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The possibility of implementing intelligent systems and the respective impact of Artificial Intelligence on inventory management and warehousing

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Master's in Business Administration

Advisors:

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March, 2022

BUSINESS SCHOOL

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Resumo

A indústria está numa nova fase: Indústria 4.0. Esta quarta revolução industrial concentra-se em melhorar os processos dentro das indústrias. A base para essa melhoria é a inteligência artificial, que, ao digitalizar as operações das empresas que atuam nos diversos setores, melhora a sua produtividade, inovação, reduz custos e melhora os seus mercados no cenário internacional. No contexto das empresas de retalho, o aprovisionamento e armazenamento de produtos é uma das operações mais importantes.

Assim, este estudo pretende investigar o conceito de inteligência artificial, ou seja, os seus benefícios, confiança e riscos para, consequentemente, analisar a possibilidade da sua aplicação na gestão de stock e armazenamento. A primeira fase do estudo passou por uma revisão de literatura, onde todos esses aspetos foram minuciosamente analisados. Em seguida, para coletar dados e chegar a conclusões, foram utilizadas duas metodologias: um questionário online e entrevistas.

Após a análise dos *outputs* do questionário *online*, concluiu-se que a Inteligência Artificial tem benefícios e indicadores de confiança que influenciam positivamente a sua implementação na gestão de stock e de armazém.

Relativamente às entrevistas, estas revelam que a Inteligência Artificial começa a ser reconhecida pelas suas vantagens, mas ainda é vista como um investimento avultado, principalmente para pequenas empresas industriais. No entanto, as aplicações que estão a decorrer são consideradas pelos especialistas de AI como benéficas, sendo a *machine learning,* a robótica e *computer vision* tecnologias que podem potenciar a produtividade das operações logísticas abordadas nesta investigação.

Palavras-chave: Inteligência artificial, gestão de stock, gestão de armazém, Indústria 4.0

Classificação JEL:

L00 Industrial Organization: General

O32 Management of Technological Innovation and R&D

Abstract

The industry is in a new phase: Industry 4.0. This fourth industrial revolution focuses on improving processes within industries. The basis for this improvement is artificial intelligence, which, by digitizing the operations of companies operating in different sectors, improves their productivity, innovation, reduces costs and improves their markets on the international stage. In the context of retail companies, the sourcing and storage of products is one of the most important operations.

Thus, this study intends to investigate the concept of artificial intelligence, that is, its benefits, trust, and risks to, consequently, analyze the possibility of its application in stock and storage management. The first phase of the study underwent a literature review, where all these aspects were thoroughly analyzed. Then, to collect data and reach conclusions, two methodologies were used: an online questionnaire and interviews.

After analyzing the outputs of the online questionnaire, it was concluded that Artificial Intelligence has benefits and trust indicators that positively influence its implementation in stock and warehouse management.

Regarding the interviews, these reveal that Artificial Intelligence is beginning to be recognized for its advantages, but it is still seen as a large investment, especially for small industrial companies. However, the applications that are taking place are considered by AI experts as beneficial, being machine learning, robotics and computer vision technologies that can enhance the productivity of the logistics operations addressed in this investigation.

Key words: Artificial intelligence, stock management, warehousing, Industry 4.0

JEL Classification:

L00 Industrial Organization: General

O32 Management of Technological Innovation and R&D

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List of abbreviations

AI – artificial intelligence

IS - intelligent systems

CR - composite reliability

AVE - average variance extracted

HTMT - Heterotrait-Monotrait ratio

VIF - variance inflation factor

Chapter I - Introduction

1.1 Contextualization

The globalization demands high requirements on the products and services provided by companies, as the notion of value perceived by customers or added value is a main variable for enterprise success (Chehri et al., 2021). Entering in Industry 4.0 or the 4th industrial revolution, in 2011, the base for generate this value is companies' digitalization (Chehri et al., 2021). Industry 4.0 has more than 100 different definitions, but all have in common the application of artificial intelligence to for improving processes, products and services allowing decentralized decisions based on real-time data acquisition (Moeuf et al., 2018). The aim is interconnectivity between key players of this new smart companies, that will create ecosystem of solid collaboration in procurement, manufacturing, sales and distribution, finance, and accounting work to achieve the company's general objectives (Chehri et al., 2021).

There are several studies that demonstrate the notoriety of the application of IA in companies from different industries, like Kaplan & Haenlein (2018), Haefner, et al. (2021), Huang & Rust (2020), Kumar & Kalse (2021) and Pallathadka, et al. (2021), it can deliver higher quality, greater efficiency, and better outcomes than human experts (Haefner et al., 2021). However, the focus in recent years has been on small and medium-sized companies, which despite existing evidence on the leverage granted by the application of intelligent systems in operations, they often limit themselves to the adoption of Cloud Computing and the Internet of Things (Moeuf et al., 2018). This is due to lack resources to invest in research and development activities(Haefner et al., 2021).

Studies, such as those mentioned above, raise awareness of the benefits of AI, as reflected in a study carried out by Schneider Electric on French companies in which 95% of business leaders are confident and ready to adapt to change (Chehri et al., 2021). The transition to Industry 4.0 impacts the entire company's operation, namely: the organization of work, the economy of the company, the management and warehousing, business strategy, and consumer habits (Chehri et al., 2021). Equipment is automated and connected, allowing remote control and management of the company. Warehousing chains can now be dynamic, putting an end to inventory management and impacting warehousing (Chehri et al., 2021).

Inventory management and warehousing are critical part of warehousing chain (SC) management (Min, 2010), since, for example, in retail organizations it's what guarantee ability to integrate and orchestrate the processes of acquiring finished goods, and delivering them to customers (Min, 2010). Taking that in account, SC management (SCM) is becoming more information intensive, and its focus has been directed toward the substitution of assets (e.g., inventory, warehouses, transportation equipment) with information, given by intelligent systems. This way, SC professionals have explored various ways to better manage information and leverage it to make better business decisions (Min, 2010).

Thus, the main objective of this study is to investigate the impacts that AI can bring to an intrinsic task for the management of organizations, Inventory management and warehousing. Therefore, it is expected that this study will contribute to the development of the scientific community, adding more knowledge on the subject and contributing to a study that relates AI with industrial management, as these are two areas with few studies in common.

1.2 Research Problem

Following the research theme: “The possibility of implementing intelligent systems and the respective impact of Artificial Intelligence on Inventory management and warehousing, this study aims to relate the theme of AI with industrial management. Considering the importance of Inventory management and warehousing for the success of a company's performance, the relevance of this study is highlighted. Thus, the study will examine the reasons that encourage managers to apply intelligent systems in Inventory management and warehousing operations, characterize these technologies and how they can benefit the organization, also leaving room for the limitations of this implementation. In short, the variables that globally influence the implementation of intelligent systems in Inventory management and warehousing will be reviewed.

The intricate need, discussed above, for successful stock management and warehousing, leads managers to look for intelligence system solutions. However, there is still a big gap in the academic context that understands the two themes, and this study aims to reduce the lack of existing knowledge as well as update existing studies in the area.

1.3 Research objectives

The aim of this study is to offer new information to the scientific community, through the integration of an essential management task of industrial organizations - Inventory management and warehousing - with Artificial Intelligence. To achieve the defined goal, two objectives were defined: to understand the factors that influence the possibility of applying intelligent systems in Inventory management and warehousing, and to understand the impact of this application.

1.4 Structure of the thesis

This research is organized into seven chapters which are detailed below. In chapter I, there is an introduction divided into framework, research issues and research objectives.

Chapter II contains the initial part of the literature review divided into two parts. The first part, with a more theoretical focus, has the overall objective of explaining the concept of Artificial Intelligence. Subsequently, topics such as the components that constitute Artificial Intelligence, such as machine learning and deep learning, and how they work were addressed. The second part of the chapter is composed of two subchapters and takes a more practical approach. These subchapters have two main objectives, namely, to show the challenges, identified by some authors, brought by AI and to highlight some impacts that these intelligent systems have on industrial management. Chapter III, where the end of the literature review is verified, is dedicated to stock and warehouse management. In an initial phase, the concept of each of these logistical components, the characteristics for a correct management of each of these activities and the different ways of operationalizing them were addressed. Also in chapter III, a method of stock and warehouse management using AI systems is discussed, as well as an explanation of the possible impacts that these same systems may have on stock and warehouse management.

Chapter IV is constituted by the theoretical approach, where the research questions resulting from the literature review and that will serve as a basis for the investigation are highlighted.

Chapter V is dedicated to the different methodologies applied to answer the research questions identified in the previous chapter, as well as the description of the samples that each research question had.

Chapter VI presents the results obtained from the different methodologies that each research question had, and their respective discussion, and the discussion includes the opinions of the authors referred to in the literature review, in order to compare both points of view and, thus, deepening the knowledge obtained from the investigation.

Finally, chapter VII consists of the conclusion, where the final considerations of the study are made, the contribution that the study had to business management, its limitations, and some suggestions for future investigations.

Chapter II - Intelligent Systems

2.1 Artificial Intelligence concept

Defining AI, it's not an easy task considering the constant change in this field, so much so that intelligence applied to the behavior of machines developed 5 years ago, nowadays it is almost no longer considered intelligence (Kaplan & Haenlein, 2019).

The idea of "a machine that thinks" can be traced to the Ancient Greeks (IBM, 2020), but the first proposal for a definition appeared in the mid-20th century, more specifically in 1956, by the researcher John McCarthy at the first academic conference on the theme, the Dartmouth Conference (Haenlein & Kaplan, 2019). The purpose of the conference was to clarify and identify a concept called "thinking machines", as reaching a consensus was proving to be a difficult path (Marr, 2018). To be comprehensive and encompass all associated areas, the author defined AI as 'the multidisciplinary technology, one with the capability of integrating cognition, machine learning, emotion recognition, human-computer interaction, data storage, and decision-making' (Haenlein & Kaplan, 2019).

In a complementary perspective to integration, AI is also defined by the authors Kaplan & Haenlein as "the system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" (Kaplan & Haenlein, 2019b, p. 17). In this definition, the authors focus more on AI as a data interpretation instrument for the evolution of knowledge.

Reviewing the latest definitions of AI, we can highlight the one developed by the authors Zhang and Lu who bring the concept as the 'study of how to make computers perform intelligent tasks that, in the past, could only be performed by humans' (Zhang & Lu, 2021). With this definition we can see an evolution of thought, as the latter no longer focuses on AI as an integration with the human component but rather to replace tasks performed by humans.

Table 1 shows the definitions of AI defended by the authors mentioned in this literature review. In short, when comparing the definitions presented, it is possible to withdraw the common idea, despite the evolution of the concept, that AI is the field of study that intends to mimic the human brain, translating into computational systems that can perform tasks that exceed human capacity.

Table 1 Summary table of the definitions of the Artificial Intelligence concept

Author	Definition of the concept of AI
(Kaplan &Haenlein, 2019)	The multidisciplinary technology, one with the capability of integrating cognition, machine learning, emotion recognition, human-computer interaction, data storage, and decision-making
(Kaplan &Haenlein, 2019)	The system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation
(Zhang & Lu, 2021)	Study of how to make computers perform intelligent tasks that, in the past, could only be performed by humans

Source: Author's elaboration

2.2 AI Components

Considering the different approaches to the concept of AI presented in the previous topic, it is important to highlight the types of artificial systems pointed out in the literature to build the structure of this area of study. The AI literature focuses on the permission of make machines to emulate human-like functioning, so that they can do things human capabilities allow, such as learning and problem solving (Russell & Norving, 2019). Thus, the criteria for the typology of these systems, by the highlighted authors, is the degree to which an AI system can replicate human capabilities.

2.2.1 Mechanical, analytical, intuitive, and empathetic

The authors Huang and Rust (2018) argue that AI can be classified into four namely mechanical (i.e., automation), analytical (i.e., propensity modelling), intuitive (i.e., generation of content) and empathetic (i.e., social robotics). For this classification, the authors are also based on the variable time, that is, as the degree of time that these intelligences need for mimic human automation, the greater will also be the degree of intelligence of the system (Annex a).

The first type is mechanical intelligence is used in activities that don't need human's intellect and creativity. Usually are "boring" operations for people that have been performed many times and thus can be done with little or no extra thought (Sternberg, 1999). They use powerful servers to do the computation, with prior knowledge, that translate intelligent algorithms in a relatively simple way to perform the necessary tasks. We can find examples of this type of intelligence in robots like Intelligent search by Google or other search engines that use powerful data to do the computation and use intelligent algorithms to figure out the meaning of queries and return with the right results (Huang & Rust, 2018).

The second type is analytical intelligence, is a step up on the level of AI, as it uses analytical skills, as information processing, logical reasoning, and mathematical skills (Sternberg, 1999). In Humans, this type of skills is about the ability to gather information from the external world and process it in a well-defined context (Sternberg, 1999). So, the machine using thus intelligence must be able to understand, interpret, and transform external information into data (Sternberg, 1999).

This intelligence is developed for complex tasks, but systematic, consistent, and predictable tasks. The most common tasks that this type of intelligence performs are the ones that are data and information intensive. Their system processes and synthesize large amounts of data and learn from them. This is suitable for mass personalization based on big data from customers, with collaborative personalization, as its necessary in-service operations. So, this is considered the most profound widespread change that AI has brought to service so far — machines that are able to make conclusions about the environment situation (Huang & Rust, 2018). the most know application was Business Machines Corp.'s (IBM) chess computer Deep Blue, a machine that beat chess Grandmaster Garry Kasparov in 1997.

The second type is analytical intelligence, is a step up on the level of AI, it uses analytical skills, information processing, logical reasoning, and mathematical skills (Sternberg, 1999). In Humans, this type the skills are about the ability to gather information from the external world and process it in a well-defined context (Sternberg, 1999). So, the machine using this intelligence must be able to understand, interpret, and transform external information into data (Sternberg, 1999).

Finally, the authors define intuitive intelligence and empathetic intelligence as the most returned intelligence. The most outstanding characteristic of these intelligences is their ability to think creatively and adjust to new situations (Huang & Rust, 2018). Comparing with the previous intelligence, analytical, machines with intuitive intelligence to develop and follow their intuition, such as a human mind, and that allows it to understand the conclusion that it takes from the environment and propose solutions (Huang & Rust, 2018). Then, one step forward, the empathetic intelligence enters in an emotional sphere, as the machine can empathize and communicate with uses for emotional support and solutions (Huang & Rust, 2018). This is the most complex form of AI as comes from the premise that to have empathy the machine must also develop its personality. Again, this type of intelligence is very useful in the service of call centers and psychiatrists, as it will help to a faster and need diagnosis of user's problems, attached to a more empathize approach to the situation (Huang & Rust, 2018).

2.2.2 Reactive machines, limited memory machines, theory of mind, and self-aware

Other authors define the types of AI using not only the degree of similarity to human capabilities but also the degree of similarity to human functions. Thus, author Simon Williams (2021) first defines 2 types of AI Type I – Based on Capabilities and Type II – Based on Functionality (annex b).

