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The impact of intelligent systems on management accounting

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Abstract

In today's competitive and changing business environment the concern about technologies and intelligent systems has gained more notoriety. However, companies still have many tasks performed by humans, in a medium-term, intelligent systems will become prevalent in companies and will perform tasks that are currently done by humans much more efficiently. There is a need for companies to adapt and to start thinking about combing human and intelligent systems capabilities. This research was focused specifically in the management accounting profession, as these professionals spend a lot of time doing repetitive tasks that can be easily and quickly accomplished by intelligent systems. In this research was studied the impact that Artificial Intelligence, Big Data and Internet of things can have in this profession. According to the questionnaire that was applied, management accountants see intelligent systems as a support to their functions, however they have a big resistance to change. Following a set of interviews conducted to intelligent systems professionals, they also support this view and appointed huge benefits of intelligent systems, although there is still a long path to go through. Implementing these technologies in management accounting daily tasks is perceived by these professionals and by intelligent systems professionals as having a lot of advantages, however there are still some barriers that need to be address as the lack of transparency of these systems and the lack of people with knowledge in both areas. Despite everything one thing is certain intelligent systems will have a huge impact in the management accounting area.

Key Words: Artificial Intelligence, Big Data, Internet of things, management accounting

JEL Classification System Code: O14 - Industrialization; Manufacturing and Service Industries; Choice of Technology; M41 - Accounting; O32 - Management of Technological Innovation and R&D

Resumo

No ambiente empresarial competitivo e em mudança dos dias de hoje a preocupação com tecnologias e sistemas inteligentes ganhou mais notoriedade. Contudo, as empresas ainda têm muitas tarefas desempenhadas por humanos, a médio prazo, os sistemas inteligentes serão prevalentes e realizarão tarefas que atualmente são desempenhadas por humanos muito mais eficientemente. É necessário que as empresas se adaptem e comecem a pensar em como combinar as capacidades humanas com as dos sistemas inteligentes. Esta investigação focou-se especificamente na profissão de contabilidade de gestão, visto que estes profissionais despendem muito do seu tempo a realizar tarefas repetitivas que podem ser facilmente e rapidamente realizadas por sistemas inteligentes. Nesta investigação foi estudado o impacto que a Inteligência Artificial, o Big Data e a Internet das coisas podem ter nesta profissão. De acordo com o questionário aplicado, os contabilistas de gestão veem os sistemas inteligentes como um suporte para suas funções, no entanto apresentam grande resistência à mudança. Após as entrevistas realizadas a profissionais de sistemas inteligentes, eles corroboram esta visão e apontam enormes benefícios dos sistemas inteligentes, embora ainda haja um longo caminho a percorrer. A implementação destas tecnologias em contabilidade de gestão é considerada por esses profissionais e pelos profissionais de sistemas inteligentes como tendo muitas vantagens, porém ainda existem algumas barreiras que precisam ser ultrapassadas como a falta de transparência destes sistemas e a falta de pessoas com conhecimento nas duas áreas. Apesar de tudo, uma coisa é certa os sistemas inteligentes terão um grande impacto na contabilidade de gestão.

Palavras-Chave: Inteligência Artificial, Big Data, Internet das coisas, contabilidade de gestão
Classificação JEL: O14 - Industrialização; Indústrias de manufatura e serviços; Escolha de tecnologia; M41 - Contabilidade; O32 - Gestão de Inovação Tecnológica e P&D

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Glossary

AI – Artificial Intelligence

IoT – Internet of things

ANN – Artificial neural networks

RFID – Radio-frequency identification

ERP – Enterprise resources planning

IMA – Institute of Management Accountants

Iscte – Instituto Superior de Ciências do Trabalho e da Empresa

PLS – partial least squares

IS – Intelligent systems

IT – Information Technology

CEO – Chief Executive Officer

α – Cronbach Alpha

CR – Composite reliability

AVE – Average variance extracted

HTMT – heterotrait-monotrait ratio

Introduction

In the last decades, we have seen several changes in the technology sector, which are increasingly complex and more advance. Technology is changing society, challenging the way we live, interact and work. We already live in a world where intelligent systems can do things that previously only humans could do. In an era of increasing digitalisation of services, it has become necessary for companies to adapt and change to meet demands, as well as integrate the new emerging technologies in their structure and study their impact across the company. The intense competition that companies face and the challenge of staying differentiated and be competitive in nowadays market has led organizations to start to realize the importance that emerging technologies have for the success of a company.

Artificial Intelligence (AI), Big Data and Internet of things (IoT) are three intelligent systems increasingly used by companies. The integration of this technologies in organizations structures remains to be very relevant because it will impact the way people work, deal with information, and is set to soon invade the businesses world. In this paper the impact and importance of each on the management accounting area will be studied. Management accountants are responsible for identifying, analysing, interpreting and communicating information to managers (Rybicka, 2018; Zahid & Vagif, 2020). Management accountants provide very important information that are used in several decisions, they are a crucial element in the decision-making process that are essential for reach all the business goals.

According to the articles published there is a clear gap on the impact of AI, Big Data and IoT on management accounting, so in this research it´s intended to study and clarify this impact. Throughout the literary review, many authors analyse these intelligent systems and the influence of it in the company in general but few authors focused specifically on this profession, and the ones who did not apply their tools in practice and left only speculations. Consequently, this investigation aims to add value by showing the benefits and relevance that these three intelligent systems have to management accounting.

The approach to Big Data and IoT is extremely relevant as we live in a digital age where the amount of information available is huge with many forms, formats and from many sources (Choi et al., 2018; Younas, 2019). Big Data is a large amount of data, that can be characterized by a 5V´s model and can be analysed for insights that lead to better decisions and strategic business moves (Younas, 2019). IoT is the network of physical and virtual objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet (Goyal et al., 2020; Mohanta et al., 2020). IoT is a more recent intelligent systems but is growing very fast and is set to keep growing in the future.

IoT is becoming one of the most important sources of big data, and the influence of it is rapidly expanding (Goyal et al., 2020; Mohanta et al., 2020). Analytics involving AI can be very helpful in analysing the immense volume of data generated, allowing it to be quickly retrieved and reviewed (Grable & Lyons, 2018; Richins et al., 2017). AI is the ability of a machine to do tasks that normally require human intelligence (Huang et al., 2019). AI and Big Data work very well together, all the information provided by Big Data is needed to train the learning algorithms of an AI in order to reach machine intelligence (Floridi, 2019; Huang et al., 2019). The ability of AI to do tasks that are usually done by humans more efficiently is an intriguing and ever more worthwhile prospect, causing these processes to be increasingly studied and refined (Huang et al., 2019; Shrestha et al., 2019).

The impact of these 3 intelligent systems on management accounting is very pertinent to study, as management accountant's role involves processing huge amounts of information and then communicating it to managers. Then, managers use accounting information to make important decisions. Therefore, study ways to simplify the daily tasks of management accountants will have a big impact in the speed and quality of the decision, which will allow the development and application of effective managerial decisions which will serve as a fundamental prerequisite for a company's competitiveness in the nowadays market (Nicoleta, 2019; Rybicka, 2018; Zahid & Vagif, 2020).

These technologies will inevitably be the future and will enable unprecedented control and power to their users. To deal with it, it will be required people that understand how to combine human capabilities with these new technologies and be capable to apply it successfully in practice.

Objectives

This research has as main objective analyse and study the impact of Big Data, AI and IoT on management accounting and answer to the four research questions that are mentioned bellow.

Resulting from the investigation taken for the purpose of the literature review, there were several points of view presented by different authors. Many studies that focused the impact of intelligent systems in companies were identified. However, there are few studies about the real impact of these intelligent systems directly on management accounting and if these professionals can use these technologies to have improvements in their productivity and efficiency. In this paper it's purposed to thoroughly understand and discuss the advantages of the integration of intelligent systems on management accounting.

As a result of such investigation, the following research questions were defined:

Q1) *How does IoT impact management accounting?*

Q2) *How can Big Data and AI improve management accountants' processes?*

Q3) *What is the possibility of implementing AI, for decision making, in management accounting?*

Q4) *What will be the shifts in management accounting profession with the massive introduction of intelligent systems into day-to-day tasks?*

Thesis structure

This dissertation aims to deepen the theme related to the impact of three intelligent systems on management accounting, namely by answering the research questions that originated throughout this project. To this end, the following structure was designed: initially an introduction of the theme under study was carried out where the relevance of the theme was demonstrated, after that the objectives of the present study were identified.

Chapter I, intends to investigate the three intelligent systems on which this investigation focuses, as well as management accounting profession and the link between them, through an in-depth study of the main authors in this area. Firstly, the concepts of AI, Big Data, IoT and management accounting is analyzed through different perspectives, after the relationship between these concepts was studied, in the end was analyzed the future of management accounting.

Chapter II comprises the theoretical approach, where is possible to observe the basis of each research questions. In this chapter is intended to carry out an analysis of each research question. Chapter III includes the methodology that was used to obtain the necessary answers, a quantitative and qualitative analysis was chosen through the elaboration of a questionnaire and interviews.

Chapter IV contains the presentation and discussion of the results. Here, the answers that will answer the research questions were analyzed and, later, compared with the authors' theories, in order to deepen the study. Finally, to conclude this dissertation and withdraw some final notes was presented a conclusion of this study, some limitations and suggestions for future researches.

