty of possible applications in a short time (Brem et al., 2021; Kakatkar et al., 2020). Hutchinson (2021), referring to these features, introduces the concept of self-innovative AI, stressing the capability of automatically embedding market inputs to enhance product features. Coming to the latest developments, generative AI is described in a Gartner report as a "revolutionary technology, capable of generating artifacts that were previously based on human creativity, guaranteeing innovative results without those prejudices typical of human experience and its thought processes". However, there is still an ongoing debate on whether AI is actually capable to perform creative tasks supporting the innovation process, as some authors argue that AI will never be capable to replicate human intuition and creativity in finding new solutions to market needs (Brynjolfsson Erik & McAfee Andrew, 2014; Jarrahi, 2018). Generative AI has the ambition to overcome these limitations, but its applications are still very limited, as well as the extant literature about it.

4. Multiple case study results

Considering the goal of this research, the most suitable starting point to analyze our findings is represented by Cooper's stage-gate model (Cooper, 1983) which describes the innovation process as a sequence of distinct phases. The coding procedure ended up with the identification of five main themes, two of which are associated with two phases of Cooper's model, namely, *Ideas identification* and *Preliminary assessment*. In addition, *Impact on Knowledge Management*, *Human-machine collaboration* and *Role of organizational setup* were considered as broader enablers of the innovation process, as they have a cross-impact across its stages.

Impact on Knowledge Management (KM) main findings highlights how AI enhances KM, enriching the value of data and knowledge for companies, thus, the innovative capability (Amabile 1997). During their training phase, algorithms can embed into their decision schemes even part of experts' tacit knowledge. Hence, they represent an efficient vehicle to make the knowledge of an expert domain accessible to a large set of stakeholders (each with its own different knowledge and expertise), facilitating knowledge recombination to find innovative solutions to complex business problems. Industries in which human intuition plays a key role benefit most from the "exportability" of expertise. Despite the lack of explainability – the algorithm is treated as a black box and its output must be accepted without fully understanding the process –, algorithms *"allows to obtain a result which is accurate and aimed at replicating experts output, thus representing a pragmatic useful instrument"* (Company θ, CEO). In terms of data empowerment, the advent of synthetic data (i.e., data artificially generated by algorithms that reflect the same properties of real-world data) allows for addressing real-world data problems like errors, missing data, and biased data collection mechanisms. In addition, testing algorithms with conveniently customized data can help in gathering insights about their functioning, addressing the limited explainability. Synthetic data are going to disrupt the AI field since they increase the efficiency and effectiveness of data collection and cleaning, enhancing algorithms' performances.

Human-machine collaboration deepens how the newest advancements in AI change the relationships between humans and algorithms. At a general level, the collaborative model is described by the human-in-the-loop paradigm (HITL), which still sees human experience and skills at the center of the process. In particular, interview insights stress the role of domain experts in the initial setup of the solution, understanding the customer's request, modeling the problem to address, and designing the solution. In dealing with these tasks, companies need *"a person who has a deep problem comprehension, who knows customers' requests and the peculiar characteristics of the solution"* (Company γ, CTO). In the same way, the value added by humans lies in the critical interpretation of the algorithm output, to fully capture all the information that it provides thanks to the data sensitivity typical of the domain expert. Only a deep understanding of the field makes it possible to seize the innovation opportunity that AI offers indirectly, such as a possible extension of the solution to new business problems. The need for a

hybrid solution between humans and machines emerges at the most effective configuration to maximize innovation capability by merging engineering and process-based innovations of AI with "artistic" and intuitive human creativity.

Role of organizational setup focuses on insights about how companies' values and practices allow the maximization of the contribution that AI can provide in terms of innovation and creativity. The main findings suggest an organization that has the flexibility to adapt rapidly to the opportunities that arise from the interaction with the machine, guaranteeing a competitive edge over competitors. In addition, companies that encourage knowledge contamination and facilitate fruitful interactions between technical and business experts meet the necessary conditions for properly designing and fine-tuning AI solutions.

