# Artificial Intelligence in Organizations in Colombia

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## Abstract

The implementation of Artificial Intelligence (AI) in organizations in Colombia has been increasing in recent years, and it is expected to continue growing in the near future. Companies in Colombia have begun to use AI in different areas, such as data analysis, customer service, process automation, and decision-making. Among the strategies applied for the implementation of AI in organizations is the adoption of cloud technologies, the use of machine learning algorithms, collaboration with technology providers and the formation of specialized teams. However, the implementation of AI in organizations has also raised concerns regarding the impact on the employability of people. Although AI is expected to improve efficiency and productivity, some tasks and jobs are also expected to be damaged by automation. It is necessary that companies in Colombia adopt policies and strategies that allow a fair transition towards the implementation of AI, to minimize the negative impact on employability and to take advantage of the benefits that this technology can offer.

**Keywords:** Artificial Intelligence, organizations.

## 1. Introduction

Artificial intelligence (AI) is an interdisciplinary field that seeks to develop systems capable of performing tasks that require human intelligence, such as reasoning, learning, and perception. The history of artificial intelligence presents ambiguity about its origin; there are some currents of scholars who express that it began in 1943 with the publication of the article "A Logical Calculus of Ideas Immanent in Nervous Activity" by Warren McCullough and Walter Pitts, where a mathematical model for the creation of a neural network was presented for the first time.

Another stream of academics defines its beginning in the 1950s, when AI was designated as an academic discipline and the first digital computers for university use began to appear.

Artificial intelligence (AI) is considered to be the most important and disruptive new technology for large organizations. In Colombia, the use of this technology is still incipient in organizations, but it is gaining strength in companies whose market niche is focused on technological processes. The application of AI in Colombian organizations represents a challenge for their technological development. Initially, AIs are focused on the automation of routine or specific processes, where it is possible to linearly represent workflows (Benbya, Pachidi, & Davenport, 2020).

The field of AI has been evolving for several years; the most recent technological advances, together with the rapid availability of data, have allowed AIs to be used with greater affinity in commercial enterprises. Internet giants such as Google, Amazon, Apple or Facebook invest significantly in AI, which underlines its relevance for business models around the world (Jöhnk, 2021).

The current challenges of AI are the performance of non-systematic cognitive tasks, that is, they are focused on decision-making and problem solving. This technology allows collaborative human-AI work and tasks where AI is the protagonist. Most autonomous AI applications are still limited to low-risk areas where the cost of failure is limited (Benbya et al., 2020).

AIs can base decision-making on five key contingency factors: specificity of the decision-seeking space, interpretability of the decision-making process and outcome, size of the alternative set, decision-making speed, and replicability. With these factors identifying human behavior, AIs can interact with people to optimally achieve the quality of organizational decision-making (Raj Shrestha, Ben-Menahem, & Von Krogh, 2019).

AI has already made inroads into mediation procedures, for which a distinction must be made between mediation and electronic mediation, and between the latter and that which uses artificial intelligence. The fact that, for this type of activity, AIs still have technological limitations and limitations with the distortion in dispute resolution (Ordelin Font, 2021) is highlighted.

## 2. PROBLEM, CAUSES AND EFFECT.

The implementation of artificial intelligence (AI) in Colombian organizations can present several challenges and problems. One of the main ones is the existing gap in terms of training and education of employees on topics related to AI and technology in general. In addition, the lack of clarity regarding the regulation and normativity of AI in Colombia can generate uncertainty in companies that seek to implement this technology in their processes. Artificial intelligence can transform business models and improve the activities of companies, at the same time some companies face many challenges when implementing this intelligence correctly (Omil, 2019).

In the changing and globalized society, companies must be efficient and respond to the needs of today's customer, therefore, they are constantly changing and the impact of innovation and technologies is increasingly necessary (Morales, 2021). AI plays a key role in this fourth industrial revolution mainly due to five characteristics, which uniquely give it a special nature:

transparency, because we do not usually detect it when we interact with a system equipped with AI; its difficulty, because the essential reference for its work is constituted by none other than human persons; its adaptability, since it is context-dependent and therefore can be polymorphic; transversality, because at present there is no area that is outside its applications; and, finally, its necessary and permanent renewal and improvement, as is inherent in the area of ICT, which lead to a need for immediacy in responses like in no other field.