Chapter I – Literature Review

1.1 Intelligent Systems

1.1.1 Artificial Intelligence

The origins of AI can be traced back to the 1940s (Haenlein & Kaplan, 2019). John McCarthy who is considered the father of AI defined it as “the science and engineering of making intelligent machines, especially intelligent computer programs.” (Bolander, 2019). However in this definition he wasn´t able to describe what intelligence is and what is necessary for a computer program to be considered intelligent (Bolander, 2019).

The word AI was then formally coined, in 1956, when Marvin Minsky and John McCarthy organize the *Dartmouth Summer Research Project on AI*. The objective of this project was to bring together

researchers from several fields to building machines able to simulate human intelligence. The well-known ELIZA computer program was created here by Joseph Weizenbaum, ELIZA was a natural language processing tool able to simulate a conversation with a human and one of the first programs that pass the Turing Test (Haenlein & Kaplan, 2019).

The Turing test was created in 1950 by Alan Turing. This test is still considered today as a benchmark to identify intelligence of an artificial system: if a human is interacting with another human and a machine is unable to distinguish the machine from the human, then the machine is said to be intelligent (Haenlein & Kaplan, 2019; Huang et al., 2019; Schoenick et al., 2017). Shoenick et al. affirm that machine intelligence today is viewed less as a binary pass/fail attribute and more as a combination of different capabilities associated with intelligent behavior (Schoenick et al., 2017).

According to the Oxford Dictionary, today AI is define as: "The theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages" (Petkov, 2020).

AI is distinct from previous generations of information technology in that it can learn and update using data. The input for the learning is data, which can include text, audio, and video and can be contextual or noncontextual. Data is essential for AI to train and then to apply its training. The ability to learn from various types of data and learn from a massive amount of data and update thoughts or actions is what makes us consider a machine to be intelligent (Floridi, 2019; Huang et al., 2019).

The methods by which AI learns from data are various computational methods, with machine learning and deep learning being especially important methods (Lewis & Denning, 2018). Beside these two computational methods it is also possible to consider others. The main ones are mentioned and explained in the table 1.1:

Table 1.1: Main AI sub-fields and respective description

AI sub-fields	*Characteristics*
Machine Learning	Provides algorithms for computers to discover information and make decisions by learning from the given data. This provides the foundation for AI to teach itself. Machine learning basically uses adaptive algorithms to build models that clarify connections between relationships, make correlational assumptions and then apply what has been learned to make future predictions (Bolander, 2019; Choi et al., 2018; Grable & Lyons, 2018; Zhang et al., 2020; Khan & Al-Habsi, 2020).
Deep Learning	It´s a machine learning technique, inspired by the structure of a human brain, it teaches a machine to go deep in its learning, by process inputs through layers in order to classify, infer and predict the outcome. Deep learning algorithms try to draw similar

	conclusions as humans would by constantly analyzing data with a given logical structure. To reach this, deep learning uses a structure of algorithms called Artificial Neural Networks (ANN). (Huang et al., 2019; Zhang et al., 2020).
Artificial Neural Networks	Works on the similar principles as of Human Neural cells. They are a series of algorithms and intelligence that captures the relationship between various underlying variables and processes the data as a human brain does. ANN programs do this by simulating what goes on the human brain by using algorithms to recognize patterns in data and then extrapolate connections, features, and outputs to make decision making faster and more accurate (Bolander, 2019; Choi et al., 2018; Comaniciu, 2020).
Natural Language Processing	A science of reading, understanding, interpreting a language by a machine. Once a machine understands what the user intends to communicate, it responds accordingly (Zhang et al., 2020).
Computer Vision	Tries to understand an image by breaking it down and studying different parts of it, uses the image and pattern mappings in order to find solutions. This helps the machine learn from a set of images to make a better output decision based on previous observations (Zhang et al., 2020; Khan & Al-Habsi, 2020).
Cognitive Computing	Refers to the computer systems inspired by the human brain, which tries to analyze text, speech, images, objects, have natural language processing capability, learn from experience, interact with humans in a natural way in a manner that a human does and try to give the desired output. This aims to help making decisions based on learning processes (Pilipczuk, 2020).

Source: Self-elaborated

These computational methods allow AI learning and the output of the learning is AI performance (Darwiche, 2018). Huang *et al.* (2019) state that AI converts data into performance in three qualitatively different ways, which they refer as AI intelligences. Some AI systems are mechanically intelligent, designed to perform repetitive tasks for consistent results; some AI systems are thinking-intelligent, designed to learn and adapt from data autonomously and some future AI systems may become feeling intelligent, designed to interact with people and respond appropriately to human emotions. Conversational AI, like chatbots that use natural language processing to process and analyze natural language data is flourishing. However true emotional machines are more difficult to achieve because they must have the ability to recognize human emotions and respond in an emotionally appropriate way.

Furthermore, Huang *et al.* (2019) study affirms that in the current economy, employment is more attributable to thinking tasks because mechanical tasks have largely been taken over by machines.

However, in the last period, AI has rapidly developed improved thinking capability. The authors of this article consider that we are entering in an economy in which the feeling tasks of jobs, such as interacting and communicating with others are becoming more important for human workers than the thinking tasks of jobs. They call this the Feeling Economy, in this economy the soft skills will become more important and a decisive factor.

This industry transformation is called the fourth industrial revolution, initiated as the digital transformation of manufacturing into connected factories that support smart decentralized manufacturing, self-optimizing systems and a digital supply chain. The Fourth Industrial Revolution called Industry 4.0 takes production to another dimension of performance, flexibility and mobility. The idea of Industry 4.0 emphasizes the role of integration of complex physical machines and devices with sensors and network software used for controlling, planning and forecasting, ensuring better results. The implementation of this will allow the development of intelligent production systems in multiple areas of organizations (Grabowska, 2020; Hermann et al., 2016; Richins et al., 2017).

The main reason for these shifts is that AI and other technologies that mimic or even beat human intelligence have advanced quickly from being mechanically capable to be thinking capable (Hermann et al., 2016; Huang et al., 2019). Additionally, the promise of fast, accurate, repeatable, and low-cost decisions, with quality approaching human-like intelligence has been an important driver of the rapid developments in AI (Shrestha et al., 2019).

AI allows the creation of new information and forecasts from data, provided that the future can be predicted by existing data (Shrestha et al., 2019). The implementing of AI today will build a strategic advantage for the future, that may leave competition faraway (Goyal et al., 2020).

Beside all the possible advantages of incorporate AI, it is much less clear what the real impact will be. Many human cognitive tasks can apparently be easily automated by AI, but there is a risk of loss in predictability and explainability. By using AI, the patterns, the answers will emerge without any explanation and because of this will be difficult to interpret. The lack of interpretability and transparency of AI-based decision-making algorithms makes it difficult to identify biases that can be embedded in the data, this can eventually lead to biased algorithmic decisions (Bolander, 2019; Burrell, 2016; Shrestha et al., 2019).

Moreover, many authors affirm that the implementation of AI in the daily routine will result in unique ethical and legal challenges (Cubric, 2020; Dwivedi et al., 2019; Haenlein & Kaplan, 2019; Robles Carrillo, 2020). Cubric (2020), Dwivedi *et al.* (2019) and Robles Carrillo (2020) also mentioned in their papers the economic and technical challenges that AI will face. Equally important are social barriers, such as increased dependence on machines, job security fears, lack of people with knowledge in this area, unawareness of potential benefits, safety issues and lack of trust in this technology (Cubric, 2020).

AI has the possibility of replacing and augment jobs, as AI technologies improve to higher intelligence levels, human jobs will tend to be transformed to focus on tasks that are more difficult for AI to assume. Automating human tasks through AI can potentially lead to significant financial gains, but it will change for sure the decision-making process. Despite AI capability to simulate aspects of human cognition, human and machine intelligence are obviously very different. Teaming up with AI is necessary and will have a deep impact on many aspects of our lives, jobs, and society as a whole, however it´s not clear yet the magnitude of this change (Bolander, 2019; Huang et al., 2019). Therefore this Fourth Industrial Revolution signifies a gigantic change in the way we live, work and relate to one another, it´s a transformation in human development and capabilities, empowered by this extraordinary technology advances (Grabowska, 2020).

1.1.2 Internet of Things

Kevin Ashton proposed the definition of IoT in 1999, he defined it as "uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology" (S. Li et al., 2015). More recently as proposed by Rouse *et al.* (2019), IoT is viewed as "a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction" (*IoT Agenda 2019*). The essence of IoT is really not in devices but rather in data gathering, processing and analyzing (Rybicka, 2018).

IoT is consider one of the most promising technologies in the current epoch. IoT application consists of different smart things that collect, process, compute and communicate with other smart things, IoT is basically the interconnection between physical objects and the digital world. The seamless interactions between large amounts of heterogeneous objects represent IoT as a disruptive technology that enables ubiquitous and pervasive computing applications (Ge et al., 2018; S. Li et al., 2015; Mohanta et al., 2020).