However, the author's definition of capabilities and functionalities does not meet the definition of the authors previously presented. Thus, Simon gives a connotation of functionality like the capabilities used as typology criteria by the previous authors. So, for this author, there are also four types of AI or AI-based systems: reactive machines, limited memory machines, theory of mind, and self-aware AI (Forbes, 2019).

Reactivate machines are like mechanical intelligence, in that they have limited ability as they only adapt or learn to a minimal level. This is due to not being able to store the collected date and consequently they cannot learn, only performing simple tasks. However, machines with this type of intelligence have an intelligence like systematic intelligence as they mimic the human capacity to react to various stimuli, and the author Williams uses the same example as Deep blue to demonstrate the application of this intelligence (Williams, 2021).

In addition, limited memory, besides having all the functions of reactive machines, are also capable of storing data. Thus, similarly to machines with analytical intelligence, they are trained by large volumes of training data that they store in their memory to form a reference model for solving future problems (Williams, 2021).

In the third position we have the Theory of Mind, like intuitive intelligence, which understands the entities it is interacting with discerning their needs, emotions, beliefs, and thought processes (Williams, 2021). However, while the intelligences mentioned above by this author are already being applied on a large scale, this type of intelligence only exists in concept or as a work in progress. This is because it is a hard task to make the machine understand human as a mind that are shaped for multiple factors that reflect your needs.

However, if the Theory of Mind AI matures, then it will create the following: Machines that think; Machines that experience emotion and Conscious machines E.g., robots can be responsive and understanding co-workers of human beings in the workplace (Davis, 2021). Finally, as theory of mind, Self-aware are not yet applicable. Furthermore, is currently only hypothetically. This is and it will always be the ultimate objective of all AI research. These AI will be more astute/smarter than the human mind, so, despite boosting, in our progress as a civilization, there is the possibility that they can elaborate schemes to take over humanity. Stephen Hawking warns 'It will either be the best thing that's ever happened to us' (vox, 2018).

Since for the author Simon features are synonymous with the capabilities mentioned by the authors Huang and Rust (2018), through their own definition of capabilities, the author defines 3 types of intelligence that are increasingly presented in their state of intelligence: Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Superintelligence (ASI) (Williams, 2021). This typology is the most used by technicians in the area to categorize existing intelligences (Forbes, 2019) (annex c).

Weak AI, the lowest stage of intelligence - Machine learning - is for the author the type of intelligence that only acts against a certain type of computerized rules in advance, not carrying out more work beyond the commands given to it (Williams, 2021). So, this intelligence only specializes in one area and solves one problem. Apple Siri is additionally a genuine illustration of Narrow AI (Williams, 2021).

General AI, the second degree of intelligence called Machine learning, are AI that has the capacity like the humans of learn thought their mistakes. As this type of intelligence learn, their system will be able to independently build multiple competencies and form connections in diverse areas of knowledge they can cut time need to solve new problems (Williams, 2021). However, despite the discovers in the area, presently, there's no genuine illustration that shows the progress has been made (Williams, 2021).

Lastly, Super AI, the ultimate stage defines by the author as machine consciousness, is much smarter than humans' brain in practical every field. Dispatch being a hypothetical idea of Artificial Intelligence, progress in this is genuine and this type of intelligence will give these systems the capacity to think, reason, tackle puzzle, make decisions, plan, learn, and convey by its own, which will bring about an incredible change in Human Civilization (Forbes, 2019). In short, although there are several types of artificial intelligence, they all grow towards evolution towards a similarity or even surpassing human capabilities and functions.

2.3 The research fields of AI

The study of artificial intelligence is quite extensive, and it is constituted by several theories, methods, and technologies. According to authors Zhang and Lu, the study of AI is subdivided into five fields: Advanced Algorithms, expert system, machine learning, decision support system and pattern recognition.

2.3.1 Advanced Algorithms

An Algorithm is sequence of a finite sequence with instructions that normally solve specific problems or to perform computation and that's the basis of AI (Zhang & Lu, 2021). This way, researchers in AI are constantly developing new combinations of sequences to analyze more data faster and at multiple levels. This development is allowing AI, in other words, to identify and predicting rare events, understanding complex systems, and optimizing unique scenarios in a faster way (Soltani, 2021). In logistics, in a way of transforming intelligent supply chain, there are companies that use advanced algorithms to connect supply chain digital information and improve the decisions relevant to make business more consciously (Soltani, 2021).

2.3.2 Machine learning

Machine learning uses as a basis an algorithm that was built to learn through the available date and still improve its performance through its experience (Zhang & Lu, 2021). This field is developed for application in statistics, where in most cases it is necessary to find hidden insights in data without explicitly being programmed for where to look or what to conclude (Zhang & Lu, 2021). Thus, the types of problems to be solved by machine learning are prediction, clustering, classification, and dimensionality reduction (Zhang & Lu, 2021). Considering these four types of learning methods, machine can be divided into four categories: supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning (Zhang & Lu, 2021).

Supervised learning refers to algorithms that use labeled data to train, to predict the type or value of new data, under the presence of a supervisor (Yagcioglu, 2020). An example of application of this type of algorithm is predicting house prices. Through the combination of numerous characteristics of houses (typology and prices) we can now train a supervised machine learning model to predict a new house's price based on the examples observed by the model (Yagcioglu, 2020). When the data has no labels, unsupervised learning is used. In short, data can be classified according to different characteristics without tags, so references from observations are used in the input data. One common approach of this type of algorithm is the search for customer segments. the technique here is to form clusters where the goal is to find natural groups or clusters in a feature space and interpret the input data. In the area of marketing, the determination of different segments of customers helps teams approach these customer segments in specific ways (Yagcioglu, 2020).

Semi-supervised learning can be understood to be a mixture of supervised learning and unsupervised learning (Yagcioglu, 2020). The goal of a semi-supervised model is to classify some of the unlabeled data using the labeled information set (Rodriguez, 2017). Google Expander is a great example of this type of algorithm building multi-graph representation of known and unknown data sources on which nodes correspond to objects or concepts and edges connect nodes that share similarities (Rodriguez, 2016). An example of machine learning in warehousing can be found in Amazon warehouses, where through different 3 types of machine nodes built a prediction model: Binary classification model, Multiclass Classification Model, Regression Model that increased the revenue by a minimum of 20 percent (Foya, 2021.).

2.3.3 Robotics

Robotics is a filter of artificial intelligence that focus on build devices that are capable of more general classes of tasks. Thus, this field aims to the connection of perception to action. Currently, this connection is made mainly by machine learning as we see in computer vision, force, and tactile perception. This intelligence only allows Robotic navigation in static environments, but the next step is the deep learning revolution, so these machines can safely explore the policy space without committing itself errors that harm the system or others. The first side of robotics accentuates industrial fields which includes logistics. Traditionally, inventory circulation is one of the most heavily operations involved with handling and checking inventory in the warehouse. Therefore, the use of AI is an effective and automated method in control. One of the most applications for inventory monitoring is Autonomous scanning robot (ASR). ASR roams around warehouse to scan the codes transmitting the information back to the warehouse management system (Foya, 2021).

2.3.4 Decision support system

The decision support system started out as a management branch in the 1970s (Ralph & Sprague, 1980). However, the concept was covering other areas (Zhang & Lu, 2021) and today it is the study of data and models that aims to help in a transition process to the solution of complex problems (Ralph & Sprague, 1980), working as an assistant to experts from different areas from managers to computer scientists (Zhang & Lu, 2021).

Finally, authors Zhang and Lu also point to the Pattern recognition subfield, which they define as the study of how to enable machines with the ability to recognize patterns of human senses such as vision, hearing and speech. Thus, within this study, two other fields of study stand out, respectively, these being computer vision and Speech recognition (Zhang & Lu, 2021).

2.3.5 Computer vision

Computer vision is the given ability to the computer to see, to replace some functions of the human eye (Stanford, 2016). Until now, it mainly used algorithms to identify and analyze images (Sandford, 2016). But it has been the sub-area of AI most transformed by the rise of deep learning. Since 2015 (Zhang & Lu, 2021), new design neural networks made computers capture images or videos in real time and interpret their surroundings, classifying the data. So now, it's the most prominent form of machine perception (Stanford, 2016).

The most widely used computer visions are facial recognition and image recognition (Zhang & Lu, 2021). Other known application is in military field, as drones are replacing human observation and measuring the trajectory for missiles (Yeung, 2020). In logistics, focusing in inventory management, Coca-Cola is a example of a company that implement a technology of AI with visual recognition. The software can learn and recognize, identify, and provide the amount and varieties of bottles stored in the Coca-Cola cooler display unit, checking in onetime the inventory level (Foya, 2021).

2.3.6 Speech recognition

With researchers pursuing a goal of 99% accuracy, it is expected that speaking to computers become increasingly common alongside more traditional forms of human-machine interaction. Meanwhile, Open AI's language prediction model GPT-3 recently produced a stir with its ability to create articles that could pass as being by a human.

Just as computers can analyze images and videos, they can also analyze audio. Thus, with machine-learning systems, speech recognition makes the computer listens and recognizes what people are saying (Stanford, 2016) with an accuracy of almost 95% (Heath, 2021). Daily examples of the application of this intelligence can be found in Siri on the iPhone, to which we ask questions through our voice, also the google translator that can collect our voice and translate it into text to automatically generate a translation is a good example of speech recognition (Yeung, 2020). For example, in inventory management there is software that provides verbal communication between the human operator and automated marketing- selling strategies to improve purchase demands (Soltani, 2021).

2.4 AI Challenges

As we have seen, the advancing of AI is exponential, however, there are still many enigmas ahead regarding its impact on the future of humanity (Williams, 2021), specifically in the labor area. Thus, the importance of dive into how AI is already impacting society and what future trends can be expected in years to come is highlighted (Haenlein & Kaplan, 2019).

For all the benefits it will bring, as more effectiveness in our daily life and the coming wave of automation, runs a significant risk of dislocation to our labor markets and economy (Kaplan, 2016). In this way, the author Williams (2021) highlights some limitations that come from the current use of AI.

First, the author highlights the problem of accessing the necessary date for the development of AI. This is currently under the power of large organizations that without regulation can leverage to create microscopic new companies that unbalance the market (Williams, 2021). Again, related to data, the author also looks at the bias problem. With the use of AI, there are some biases of the markets to consider (Williams, 2021). Although AI does not have in its essence to prejudice (Kaplan & Haenlein, 2018), the process of learning can make an inclination to inequality and end in biased data (Williams, 2021). For example, until recently self-driving cars were better in detecting lighter skin tones than darker ones, due to the type of pictures used to train such algorithms (Kaplan & Haenlein, 2019).

Unemployment is the next problem that Williams talks about, which may arise from the use of AI. Humanity has already faced major changes in the labor market as is the example of the Industrial Revolution from 1820-1840 (Kaplan & Haenlein, 2019). Although at that time, until more recent years, there was time to accommodate employees who were no longer needed in areas such as agriculture, nowadays we are not aware of how quickly and widely the new technologies will facilitate automation of workers' skills (Kaplan, 2016). Williams takes a more negative view of AI robots accomplishing comparative work with a great deal of power, believing it can create a disadvantage for Humans (Williams, 2021). However, Kaplan believes that it may be more useful to think about what are going to be the obsolete skills, a process economists call "de-skilling," in a way to employees focus on the skills robots cannot replace, creating new areas to accommodate those employees (Kaplan, 2016). For example, we don't know if students prefer to be educated by smart machines or by human teachers.

Although AI systems are cheaper than highly paid faculty members, but education can become less personal (Kaplan, 2019). Other small issues are addressed by Williams (2021), but still important. Costs is one of them as equipment, specialized labor work and energy that are expensive sources but very necessary for AI development what can create big disadvantages for more small companies. Complementing, Williams (2021), the author Minh (2020) speaking specifically of AI in industry refers to high initial investment and lack of clear roadmap for investment, since this technology requires complex software and high-performance hardware.

This reality is very hard for a small company to handle (Minh, 2020). Still comparing with the perspective of Williams (2021), when it comes to human resources, which are needed specialized, author Minh (2020) also states that in industrial companies there is an insufficiency of AI brainpower and talent. This is because these types of resources are still rare, despite already growing in the area, and very expensive with the need for training (Minh, 2020).

Other not so big issue is Adversarial Attack related to security faults, as it's easy to trick the data models, adjusting it to deviations in conditions as guard purposes that might put lives in harm's way (Williams, 2021).

Finally, the biggest issue that as to be addressed is the no agreement on Safety, Ethnics, and Privacy. Williams (2021) highlights the lack of limits in the use of AI. There is no regulation about liberties or privileges for these robots. The area of reasoning of AI keeps on being in its developing stages (Williams, 2021). This is verified by other authors like Minh (2020), that states that AI is a powerful instrument to support hackers, making it a weapon to blackmail companies. The authors Hoffmann & Nurski (2021) emphasize this issue as well by verify in their study hat workers are less willing to adopt the technology because of the system's lack of transparency, reinforced by privacy concerns and doubts about data security. Also, in this topic, but reporting to ethics, the authors Forradellas et al. (2021) agree with author Williams (2021) since, despite of all high intensity in the last five years in AI regulatory field by European commission, new regulations do not regulate key issues such as liability or intellectual property or other forms of protection of algorithms (Forradellas et al.,2021).

Taking the limitations into account, all the authors referenced agree on a regulatory basis, that need intervention in the domain of AI, especially when reaching humanized AI. But all the authors find the same problem: there as some specialists who don't see interest in this regulation as it works as a slower pass for the progress of AI (Kaplan, 2016).

Together the authors Kaplan and Haenlein, advocate a middle ground of common norms instead of trying to regulate technology itself (Kaplan & Haenlein, 2019). In other words, covering the relationship and not focusing only on AI, for example, include requirements for testing and transparency of algorithms that also eliminate the need for constant updates in response to technological advances (Kaplan & Haenlein, 2019). But still this proposal cannot avoid deliberate hacking of AI systems, the unwanted use of such systems for micro-targeting based on personality traits, or the generation of fake news (Kaplan, 2016).

However, despite Williams' vision, Kaplan, and Haenlein highlight some of the regulations already made by great world powers, such as the European Union with the introduction of the

General Data Protection Regulation (GDPR) that significantly limits the way in which personal information can be stored and processed (Kaplan & Haenlein, 2019). Unlike China and the United States, there are less barriers for firms to use and explore AI. Inevitably, this will create a large discrepancy as AI develops in each power, and the development of AI will be slowed down in the EU compared with other regions, raising questions of how to balance economic growth and personal privacy concerns (Kaplan & Haenlein, 2019). However, the authors agree with this international regulation as the EU did, like what has been done regarding issues such as money laundering or weapons trade for an economic and social harmony (Kaplan & Haenlein, 2019).

2.5 AI in industrial management

There are several articles that focus on the applicability of artificial intelligence to different areas of industry, including the retailing industry (Costa et al., 2020), the automobile industry (James et al., 2022), medicine (Mesquita, 2017), and even in education (Ara Shaikh et al., 2021). The studies referenced, in addition to explaining the different applications of AI in each sector, have as a common denominator the facilitation of AI in tasks that require decision-making.