The suspicions and cautions shown by society in the face of AI-based systems are justified because it is proven that when these systems are managed with intelligent automation techniques they can increase and, in some cases, replace, through completely autonomous programs, people's ability to act and make decisions. In what follows, for short, we will call these systems autonomous decision systems (SAuD) (Verdegay et al., 2021).

It seems that our day-to-day lives are controlled by artificial intelligence (AI), algorithms, and that our future will depend on them. They are present daily in the media, in our conversations or on social networks. And the truth is that the news that refers to them worries and frightens us to the point of provoking our distrust. We tend to talk about them and their consequences emphatically, but often with great ignorance, enabling unfeasible scenarios or scenarios that are difficult to justify scientifically (Verdegay et al., 2021).

The general objective of this paper is to analyze the application of artificial intelligence (AI) in organizations in Colombia. To achieve this objective, three specific objectives have been proposed. First, it seeks to identify strategies to implement artificial intelligence in organizations. Secondly, it aims to investigate the experiences obtained from the influence of artificial intelligence on decision-making within organizations. Finally, we want to describe the impact of artificial intelligence on the employability of people in these organizations.

## 3. JUSTIFICATION

The potential of AI and robotics must be harnessed, while literacy is key, accompanying the transition so that workers can acquire new skills and generating fertile ecosystems so that vulnerable people are not left behind (Corvalán, 2019). The labour market increasingly demands a prepared workforce, with digital and creative skills, who know how to adapt to technological changes. And this adaptation is key, since today's skills will probably be obsolete in a few years (Corvalán, 2018). It is essential that Latin America promotes the training of workers who are in a situation of vulnerability, so that the inevitable transition to ecosystems of greater automation is inclusive (Ovanessoff & Plastino, 2018, p. 46).

Valencia (2022) mentions that companies, governments, and non-profit organizations benefit from applying artificial intelligence. According to research conducted by McKinsey between 2017 and 2018, the number of companies that applied at least one intelligent system to their processes grew by more than 50%. It also states that applying artificial intelligence must be done carefully so as not to cause damage that is unintentional but that can be significant, both for employees and for the reputation of the brand.

Organizations have understood that sustainability does not depend only on the implementation of technology in their processes, but also on the scientific spirit that it has to respond to the changing environments of the environment, reaching an accelerated pace, willing to reinvent itself along the way in a strategic and shrewd way, understanding that the challenges are increasingly strong and access to the source of information is massive and in real time (Tsekeris, 2019). There is a factor that is currently fundamental for the development of competitiveness in organizations, and it is that component that integrates, streamlines and manages knowledge in real time, due in large part to technology and robotics as the basis of what is known today as AI and that has provided fundamental tools to the different disciplines of the professional field (Makridakis, 2017).

Bringing AI to be implemented in public service providers challenges them to become modern and sustainable organizations that can respond faster to different social problems or, failing that, can optimize their processes and resources, leading them to develop competitiveness in the entity. To address the issue of AI, it is necessary to have the character to face divided opinions in sectors of a public nature, because there are conservative currents that see it as a threat and others that recognize it as a solution to many social and innovation problems.

## 4. BACKGROUND

Since the time of the Greek philosophers, humanity has sought to create machines that emulate human capabilities. However, it was not until the 1950s that the term "Artificial Intelligence" (AI) was coined to refer to the ability of machines to simulate human thought and learning. Since then, AI has evolved rapidly and has become an essential tool in most industries, including education, health, transportation, and finance (Túñez, 2021).

During the 1950s and 1960s, AI research focused on solving problems through the use of rules and algorithms. One of the first AI programs was the Logic Theorist program, developed by Allen Newell and Herbert Simon in 1956, which could prove mathematical theorems using logical rules. Other significant advances of this era include the development of the first expert systems and the initiation of research into machine learning (Gallegos, 2021).

In the 1970s, AI suffered a slowdown in its development due to a lack of significant advances and a lack of funding for research. However, starting in the 1980s, AI began to re-emerge thanks to the development of new techniques and algorithms, such as neural networks and deep learning. These techniques allowed for the creation of more complex systems and the resolution of more complex problems.

On the other hand, there are also negative experiences with the application of artificial intelligence in decision-making. For example, Amazon's facial recognition system, called Rekognition, has generated controversy due to its potential racial and gender bias in identifying people (Mitchell et al., 2021). In addition, the lack of transparency in artificial intelligence algorithms can lead to distrust in users and customers, which could negatively affect the company's image.

