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Artificial intelligence as an enabler for entrepreneurs: a systematic literature review and an agenda for future research

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Abstract

Purpose – While the disruptive potential of artificial intelligence (AI) has been receiving growing consensus with regards to its positive influence on entrepreneurship, there is a clear lack of systematization in academic literature pertaining to this correlation. The current research seeks to explore the impact of AI on entrepreneurship as an enabler for entrepreneurs, taking into account the crucial application of AI within all Industry 4.0 technological paradigms, such as smart factory, the Internet of things (IoT), augmented reality (AR) and blockchain.

Design/methodology/approach – A systematic literature review was used to analyze all relevant studies forging connections between AI and entrepreneurship. The cluster interpretation follows a structure that we called the "AI-enabled entrepreneurial process."

Findings – This study proves that AI has profound implications when it comes to entrepreneurship and, in particular, positively impacts entrepreneurs in four ways: through opportunity, decision-making, performance, and education and research.

Practical implications – The framework's practical value is linked to its applications for researchers, entrepreneurs and aspiring entrepreneurs (as well as those acting entrepreneurially within established organizations) who want to unleash the power of AI in an entrepreneurial setting.

Originality/value – This research offers a model through which to interpret the impact of AI on entrepreneurship, systematizing disconnected studies on the topic and arranging contributions into paradigms of entrepreneurial and managerial literature.

Keywords Entrepreneurship, Artificial intelligence, Machine learning, Deep learning, Innovation, Technology

Paper type Research paper

Introduction

We stand at the beginning of a new era of the industrial revolution. While the third revolution focused on the introduction of computers in manufacturing, with the new paradigm (i.e. Industry 4.0), technological evolutions and futuristic models create smart and intelligent systems with automation and completely digitalized production methods (Muhuri *et al.*, 2019).

Industry 4.0 refers to the shift from a manufacturing paradigm, where machines simply operationalize routines, to digital manufacturing, where machines are capable of communicating with each other, self-monitoring and collaborating autonomously (Oztemel and Gursev, 2018).

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This enables faster, more flexible and more efficient processes, producing higher-quality goods with advanced levels of customization, increasing manufacturing productivity, and, in turn, allowing an industrial growth (Schlick, 2014).

In this new revolution, artificial intelligence (AI) plays a key role. It can be defined as intelligence demonstrated by machines – or, in terms of an academic field, the examination of how digital computers and algorithms perform tasks and solve complex problems that would normally require or exceed the human intelligence, reasoning, and prediction power needed to adapt to changing circumstances. This modern definition has been evolving since the first definition of AI was presented by computer scientist John McCarthy more than 60 years ago, considering AI as "the science and engineering of making intelligent machines" (Andersen, 2002; McCarthy, 1958). Within AI terminology, machine learning is frequently categorized as a subset of AI, with deep learning considered to be a subset of machine learning (Obschonka and Audretsch, 2020).

However, this revolution also requires changes to be made to the organizational dimensions of a firm (Manesh *et al.*, 2021). For example, thanks to the integration of AI processes, some of the most automated workplaces are experiencing a renaissance in terms of human work. In many cases, AI frees time, creativity and human capital, leaving people to work in a more human and less automatic way. AI empowers people with powerful tools to do more and act with superhuman abilities. In doing so, AI has the potential to re-humanize work, giving us more time to be human rather than working as machines (Daugherty and Wilson, 2018).

On the other hand, AI also holds critical consequences for organizations facing increased pressure in terms of productivity and the need to stay competitive. This situation may also lead to increases in unemployment and inequality, as it did in the first wave of mechanical automation, disrupting manufacturing and subsequently destroying retail in the second wave of digital innovation (Chalmers *et al.*, 2021).

In a nutshell, the main future challenge pertains to utilizing the advantages of availing AI technologies, in terms of new opportunities and productivity improvements, while avoiding the disadvantages in terms of job losses and greater wealth inequalities (Makridakis, 2017).

AI has the potential to offer both positive and negative consequences to society at large. Here, a prominent role will be played by entrepreneurs and the ways in which they are able to use these technologies. A variety of potential approaches, scenarios and contrasting findings still populate academic debates around AI, creating a "green field" (Lévesque *et al.*, 2020). We therefore intend to perform a systematic literature review with regards to the relationship between AI and entrepreneurship, offering potential directions for further research.

There are several reasons why this inquiry is appropriate and timely. First, in order to thoroughly capitalize on the results of pertinent academic literature, there is a need for systematization. To the best of our knowledge, this study is the first of its kind, although inspiring and brilliant contributions have already been produced (e.g. Chalmers *et al.*, 2021; Obschonka and Audretsch, 2020).

Second, the actual pervasiveness of AI offers new business opportunities like never before. Many entrepreneurs can access AI solutions easily, as these solutions are no longer futuristic or elitist innovations and are instead available at a relatively affordable cost. This implies that AI is no longer a privilege adoptable only by big firms (Iansiti and Lakhani, 2020). This could have an exponential impact on developing entrepreneurship.

Third, although COVID-19 has sadly led to many causalities and deaths, the pandemic and its aftermath may serve to accelerate and advance the adoption and use of digital and modern technologies, such as AI (Amankwah-Amoah *et al.*, 2021). As a result of public health policies (e.g. lockdown), digitalization has been forced upon organizations, stimulating a jump in remote-controlled and automated processes (Ratten, 2020). This momentum created a renovation in approaches to work. After a crisis as difficult as the current one, society can be seen to unleash dormant forces in order to make recovery possible (Cadena and Ferrari-Haines, 2020). From an instrumental point of view, the huge amount of financial resources allocated to facilitating the

COVID-19 recovery offers a clear push to sustainable digital transformation. For example, the European recovery plan, i.e. the Next Generation EU (NGEU), has allocated a total of €750 billion to supporting European countries via new reforms and investments, specifically in the area of digitalization (Crescenzi *et al.*, 2021). Thus, entrepreneurs have been given the unique opportunity to set up or boost the digital transformation of their companies using public subsidiaries and entrepreneurial funds.

This paper's contribution is twofold. First, at a theoretical level, as premised, this is the first study to systematize existing literature on entrepreneurship and AI. Specifically, our systematic literature review highlights four well-polarized clusters representing the positive impact of AI on entrepreneurship in terms of: "opportunity," "decision-making," "performance" and "education and research." We investigated each thematic cluster by reviewing the most relevant contributions within them and following a structure that we called the "AI-enabled entrepreneurial process."