Focusing on the business context, where Inventory Management and Warehousing is mostly used, the use of artificial intelligence has increased in the last 20 years, and companies are also taking advantage of its application as it has already started to impact the organizational structure of corporations' world level (Kaplan & Haenlein, 2019). The use of AI is more pronounced in large companies such as Google, Facebook, Bumble, Netflix, Amazon, etc., given its power for investment. However, they are setting an example for smaller companies that aim to increase its production and operations to compete and grow (Kumar & Kalse, 2021). AI can deliver higher quality, greater efficiency, and better outcomes than human experts (Haefner et al., 2021).

In this way, researchers' interest in replacing humans in human organizational operations increases every day (Haefner et al., 2021). Author Kaplan argues that it is not a direct replacement but rather human skills, facilitating the work of other human resources, thus reducing the number of employees needed (Kaplan, 2016). This idea is also defended by the authors Huang and Rust who developed the AI Job Replacement theory, describing it as a model that helps managers and workers decide to equip themselves with the right skills to maintain employability (Huang & Rust, 2020). However, there is still a theory that argues that the jobs that will be replaced by artificial intelligence, in the short term where it is still only possible to apply machine learning, are mechanical jobs. Humans will perform work related to feeling (Haenlein & Kaplan, 2019). This issue raises some concerns about job replacement, given that

74% of Europeans expect that AI will destroy more jobs than it creates, and 44% of workers think their current job could at least partly be done by a robot or AI (Hoffmann & Nurski, 2021).

Considering AI's potential to take on traditional 'human' tasks in organizations, dynamizing the most important processes affecting the firm's long-term survival and competitive advantage – innovation – it’s essential (Haefner et al., 2021). Thus, Artificial intelligence today can analyze all the activities performed by studying organization and consumers behavior and computing possibilities through an algorithm and can manage demand–supply (Pallathadka et al., 2021).

Considering the current context of high competitiveness, industrial management is one of the areas that shows the greatest application of AI in its operations, as a vehicle for business success (Min, 2010). The introduction of applications such as Big Data, and the industrial Internet of Things Technologies, revolutionized the industry and companies entered the 4.0 revolution (Chehri et al., 2021). The main objective of companies in the industry that focus on provision of services based on consumption of resources is to fundamentally increase quality customer service (Sergienko & Kraynik, 2021). However, to guarantee the efficiency of the processes, it is necessary that the consumed resources are rationed (Sergienko & Kraynik, 2021). Thus, in industry 4.0, the use of intelligent systems allows interconnected operations to achieve a qualitatively different, higher level of indicators of economic activity of the enterprise (Sergienko & Kraynik, 2021). For example, companies like Kodak, started by analyzing their operations to make them more efficient, thus analyzing the thinking processes of experienced order pickers they developed a rule-based expert system to select the optimal order-picking path in a warehouse (Min, 2010).

Also, demand forecasting models were conceived through information exchange among multiple SC partners and learn from the past forecasting experience (Min, 2010). As illustrated in these examples, expert systems and agent-based systems are useful sub-fields of AI tools that restructure a company's logistical operations (e.g., warehousing, joint demand planning, inventory control) (Min, 2010).

However, despite the current context of industry 4.0, defined by the authors Trappey et al. (2016) as a *general concept enabling manufacturing with the elements of tactical intelligence using techniques and technologies such as Internet of things, cloud computing and big data*, for many companies this approach seems too rigid or difficult to apply in SMEs due to a lack of expertise and leadership (Buchenkova et al., 2021). Complementing this idea, the authors Hoffmann & Nurski (2021) point that lowering the levels of formality, as well increasing worker data literacy are both essential to make AI more useful in employees’ day-to-day work, and consequently increasing technology acceptance and stimulate innovation. Furthermore, similarly, the authors Abonamah et al. (2021) point top-down leadership model that sets up clear AI goals, to engage their employees by energizing them to drive through the AI journey.

Specifically in the areas related to logistics and supply chain, this reality still stands out with more evidence, as it requires the comprehension of complex (Hoffmann & Nurski, 2021), interrelated decision-making processes and the creation of intelligent knowledge where AI's potential applications could be crucial to joint problem-solving of the company, increasing work efficiency (Soltani,2021) and consequently, increasing profit margin (Buchenkova et al., 2021).

Chapter III – Inventory management and Warehousing

3.1 Inventory Management and Warehousing Concept

To advance the existing literature on Inventory Management and Warehousing, it is necessary to clarify the two concepts that serve as the basis for the application of artificial intelligence in this study.

In the industrial management area, the logistics component stands out due to its importance for the correct management of operations. Considering the current context portrayed in the previous topic, competitiveness requires that logistical operations within companies be interconnected. Two of the largest logistics operations in a provision of services company based on consumption of resources is inventory management and warehousing (Sergienko & Krasnik, 2021). These are essential for successful operations.

Inventory management, according to the authors Singh and Verma (2017) is defined as "the continuing process of planning, organizing and controlling inventory that aims to reduce the investment in inventory while balancing supply and demand". The authors Teerasoponponga and Sopadang (2022) add that inventory management involves replenishing, stocking, tracking, and prioritizing inventories. The goal is to determine the correct replenishment policy (i.e., time and quantity to order) that satisfies the cost and service level ratio. Later, Warehouse management is the step in the supply chain process that manages storage. The main tasks of this logistical activity are to ensure the accuracy of the inventory quantity while the accurate counting the quantity of goods, providing accurate information data for management decisions and analysis. Also, the correct storage of the products is a purpose of this activity. To do inventory exit serval ways, the most common way of inventory is periodic inventory. The time interval can be divided by day, month, quarter and year, and the choice of the specific time depends on the specific situation of each company (Singh & Verma, 2018).

Taking in account the importance of these two steps of the supply chain, improvements in their strategies have attracted increasing attention by numerous researchers (Sergienko & Krasnik, 2021). Improving inventory and warehousing management decisions could help to increase the performance of enterprises' operations (Singh & Verma, 2018).

After explaining the concepts underlying this study, the functions of each logistical activity addressed will be detailed, as well as prospects for the interconnection of both.

3.1.1 Inventory management

Inventory is the main variable in inventory management, representing one of the most important assets of a business. As previously mentioned, since the mid-1990s, there has been a large increase in annual number of inventory management articles, with the aim of improving processes; ensure efficient, effective, forward reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption to meet customer's requirements (Singh & Verma, 2018). Initially, researchers pointed to traditional inventory control models and approaches to reduce the quantity of inventory that warehouse must have, which refers to reducing the safety of stock by centralization of warehouse locations (Singh & Verma, 2018).

Currently, in general, the process at the level of inventory management operations is a supervision of the supply, storage, and accessibility of items to ensure an adequate supply without excessive oversupply. In other words, simple as old commerce, itself-seeking goods, buying them, storing them, and distributing them (Song et al., 2021). At the strategic level, the objective of manufacturing and non-manufacturing operations meets the needs of their customers. Another aspect to consider in inventory management is the space occupied and the capital tied up. Therefore, inventory planning is essential to minimize the total inventory ordering, holding, and shortage costs. Topics that cover these issues include single-stage or multistage inventory planning and static or dynamic optimal inventory control (Song et al., 2020). To complement the process in this area, which is dynamized in most companies, both at the operations and at the strategic level, the literature today points to important new themes to be highlighted.

Carrying out stock to increase customer response speed is a common practice, but currently the literature points to fixed lifetime items as products that should be discarded. (Singh & Verma, 2017). And finally, the improvement of operations through the application of intelligent systems that have been developed to collect and transmit data about the state of a product (Singh &Verma, 2017). The authors Teerasoponponga & Sopadang (2022) accurate forecasting also plays an essential role in retail operations, reaffirming the idea of lack of a good forecasting system can lead to lost sales or excess inventory, which imposes extra costs on the firm (Teerasoponpong & Sopadang, 2022). Although traditional forecasting methods prevail, in the study by the authors causal methods by AI, they are proven to be more accurate and precise (Teerasoponponga & Sopadang, 2022).

3.1.2 Warehouse management

Warehousing is one function in the logistics process that depends on different variables of the company: type of sales channels (e-commerce, retail, indirect channels, omni-channels), from different production philosophies (e.g., lean or agile), different managerial perspectives (e.g., economic efficiency, green performance and social responsibility), and the choice between old and new technologies [e.g., bar coding, different degrees of automation, decentralized control, cyber-physical systems, voice picking, warehouse management systems (WMS) , etc.]. These different demands impose challenges and opportunities for the warehousing operations. Despite the traditional forecasting methods prevail, in the study of causal methods by AI are proven to be more accurate and precise (Teerasoponponga & Sopadang, 2022). So, in warehousing there are different aspects to consider like warehouse design, operation and performance evaluation, Human resource management, Technology and equipment, Performance evaluation, Storage and picking (Davarzani & Norrman, 2015).

Regarding Infrastructure design, according to the authors' study, space organization has a great impact on operations. Typically, the increase in sales volume causes an issue of lack of space for which the study concludes that by right type of shelving and storage equipment can be resolved. This change can decrease overhead expense and increase the productivity.

Another important aspect in warehousing is the organization of the operational strategy. Considering the continued growth of Global competition, this factor becomes quite relevant. To keep up with this constant competition, companies must move towards more customized demands, order consolidation and big fluctuation in demand. Additionally, the study concludes that it is necessary to pay attention to the direction of sales for e-commerce, warning that operations must also be adapted to this growing reality (Davarzani & Norrman, 2015)

Human resources are also a fundamental component of these logistical operations, and the study points out that the repetitive work of picking during a whole day influence workers and can negatively affect their performance. Training and motivation can be a solution, but the introduction of AI systems can solve the tasks that do not need as much human intervention (Davarzani & Norrman, 2015).

Following the context of the last aspect discussed, Technology and equipment can intervene in improper shelving and inflexible equipment, increasing the efficiency of operations. However, the more automated a warehouse becomes, the more inflexible it can become for employees to use it (Davarzani & Norrman, 2015) Thus, the study underlines the importance of a balance between automation and flexibility in the handling of intelligent systems. This balance can usually require large investments, and that is why some studies such as Szedlak et al. (2020.) state that small and medium-sized companies do not adhere to intelligent systems in their logistics operations. Another application of AI may be in the accuracy of information on inventory and storage location, which can potentially reduce discrepancies (Davarzani & Norrman, 2015). Performance is also a detail to be considered in the inventory management for the company to obtain which characteristics of its operations have to be improved to maintain the desired performance (Davarzani & Norrman, 2015)

As for storage, in inventory management, the correct allocation and re-allocation of their items is necessary. Considering dead items (obsolete SKUs) and fast movers must have their own places to facilitate their movements. Thus, the study concludes that appropriate classification of the goods and storage location assignment play critical roles in warehouse operation cost (Davarzani & Norrman, 2015)

Finally, in the tasks related to Picking, which is considered in the study as the most cost-driving activity in warehouses, it is important to optimize the process to be smooth and cost-efficient (Davarzani & Norrman, 2015)

3.1.3 Collaborative models

Another trend addressed in the literature is the integration of different logistic operations in the supply chain. Bearing in mind that the study in question only focuses on the two main activities of companies in the industrial parts retail sector, the main advances in the study of the integration of these two logistics activities will be reported.

The objective of integrating these logistical operations is to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantity, to the right locations, and at the right time, always minimizing costs (Singh & Verma, 2017). The sharing of information between departments plays a significant role in planning, and in the case of inventory and warehousing, the fact that there is accurate information about the inventory allows for better purchases and, consequently, more suitable stock.

3.2 Inventory management and Warehousing with AI systems and their impacts

As mentioned earlier, industry 4.0 is the new path for companies in various existing industries (Minh, 2020). This revolution results from the use of AI in its operations, which is seen as a competitive advantage (Minh, 2020). This use has been studied by numerous researchers in the field of logistics, namely by Kaplan and Hoenlein (2019). The results demonstrate that more research is needed in this field (Soltani, 2021).

However, from the existing studies, it is possible to highlight the use of the Internet of Things (IOT), which leads us to the concept of smart logistics. This concept opens the door to a new logistical era, which changed both inventory management and warehousing by promoting the informatization and standardization of logistics networks, enabling information sharing and interconnected communication (Wang, 2021). The application of intelligence systems has a big impact on the core competitiveness of logistics enterprises (Wang, 2021). For example, according to the China Logistics Data Information Center, China's total social logistics reached 229.7 trillion yuan in 2016 and 252.8 trillion yuan in 2017, expressing a 10.53% that indicates the development of the logistics system (Wang, 2021).

However, author Wang also points out the disadvantages of this use, namely incomplete policies for Smart Logistics Industry. This is also pointed out by authors Forradellas et al. (2021), alerting to the fact that 55% of companies overestimate the maturity of their responsible artificial intelligence initiatives, may question issues such as justice and equity, mitigation of social and environmental impact, and human or ethical AI. In addition to this disadvantage, the author also highlights the lack of talent to deal with smart logistics technologies (Wang, 2021). This disadvantage is also underlined by the author Minh (2020), that says companies still have a problem of inadequate expert knowledge of staff. This happens because the demand for machine learning skills moves quickly and companies have a hard time to find well-trained staff, adding the fact that it requires big investment in human resources (Minh, 2020).

According to the authors Niranjan et al. (2021) this lack of knowledge translates into difficulties in implementing intelligent system, in companies with this type of human resources, as AI is esoteric and difficult to comprehend. The last disadvantage pointed by the author is related to Decentralized Management (Wang, 2021). The problem of changing the centrality of operations that can be a complicated process for companies that have to get used to a more comprehensive and globally managed operating environment (Wang, 2021).

Finally, author Wang also opinions out the aspect that smaller companies or those with operations in rural areas can be harmed by the lack of monetary power or lack of access to information, necessary to adapt to smart logistics (Wang, 2021). This perspective is complemented the author Minh (2020), referenced earlier, that states that small companies, for lack of resources, are often not able to meet the high prices that AI's complex software and high-performance hardware require. Furthermore, Rana et al. (2021) warn that lack of resources can result in poor data quality in which the outputs of the whole system will be inappropriate, leading to a suboptimal business decision, and consequently putting the firm at risk.

Another important topic in terms of the impacts of AI on the industry is raised by authors Dubey & Singhal (2021) that state that the use of IoT devices helps to keep assets and information secure by preventing theft. This IoT is translated into video surveillance cameras with Remote sensing and alarming system that allows control of warehouse security anywhere at any time (Dubey & Singhal, 2021). In opposition, the author Minh (2020) raises issues of security constraints on the part of AI, seeing intelligent systems as potential weapons of blackmail by hackers. For example, they can force the company to produce and reserve the inventory, without paying anything to the company (Minh, 2020).

