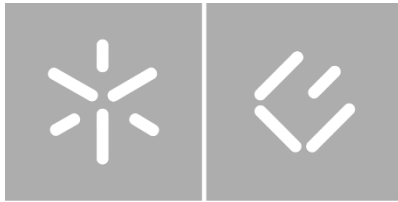


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**Artificial Intelligence empowerment in
managerial decision-making**



Universidade do Minho
Escola de Economia e Gestão

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in managerial decision-making**

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Working hard is important and with the right people supporting, creates success.

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

RESUMO

A inteligência artificial (IA) é um dos temas mais interessantes de estudo e desenvolvimento, e fascinante no que às diferentes aplicações e usos diz respeito.

O objetivo deste trabalho de pesquisa foi compreender a relação da IA na tomada de decisão na gestão. Assim, a teoria desenvolvida focou-se no crescimento da relação entre tecnologia e a gestão, no que toca à tomada de decisão, salientando a evolução dos sistemas de informação (SI) à IA em termos de tomada de decisões estratégica, tática e operacional. Nesta linha de pensamento, o objetivo era perceber se o uso da tecnologia/IA era condicionado pelas características das empresas, em termos de pequenas, médias ou grandes empresas. Também, analisar o potencial da IA e/ou tecnologias nas empresas, de forma a perceber as mudanças sentidas nas organizações devido às alterações provocadas pela IA/tecnologia. Adicionalmente, passou por perceber o impacto da IA nos gestores, em termos de cooperação, se estavam no peso ideal para trabalhar e para construir o sucesso, e se tinham sugestões para atualizar ou implementar IA nas empresas. A amostra é composta por administradores e *CEOs* de pequenas, médias e grandes empresas, que foram submetidos a uma entrevista.

Os resultados do conteúdo de análise das entrevistas reforçam as ideias exploradas na revisão da literatura, mostrando que o uso da IA na tomada de decisão era maioritariamente presente em grandes empresas, empresas com maiores condições para investir, já em PME notou-se uma maior utilização de SI combinado com a racionalidade humana. A teoria do caos, permitiu perceber que as empresas apresentadas na pesquisa não implementam IA/tecnologias nos processos como uma tentativa de resolver problemas, mas de entender se o seu uso traria benefícios. Além disso, percebeu-se que as empresas não tinham conhecimento das potencialidades da IA para aplicar nas diversas áreas, mas que eram conscientes do seu valor. Por fim, relativamente aos impactos das tecnologias/IA nos trabalhadores, foi sentido pela maioria uma resistência para a sua implementação, vendo-as como uma ameaça, mas aceitando assim que observavam melhores, mais rápidos e precisos resultados. Os entrevistados, conscientes do peso da IA no mundo, mencionaram que o motivo desta resposta era derivado do medo do desconhecido, não os impedindo de crescer, implementar e aprender.

PALAVRAS-CHAVE: Inteligência artificial, sistemas de informação, tomada de decisão na gestão, teoria do caos, grandes empresas e PME.

ABSTRACT

Artificial intelligence (AI) is one of the most interesting topics to be studied and developed and fascinating in terms of the different applications and usages.

The aim of this research work was to understand the relationship of AI in managerial decision-making. Hence, the theory developed was focused on the growth of the relationship between technology and management, specifically in decision-making, noticing the evolution of information systems (IS) to artificial intelligence directed to strategic, tactical, and operational decision-making. This line of thought was followed to understand if the usage of technology and AI was conditioned by firms' characteristics, in terms of being small, medium, and big firms. The research focused also in analyse the potential of AI and/or technologies in firms, more precisely, understand the changes on organizations due to the alterations provided by AI and technology. Also, understand the impact of AI in managers, in terms of cooperation if it was in the ideal weight to work and build success, and if they had suggestions to upgrade or implement AI within their firms. The sample was composed by administrates and CEOs of small, medium, and big firms, that were submitted to an interview.

The results of the content of analysis of the interviews reinforce the ideas exposed in the literature review, showing that the use of AI was most used in big firms, with higher conditions to invest on it, rather than in medium and small firms, that use IS combined with human rationality. With the help of chaos theory, it was perceived that the firms presented in the research do not implement AI/technologies in their processes as an attempt of solve problems but to understand if their usage would bring valuable benefits to them. Additionally, it was observed that the firms were not owning knowledge of the potentialities of the vast existence of tools with AI to apply in several areas but know that it builds success. Finally, there were requested the impacts of technologies and AI in the workers within firms, demonstrating that most of them offer resistance when implementing AI and technologies, feeling threatened but ends with the acceptance of it by seeing the better, quickly, and accurate results presented by it. The requested people mentioned that most of them fear the unknown, but it does not stop them from growing and working in the process of implement and know it, being aware of the increase its applications in the world.

KEYWORDS: artificial intelligence, information system, managerial decision-making, chaos theory, big firms, SME.

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LIST OF ABBREVIATIONS

AI – Artificial intelligence

ANNs – Artificial Neural Networks

BI – Business Intelligence

CEO – Chief Executive Officer

CFO – Chief Financial Officer

CRM – Customer Relationship Management

CSRC – Computer Security Resource Center

DL – Deep Learning

DSS – Decision Support System

EDP – Electronic Data Processing

ICT – Information and Communication Technology

IT – Information Technology

KPI's – Key Performance Indicator

MBA's – Management by Algorithms

MIS – Management Information System

ML – Machine Learning

NLP – Natural Language Processing

OGY – Ott, Grebogi and Yorke

QCA – Qualitative Content Analysis

SCM – Supply Chain Management

SME – Small and Medium Enterprises

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1. INTRODUCTION

The relationship between humans and artificial intelligence (AI) turned into a success, convincing government agencies to fund AI research at several institutions. Over the last few years, AI has been a target of strong growth both in study and development. Expecting large impacts and influencing the world in a lot of segments. Hence, it is of utmost importance to take great care in aligning technological advancement with the ethical issues attached to it.

Alongside, organizations seek to find and discover new technologies and tools to foster benefits and advantages, to keep up their competitiveness and innovation on the market. This is where AI arises as one of the most powerful tools in the achievement of significant productivity gains in organizations.

The practical results of AI applications, in the most diverse business niches, are increasing higher and higher insofar in value and importance, getting closer to managerial decision-making in corporations.

Since organizations' current concern is to provide the best they can to their employees increase their own value, and have a successful future, managerial decision-making has a strong weight when it comes to maximizing all variables.

Read and study these two topics allows researchers to perceive that a significant number of areas, cooperating with artificial intelligence, are bringing effective and efficient decisions, and, consequently, growing exponentially as a firm. Decisions made or helped by AI encounters a very large number of data and interactions, having the capability to learn and reproduce a solution each time, and when in a very similar situation it can come up with a better solution. As such, the aim of this research was to look through the relation of AI and humans within organizations specifically in the process of decision-making, being them small, medium, or big firms.

The data collection was based on chaos theory considering that humans are unpredictable, and AI could help to get better decisions, and by that understand if the need of AI was perceived as a consequence of chaotic situations.

Since this cooperation has been a true success in a significant number of organizations, the theme seemed interesting to understand the repercussions of it in workers, if it was felt as a threat to their positions in firms, even though it was a showed golden key.

2. LITERATURE REVIEW

2.1 LITERATURE REVIEW PROCESS

The main scope of this section was to understand the state of the current research in artificial intelligence, decision-making and AI empowerment in managerial decision-making. The questions that build up the literature review were:

- What research has been done on the type of models and steps of decision-making and on the type of management decision (operational, tactical, and strategic)?
- What research has been done on the relation between decision-making through different styles of management?
- What research has been done on the process of acceptance, rejection and symbiosis of human and machines in organizational decision-making?
- What research has been done on information technology that exists to help managers making their decisions?
- What research has been done on AI regarding decision-making and the respective tools?
- What research has been done on technologies and artificial intelligence implementations barriers?
- What research has been done on the integration of technology and AI in the success of firms?

These questions resulted in a literature review divided in seven parts, each scrutinizing the most important points to build the theoretical research.

The keywords used in data collection were decision-making, decision-making in organizations, information technology, artificial intelligence, Big Data, AI based-systems, information systems, human-technology cooperation, machine learning, digital assistances, managerial decision-making, strategic, tactical and operational decision-making, acceptance, managers' individual differences, big firms and SME.

The databases used in the search of identified keywords were Scopus, ScienceDirect, ProQuest, Web of Science, ELSEVIER, and Google Scholar.

As an exclusion criterion in the following, there were not considered conference papers, calls-for-papers in special issues, introductions of proceedings, and technical reports.

2.2 LITERATURE REVIEW FINDINGS

2.2.1 DECISION-MAKING AND ORGANIZATIONAL DECISION-MAKING

Decision-making is a cognitive process with a huge value in every personal and professional individual life. From the very first second of waking up, with small-scale decisions, such as eating healthy and exercising regularly, to every blink of an eye, with important and consistent decisions, such as buying a house or hiring an employee.

The sense of responsibility to make clear decisions grows with humans' development themselves since everyone has their past, their experiences, their knowledge, and their beliefs. And naturally, are influenced by what surrounds them and the specific situation in which each fit.

Considering that decisions are done predominantly by humans, this process handles either risk or uncertainty. Since people's brains drain things differently depending on different situations, if two different managers experience the same situation, being either in the same or in a different organization, their feedback, decision, and action will be different. Consequently, decisions always influence and determine the future of all the interested parts and guide the course of the group/organization through success (Papadakis et al., 1998).

(Uzonwanne, 2016) cited the definition of decision-making as it was asserted in the business dictionary, "*the thought process of selecting a logical choice from the available options.*" (*Decision Making n.d.*). This process outcome results from the behaviour and style of each individual while deciding. As such, (Scott & Bruce, 1995) accorded that there were four main styles of decision making, the rational decision making style – which consists of a decision that is more studied, thought and logical, less based on daily bases and predisposition –, the intuitive decision-making style – a decision based on hunches –, the dependent decision-making style – a decision that is made with the help of others directions and advice –, and finally, the avoidant decision-making style – a decision that is avoided to made altogether. By exploring and observing many processes of decision-

making, many studies placed rationality as the main variable regarding the decider, taking on individuals as completely rational being. Meaning that among all the possible alternatives to choose, individuals based their responses in research and logical evaluations, considering reason and facts.

Within organizations, decisions are hierarchical due to the magnitude of importance. And the way they were studied was based on rational models, (Zand, 1957) asserted that administrative decision-making was assumed to be rational. Videlicet, individuals are completely rational and complete successfully all the steps to decide. I.e., in the first instance, know how to identify and understand the problem, afterward can generate all the alternatives to solve it, then analyse their consequences and outcomes, knowing the decision criteria, and finally have the ability to make the optimal choice and implement it; considering in all steps past situations to avoid making the same mistakes.

Nevertheless, Herbert Simon (1982, 1997, 2009), the first one to present a different framework when referring to organizational decision-making, noticed that the rationality topic became to be talked with a lot more sensibility because of its limitations. (Zand, 1957) has strengthened the term invented by H. Simon, *bounded rationality*, defined under the assumption that the decision-maker looks after the best decision but normally doesn't make the optimal one, contenting themselves with the sub-optimal or the most satisfying decision, not being completely rational. This was explained by limitations due to each specific person as a decision-maker, decisions were many times based on each individual true of nature, having the possibility to be based on an incomplete and inadequate incomprehension of the problem. Also, the decision-maker was not capable of generating all the existing and possible alternatives that would lead to the best solution, since human brain limitations are more often related to memory, and there was a large possibility of evaluating and predicting wrongly all the alternatives' consequences.

Bounded rationality, as a term that fits lives reality, had opened the connection to artificial intelligence in the matter, promoting the interest in the possibility of being a powerful tool in the future (Pomerol & Adam, 2004).

Regarding the types of decisions, on the one hand, Gory and Morton (1971) discussed three types of decision according to their structure, structured decisions –

where variables can be measure quantitatively –, unstructured decisions – variables that compromise decisions cannot be measured – and finally, semi structured decisions – that are between structured and non-structured decisions. (Asemi et al., 2011).

On the other hand, two terms came up throughout Simon's researches (1997), programmed decisions – decisions that are repetitive and routine, meaning the procedure is repeated over and over each time it occurs, frequently guided by management guidelines –, and non-programmed decisions – that are one time decisions and less structured than programmed decisions (Asemi et al., 2011).