Second, we created a framework that would be able to interpret the impact of AI on entrepreneurship and, through this, offer specific areas that may be of interest in the future. This could prove useful for researchers, entrepreneurs and aspiring entrepreneurs (as well as those acting entrepreneurially within established organizations) who wish to harness the potential of AI.

This paper is organized as follows. In the next section, the relationship between AI and entrepreneurship is shown. Subsequently, the methodology adopted to implement our analysis is outlined. In the fourth section, the cluster analysis results are presented and, in the fifth section, a framework is proposed to interpret the impact of AI on entrepreneurship and suggest an agenda for future research. Finally, the conclusions and limitations of the study are given.

The relationship between AI and entrepreneurship

The term "Industry 4.0" was coined by Kagermann *et al.* (2011), combining the virtual and the real world with an emphasis on engineering applications, such as robotics, digitalization and automatization. Researchers have dealt with automation using AI technology since the 1950s with theoretical machine learning models, but the recent advancements of revolution 4.0 have provided them with a platform to actualize these theoretical models (French *et al.*, 2021).

In this revolution, AI is considered a dominant research area and its applications are expected to spread into any domain requiring human intelligence (Oztemel and Gursev, 2018).

AI is central to all Industry 4.0 technological paradigms. It is used in smart factories, which are fully connected manufacturing systems, mainly operating without human intervention thanks to the generation, transfer and analysis of the flowing data required to perform inherent tasks for production (Lasi *et al.*, 2014). AI maintains intelligent control over the entire system, specifically scheduling interventions for the automated machines, designing working flows of operations, controlling the quality of outcomes, and automatically programming and performing maintenance activities (Meziane *et al.*, 2014; Murray, 1999).

Similarly, AI is integral to the Internet of things (IoT), which is an extended and connected network of physical devices that can interact and communicate amongst themselves and can be controlled or monitored remotely (Ashton, 2009). For IoT, AI processes and transforms vast volumes of data to create useful outcomes, interconnecting the software languages that IoT devices enforce (Ahmad *et al.*, 2021).

AI is also used in the augmented reality (AR) paradigm, which is a human-computer interaction system that blends real and virtual 3D objects in real time (Azuma *et al.*, 2001). AI improves the accuracy and robustness of image processing and its correlated tasks (Sahu *et al.*, 2020).

Finally, AI is coupled with blockchain, which is a distributed chain that keeps records of digital assets securely and transparently (Treiblmaier, 2018). As AI relies on data to learn and make final decisions, this combination permits AI to work on trusted, digitally signed, and

securely shared data in a decentralized ledger, thereby leading to more trusted and credible outcomes (Dinhand and Thai, 2018).

These new innovations are changing technological entrepreneurship, particularly when it comes to new venture creation processes (Elia *et al.*, 2020). AI holds particularly crucial implications in terms of how entrepreneurs develop, design and scale their companies during the entrepreneurial process (Chalmers *et al.*, 2021). As any radical innovation, AI can empower entrepreneurs and enable the creation of new opportunities, introducing new products or services via entrepreneurial means (Obschonka and Audretsch, 2020).

Moreover, AI techniques can improve decision-making systems adopted by entrepreneurs, increasing the quality of the decisions made in terms of their effectiveness and efficiency, thus enhancing the operational performance (Kraus *et al.*, 2020).

Furthermore, AI can not only improve the performance of AI-driven organizations, but also encourage more traditional firms to develop their business models using AI-based solutions. The emergence of the age of AI has therefore created the greatest entrepreneurial opportunity in the history of civilization (Iansiti and Lakhani, 2020).

Methodology

In order to perform an accurate analysis of entrepreneurship and AI as a field of research, as well as to collect and link together as many relevant existing studies as possible, we performed a systematic literature review (Tranfield *et al.*, 2003).

The iterative search process of defining the query for our systematic literature review analysis began by focusing on two main classes of terms: one related to "entrepreneurship" and one related to "artificial intelligence." For the former, we included all forms related to entrepreneurship ("entrepreneur*"), also adding "venture creation"; in reference to the latter, we included the acronym "AI" and its subsets, such as "machine learning" and "deep learning." The final query was: ("entrepreneur*" OR "venture* creation") AND ("artificial intelligence" OR "AI" OR "A.I." OR "deep learning" OR "machine learning").

The review was limited to English journal articles (peer-reviewed) published up until December 31, 2020 (David and Han, 2004; Light and Pillemer, 1984), across three databases – Scopus, Web of Science and EBSCO – searching for terms in the article's title, abstract and keywords.

In the first instance, 433 papers were found using the search strings developed: 257 entries on Scopus database, 111 entries on Web of Science database, and 65 entries on EBSCO database. As the second step, we identified and eliminated duplicated studies, of which there were 102 papers. By the end of this stage, there were 331 papers. The third step was to read all of the abstracts. We subsequently removed 271 studies that were not relevant to the research: 65 papers did not deal with AI, 85 papers did not deal with entrepreneurship, and 121 papers did not link the two topics. As shown in Figure 1, there were 60 articles: 24 theoretical papers, 31 empirical (quantitative) papers, and 5 empirical (qualitative) papers.

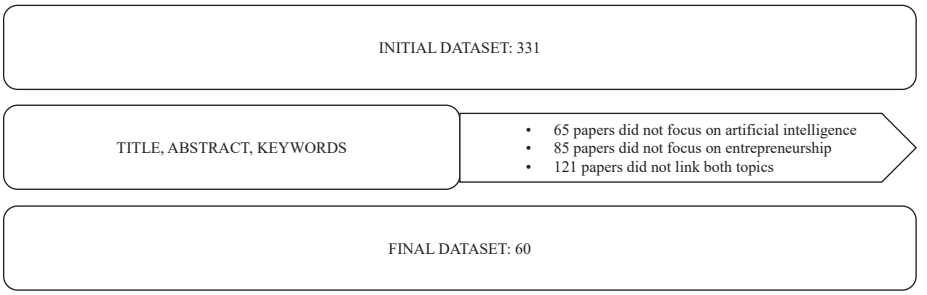

Figure 1.
Protocol for selecting papers

Results of the systematic literature review

The sample of papers within this systematic literature review (60) are grouped into 4 clusters representing the differences in the impact of AI on entrepreneurship, allowing for multiple entries of a paper across different clusters according to its multiple foci (see Table 1). These clusters are (1) the "opportunity" cluster, composed of 11 papers dealing with AI as an enabler for entrepreneurs to create new opportunities; (2) the "decision-making" cluster, made up of 24 papers considering AI as an enabler for entrepreneurs to make better predictions and, hence, better decisions; (3) the "performance" cluster, composed of 18 papers related to the improvements achievable thanks to AI with regards to a firm's performance; and (4) and the "education and research" cluster, which is a general cluster primarily related to theoretical debates surrounding the recent evolutionary trends of the discipline and its implications for the educational sector (12 papers).