IoT infrastructure is interlinked in three layers: sensing, network and application layer. The sensing layer function is collecting information from devices in real time. The network layer transmits the information collected from the sensing layer to the data processing center, with the help of efficient wireless network. The network layer works like a link between databases, operating systems and applications, it comprises of storage on demand and various other tools for computing and data analysis. It is cloud based and uses big data analytics[1]. Lastly, once data is uploaded to the cloud it can be processed by different tools and applications, the application layer has the ability to apply this

[1] Big data analytics refers to the is the use of advanced analytic techniques to analyze large volumes of data.

information to different things and tasks of the daily life (Goyal et al., 2020; Mohanta et al., 2020; Wu et al., 2019).

The IoT sensing layer consists of smart devices, sensors, actuators, RFID, other support technologies and the Internet to build an intelligent system (Goyal et al., 2020; Mohanta et al., 2020). There are different types of sensors, such as light, temperature, motion and pressure sensors, all of them are responsible for sensing and colleting the data from environment, they basically convert a physical attribute to an electrical signal (Goyal et al., 2020). An actuator operates in the reverse direction of a sensor, they turn an electrical input into physical action, they are responsible for performing the actions upon information from the system to affect the state of object or environment (Goyal et al., 2020).

The sensors and actuators embedded in the smart devices are connected via wireless networks. RFID makes use of electromagnetic fields for identifying and tracking the tags which are attached to various devices. These tags contain the data related to specifications of devices which is stored electronically. IoT applications use frequently RFID because they are very good at identifying and capturing data automatically, which is very useful for collecting real time data for supporting decision making (Goyal et al., 2020).

The unique features of IoT include extreme heterogeneity, large scale data, variety, unstructured feature, noise, high redundancy massive number of devices, and unpredictable dynamics partially due to human interaction. The varieties and capabilities of IoT devices have increased in recent years. Nowadays, it is very common to see high capacity IoT devices which capture high-precision data or high resolution images in very frequent intervals and upload the data to some cloud computing platform via wireless communication networks (F. Li et al., 2020).

The increase adoption and improvement of IoT is possible due to the rapid development of enabling technologies such as big data analytics, cloud computing, AI, control systems and wireless sensor networks (Goyal et al., 2020; F. Li et al., 2020; S. Li et al., 2015; Mohanta et al., 2020). Cloud computing is availability of storage facility on demand along with power of computing and assures security to the data (Goyal et al., 2020).

As the data generated by the IoT devices are massive, implementation of IoT comes with lots of challenges (Mohanta et al., 2020). The standardization, interoperability, data storage, processing, trust management, high implementation costs, confidentiality, integrity, availability, lack of knowledge and risk awareness, compatibility and effectiveness of the operations on a global scale are some of the open challenges in various IoT applications (Brous et al., 2020; S. Li et al., 2015; Mohanta et al., 2020).

To optimize IoT infrastructures one big challenge is to put the application processing and computing in real-time. Machine learning is recently used to make the IoT system more intelligent and independent to make a decision, this can help IoT to compute in real-time. AI can be deployed to make

the IoT system better in decision making and doing computation. IoT and AI combine can improve the analysis of the system, operational efficiency, save unnecessary expenses, detect possible mishap and failures in advance and improve the accuracy rate (Mohanta et al., 2020).

Security and privacy issues also exists in IoT infrastructure, which needed to be addressed to build trust among end-users and make the system temper-proof. Information confidentiality, human privacy and security are critical because of its deployment, mobility, and complexity, this needs to be address in order to have successful IoT applications (S. Li et al., 2015; Mohanta et al., 2020).

The IoT will drastically change the way we live on several aspects, by enabling communications with and among smart objects (Goyal et al., 2020).

1.1.3 Big Data

The act of accessing and storing large amounts of information has been around a long time. But the concept of big data has been defined in 2001 when analyst Doug Laney defined the increase of data with a 3Vs model, which considers the volume, velocity, and variety of data (Félix & Thomas, 2004).

Volume, refers to the massive amount of data which are being generated, gathered, and processed. It can be in the size of petabytes, exabytes, zettabytes or even more. Velocity, refers to the speed at which data are generated, processed, and moved between different systems and devices. Variety, refers to the different types of data that can be used for achieving desired information and to the diversity of data sources, forms and formats (Chen et al., 2014; Félix & Thomas, 2004; Lawson, 2019; Younas, 2019).

A few years later, experts have also identified other aspects that are crucial for companies to keep in mind if they want to make the most of their data. Since Laney's original work, another two concepts have been added, veracity and value. Veracity, refers to the "trustworthiness" of data, the quality of it such as correctness, consistency, trust, security and reliability (O'Leary, 2015; Rowe, 2016; Younas, 2019). Value refers to the different types of benefits that can be derived from processing and analyzing big data (Younas, 2019).

So, the recent studies consider a 5V´s model (Ge et al., 2018; Grable & Lyons, 2018; O'Leary, 2015; Rowe, 2016; Younas, 2019; Gärtner & Hiebl, 2017). Big data now is defined as "a large volume of complex, structured, semi-structured and unstructured data that are generated in a large size and that arrive (in a system) at a higher speed so that it can be analyzed for better decision making and strategic organization and business moves" (Younas, 2019).

Big data are generated from an increasing plurality of sources including web, mobile transactions, IoT, enterprise resources planning (ERP) systems[2], publicly available data, cloud platforms, private data, user-generated content, social media as well as purposefully generated content through sensor networks or business transactions such as sales queries and purchase transactions (Choi et al., 2018; George et al., 2014). Additionally, data sets arrive in a variety of formats text, graphic, audio, video and the number of data types continues to grow (Chen et al., 2014; Choi et al., 2018).

The approach to Big Data is as follows: "it includes what can be realized in a huge scale, and cannot be done in a small one; in order to get a new knowledge or creation of a new value in a way, that can change markets, organizations, relationships between governments and citizens, etc." (Schönberger & Cukier, 2017: 19).

The proliferation of mobile devices ensures that companies can gather more data on consumers than ever before, and the rise of the IoT will amplify this abundance of data (Rowe, 2016). IoT is not only an important source of big data, but also one of the main markets of big data applications given that millions of things or devices are generating and consuming a large volume of data (Younas, 2019). IoT becomes now an important source of contextual data with an enormous volume, variety and velocity, through Big Data analytics is possible to extract useful information from this massive data streams (Ge et al., 2018; Goyal et al., 2020). Big data analytics use advanced analytic techniques to process huge volumes of data (Big Data) from different sources and different formats to uncover hidden patterns, unknown correlations and discover other useful information (Choi et al., 2018).

Big Data analytics have emerged as a critical data analytics tool to bring the knowledge within IoT infrastructures to better meet the purpose of the IoT systems and support critical decision making and business optimization (Ge et al., 2018; Goyal et al., 2020). These two technologies are inter-dependent and should be jointly developed (Brous et al., 2020; Rybicka, 2018).

This variety of data sources has advantages and disadvantages. It´s good because companies have an increasingly large diversity of channels from which to pull information, but at the same time it can be difficult to filter through that information to find the most valuable content (Rowe, 2016). Moreover, there are obvious ethical and privacy concerns whenever a business collects microlevel data about consumers (Brous et al., 2020; Grable & Lyons, 2018). With big data, the increased volume and variety of different data increase the probability that data elements that usually are not together will be available and could be placed together, ultimately compromising privacy (Mohanta et al., 2020; O'Leary, 2015).

[2] ERP systems is the integrated management of main business processes, often in real time and mediated by software and technology. ERP software integrates the various functions of the organization into one complete system to streamline processes and information across the entire organization.

Additionally to this, due to grow of social media content there is a transition of structured data to unstructured data, which is more difficult to analyze (Richins et al., 2017). These diversity of data sets are extremely valuable because of the vast information hidden within the data structures (Chen et al., 2014). When analyzed computationally, as mention before, big data can provide more precise insights into hidden patterns, trends, and associations, especially in the context of decision making (Grable & Lyons, 2018).

Nowadays, there are a range of specialized techniques for analyzing Big Data, businesses typically use one of three computational models to deal with large data sets: data mining, ANN, and machine learning (Grable & Lyons, 2018). ANN and machine learning use AI algorithms to quickly analyze large volumes of data. Data mining models are usually developed based on machine learning and statistics (Choi et al., 2018). Data mining uses existing information and data analytics to search for hidden or emerging patterns in data to explain a particular phenomenon or predict future trends (Grable & Lyons, 2018). Deep learning is also very helpful for analyzing big data, with deep learning is possible to isolate hidden patterns and to find answers without over-fitting the data (Richins et al., 2017). Big Data analytics is fast becoming a tool that not only analyzes patterns but can also provide the predictive likelihood of an event (Choi et al., 2018).

The defining parameter of Big Data is the high value of information hidden in the data. We are now in the big data era, organizations are exploring how large volume data can be usefully deployed to create and capture value for individuals, businesses, communities and governments (George et al., 2014; Grable & Lyons, 2018).

The ability to pull valuable information from Big Data and use that information quickly and properly is the key (Rowe, 2016). Big data, due to its volume, micro-level detail, and multi-faceted richness have a huge and increasing potential in creating value for businesses which is the ultimate business goal for any enterprise (George et al., 2014; Rowe, 2016). The literature has identified big data as “the next frontier for innovation, competition, and productivity” and the “next big thing in innovation” (Ghasemaghaei & Calic, 2020).