The use of artificial intelligence (AI) in organizations has been a topic of great interest in recent years, as it has been shown to improve efficiency, reduce costs, and increase productivity. In Colombia, companies have also begun to implement this technology, which has generated a series of opportunities and challenges.

In administrative terms, the sustainability of companies is defined by effectiveness, efficiency and effectiveness, understanding them as the bases for any organization to be sustainable. Under these considerations, AIs have been characterized by their great productivity in accelerating searches and handling volumes of information, and the automation of repetitive processes. These advantages have a great impact on the companies where these activities are present.

In Colombia, the first reference to AI was in the 1980s, when the National University of Colombia created the Artificial Intelligence Laboratory. In the 1990s, the Center for Research in Information and Communication Technologies (CITIC) was created, which has promoted research in AI and other information technologies. However, interest in AI has been manifested for several decades, but it was from the creation of the Ministry of Information and Communications Technologies (ICT) in 2009 that research and the implementation of AI in the country began to be promoted. Currently, Colombia stands out for being one of the leading countries in the region in terms of the adoption of AI technologies in companies and organizations.

The National University of Colombia has been a benchmark in AI research, with the Intelligent Systems Research Group and the Master's Degree in Artificial Intelligence, which aims to train highly trained professionals in the area. In addition, in the business sector, large Colombian companies such as Bancolombia and Grupo Éxito have implemented AI technologies in their operations, improving efficiency and reducing costs (Montoya, 2021).

It is important to note that the implementation of AI in Colombia is still in an early stage, although more and more companies are interested in its use. According to a report by the consulting firm PwC, 51% of companies in Colombia have already implemented some type of AI technology in their operation (PwC, 2020). Furthermore, the AI market in Colombia is expected to grow at a compound annual rate of 40% between 2019 and 2025 (ResearchAndMarkets.com, 2019).

In Colombia, the development of artificial intelligence has been driven in recent years by various factors, such as the adoption of digital technologies in companies, the increase in data processing capacity, and the presence of trained talents in the field. According to the World Economic Forum report of 2019, Colombia ranks 62nd out of 141 countries in the index of readiness for the adoption of artificial intelligence, which indicates a potential for development in the country.

However, there are significant challenges, especially with regard to the impact on employment. As companies automate processes, some jobs may be eliminated or replaced by technology. According to a study conducted by the McKinsey Global Institute, in Colombia, 55% of work activities have the potential to be automated to some degree (Valencia, 2022). This means that the implementation of AI can have a significant impact on the labor market in the country.

The benefits of incorporating AI into productive sectors of the economy result in greater efficiency, improved productivity, and reliability. This context, known as positive innovation, is not generally accepted globally, as labour displacement estimates may affect one-third of current work activities by 2030 (Dwivedi et al., 2019).

According to Henman (2020), the combination of new digital technologies such as mobile applications and accelerated developments in network technology and wi-fi coverage, allow the collection of geo-encoded data, which give rise to Big Data sets, which are analyzed and processed by AI to optimize decision-making. Automated administrative decision-making processes are continuously expanding, and AI through machine learning provides more arguments for decision-making in complex circumstances.

The strategies for implementing AI in companies' processes and operations are diverse. One of them is task automation, which reduces costs and improves efficiency in the execution of repetitive processes. Another strategy is the implementation of chatbots and virtual assistants, which improve customer service and reduce response time. Work is also being done on the development of predictive analysis and machine learning algorithms, which allow for better and faster decisions.

The impact on employability of the adoption of artificial intelligence in organizations has raised certain concerns about the impact it may have on people's employability. On the one hand, the implementation of artificial intelligence technologies is expected to generate new jobs in areas such as programming, data analysis, and systems management. However, there are also fears that the automation of tasks and the replacement of jobs with robots and artificial intelligence systems could lead to a reduction in jobs in some sectors.

AI began its development with great difficulty and uncertainty, but currently, AIs are going through a stage of great advances and growth. This boom is mainly due to the availability of large amounts of data (big data), graphics processing (GPU) and tensor processing; which is why AI will have a direct influence on the decisions of organizations. This is because everything around us today, from culture to consumer products, is related to some intelligence product.