Each cluster arising from our research can be considered a step in what we have called the "AI-enabled entrepreneurial process." This scheme is visually presented in Figure 2, where "opportunity," "decision-making" and "performance" are three sequential phases of the process, while "education and research" accelerates and positively affects the entire process.

Cluster: opportunity

In the "opportunity" phase of our framework, the entrepreneur is engaged in operating digital transformation through AI. Different efforts power a new range of business opportunities. As new opportunities emerge, the entrepreneur faces new strategic options and, in light of these, is offered the opportunity to re-shape his/her own business models. In this phase, the entrepreneur looks at traditional approaches to understand how they could be enhanced by AI.

The first stream of studies that emerges from our analysis reveals positive outcomes in terms of the introduction of new products/services and business models. AI and big data can function as external enablers of new entrepreneurial activities. This could be considered an example of the radical external changes that empower and enable new economic activities

Opportunity	Decision-making	Performance	Education and research
Brown (2017)	Ahmad *et al.* (2019)	Alotaibi *et al.* (2020)	Bogoviz *et al.* (2019)
Chalmers *et al.* (2021)	Antretter *et al.* (2019)	Brynjolfsson and Mitchell (2017)	Cantú-Ortiz *et al.* (2020)
Ehret and Wirtz (2017)	Baldegger *et al.* (2020)	Calvo (2018)	Khalid (2020)
Elia *et al.* (2020)	Dellermann *et al.* (2019)	Darwish *et al.* (2020)	Lévesque *et al.* (2020)
Garbuio and Lin (2019)	Duan *et al.* (2020)	Dubey *et al.* (2020)*	Mavlutova *et al.* (2020)
Makridakis (2017)	Dubey *et al.* (2020)*	Guerzoni *et al.* (2020)	Obschonka and Audretsch (2020)*
Mamedov *et al.* (2018)*	Evans *et al.* (2017)	Huibers (2020)	Prüfer and Prüfer (2019)
Mariani (2019)	Fish and Ruby (2009)	Kamishima *et al.* (2018)	Rath *et al.* (2019)
Obschonka and Audretsch (2020)*	Glupker *et al.* (2019)	Kraus *et al.* (2020)*	Ratten (2020)
Palmié *et al.* (2020)	Ivashchenko *et al.* (2020)	Mamedov *et al.* (2018)*	Tarabasz *et al.* (2018)
Townsend and Hunt (2019)	Juric *et al.* (2019)	McKenzie and Sansone (2019)	Tkachenko *et al.* (2019)
	Katsamakas and Pavlov (2020)	Obschonka *et al.* (2020)	Zhang and Van Burg (2020)
	Kraus *et al.* (2020)*	Palanivelu and Vasanthi (2020)	
	Lichtenthaler (2020)	Ramesh *et al.* (2018)*	
	Liebregts *et al.* (2020)	Sabahi and Parast (2020)	
	Lin (2019)	Suguna *et al.* (2019)*	
	Lin *et al.* (2019)	Szalavetz (2019)	
	Nie (2020)	Zemtsov (2019)	
	Raab *et al.* (2020)		
	Ramesh *et al.* (2018)*		
	Suguna *et al.* (2019)*		
	Tomy and Pardede (2018)		
	Wang *et al.* (2020a)		
	Wang *et al.* (2020b)		

Note(s): *Papers used in more clusters

Table 1.
Papers included in the systematic literature review

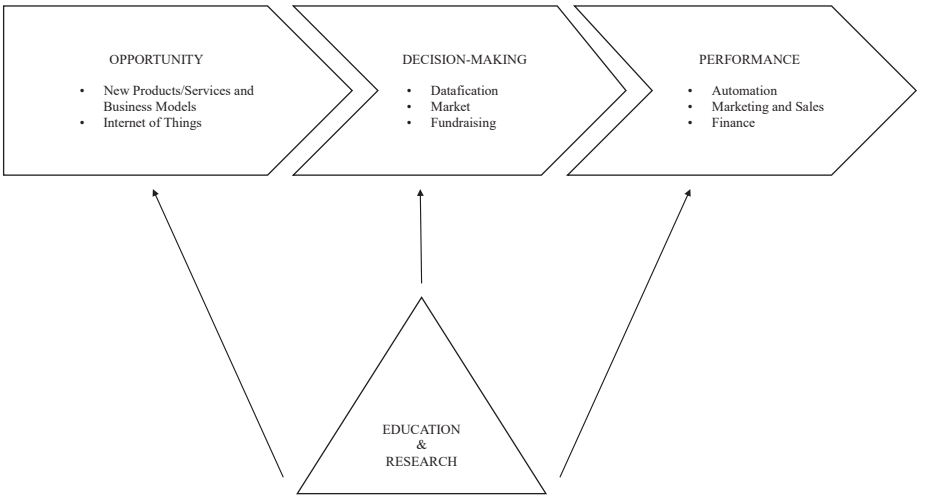

Figure 2.
The AI-enabled entrepreneurial process – Cluster interpretation

that introduce new products or services via entrepreneurial means (Obschonka and Audretsch, 2020).

This has crucial implications when it comes to our thoughts on how entrepreneurs develop, design and scale their companies. This technology will influence whether or not individuals decide to set up companies in the first place and may dictate their quality of life if they choose to do so (Chalmers *et al.*, 2021).

The AI revolution is predicted to come into full force within the next twenty years. It will have a greater impact than both the Industrial and Digital revolutions combined. The speed of the technological change emerging as a result of the AI revolution will open up huge opportunities for growth and profitability but, at the same time, will bring about challenges and fresh competition from new garage-style startups. Breakthrough ideas can come from anywhere, and their development will be rendered simpler through venture capital and crowdsourcing (Makridakis, 2017).