Ideas identification theme illustrates how AI discovers, generates, and proposes business ideas to innovate. Regarding product (and service) improvements, AI computational capability allows for *"identifying new patterns and correlations among data that human operators did not think in the initial settings"* (Company ε, CTO). This represents a source of ideas for improving predictive performances and enlarging the offer, combining market data analysis with customer clustering. Data-rich industries like the financial and healthcare ones represent fertile grounds for these applications, as AI empowers the value of data as a core asset. The advent of synthetic data and generative AI, on the other side, empowers human creativity with images, text, and audio artificially generated. In this regard, although generative AI represents a game changer in content-making, the differential aspect, where most of the competitive advantage takes place, is understanding how to leverage these opportunities and acting complementary to the algorithms. In the content-making industry *"humans still play the main role, their intuition and creativity cannot be replaced by machines but rather augmented through complementary tools which speed up the process"* (Company γ, CPO). Lastly, AI solutions are characterized by high flexibility and replicability. Regardless of the domain-specific aspects, their design is based on mathematical and statistical models that can be generalized to many applications. *"Once they have been developed, high standardization makes AI solutions suitable for many other business issues"* (Company η, CIO), opening opportunities for business scalability towards new domains.

Preliminary assessment is the beginning of the converging phase of the innovation process, i.e. identifying which ideas are worth to be developed. Hence, the pain point is the uncertainty and the availability of data to assess the attractiveness and feasibility of ideas. AI is a tool that addresses this barrier, allowing simulation analysis that considers

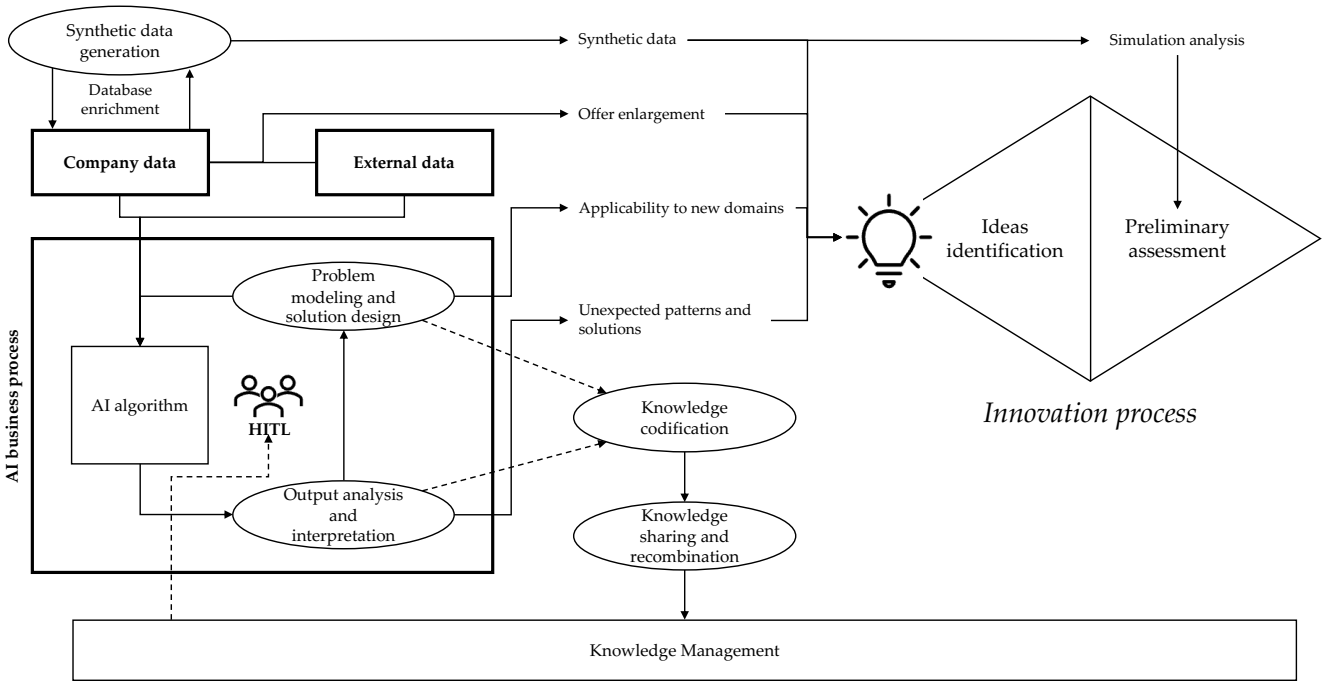

Figure 1 - Visual framework which allows for a systemic view of the findings

plenty of scenarios. Even in contexts of data scarcity, the generation of synthetic data is a powerful tool that allows for more consistent and robust simulations, reducing uncertainty and undertaking more informed decisions. The use of synthetic data was pointed out mainly from the content-making industry while the finance and healthcare sectors stressed the capability of AI to increase the probability of market validation (Giuggioli & Pellegrini, 2022). Figure 1 allows for a systemic view of the identified themes, highlighting their interactions and synergies.