On the other hand, there are also those who see AI as an opportunity to generate employment and improve the quality of existing jobs. According to a report by the International Labour Organization, AI can improve the efficiency and quality of work in some sectors, and can generate new jobs in others (Nava, 2020). In addition, the implementation of AI can also improve the productivity and competitiveness of companies, which in turn can generate more employment.

## 5. THEORETICAL FRAMEWORK

Artificial intelligence (AI) is a branch of computer science that focuses on creating systems and algorithms that can simulate human behavior and make decisions autonomously. According to Silver et al. (2021), AI can be defined as "the study of how to make computers perform tasks that, currently, humans do better". This definition shows that the goal of AI is to mimic human intelligence, although this does not mean that it is intended to create an exact copy of the human

brain, but rather a series of techniques that allow tasks to be performed more efficiently and accurately than humans.

One of the earliest antecedents of AI was the Turing machine, created by British mathematician Alan Turing in 1936. The Turing machine was designed to demonstrate that any mathematical problem can be solved by a machine by executing a series of logical instructions. This idea laid the groundwork for the further development of AI. Another important milestone in the development of AI was IBM's chess program, Deep Blue, which in 1997 managed to beat the then world champion Garry Kasparov in a chess match. This fact showed that AI was capable of outperforming humans in certain complex cognitive tasks.

The incorporation of AI in the field of engineering projects has already been carried out with results that show the weaknesses and ambiguities present in professional training, highlighting the difficulty of deepening and raising awareness of the contents and their globality; the application of AI in this area allows cognitive monitoring of the stakeholder and the development of the project, highlighting case-based reasoning to offer alternative solutions when difficulties are encountered in the acquisition of knowledge (Vahos, 2013).

Organizations are implementing various strategies for the implementation of artificial intelligence, among them are: adequate selection of projects, which are suitable for the implementation of artificial intelligence and that generate value in the short term; creation of multidisciplinary teams that include experts in technology, mathematics and business, which must work collaboratively to achieve a successful implementation; the adoption of artificial intelligence tools and technologies, the continuous training and training of employees and continuous evaluation of results.

Concisely, the implementation of artificial intelligence in organizations requires a well-defined strategy and the adoption of appropriate tools and technologies, as well as the training and education of employees and the continuous evaluation of results.

As a result of the research carried out by Almonacid and Coronel (2020), where they highlighted the capacity of computing and the possibilities for overcoming human limits, they raised the need for a reasonable implementation of it; they also stated that in areas such as contract law it is unfeasible to continue with practices and studies that do not involve technology; ignoring its potential and applicability leads to a loss of competitiveness in the face of those who implement it.

In the journalistic area, the panorama is very similar to the area of law, highlighting the position of the implications of the social, practical, sociopolitical, psychological, legal and occupational order; but even with these discrepancies, the panorama offered by AIs to expand their opportunities and tell stories in different ways is attractive. It is highlighted that information production should be governed by traditions in which ethical norms are a procedural horizon, not imposed by a market or economic logic (Lassi, 2022).

Previously, as Granados and La Peña (2021) describe, studies on AI focused on the impact of technology on international affairs, but few have analyzed the effect on the structure of the international system. The results obtained from the study revealed the complexity of the current

international system and network science methodologies were proposed to identify the emergence of AI in the international system, finding in the relationship between technology and globalization three implications: AI is a complex system and a dynamic source of international power, data increases its global relevance as raw material for AI, and the international fitness of each country is essential for the evolution of the structure of the international system when considering AI.

Considering that the global knowledge network is a system where scientists can share information around the world, it is evident that countries are trying to attract and retain international talent, as are restrictions on access to knowledge, strengthening intellectual property laws and creating a hostile environment for scientists or foreign companies (Granados & La Peña, 2021).

Three stages can be identified that define the development of artificial intelligence: weak artificial intelligence, aimed at automation and systematization; artificial general intelligence (AGI), which stands out for human-machine integration and interaction; and a third stage, artificial superintelligence (AIS), in which the transformation will be sensational. The critical factor of human intelligence is in the interpretation of reality, while for artificial intelligence, its critical factor is oriented towards effectiveness and efficiency in the interpretation of reality (Cabaneles, 2019).