In fact, the real power of AI lies in its propensity to bring about new opportunities for entrepreneurs when it comes to solving specific problems with applications and verticals, such as messaging bots and intelligent virtual assistants. However, the design of business models is fundamental when taking useful technologies into the marketplace (Garbuio and Lin, 2019).

The second stream of studies focuses specifically on the IoT and is strongly connected with AI in terms of data. Nowadays, digital technologies and knowledge digitalization are changing technology entrepreneurship and new venture creation processes as a whole. The concept of digital entrepreneurship is accentuating the emergence of a new entrepreneurial paradigm which is focused and/or enabled by the adoption of Internet and digital technologies. This leverages the innovation potential embedded into both large groups and dispersed individuals from different backgrounds participating in entrepreneurial activities (Elia *et al.*, 2020).

In this context, AI has positive effect on the economy, furthering the development of entrepreneurship while opening up new opportunities for companies. Organizations are already using facial recognition and voice identification functions to automate existing products and services. Smart systems are also capable of controlling air traffic or performing integrated medical diagnostics (Mamedov *et al.*, 2018).

The torrent of passively sensed data by the IoT, combined with big data technology, is creating a new type of entrepreneurship: sensor-based entrepreneurship. This can be considered a subcategory of digital entrepreneurship, in which products or services are derived from data collected from sensors and relative devices. IoT will change how we interact with objects and how we interact with each other. In particular, this new data will change how companies interact with their customers, as it can be used to help them build better relationships (Brown, 2017).

The IoT presents new opportunities and threats that companies are unable to address using existing business models. In fact, the IoT unlocks information from the manufacturing process, shows its impact on transaction costs and thereby lowers the bar for non-ownership business models. The IoT therefore impacts upon the systematic design of business models (Ehret and Wirtz, 2017).

Big data analytics promises to enhance a number of digital technologies in tourism and hospitality that heavily rely on data, such as AI and the IoT. A new digital entrepreneurship field could be formed within this industry. The development of AI, when applied to data mining and predictive analytics, could lead to the development of effective digital business models to support product, process and business model innovation (Mariani, 2019).

Cluster: decision-making

In the "decision-making" phase of our framework, AI could help the entrepreneur to transform available data into accurate predictions. Humans and machines have strengths and weaknesses. Humans perform better when data is scarce, while machines are often more effective when there is lots of data to examine. Therefore, in this phase, the entrepreneur is able to make the best decisions, thanks to AI.

The first stream of studies to emerge from our analysis highlights the benefits in terms of datafication. As firms generate more data, the need to develop predictive analytics becomes crucial. This can improve decision-making processes and can enhance decision support for entrepreneurs. Specifically, deep learning can improve decision support within core areas of business operations, increasing the quality of the decisions made in terms of effectiveness and efficiency (Kraus *et al.*, 2020).

In fact, modern data science techniques can advance our understanding of important decisions made by entrepreneurs (e.g. entrepreneurial decisions), as well as those made by others that directly affect entrepreneurs (e.g. investment decisions). The emerging domain of social signal processing, referring to a number of modern technologies utilizing AI, holds the potential to automatically detect and analyze signals being sent during human-to-human interactions (Liebregts *et al.*, 2020).

This datafication has become increasingly crucial in improving innovation, entrepreneurship analysis, trend prediction, and decision support for entrepreneurs. Therefore, there is an urgent need to apply big data to entrepreneurship (Nie, 2020).

Moreover, data can also be useful when it comes to one of the most critical tasks for startups: the validation of their business model. A hybrid intelligence decision support system can allow for the iterative validation of a business model through the combination of both social interaction with stakeholders (e.g. partners, investors, mentors, and customers) and the analysis of the uncertain phases of business model development in early-stage startups. This new class of decision support systems might be useful in supporting entrepreneurs in uncertain contexts. With increasing uncertainty, the relative advantages of statistical methods in providing decisional guidance decreases and the value of human intuition increases (Dellermann *et al.*, 2019).

Other studies within this stream specifically consider the variable of uncertainty. Decision-making in instances of uncertainty is fundamental to the entrepreneurial process

because one reason why many managerially capable professionals are not willing to start new businesses is the uncertainty of their environment. In order to address this problem, uncertainties combined with relevant data sets can be used to predict the future success of a perceived opportunity by using data analysis techniques in the pre-startup phase. This form of evaluation enables the decision-maker to identify the uncertainties which are having a high influence on the final outcome, enabling them to utilize resources efficiently (Tomy and Pardede, 2018).

This is also in line with another study that explored challenges that entrepreneurs face in relation to changing business environments, with focus on the use of AI and IoT. Both can prove beneficial if the entrepreneur is able to meet the challenges and the costs associated with their integration, which vary depending on the business. Each entrepreneur should explore the potential for adoption within his/her own company in order to determine the specific challenges they may face in light of changing business environments. They should make the decision for themselves, considering whether or not they will choose to overcome these challenges and whether the risk of integration of AI and IoT will be worth it for their specific business (Ahmad *et al.*, 2019).

Such findings have led us to debate a second stream of studies, centered specifically around market analysis. Machine learning algorithms are also useful when analyzing sales volumes, attempting to discover the products most likely to be purchased, or providing recommendations regarding prices. In fact, predictive machine learning techniques can be applied to transactional data from historical sales in order to forecast the sales volumes of new or existing products. These findings are useful when it comes to discontinuing old products and introducing new products (Ramesh *et al.*, 2018).

Customer group prediction remains a challenging task for all entrepreneurs. This results in the use of machine learning algorithms in order to cluster customer groups and predict customers' demands, aiding decision-making processes with regards to manufacturing products. In fact, the prediction and clustering of customer behavior results in an increase in decision-making processes pertaining to manufacturing design (Suguna *et al.*, 2019).

From another perspective, one of the most critical impediments for small businesses is considered to be the process of finding international markets. Although these businesses may be interested in growing their sales via exportation, they do not often have the time or money and, above all, the knowledge to begin these processes. In order to solve this problem, AI approaches have been shown to be useful for startups when it comes to their market screening efforts (Fish and Ruby, 2009).