Programmed decisions being repetitive and normally guided, take past references and experiences into account to decide. As Simon's research gradually grew towards computers, information systems become to be seen as a vital tool to reunite most of the data regarding the organization, to provide better results and help managers avoid forgetfulness and unnecessary mistakes.

In addition, due to hierarchical positions in management, there are three types of decisions, according to (British Broadcasting Company, n.d.) they are, operational decisions – that lead to simple and day-to-day decisions –, tactical decisions – that are up to the middle hierarchy managers, related to medium and short term decisions, - and strategic decisions – that are made by managers in the top of the hierarchy, regarding long-term and complex decisions, that determine the future of the organization. The focus in this research is going to be in strategic decisions.

2.2.2 HUMAN-TECHNOLOGY COOPERATION WITHIN ORGANIZATIONS

The cooperation between humans and machines have won extreme prominence when human operators realized they did not have full control over events. Humans tend to control situations by means of a system of reasoning, relying on shortcuts or practical rules that circumvent the high cost of processing a lot of information.

It was believed that technology could be a useful tool in many areas, processes, and activities, however it has been a long way to tackle against the fear of this engine. Technology is a complex subject, (Brangier & Adélé, 2014) alleged that in many ways it is accepted and in many others it is rejected and criticised, but the major factors in the big picture of human-technology relation is living with it, being transformed by it, the degree of dependence of it, and increase ourselves and others by it.

This very fresh world of human-technology had been trying to symbiose human improvements with technology improvements, in a way of an extension of human's cognitive, social, physical and perceptive capacities. The dependence of Information and Communication Technology (ICT), for example mobile phones and television, had been increasing as the years are passing by, since the contribution of this features had been shaping and efficient in society and individuals.

From a variety of appearances, (Brangier & Adelé, 2014) considered that individuals give a great importance to the compatibility of their psychological and mental characteristics with technology physical and technical characteristics. People try to be comprehended, understood, accepted, and wants to be self-confident and secure near to someone or something, if technology transmits, has a role paper or moves closer to that in their lives, its acceptance would be easier.

Although, the sense of fear of the unknown, of being under control, being dominated by something, have something facing them, and in many cases knowing more than them make people resist to cooperate with it.

As such, the path of human-technology cooperation had passed through three main stages (Brangier & Adelé, 2014):

1. Rejection – related to the unknown, the difficulty to be used, the interruption of daily routines, not useful, and not used by the surrounding environment.
2. Acceptance – easy to use and learn, increase efficiency, time saving, fits well in the daily routine and is used and recommended by others.
3. Symbioses – is familiar and normal to people, feel adapted and stronger when coping with it, and doesn't picture their life without it.

This process depends a lot on the time of acceptance regarding all the different engines, for example computers, mobile phones and internet had different times of acceptance and symbioses due to each individual initial reaction time, many reject instantly and provide enhanced resistance to accept and others are ore open minded to this topic.

Following this line of thought, organizations, characterized by a higher degree of complexity, propelled by economic and social variables constantly changing, began to try to promote the acceptance in the use of technology, in many forms, as a promising, innovative, and comfortable solution to be constantly in a strong position in the market.

2.2.3 INFORMATION TECHNOLOGY AND ITS RELATIONSHIP WITH DECISION-MAKING

(Mukherji, 2002) reiterated that the implementation of technology in organizations has had major implications regarding what they were capable of doing in difficult situations with the presence of it as structures. The only way these symbiose was possible was because of the inclusion of Information Technology (IT).

Information technology, defined by *Computer Security Resource Center* (CSRC.NIST.gov, 2021), is any equipment or interconnected equipment system or subsystem with the purpose of automate, acquire, storage, manipulate, manage, move, control, display, switch, interchange, transmit or receipt data or information of an executive agent.

Within organizations the IT used was especially hardware and software in computers, that has grown in order to fit and fulfil each organizational environmental and strategic requirement. The combo of hardware, software, data, information, and communication was the base of the formation of an information system by means of mostly computers. The main objective of organizations was to decentralize their information systems, to subsequently decentralize their structures to combine in an efficient relation with their environments.

More and more in the digital era, information was and is power, and power was and is given by information, as such, to build and work for a better future and reach the ultimate success at the time, or even one step forward from competitors, technology is the precious tool. A tool that when well developed, well applied and well done to evolve, will lead to great results one behind the other.

The usage of technology excels in all areas of business, because of its promptness and standardization on tasks, its improvement in processes, its reduced costs in production and administrative, its higher security in all stages of business, its increasing credibility in process and information, and, also as the main focus of this research, its assistance and support in decision-making.

(Mukherji, n.d.) addressed that in a first stage, within organizations, the technology used was only based in computers with centralized systems and with smaller functions. Most of information were regarding accounting departments and were gathered in

Electronic Data Processing (EDP). Although, with the growth of data processing and the increasement of data processing capabilities, management became to have its own department of technology information, called Management Information System (MIS).

Management Information System, asserted by (Asemi et al., 2011), is an organizational computer-based system of information of the past, present and projections of the future. To assist managers on planning, control and operation activities and provide clear, confident and uniform information to decide and solve organization's problems. This engine provides an organization-wide information resource and analyses the situation, finds the problem and tries to understand it and provides the tools to make decisions, being characterised by:

- MIS is for individual decisions-makers.
- MIS generates reports with fixed and standard information.
- The programmer develops the MIS computer system, and the user only designs the report.
- MIS usually requires formal request to the information system department for report.
- Most of MIS' types of reports are scheduled and demanded.
- External data is used by the MIS but is not caught by the organization, such as information about costumer, supplier and competitors.

Developments made by computer-based systems led to another more specific system, the Decision Support System (DSS). This system was also designed to managers, supporting individually or in groups, but for any organization level of decisions in the process of solving semi-structured and unstructured decisions. (Asemi et al., 2011) pointed out that DSS characteristics were:

- DSS has a knowledge component to invest in efficiency and effectiveness.
- DSS handled more amount of data.
- DSS explores their variables in a graphical orientation.
- DSS provides the optimal answer to smaller problems.
- DSS provides a heuristic vision to complex problems, providing a really good answer but not necessarily the optimal one.

- DSS performs what-if analysis, the possibility of try hypothetical changes to data and observe results, and also, goal-seeking analysis.

Comparisons made by (Asemi et al., 2011) between MIS and DSS concluded that these two, across the variety of systems in the business world, were the best. Result managers' need of having precise and suitable data and reliable information in all levels of organizational hierarchy.

MIS gathered its information based on database reports and mathematical models and DSS considered computer solutions and managers solutions. As such, DSS was ratified as the broader for decision-making in organizations because it could support the same steps as MIS and provides more roles in decision-making and problem solving.

2.2.4 ARTIFICIAL INTELLIGENCE AND ITS RELATIONSHIP WITH DECISION-MAKING

Apart from IT, since the 50's artificial intelligence was being studied, and with the years passing by, the interest and search for technology that had the ability to provide human activities that combine automation and dynamic actions were increasing and getting into the market of all areas.

What is this so-called concept of artificial intelligence in the days of today? Artificial intelligence is a computer science that studies and develops computer programs to simulate cognitive functions and execute tasks that involve human intelligence to do it, such as learning, precepting, interacting, problem-solving and decision-making (Ziyad, 2019).

AI has in its roots many areas that are always in a developing and connecting process with each other to increase its efficiency and effectiveness, such as philosophy, logic, computation, psychology, biology, and evolution. The study of this areas provided the building of computerized systems that solve human problems. Through this six major subjects, artificial intelligence developed subfields that characterized the developments achieved, such as machine learning (ML), Natural Language Processing (NLP), expert systems, vision, speech, planning and robotics (Bullinaria, 2005).



Figure 1. Artificial intelligence subfields.

Vision through AI was developed to improve image understanding and recognition and decrease costs in acquire this information in a larger amount of data. Speech through AI is useful to recognize speech and produce text and/or convert text into speech. Planning through AI are the autonomous techniques used to pursuit a goal with only the starting state of a situation, which aims to solve planning and scheduling problems.

In terms of robotics, two different relations were in the matter, robotics itself and robotics related to artificial intelligence. Based on robotics, on one hand there are the creation of robots, programable machines, that develop tasks autonomously, however, on the other hand, there are AI robots, that are robots that execute tasks according to human's intelligence developed by artificial intelligence (Owen-Hill, 2017).

Regarding natural language processing, it is the process of understand and respond to human language. Through AI this subfield tries to process all the information received by humans in a written and spoken way, dealing with a complex problem regarding all the contexts, errors, figures of speech, colloquialisms and slangs, ambiguity, languages, and lack of research and development (Roldós, 2020).

About machine learning, according to (Pallathadka et al., 2021), this subfield consists in the area of data mining that provides to a computer program the capability of growing accurately when predicting outcomes, with no need of programming it, each strategy used by ML based on a learning algorithm. Advances in ML, (Janiesch et al., 2021), had given the possibility of AI to enter on society, both in the personal and professional lives, penetrating businesses and making a huge contribute in augmenting decision-making for productivity, engagement and employee retention, trainable assistant systems that are adaptable to each specific individual preferences and trading agents shaking traditional finance trading markets.

Machine learning can distinguish three types, - the supervised learning - , that has a training dataset of inputs to reach a target value of output, for example to forecast stock markets, understand customers perceptions, analyse customer needs or sech products; -

the unsupervised learning - that requires the pursuit of patterns in a learning system without any pre-specifications, for example in market segmentation; and - the reinforcement learning - that tries to achieve a goal by a list provided itself by means of the principle of trial and error, for example for market-making.

Researchers had put many efforts to improve the accuracy on learning algorithms, one of that was in the evolution of artificial neural networks (ANNs), that gave birth to a subset of machine learning, summarized as deep learning (DL). Deep learning performance can be superhuman, an example of that is *AlphaZero*, an AI programme developed by Google DeepMind, that has beaten *Skotfish*, up to the date the greatest chess program of the world. *AlphaZero* was a son of the exclusive IA training, their creators only gave it the rules of chess and the instructions to develop strategies to maximize the proportions of victories over defeats. It has its own logic of reasoning, playing in ways that humans had never played and sacrificing pieces that humans never consider to sacrifice (Kissinger et al., 2021).

Finally, the expert system, a system that is basically knowledge-based systems, systems that use knowledge, derived by experts, for their processing in solving problems, rather than just information. This systems do goal oriental, nonprocedural and heuristic processing, with a huge regard to assist and support decision-making (Peyton, 1985).

As such, AI had been in the mouth of every organization regarding any role to perform, from operational roles to more cognitive functions. The application of AI that is discussed in this research is on decision-making, being a remarkable step in the AI history and in a developing process in its initial phase.

The role of AI in decision-making, discussed by (Duan et al., 2019), could be in support and/or assist human decision-makers but also replace them. Even to other authors, it could release six different functions, as assist, criticise, give a second opinion, be an expert consultant, a tutor and an automaton.

For this very reason, AI is a topic of constant discussion when speaking about decision-making. People want their decisions to be the best for themselves and their environment, searching for the best methods, tools and systems to provide it. Although, many fears to lose power or their positions, be less leader, know less and culturalisms take place when accepting the inclusion of AI.

On one hand, AI could jeopardize the willingness, the eagerness, the satisfaction of work, the confidence, and some individual characteristics of managers. On the other hand, AI could provide decisions much more enhanced, from existing systems to platforms and gadgets.

In a conclusion term, AI could be seen as a benefit towards managerial decision-making, since it has the capability to group a large amount of data with different tools, providing managers the choice to select the data they want and the analysis of it too. The cooperation between both could be a surplus-value, gaining all managers, employees, and the organization.

2.2.5 INFORMATION TECHNOLOGY IN STRATEGICAL, OPERATIONAL AND TACTICAL DECISION-MAKING AND ITS INFLUENCE IN FIRMS SUCCESS

Information technology provided information systems and the implementation of it in firms was with the objective of providing solutions to businesses.