The authors Teerasoponponga and Sopadang (2021) also raise important insights regarding the impact of AI on the industry. They main idea emphasized is the use of the AI as a decision support system for decision making in inventory management and storage (Teerasoponponga & Sopadang, 2021). Also reinforcing this idea, Pallathadka et al. (2021) argue that in inventory management and storage, algorithms are the most used method by companies, as they allow predicting future sales and maintain inventory, accordingly, as well optimizing storage strategy. This method allows better decisions by industrial managers (Pallathadka et al., 2021). In the same point of view, the authors also advocate the use of DSS to improve prediction performance and optimization time (Pallathadka et al., 2021). Foya (2021) is other author that underlines the realizations of the authors Teerasoponponga and Sopadang (2021) and Pallathadka et al. (2021). The author advocates that the development of new AI technology is used to perform tasks accurately (Foya, 2021).

In this way, by implementing AI to their businesses improves performance by removing errors that were caused by manual operations (Foya, 2021). This happens thought the use of accurate data, allowing accurate sales forecasting (Sohrabpour, 2021); improved productivity because of minimum error occurrence, and moreover, employees enhance their performance and accuracy decisions (Foya, 2021). Consequently, this use of AI culminates in the minimization of costs and assurance of customer satisfaction (Foya, 2021).

In a broader perspective, but complementary to that of the authors Teerasoponponga and Sopadang, the author Soltani (2021) describes other several applications of AI in inventory management, like the use of AI translated into computer vision in an experimental system with a camera-equipped robot that can check the stock inventory shelf by shelf. This author also highlights the use of chatbots to obtain immediate information in the field of commodity, stock inventory, stocking costs, and other affairs of purchase, allowing the obtainment of predictive analysis of demand forecasts in uncertainty markets (Soltani, 2021). This is a clear example of how to improve employee motivation through AI, using their skills more usefully and leaving simpler tasks for intelligent systems, meeting the idea of the before mentioned author Davarzani & Norrman (2015). These last authors meet all the benefits mentioned, highlighting the optimization of the storage strategy, by exploring these dynamics of goods in the warehouse to identify key factors of decision making on storage policy; Cargo location layout, developing models to connect operations requirements and goods characteristics to warehouse design and finally warehousing workflow, by understanding the connection of warehouse and other departments (Davarzani & Norrman, 2015).

However, despite all the latest benefits presented by the authors, there are other studies such as Niranjan et al. (2021) and Minh (2020) that call attention to Technical problems, since technology is not perfect and for example, forecasting sales in the wrong way can lead to bad purchasing (Minh, 2020) and also for dependence, since the data gets bigger, it is harder to use traditional methods to accurately analyze it (Niranjan et al., 2021).

In conclusion, through the applications of the already mentioned studies, AI in inventory and warehouse management is evolving, supporting decision-making in industrial management (Teerasoponponga & Sopadang, 2021). This application of intelligent systems in logistics activities is a great example of how tasks can be carried out with great efficiency and effectiveness, improving the organization's performance (Minh, 2020). This makes faster and more complete inventory and warehouse operations possible today (Foya, 2021). However, it is necessary to consider the disadvantages that AI entails, with special attention to safety (Foya, 2021) and the need to regulate it (Forradellas et al., 2021) in its application in the logistics areas addressed.

Chapter IV – Theoretical approach

The approach taken in this investigation, in chapters II and III, to the different perspectives of the various authors who discuss the themes of artificial intelligence, inventory management and warehousing, allowed to reach some gaps in the literature that interconnect the areas addressed. Thus, the research questions of the present project emerged, which will be debated throughout this chapter.

The first question was outlined to understand the impact of the application of intelligent systems on inventory management and warehousing. For this purpose, four variables were analyzed, namely the benefits, characteristics, trust, and risks.

Regarding benefits, the fourth revolution in industry continues to be spurred on by the application of AI (Soltani, 2021). Companies see the automation of their operations as a competitive advantage to remain at the forefront of the competition increasingly felt with the evolution of times. Thus, despite the difficulties experienced by small and medium-sized companies in implementing AI, evaluating the benefits that accrue from the application of intelligent systems in organizations allows to understand the gaps in operations that can be filled by the presence of more automation in the organizational environment, and then achieve more efficient performances with greater monetary return (Chehri et al., 2021). The authors considered for this study point serval benefits in applying AI to this logistics areas. The author Foya (2021) talk about data accuracy, improvement of productivity, quick decision-making and consistently assurance of customer satisfaction when applying AI to inventory management.

Also, the author Sohrabpour (2021) indicates that the abundance of data also simplifies the more accurate forecasting, advising that Inaccurate or lack of forecasting in a firm can lead to poor inventory and material flow management, loss of sales or excess of products and customer dissatisfaction. Finally, the authors Davarzani & Norrman (2015) mention optimization of storage strategy, better cargo location, better warehousing workflow and mobilization of the enthusiasm of employees as strong benefits arising from implementing AI in inventory management and warehousing.

It is also important to highlight the study by authors Hoffmann and Nurski (2021) who talk about trust in companies in the implementation of intelligent systems in companies. The authors explain that one of the main reasons for the existing apprehension of the use of AI in inventory management and warehousing is the fear of job replacement, that is, intelligent machines reduce the need for labor, meaning layoffs. The authors also highlight the lack of knowledge in handling AI applications, which leads to distrust in the application of these tools.

Another study that also mentions a factor that can impact confidence in the implementation of artificial intelligence in stock and storage management is the work of the author Soltani (2021), who refers to the efficiency at work that these systems provide. This author points out that implementing Bot, AI-equipped purchase, and integrating it with database for immediate better access to information reduced inefficiency in stock management operations. Complementarily, the authors Abonamah et al. (2021) proposes an artificial intelligence-based organizational framework to gain value-added elements, pointing out the global involvement of employees as an impacting factor in the logistical areas relevant to this study. These authors point to the concept of AI leadership capability driven using AI in logistical operations, which translates into a top-down leadership model that occurs by setting up clear AI goals, then engaging their employees by energizing them to drive through the AI journey (Abonamah et al., 2021).

Finally, for the last hypothesis associated with this research question, the study by Minh (2020) will be addressed. When addressing the impact of IoT on logistical operations such as inventory management and warehousing, the study on organizations concluded that Lack of environmental knowledge is one of the risks associated with applying AI in these operations (Minh, 2020).

The authors Niranjan et al. (2021) complements this risk, revealing that subsequent dependence on intelligent systems to manage this type of operations that can also become a threat to the efficiency of the operations in question. Also, Rana et al. (2021), address the issue of poor data quality that can result in incorrect decisions and competitive disadvantages, becoming a risk in the implementation of intelligent systems in the logistical areas of stock and storage management. Wang (2021), also looking at the risks of this theme, presents the concept of Decentralized Management, resulting from the globalization of information that translates into a collective development industry interconnected with each other, which, when not provided with good communication, can result in a risk for the company.

Based on the reading of the studies of the various authors presented, the first research question was outlined:

Q1 – What are the main benefits, reliability, and risks of AI that influence the possibility of implementing intelligent systems in inventory management and warehousing?

In sum, this first research question was based on the conclusions of the pointed authors, with emphasis on the authors Chehri et al. (2021) who argue that intelligent systems applied in different industries assume the position of support in decision-making and in improving the efficiency of their operations. However, Forradellas et al. (2021) warn for the associated risks by pointing out that one of the solutions is regulation of the application of intelligent systems.

Not only this limitation was pointed out, but also the lack of knowledge and fear of job replacement on the part of human operators. Thus, considering the importance of the correct application of AI for efficient operations, to assess the current use of AI in companies, the second research question emerged:

Q2 – What is the use and investment in AI systems in industrial companies?

The second research question begins the phase after analyzing the possibility of implementing AI in logistical operations of stock management and storage. In this second phase, where the objective is to complement the possibility of implementation, it is intended to understand the impact of the application of AI in the logistical areas addressed. In the first instance, in this research question, the objective is to understand the use of AI in industrial companies. This issue was raised through the information provided by the authors Teerasoponponga and Sopadang (2021) from their statement of use of intelligent systems in logistics operations as complex decision tools in sourcing and inventory management due to uncertainties and their limited resources and data.

So, although authors (Chehri et al., 2021) affirm the increase of productivity by companies when applying intelligent systems in these two types of logistic operations (Inventory Management and Warehousing), Teerasoponga and Sopadang (2021) highlight the lack of application of small and medium-sized companies, and hence the need to also understand the level of use and investment of AI in companies' operations (Q2).

Q3 – What type of AI is most used in Inventory Management and Warehousing? What impacts might it have on the organization's performance?

In the third research question at an early stage, the objective is to understand which main intelligent systems are used in Inventory Management and Warehousing logistics operations, and, in a second phase, to discover the impact of these applications on the organization's performance.

Kaplan and Hoenlein (2019) address in their study the different types of artificial intelligence used by companies, these three being: Analytical AI, Human-Inspired AI and Humanized AI. In their corporate approach to AI, these authors state that AI has already started to impact every single element of a firm's value chain, and the transformation of service industries is already felt. Soltani (2021), as previously mentioned, views AI primarily as a decision support system that favors better corporate decisions. This statement is reflected in the study by author Wang (2021), who concludes Intelligence and the Internet of tings by enabling visual information technology, intelligent robot operation, vehicle scheduling, and cargo traceability allow smart logistics based on more assertive cooperative choices. Dubey & Singhal (2021) also highlight examples of more IoT technologies used by companies in their logistics operations, such as global positioning system (GPS), read-frequency identification (RFID), Wi-Fi, quick response (QR) codes, etc. These are considered an efficient way of not only minimizing the operating cost, but also increasing the speed of response and implementing the competitiveness of enterprises.

Q4 - Where could AI impact in terms of operational improvement in the areas of Inventory Management and Warehousing?

According to authors such as Wang (2021), Soltani (2021) and Forradellas et. Al. (2021) application of intelligent systems have a great impact on logistics activities, as it was shown that tasks can be carried out with great efficiency and effectiveness, improving the organization's performance.

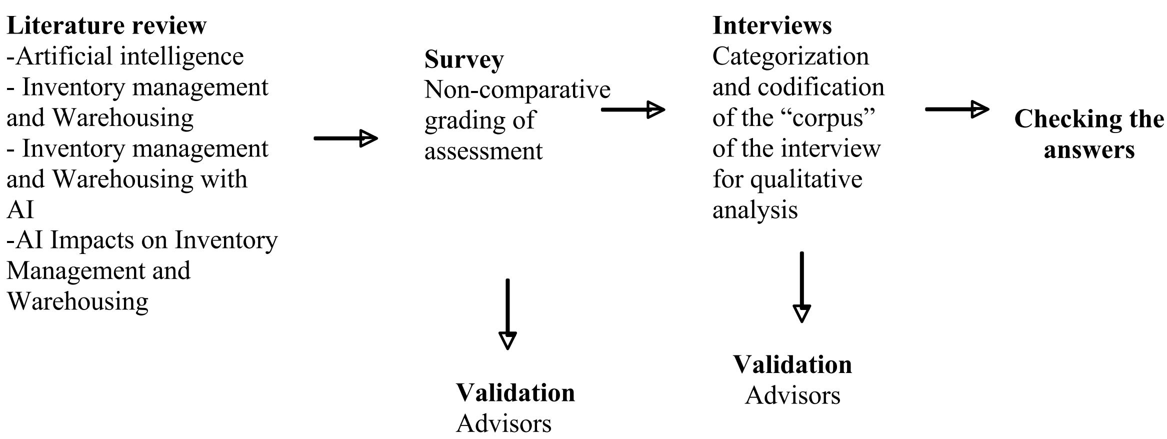
For example, the authors Teerasoponga and Sopadang (2021) claim that intelligent systems in logistics operations in food companies provide decision support solutions, integrating the selection of recommended suppliers and optimal order quantities shaping their inventory management policies in a good way. Additionally, Dubey & Singhal (2021) say that software systems used in logistics (logistics information system, warehouse system, time management system, operation, customer relationship management, and supply chain management) have maximum effects if high-quality information on the current state of objects on a network. Finally, another important example of impact given by the authors Davarzani & Norrman (2015) states that AI in storage helps workers realize products that they were not even aware of, and, also, in layout design for product accommodation, AI helps planning space, solving this most common warehouse problem.

In this way, the last question comes from Q3 since after obtaining knowledge about the type of AI and its impact on the analyzed logistics operations, it is important to obtain real clarification on the impact of intelligent applications by industrial managers. That is, to get a reliable opinion on what type of AI could be applied to solve problems in Inventory Management and Warehousing logistics operations, as well as how the identified IS could be technically executed.

Chapter V – Methodology

The figure below (fig.1) shows the steps taken during this thesis. In a first phase, a literature review was carried out, followed by fieldwork, which included the questionnaire and interviews. As described above, the basis of these two instruments were research questions. To the collected data, a quantitative analysis was applied to the results of the questionnaire and a qualitative analysis to the results of the applied interviews.

Figure 1 Research model



Source: Author's elaboration

In the following table, a synthesis was made that interconnects the objectives of the study and the respective research questions, literature review and methodology for analyzing the data collected.

Table 2 Relation between literature review, objectives, research questions and methodology

Study Objective	Research Questions	Literature review	Methodology	Questions in Surveys
OBJ 1 – Understand the factors that influence the possibility of applying intelligent systems in Inventory Management and Warehousing	(Q1). What are the main benefits, confidence and risks of AI that influence the possibility of implementing intelligent systems in Inventory Management and Warehousing?	(Foya, 2021) (Davarzani & Norrman, 2015) (Pallathadka et al. 2021) (Hoffmann & Nursk, 2021) (Abonamah et al., 2021) (Minh, 2020) (Niranjan et al., 2021) (Rana et al., 2021) (Wang, 2021) (Soltani, 2021) (Minh, 2020)	Quantitative approach - SmartPLS	Section 2, Section 3, section 4 and section 5 of the questionnaire
OBJ 2 - Understand the Impact of AI on Inventory Management and Warehousing	(Q2). What is the use and investment in AI systems in industrial companies?	(Teerasoponponga and Sopadang, 2021) (Chehri et al., 2021)	Qualitative approach – Interviews with MAXQDA 200.1 software	Interview script
	(Q3). What type of AI is most used in Inventory Management and Warehousing?	(Kaplan and Hoenlein, 2019) (Soltani, 2021) (Wang, 2021) (Dubey & Singhal, 2021)	Qualitative approach – Interviews with MAXQDA 200.1 software	Interview script
	(Q4). Where could AI impact in terms of operational improvement in the areas of Inventory Management and Warehousing?	(Wang, 2021) (Forradellas et al., 2021) (Dubey & Singhal, 2021) (Teerasoponponga and Sopadang, 2021) (Soltani, 2021) (Davarzani & Norrman, 2015)	Qualitative approach – Interviews with MAXQDA 200.1 software	Interview script

Source: Author's elaboration

5.1 Research model

Since the present study has two objectives (Table 2), it was decided to carry out two methodologies for each of the objectives.