5. Conclusions

5.1. Main Findings

From a general point of view, all the interviewees pointed out a strong implication of AI as a linchpin element, not only in the core operating processes but also as an innovation and creativity enabler.

[RQ1] AI impacts different stages of the innovation process in many ways. Starting from the "divergent" stage of Cooper's framework, AI acts as an enabler of innovation by increasing business opportunities as inputs of the process through *(i)* offer enlargement, *(ii)* generation of synthetic data (e.g., images, texts, audio), *(iii)* scalability opportunities, and *(iv)* increasing of predictive performance. Moving to the "convergent" stage of the process, AI processing capability provides support in screening and selecting the most valuable opportunities through data simulation analysis. Moreover, synthetic data generation represents a "way out" for contexts limited by data scarcity. Three main themes emerged as broad enablers of the innovation process. The organizational setup has to follow some requisites in terms of practices, policies, and company organization. In particular, the facilitation of knowledge contamination, the creation of heterogeneous teams, and fluid management of the innovation process. Knowledge has emerged as a key baseline of the creative process. AI arises as a strengthener of the firm's knowledge asset, increasing the accessibility of expert competences through knowledge skill tools that enable knowledge recombination among all the shareholders involved.

[RQ2] Humans and machines collaborate according to the human-in-the-loop (HITL) paradigm (Zanzotto, 2019). We can report remarkable steps ahead made by algorithms and their capability even in terms of creativity and innovation support. Still, the role of humans remains essential in stages such as problem modeling, solution design, and output interpretation. AI acts as a tool that empowers and breaks down barriers to human creativity rather than replacing it.

5.2. Implications

Our work contributes to consolidating the stream of literature regarding the role of AI in creativity and innovation, enriching Cooper's framework with innovative insights and addressing the future research suggested by Paesano (2021) and Schiavone et al. (2022). Secondly, we consolidate also the literature results about the relationship between humans and machines, by describing the dynamics in a structured way. The point of contact between the two areas has been highlighted through the development of a visual framework that systemically portrays the findings and the innovative aspects of those. Of particular novelty are findings about synthetic data which affect innovation not only as a primary input that triggers the process but also as a database enricher and simulation analysis enabler. This contributes to the development of the results of the studies of Brem et al. (2021) and Dellermann et al. (2019). The findings about the flexibility of the algorithm point out the role of AI as a driver for business model scalability towards new domains, leveraging the high applicability of algorithm solutions. On the other side, pattern identification and ideas generation enforce views of Eriksson et al. (2020) and Hutchinson (2021) with innovative insights. Arguments about synthetic data also fuel the literature about the bond between creativity and knowledge management (Bettiol et al., 2012; Yeh et al., 2012) and, to some extent, go against a stream of literature that sees humans as the only actors of the innovation and creaticity process (Holford, 2019). The present work contributes to the currently open debate about AI and job replacement (Autor et al., 2003; Brynjolffson & Mtchell, 2017) in light of the recent sophistication of AI, contributing to addressing the questions proposed by scholars such as Brem et al. (2021). Our reasoning about the human and machine

system consolidates the collaboration paradigm (Fossen & Sorgner, 2021; Zanzotto, 2019).

From a managerial viewpoint, one of the pervasive findings of our research is that companies must embrace an organizational setup that can allow for extracting the maximum value from AI. This is strictly connected with another implication, precisely, companies' awareness about the role of knowledge – and KM – as an enabler of the innovation process. Our research claims the generative part of AI as a tool for content creation, such as supporting social media management efficiently and effectively. Moreover, we highlighted the role of synthetic data to address the problems of data scarcity and increase data accessibility and its democratization, which, in a world dominated by data, might reshape the competitive scenario.

5.3. Limitations and further development

This research does not lack some limitations. Concerning the research design, the choice of industries and geographical scope could have led to bias or a suboptimal result. Some intrinsic characteristics of the companies investigated led us to miss some important insights about the whole innovation process, concerning the development and commercialization of the product. Additionally, the limited number of case-study about the generativity aspects of AI and the approach to AI as a black box limited a deep understanding of the newest developments.

Future literature could look towards an extension of the research boundaries in terms of geographical scope and industry choice. Complementary insights might be gathered by analyzing the latest AI features from a technical view and by analyzing established companies, highlighting the innovation process characteristics *before* and *after* the adoption. A quantitative design could also be interesting to assess the correlation and/or causality between AI adoption and the firm's innovative capability.

References

For every reference, see chapter 6 – Reference.