The third and final stream pays attention to fundraising and, in particular, to crowdfunding, which has become an important channel for entrepreneurs to use in order to raise funds for their startup projects. Deep learning holds the potential to predict crowdfunding project fundraising outcomes in advance, which has important implications for founders, investors and crowdfunding platforms in terms of decision-making. For founders, if companies know beforehand which factors might improve their financing success rate, they can focus on these aspects in order to improve their financial performance and reduce opportunity costs. Investors, through predictions, can avoid high-risk or failure-prone projects and use their limited funds to support projects with higher success rates, increasing the likelihood of them being rewarded for their investment. For crowdfunding platforms, improving the project's financial success rate affects its profitability (Wang *et al.*, 2020b).

The extraction of semantics from the textual descriptions of projects can predict their fundraising outcomes. In particular, the topical features of these projects facilitate the prediction of fundraising success but can also help explain why backers are willing to support certain crowdfunding projects. By mining the topical features from project descriptions, entrepreneurs can better understand the determinants of fundraising success

and can better present and promote their projects in advance. This effective promotion can lead to the success of these projects (Yuan *et al.*, 2016).

These findings are in line with another study that demonstrated that deep learning regarding text content emphasis detection from various textual sources can estimate the impact of text content emphasis on the success of fundraising campaigns. This is important when making investment decisions (Wang *et al.*, 2020a).

On a different note, machine learning-based facial feature detection techniques can also measure the facial trustworthiness of entrepreneurs who are crowdfunding. Entrepreneurs who look more trustworthy have been shown to be more likely to succeed in the crowdfunding market. Therefore, these findings may encourage crowdfunding practitioners and regulators to acknowledge the importance of entrepreneurs' facial trustworthiness in influencing founders' decision-making processes (Duan *et al.*, 2020).

These findings are also in line with another study that proved that facial expressions of happiness and sadness positively affected the funding decision. Therefore, an emotional approach to potential investors might thus be a viable strategy in reward-based crowdfunding (Raab *et al.*, 2020).

Furthermore, machine learning techniques can be applied to evaluate the market reaction for startups pre-login in an equity-crowdfunding platform using a Decision Tree algorithm, which can obtain the rules of the market's reaction to startup firms and forecast the degree of reaction. The findings of this study showed that the crucial features involve: additional paid in capital retained earnings, non-current liabilities and total capital. Therefore, startups should concentrate on these features before they log in (Lin, 2019).

These findings correlate with another study that instead applied the Random Forest algorithm to an AI model to forecast the market's reaction to startups as they were listed on an equity-crowdfunding platform. The results not only filled the gap by detecting market reactions in equity crowdfunding, but the proposed Random Forest model replaced the traditional statistics analytical technique when evaluating market reaction (Lin *et al.*, 2020).

Moreover, machine learning algorithms can also examine how network position determines the success rate of investors, improving predictions of venture capital performance. Startups could save time and effort if they are told who to focus their pitches on. Moreover, if any particular investors are interested in financing new ventures, this might also suggest a way of improving their chances of success (Glupker *et al.*, 2019).

Cluster: performance

In the last sequential phase of our framework, i.e. "performance," after identifying the opportunity and making the decision to pursue it, the entrepreneur should act upon their decision to improve the performance of the business. The entrepreneur, working as an ally alongside intelligent machines, is able to take advantage of the complementarities of human work and machine learning to obtain the best result possible.

The first stream of studies that emerged from our analysis highlighted advantages in terms of automation. Digital computers have transformed work across almost every industry of the economy over recent decades. We are now at the beginning of a more rapid and large transformation due to recent advancements in machine learning that are able to accelerate the pace of automation itself. In fact, each time a machine learning system becomes more cost-effective than humans at a task, entrepreneurs will seek to substitute machines for people. This can affect the economy, shifting labor demand, lowering prices, boosting productivity and restructuring industries (Brynjolfsson and Mitchell, 2017).

With the development of new technologies, many routine operations have become automated. At the same time, AI systems are starting to threaten medium-skilled professional jobs. Therefore, entrepreneurship should be promoted as a good alternative to employment,

along with retraining for STEAM professions that are less subject to automation: science, technology, engineering, art and mathematics (Zemtsov, 2019).

The fact that deep learning networks help to improve operational performance has also been validated. Deep learning is an effective method that can outperform its traditional counterparts in terms of both prediction and operational performance from the family of data-analytic models (Kraus *et al.*, 2020).

Moreover, AI-solution providers induce productivity and resource efficiency improvement in technology adopters by enabling upgrading processes. Specialization in AI-associated activities contributes to upgrading for three reasons: it suggests a higher average local unit value added than that of manufacturing activities; it contributes to the intensification of foreign-owned companies' local backward links; and it diversifies and increases drivers of growth (Szalavetz, 2019).

AI-related technology collects a huge amount of unlimited data that could be analyzed to measure entrepreneurs' performance by providing quick solutions and guidance for their practices. If all practices use software to drive various aspects of the business, including operations and productions with automated procedures, this changes the way entrepreneurs perform and could result in an optimized scale of productions with innovated processes that are not available today. Therefore, entrepreneurship obtains many benefits from the use of AI as it creates unique opportunities with which to grow the business and support the improvement of business operations at a very low cost, along with high efficiency rates that help to ensure the growth of the business in the global market (Darwish *et al.*, 2020).

The second stream of research involves marketing and sales. Most firms stated that AI helps them to develop sales and marketing strategies that lead to substantial improvements in business performance (Palanivelu and Vasanthi, 2020).

In particular, AI will not only help the entrepreneur to make better decisions regarding the market, as previously stated, but these crucial decisions powered by AI also lead to positive consequences in terms of performance. In fact, some of the main potential benefits of machine learning algorithms pertain to the exploration of deeper insights into sales, product data and sales opportunities, excluding improved planning and inventory management. Therefore, most companies found that these algorithms made a crucial impact on their key performance indicators for sales (Ramesh *et al.*, 2018).

These findings are in line with another study which predicted customer behavior thanks to machine learning algorithms. It proved that predictions of customer groups have a direct impact on the total revenue of the organization. Therefore, the successful sale of any product can be decided based on the prediction of the customer's expectation and the level of customer (Suguna *et al.*, 2019).

The third and final stream focuses on finance. AI positively influences the economy, furthering the development of entrepreneurship. This contributes to the rapid development of productive powers in society. In fact, private research and developments, as well as state investments into AI, all have an important influence on economic growth (Mamedov *et al.*, 2018).