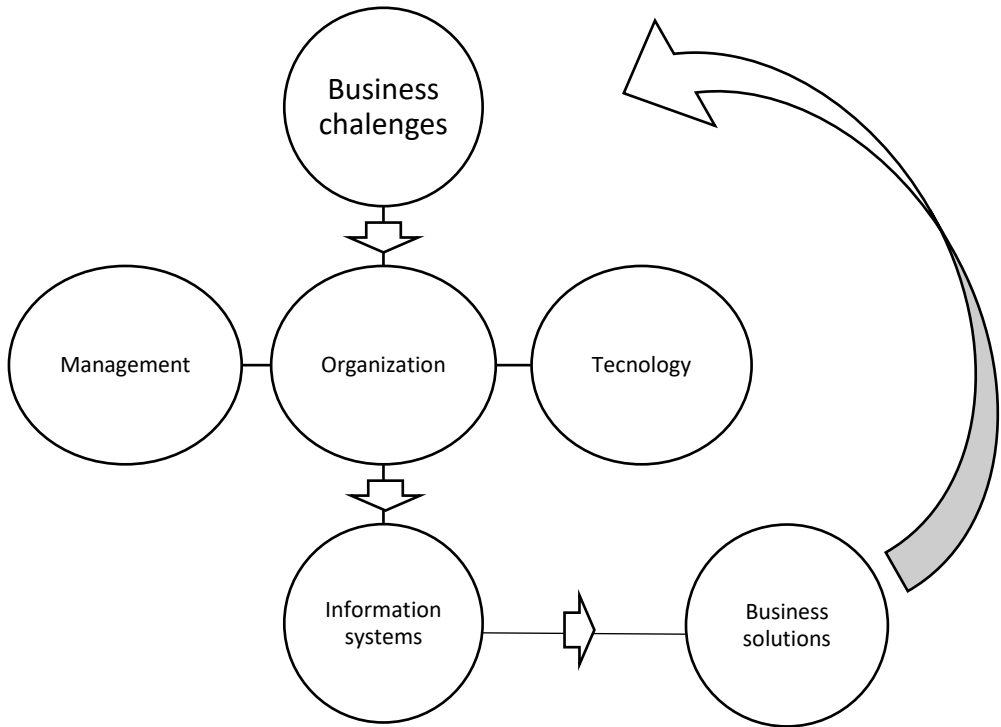


Figure 2. Information systems and its relation to businesses.

The illustration above, based on (Laudon & Laudon, 2019), shows that business challenges have three categories, management – responsible to know how to deal with several situations faced by organizations, make decisions and formulate action plans to address problems –, organization – composed by set of systems regarding the different

departments and areas within firms to lead the path of business –, and technology – is the implementation of technology solutions, with hardware and software, in order to firms build their information systems.

In this research the focus of technology solutions is on management support tools such as business applications, having examples of tools as ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCM (Supply Chain Management). These three examples help managers to streamline information processes regarding strategic, operational and tactical activities, storing information about different areas, like finance, human resources, production, sales, marketing, clients and supply chain (Martins, 2009).

The company that best adapts the applications of information systems to its operations, and that uses it more effectively in decision-making processes, will have greater competitive advantage in its sector of operation. Thus, the IT becomes a strategic resource for the organization, which applied efficiently and effectively becomes a critical success factor (Coelho, 2013).

Overall, information systems are a competitive factor, when maximizing its use, being crucial in strategic decision-making, helping administrative to make supported and reliable decisions (Martins, 2009).

And since communication and the process of decision-making are two factors that increase the efficiency and effectiveness of firms, and since information systems are focused on helping on it, the cooperation between both could provide a greater quality and less costs to firms' products and services, improving the firms' success in a medium and long run.

2.2.6 ARTIFICIAL INTELLIGENCE IN STRATEGICAL, OPERATIONAL AND TACTICAL DECISION-MAKING AND ITS INFLUENCE IN FIRMS SUCCESS

With the urge of technologies, artificial intelligence is intersecting information technology with the aim of predict things in the systems that are applied to firms to prevail more time in equilibrium.

According to (Duan et al., 2019), the role AI, through expert systems, could be used in the three levels of organizational decision-making, strategic operational and tactical.

Believing that in a replacement role, expert systems are effective in operational and tactical decisions but have limitations in strategical decisions, and in a support role, can make users make better decisions in all three levels of decisions, depending on their users to be reach higher levels of effectiveness. As such, expert systems are seen as a stronger tool, in strategical decision-making without replacing decision-makers but supporting them in unstructured decisions.

Although, there are many applications of AI in business, e-commerce and finance, that are becoming usual in markets, more specific to operational and tactical decisions, (Pallathadka et al., 2021) presented a few examples, among them:

1. Chatbots, used in e-commerce and finance, developed with AI and machine learning to improve client's satisfaction and better services to clients.
2. Image search, used in e-commerce, developed with AI to provide customers better services with image search.
3. Handling customer data, with more detailed data processing of clients through AI to have better results in all areas of the firm.
4. Inventory management, with AI, to analyse past data about sales and find a correlation with present and future sales.
5. Cybersecurity, as a machine learning tool to detect vulnerabilities and frauds in systems and to provide better security.
6. Human resources, with AI engines to help on choose the best candidate to fulfil the job position.

These tools are the most provided to firms to have better results in all areas and departments building efficient and effective operational and tactical decisions, since these applications are believed to construct reliable outcomes.

Artificial intelligence provides from the vaguest to the most specific and adaptable tools to companies, varying on prices from zero to millions, and depending on innovative breakthroughs.

All successes that are talked with implementations of AI in firms is because of the persistence and determination of inventors and technical engineers. And evidently the money and the proper investments to implement it, AI is on the market to everyone but only the ones that has money and resources to invest on it, are the holders of the biggest

success stories. Growing and increasing their competitiveness and innovation when compared to others (Makridakis, 2017).

The implementation of AI has a heavy reliance on the administration mindset and company culture, constituting barriers to its entrance, resulting from the lack of knowledge of its advantages and practicalities in the current digital world, the fear of the unknown, and a lack of strategy to address to it (Marr, 2019).

2.2.7 INFORMATION TECHNOLOGY VS. ARTIFICIAL INTELLIGENCE IN SMALL, MEDIUM, AND BIG FIRMS

In general, knowing that digital transformation is a fluid and constant process, the application of technologies with or without artificial intelligence has become an increasingly indispensable tool that comprises the competitiveness and innovation on the market.

The presence of technologies had been in a constant growing since organizations look at technologies and innovation has a priority and are speeding up their technological project.

Although, the implementation of technologies and AI has offered some resistance. Due to the lack of resources and the heavy influence of the administration mindset and company culture. Constituting barriers resulting from the lack of knowledge of its advantages and practicalities in the current digital world, the fear of the unknown, and a lack of strategy to address to it. This set of factors increase the resistance probability of changing within organizations (Marr, 2019).

On the one hand, there are small and medium enterprises (SME) that have presence of technologies and less presence of IA in their firms, evidently, the lack of resources shapes directly the capability of firms to invest in technologies. Although, the ones that have AI are a proof of an increasing of their competitiveness and innovation. (Wattanajatra, 2021) spotted some benefits to business that are implemented in some of SME, such as, the study of the behaviour of clients and potential clients, make predictions of what is going to be more sold, use chatbots to provide a quickly and efficient attendance to a customer, and the automatization of processes. In SME the applications of AI are more directly to operational and tactical processes and decision-making, with no

major investments in tools to help or assist in strategic decision-making. Being strategic decision-making based in information systems.

On the other hand, AI has already placed in few successful enterprises, with the basic tools, and had evolved them in more complex processes and activities. Amazon, Netflix, Google and other big firms, already uses Management by Algorithms (MBAs) as the new normal, replacing not so good managers for autonomous algorithms. Other big firms are implementing Power BI (Power Business Intelligence), a tool that unifies information and manage data, optimizing intern reports. And many of them are using AI as a tool to promote a greater security. In big firms, the investments in AI are higher and more, are being developed in the direction of help, assist or even replace strategic decisions, being already replacing people's jobs in operational and tactical decisions (Microsoft, n.d.).

2.3 RESEARCH OBJECTIVES

AI research has taken the development of expert systems that mimicked decision-making processes of people. AI has been penetrated human life, including work, since its appearance, being a delicate subject when calling into question the process of decision-making by humans versus the process of decision-making done by humans and technologies and/or machines in cooperation. Consequently, organizations had to analyse if AI competencies would be a good implementation in systems and what would be the repercussions, if positive or negative, in managers and employees.

In this way, the research aimed to understand:

RQ1: Understand the processes of strategic decision-making in small, medium and big firms and if they have the cooperation of technologies and/or AI in it.

RQ2: Analyse the potential of artificial intelligence and/or technologies within the firms. More precisely, understand the changes on organizations due to the alterations provided by AI and technology.

By that, understand the impact of AI in managers, if the cooperation of it is in the ideal weight for their work and success, and if they had suggestions to upgrade or even implement AI within their firms.

3. METHODOLOGY

To address a positive balance in complete the research objective, the research methodology chosen was the qualitative research.

This qualitative research was based on exploratory research that aimed to study the topic of artificial intelligence, that is relatively new, in terms of its implementation on strategic decision-making, to the specific country that this research was made, companies headquartered in Portugal.

This type of research, (Piovesan & Temporini, 1995), was made to get familiarized to the research topic since its examination is relatively new in its studies. There are a lot of studies about artificial intelligence, decision-making and its relationship with management, but few when approaching its relation to strategic decision-making. Therefore, this research came through defunded principles such as the improvement of learning when the topic is known and better understood; and knowledge must be open-ended.

The qualitative research methodology, (Gerring, 2017), is used to understand and explore an idea. It is expressed in natural language, comprising small samples selected in a non-random way. Usually involves qualitative research methods, such as ethnography, in-depth interviews, newspaper articles, photographs, official records, amongst others, allows the formulation of hypothesis, and is analysed by summarising, categorizing, and interpreting.

Qualitative methodology matches the research developed to the extent of gathering information to understand the presence, usage, pros, and cons of artificial intelligence (in the form of software, algorithm, or technology assistant) in decision-making within organizations.

To embrace the theory developed above, the data collected was based on a theory, the *Chaos Theory*. The definition, explanation and purpose of this concept was very important to show how this theory have helped in the extraction of data, in an organized, semi-structured and sequenced way. For a better understanding of all concepts, some examples were presented regarding the application of it in other areas than the area that was in research.

3.1 THEORETICAL FOUNDATION – CHAOS THEORY

Chaos theory is one of the most important scientific studies in the present, since it is used in all subjects that comprises both exact and human sciences. It consists in the occurrence of small changes in a primary phase of an event, that could create unpredictable, drastic and profound alterations.

Given that the main point of this research was to study and understand how the cooperation with artificial intelligence could improve decision-making in managerial systems, chaos theory was a helping hand. Chaos theory works with disruptions, that in this research could be related both with humans, as for misinformation and lack of memories, and artificial intelligence, as for technological systems and algorithm's mistakes, that interfere with strategic decisions within organizations.

According to (Vieira et al., 2015), chaos theory characterizes a non-linear dynamic system that reconciles the elements of unpredictable, being ideal to understand the strategy when long-run planning is quite difficult, and helps industries reaching a stabilized equilibrium requiring or not complex solutions.

This theory, applied in organizations, and based in physical science, leads with a lot of uncertainty since all the interested parts tend to have particular and independent behaviours, and having different reactions to uncontrollable variations of external conditions.

Thereby, the percentage of a state of chaos increase within an organization, given that there is a lot of interested parts to deal with. Consequently, very different outcomes emerge, and dramatic changes could happen in unexpected ways.

In this line of thought, the conceptualization of the *Butterfly effect* came up to gather this theory, explaining how a minimal change in a certain situation/place could make a critical turbulence in a long-distance space (Altinay & Kozak, 2021). Consequently, the only predictions that could be close to reality were short-run forecasts and patterns, needing adaptative guidelines to deal with the level of complexity.

Hence, some authors, as (Kumar & Sharma, 2021) and (Altinay & Kozak, 2021), approached chaos theory subdivided by stages, bifurcation, fractals, self-organization and strange attractors.

Bifurcation

Bifurcation explains that in a chaotic scenario is implicit that something is the reason to trigger the whole situation. Meaning in another words that bifurcation is the disruption points that sparks chaos, changing the equilibrium stage of an organization. This first stage is very important, because managers need to try to understand, develop and guarantee a rescue plan.

Fractals

Upon the bifurcation phase, it is necessary to analyse, collect and comprehend the whole disruptive situation, by means of “fractals”. According to (Vieira et al., 2015), the word fractals has its origin in the latin word *fractus* and the verb *frangere*, that means “break down into fractions”. Being characterized by the similarity of each individual piece with the whole object/situation, showing a repetitive pattern. And management scenarios fractals were ramifications of an entire structure regarding the coherent behaviour.