1.2 Management Accounting

1.2.1 The importance of management accounting

Accounting is the unparalleled judge of the past, the necessary guide to the present and the indispensable advisor of the future in each enterprise (Nicoleta, 2019). Management accountants is a profession that prides itself as dwelling in the future, against financial accountants that score keep the past (Lawson, 2019; Ratnatunga, 2015). The definition of management accounting stated by Institute of Management Accountants (2019) is the following: “Management accounting is a profession that

involves partnering in management decision making, devising planning and performance management systems, and providing expertise in financial reporting and control to assist management in the formulation and implementation of an organization's strategy" (Rybicka, 2018). Management accounting have two essential elements: quality of the information system and choice of the right strategy (Rybicka, 2018).

The main role of management accounting can be defined as an integrated system of cost and income accounting, rationing, planning, control and analysis, which provides information for operational management decisions and coordination of possible problems of the future development of the company (Zahid & Vagif, 2020).

Therefore, management accounting is an indispensable practice and activity for organizations because it not only allows for a better knowledge of the costs but also allows the setting of the sales prices and the realization of forecasts. Management accountants provide financial and non-financial information to managers, their role is like a management adviser providing the means and the tools needed for the decision making and the achievement of the organizational performances (Nicoleta, 2019; Rybicka, 2018; Zahid & Vagif, 2020). With expertise in strategic formulation, implementation and monitoring, accountants are able to identify key competitive factors idiosyncratic to the firm, select appropriate measures of those factors, and successfully communicate that information throughout the company (Richins et al., 2017). Then, managers use accounting information to ensure the survival and the desired performance of the entity they are responsible for, by tracing the general plan to be followed and implementing an optimal strategy (Nicoleta, 2019).

Nowadays with globalization and the digital revolution is necessary to change many aspects in the functioning of enterprises (Nicoleta, 2019; Rybicka, 2018). In the new current environment, the entity is automated and computerized, products have a short life cycle and services have regularly changes to adapt to consumer necessities. In the field of competition, we can see an evolution of the criteria that characterize the way of its manifestation, from purely quantitative criteria (price) to qualitative criteria (product quality, security of services offered). However in the management accounting area the information systems only integrates to a small extent the qualitative aspects, generally are limiting to the quantitative ones (Nicoleta, 2019).

Based on this market shift there is a need to redefine new business processes due to the present volatility, lack of predictability, complexity and ambiguity of economic phenomena. The actual management methods, focused on stability and predictability, become no longer useful. Digital transformation is no longer a mean for competitiveness but rather the decisive factor needed to keep the organization in the market. The new emerging technologies allow the improvement of relationships between customers and suppliers, high improvements of processes inside the organization and modelling production processes (Nicoleta, 2019; Rybicka, 2018).

According to accountancy specialists, traditional costing and measurement systems are almost incompatible with the use of these emerging technologies (Haenlein & Kaplan, 2019). The constant evolution of technical progress, the changes in the conditions of competition in the internal and external markets have put their mark on traditional calculation methods (Bhimani, 2020; Nicoleta, 2019). These methods lead to obtain late and unhelpful information, they are characterized at some extent as ineffective, leaving the place for modern calculation systems to suit the current requirements (Bhimani, 2020; Nicoleta, 2019). Therefore management accounting will be disrupted by new technologies, like big data, AI, blockchain[3], machine learning and robotics process automation (Lawson, 2019). Management accounting transformation is needed, an adaptation to the realities and exigencies of the present, the modification of the tools, processes and work methods in order to respond to the current economy (Nicoleta, 2019).

Management accounting is more and more the main element of the management process, not only at the operational level, but also at the strategic level. Management accounting now is related to the settlement of the organization's strategy, long-term planning, strategic decision-making and strategic control. Additionally, it plays an important role in risk management for securing the company's performance. An appropriate accounting system has a wide range of instruments that allow for reducing the negative effects of risk and taking advantage of opportunities inherent in this company's risk (Rybicka, 2018).

The digital revolution can pose to management accounting a paradox. On the one hand, it will increase the opportunity to give higher visibility to organizational actions, a dream of full control where distance is cancelled, where databases and statistical models know individuals better than the individuals themselves and are able to predict their desires and future actions. On the other hand, it will augment uncertainty. Spurious correlations and the need to choice from huge volumes of data and options will increase (Quattrone, 2016).

The need to manage several and complex problems faced by any organization makes management accounting one of the handiest tools available to the manager, which he can use to evaluate opportunities, orientate directions of action, and develop the company strategy. Management accountants possess high value for the businesses, by identify part of the solution and eliminate part of the problem (Nicoleta, 2019).

[3] Blockchain technology is a digital record of transactions, a distributed ledger technology that allows data to be stored globally on thousands of servers, while letting anyone on the network see everyone else's entries in near real-time.

1.2.2 The impact of intelligent systems on management accounting

We are in the center of a technological revolution that will drastically change the way in which enterprises function (Bhimani, 2020; Rybicka, 2018). Multiple companies have started to introduce numerous IoT based products and services (Wortmann & Flüchter, 2015).

The benefits of IoT technologies for organizations are primarily derived from the availability of more information which is automatically collected and readily shareable soon after it is generated (real-time information) (Brous et al., 2020; S. Li et al., 2015).

The categories of benefits of IoT adoption in organizations can be summarized as: huge volumes of data for decision making, improved timeliness and speed in decision-making (this allow to save time and money), capacity of monitor the overall business processes, improved planning due to insights created by higher volumes of data, improve productivity, reduction of operational costs due to improved data quality and possible new revenue streams due to linking capability of data and better communication with clients due to open nature of the data (Brous et al., 2020).

IoT basically increase the horizontality of organizations, the businesses can benefit from the IoT at the levels of intra- and inter-organizations. The organization becomes a set of social networks that bind different stakeholders inside and outside the company (Pauget & Dammak, 2019).

IoT technologies will not only helps as a support function but as a core element of value creation and a source of competitive advantage (Wortmann & Flüchter, 2015). All of this can augment the performance of organizations, simplified business processes, enhanced efficiency, improving operational planning and the ability to react quickly to unexpected events (Brous et al., 2020; S. Li et al., 2015).

IoT and the explosion in the adoption of social media technologies have been intensifying a lot the Big Data growth and impact (Rybicka, 2018). “The sheer volume of data available to us is greater than ever before”, writes Meghann York, director of product marketing at Salesforce Marketing Cloud. “All of this data can be turned into actionable insights that drive business decisions and can help transform every customer interaction, create operational efficiencies, and more” (Rowe, 2016).

According to several authors, the developments in Big Data systems, combined with the use of intelligent algorithms, can significantly helping companies in several dimensions: time saving, helping firms cut costs, intelligent decision making, strategic business moves, helping in customer relationships (quickly respond to shifts in consumer demand), allowing managers to detect problems within a business structure and ultimately can enhance production efficiency and competitiveness. Using big data enables managers to decide based on evidence rather than intuition therefore managers can manage more precisely than ever before. For that reason, it has the potential to revolutionize the

structure of an organization (Chen et al., 2014; Ghasemaghaei & Calic, 2020; Grable & Lyons, 2018; McAfee & Brynjolfsson, 2012; O'Leary, 2015; Rybicka, 2018).

Andrew McAfee and Erik Brynjolfsson (2012) conducted interviews with executives at 330 public North American companies about their organizational and technology management practices, to test the hypothesis that data-driven companies would be better performers. Across all the analyses they conducted, they reach to this relationship: The more companies characterized themselves as data-driven, the better the performed on objective measures of financial and operational results. Mainly companies in the top third of their industry in the use of data-driven decision making were, on average, 5% more productive and 6% more profitable than their competitors. It was statistically and economic significant and was reflected in the increases in stock market valuations. According to this study, using big data leads to better predictions and better predictions yield better decisions (McAfee & Brynjolfsson, 2012).

According to Akter *et al.* (2016) study, 87% of firms believe that big data will change the competitive landscape, and 89% believe they will lose considerable market share if they do not adopt big data within the next few years. According to Müller *et al.* (2018) study, big data has the potential to enhance firm performance by on average 5,9%. For Ghasemaghaei & Calic (2020), firms that use big data in their business processes may have a better chance of enhancing their operating efficiency and revenue growth compared to their competitors.

When access to information is instantaneous, alternatives can be evaluated on the moment, actions can test, and alternatives can be compared in parallel. For this reason, beyond the huge impact in companies, big data has the potential to completely change management accounting functions. The rise of big data will impact management accounting controls, information and decision making, not only in the way decisions are made, but also in terms of processes and competences. This will reshape the managerial process placed on more traditional information (Bhimani, 2020; Rybicka, 2018).

Decision-making frequently focuses on detecting reasons of actions to infer relationships or predict future events. Data-driven decision-making, on the other hand, focuses on relationships and patterns in data that can support actions, where the "why" becomes secondary. If a pattern exists and is constant over time, then managers can base decisions on it. An example would be whether data on buying behavior shows a stable pattern over time; if so, the firm could base sales activities on this pattern without having to study the underlying reasons of the behavior. Such changes in the decision-making process can impact a lot the management accountants' role in organizations, the use of accounting data and the organization of the accounting function (Rikhardsson & Yigitbasioglu, 2018).

Additionally, the possibility to analyze data about entire populations instead of having to rely on samples has implications for the use of several management accounting techniques. Advances in

statistical forecasting techniques and access to external data could improve forecasting accuracy, leading to better estimates of resource use and costs and improving budgeting (Nicoleta, 2019).