Kuzior et al. (2019) consider the organizational capacities of applying AI technologies in the sustainable development model of the organization, developing the combinatorial model of artificial intelligence for decision-making on organizational development; developing the classification model, the model for calculating the degree of truth of fuzzy inference rules, the situational model of decision making, and the model of fuzzy selection of decisions by making variants.

As Barrios Tao et al. (2020) exposed, in their discussion on subjectivities and artificial intelligence: challenges for "the human", the concern about advances in AI developments generates new questions about the human being and the responsibility that falls on humanistic training; the humanities must strengthen their responses to the new challenges posed by the development of strong AI systems.

According to Ocaña et al. (2021), AI offers enormous potential in transforming and augmenting human tasks and activities within a wide range of industrial, intellectual, and social applications. AIs are currently present, and we normally use this technology in our daily lives.

Currently, the dizzying growth in the development of AI facilitates multiple tasks of greater complexity by providing optimal solutions to face complex problems. The innovations incorporated by artificial intelligence carry digital and technological strategies that are increasingly close to the way the human brain works, managing in many aspects to overcome the restrictions and contradictions of human intelligence. The emergence of several disciplines derived from the use of artificial intelligence, such as Big Data and Machine Learning, have managed to incorporate advances in algorithmic machine learning and autonomous decision-making into the context of management, softening the generation of opportunities for constant innovation (Maita-Cruz et al., 2022).

The construction industry is considered a potentially viable alternative, but as in other professions, there is the specter of replacements in jobs that the implementation of AI would cause; it is for this reason that some countries are including laws in their legal frameworks that limit the use of artificial intelligence in the construction industry, limiting access to and use of new technologies (Mendoza et al., 2022).

Although the principles of AI are long-standing, there is a significant step that has been taken in recent years: one of the branches of AI, called machine learning, has advanced dramatically in the last decade, especially in the field of deep learning, which involves the use of artificial neural networks (Moloi, 2021).

What about the effects of AI according to socio-professional category, salary, and level of education? Research results on this issue have also been mixed. Although the estimates of most research suggest that AI will affect all professional categories, whether they are low, medium or high skilled, some categories will be more threatened than others. The aforementioned studies indicate that low- or low-skilled jobs that are low paid and do not require a particular degree or vocational training will be the most exposed to the risk of automation (Frey & Osborne, 2017).

Studies agree that the least exposed qualified professional categories will continue to be those that are essentially based on social competences (such as teachers or management positions, among others) or on cognitive competences to manage complex problems. Research-related jobs, for example, that entail higher academic levels (such as PhDs), will be saved: these are jobs that are often based on the ability to analyse complex phenomena and understand them systemically, even if some of their tasks (such as data use and processing) can be adapted to machine learning (Brynjolfsson, Mitchell, & Rock, 2018).

Artificial intelligence has its roots in computer science and has evolved over time to become an important tool in many areas of society. The antecedents of AI date back to the 1930s and have evolved over the years. Colombia, although relatively new to AI development, has made great efforts in recent years to foster research and development in this area. AI is constantly evolving and is expected to continue transforming the way we live in the future.

The application of artificial intelligence in decision-making in organizations has had a significant impact on the efficiency and effectiveness of organizations, such is the case of the accuracy of predictions; It has significantly improved the accuracy of predictions in different fields, such as in sales forecasting, medical diagnosis, and financial risk prediction.

Another impact where the benefits of AI are evident is in the reduction of human errors. The implementation of artificial intelligence in decision-making has reduced the incidence of human error in different processes, such as image classification, fraud identification, and candidate selection in recruitment processes. The acceleration of the decision-making process has also benefited from artificial intelligence, which has made it possible to significantly accelerate the decision-making process in different fields, such as real-time security threat detection and supply chain optimization.

Despite the aforementioned benefits, the implementation of artificial intelligence in decision-making also presents challenges, such as a lack of transparency and the possible introduction of

biases into algorithms. In addition to the aforementioned benefits and challenges, the implementation of artificial intelligence in decision-making in organizations has also had an impact on organizational structure and employee training.

In terms of organizational structure, the implementation of artificial intelligence has generated the need for teams specialized in data management and algorithm development. This has led to the creation of new areas in organizations, such as data science and artificial intelligence departments.

Employee training, the implementation of artificial intelligence has generated the need for employees to develop new skills, such as the ability to analyze data and work with algorithms. This has led to the implementation of training programs for employees and the need for a workforce that is more skilled in the use of artificial intelligence technologies.