Although, as referred above, chaotic situations are believed to be in every aspect unpredictable, random, and disorganized. Nonetheless, there are some patterns that chaos creates itself, being noticed by repetitive patterns within an organization. I.e., the presence of self-similar components, across both people and algorithms, that ends with equal outcomes in same situations, requiring truthful and accurate data to avoid faults in the next stages.

In this stage is important that managers and technological systems and algorithms describe and measure the impact of complex systems and implement holistic approaches to see the bigger picture.

Self-organization

While passing through a chaotic situation, with a lot of changes, risk and unpredictability, organizations must be very cautious with everything. Mostly because

every action and decision, whether big or small, and whether operational, tactical, or strategic, will define their path.

As such, self-organization is a key stage. Allowing the reorder of the chaotic system, and changes in the level of knowledge, structure, procedures, and hierarchy, resulting in a system with a new form, more complex and rigorous.

In this stage, organizations should make short-run decisions to guide long-run decision-making, strategic decisions, and also, managers should guarantee the reinforcement of trust in all stakeholders.

Strange attractors

Upon the reinforcement of trust, managers appear as strange attractors, terminology used as the basic and principal values that unify all the stakeholders to reach the same big goal, promoting actions to generate benefits (Zahra & Ryan, 2007).

This would avoid more chaotic changes, guiding all members of the organization, including managers, employees, and customers, to walk in the same direction and achieve a new equilibrium.

In this stage managers play the role of leaders and must take quick actions and develop new politics that rebuild trust, confidence and solve misunderstandings, by the use of fractals, in all organizations' actors.

3.1.1 CHAOS THEORY: ITS APPLICATION IN DIFFERENT SCENARIOS

The understanding of chaos theory would help make a complex system more predictable. As far as the subject that is being studied in a chaotic situation presents characteristics such as being non-linear, have sensitivity to initial conditions, have no periodic behaviour, and chaotic motion deals with difficulties in forecasts and looks random (Biswas et al., 2018).

Thus, this theory could be applied to a large number of threads and have been increasing the list since their beginning. Some examples are addressed to the areas of economics, biology, computer science, engineering, finance, algorithm trading, meteorology, politics, population dynamics, psychology, robotics, etc.

Regarding biology, chaos theory had been applied to human bodies, given that human bodies functionality depends on the rhythmical movements and journeys of several dynamic systems, such as the beating heart, the process of breathing, the process of see and focus of the eye, and many others. (Biswas et al., 2018) showed that the application of this theory was a major advantage to develop control strategies in some diseases, such as is cardiac arrhythmia and epileptic brain seizures. This two were considered to be instances by chaos but their changes were too quickly to be developed by a mathematical model. As such,

E. Ott, C. Grebogi and J. A. Yorke were the first to make the key observation that the infinite number of unstable periodic orbits typically embedded in a chaotic attractor could be taken advantage of for the purpose of achieving control by means of applying only very small perturbations. After making this general point, they illustrated it with a specific method, since called the OGY method (Ott, Grebogi and Yorke) of achieving stabilization of a chosen unstable periodic orbit. In the OGY method, small, wisely chosen, kicks are applied to the system once per cycle, to maintain it near the desired unstable periodic orbit (Fradkov and Pogromsky 1998). The weaknesses of this method are in isolating the Poincaré section and in calculating the precise perturbations necessary to attain stability. (quoted by Biswas et al., 2018, p. 131)

Based on this method, there was developed a model to control the chaotic event of epileptic scenarios, with a control technique by waiting for the system to make a close approach to an unstable fixed point along the stable direction, and then make a minimal intervention to bring the systems back on the stable manifold.

Many efforts had been done in medical situations, but conclusions showed that human systems are composed by a lot of variables in constant and unpredictable changes, being difficult to have the exact prediction and consequently the exact solution. Although, predictions and solutions that had been made became a big help to trace, control and monetarize chaotic situations.

Regarding engineering, (Deepalakshmi et al., 2022) highlighted the engineering design context, that is described by elegance as a complex system designed with less hardware, less space, size and guaranteed cost and speed. As such, the chaotic situation

exits through complex dynamics and unpredictability in the time and space, being difficult to model these dynamics in nonlinear system's form.

Some examples were presented, outstanding the congestion control of data traffic on the internet. With the time passing by, data traffic through the internet demonstrated to be chaotic, and the solution of it was through applications of appropriate control techniques (fuzzy, neural network and some evolutionary algorithms) to enhance the process of decongestion and control. Recent studies of chaos resulted in the upgrade of integer-order systems to fractional-order systems, due to the limitations of the integer-order that had security breaches because of attacks of cybercriminals. Fractional-order chaos came modelled with fractional calculus (integral and derivatives), focusing on integration and differentiation of arbitrary order, culminating in fractional-order systems with better security templates to design systems to fight over stress that was provided by these attack dynamics.

Regarding management, the chaotic situations are present in the unpredictability of events, behaviors and changes in the environment and technology. As such, to maintain the equilibrium of organizations and bypass the volatility and vulnerability of chaotic events, more effort and attention is needed. (Debnath, 2022) stated that the unpredictability of systems could not be predicted but the randomness could be expected according to mathematical methods.

(Englund, R. L., 2009) gave an example regarding behaviors, acknowledging that chaos theory was useful to guide behaviors in an organization that depended on project-based work for its vitality. Theory said that small initial conditions would have huge influences on outcomes, contributing to the guidance of regular patterns of human behaviors and get around of unpredictability and chaotic situations. By that, the environment of the organization would be better to walk through the success.

3.1.2 CHAOS THEORY AND ITS RELATION TO THIS RESEARCH

The use of chaos theory in this research was used to scrutinize data about the implementation/inclusion of artificial intelligence within organizations.

Organizations, at the very begin, suit this theory because of its own non-linear complex systems, since their complexity reach a higher level and tend to always throw off

balance and origin chaotic situations. These chaotic situations have their origin in external or internal factors that are unknown and unpredictable most of the time.

The very objective of this line of thought was to understand, throughout the four stages presented in this theory. Firstly, with bifurcation find what was the cause or the variables that made the implementation of technology and/or AI in their systems be needed, secondly, via fractals understand the impact and changes of this implementation, both in people and areas. Then, through self-organization describe what was done within the organization, the decisions, measures taken, actions, policy changes, while AI was being implemented. Finally, with the final stage, strange attractors picture the new normal of the organization and understand if there was a new actor in it.

The presentation of the results extracted by this line of thought aimed to follow a time segment where these four stages are present as the detection, the impact, the action and the handle of it.

The scrutinize of this information was made backwards, figuring the past to understand the present and what changes could be done to bring a better, innovative and promise future to organizations. This to make more reliable predictions about the short-run and help in the long-run, to try to be close to a constant or increasing equilibrium through time.

3.2 DATA COLLECTION

(Assarroudi et al., 2018) suggested a method on directed Qualitative Content Analysis (QCA) that defends three phases, the preparation of it, the organizing of it and the reporting. Although the research had these three phases, the only one that was based on this method was the preparation phase, being the organizing and the reporting phase done, but in a different way.

In this part of the chapter, the only phases presented are the preparation and the organizing phase, being the phases matching the data collection.

The preparation phase consisted of:

1. *The acquisition of general skills*, as a qualitative researcher, such as the ability to develop skills to promote a fluid and fluent dialogue. And conduct the

interview based on original sources, as the base of the questions of the interview was chaos theory (explained in section 3.1).

2. *Select the appropriate sampling strategy.* The strategy to reach small, medium and big firms to obtain information about the research topic (detailed in section 3.2.1). The process of collecting data was achieved with the individual approach of respondents through e-mail, with a short presentation of the interviewer, the theme, what was their role and importance in the study and with a final question about their ability to schedule the interview (Attachment 1).
3. *Develop an interview guide.* The qualitative research was made through semi-structured interviews that followed a script. The script followed, in a major weight, through the theory explained above, chaos theory. The interview guide (Attachment 2) was divided in three parts. Firstly, the presentation of the interviewer and the contextualization of the research objectives, secondly, the obtention of information about the respondent and the respective organization. Then, a total of eight major prepared questions and some sub-questions about the research, with a leeway to make any change and alterations in the order of questions needed. And the part of acknowledging the respondents and their outcome.
4. *Deciding on the analysis of manifest and/or latent content.* The content aimed only to analyse the manifest content, the text only, and not the latent content, meaning that there was no description of the phases of the dialogue with silence, sighs, laughter, posture, etc.
5. *Conducting interviews.* The interviews were made through a web-based platform of video conferencing called *Zoom*, or in some cases, through a video-call by *WhatsApp* application. The usage of *WhatsApp* application was only needed when the *Zoom* platform was down for some firms. Each interview was recorded audio and image format, via *Free Cam 8* when executed in computer and screen capture when executed through mobile phone. All records were made under the consent of the respective respondent, and with regard of ethical questions.
6. *Specifying the unit of analysis.* In this research the unit of analysis was the transcription of interviews and the notes taken, if so.

7. *Transcribing interviews.* The transcriptions of interviews are presented in Attachments 3, 4, 5, 6 and 7, where it can be find the transcription of each individual interview according to chronological order.
8. *Immersion of data.* By reading and reviewing the transcript interviews several times and extract related meanings.

The organization phase was to understand the role paper of AI in strategic decision-making, and if it did not exist, understand the role of AI and advanced technology in other processes within each firm, being small, medium, or big firms. Following that, the assistance of the questions regard chaos theory, considering direct questions about the studied problem. The initial question served to set the direction of the interview, knowing if AI was used in decision-making or not, as the main category of the research. From that point, questions about subcategories were guided by the methodology above explained about chaos theory, allowing the sensing of a conduct line, and scrutinize the causes of the chaos that the implementation of technology and/or AI brought – bifurcation –, scrutinize the consequences of the chaos – fractals –, manage the chaos through coping – self-organization –, and finally manage the chaos through caution – strange attractors. With the three final questions, more judgmental, it was possible understand the feedback of cooperation with AI and technology in their firms.

The reporting phase was the phase regarded to the data analysis, being detailed in chapter 3.3.

3.2.1 PARTICIPANTS

As it was mentioned in point 2 of data collection, a sample strategy had to be done.

In a first stage, the target population in this study were people that work within an organization with or without profit-making and firms, more specifically managers since their power is deducted to make broader and greater-weight decisions. However, as the focus of this research had become more precise in the decisions made, strategic decisions-making, the sample had to be reduced to CEO's, executive officers and managers that usually make non-routine decisions that have long-term consequences (Hedelin & Allwood, 2002).

Regarding the organizations or firms, they worked on, there was no constraint at if they cooperate or not with artificial intelligence in strategic decision-making, although,

the only sought-after and crucial factor present in all firms was the automatization of processes. This automatization of processes was also linked to decision-making in order to cooperate with data bases in decisions and with technology or algorithms and machines in other departments and tasks.

The population quested was very tough to get in contact to, but the only way to make this happen was with persistence and patience in order to have an arrangement to schedule.

In this selection any demographic characteristics were not taken as relevant, the only preference was their function in the company and the type of decisions they made.

Table 1. Summarize of interviews via Zoom.

Respondents		Company	Function in the company	Duration (approx.)
A.	Marcus Teschner	COINDU.	CFO – chief financial officer.	30 minutes.
B.	João Vale	LEROY MERLIN.	Store director in Braga.	40 minutes.
C.	Ricardo Costa	Grupo Bernardo da Costa – Grupo BC.	CEO of Grupo Bernardo da Costa and administrator of the firms in that group, such as IBD Global Portugal, IBD Global España, A-Touch Winwel, AVPro, Academia Bernardo da Costa, Global America and SGC Cameroon; and President of AEMinho – Associação Empresarial do Minho.	40 minutes.
D.	Emanuel Guimarães	Soguima.	Operations director at Soguima SA and co-founder of Lufie London Ltd.	30 minutes.
E.	José Manuel Freitas	ALseguros.	CEO of ALseguros.	35 minutes.

On the following, the sample was composed by 5 executive officers and managers that generally made strategic decisions within their respective firm. Each decision-maker was connected to the respective organization; therefore, the organization sample was composed by 5 different companies, such as COINDU; LEORY MERLIN in Braga; Grupo Bernardo da Costa, composed by IBD Global Portugal, IBD Global España, A-Touch Winwel, AVPro, Academia Bernardo da Costa, Global America and SGC Cameroon; Soguima; and AL seguros.