Big data technologies enable the use of data types such as video, audio and textual data in management accounting activities. This could mean new ways of controlling employee behavior through the monitoring and analysis of real-time events, for example, monitoring voice patterns of customers in online sales calls and suggesting sales tactics for sales persons in real time, or interpreting facial expressions of shoppers from video feeds to optimize customer service. Companies can also use data to track productivity and prompt the creation of corresponding performance measures. Access to real-time data, the possibility of working with population data, the increasing processing capability of statistical analytical tools and developments in visualization methods mean that managers can search for new patterns, correlations and links in data (Nicoleta, 2019; Warren et al., 2015).

By using big data analytics, management accountants can broaden their controlling and monitoring techniques providing the power to identify areas of improvement and some opportunities (Bhimani, 2020; Rybicka, 2018). There are various opportunities for management accounting such as: integration of new data channels, include unstructured data, automatic generation of data, cost and time optimization, real-time data, improvement of operational and strategic planning, as well as improvement of decision support for highest level on managers (Rybicka, 2018). Big data will contribute to the growth and evolution of effective management systems and budgeting procedures (Nielsen, 2018).

On the other hand, there are some challenges for management accountants such as: overload of information and data veracity, changing cost structure, take wrong decisions much more quickly than before and lack of resources (insufficient people with knowledge in this area) (Gärtner & Hiebl, 2018; Quattrone, 2016). Moreover, the digital revolution has challenge transparency, unveiling data that were not presupposed to be made transparent (Quattrone, 2016). Additionally, using more data can increase the power of analysis, but it fails to remove inaccuracies or biases present in Big Data (Elliot et al., 2020; Richins et al., 2017). Despite this challenges, big data offers a new opportunity for management accountants to play an active role in data creation and decision support (Rikhardsson & Yigitbasioglu, 2018; Rybicka, 2018). For extract the most value from big data sets companies are using analytics involving AI.

In recent years, the convergence of AI and Big Data in the management accounting area is acquiring popularity (Pilipczuk, 2020). Big data and AI bring opportunities for better decision-making (Elliot et al., 2020). Continuous progress in AI and machine learning, coupled with a growing ability to analyze Big Data will change task structures within the accounting profession, and this will provide opportunities for accountants to leverage their current skills in conjunction with newly acquired ones (Richins et al., 2017).

By synthesizing strong patterns from large data sets, AI and, in particular, machine learning algorithms allows the creation of new information and predictions from data, provided that the future can be well predicted by existing data. By using AI it is possible to: reduce human error, increase performance and customer satisfaction and have fast, accurate, repeatable, low-cost decisions, with quality approaching human-like intelligence (Cubric, 2020; Shrestha et al., 2019).

Shrestha *et al.* (2019) study analyze how AI changes the internal functioning of firms, specifically group dynamics and organizational decision making. These authors compare human and AI-based decision-making characteristics along five key conditions: specificity of the search space, interpretability of the decision-making process and outcome, size of the alternative set, decision-making speed, and replicability. Table 1.2 summarizes the characteristics of human and AI-based decision making along these conditions.

Table 1.2: Comparison of AI-Based decision making and Human decision making (Shrestha et al., 2019)

Decision-Making Conditions	AI-Based Decision Making	Human Decision Making
Specificity of the decision search space	Requires a well-specified decision search space with specific objective functions.	Accommodates a loosely defined decision search space.
Interpretability of the decision-making process and outcome	Complexity of the functional forms can make it difficult to interpret the decision process and outcomes.	Decisions are explainable and interpretable, though vulnerable to retrospective sense-making.
Size of the alternative set	Accommodates large alternative sets.	Limited capacity to uniformly evaluate a large alternative set.
Decision-making speed	Comparatively fast. Limited trade-off between speed and accuracy.	Comparatively slow. High trade-off between speed and accuracy.
Replicability of outcomes	Decision-making process and outcomes are highly replicable due to standard computational procedure.	Replicability is vulnerable to inter- and intra-individual factors such as differences in experience, attention, context, and emotional state of the decision maker.

Bolander (2019) also studied how AI impact decision making. This author affirms that we potentially might lose something by automation through AI because we cannot yet communicate with AI systems the way we communicate with humans and AI systems cannot explain their own reasoning and behavior the way humans can. A main output problem of AI algorithms is that many of those algorithms make a binary classification (yes/no) with no additional explanation provided and no ability to have a dialogue with the algorithm about the reasoning underlying the classification.

According to Shrestha *et al.* (2019), Bolander (2019) and Burrell (2016) the lack of transparency and interpretability of decisions is still a big limitation of AI systems. Another problem is that the full delegation of decision making to AI systems involve critical limitations, as machine-learning algorithms can acquire and replicate implicit human biases for example toward race and gender.

Human intelligence and machine intelligence have distinct set of strengths and weaknesses (table 1.2). Some tasks that are easy for humans to solve have turned out to be extremely difficult for machines, and vice versa. Humans have a very flexible intelligence, are good at abstract thinking and conceptualizing the world. This is good at solving problems that are not very clearly delimited and well-structured (but where the solutions do not have to be either). Conversely, machines are primarily good at clearly delimited and well-structured problems but can then also provide solutions that are very precise and well-structured (Bolander, 2019; Shrestha et al., 2019).

Based on this, Shrestha *et al.* (2019) developed a framework to explain under which conditions organizational decision making should be fully delegated to AI, hybrid (either AI as an input to human decision making or human decisions as an input to AI systems) or aggregated (humans and AI take decisions together).

In order to successfully introduce AI in a company is essential that the professionals that will deal with it have trust in this technology. As stated by Siau, K. and Wang (2018) “Trust is crucial in the development and acceptance of AI. Trust building is a dynamic process, involving movement from initial trust to continuous trust development. Continuous trust will depend on the performance and purpose of the artificial intelligence”.

Moreover, on a study conducted by Bitkina *et al.* (2020) the regression analysis performed showed that the perceived performance of AI and success/failure of performing tasks are significant predictors of the perceived trust. Perceived trust depends on user expectations, and the perceived performance grows along with trust. Additionally, performed analysis shows that the growth of task complexity undermines the perceived trust and perceived performance of AI (Bitkina et al., 2020).

The PricewaterhouseCoopers study about AI realized in Germany reveals that 72% of companies believe that AI will be the competitive advantage of the future, 67% believe that AI has a positive influence on the company by combining it with human’s knowledge and 54% confirm that AI has already increased productivity in their companies (Alina, 2018). Thus, a major opportunity exists for interdisciplinary work between accounting specialists and AI professionals.

Most organizations report measurable benefits from AI where it has been deployed, thus AI seems to create huge value for companies. Güngör (2020) conducted a short survey to 105 business professionals mainly from Europe about their perceptions about the value and risks of AI. Survey results further indicated that perceived value creation with AI is predominantly for shareholders (7.39

on a scale from 0 to 10) and for customers (7.15) while employees and society were perceived as negatively (Güngör, 2020).

In management accounting profession, where people deal with repetitive tasks, AI is a replacement of human capabilities for the better. Any tasks or analysis performed by AI result in almost instantaneous outputs (Shrestha et al., 2019). This guarantees better improvements in the timeliness of information and productivity (Petkov, 2020). For the purposes of accuracy, if AI is ‘‘trained well,’’ that is, it is programmed in a way to correctly apply principles as they come up, the information would be accurately and more consistently prepared (Petkov, 2020; Shrestha et al., 2019).

Cognitive computing, which is associated to AI, can also help accountants with deep analytics (Pilipczuk, 2020). It can be used in risk mitigation, detecting problems in structured and unstructured data and improving the user overall experience (Pilipczuk, 2020). In 2019 Forbes wrote that “the use of cognitive technologies already has changed the accounting profession”. Automated solutions make the accountant’s job easier, eliminating much of the manual processing of data. Such tools also provide transparency, (…) compressing the margin of error” (*Forbes Insights: The Next-Generation Accountant*, 2019).

According to Jim Boomer (2017), “it will serve as a complement to the evolution of management accountants from technical advisors to strategic, value-added advisors”, which does not mean that cognitive computing does not present any risks to the accountant profession (*Cognitive Computing and the Future of the Accounting Profession | CPA Practice Advisor*, 2017).

The question is less whether AI will play a role in these elements but more which role it will play and more importantly how AI systems and humans can coexist next to each other (Haenlein & Kaplan, 2019).

1.2.3 The future of management accounting

Technology is transforming the role of management accountants at an unprecedented speed (IMA, 2019). These new technologies will have a major impact on cost management and decision making (Rybicka, 2018). Data analytic techniques applied to Big Data have the potential to substitute several of the tasks traditionally executed by accountants. But this does not mean that accountants will become obsolete. Instead, the Big Data revolution will lead to automation of the more repetitive tasks, allowing accountants to focus their attention on opportunities to provide value to their company (Richins et al., 2017). They will spend less time collecting and organizing data and more time evaluating, analyzing, and interpreting it (Lawson, 2019). Although data analysts have skills to carry out the analyze, identifying correlations and algorithms, management accountants’ capability to understand

the language of business provides them with the ability to identify and interpret relevant data that can be turned into optimal strategies for the company (Nicoleta, 2019).