Furthermore, machine learning algorithms can analyze the level of innovativeness of startups. This is strongly connected to their performance in terms of mortality. It has been proven that innovative firms are more likely to survive than those that are not innovative (Guerzoni *et al.*, 2020).

Cluster: education and research

Finally, the "education and research" element serves as an accelerator of other phases. AI is a powerful tool for both educational and research purposes and it can also have a practical impact too. The entrepreneur could receive dedicated training or be given more information about AI-related tools to enable him/her to face emerging challenges. This also might close

the gap between the theory of the entrepreneurial research and its everyday practice in the business world through mutual contributions shared from both sides.

The first stream in this cluster deals with education. The worldwide use of online teaching that was adopted to decrease the spread of the COVID-19 pandemic has generated an increase in the use of digital technology. Specifically, managing the virus is difficult for education in entrepreneurship due to the need for practical and real-life examples. Therefore, the application of augmented reality and AI is crucial in order to simulate a real environment, enabling a more community-orientated approach to the study and practice of entrepreneurship (Ratten, 2020).

In particular, digitalization creates huge possibilities when it comes to using automatic digital tools in education solutions, using a form of AI that might be scalable and widely applied for distance learning, as evidenced by the crisis caused by COVID-19. There is the possibility of increasing entrepreneurial aspirations, thanks to the development of new and innovative teaching and learning techniques in entrepreneurship (Mavlutova *et al.*, 2020).

In fact, AI positively impacts entrepreneurship by increasing entrepreneurial orientation. Students are more willing to learn about entrepreneurship activities in universities where AI learning is offered. Therefore, it has a key role in boosting entrepreneurial activities at a university level (Khalid, 2020).

Moreover, AI and big data might also enrich the practice field of entrepreneurship education and training in a new way. In extreme cases in which algorithms take over some entrepreneurial tasks from humans, these intelligent machines themselves could receive a sort of entrepreneurship education/training. Therefore, it is crucial to teach entrepreneurship AI and big data techniques in order to better prepare future entrepreneurs (Obschonka and Audretsch, 2020).

In our age of continuous disruption, the role of business education is evolving at a faster rate than ever. The creation of new graduates requires an innovative mindset and the agility to evolve and adapt each time, focusing on disruptive innovation through digital transformation. The technology-based classroom of the future, with an immersive interaction with AI and other modern solutions, along with the necessary modifications in teaching, learning, and skills development, may become a fundamental element to success and business leadership in the digital world (Tarabasz *et al.*, 2018).

These findings are in line with another study that examined the role and impact of Industry 4.0 in promoting innovation and entrepreneurship when creating enterprises through the modification of education systems. The introduction of modules on components of Industry 4.0 (in different phases of the educational career of individuals) with prospects or competencies could shape a technology-enabled society through qualitative workforce creation, whilst also cultivating enthusiasm regarding innovation and entrepreneurship (Rath *et al.*, 2019).

Therefore, AI technologies play a key role in the development of technologies that lead to digital transformation. Understanding and knowledge regarding its strategic impact is a must for decision-makers responsible for business success (Cantú-Ortiz *et al.*, 2020).

However, digital modernization of the sphere of higher education stimulates the reduction of the universities' need for academic and teaching staff, leading to unemployment. Therefore, the digital modernization of the economy, on the basis of new technologies from Industry 4.0, will lead to the creation of a new type of educational service provided through the entrepreneurship of universities: AI training of business. This will guarantee the development of university entrepreneurship as well as the growth of employment opportunities for academic and teaching staff in the sphere of AI, which will not depend on the number of students, but will rather be connected to demand for AI training from digital businesses (Bogoviz *et al.*, 2019).

The second and final streams focus on research. The data revolution might bring about not only new opportunities for entrepreneurship research and practice, but also new challenges and open questions. In fact, AI and big data might not only enrich future entrepreneurship research and influence methods, but it could also target the study of these methods in entrepreneurship research. Therefore, the research domain and the real-world phenomena might co-evolve towards an AI-infused conglomerate of research and practice. This could mean that AI might further close the gap between research and practice (Obschonka and Audretsch, 2020).

Ongoing datafication, coupled with gigantic technological progress in the domain of AI, is changing all aspects of our lives. This disruption at an economy-level is reflected in the world of research, supported by developments in data science. These new techniques use algorithmic models to discover structures that were not specified in advance. These methods also allow us to use more real-time data sources to conduct analyses that would not have been possible otherwise. Therefore, they improve the accuracy and value of entrepreneurship research (Prüfer and Prüfer, 2019).

These studies correlate with research asserting that the fields of AI and big data deal with a huge amount of information and offer potential lessons in the entrepreneurship field via analogous transfer or cross-pollination. In particular, entrepreneurship research can learn from one branch of AI studies called "genetic algorithm", which is a design field that creates solutions for complex, unstructured and non-analytical problems (Zhang and Van Burg, 2020).

AI can play a crucial role and many considerations highlight its importance and its downsides regarding entrepreneurship research. AI, as a measurement method, can detect the entrepreneurial potential in individuals or projects better than human experts can, owing to humans' limited intelligence in detecting or assessing such potential. However, AI also brings with it several methodological challenges. For example, the need for entrepreneurship scholars to be well versed in the human-AI connection to ensure that human understanding guides AI analysis. Entrepreneurship researchers will likely also need to partner with researchers in other computing analytics fields who better understand emerging AI techniques, along with the relevant technological infrastructure. Therefore, AI is a great opportunity and a powerful tool with which to advance entrepreneurship research and increase its relevance when used to complement traditional research (Lévesque *et al.*, 2020).

Discussion

A widespread prejudice is that intelligent systems will gradually replace humans one sector after another. However, while this may be true to a limited extent for some jobs, and although AI is often used to automate certain functions, AI's greatest potential is in complementing and enhancing human capabilities. Human strengths, such as creativity, improvisation, dexterity, judging and social and leadership skills, are still relevant and important, as are the strengths of machines, such as speed, accuracy, repetition, predictive skills and scalability (Daugherty and Wilson, 2018).

We believe that this reasoning is also true for entrepreneurship, as the process by which individuals recognize and exploit new business opportunities by founding new ventures (Shane and Venkataraman, 2000).

To guide this discussion analytically and provide detailed further research directions, we followed a recent established methodology (e.g. Flamini *et al.*, 2021; Pellegrini *et al.*, 2020). This consists of comparing the cluster results against theoretical frameworks or models that are already present in academic literature.