This selection was previously studied and had a list of preferred companies. Although, as it was expected, the majority of them was not possible to be reached because of their responsiveness and availability to do it.

3.2.2 SEMI-STRUCTURED INTERVIEW

The technique used to gather information about the research topic was through interviews, that are one of a few techniques used in a qualitative research methodology and the most suitable to this specific research.

An interview, according to (Britto Júnior & Feres Júnior, 2011), is a technique of data collecting with a rational form to conduct, in an effective and complete way, the researcher. It can provide a deeper comprehension of the theme, contextual information to explain specific results, gives to the researcher the possibility to clarify things at the time and has the advantage of being more straightforward, personalized, spontaneous, and flexible. Although, some disadvantages or limitations could emerge in the process, such as the lack of motivation or knowledge by the respondent, other interpretations of the questions, wrong answers given consciously or unconsciously, and the influence felt by the respondent for various aspects.

Being interviews a precious tool, the interviews performed under the research were the type of semi-structured interviews, characterized by a set of open-ended questions that allow for a spontaneous and in-depth responses. This involves the preparation of a guide with pre-defined broader questions regarding the principle objectives to study, allowing the conversation to look after descriptive responses and other topics of subjects related to it, giving the researcher the opportunity to put the respondent more comfortable (Baumbusch, 2010).

3.3 DATA ANALYSIS

As was mentioned above, this qualitative research was based on the chaos theory and the data collection was made through interviews.

Due to the duration of interviews, the research aim was not supported to be considered a case study. As such, to analyse the data collected the technique used was the content analysis.

The reporting phase, the third phase mentioned in chapter 3.2, is the phase dedicated to data analysis.

In this phase, after the transcription of interviews, came the reading of it several times to underline and highlight the principal content of answers and gather the information that was straight to the point of each question, to extract.

The analysis of content was focused on examine answers, question by question. In this way, the presentation of results and the discussion of it was provided question by question with a summary of each respondent to the respective question, with an enumeration of the principal findings, and as a conclusion, the report of a discussion with the comparison of answers and showing the similarities and differences of each answer.

Also, a trustworthiness criterion was adopted along all steps of the data collected and analysed.

4. RESULTS AND DISCUSSION

The firms and groups of firms questioned in this research had involved small, medium, and big firms.

COINDU, a multinational big firm, is a leading supplier of seat covers to the Automotive industry with production in Portugal, Romania, Mexico, and Germany. And has its historical roots in Portugal due to the importance of sewing in the value-chain. The contribute given was done by Respondent A, Marcus Teschner, the group CFO of *COIUNDU*, being responsible for the administration of management financial risks.

The following firm is *LEROY MERLIN*, a big firm that belongs to the *ADEO Group*, comprises a chain of stores that sell DIY, construction, decoration, and garden items, operating in Portugal, Spain, France, Poland, Italy, Brazil, Russia, China, Greece, Romania, Ukraine and Cyprus. The feedback given was through Respondent B, João Vale, the store director of *LEORY MERLIN* of Braga in Portugal, being responsible by the human resources, the materials and financial issues in the respective store.

Afterwards, Grupo Bernardo da Costa, a family group composed by 8 firms around the world, that aim to conserve the well-being of their people. The 8 firms are *IBD Global* (Distribution of Electronic Security Solutions, in Portugal and Spain), *Academia Bernardo da Costa* (Training and Consulting, in Portugal), *iNERGIA* (Electrical installations, in Portugal), *A-Touch Winwel* (Domotic, in Portugal), *AVPro* (Professional Sound and Video, in Portugal), *Global America* (Installation and distribution, in Brazil) and *SGC Cameroun* (Civil Construction and Public Works, in Camaroon) and finally, *BC Safety* (Personal Protective Equipment, PPE, in Portugal). Almost all firms are small firms apart from BC safety, that is a medium firm, and IBD Global, that is a big firm. The representation of this group in this research is done by the CEO of Grupo Bernardo da Costa, administrator of the firms in that group and President of AEMinho – Associação Empresarial do Minho, Ricardo Costa, Respondent C.

Then, Soguima, SA., a medium firm, that is a reference in the transformation and marketing of fish products, having their brand and products present in more than 30 markets. The presence of this firm in this research is made through Respondent D, Emanuel Guimarães, an operations director at Soguima SA. and co-founder of Lufie London Ltd.

As a small firm, there was Alseguros, a company committed to the commercialization of credit and security insurance, as its main vectors, it offers solutions to support credit management and control in the internal and external market. The feedback given to this research was through José Freitas, CEO of ALseguros, responsible for management and commercial.

Presented all firms regarding their dimensions and objectives, the results about the research made are going to be presented divided by questions, according to the interview guide, one question by one question, with the responses of each interviewed.

4.1 INFLUENCE OF AI IN STRATEGIC DECISION-MAKING

The first question of the interview was “**Does your firm cooperate with AI in the decision-making processes?**” and the answer was to understand if AI had a role paper in the firm in decision-making processes, more specifically in respondents’ decisions, strategic decisions.

Analysing the answers given to question number 1, it was shown that all respondents answered no, except for respondent B, that said yes.

Respondent A, COINDU administrative, answered no, referring that their decisions were based on information systems, traditional controlling and KPI’s (Key Performance Indicator) but entirely decided with their human sensitivity.

Respondent B, Leroy Merlin store director, was the only one saying that AI is used in decision-making, mentioned that the firm was becoming more and more a *data driven* firm, stating that their “(...) increasingly basing their decisions on data analysis and not just on convictions and assumptions, (...)”.

Respondent C, Grupo Bernardo da Costa administrative, said no too and pointed out that their decisions were made through data extracted from ERP software combined with human and empirical sensitivity.

Respondent D, Soguima administrative, also said no and stated that their decision was based on databases, market factors, KPI’s and human sensitivity.

And finally, respondent E, Alseguros administrative, pointed out that their decisions were entirely made by humans and the only frame of technology worn was database with customers information.

All respondents, apart from respondent B, do not use AI in strategic decision-making, but uses IT tools. Respondent B is the only one using AI in strategic decision-making.

According to most responses given, a sub-question had to be done, **“Do you have any processes or activities where you have the cooperation of AI or advanced technology in it?”**, to try to find out if there was any presence in activities, processes or departments of artificial intelligence and/or advanced technology in firms.

Respondent A talked about the presence of AI in processes that are done by human capital, being used in operational decisions, such as in production when cutting leather and fabric in geometric forms, and to measure the quality of manual work of sewing.

Respondent C mentioned a platform they implemented to make a diagnosis about the mental health of employees and help promoting their welfare, with the purpose of enhance tactical decisions. Also, stated that they worked with AI and technologies, result of the products they sell, but nothing related to decision-making.

Respondent D stated that there is no presence of AI but there was a presence of a software in operational processes that perceive the real time productivity and production, influencing directly tactical and operational decisions.

Respondent E stated no presence of AI and advanced technology in any process or activity.

Respondent B had also extended himself in the theme and talked about other presence of AI in the firm, speaking about AI tools that sponsor tactical decisions, such as their supply chain tool in logistics to buy stock, the updates on the website to promote online sales and a satisfaction survey that makes a report and helps on trace actions.

This sub-question made all respondents thought about tools with AI and advanced technology and realize that these tools help to build stronger, more confident, and more realistic decisions, as they mentioned. And that their contribute was directly affecting

operational and tactical decisions, and, as it was expected, consequently influence the long-term performance and, therefore, impact strategic decisions.

4.1.1 OVERVIEW OF RESEARCH QUESTION 1

There was perceived that AI was, for sure, not used in strategic decision-making in the small and medium firms questioned, COINDU, Grupo Bernardo da Costa, Soguima and Alseguros. They use information technology, through information systems to gather their data and help in the process of decision-making.

Leroy Merlin, the big firm, was the only one using AI in strategic decision-making.

However, the all-sample, except Alseguros, the smallest firm, use AI in operational management, influencing operational and tactical decision-making process. Alseguros only uses technologies in the operational management, but only tools to make online work.

According to the responses given above, with a sample of 5 firms, on the one hand, there was one using AI in strategic decision-making, Leroy Merlin, the biggest and most known firm of all. On the other hand, there was 3 firms that use AI and advanced technology in operational and tactical decisions. And 1 firm, Alseguros, the smallest of them, an insurance company, that doesn't use AI and no advanced technology in any decision, neither in strategic, in tactical and in operational decisions.

After understanding the role of AI in all quested firms and understanding the role of information systems and databases on them, chaos theory purpose in this research had to be studied.

4.2 CHAOS THEORY

Subconsequently, question number two had to slightly change on firms that had no presence of AI strategic decision-making and focus on AI usages within the firms. Being **“In your perspective, what were the motives/turning points that made AI inclusion necessary in the processes of decision-making/activities/departments?”** searching for when decision-making/activities/departments become to be feared, concerning the bifurcation phase.

Respondent A mentioned time consuming, being expensive and had no improvements and not fitting the requirements, concerning human weaknesses. But the realization of this factors was only perceived after they observe the results with new tools implemented.

Respondent B spoke about the motives that made them implement AI in decision-making, noticing that humans have their weaknesses and that sometimes brought less assertiveness, less confidence, ambiguity and assumption-based decision.

Respondent C talked about gradual implementations of advanced technologies, usually in a trying mood to see if it could bring benefits not because of any difficult circumstance.

Respondent D stated a presence of little gaps in terms of accuracy on controlling systems and on production management, mentioning that the work done by human resources not always caught mistakes. Mentioning that only after the implementation of that specific tools the results were seen and perceived that it was a crucial tool in terms of innovation and competitiveness to the firm.

Respondent E has no answer to give in this question due to the fact of not using AI or advanced technology in the firm.

As such, on the one hand, respondent A, C and D figured out that their turning points were only perceived in a post implementation phase of the tools. In a pre-implementation phase, they were believing and trusting in their technical team's knowledge to invest. On the other hand, respondent B was the only one aware of the factors that made the changes needed.

Following the stages of chaos theory, comes the fractals phase, with the third question as **"What were the impacts noticed according to the changes that were happening through the time with that inclusion?"** seeking to understand the consequences of the causes referred in the bifurcation phase.

All respondents, apart from respondent E, mentioned human resources weakness and the benefits of the implementation of tools in operational processes. Stating that the automatization of that processes brought efficiency and effectiveness on production and

productivity. Also, all of them stated that it brought improvements to the firms at the big picture, even respondent E mentioned that he believed on improvements with it.

Other impacts noticed were time saving, less expensive, accuracy, safety, and reliability.

It is important to refer that only respondent B had usages of AI in strategic decision-making, the other respondents, B, C and D, apart from respondent E, only use AI and advanced technology in operational management, that directly influence operational and tactical decision-making.

Regarding departments, respondent A, B, and E, did not mention alterations on it and respondent C and D said that there was no significant impacts on departments, they felt affected but in a positive way, more supported.

Afterwards, there was self-organization stage with question number four, "**I would like you to describe a little what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures since the need of AI in the firm were being sensed.**", to understand what were the alterations that made possible the resolution of chaos.

Respondent A, C and D stated that there were no changes in policies and organizational environment, however respondent C mentioned that the changes made were on software, gradually, to fit better the aims of the firm.

Respondent B stated that there were no changes in policies but there were improvements in organizational environment due to their developments on it.

Respondent E had no answer to give in this question due to the fact of not using AI or advanced technology in the firm.

Furthermore, respondent A, B and D claimed rises on production and brand expansions.

As an overall, the changes felt regarding policies and organizational environment had no significant weight, the major changes were seen in terms of production and productivity, greatly hampered the company's growth.

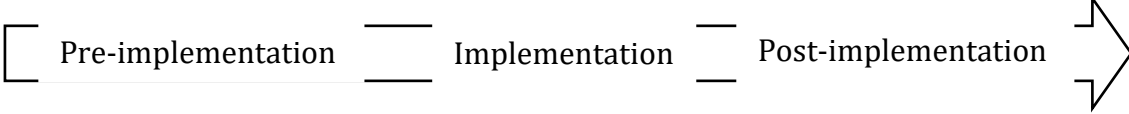
As the last stage, there was the strange attractor phase with the fifth question as **“What is the new normal of the organization in terms of decision-making assisted by AI, and is there any new actor? Or What is the new normal of the organization with the implementation of AI or advanced technology and is there any new actor?”** to understand if AI or advanced technology had a fundamental function in the organization and if it had changed the way things were.