For the first objective, questionnaires were chosen since the purpose is to understand factors that affect the application of AI on logistics area, a more generalizable facts about a topic (Streefkerk, 2019). In this type of methodology, the results are more direct since the applied questions are closed and the results are more easily analyzed and interpreted (Goundar, 2012). To compensate for the lack of the presence of a moderator and guarantee the veracity of the respondents' opinion, there are control questions in the structure of the applied questionnaire. In addition to this aspect, to define social clusters (such as gender, age, educational qualifications, work area and professional experience) there are also identification questions (Goundar, 2012). Jones et al. (2013) state that this is the best method to gather large amounts of information and have the availability of validated models, in addition to being an economic solution. However, authors Kelly et al. (2003) alert to the low response rate, and the author Ball (2019) to the lack of a representative sample because respondents have the same interests and similar perspectives.

In contrast, for the second objective of the study, interviews were designed, since we want to understand the actual impact of the AI on Inventory Management and Warehousing, a more real experience perspective of managers. The interview, according to Check & Schutt (2012) are defined as "the collection of information from a sample of individuals through their responses to questions". Goundar (2012) states that the moderator method is the best to collect more sincere and complex answers when the unit of analysis is people, resulting in data with richer content.

5.1.1 Quantitative Analysis

Regarding the questionnaire, it is based on the literature review carried out and built in the Google forms tool. After validation by the advisors, it was launched online and a link to it was generated. The link was published on the *linkedin* platform and through contact via email.

The structure of the questionnaire was designed in 6 sections. The first section was designed to select respondents, so that only people linked to industrial management and AI responded to the survey. The intermediate sections were structured to respond to the first objective, and for these the Likert response method with five levels (the extremes signify opposite positions) was used. Finally, the sixth section used the multiple answer method to create social clusters, where each of the respondents is inserted.

Respondents answered the questionnaire between the 20^{h} December and the 30th ^{of} December, and 107 responses were collected. These collected data were transformed into Excel format and transferred to the SmartPLS 3 software. This program aims to formulate a structural equation model (Structural Equations Modeling or SEM), which translates into a map of structural coefficients that measure and analyze the relationships of observed and latent variables. The use of these models has covered several areas of study, ranging from psychology and communication studies to international business and marketing, and its applicability made this method the most attractive for researchers to carry out analytical analyzes (Davvetas et al., 2020). In addition to its intrusion in a multitude of studies, the facility to explain and predict the behavior of individuals, groups and organizations contributed to its popularity (Tarka, 2018).

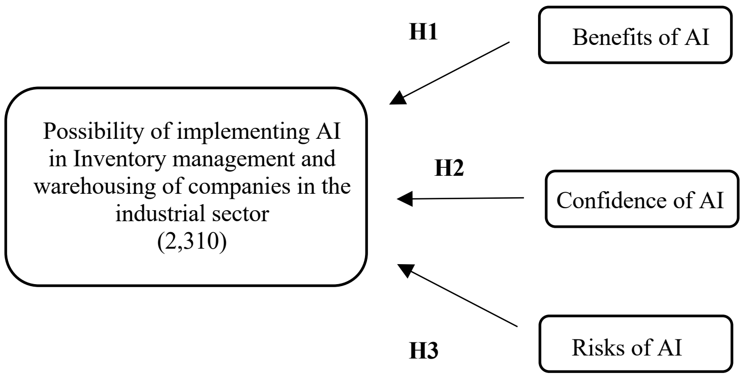
The analysis of the relationships between the variables, through this model, involves not only analyzing the existence of the relationship itself, but also the type of effect that the variables have on each other, for example, perceiving cause-effect relationships and the level of effect between the independent variables on the dependent one (Tarka, 2018). Additionally, the author Suhr (2006) reinforces the idea of analysis of the type of relationship stating that SEM allows researchers to recognize the imperfect nature of their measures. According to authors Kenneth Bollen and Noble (2011), SEM are characterized by including two or more equations in their model with several explanatory variables in each equation, allowing to correlate with each other.

The analysis process using an SME model begins with assessing the covariance structure of variables through confirmatory factor analysis. Next, definition of measure scales to assess the validity, reliability, and predictability of such scales. Finally, the model, by allowing simultaneously estimate more complex model structures that involves variables operating simultaneously as both causes and outcomes of other variables in the model, enables the estimation of both direct and indirect effects among a set of variables of interest (Davvetas et al, 2020). Applying a SME model to the study in question, initially, to test the conceptual model, the structural equation modeling technique based on variance - partial least squares (LPS) - was applied. Subsequently, the next phase was the analysis and interpretation of data which was carried out in two phases. A first phase that assessed the reliability and validity of the measurement model and a second phase that analyzed the structural model.

To build the conceptual model to respond to the first objective of the study, Figure 2 and Table 3 were developed, considering the hypotheses represented.

H1 – The benefits of AI in Inventory Management and Warehousing that positively impact the possibility of implementing these systems in Inventory Management and Warehousing -, H2 – Confidence in implementing AI in Inventory Management and Warehousing that positively impact the possibility of implementing these systems in Inventory Management and Warehousing; H3 – The inherent risks of AI in Inventory Management and Warehousing that impact negatively the possibility of implementing these systems in Inventory Management and Warehousing

Figure 2 Conceptual model and hypotheses to be tested with Smart PLS



- Data accuracy is a strong benefit for implementing AI in Inventory management and warehousing (Foya, 2021)
- Accurate Sales forecasting is a strong benefit for implementing AI in Inventory management and warehousing (Sohrabpour, 2021)
- Improved productivity is a strong benefit for implementing AI in Inventory management and warehousing (Foya, 2021)
- Quick decision-making is a strong benefit for implementing AI in Inventory management and warehousing (Foya, 2021)
- Optimize storage strategy is a strong benefit for implementing AI in Inventory management and warehousing (Davarzani & Norrman, 2015)
- Cargo location layout is a strong benefit for implementing AI in Inventory management and warehousing (Davarzani & Norrman, 2015)
- Warehousing workflow is a strong benefit for implementing AI in Inventory management and warehousing (Davarzani & Norrman, 2015)
- Mobilizes the enthusiasm of employees is a strong benefit for implementing AI in Inventory management and warehousing (Davarzani & Norrman, 2015)
- Minimizes costs is a strong benefit for implementing AI in Inventory management and warehousing (Foya, 2021)
- Ensures customer satisfaction is a strong benefit for implementing AI in Inventory management and warehousing (Foya, 2021)

- Job replacement using AI is a confidence factor in implementing AI in Inventory management and warehousing (Hoffmann & Nurski, 2021)
- Specific knowledge using AI is a confidence factor in the implementation of AI in Inventory management and warehousing (Hoffmann & Nurski, 2021)
- Work efficiency using AI is a confidence factor in the implementation of AI in Inventory management and warehousing (Soltani,2021)
- Global employee involvement using AI is a confidence factor in implementing AI in Inventory management and warehousing (Abonamah et al., 2021)

- Lack of environmental knowledge is a major risk of AI in Inventory management and warehousing (Minh, 2020)
- Lack of resources is a major risk of AI in Inventory management and warehousing (Minh, 2020)
- Dependence is a major risk of AI in Inventory management and warehousing (Niranjan et al., 2021)
- Poor data quality is a major risk of AI in Inventory management and warehousing (Rana et al., 2021)
- Decentralized Management is a major risk of AI in Inventory management and warehousing (Wang, 2021)

Source: Author's elaboration

Possibility to implement AI in Inventory management and warehousing

Table 3 Relationship between conceptual model variables and questionnaire questions

Variable Dependent		Questionnaire Question (answers 1 to 7)
Possibility of implementing AI in Inventory management and warehousing		There is a possibility to apply AI in Inventory management and warehousing
		I see value in implementing AI in Inventory management and warehousing
Variable independent	**Indicator**	**Questionnaire Question (answers 1 to 7)**
Key Benefits of Implementing AI in Inventory Management and warehousing	Data accuracy	Data accuracy is a strong benefit for implementing AI in Inventory management and warehousing
	Accurate Sales forecasting	Accurate Sales forecasting is a strong benefit for implementing AI in Inventory management and warehousing
	Improves productivity	Improved productivity is a strong benefit for implementing AI in Inventory management and warehousing
	Quick decision-making,	Quick decision-making is a strong benefit for implementing AI in Inventory management and warehousing
	Optimize storage strategy	Optimize storage strategy is a strong benefit for implementing AI in Inventory management and warehousing
	Cargo location layout	Cargo location layout is a strong benefit for implementing AI in Inventory management and warehousing
	Warehousing workflow	Warehousing workflow is a strong benefit for implementing AI in Inventory management and warehousing
	Mobilizes the enthusiasm of employees	Mobilizes the enthusiasm of employees is a strong benefit for implementing AI in Inventory management and warehousing
	Minimizes costs	Minimizes costs is a strong benefit for implementing AI in Inventory management and warehousing
	Ensures customer satisfaction	Ensures customer satisfaction is a strong benefit for implementing AI in Inventory management and warehousing
Confidence in AI in Inventory Management and warehousing	Job replacement	Job replacement using AI is a confidence factor in implementing AI in Inventory management and warehousing
	Specific knowledge	Specific knowledge for the use of AI is a confidence factor in the implementation of AI in Inventory management and warehousing
	Work efficiency	Work efficiency using AI is a confidence factor in the implementation of AI in Inventory management and warehousing
	Global employee involvement	Global employee involvement using AI is a confidence factor in implementing AI in Inventory management and warehousing

Variable independent	**Indicator**	**Questionnaire Question (answers 1 to 7)**
Greater AI Risks in Inventory Management and warehousing	Lack of environmental knowledge	Lack of environmental knowledge is a major risk of AI in Inventory management and warehousing
	Lack of resources	Lack of resources is a major risk of AI in Inventory management and warehousing
	Difficulty of implementation	Implementation difficulty is a major risk of AI in Inventory management and warehousing
	Poor data quality	Poor data quality is a major risk of AI in Inventory management and warehousing
	Decentralized Management	Decentralized Management is a major risk of AI in Inventory management and warehousing

Source: Author's elaboration

5.1.2 Sample Description

The sample obtained for this analysis comprises 107 respondents. Preliminarily, the analysis aims to obtain the necessary data to draw theoretical and empirical conclusions. Then, the objective of the analysis was oriented towards the characterization of the sample to understand its origin and dimension of professional knowledge and experience (Prodanov & Freitas, 2013). In this way, variables such as the area of work, gender, age group, level of education and years of professional experience were analyzed.

Of the 106 respondents, according to table 4, 19 respondents (17.8%) work directly with AI, 35 respondents (32.7%) work in Industrial Management, 17 respondents (15.9%) work in stock and warehouse Management and 36 respondents (33.6%) work in two of the areas. Regarding gender, 86 (80.4%) of the respondents are male and 19 (17.8%) are female. 2 respondents (1.8%) preferred not to mention their gender.

About age group, 21 respondents (19.6%) are between 18 and 25 years old, 34 respondents (31.8%) are between 26 and 35 years old, 26 (24.3%) between 36 and 45 years of age, 26 (21.5%), between 56 and 65 years of age and 3 (2.8%) are over 65 years of age. In the present study, no response was obtained from respondents under 18 years of age.

Regarding the level of training, 32 respondents (29.9%) have completed secondary education, 32 (29.9%) have a degree and 15 (14%) respondents do not. 23 respondents (21.5%) have a master's degree and 5 (4.7%) a doctorate. In the present study, no response was obtained from respondents with an education level below secondary education (basic education).

Finally, regarding years of professional experience, 22 respondents (20.6%) have less than 5 years of experience, 28 (26.2%) have between 5 and 10 years of professional experience, 15 (14%) between 11 and 15 years and 42 respondents (39.2%) had more than 15 years of experience.

Table 4 Sociodemographic characterization of the sample (Questionnaires)

		N	%
Professional area	AI	19	17,8
	Industrial management	35	32,7
	Stock and warehouse management	17	15,9
	Other	36	33,6
Gender	Female	19	17,8
	Male	86	80,4
	Not identified	2	1,8
Age group	Under 18 years old	0	0
	Between 18 and 25 years old	21	19,6
	Between 26 and 35 years old	34	31,8
	Between 36 and 45 years old	26	24,3
	Between 56 and 65 years old	26	21,5
	Over 65 years	3	2,8
Academic level	Basic education	0	0
	High school	32	29,9
	Undergraduate	32	29,9
	No bachelor	15	14
	Postgraduate	23	21,5
	Phd	5	4,7
Years of professional experience	Less than 5 years	22	20,6
	Between 5 and 10 years	28	26,2
	Between 11 and 15 years	15	14
	More than 15 years	42	39,2

Source: Author's elaboration

5.1.3 Qualitative Analysis

Going to the interviews, a script was created for each one. After validation by the advisors, they were conducted in person and the responses recorded in digital format. The structure of the three types of interviews elaborated consists of 2 questions. Thus, for each of the questions Q2, Q3 and Q4, inherent interviews were constructed.

The first interview, for Q2, aims to understand the use of IA by industrial managers in inventory management and inventory operations, as well as the organization's investment in it. Then, for Q3, also applied to industrial managers, the interview consists of two questions that try to collect data on the type of AI most used in Inventory Management and Warehousing, and in a second question the impact of the same on the organization's performance. Finally, in the last interview structure for question Q4 the data collection is directed towards where AI impact in terms of operational improvement in the areas of Inventory Management and Warehousing could.

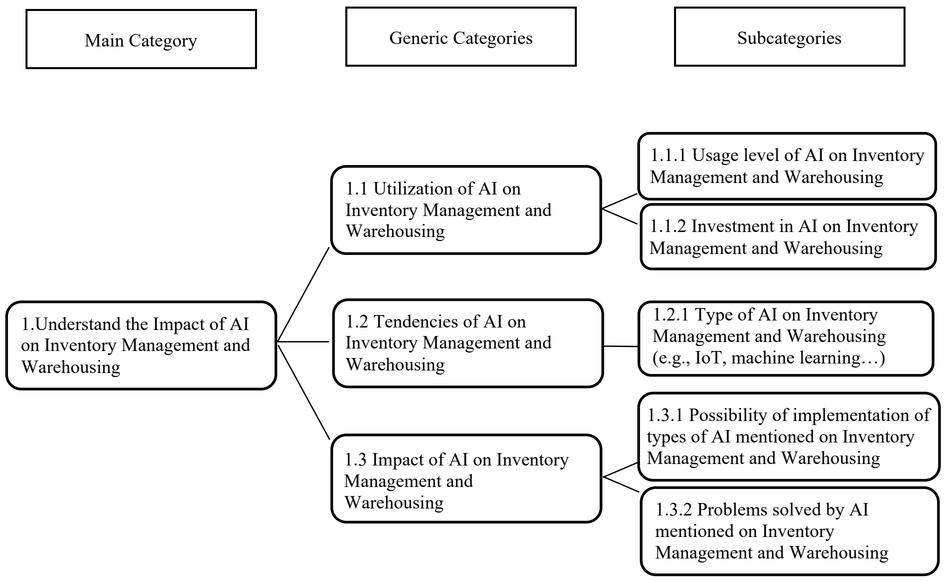
This final question arises from question Q3, which, based on its answers, interviews were carried out for Q4 with IS experts to ask if it would be possible to implement what the interviewed managers idealized in terms of the application of AI. Thus, realizing what type of IS could be applied to solve the problems raised by the interviewees and how they could be performed technically.