For this purpose, we used a recent theoretical model built specifically to interpret the role of AI in the entrepreneurial process (Chalmers *et al.*, 2021). This model is composed of five

parts, aggregated in three levels: antecedents of venture formation (first block); firm-level activities (three middle blocks); and entrepreneurial outcomes (last block). Specifically:

(1) The first part, "antecedents", refers to entrepreneurial intentions. In this first phase, AI has the potential to impact both the likelihood of an individual deciding to start a venture and the type of venture that they go on to found.

(2) The second part, called "prospecting," explains the potential of these AI algorithms and demonstrates how they can be used to identify and exploit entrepreneurial opportunities.

(3) The third part is called "organizational design" and it deals with new forms of organizational structures and decision systems. Specifically, it analyzes how AI can implement automated decisions, suggesting actions based on available data.

(4) The fourth part is called "exploiting." It focuses on increasing productivity, performance, and rapid growth, specifically addressing how AI plays a role in improving selling function processes and scaling rapidly without traditional constraints and challenges.

(5) The last part, "outcomes," pertains to entrepreneurial rewards. Scaling a business using AI can result in highly technologically literate entrepreneurs gaining much higher financial returns with much less effort than more traditional forms of entrepreneurship.

We crossed our four thematic clusters with the five parts of Chalmers *et al.*'s (2021) schematization to show the most relevant emerging areas. These are yet to be fully addressed and could thus develop interesting avenues for future research (Table 2).

	Antecedents of venture creation	Prospecting	Organizational design	Exploiting	Outcomes of venture creation
Education and research	AI implemented in digital learning as an enabler for antecedents of venture creation				AI combined with ethics as an enabler for outcomes of venture creation
Opportunity		AI coupled with neuroscience as an enabler for opportunity identification and exploitation			
Decision-making			AI applied to entrepreneurs' communication as an enabler for fundraising		
Performance				AI used alongside blockchain as an enabler for automation and scaling	

Table 2.
The AI-enabled entrepreneurial process – Framework

The focus of "education and research" on the "antecedents of venture creation" is interesting. Indeed, the application of AI to digital learning holds the potential to enable us to further understand and stimulate entrepreneurial intentions and orientations, forming new ventures. As premised, the COVID-19 pandemic boosted digitalization which, in turn, created great opportunities in the field of education. The development of these new and innovative teaching techniques in entrepreneurship could increase entrepreneurial aspirations, thanks to enhanced and more engaging learning processes, whereby students learn by doing and by reflecting on their experiences (Mavlutova *et al.*, 2020). Increased engagement in light of AI-supported teaching strategies may also improve and develop entrepreneurial intentions and orientations (Khalid, 2020). In this scenario, the role of business education and entrepreneurship in creating new graduates with an innovative and digital mindset is crucial. The AI technologies in classrooms and the necessary modifications made to teaching could become instrumental in adapting and evolving to fit the AI revolution (Tarabasz *et al.*, 2018). This could form a technology-savvy society through qualitative workforce creation and the cultivation of enthusiasm with regards to innovation and entrepreneurship (Rath *et al.*, 2019). Therefore, it is possible to suggest that entrepreneurship, also supported by AI, could be introduced from High School levels up to the Higher Education curricula. Moreover, entrepreneurship education also recommends the adoption of AI and AR solutions in classrooms to enable more immersive and engaging lessons through programming exercises, automatic digital software assessing startup ideas and interactive workstations, smartboards and video display walls. Thanks to experiential learning, students will be able to unleash the force of AI in their future work, as well as increase their interest and capabilities in entrepreneurship. However, several potential barriers oppose this scenario. First is the lack of proper teachers/trainers in digital skills. Improvement in trainers' digital competencies is therefore required. Second, there is usually a lack of funding for schools and universities. AI learning services require significant financial investment, and government funding should be dedicated to foster this approach. Therefore, future research should study how academia can renew its curricula to reach the full potential of AI in entrepreneurship and develop skilled human resources for this digital revolution.

Another interesting area for further development concerns the "opportunity" and "prospecting" categories. AI, coupled with neuroscience, could allow us to better understand entrepreneurial cognitive processes. These could relate to the identification, evaluation, and exploitation of opportunities. Scientists have found that the individual's cerebral hemispheres are responsible for important mental impulses that condition the process of pursuing opportunities. Specifically, the left hemisphere of the human brain is responsible for the accumulation of knowledge, enabling an individual to behave according to well-established patterns, while the right hemisphere is oriented towards the search and discovery of innovations (Goodwin, 2013). Through the synergy of the two hemispheres, entrepreneurs use their exploratory imagination and creative ability to allocate and recombine physical and intangible resources (Krueger and Mellani, 2010). Thus, neuroscience coupled with AI can capture hidden mental processes and thus contribute to our understanding of the role of intuition, emotions, insights and implicit attitudes in the entrepreneurial process (Nicolaou *et al.*, 2019). Indeed, deep learning has already been used to model and control how convolutional layers and recurrent connections in the cerebral cortex function during crucial processes, such as memory, visual processing and motor control (Macpherson *et al.*, 2021). Similarly, AI has the potential to become humanity's best tool for advancing its own creativity and stimulating entrepreneurial minds through new ways of utilizing data (Hisrich and Soltanifar, 2021). For example, AI and its ability to process and collect big data could lead to better and more interpretative models of interpreting how the brain reacts during creative efforts or during other intuitive and cognitive processes vital to entrepreneurial success. Having substantial information on how these processes function could lead us to a better

understanding of how they can be technologically induced, thus creating instruments to recreate stimuli or track neural activities. Consequentially, in the future, entrepreneurs could be stimulated during opportunity recognition and/or the exploitation phase, and could be supported over the entire entrepreneurial process. Therefore, further research should investigate how different cognitive processes and the differing mental schemata of entrepreneurs could be used and recreated through AI-based technologies.