All respondents, except respondent E, focused their answers on the last part of the question, referring that none of them had AI or advanced technology as a new actor. Although, they made clear that it has play in the processes. Also, none of them felt the company transformed but saw little differences on their results year after year.

4.2.1 OVERVIEW OF CHAOS THEORY

The chaos theory could be shown in the table above with a timeline of all phases.

Table 2. Synthesis of chaos theory through a timeline with respondents' excerpts.



	Bifurcation	Fractals	Self-organiza- tion	Strange attrac- tor
Focus of the ques- tions	Find disruption points/motives that made necessary the implementation of AI or advanced technology.	Look after the impacts during implementations of AI and/or advanced technology.	Understand if there were any changes.	Understand the role paper of AI and advanced technologies and if there was a new actor, and a new normal.
Respondent A	“(…) this kind of process is way much possible and less expensive with artificial intelligence. “(…) So, the need of it was perceived by our IT team analysing and observing the positive outcomes of its implementation while it was being used.”	“Efficiency and improvements in the processes that it is used.”	“There were no alterations in terms of policies or organizational environment, but there were significant improvements in terms of production and productivity.”	“No, (…) we believe this will bring us competitiveness and more added value for our exports.”

Respondent B	<p>“(…) allow us to make decisions much more assertive and based on facts and not on assumptions. (…) and with AI it is even more beneficial to organize more assertive and less ambiguous decisions. It brings more confidence in decision making.”</p>	<p>“(…) and the decision-making we created was much more relevant and brought much faster results.”</p>	<p>“(…) no alterations regarding policies, there were changes in organizational environment (…). Also, there were improvements in sales in all stores (…)”</p>	<p>“In our case, AI is not a new actor yet (…)”</p>
Respondent C	<p>“I think we had no motives to implement AI, we always implement it informed and with the proper technic team to have improvements, it was not implemented based on difficult situations or periods.”</p>	<p>“The effectiveness and speed of data processing. (…), we can usually get the most reliable data. (…) The most affected departments were purchasing departments, inventory analysis, best-selling products, and more obsolete products.”</p>	<p>“We have been working with software for more than 30 years and they have always been improved with a more specific adaptation to the company and the goal that is proposed to them in the organizational environment.”</p>	<p>“(…) there is a new normal, but that has not been drastically felt because it has been improved in a gradual process over time. There's no new actor because we've always had technology accompany us.”</p>
Respondent D	<p>“(…) Therefore, we develop in the part of the factory the innovation and implementation of the most rigorous control systems and production management, (…). (…) although we do feel the difference it made.”</p>	<p>“(…) because they realize that the benefits are not only for production increases but is also related to the accuracy, safety, and improvement of their work. At this time within the company no department has suffered from the inclusion of technologies, just feel more supported to make their decisions and progress all as one.”</p>	<p>“(…) noted in the expansion of the brand and in the increases in production, (…). Moreover, there have been no changes in internal policies or organizational environment. We just bet and realized that we could grow.”</p>	<p>“There is a new normal in decision making (…). However, it only influences the decision, does not own it. In terms of a new actor, I don't think technology is a new actor here at the company, it's just another player in the process.”</p>

Respondent E

“In terms of financial costs and even saving time. (...) work with much more positive and confident results.”

Accordingly to the results presented based on chaos theory guideline, the implementation and entrance of AI tools or advanced technology in firms was not seen as a rupture, because in most of them implemented AI and technology in a gradual way, not causing any kind of imbalance or chaos.

In fact, all respondents did not consider that AI would ever take actual humans' positions or substitute them on strategic decision-making, by that moment AI and advanced technology were only being implemented in operational management.

Respondents didn't feel the necessity of AI or advanced technology in their firms, however, almost all of them use it on operational levels. They all were aware of the uses of tools but not really informed of the vast potentialities of it. It meant that all interviewed firms, apart from Leroy Merlin, seemed to be not prepared to introduce AI in strategic decision-making due to their lack of knowledge in their potentialities.

This is probably why, many of them assumed a conservative approach of the theme and of following others, for example respondent A said, “To my knowledge there is not yet any application available in our market, but also there's not even a customise application that is already applicable to high level management decisions, only for operation decisions.”

4.3 RELATIONSHIP BETWEEN AI/ADVANCED TECHNOLOGY AND THE SUCCESS OF FIRMS

To understand if the cooperation of AI and advanced technology were in the right proportions within each company, question number six was **“Is the actual cooperation between AI and technology and the process of decision-making, in your believed, on the right proportions for the organization?”**.

Table 3. Cooperation proportion of AI and technology with humans meeting respondents' opinion.

	Respondent A	Respondent B	Respondent C	Respondent D	Respondent E
Right proportion	X			X	X
Wrong proportion		X	X		

More than half of the questioned people in this research answered yes, meaning that the cooperation between AI/technology and the process of decision-making were in the right proportions. Both respondent A, D and E had shown some lack of knowledge in the matter when talking about the presence of AI in decision-making and also fear of the unknown.

However, respondent B and C claimed that both, AI/technology and humans, have room for improvement and therefore more advances in technology/AI in firms could be implemented, and just aren't because of the lack of knowledge of their teams in so complex matters.

In a way to understand the impacts felt in heart of the firm, the assembly of workers, with the implementation of AI and technology, question seven was **“Talking about you, or even about the people in the organization that work directly with AI/technology, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in themselves, etc.)”**

Respondent B mentioned that, in decision-making, people felt more prepared and informed with the help of AI, this is, more self-confident. And, until that moment, he did not realize there was no one that was feeling diminished by it.

Respondent C and D also mentioned that people felt self-confident because of the better results with the help of technologies.

Respondent E did not talk about this question because there was no usage of advanced technologies.

All respondents, as a positive impact, highlighted as the feeling most said their sense of feel more supported. As a negative impact, the most said feeling was the fear of being replaced.

Finally, to better understand the respondents and respective firms open mind with AI and technology and balance if they were up to innovate and invest more or if they prefer to be risk-averse on this subject. With question number eight as **“Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.”**

Respondent A asserted that until that moment there was no intentions of new implementations since the COINDU is focused in improve the tools they have and adjust it more and more to the firm.

Respondent B showed some ideas about new implementations, focusing on more micro alternatives, to the stores. Stating that advanced technologies and AI are increasing innovation and competitiveness in their firm.

Respondent C said that their firm were implementing at the time a new tool, directed tool customers, and felt that developments in data analysing would be very interesting to increase competitiveness.

Respondent D stated that new implementations would be interesting, mentioned implementation in decision-making, believing that AI and advanced technologies head to innovation and competitiveness.

Respondent E stated that finds difficult to develop tools for insurance subjects but believes everything has space to develop. And if at the time there are proper tools their firm would be totally available to implement and try it, to cultivate innovation and competitiveness.

All respondents, apart from respondent A, outlined innovation and competitiveness while talking about new implementations of AI, seeing in it a way to grow and be more successful.

4.3.1 OVERVIEW OF RESEARCH QUESTION 2

It was perceived, by respondents that cope with AI, that the impacts felt by workers varied according to people's acceptance and rejection of coping with AI/technologies. But with time all become to felt familiar with it and also like working with it, but in a first instance, they were fearing of the unknown.

However, respondents felt that the inclusion of it within organizations, after the lead time, increases the results and the success of firms, considering it as a golden tool.

5. CONCLUSIONS

Is AI giving power to managerial decision-making?

The research done and the theory presented above, showed that AI is increasing its importance in the business world. Companies began to perceive that Big Data is the key to make better decisions, and artificial intelligence has the power to analyse it in a rigorous way. Although, many firms do not have openness or availability or resources to invest on it, constituting barriers to grow their competitiveness and innovation in the market compromising their success.

The research through interviews were focused on strategical decision-making on its development. However, some limitations were presented. Firstly, reach administrative people, related to strategical decision-making, was really tough due to their availability or lack of response, and some that were enquired talked about having no knowledge about the theme and preferred not to answer. And secondly, the fact that most of them do not used AI in strategical decision-making, caused some changes in order to understand the role paper of AI in firms and also technology if there was no presence of AI in any part of the firm.

The ambition of these work was to understand the power of AI in managerial decision-making and through the research made in strategic decision-making only the biggest firm had it. With the limitation of only one firm cope with AI in a strategic level of decision, the direction of the question was to revert to operational and tactical decision-making. All of them, apart from the smallest, the insurance company, used AI in operational management but without perceiving that, before its implementation, the company would have gained such a significant growth as a brand. And the smallest firm, that had no connections to AI, limited the interview by the use of opinion questions, despite showing interest in coping with it, knowing that it is a golden key to the ones that apply it.

As such, AI is seen as a precious tool and a proof of success in the firms that use it, and even the ones that do not use it are curious about the empowerment that it has and would have in the future. In my opinion, the growing of AI, in decision-making in firms, should be done with the proper knowledge and investment, since it is not a simple or a quick paradigm change, and needs to be specific to each company to give better results.

ATTACHMENTS

Attachment 1.

EMAIL TO REQUEST THE INTERVIEW

Subject: Interview schedule

Dear Mr./Mrs. _____ ,

I hope you find yourself with a good health!

I am sending this e-mail with the purpose of schedule an interview due to the master's thesis that I am developing - "Artificial Intelligence empowerment in managerial decision-making" - as a master student in the Master of Business and Management at University of Minho.

My interest in this interview is based on my willingness to collect information on the use and interaction of Artificial Intelligence, in the decision-making process, more specifically in strategic decision making.

Therefore, I believe that this interview will be an asset to my study and to the successful collection of information about my dissertation.

With appreciation by your availability and looking forward to meeting you soon.

Kind regards,

Ana Isabel Vilaça Gomes.

Attachment 2.

INTERVIEW GUIDE

Part 1. Contextualization of the developing research.

Understand the processes of decision-making in your firm/organizations and the potential of AI on the processes. More specifically, understand the process of strategic decision-making, decision made according to the long-term, as well as the help given by AI in those; understand the impact of AI presence in decision-making; understand the ideal equilibrium of the cooperation of AI with strategic decision-making; and understand if there are suggestions to improve AI or even to adapt it better to the organization's environment.

Part 2. Data to extract about the respondent.

The main objective is to deepen knowledge about them, as employee/CEO of, and about the firm/organization/store. Such as, name; function performed; and about the firm (small, medium, or big firms).

Part 3. Interview questionnaire.

Table 4. Interview questions straight to the research objective.

Questions	Objective	Chaos Theory
1. Does your firm cooperate with AI in the decision-making processes?	Understand if AI and/or advanced technology have a role paper in the firm in decision-making processes. If not, try to understand the role of AI or technology in other parts within the organization.	
2. In your perspective, what were the motives/turning points that made AI inclusion necessary in the process of decision-making, normal activities or even in departments?	Try to understand what the situation was, where decision-making/activities/departments become to be feared (e.g.: lack of confidence).	Bifurcation.

<p>3. What were the impacts noticed according to the changes that were happening through the time of that inclusion?</p>	<p>Understand the consequences of the causes referred in question number 2.</p>	<p>Fractals.</p>
<p>4. I would like to ask if you to briefly describe what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures since the need of AI in the firm were being sensed.</p>	<p>Understand what were the changes noticed that made possible solve the chaos.</p>	<p>Self-organization.</p>
<p>5. What is the new normal of the organization in terms of decision-making assisted by AI, and if was there any new actor?</p>	<p>Understand if AI had a fundamental role paper in the organization and have changed the way things were.</p>	<p>Strange attractor.</p>
<p>6. Is the actual cooperation of AI and the process of decision-making, in your believed, on the right proportions for the organization?</p>	<p>Understand if the cooperation of AI and technology were in the right proportions to the respondent.</p>	
<p>7. Talking about you, or even about the people in the organization that work directly with AI, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in themselves, etc.)</p>	<p>Understand the impacts felt in the human part of the firm by the implementation of AI and technology.</p>	
<p>8. Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers to improve.</p>	<p>Understand if their availability to innovate and invest in more competitive factors, such as AI and technology, or if the fear of the unknown was greater.</p>	

Part 4. Acknowledgements

Thank you very much for your contribution, it was a privilege to talk and hear you.

Attachment 3.

TRANSCRIPTION OF THE INTERVIEW OF RESPONDENT A.

Question 1: Does your firm cooperate with AI in the decision-making processes?

We are using processes with artificial intelligence but not in decision-making. Well, we only use the help of another things like information systems.