To manage and monitor advanced technologies and capitalize opportunities while avoiding the pitfalls, management accountants will need to develop high cognitive abilities, like data science and analytics skills to solve strategic tasks, which will increase in the near future. These technologies create new trends toward cognitive managerial accounting (Pilipczuk, 2020).

To keep pace with the changing business environment and advances in technology, Institute of Management Accountants (IMA) has analyzed the emerging competencies needed by management accountants to protect their careers in the future and has updated the IMA Management Accounting Competency Framework, represented in figure 1.1. It covers the essential competencies needed for today´s management accountants in six domains: Strategy, Planning & Performance, Reporting & Control, Technology & Analytics, Business Acumen & Operations, Leadership, and Professional Ethics & Values. Each skill area comprises specific knowledge and skills required to manage technology and analyze data to enhance organizational success. Management accountants can use this framework as a guide to keep their skill sets relevant for today's business environment (IMA, 2019).

Figure 1.1: Management Accounting Competency Framework (Lawson, 2019)

Pilipczuk (2020) research´s also revealed that the competencies needed for management accountants are technical skills, cognitive skills and social and behavior skills. As stated by Pilipczuk (2020) "The future management accountants should not only be technically strong, but also have high cognitive abilities in order to support strategic decision-making and drive the business forward through increasingly large data sets".

Combining knowledge of technology with strategic skills will enable these professionals to decipher and communicate the story the data is telling (Richins et al., 2017). The role of management accounting has changed from directing primarily on budgeting, costing and analysis to developing and implementing strategies that promote increased company's performance while managing risk (Sulaiman et al., 2008).

The deep integration of this emerging technologies will introduced giant changes, such as reengineering accounting procedures (change cost management and decision-making process), reducing information errors and distortions, improving efficiency and consequently promoting the

transformation of accounting career structures (Zhang et al., 2020). Companies that figure out how to combine management accounting knowledge with emerging technologies will have success for sure.

Chapter II – Breaking down the Investigation

Resulting from the investigation taken for the purpose of the literature review, there were several points of view presented by the different authors. In an increasingly competitive and uncertain environment, companies are integrating new emerging technologies like IoT, Big Data and AI in their structure to have an increase in productivity and efficiency.

The majority of the authors mentioned in this investigation agree that intelligent systems will have a huge impact on management accounting and consequently on the entire company. Although there are many studies that estimate the impact of the integration of intelligent systems on the productivity of companies and predict the future of the management accounting profession. There is no literature that demonstrates in practice the real impact of intelligent systems in the daily work of management accountants and how these emerging technologies could impact their productivity and efficiency levels. Most of the existing literature spoke about possibilities, what is probable to occur, but not about concrete cases and the respective results.

As a result of this investigation, some research questions have arisen, which will be addressed and discuss in detail in this chapter.

IoT emerge as a very current and fast-growing intelligent system. As mentioned by Brous *et al.* (2020) and S. Li *et al.* (2015) the benefits and impact of IoT technologies for organizations are massive resulting from the availability of huge amounts of information which is automatically collected and share over a network after it is generated. According to Pauget & Dammak (2019) IoT has the capability to increase the horizontality of organizations. According to Wortmann & Flüchter (2015) IoT technologies will be a fundamental element of value creation and a source of competitive advantage. However, there is no literature about the impact and advantages of IoT specifically on management accounting. Following this gap, the first question arises to know in practice which benefits IoT could bring to the daily work of these professionals:

Q1: *How does IoT impact management accounting?*

IoT is tightly connect to another intelligent system, Big Data. Big data enable the use of huge amounts of different data types (Warren et al., 2015; Rybicka, 2018). According to Warren *et al.* (2015), this could mean new ways of track productivity and prompt the creation of corresponding performance measures. Through Big Data analytics management accountants can extract valuable insights from data (Bhimani, 2020; Rybicka, 2018).

With access to huge volumes of data companies can start to implement data-driven decision. Data-driven decision-making are based on patterns in data that can support actions. For Bhimani (2020), Rikhardsson & Yigitbasioglu (2018) and Rybicka (2018), this will impact management

accounting controls, information and decision making. According to Rybicka (2018), management accountants can count now with automatic generation of data, this huge amount of real-time data will allow faster and higher quality decisions, improving the decision support for managers.

For Elliot *et al.* (2020) couple these two technologies could improve the decision-making process. Analytics involving AI are very helpful in analyzing the immense volume of data, any tasks or analysis performed by AI result in almost instantaneous output (Richins et al., 2017).

The integration of this emerging technology in the management accounting field will introduce tremendous changes, such as change cost management and decision-making process, automatic generation of data, improvement of operational and strategic planning and cost and time optimization (Rybicka, 2018). Zhang *et al.* (2020) also mentioned the advantages of reducing information errors and distortions, better decisions and improving efficiency. According to Cubric (2020) and Shrestha *et al.* (2019), although they not focused specifically on management accounting profession, by using AI in a company it is possible to: reduce human error, have fast, accurate, repeatable, low-cost decisions, with quality approaching human-like intelligence.

Shrestha *et al.* (2019) and Bolander (2019) studies analyze how AI affects decision making by comparing the characteristics of both in different conditions. Both studies conclude that human intelligence and machine intelligence have very different set of strengths of weaknesses. However, there are no studies that analyze the likelihood of companies implementing AI in the decision-making process in management accounting in the near future.

On the other hand, there are some challenges for management accountants related with the lack of interpretability and transparency of AI-based decision-making algorithms (Bolander, 2019; Burrell, 2016; Shrestha et al., 2019). Another thing that is important to take on consideration in practice is that Intelligent systems have difficulties at solving problems that are not very clearly delimited and well-structured (Bolander, 2019).

According to Richins *et al.* (2017), this will have a big impact in the management accounting profession. Therefore, the question is less whether AI will be the future but more which role it will play and more importantly how AI systems and humans can coexist and work together.

Subsequent to these perceptions, the second question arises in order to understand the real impact of Big Data on management accountants and how analytics involving AI could be used to analyze these huge volumes of data to simplify and improve this professional's daily work:

Q2: *How can Big Data and AI improve management accountants' processes?*

AI and, particularly, machine learning technology enable the creation of predictions for the future by using the information present in the existing data. Shrestha *et al.* (2019) developed a framework outlining the characteristics of AI systems and humans and explained in what way and in what

situations AI and Human intelligence can be combined to optimize the decision making to benefit the quality of organizational decision making.

With this framework is possible to successfully combined and exploit the advantages of each. However, this framework was not applied in the management accounting area and this study does not explore the probability of this framework being successfully implemented in practice and what variables are necessary to take into account for this probability to be higher (Shrestha et al., 2019).

Güngör (2020) conducted a survey to business professionals about their perceptions about the value and risks of AI. Survey results further indicated that perceived value creation with AI is predominantly for shareholders and for customers while employees and society were perceived as negatively.

According to Petkov (2020) and Shrestha *et al.* (2019) AI brings a huge value to human capabilities, as efficient and advance algorithms have enabled AI-based decision making to occur at a near-instantaneous speed. This leads to improvements in the timeliness of information, productivity and efficiency. With so much value, AI is increasingly used in different areas of companies. Güngör (2020) agrees with these authors by mentioned in their study that most organizations report measurable benefits from AI.

Siau, K. and Wang (2018) affirm in their study that besides the perceived value, trust is crucial in the development and acceptance of AI. Bitkina *et al.* (2020) study also demonstrates that the perceived performance of AI is a significant predictor of the perceived trust. Perceived trust depends on user expectations, and the perceived performance grows along with trust. Furthermore, performed analysis shows that the growth of task complexity undermines the perceived trust and perceived performance of AI (Bitkina et al., 2020).

Following this gap, the third question appears as complement to the studies mentioned above as an attempt to predict the probability of companies adopting AI systems in management accounting as none of the previous studies focused specifically on this profession. The probability of adopting AI will be measured based on three independent variables: the value of AI for management accountants, the challenges in AI implementation and the level of trust in AI by these professionals in order to be possible AI implementation:

Q3: *What is the possibility of implementing AI, for decision making, in management accounting?*

Technology is changing and transforming the role of management accountants at a unique speed. These emerging technologies have the potential to replace many of the tasks traditionally performed by these professionals (Rybicka, 2018). According to Richins *et al.* (2017) this does not mean that management accountants will become obsolete. Management accountants' ability to understand the language of business makes them essential (Nicoleta, 2019). The integration of intelligent systems will

lead to automation of the more repetitive and manual tasks, allowing accountants to spend more time analyzing and interpreting the information generated and focus on opportunities to identify areas of improvement in order to deliver value to their companies (Lawson, 2019; Richins et al., 2017; Bhimani, 2020; Rybicka, 2018).

For Pilipczuk (2020), to manage and monitor these emerging technologies, that will increase in the near future, management accountants will need to develop high cognitive abilities, like different IT skills and analytics skills. The Institute of Management Accountants has analyzed the emerging competencies needed by management accountants to protect their profession in the future. The updated Management Accounting Competency Framework covers the competencies needed in six domains: Strategy, Planning & Performance, Reporting & Control, Technology & Analytics, Business Acumen & Operations, Leadership, and Professional Ethics & Values (IMA, 2019).