Overall, the implementation of artificial intelligence in decision-making in organizations has generated a significant transformation in the way decisions are made and in the organizational structure. While it presents challenges and risks, it also offers significant opportunities to improve the efficiency and effectiveness of decision-making processes and to identify new business opportunities.

## 6. RESULTS AND DISCUSSION

The implementation of artificial intelligence could result in job losses in some sectors, but also in the creation of new jobs in other sectors. This means that automating processes through artificial intelligence can affect employment in some roles, but it can also create new job opportunities in the management and maintenance of these technologies.

The adjustment of input consumption, as well as the increase in labor efficiency, has been possible through the use of digital technologies, including initially access to internet networks, access to technology through mobile devices, and more recently data analytics and artificial intelligence. On the other hand, the use of applications developed for the sector as support in the different stages of the production chain, resulting in sources of information that allows greater reliability to buyers of products and consumers. In this way, global technologies such as in-situ sensors and the use of remote satellite data make it possible to improve the accuracy and reduce the cost of monitoring crop growth while verifying the quality of the land or the volume of water available (OECD, 2019).

In addition, artificial intelligence can also improve productivity and efficiency in organizations, which can lead to increased demand for work in other sectors; Artificial intelligence has the potential to increase labor productivity in the next decade. The digitization of files will make it possible in the future to apply artificial intelligence techniques for data analysis, for example, to know how laws are being applied in reality and to measure the consistency or inconsistency of judicial decisions of different judges on the same point of law (Copus & Hübert, 2017).

Some specific applications of clustering algorithms include fake news detection (Hosseinimotlagh & Papalexakis, 2018) and spam filters. In these cases, the algorithm does not

depend on a previous classification, but on the automatic grouping of the different data through statistical methods.

Artificial intelligence tools, particularly those that allow legal knowledge to be aggregated to make it available to judges and parties, can also contribute to generating greater consistency in the application of the law. There are already machine learning techniques that can detect inconsistencies and even instances of discrimination or the use of extralegal factors in dispute resolution (Copus & Hübert, 2017).

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Importantly, the implementation of artificial intelligence may require specialized skills and knowledge, which may increase the skills gap in some sectors and may result in the need for training and job retraining for workers. Therefore, it is important for companies to consider the impact on employees when implementing artificial intelligence and work together with workers to ensure a fair and equitable transition.

The risk to the transparency and motivation of decisions has been discussed in the Wisconsin Supreme Court's decision in State v. Loomis, in which the use of COMPAS was allowed as a tool to assist in the determination of an individual's dangerousness, but not as the only criterion for deciding (Liu, Lin, & Chen, 2019).

The implementation of artificial intelligence in organizations can have an impact on people's employability, both in terms of job loss and the creation of new job opportunities. Therefore, it is important for companies to carefully consider the impact on employees and work together with them to ensure a fair and equitable transition.

However, it is a sign of the need for a public policy on artificial intelligence in justice to be accompanied by a discussion on the legal and ethical limits of automated data processing. The variables taken into account by Prisma to predict recidivism may be somewhat close to those that have been strongly discussed in the United States (Liu, Lin, & Chen, 2019; Dressel & Farid, 2018).

## 7. CONCLUSIONS

Artificial intelligence is a rapidly growing field with many potential applications. AI can improve efficiency and accuracy in a wide variety of industries, but it also poses significant challenges in terms of transparency, privacy, and data security. It is important that advances in AI are used responsibly and that the ethical and societal challenges posed by this technology are addressed.

The experiences of applying and influencing artificial intelligence in business decision-making are varied and depend on the specific context and implementation. Although there are success

stories, there are also cases in which caution should be exercised and the possible negative impacts should be carefully evaluated.

The implementation of artificial intelligence can have a mixed impact on the employability of people in organizations. While it presents challenges, it also offers significant opportunities to create new jobs and improve the quality of work. It is important for organizations and governments to implement strategies to maximize the benefits and minimize the risks of implementing artificial intelligence in the labor market.

AI has the potential to transform the way organizations in Colombia do business, but it also poses significant challenges in terms of employment and adaptation. To maximize the benefits of AI and minimize its risks, policies and strategies that foster training, ethics, and interdisciplinary collaboration need to be adopted.

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