It is not supported by anything else, so it is nothing like, for instance, comparing to a “diagnosis system”.

We have traditional controlling and information systems for management in all the areas, in sales, in finance and also in qualities, we also have different applications over the processes, we have KPI's for everything, but we do not have AI in further decision-making.

Sub-Question A.1: But do you have any processes or activities where you have the cooperation of AI in it?

What we do, for instance, is a typical activity on cutting leather and fabric and we use a pattern, which is called, let's say, the next thing of geometry, where we use interactive approach with artificial intelligence that is improving and optimizing the yield, we can get out of a given geometry of a given surface.

Another area where we use this, is for instance to measure the quality of manual work, the manual work consists in suing, so working with a sewing machine is still a manual work. And the camera system that is used to measure the accuracy of the individual sewing stitches is measured by a kind of an artificial intelligence whether it is fitting or not the quality requirements.

These are typical applications but for decision making in management or so far, we don't have any applications.

Question 2: In your perspective, what were the motives/turning points that made AI inclusion necessary in the processes that you talked about?

Regarding the activity of cutting leather and fabric was through the comparison of doing it manually and with the help of AI. The manual way of doing it made us understand that with the help of AI we achieve improvements which were and are significant in usage because this kind of process is a much possible way and less expensive with artificial intelligence.

About measuring the quality of manual work was to understand if it was fitting or not the quality requirements.

So, the need of it was perceived by our IT team analysing and observing the positive outcomes of its implementation while it was being used.

Question 3: While you were implementing the AI, what were the impacts noticed according to the changes that were happening through the time of that inclusion?

Efficiency and improvements in the processes that it is used.

Question 4: I would like to ask you to briefly describe what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures since the need of AI in the firm were being sensed.

There were no alterations in terms of policies or organizational environment, but there were significant improvements in terms of production and productivity.

Question 5: What is the new normal of the organization assisted by AI, and is there any new actor?

No, there is not a new actor. We are investing more and more in the qualification of human resources, in digitalization, in the automation of processes and in innovation, and we believe this will bring us competitiveness and more added value for our exports.

Question 6: So, at this point, in your company, do you believe that AI and technology are in an ideal weight?

Yes. Because we already have some heavy and significant implementation of industry 4.0, not having these processes I wouldn't see it. It's kind of a level to reach before having the need to use higher levels of automated processes. Otherwise, it doesn't make sense to us.

Sub-question A.2: Are you thinking about implementing AI in the strategic decision-making process?

No, because of two issues: one is quantitative, and another is qualitative.

The quantitative issue is regarding the cases where we are using iterations. What you can handle manually or see manually is let's say 5,6 maybe up to 10 iterations, to improve geometry the artificial intelligence is useful because goes up to 1000 steps/iterations. This is the quantitative issue where artificial intelligence is helping and improving.

On the other hand, the quality, it also needs to be precisely defined and related to an existing process. Now when we talk about management decisions, that are relevant, first of all they are compared to automated processes, they are very few.

So, it is accepted or not accept order, it defines a price for a quotation, it is deciding about capex project or not, so each time it is a discreet event, which does not happen too often. And therefore, there is no issue about not being able to manage quantity and then each process on its own has, let's say, conditions that might be subject to change.

So, we had, if we look back at the last two years, we had covid, it has been changing everything in all supply chains, so therefore decisions had to be made and the process have to be redefined from scratch under a modified environment.

We are supplier to the automotive industry, so last year we had to completely review a lot of things due to the shortage of semi-conductors which was affecting all our customers, so a lot of projects in terms of volumes were not valid anymore.

This year, we have also a new change in the world, the war, and this is also affecting the supply chain. So, therefore there is no standardisation of the process, which basically allows me to say that there is always a limited number of triggers for decision that I can outsource for my brain into a machine.

Sub-question A.3: Yes, I understand but are you open-minded or do you want to cooperate with AI? With your ideal weight of it, of course.

Yes, I would like to do it. But what would be the example where you could see somewhere else already using AI in decision-making?

Interviewer: I know an example here in Portugal that uses algorithms that try to put the right options to decide, they are developing its own algorithm to provide it the capability to learn more and more and make itself develop according to the errors made and be more adaptative to their organizational environment.

To my knowledge there is not any application available in our market yet, but also there's not even a customise application that is already applicable to high level management decisions, only for operation decisions.

The highest level which it is commonly used today, from what I know, and you know more about it because you're working on that, is in medicine. In medicine it's fantastic because you have a high-level professional, and it is easier to have access to unlimited database of knowledge to combine with his ability with their decision-making in a diagnosis with the help of artificial intelligence.

But it is not management because at the end of the day doctors are highly trained professionals, and repeats diagnosis 20 times a day on each new customer. This is a repetitive process, is an operational process. And the management decision in a company for more important subjects or things that do not happen on the repetitive base it's something completely different so therefore I do not see that yet.

Question 7: Talking about you, or even about the people in the organization that work directly with AI and technology, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in themselves, etc.)

I think on the positive side, we have the support, the replacement of automated process like any kind of automation which is positive. And on the negative side it can make people redundant, it is like productional automation but at another level, it is also replacing a pilot by an automated pilot.

Question 8: Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.

Well, we have our own IT and process engineering team, we have machine suppliers developing also. It is basically a combination between machine suppliers and our own resources, and they are the base of all implementations. Until now we are adapting and adjusting what we have implemented, and we are not thinking about new implementations.

Attachment 4.

TRANSCRIPTION OF THE INTERVIEW OF RESPONDENT B.

Question 1: Does your firm cooperate with AI in the decision-making processes?

Yes, more and more.

We don't use any kind of artificial intelligence in stores, but we're increasingly using it at the central level, which obviously resonates with operations and later in stores.

From last year we became a much more company, as we call it, data driven. Data driven is an English term used to show that companies are increasingly basing their decisions on data analysis and not just on convictions and assumptions or what we usually call, in everyday language, the "I think that ...".

And therefore, today we already have a very robust database of all our activity in the most diverse areas, in the customer, in logistics, in the products, in the offer, in sales, etc. We already have data from all our activity where it is possible to base our decisions more and more on this data analysis.

Sub-question B.1: But do you have any processes or activities where you have the cooperation of AI in it?

Starting last year, we introduced some artificial intelligence tools to help us make some decisions in what is given with a gigantic volume and done exclusively with human analysis becomes more difficult.

I can give some examples, we have implemented a tool, called RELAX, a supply chain tool in our logistics area, which was implemented last year, to completely revolutionize the way we buy stock. Therefore, it is a very important part in a company like ours that operates in the retail area, and so the purchases of stock that we make daily for all our stores and for our central stations are very important for our economic performance and sales.

This tool already holds AI, that is, until last year we had specialized teams that made the purchase of stock every day for each store specifically and central posts, and now continue to be the people to make these purchases, but with one this tool, which has an algorithm with AI working behind and that greatly facilitates this work of shopping. This tool, having already incorporated several AI algorithms, can predict things that normally the human eye escaped our teams. We based our purchases a lot on the history of the previous year and now with this tool, it has a number of parameters, that gives us predictions that are not only based on history but also based on the present.

To make this more concrete, I can explain it a little bit more. This tool considers variables such as market trends, also has the time, that is, the weather conditions, directed to our seasonal sections in store such as the garden section, the swimming pools, heating, air conditioning, air conditioning, etc. And therefore, the tool alone calculates whether we will sell more such items or not. It also considers the articles that are most searched in our online and also at the store level, that is, the tool will search for data of both the most searched products in the whole country and also specifically the most searched products per store, for example only in Braga. For example, if there has been a change of

microclimate and people in Braga are looking for a certain product, the tool takes into account this and directs our purchases more to this demand, for later sale.

It also takes into account events that do not happen every year, but happen in a specific year, for example, covid, we in the confinement period last year, in February, April and March, most of the trade was closed but our stores were still open, we had a very strong sales boost, which was exponential in some families, notably focused on what people needed most for comfort at home to be confined. And we also had in online shopping. That is, it was a specific event at that time and that does not repeat itself in the following years, and we without the tool we were going to buy stock based on this history but this is no longer repeated in the following year, and therefore the tool already takes into account these events and already relativizes this boom in online sales and families of the previous year and no longer makes purchases based on the previous but according to a more current forecast and counting that COVID will no longer provide the same scenarios.

Another example, which has to do with the site. Since we at Leroy Merlin have been triggering our online sales for 2 years, we have been doing a lot of activity on the site.

This is because online sales began to have a very strong weight in the company. Today our site is already built with some AI tools, namely in online campaigns, for example in order as we present the articles that have to do with a series of data analysis based on online consumer behavior. The tool already highlights the articles best evaluated by our customers and the most sought after both in terms of sales and in terms of clicks.

Another example still has to do with a new tool that was launched very recently and that has to do with an action that we have in our company. We do employee satisfaction surveys quarterly and in this survey there are some answers that are straightforward, the responses that are scaled, from 1 to 10, where people answer about a particular topic if they are very satisfied (10) or completely dissatisfied (1); and there are also open answers where employees can write about the form of text, what they value most, what they liked most to live and suggestions or improvements that they liked to see in our store. And so when it comes to text data analysis is always more difficult and takes a long time. And that's how this year's AI tool was implemented to do the analysis of responses and prepare a report with the mood of the store. And it's a pretty big help in terms of time spent on data analysis, and also in tracing action plans.

These are the two most practical examples that have a great impact on the company and that influence our daily life and decision-making.

I don't have any information from other strands with artificial intelligence that we have. But we will certainly have other tools in other departments but i don't know about.

Question 2: In your perspective, what were the motives/turning points that made AI inclusion necessary in the process of decision-making, normal activities or even in departments?

All the tools that have AI are already very robust are already very well prepared and therefore allow us to make decisions much more assertive and based on facts and not on assumptions.

Decisions based only on the human factor are mostly based on our beliefs and what we believe it is and what may not be.

Today how technology has evolved in such a way and databases in all areas of the company are already so robust and we have data so consolidated that the smartest way to use this data is to analyse with more appropriate tools, and with AI it is even more beneficial to organize more assertive and less ambiguous decisions.

It brings more confidence in decision making.

Question 3: What were the impacts noticed according to the changes that were happening through the time of that inclusion?

We noticed that the action plans we created and the decision-making we created were much more relevant and brought much faster results.

And it surprised us because we did some decision-making exercises without and with these tools, without and with data analysis, without and with AI and then we saw that the decisions made, in some cases, were different.

So, we saw that there was some change here regarding what I said about "I think", we made some decisions based on feelings, in what we thought was the best and when they were based on the databases they were more concrete and attacked our challenge much better.

Question 4: I would like to ask you to briefly describe what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures since the need of AI in the firm were being sensed.

Within the store there was no alterations regarding policies, there was changes in organizational environment given the tool developed for workers satisfaction. Also, there was improvements in sales in all stores due to the tool developed to predict real results to purchase according to each specific store.

Question 5: What is the new normal of the organization in terms of decision-making assisted by AI, and is there any new actor?

In our case, AI is not yet a new actor, but I believe that will happen. And I believe that today in Leroy's stores there are still no functions only taken by AI, but I would say that in a year's time we will have because we are already thinking about it and how we will develop this function but will always have the help of the human hand dedicated to full time for that.

Sub-Question B.2: Do you think there will be people being replaced by AI or more advanced technologies?

It is difficult to answer this question with the information we have today, but I believe it may be possible.

Question 6: Is the actual cooperation of AI and the process of decision-making, in your believed, on the right proportions for the organization?

I'd say not yet, we still need to develop more when we talk about the store. Because the examples I gave are examples that we use AI in the company to make several decisions, but we are still in a more macro context, of company, and not to the micro context, more store driven. Because we do not yet have tools that allow us to make decisions in the store and I believe they will be developed soon but not for now.

I believe that the ideal weight would be more human than AI, but it also depends a lot on how the company operates. Because we hear value people very much and we are sure that they are a differentiating factor in the market, which is precisely the relationship with our customers. And I see that AI is something that will be part of and that will surely help us but that will not replace our people. But I believe that in the areas of technology and industry there may be a greater replacement.

Question 7: Talking about you, or even about the people in the organization that work directly with AI, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in their selves, etc.)

People were affected, yes, but they dealt with it in a positive way. I have no reports of anyone who has felt diminished or replaced.

The human factor for us continues, we don't replace people with machines or AI, we put people making decisions with much more information and with that support, so that they feel more prepared. They see this as a very effective and pertinent help and not someone who makes the decisions for them.