For each type of interview, 17 elements that best represented the phenomenon investigated in terms of knowledge were interviewed. Thus, for questions Q2 and Q3 industrial managers were interviewed and for question Q4 IS experts were interviewed for the purposes explained above. It is important to mention that this number of interviews had an intentional character, and it is framed in the parameters recognized by the author Vielas (2009) as acceptable, since he says that this value guarantees a good degree of reliability (Vilelas, 2009). However, the choice of the number of 17 interviewees for each interview applied also occurred since after the 11th interview, the answers entered in a loop phenomenon, which led to the end of the application of interviews in the 17th interview.

Thus, the qualitative methodology used resulted from the analysis of a set of interviews, which sought to measure the phenomenon under study at the level of social dynamics framed in the theme of AI in industrial management. To inductively analyze the information, which is only possible to achieve from the observation and collection analysis *in loco*, we tried to understand the meaning that people attribute to the analyzed phenomena since, according to Vilelas (2009), acts, words and gestures can only be understood in their context.

About the analysis technique used to interpret the data collected from the interviews, a content analysis was performed where the semantic structures (signifiers) were related to the sociological structures (meanings) of the statements, with the aim of articulating the surface of the texts with the factors that determine their characteristics [(psychosocial variables, cultural context and context, processes, and message reproduction) – (Duriau et al., 2007)]. In Figure 3, the categorization and codification of the corpus of the interview that gave rise to the qualitative analysis is detailed.

Figure 3 Categorization and coding of the interview corpus for qualitative analysis



Source: Author's elaboration

So, after the content analysis, which went through voice reproductions, the process of explanation, systematization, and expression of the content of messages, it was organized according to the three chronological poles of Bardin (1977). According to the author's organization, in a first phase there was the organization and systematization of ideas, and in a second phase, all the material was explored, and in the end the treatment and the respective interpretations of the obtained results were carried out.

Although the qualitative methodology used allows for more reliable data due to its in loco characteristic, which allows for more authentic statements, on the other hand, it also has some disadvantages. One of the main disadvantages presented in using this type of technique is the difficulty generated in grouping and comparing answers, due to their heterogeneity, which led to a consequent difficulty in synthesizing the data (Vilelas, 2009). The response rate considered satisfactory is also considered as another disadvantage, since the sample is still considered small, and the conclusions of this thesis must take this aspect into account. Finally, based on this last disadvantage, it is possible to highlight the impossibility of generalizations.

5.1.4 Sample description

Regarding the people interviewed, the entire sample was either related to AI or industrial management so that the inputs collected were relevant and would reliably contribute to the study in question. The contacts were obtained through professional experience in industrial management, and the interviewees were experts in AI and were invited through the social network LinkedIn to participate in the investigation. After completing the interviews, a content analysis was performed to obtain analytical data for theoretical and empirical conclusions.

Of the 17 interviews carried out, according to table 5, 9 (53%) were carried out with people connected with industrial management, specifically with stock and warehouse management, and 8 (47%) with people connected with the IA area. Regarding gender, 6 respondents (35.3%) are female, with the rest of the interviews conducted with 11 male participants (64.7%). Finally, regarding the level of academic training, 4 (23.5%) of the interviewees completed a degree, 8 (47%) a master's degree and 5 (29.5%) have no degree.

Table 5 Sociodemographic characterization of the sample (Interviews)

		N	%
Professional area	AI	8	47
	Industrial management	9	53
Gender	Female	6	35,3
	Male	11	64,7
Academic level	Undergraduate	32	23,5
	No bachelor	15	29,5
	Postgraduate	23	47

Source: Author's elaboration

Although the number of responses is considered satisfactory, the conclusions of this investigation should be read with caution from a sample considered small.

Chapter VI - Presentation and discussion of results

6.1 Main benefits, confidence, and risks in the possibility of implementing intelligent systems in stock and warehouse management

Data analysis and interpretation of the first objective of the study was based on the two-phase approach, referenced by the authors Hair et al. (2017). According to the authors' explanation, the degree of reliability and validity of the measurement model is the first phase of this stage of the investigation, and later, in a second phase, the degree of reliability and validity of the measurement model must be evaluated and then the evaluation of the structural model. Regarding the assessment of the quality of the measurement model, the following individual indicators were examined: Composite reliability (CR), convergent validity, internal consistency reliability and discriminant validity.

The results showed that the standardized factor loadings of most items are greater than 0.6 (Figure 4), and were significant when $p<0.001$, which showed the reliability of the individual indicator (Hair et al. 2017). Internal reliability was confirmed because all Composite Reliability values of the constructs are greater than 0.7 (Hair et al. 2017), as shown in Table 6.

Table 6 CR, AVE, correlations, and discriminant validity checks

	CR	AVE	1	2	3	4
(1) Benefits of AI	0.906	0.499	**1.000**	0.294	0.633	0.612
(2) Confidence AI	0.629	0.342	0.294	**1.000**	0.324	0.345
(3) Possibility of Implementing AI	0.888	0.799	0.633	0.324	**1.000**	0.421
(4) Risks AI	0.804	0.814	0.612	0.345	0.421	**1.000**

Source: Author's elaboration

To conclude the convergent validity, three criteria were analyzed (Bagozzi & Yi, 1998). The first criterion establishes that all positive and significant items must be in the respective constructs. The second criterion states that all constructs must have a CR value greater than 0.7. Finally, the last criterion defines that the AVE (average variance extracted) must exceed the minimum value of 0.50. Through the table above we can verify that the three criteria are verified, and it is thus possible to verify the convergent validity.

About discriminant validity, two approaches were used. The first approach used, developed by the authors Fornell & Larcker (1981), defines that the square root of the AVE (values represented on the diagonal of the table in bold) must be greater than its highest correlation with any construct, a criterion that is met as can be seen in Table 6. The second approach involved the analysis of the HTMT ratio (heterotrait-monotrait ratio) (Hair et al. 2017; Henseler et al. 2015). The authors define that for the model to offer more evidence of discriminant validity, the values of this ratio must be less than 0.85, something that values above the diagonal meet.

Moving on to the evaluation of the structural model, this was carried out in three stages, according to the author Hair, et al. (2017). In this evaluation, the sign, magnitude, and significance of the structural path coefficients were firstly analyzed; Next, the focus was on the R2 value for each endogenous variable as a measure of the model's predictive accuracy and, finally, in the last step, Stone-Geisser's Q2 values were considered as a dimension of the model's predictive relevance. However, to proceed with the evaluation of the structural model, the authors refer to the primordial need to verify collinearity (Hair et al. 2017). For this purpose, the authors refer to the need for the variance inflation factor (VIF) values to be all lower than 5, an aspect that is verified in this model, since the values are in a range of values between 1,413 and 4,477. In this way, the requirement defended by the authors is fulfilled, as the values do not indicate collinearity.

In the evaluation of the model, it was found that the coefficient of determination of R2 for the endogenous variable of possibility of implementing AI in stock and warehouse management is 42.1%, thus fulfilling the requirement of the authors Falk & Miler (1992) that the value of this coefficient must be greater than 10%. As for the Q2 values for the endogenous variable, it is 0.293, which, according to Hair et al. (2017), indicates a predictive relevance of the model.

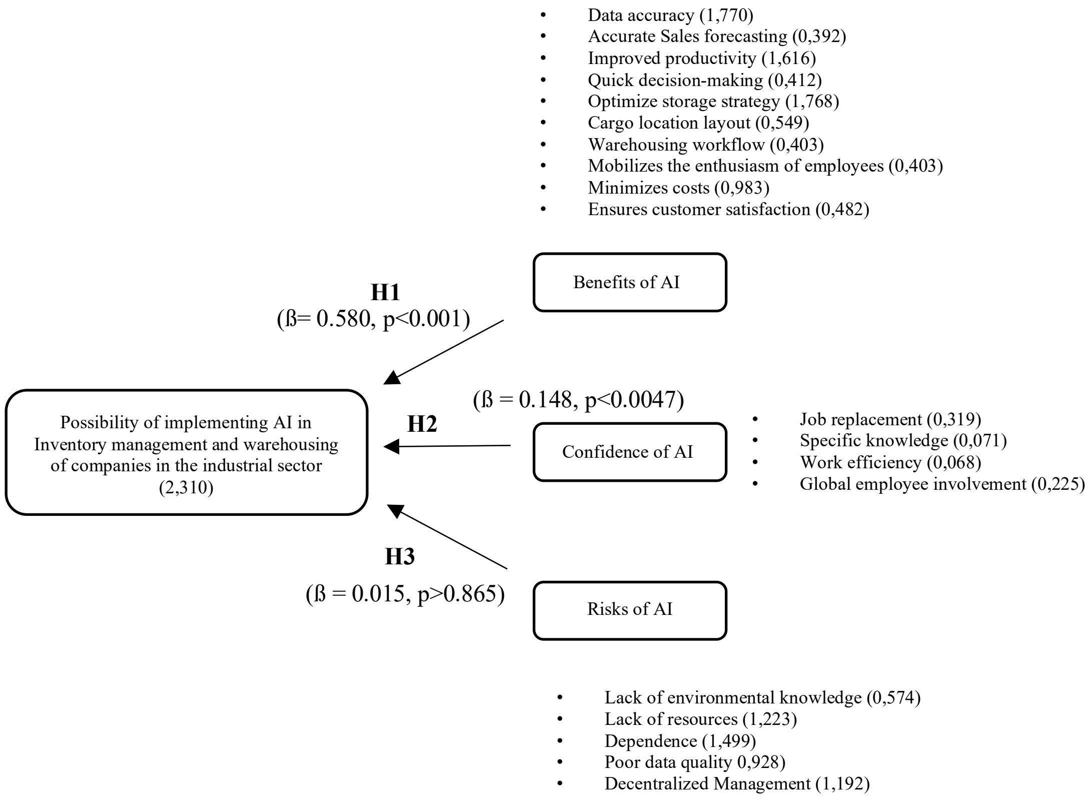
Table 7 Direct relationships between constructs

	Original sample	**Standard deviation**	**T statistics**	**P values**
Benefits of ai -> possibility of implementing AI	0.580	0.097	5.985	0.001
Confidence ai -> possibility of implementing AI	0.148	0.074	1.988	0.047
Risks ai -> possibility of implementing AI	0.015	0.089	0.170	0.865

Source: Author's elaboration

The results in Table 7 show that the benefits of AI have a positive impact on the possibility of implementing AI in stock and warehouse management (ß= 0.580, p<0.001), which tells us that AI has intrinsic benefits that can be useful in stock and warehouse management, confirming hypothesis H1. A similar effect also happens with the confidence to use AI. This also has a positive impact on the possibility of implementing intelligent systems in stock and warehouse management (ß = 0.148, p<0.001), which tells us that, in fact, AI confidence indicators are real motivations to use AI in stock and warehouse management, proving hypothesis H2. Finally, for H3 no statistical evidence was found to support the possible impact of the risks associated with AI.

Figure 4 Conceptual model tested with SmartPLS3 with associated values



Source: Author's elaboration

Repeating the initial idea, the conceptual model was exposed to several tests using the SmartPLS 3 software with the primary aim of responding to the objective of the present investigation - What are the main benefits, trust and risks in the possibility of implementing intelligent systems in stock management and storage". Thus, as illustrated in Figure 4, three factors were identified to explain the possibility of implementing AI in stock and warehouse management, and these are the benefits of AI that best motivate the implementation of AI in stock and warehouse management, identified by Foya (2021), Sohrabpour (2021), Davarzani & Norrman (2015), the confidence factors for the implementation of AI in stock and warehouse management, identified by Hoffmann & Nurski (2021), Soltani (2021), Abonamah et al. al. (2021) and finally the risks associated with this type of technology in its application in stock and warehouse management, identified by Minh (2020), Niranjan et al. (2021), Rana et al. (2021), Wang (2021).

Regarding the main confidence indicators to implement AI in stock and warehouse management, the results are not entirely in line with the theory of the authors studied. First, the results of the model that are in line with the ideas of the authors presented, show that Specific knowledge (Hoffmann & Nurski, 2021) and Work efficiency (Soltani, 2021) are demotivators to use intelligent systems in stock and storage management. The point where the results are not in line with literature review is regarding the variable Global employee involvement (Abonamah et al., 2021) and Job replacement (Hoffmann & Nurski, 2021). According to the model, these are very significant in terms of positively influencing the implementation of AI in stock and warehouse management, having been removed from the model.

Finally, through the conceptual model, no static evidence was found that would allow understanding the impact of the greatest risks of AI in stock and warehouse management pointed by the authors studied. This, since the data was not significant to demonstrate an existing relationship between the application of AI in management and warehouse, with the risks pointed out by the authors presented and used as indicators in the developed model.

After identifying the three generic categories with an impact on the possibility of implementing intelligent systems in stock and warehouse management, we proceeded to test the hypotheses formulated in the methodology chapter. The conceptual model is composed only of direct effects and the results show that the benefits of intelligent systems positively impact the possibility of implementing AI in stock and warehouse management, confirming hypothesis H1 of the study. Thus, it is concluded that, in fact, AI has benefits, such as data accuracy (Foya, 2021), accurate sales forecasting (Sohrabpour, 2021), Warehousing workflow, (Davarzani & Norrman, 2015) and the optimization of storage strategy (Davarzani & Norrman, 2015), which can really be used by companies and thus increase the possibility of using AI in the management problem that is stock and warehouse management.

Regarding confidence indicators, the results show that some of these also positively impact the possibility of implementing this type of technology, confirming hypothesis H2 of the study. In summary, as stated by the authors, the lower the confidence in some aspects of AI, such as the need for Specific knowledge (Hoffmann & Nurski,

2021) and Work efficiency (Soltani, 2021), the lower the possibility of implementation of these systems in stock and warehouse management.

Finally, no static evidence was found that would allow understanding the impact of the greatest risks of AI, not proving the H3 hypothesis.

In general, the model shows that, considering the main benefits and reliability indicators, it is possible to implement intelligent systems in stock and warehouse management, a conclusion that is in line with the study carried out by Kaplan & Haenlein (2019).

6.1.1Situations where humans must replace and control AI systems

Generic category 1.1 aimed to question respondents to understand in which situations industrial managers use AI on inventory management and warehousing. This category was subdivided into subcategories translated into two questions: one on the level of use and if there is use, a question regarding the estimated amount of investment in this type of technology in these company operations.