According to Richins *et al.* (2017), combining the advantages of technology with strategic skills will enable these professionals to discover and efficiently communicate the valuable insights hidden in data. The role of management accounting has changed from directing primarily on budgeting, costing, variance analysis to developing and implementing strategies that promote increased company's performance while managing risk (Sulaiman et al., 2008).

On the other hand, there are some challenges for management accountants related with inaccuracies or biases that can be present in the huge amount of data, the possibility of take faster wrong decisions and the necessity of development new capabilities to deal with these new technologies (Elliot et al., 2020; Richins et al., 2017). According to Shrestha *et al.* (2019) and Bolander (2019) the total delegation of decision making to AI systems can involve critical limitations, as machine-learning algorithms can acquire and replicate implicit human biases. Gärtner & Hiebl (2018) and Quattrone (2016) also mentioned in their studies the overload of information and data veracity, the lack of people with knowledge in this area, changing cost structure and the possibility of faster false decisions as main challenges.

Besides this, many authors affirm that the implementation of AI in an organization will face ethical and legal challenges (Cubric, 2020; Dwivedi et al., 2019; Haenlein & Kaplan, 2019; Robles Carrillo, 2020). Cubric (2020), Dwivedi *et al.* (2019) and Robles Carrillo (2020) also mentioned in their papers the economic and technical challenges. Equally important are the social barriers, such as dependence on non-humans, job security fears, lack of knowledge and understanding of potential benefits and lack of trust (Cubric, 2020).

Following this perception and all the questions set above, the fourth question arises in order to confirm these authors believes and access in practices the changes that will be introduced in this profession with the deep integration of these emerging technologies:

Q4: *What will be the shifts in management accounting profession with the massive introduction of intelligent systems into day-to-day tasks?*

Chapter III – Methodology

3.1 Research Model

Research is a logical and methodical search for new and valuable information on a particular topic. Research methodology is a science of studying the structured process of conducting research and subsequently a systematic way to solve research problems. Is the study of a set of practices used by the scientific community as valid for the exposition and confirmation of a given theory that can lead to new contributions to the existing knowledge. Research methodology explains the methods by which you may proceed with your research, all the methods used by a researcher during a research study are termed as research methods. Research methods are used to collect samples, data and ultimately find a solution to a problem to solve the research problems. Ideally a research should incorporate qualitative and quantitative methodologies (Fortin, 2009; Goundar, 2012; Rajasekar et al., 2006).

With regard to the present investigation, it is an exploratory research, and was conducted from a non-probabilistic sample for convenience[4], constituted according to the availability and accessibility of the elements addressed (Vilelas, 2009). In this case the data collection was through the application of questionnaires to accounting professionals (annex A) and semi-structured interviews (annex B) to intelligent systems professionals, from different nationally and internationally companies. To the questionnaires analysis was used quantitative methods for the interviews analysis was used qualitative methods.

The questionnaire is composed mainly by closed-ended questions which facilitate the act of inquiring, it also has open-ended questions that on the other hand, have a greater margin of freedom in the responses, as well as allowing the collection of a greater amount of information. The questionnaire is therefore a widely used tool for obtaining focused information. It is the most used method in the management area due to the greater advantages in terms of cost reduction, greater probability of treatment data and error reduction (Vilelas, 2009).

The semi-structured interview technique used was developed on a more or less structured basis of questions, even though the interviews were conducted through a list of points of interest in a pre-structured script it implies an adaptable and not rigid character, leaving it almost always that the conversation took place in a fluid way (Fortin, 2009; Goundar, 2012; Vilelas, 2009).

[4]This occurs when participation is voluntary, or the elements of the sample are chosen for the sake of convenience. Therefore, this sample is not representative of the population, so the results of this investigation will have to be read with great caution to be able to generalize to the population in general.

Therefore, the choice of this type of interview had advantages like its little formalization and great flexibility that allowed a deeper and richer dialogue, capturing not only the answers to the selected topics and the attitudes, values and ways of thinking of those who were interviewed, which is only possible to accomplish from the observation, collection and analysis "in loco" of the scientific facts. This allows the collection of many important data generating information that could arise spontaneously. Additionally, it had the advantage that there was no need for a uniform collection of quantified and comparable data from all respondents, which meant that it was not necessary to use strict criteria that in many cases impair the depth of the investigation (Fortin, 2009; Goundar, 2012; Vilelas, 2009).

In terms of disadvantages, due to its heterogeneity in terms of responses obtained, there was in fact some difficulty in grouping and comparing responses whenever it was necessary to make this same comparison, which caused some difficulty in synthesizing the data (Vilelas, 2009).

In this sense, in the first phase, the online questionnaire was posted on Linkedin, mentioning the objectives of it and with a Link in order to give access to the online questionnaire. In addition, I got in contact via email with Iscte professors with experience in the area of management accounting and asked for help with networking and dissemination of the questionnaire to colleagues and professionals in the field. The questionnaire was developed based on the literature review. It was constructed using the Google Forms[5] application associated with a Link to make possible its access through the internet before its application was validated by specialists. The questionnaire was voluntary and anonymous and was completed online. A total of 131 complete questionnaires were received. Data collection occurred between January 1st and 30th.

In a second phase, 18 interviews were conducted to experts in intelligent systems to understand their point of view about this theme and what benefits could these intelligent systems bring to management accountants daily tasks. The interviews were done online, through zoom platform, and took place between February 1st and 26th 2021. They were recorded, in audio support, for later transcription and analysis of content. They had an average duration of 20 minutes and were transcribed chronologically, in Word document format, with fidelity to the speech. 18 interviews were carried out because the answers given were already being repeated, thus reaching a loop. This value guarantees a certain degree of reliability according to Vilelas (2009), as it fit the parameters recognized by the author as acceptable, varying between 15 to 20 interviews.

In the table 3.1 can be observed the relationship between objectives, research questions, questionnaire/ interview questions, data analysis technique and literature review which allows a

[5] Google Forms - Application associated with the WEB organizer that allows access to quick response files that are accessible and confidential to the user.

succinct understanding of the origins of the present study. In the first column, it is possible to observe what the study objective is, in the second column which are the research questions, all of them originated from the literature review. The third column presents the question that were made in the questionnaire or in the interview with the purpose of collecting data to answer to the respective research question. The fourth column presents the data analysis technique used for each research question. Finally, the fifth column aims to indicate which authors gave rise to the respective research questions.

Table 3.1: Relationship between, objectives, research questions, data analysis technique and literature review

Objective	Research Questions	Questionnaire/ Interview	Data Analysis Technique	Literature Review
OBJ - Examine the impact of 3 intelligent systems on management accounting	*(Q1).* How does IoT impact management accounting?	*Management accountants* Questionnaire (12; 13; 13.1; 13.2; 14; 14.1)	*Management accountants* Descriptive analysis	Brous et al. (2020); S. Li et al. (2015); Pauget & Dammak (2019); Wortmann & Flüchter (2015)
		Intelligent systems (IS) professionals Interview (5)	*IS professionals* Content analysis from MaxQDA system	
	(Q2). How can Big Data and AI improve management accountants' processes?	*Management accountants* Questionnaire (1; 2; 2.1; 4; 5; 9; 10; 10.1; 11)	*Management accountants* Descriptive analysis	Elliot et al. (2020); Richins et al. (2017); Rikhardsson & Yigitbasioglu (2018); Rybicka (2018); Bhimani (2020); Warren et al. (2015); Zhang et al. (2020); Cubric (2020); Shrestha et al. (2019); Bolander (2019); Burrell (2016)
		IS professionals Interview (1; 2; 3)	*IS professionals* Content analysis from MaxQDA system	
	(Q3). What is the possibility of implementing AI, for decision making, in management accounting?	*Management accountants* Questionnaire (2.2; 3; 6; 8)	Smart-PLS	Shrestha et al. (2019); Bitkina et al. (2020); Siau, K., and Wang (2018); Petkov (2020); Güngör (2020)

	(Q4). What will be the shifts in management accounting profession with the massive introduction of intelligent systems into day-to-day tasks?	*Management accountants* Questionnaire (7; 16; 17; 17.1; 18; 19)	*Management accountants* Descriptive analysis	Lawson (2019); Rybicka (2018); Pilipczuk (2020); Richins et al. (2017); Bhimani (2020); Nicoleta (2019); Sulaiman et al. (2015); Gärtner & Hiebl (2018); Cubric (2020); Dwivedi et al. (2019); Haenlein & Kaplan (2019); Robles Carrillo (2020); Quattrone (2016); Elliot et al. (2020); Shrestha et al. (2019); Bolander (2019)
		IS professionals Interview (4; 6; 6.1; 7)	*IS professionals* Content analysis from MaxQDA system	

Source: Self-elaborated

3.1.1 Qualitative Methodology

In terms of the qualitative methodology used, this resulted from the analysis of the interviews that were carried out in the research question number 1, 2 and 4, seeking to measure the phenomenon under study. Trying to understand how intelligent systems can be used in the benefit of management accounting profession and the meaning that intelligent systems (IS) professionals attribute to the analyzed phenomena. Qualitative methodology is highly subjective, designed to look beyond the percentages to gain an understanding of feelings, impressions and viewpoints. It used to explore the nature of a problem, issue or phenomenon without quantifying it (Goundar, 2012).