Third, AI could enable us to better understand entrepreneurial "decision-making", specifically when it is applied to an "organizational design." This would offer several ways of implementing such a decision. Specifically, AI could be applied to entrepreneurs' communication, enabling individuals to accrue more funds (entrepreneurial finance). Entrepreneurs who can communicate their potential and that of their projects effectively are more likely to succeed in engaging investors (Clark, 2008; Mason and Harrison, 2003). With this in mind, several attempts have been made to use AI to codify entrepreneurs' communicative behaviors and analyze the presentations of startups, especially in relation to crowdfunding projects. For example, by applying psychological theories, such as the impression management theory (Goffman, 1959), it has been proved that self-presentation and exemplification techniques are positively associated with crowdfunding success (Korzynski *et al.*, 2021). Similarly, body language and non-verbal communication positively encourage backers to invest in crowdfunding projects (Duan *et al.*, 2020; Raab *et al.*, 2020). While previous researchers have focused on the crowdfunding platform, less is known about other forms of access to entrepreneurial finance. For example, a promising avenue could be related to video pitches used for candidacies into the programs of startup accelerators. AI could thus hold the unexploited potential to discover and precisely gauge the impact of communication on several funding decisions. This would be beneficial for both entrepreneurs and investors. Entrepreneurs could use this knowledge and consequently modify their behaviors to increase their likelihood of being financially backed. Investors, on the other hand, could rationalize their funding decisions. Therefore, forthcoming research should aim to develop AI in the service of entrepreneurial finance.

The focus on "performance" should be directed to the specific "exploiting" process of an opportunity. With this in mind, AI coupled with blockchain could serve as an enabler for automation and scaling. Blockchain facilitates the validation of data sharing in less trusting environments, thanks to the increased security conferred by big data (Wang *et al.*, 2019). In this context, blockchain might help smart factories to further automate by processing more significant volumes of data using fewer resources and at a lower cost, but with significantly less risks. Specifically, this technology could contribute to Industry 4.0 by automating and integrating the different phases of the production process, tracking and tracing the products' life cycle and finally sharing and securing data (Aoun *et al.*, 2021). For example, an Industry 4.0 organization might use AI coupled with blockchain to manage financial accounting, legal work, and compliance requirements (Susskind and Susskind, 2015). Moreover, the combination of blockchain with AI could also change the ways in which audits are carried out, eliminating the need for current auditing tools, such as sampling, confirmations, and traditional ways of gathering evidence (Zemánková, 2019). We believe that the use of blockchain technology is expanding beyond its primary application in the financial arena and may become a fundamental element of business and organizational practice. Its capability to collect and manage data properly while establishing an efficient management system could be a crucial resource for entrepreneurs. Therefore, future research should study the ways in which we might mitigate the uncertainty and volatility of blockchain and how we could design more efficient incentive mechanisms to promote the cooperation of all participants in the data sharing processes necessary for this technology.

Finally, the "education and research" category could also investigate the "outcomes of venture creation"; particularly with regards to AI and its broad applications, which are

disruptively transforming the daily lives of human beings. For this reason, we must urgently address the ethical issues arising from this (Zhang *et al.*, 2021). On the one hand, AI has the potential to re-humanize work, freeing up time and leaving people to work in a more human and less automatic way (Daugherty and Wilson, 2018). On the other hand, this may also lead to an increase in inequality and unemployment (Chalmers *et al.*, 2021; Whittaker *et al.*, 2018). Therefore, without a process that takes into account the plurality of voices in a democratic society, AI risks becoming a tool for settling disparities, where software leads to uncontrolled monitoring, facial recognition systems lead to discrimination, and targeting algorithms lead to behavior manipulation. The outcomes of an AI-related entrepreneurial activity should be measured not only in terms of financial and economic returns, but in a broader sense, including a principle of equity. These issues exist and so they should be openly addressed by teachers and researchers: from data transparency to the issue of unemployment, developing corporate initiatives of reskilling to support employees in acquiring digital skills for the technological revolution. For this reason, the inclusion of ethical education in AI-related curricula could prevent the risks related to AI. Therefore, further research should investigate how entrepreneurs can obtain the benefits of AI while avoiding the potential pitfalls (e.g., inequality and unemployment but also pitfalls resulting from the use of AI such as energy consumption), as well as governing AI in a more democratic and ethical way through new corporate social responsibility strategies.

To sum up, the entrepreneur must carefully evaluate when and how to use AI. Some types of AI will influence the economy of a company in such an incisive way that they are no longer used simply to increase productivity in relation to strategies, but rather to modify the strategies themselves (Agrawal *et al.*, 2018). Therefore, all of these findings lead us to the provocative and final question for forthcoming research: whether or not AI might be able to replace the entrepreneur someday as well, or whether the entrepreneur and AI will work in symbiosis throughout the "AI-enabled entrepreneurial process."

Conclusion

To the best of our knowledge, this is the first study to map and systematically analyze academic literature concerning the relationship between entrepreneurship and AI. To address the research gap, we conducted a systematic literature review of 60 articles.

We dealt with AI as an enabler for entrepreneurs and we demonstrated that AI has profound implications on entrepreneurship. Specifically, we found four positive influences that we also saw as phases of our "AI-enabled entrepreneurial process."

First, in the "opportunity" phase, AI enables the entrepreneur to create new opportunities. Second, in the "decision-making" phase, AI enables the entrepreneur to make better predictions and, therefore, make better decisions. Third, in the "performance" phase, AI enables the entrepreneur to improve the performance of his/her own company. Last but not least, "education and research" accelerates the entire process and closes the gap between entrepreneurship research and practice.

This research offers a model through which to interpret the implications of AI on entrepreneurship. This could prove helpful for researchers, entrepreneurs and aspiring entrepreneurs (as well as those acting entrepreneurially within established organizations) who want to utilize the force of AI in entrepreneurial contexts. Moreover, it provides an agenda for future research, taking into account the emerging technological paradigms and challenges caused by this revolution.

One limitation of this article relates to the methods of exclusion during the systematic literature review. Another limitation of this paper pertains to the fact that this topic is still quite new and there is a relatively small number of published research on it. However, this study could be useful in setting a benchmark for further research in such a promising field.

Scholars are invited to build on this research and the proposed framework, analyzing new studies as well as other future impacts of AI on entrepreneurship.

To conclude, we believe that we are at the beginning of a new era of industrial transformation, and that the entrepreneurial actions we make today will influence the future. The main advantage of AI should be its ability to increase human skills. Therefore, relinquishing to AI all automatic processes that it can govern in a more efficient, precise and faster way than a human would allow entrepreneurs to better express their creative, empathic and visionary potential in a way that no algorithm would be able to match. With this in mind, AI does not become a dangerous enemy, but rather an enabler for entrepreneurs.

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