Table 8 Usage level of AI on Inventory Management and Warehousing

TEXT	GENERIC CATEGORY	NUMBER OF TIMES	INTERVIEWED
We don't use	1.1.1	2	1,3
We don't use it, because our stock is for the processing industry and not for commercialization, being easy to manage without IS	1.1.1	1	8
Now we do not use it, but we are studying it through market consultation.	1.1.1	1	5
We use a management program, but we do not have a demand forecasting system, purchase, or intelligent allocation of components/products within the various warehouses. Operations and decisions are made manually.	1.1.1	2	4,5
We use, more and more, we seek to invest in this aspect, in terms of stock control and storage of the various products (finished products; raw materials and parts warehouse)	1.1.1	1	7
We use	1.1.1	1	2

Source: Author's elaboration

For the first category, as can be seen in Table 8, there are two distinct situations: non-use and AI use, with the two situations occurring in a similar way, that is, for each of the situations there are the same number of companies to use and not use AI in your stock and warehouse management operations.

In the view of the 4 interviewees who do not use AI in their stock and warehouse management operations, the statement of one of the interviewees who declares that *'although many companies have and use AI, not all of them do it correctly stands out. This is the sad reality. This is to say that any AI system that has as a principle to learn about transactions made in the past, comes up against the fact that said data are unreliable or incomplete. That is, AI will mislead, giving a wrong output.'* Justifying your company's reason for not using AI in its operations. This view is in line with the ideas of the author Williams (2021) presented throughout the literature review chapter.

The other situation pointed out by one of the interviewees (a total of 1 response) for the non-use of AI in this type of logistical operations is, according to the interviewee, related to the fact that *'our type of industry is processing and not commercialization, our stock is relatively easy to manage without intelligent systems. We manage through Excel lists, with inputs and outputs, but with manual entries.'* This last conclusion of the interviewee is exactly in the same line of thought of the authors Williams (2021), Minh (2020) and Szedlak et al. (2020.), showing us that small manufacturing industries are not so motivated to implement AI in their stock and warehouse management operations because the benefits do not outweigh the returns in their view. It is important to mention that these two interviewees are both industrial managers of companies in the transformation industry, where the materials used are directly applied to the work.

Finally, the last situation presented of not using AI demonstrates the willingness to apply it in its operations, recognizing, through the following words, the motivation for implementation: '*Not yet, but we are studying with market consultation.'* This demonstration of recognition of the importance of AI is in line with the ideas of authors Kaplan & Haenlein (2019), who mention that companies are gaining awareness of applying AI in their logistics operations.

Regarding the participants who responded affirmatively to the use of AI in stock and warehouse management operations, there are two situations. In the first situation, the company only uses a management program for stock control and not, according to the interviewee, '*for forecasting demand, purchasing or intelligent allocation of components/products within the various warehouses.'* Operations and decisions are made manually. This type of use is again in line with the vision of the authors Williams (2021), Minh (2020) and Szedlak et al. (2020.) that denote resistance on the part of managers to invest in AI due to the high initial monetary commitment.

The second situation of using AI in this type of operations already reports a more global view of AI in stock and warehouse management operations, and the interviewee states, '*We used. We are increasingly looking to invest in this aspect, in terms of stock control and storage of the various products (finished products; raw materials and parts warehouse).'* This use is referenced by the authors Song et al. (2020) that defined AI to dynamic optimal inventory control and by the authors Davarzani & Norrman, (2015) that highlight the optimization of the storage strategy, by exploring these dynamics of goods in the warehouse to identify key factors of decision making on storage policy.

Still in this category, the second subcategory tries to understand the capital invested in this type of technologies in the logistics areas addressed. It was concluded that the values are discrepant, with large production companies investing much more (€1 000 000), processing companies invest (€ 150 000) and industrial material resale companies are those that invest less capital (€ 6 000 €). This situation can be verified by author Minh (2020) who speaking specifically of AI in industry refers that this technology requires complex software and high-performance hardware, a reality that is very hard for a small company to handle in terms of investment (Minh, 2020).

6.1.2 Trend of AI systems in stock and warehouse management

Moving on to the second generic category, the objective was to try to understand the trends of intelligent systems in industrial companies, in terms of stock and warehouse management. Thus, for this category, the interview consists of one question, which translate the subcategory that try to collect data on the type of AI most used in Inventory Management and Warehousing. In this subcategory, the use of image recognition and robotics stands out, using QR codes to identify for picking incoming and outgoing material, and robotics, for arranging items on the shelves of warehouses. This use was identified by author Soltani (2021) who described several computer vision applications of AI in inventory management, which were for example, translated into an experimental system with a camera-equipped robot that can check the stock inventory shelf by shelf. Also, two of the interviewees declared to use management programs, which, in the words of one of the participants, *as they get more data, it gets smarter*, thus being considered a form of machine learning. This use of management programs underlines the author's idea Sohrabpour (2021) who, as mentioned in the literature review, defends thought the use of accurate data applied in machine learning programs, generate accurate sales forecasting for minimization of costs and assurance of customer satisfaction.

Table 9 Type of AI on Inventory Management and Warehousing (Interview 2)

TEXT	GENERIC CATEGORY	NUMBER OF TIMES	INTERVIEWED
Robotics	1.2.1	1	2
Image recognition	1.2.1	2	7
Machine learning	1.2.1	2	4,5

Source: Author's elaboration

6.1.3 Impacts of AI systems on stock and warehouse management

Finally, in the last generic category the interview structure had the data collection directed towards where AI impact in terms of operational improvement in the areas of Inventory Management and Warehousing could. This final question arises from the last generic category, which, based on its answers, interviews were carried out for this third generic category with asking IS experts if it would be possible to implement what the interviewed managers idealized in terms of the application of AI. Thus, realizing what type of IS could be applied to solve the problems raised by the interviewees and how they could be performed technically.

Table 10 Type of AI on Inventory Management and Warehousing (Interview 3)

TEXT	GENERIC CATEGORY	NUMBER OF TIMES	INTERVIEWED
Robotics	1.3.1	2	4,7
Image recognition	1.3.1	6	1,2,4,6,7,9
Machine learning	1.3.1	8	1,2,3,4,5,6,7,9

Source: Author's elaboration

In general, as can be seen in table 10, most respondents consider machine learning to be the most economical and easily applicable solution. One interviewee state that *"machine-learning algorithms enable detailed stock movement forecasting and management that lower operator error and processing times can be reduced, with corresponding increases in overall efficiency and productivity. Forecasting demand for new products with machine learning is being applied to today with strong results, it* *allows key leads to plan inventory purchases from suppliers based on forecasts from demand planners and changing supply and demand."* This view is in line with the view of the author Sohrabpour (2021) who defends, thought the use of accurate data, accurate sales forecasting for minimization of costs and assurance of customer satisfaction. The second application of AI, as can be seen in table 10, the most mentioned was visual recognition, with 6 respondents pointing it out as a good solution to optimize stock and warehouse management.

One of the interviewees specifies '*Radio frequency identification (RFID) is replacing paper trails and bar code scanners for the organization and control of inventory, tracking products with digital tags, and enabling a more precise and accurate inventory control.'* This is in line with the ideas of the authors Wang (2021), who concludes Intelligence and the Internet of things by enabling visual information technology allows smart logistics based on more assertive cooperative choices.

Finally, the last solution pointed out was AI-powered robots that, according to one of the interviewees, "provide real-time tracking of products and for the warehouse they can locate wares and scan their conditions, collecting the needed data for further analysis." This statement translates a view like the author Foya (2021) who defends robotics as an effective and automated method in control, filling the gap of inventory circulation being one of the most heavily operations involved with handling and checking inventory in the warehouse.

Table 11 Problems solved by AI mentioned on Inventory Management and Warehousing

TEXT	GENERIC CATEGORY	NUMBER OF TIMES	INTERVIEWED
Inventory optimization	1.3.1	8	1,2,4,5,6,7,8,9
Safety	1.3.1	5	1,4,5,7,9
Warehouses free employees	1.3.1	1	6
Saving costs	1.3.1	7	1,2,3,4,5,6,9

Source: Author's elaboration

Still in this category on the impact of AI, for the subcategory where it was analyzed, through the interviewee's experts in AI, as can be seen in table 11, inventory optimization was identified as the greatest benefit. According to one of the interviewees, *'By implementing AI solutions, you minimize the risks of overstocking and understocking in a changing market. Reducing the errors and issues in inventory management, the* *business can increase customer satisfaction and save costs.'* This vision can be found again in the words of the author Sohrabpour (2021) who defends, thought the use of accurate data, accurate sales forecasting for minimization of costs and assurance of customer satisfaction.

Another benefit mentioned, as can be seen in table 11, by 1 interviewee is the evolving concept of Warehouses free employees, which according to this can be allocated for more urgent and vital tasks that require human cognition, in addition to helping with security issues. Another interviewee, on this idea, complements saying *'Alibaba's warehouses use AI robots that do 70% of the work at these facilities. These AI robots can sort, transport, and arrange items at the warehouse.'* This view confirms the view of the author Kaplan who believes that companies with AI can start moving to a process that economists call "de-skilling," in a way to employees focus on the skills robots cannot replace, creating new areas to accommodate those employees and leave mechanical task for robots (Kaplan, 2016).

Chapter VII - Conclusion

7.1 Final Considerations

Nowadays, AI is a trendy topic among investigators of different fields as retailing industry (Costa et al., 2020), the automobile industry (James et al., 2022), medicine (Mesquita, 2017), and even in education (Ara Shaikh et al., 2021). All investigations on this topic have a common denominator: the facilitation of AI in tasks that require decision-making.

Focusing on the business context, where Inventory Management and Warehousing is mostly used, the use of artificial intelligence has increased in the last 20 years, and companies are also taking advantage of its application (Kaplan & Haenlein, 2019). This opened the door for a revolution on the industry field: industry 4.0 that results from the use of AI in its operations, which is seen as a competitive advantage (Minh, 2020). After extensive research on AI and stock and warehouse management, and analysis of a questionnaire with 107 responses and 17 interviews, it was possible to reach several conclusions.

The conclusion of the initial phase of the investigation, the literature review, allowed the definition of research questions and variables that would give answers to them, trying to validate the ideas of the authors exposed during the literature review.

The first research question focuses on the variables that influenced the implementation of AI in stock and warehouse management. Through the literature review, and subsequent creation of the conceptual model, the variables were divided into three groups, namely benefits, trust and risks.

As for the benefits, through the literature review, those that mainly motivate the implementation of AI in stock and warehouse management were identified, namely: Data accuracy (Foya, 2021); Accurate Sales forecasting (Sohrabpour, 2021); Improved productivity (Foya, 2021); Quick decision-making (Foya, 2021); Optimize storage strategy (Davarzani & Norrman, 2015); Cargo location layout (Davarzani & Norrman, 2015); Warehousing workflow (Davarzani & Norrman, 2015); Mobilize the enthusiasm of employees (Davarzani & Norrman, 2015); Minimizes costs (Foya, 2021) and finally, Ensures customer satisfaction (Foya, 2021). However, after analyzing the questionnaire outputs, it was concluded that Data accuracy (Foya, 2021); Accurate Sales forecasting (Sohrabpour, 2021); Optimization of Warehousing workflow (Davarzani & Norrman, 2015); and Optimization of storage strategy (Davarzani & Norrman, 2015), according to the conceptual model, are the benefits that show a significant influence on the possibility of implementing AI in stock and warehouse management.

Regarding AI confidence indicators, the authors present Job replacement (Hoffmann & Nurski, 2021); Specific knowledge (Hoffmann & Nurski, 2021); Work efficiency (Soltani, 2021); Global employee involvement (Abonamah et al., 2021) as the best confidence indicators that influence the decision to implement AI in stock and warehouse management. In this case, through the questionnaires it was possible to conclude that the results of the model are in line with the ideas of the authors presented, showing that Specific knowledge (Hoffmann & Nurski, 2021) and Work efficiency (Soltani, 2021) are demotivators to use intelligent systems in stock and storage management. The point of contention is regarding the variables: Global employee involvement (Abonamah et al., 2021) and Job replacement (Hoffmann & Nurski, 2021). According to the model, these are very significant in terms of positively influencing the implementation of AI in stock and warehouse management, having been removed from the model.

The last group of variables that influence the possibility of implementing AI, as mentioned earlier, are the risks of these technologies. The authors say that these are lacking Lack of environmental (Minh, 2020); Lack of resources (Minh, 2020) Dependence (Niranjan et al., 2021) Poor data quality (Rana et al., 2021) and finally, Decentralized Management (Wang, 2021). According to the conceptual model, no static evidence was found that would allow understanding the impact of the greatest risks of AI in stock and warehouse management. In other words, the five variables initially identified by the authors cannot be sustained with statistical evidence.

After analyzing the data taken from the questionnaires, it was concluded that both the main benefits and some of the confidence factors of AI that best serve stock and warehouse management, positively affect the possibility of implementing intelligent systems in the management problem that the warehousing and organization of the warehouse. As argued by the authors, the greater the perceived benefits of using AI, such as Data accuracy (Foya, 2021); Accurate Sales forecasting (Sohrabpour, 2021); Optimization of Warehousing workflow (Davarzani & Norrman, 2015); and Optimization of storage strategy (Davarzani & Norrman, 2015), the greater the possibility of implementing these systems in stock and warehouse management. Regarding AI confidence indicators, such as Global employee involvement (Abonamah et al., 2021) and Job replacement (Hoffmann & Nurski, 2021), can really be leveraged by organizations, increasing the possibility of using AI for stock management and warehouse.

On the other hand, according to the model, the risks of AI do not in any way impact the possibility of implementing AI in stock and warehouse management. In fact, the authors studied warn of some risks of these systems, such as Lack of environmental (Minh, 2020); Lack of resources (Minh, 2020) Dependence (Niranjan et al., 2021), Poor data quality (Rana et al., 2021) and finally, Decentralized Management (Wang, 2021) that end up creating barriers when thinking about using this type of technology for stock and warehouse management. However, the authors' ideas are not verified in this study, and the perception of the risks for the implementation of AI in stock and warehouse management does not influence the decision of organizations when implementing these technologies.

The remaining research questions (Q2, Q3 and Q4) aimed to understand the impact of AI on stock and warehouse management. To answer these research questions, 17 interviews were carried out.

The second question (Q2) was related to the current use of AI in industrial companies in terms of stock and warehouse management. Two situations occurred in the interviews: companies that use and do not use AI in their operations, and the statements were divided equally. The type of use is in line with the authors Kaplan & Haenlein (2019) who declare that companies are becoming aware of the benefits of AI implemented in their logistics operations. And the non-use is verified by the words of the authors Williams (2021), Minh (2020) and Szedlak et al. (2020.), showing us that small manufacturing industries are not so motivated to implement AI in their stock and warehouse management operations because the benefits do not outweigh the returns in their view.

Of the respondents who responded that their company applies AI in its stock and warehouse management operations, it was found that larger companies are investing large capital in AI and small companies are still showing caution in their investments. This view again confirms the ideas of authors Williams (2021), Minh (2020) and Szedlak et al. (2020.) that denote resistance on the part of managers to invest in AI due to the high initial monetary commitment.