Question 8: Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.

My suggestion is to even implement AI more locally but on a micro plane.

In ways like getting something to help us better understand the local reality. This is because we have 48 stores in the country and each store has its own specificity, has its own culture. I can say that there are articles that the store here in Braga sells a lot and, in the South, does not sell anything, and vice versa.

Customers are very different from store to store, we have 48 stores and they in terms of customer behaviors, sales, and challenges to continue growing are very different. And we still need to adapt our decisions to the site and so the help of AI. In order to decentralize.

We at Leroy, we are very open to the inclusion of new technologies and AI because we see it in a positive way and each added value to innovate and be more competitive.

Attachment 5.

TRANSCRIPTION OF THE INTERVIEW OF RESPONDENT C.

Question 1: Does your firm cooperate with AI in the decision-making processes?

We work with artificial intelligence on security, on the products we sell. In decision-making, there is little, is used in the analysis of data processing.

All the data extracted from our software, ERP, allows us to then make series of decisions, process decisions, procedures and even organic. Decisions are not 100% data-based, there is a lot of human and empirical sensitivity, but there is a basis given by the presence of the data that is provided by the software.

However, there is not the whole presence of machine learning.

Sub-question C.1: But do you have any processes or activities where you have the cooperation of AI in it?

In the human resources department, we use a platform directed to the mental health of employees, flex health, which processes data through a questionnaire answered by employees that provides a result on the mental health status of employees and teams.

Also, we have technicians who work with artificial intelligence, fruit of the products we sell, but not directed to this type of specific software to make decisions.

This is interesting to think because there is a lot that we do not associate with where artificial intelligence is and it turns out to be present.

Question 2: In your perspective, what were the motives/turning points that made AI inclusion necessary in the process of decision-making, normal activities or even in departments?

I think we had no motives to implement AI, we always implement it informed and with the proper technic team to have improvements, it was not implemented based on difficult situations or periods.

Question 3: What were the impacts noticed according to the changes that were happening through the time of that inclusion?

The effectiveness and speed of data processing.

And, the fact that we consider it reliable, by the way they are treated as long as we put the correct parameters, we can usually get the most reliable data. What's more, often when we are treated by humans there is always some superficiality in the treatment and, therefore, it was perhaps the main factor.

It is not that we do not believe in people, in fact, in the group we value people a lot, but there is always data that to be treated only by people are directly impacted by subjectivity. And what we consider is that our data processed by artificial intelligence, or the computer part is obtained with more impartial information.

The most affected departments were purchasing departments, inventory analysis, best-selling products, and more obsolete products.

Question 4: I would like you to briefly what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures that the need of AI in the firm were being sensed.

We have been working with software for more than 30 years and they have always been improved with a more specific adaptation to the company and the goal that is proposed to them in the organizational environment.

Question 5: What is the new normal of the organization in terms of decision-making assisted by AI, and is there any new actor?

There was no impact that transformed the company, that is, there is a new normal, but that has not been drastically felt because it has been improved in a gradual process over time. There's no new actor because we've always had technology have always with us.

Question 6: Is the actual cooperation of AI and the process of decision-making, in your believed, on the right proportions for the organization?

In my opinion, we can always improve processes, and I think artificial intelligence will always help.

Therefore, it is in constant evolution and will not stop because the market also does not because there is more and more data to be processed and so this evolution that is made in software providers also have to keep up.

Now if you ask me if the percentage, at this moment, in the company or in the group is ideal, I cannot answer. I believe that there must be always a human component and maybe at the moment it is 40%/60% in technology/AI cooperation with the human component, but it could go to 60%/40%, not necessarily in decision-making, but in companies as a whole.

But it's a difficult question to answer right now.

Sub-Question C.2: Do you think that if they ever implement artificial intelligence in decision-making, it will be a unique position for it, or will it always have the human hand?

In our company I believe that will always have the human hand, I do not see a single position and exclusively for this nowadays.

Question 7: Talking about you, or even about the people in the organization that work directly with AI, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in themselves, etc.)

In terms of negative impacts, in people this was not felt, but also because we also value a lot people, I believe that there are no reason to fear technology because people will always be important. Although, the help of some technologies in processes made people feel supported and confident in what they were doing.

The impact felt in companies and, therefore, in the group was on development and competition in companies.

Question 8: Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.

We are currently implementing the interaction part primarily with customers, so that the most complete data analysis is available and for better and easier interaction with customers. We have been implementing this project for 6 months and is expected to be completed between June and July this year, and therefore is another benefit that will exist in the organization.

Moreover, it is as I told you, the more data we can deal with, the more information we must be able to make the best decisions and it is in this evolution that we are focused on this point in the group, in our context.

Sub-question C.3: That is, what cooperates in decision-making processes are only the database and information technologies?

Yes, that's all. I do not see, at least in a short time, the decisions to be made by "machines" and not by people. Although technology, artificial intelligence, is part of and has a big weight when making the decision, I don't see the possibility that the decision will be made solely by them.

Honestly, I think it may be the future, but always with collaboration and cooperation with humans, in this scenario I can imagine.

On this subject I feel that there is still some scepticism, and although I consider myself current, I still consider myself very lay in the matter. I see artificial intelligence on the perspective of the product and not about the optics in decision making.

And as whole these developments culminate in the increase of competitiveness.

Sub-question C.4: Do you feel that sometimes people may feel threatened by the unknown or because they don't know the topic so well and so they don't go deeper or explore so much?

I don't happen to feel threatened by the matter, however I haven't been awakened to this situation yet, and also the company is very involved in the way we've done things historically. However, I have no problem if one day changes and decisions are made by

artificial intelligence, but always with the human hand cooperating. Because more and more this matter is of greater confidence.

And of course, the unknown scares, but it is necessary for us to think that we will always be useful, and that human contact is a differentiating factor.

Sub-Question C.5: Then artificial intelligence does not propose to any position?

No, not right now, but we don't know the future.

Attachment 6.

TRANSCRIPTION OF THE INTERVIEW OF RESPONDENT D.

Question 1: Does your firm cooperate with AI in the decision-making processes?

In terms of artificial intelligence in decision-making processes we do not use.

Our decisions are made based on feelings and are also obviously on market factors, also in the evolution in certain KPIs that we have. Through the monitoring of the information that makes us grow in the market, in terms of customer information, sales, this is ultimately combined and culminates in a decision. But very much based on what we think is right.

However, in terms of decision support we have our databases, with information on customers, the logistics of the flow of goods in the different markets in which we operate, the national trade associations and product analysis information.

Sub-question D.1: But do you have any processes or activities where do you have the cooperation of AI in it?

At the level of production proportions, we have implemented a software that allows us to perceive in real time the productivity within the factory and consequently realize if we are following and meeting the objectives.

In terms of help in processes and activities within the factory, the technological function is fully mechanized and implemented to streamline processes and specify the work, but does not have any kind of autonomy, it is all controlled and mechanized by workers.

Our goal with the computerization of some processes is to optimize production and make production follow the growth and expansion of the brand, so that production improves in terms of quality and time consuming, and also that promotes greater safety to employees.

Question 2: In your perspective, what were the motives/turning points that made AI inclusion necessary in the process of decision-making, normal activities or even in departments?

Soguima has spared no effort to keep up with evolving market trends and new production technologies. Therefore, we develop in the part of the factory the innovation and implementation of the most rigorous control systems and production management, but always accompanied by the hand and human eye to certify the effectiveness of the technological process.

We do not feel the need to implement technology, although we felt the difference it made.

Question 3: What were the impacts noticed according to the changes that were happening through the time of that inclusion?

As far as people are concerned, they usually offer some resistance and it is normal, but it is also normal that after some time they adapt and become familiar with the benefits that technological innovations bring and accept their inclusion in the processes. Also, because they realize that the benefits are not only for production increases but is also related to the accuracy, safety, and improvement of their work.

At this time within the company no department has suffered from the inclusion of technologies, just feel more supported to make their decisions and progress all as one.

Question 4: I would like to ask you to briefly describe what happened to the organization due to the changes felt in terms of decisions/actions or even the taken measures that the need of AI in the firm were being sensed.

Process automation was strongly noted in the expansion of the brand and in the increases in production, which was able to respond in the best way to our customers' expectations and present products that met the most demanding requirements of quality and food safety. Moreover, there have been no changes in internal policies or organizational environment. We just bet and realized that we could grow.

Question 5: What is the new normal of the organization in terms of decision-making assisted by AI, and is there any new actor?

There is a new normal in decision making because we have managed to grow and of course with the help of technology this has become as quickly as possible, and our decisions are evaluated in a new way. However, it only influences the decision, does not own it.

In terms of a new actor, I don't think technology is a new actor here at the company, it's just another player in the process.

Question 6: Is the actual cooperation of AI and the process of decision-making, in your believed, on the right proportions for the organization?

In my opinion, it is in the right proportions for the knowledge I have in the area, because it is meeting the expectations we have and monitoring and strengthening our growth. However, I believe that there could be greater intervention, both at the level of decisions to be made and at the level of processes and departments.

I believe that the future will be mostly composed of technologies and AI, however the knowledge we have about it is still very little and the fear we have about the unknown is capable of being even greater.

Here at the company, I believe that we will always give due importance to the human being and that he will always have a higher percentage to decide than AI, seeming to me totally possible the cooperation between the two.

Question 7: Talking about you, or even about the people in the organization that work directly with AI, what were the impacts noticed, both positively and negatively? (e.g.: if there was any lack of confidence in their selves, etc.)

All of us as humans are afraid of the unknown and we don't accept it until we adapt to it.

There are always those people who are initially against it but try to perceive and observe and only then draw conclusions, realizing that technologies can help and contribute to a better and safer work, and that they are not expendable by cooperating with it. Ending on feeling more backed and confident in their work.

And of course, there are also people who feel distrust of technologies with their insecurity and fears about the position in the company and even fear dismissal because they are no longer useful or can be exchanged.

Question 8: Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.

At the moment we believe that we could use the help of more technology or even AI to be more innovative and increase competitiveness, but we are not informed about it and I think in Portugal it is not common yet.

In my opinion, it would be interesting to implement a tool directed to decision-making to experiment and see the results, understand the impact of it and the differences it could cause in the company, but always with a hand of people behind, and with a last decision of a human.

Attachment 7.

TRANSCRIPTION OF THE INTERVIEW RESPONDENT E.

Question 1: Does your firm cooperate with AI in the decision-making processes?

We do not use artificial intelligence in any type of activity in the company.

We are a company with few employees and therefore the work is all done by us, of course with the help of technologies in the processes as is the example of social media assistance, the website and video conferences. And for customer information we have our database, CRM, but that only saves the data.

Question 3: What impacts would you think you could have cooperation with more technology or even AI?

In terms of financial costs and even saving time. I was able to realize this when we started to have an online work regime, still with gives in when necessary to make face-to-face meetings. But since we started working online that our workers are much more productive, there is a better relationship between us and there is much more motivation to do things, which ends up culminating in work with much more positive and confident results.

Question 6: Is the actual cooperation of AI and the process of decision-making, in your believed, on the right proportions for the organization?

Personally, I think it is in the right proportions also because we are not aware of some kind of tool that operates and is an asset to our services due to its complexity.

For example, if I take out health insurance for an older couple, it's completely different from taking out health insurance for a younger couple, because it assumes that the point of wanting to have children will no longer fit into one.

There are these little things that make customer service must be customized and well-studied more by the human part.

But I think you're always going to have to have more human hand than AI because it's a differentiating factor.

In an increasingly competitive market, the proximity to our Policyholders/Clients allows us to provide a high quality of service, with permanent assistance, based on a high degree of professionalism.

I think this also derives a little from our culture here in Portugal, that we value people and their abilities, so we are afraid of being replaced. But of course, this also involves fear of the unknown and a lack of information on the subject.

Question 8: Is there any suggestion or willingness to implement or adapt any tool/software/algorithm/etc. in any department or activity? That would help be more specific to the firm organizational environment/workers improvement.

In the future I can visualize cooperation with Artificial Intelligence, yes, if it is well developed in this area. But I find it difficult because, for me, this area is an area with lots of details and details that insurance to insurance change depending on the customers.

However, if it develops and we get to know it, I think it would contribute to our growth and innovation.

Sub-question E.1: Do you have any team dedicated to technology or this branch?

No, here at the company, since it's a small company we don't have.

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