The third question (Q3) addressed AI trends that industrial companies apply in their stock and warehouse management operations. Through the interviewees who claimed to use AI in the logistical operations, the investigation tried to find out what types of AI are currently used in this branch. In this way, robotics and visual recognition were the verified typologies, which are in line with the author Foya (2021) who defends robotics and computer vision as effective and automated method in control, filling the gap of inventory circulation being one of the most heavily operations involved with handling and checking inventory in the warehouse.

Finally, in the last research question, for which interviews were also carried out, we tried to understand the impact of the IAs referenced by the interviewees through the input of IA specialists. Through the insights of the managers interviewed, we sought to critically understand whether current AI applications are the ones that most positively contribute to the efficiency of companies' management and stock and warehouse operations. In this way, the experts agreed on the use of visual recognition and robotics, adding machine learning as a technology that can greatly contribute to stock optimization issues. This view is in line with the authors Sohrabpour (2021) who, as mentioned in the literature review, defends thought the use of accurate data, accurate sales forecasting for minimization of costs and assurance of customer satisfaction.

7.2 Contribution to business management

The use of artificial intelligence has increased in the last 20 years, and companies are also taking advantage of its application (Kaplan & Haenlein, 2019). This study intends to contribute to the best application of AI regarding industrial management, leading research into the possibilities of applying AI in stock and warehouse management. To this end, the main factors that affect this application were analyzed, and the main benefits, trust factors and risks of AI that have the power to influence this implementation, as well as impacts on the organizational structure and operations of companies in the industrial branch.

As mentioned by authors Kaplan & Haenlein, (2019) being a recent topic, there are still many gaps in the information related to this topic. In this way, this study also intends to contribute with scientific knowledge to the scientific community with details about the best way to apply, giving details about the organizational structure as well as changes in the operations of industrial companies. Specifically, this study addresses the benefits of AI in its implementation in stock and warehouse management, the main confidence indicators that lead to this application and the associated risks.

However, the need for continuous research on this topic is underlined, since the area is very extensive, and the applications are multiple. In this way, the continuation of research that relates AI to industrial management is intrinsic to the economic growth of industrial companies.

7.3 Study limitations and Suggestions for future investigations

To carry out this thesis, the sample obtained, including respondents and interviewees, was reduced, and this situation is considered a limitation for this investigation. Thus, the generalization of the results obtained, which proves the literature review, must be cautious. Another limiting factor is again related to the sample, because the results may have been biased since there is no correct perception about artificial intelligence.

Regarding to the suggestions, the first one meets the limitation of the study, since a larger sample applied can contribute to more representative results on the subject. Another suggestion addresses the specificity with which this theme can be applied, that is, applying this theme to specific international markets and understanding the influence of AI on stock and warehouse management operations in international organizational structures. Finally, the last suggestion concerns the risks of AI identified in the literature. Since the conceptual model was not able to translate the impact of the threats pointed out by the authors, it would be extremely interesting to deepen this theme to understand the real risks of AI in stock and warehouse management.

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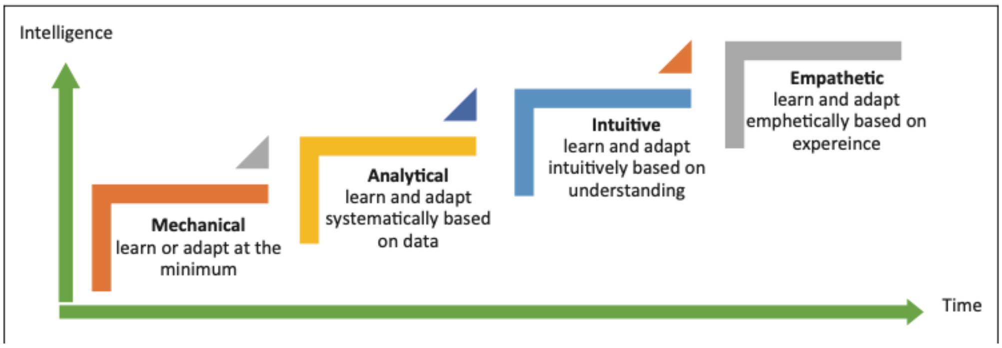
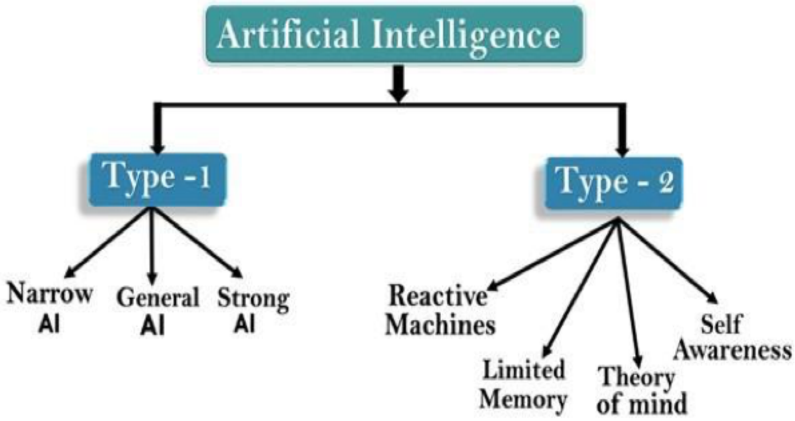
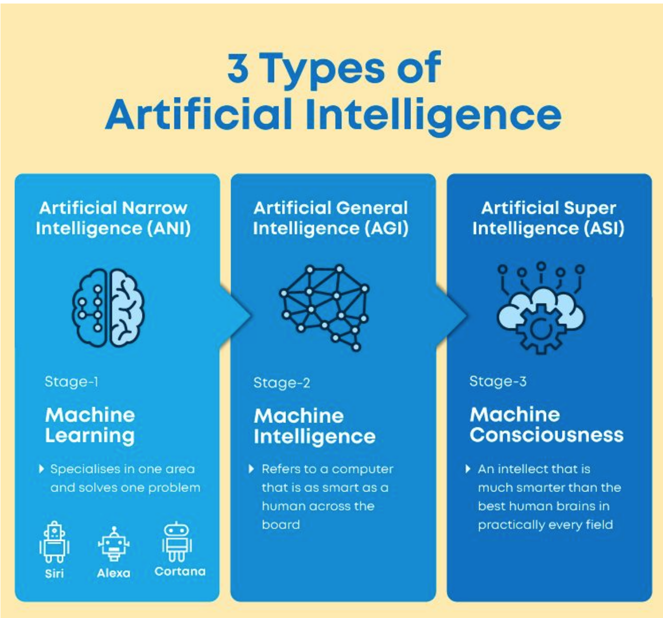
Annex 1



Annex 2



Annex 3



Annex 4 Structure of the online questionnaire

Questionário sobre implementação de sistemas inteligentes nas áreas de gestão de stock e armazenamento

Este questionário tem como objetivo conhecer os fatores que afetam a aplicação da inteligência artificial em duas importantes àreas da logística, gestão de stock e armazenagem.

Os dados recolhidos serão usados para fins académicos, estando garantido o anonimato dos seus participantes.

Esta dissertação de mestrado realiza-se no âmbito do curso de Master (MSc) in Business Administration do Instituto Universitário de Lisboa Buiness School (ISCTE IBS) para obtenção do grau de mestre.

Para qualquer esclarecimento ou informação adicional, por favor contacte a autora do estudo, Mafalda Gonçalves, através do seguinte endereço eletrónico: mcpgs@iscte.pt

Obrigada pela sua participação!

* Required

1. Qual a sua área profissional?

Mark only one oval.

- ◯ Gestão industrial
- ◯ Gestão de stock e armazenamento
- ◯ Inteligência artificial
- ◯ Outra

Skip to question 2

Possibilidade de implementação de Inteligência Artificial (IA) na gestão de stock e armazenamento

Escolha apenas uma oval.

2. Existe a possibilidade de aplicar Inteligência Artificial na gestão de stock e armazenamento

Mark only one oval.

	1	2	3	4	5	6	7	
Discordo	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Concordo

3. Vê valor na implementação de Inteligência artificial na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Discordo	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Concordo

Skip to question 4

Principais benefícios da implementação de inteligência artificial (IA) na gestão de stock e armazenamento

Avalie as seguintes motivações em uma escala de 1 a 7, onde 1 significa ser uma motivação mais fraca e 7 é um benefício mais forte para uma empresa implementar sistemas inteligentes na gestão de stock e armazenamento

4. Precisão de dados é um grande benefício da implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

5. Previsão de vendas exata é um grande benefício da implementação de IA na gestão de sto e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

6. Melhora a produtividade é um grande benefício da implementação de IA na gestão de stoc e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

7. Tomada de decisão rápida é um grande benefício da implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

8. Optimização da estratégia de armazenamento é um grande benefício da implementação c IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

9. Melhoria do Layout de localização do stock é um grande benefício da implementação de I/ na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	◯	◯	◯	◯	◯	◯	◯	Beneficio muito forte

10. Melhoria do fluxo de trabalho no armazém é um grande benefício da implementação de I na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	◯	◯	◯	◯	◯	◯	◯	Beneficio muito forte

11. Mobiliza o entusiasmo dos funcionários é um grande benefício da implementação de IA n gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	◯	◯	◯	◯	◯	◯	◯	Beneficio muito forte

12. Minimiza custos é um grande benefício da implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	◯	◯	◯	◯	◯	◯	◯	Beneficio muito forte

13. Garante a satisfação do cliente é um grande benefício da implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Beneficio muito fraco	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Beneficio muito forte

Skip to question 14

Principais características da inteligência artificial (IA) na sua implementação na gestão de stock e armazenamento

Segundo vários autores, como Soltani (2021), Teerasoponponga e Sopadangb (2022), Pallathadka et al. (2021), Minh (2020), existem alguns sistemas inteligentes que impactam positivamente a possibilidade de implementação de IA na gestão de stock e armazenamento. Usando uma escala de 1 a 7, em que 1 significa nada importante e 7 muito importante, como classificaria a importância das características identificadas para melhorar a gestão de stock e armazenamento.

14. Reconhecimento de imagem é importante para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	⬭	⬭	⬭	⬭	⬭	Muito importante

15. Sistema de apoio à decisão é importante para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	⬭	⬭	⬭	⬭	⬭	Muito importante

16. Algoritmos são importantes para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	⬭	⬭	⬭	⬭	⬭	Muito importante

17. Reconhecimento de fala é importante para melhorar a gestão de stock e armazenamentc

Mark only one oval.

	1	2	3	4	5	
Nada importante	⬭	⬭	⬭	⬭	⬭	Muito importante

18. Robótica é importante para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	⬭	⬭	⬭	⬭	⬭	Muito importante

19. Machine learning é importante para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	◯	◯	◯	◯	◯	Muito importante

20. Deep learning é importante para melhorar a gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	
Nada importante	◯	◯	◯	◯	◯	Muito importante

Skip to question 21

Confiança na inteligência artificial (IA) na sua implementação na gestão de stock e armazenamento

Segundo os autores Hoffmann & Nursk (2021) alguns fatores, como a substituição de empregos, podem tirar um pouco da confiança dos gestores na aplicação da IA em operações na gestão de stocks e armazenamento. Avalie os seguintes fatores de IA, numa uma escala de 1 a 7, que podem ser um fator de confiança na implementação de IA na gestão de stock e armazenamento, sabendo que 1 significa não ser um fator de confiança e 7 um fator de confiança.

21. Substituição de emprego durante o uso de IA é um fator de confiança na implementação IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	◯	◯	◯	◯	◯	◯	◯	Fator de desconfiança

22. Segurança durante o uso de IA é um fator de confiança na implementação de IA na gestã de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Fator de desconfiança

23. Conhecimento específico durante o uso de IA é um fator de confiança na implementaçãc de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Fator de desconfiança

24. Fácil acesso aos dados durante o uso de IA é um fator de confiança na implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Fator de desconfiança

25. Eficiência no trabalho durante o uso de IA é um fator de confiança na implementação de I na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Fator de desconfiança

26. Envolvimento global do funcionário durante o uso de IA é um fator de confiança na implementação de IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Fator de confiança	◯	◯	◯	◯	◯	◯	◯	Fator de desconfiança

Skip to question 27

Riscos da implementação de inteligência artificial (IA) na gestão de stock e armazenamento

Avalie os seguintes riscos de IA, que podem ser limitações na gestão d stock e armazenamento, numa escala de 1 a 7, sabendo que 1 significa não ser um risco e 7, um grande risco.

27. Falta de conhecimento laboral é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

28. Problemas de segurança são um grande risco da IA na gestão de stock e armazenamentc

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

29. Falta de recursos é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

30. Problemas técnicos são um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

31. Dependência é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

32. Dificuldade de implementação é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

33. Má qualidade de dados é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

34. Falta de regulamentação é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

35. Problemas éticos é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

36. Gestão descentralizada é um grande risco da IA na gestão de stock e armazenamento *

Mark only one oval.

	1	2	3	4	5	6	7	
Não risco	◯	◯	◯	◯	◯	◯	◯	Risco

Skip to question 37

Motivação de implementação

Escolha apenas uma ova

37. Considerando todas as suas respostas anteriores e a próxima escala de 1 a 7, onde 1 significa improvável e 7 significa muito provavelmente, qual é a probabilidade de uma empresa implementar IA para gerenciamento de stock e armazenamento. *

Mark only one oval.

	1	2	3	4	5	6	7	
Improvável	◯	◯	◯	◯	◯	◯	◯	Muito provável

Skip to question 38

Informações sociodemográficas

Escolha apenas uma ova

38. Género *

Mark only one oval.

◯ Masculino
◯ Feminino
◯ Prefiro não dizer.

39. Idade *

Mark only one oval.

◯ Menos de 18 anos
◯ Entre 18 e os 25 anos de idade
◯ Entre os 26 e os 35 anos de idade
◯ Entre os 36 e os 45 anos de idade
◯ Entre os 56 e os 65 anos de idade
◯ Mais de 65 anos de idade

40. Nível de educação *

Mark only one oval.

- Ensino Básico
- Ensino secundário
- Não licenciado
- Licenciatura
- Mestrado
- Doutoramento

41. Anos de experiência profissional *

Mark only one oval.

- Menos de 5 anos
- Entre 5 e 10 anos
- Entre 11 e 15 anos
- Mais de 15 anos

O questionário chegou ao fim. Obrigada pela sua colaboração!

Annex 5 Interview Guide 1

1 - A sua empresa utiliza sistemas inteligentes na gestão de stocks e operações de armazenagem?

2 Em caso afirmativo, qual o investimento implícito neles?

Annex 6 Interview Guide 2

1 - Qual o tipo de inteligência artificial é mais utilizado na sua empresa para as operações de gestão de stock e armazenamento? Reconhecimento de imagem, Sistema de suporte à decisão, Algoritmos, Reconhecimento de fala, Robótica, machine learning, deep learning?

Annex 7 Interview Guide 3

1- Os gestores de empresas de fabrico de máquinas, os quais só fazem stock de artigos para a produção e não para venda direta, como devem aplicar a AI para melhor gestão interna de stock? Que problemas podiam resolver e desafios levantados pelos mesmos?