Because qualitative analysis is subjective and deals with a sample size, projectability is not possible, it is difficult to apply conventional standards of reliability and validity. Another common misunderstanding is the expectation that qualitative research will always give definitive conclusions. In fact, the results will probably not provide researchers with definitive conclusions, but only with enough information to establish a firm basis for decision making (Goundar, 2012).

In terms of the qualitative analysis technique used to analyze the data from the interviews was used the (MAXQDA 2020) (Software, 2019). Through MAXQDA it was possible to classify relevant information from the various interviews carried out and then categorized according to the coding below figure 3.1. Through the MAXQDA system, a word search was also carried out to make a general analysis of all the answers given to certain categories in order to be able later to present the results in graphs with the responses given by each interviewee. This allows to have an overview of answers most pointed out by the respondents for each of the categories.

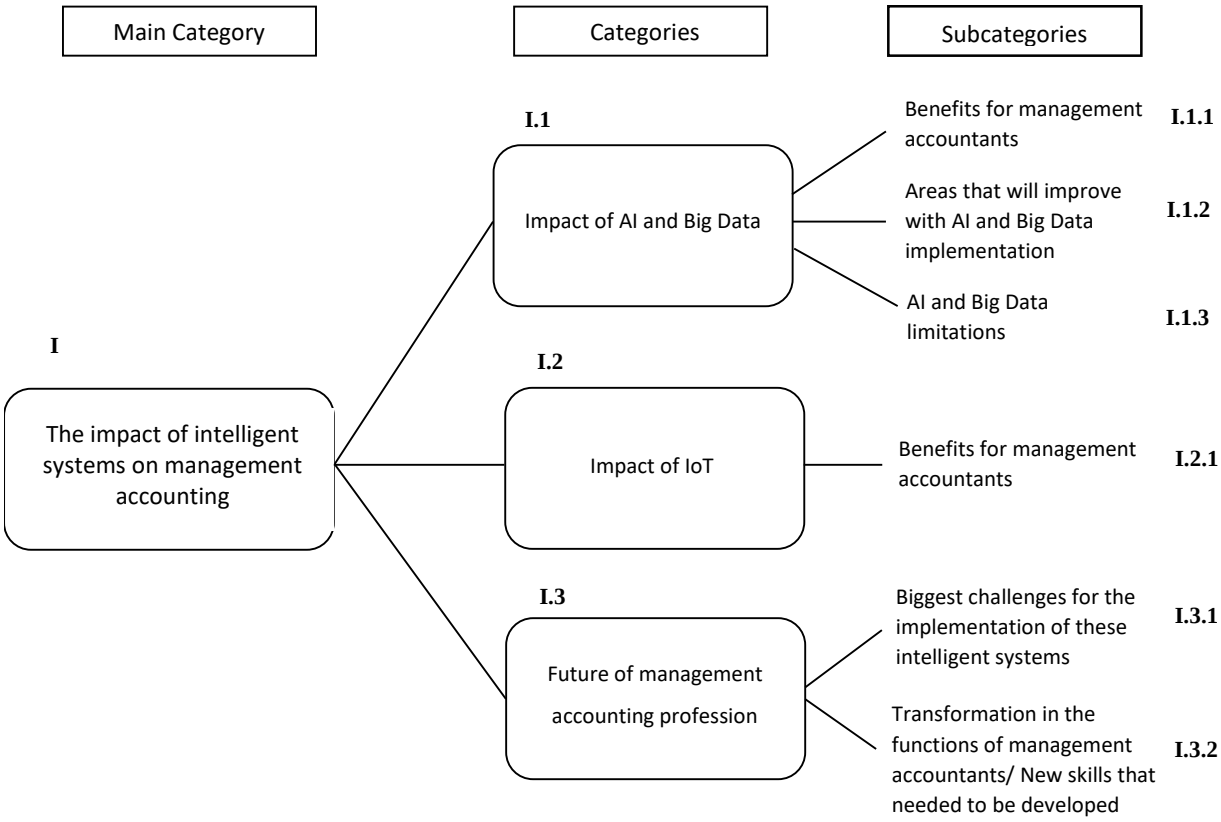


Figure 3.1: Categorization and codification of the interview "corpus" for qualitative analysis

Source: Self-elaborated

3.1.2 Quantitative Methodology

In terms of quantitative methodology, it was used to carry out the treatment of collected data from the online questionnaires. Quantitative methodology is more appropriate to determine the extent of a problem, issue, or phenomenon by quantifying the variation, which provides results that are easier to interpret. Using a series of tests and techniques, quantitative research will offer a higher probability of yield data that is projectable to a larger population. Because it is extremely dependent in numbers and statistics, quantitative research has the ability to effectively translate data into easily quantifiable charts and graphs (Goundar, 2012).

However, quantitative research does have its limitations. Large samples are required, which can be very difficult and expensive to acquire. Quantitative research, by virtue of its short and rigid structure, is not the most flexible method of research and, when handled improperly, is especially vulnerable to statistical error. The misappropriation of sampling can completely undermine the accuracy, validity, and projectability of a quantitative research study (Goundar, 2012).

In terms of quantitative was use in all research questions descriptive statistical analysis, using the exposure of the results obtained through tables and charts with a set of techniques and rules that

summarized the information collected from the questionnaires. In the third research question was also applied analytical statistics in order to test the model bellow (figure 3.2).

To answer to the third research question, the dependent variable which corresponds to the probability of adopting AI, for decision making, in management accounting was measure using three independent variables: the value of AI for management accountants, the challenges in AI implementation and the level of trust in AI by these professionals to be possible AI implementation. These items were measured using a non-comparative evaluation scale, which allowed to evaluate each statement using a five- item scale, where 1 corresponds to very low and 5 corresponds to very high. In the figure bellow it´s presented the relationship between these five variables.

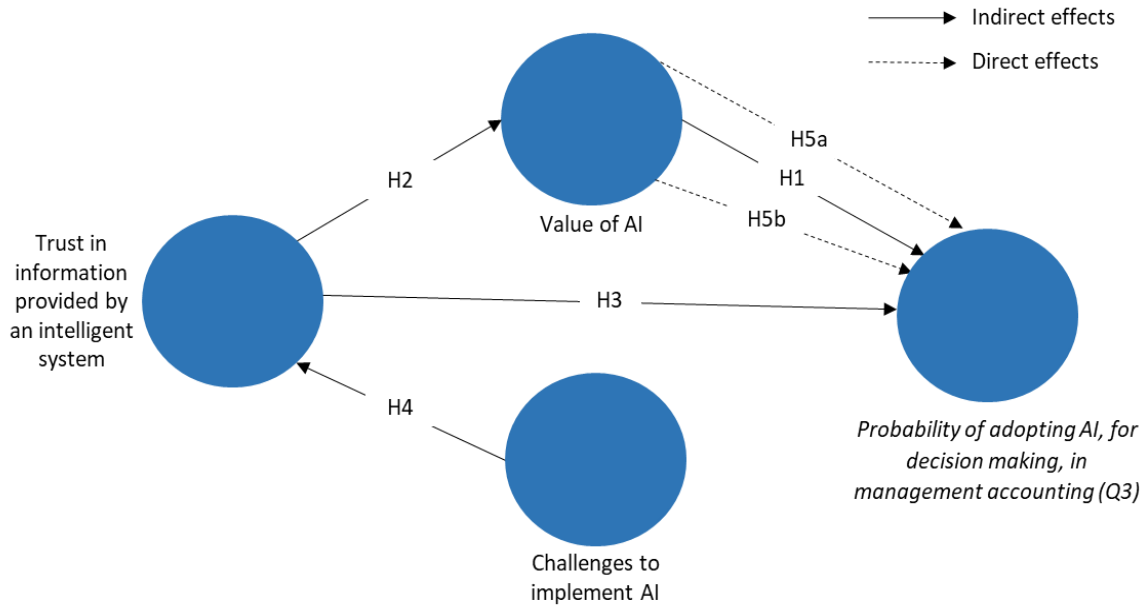


Figure 3.2: Shows the conceptual model

Source: Self-elaborated

To validate the third research question, its purpose to evaluate the validity of the four hypotheses, which are appropriately presented bellow and are consequently theoretically framed in order to address its academic validity and relevance.

H1: The value of AI for management accountants positively relates with the probability of adopting AI, for decision making, in management accounting.

H2: The level of level of trust in information provided by an intelligent system positively relates with the value that AI have for management accountants.

H3: The level of trust in information provided by an intelligent system positively relates with the probability of implementing AI in management accounting.

H4: The challenges in AI implementation negatively relates with the level of confidence in AI by management accountants.

H5a: The value of AI for management accountants mediates the relation between level of level of trust in information provided by an intelligent system and the probability of adopting AI, for decision making, in management accounting.

H5b: The value of AI for management accountants and the level of level of trust in information provided by an intelligent system mediates the relation between the challenges in AI implementation and the probability of adopting AI, for decision making, in management accounting.

To test the conceptual model above was used partial least squares (PLS), which is a variance-based structural equation modelling technique, by means of SmartPLS 3 software (Ringle et al., 2015).

3.1.3 Sample characterization

Before analyzing the results, the sample was characterized. In terms of the questionnaire, 131 professionals participated in the survey, 55% of whom were female and 45% of whom were male. Regarding the age of the inquiries 6% were between 18 and 24 years old, 50% were between 25 and 34 years old, 16% were between 35 and 44 years old, 23% were between 45 and 54 years old and 5% were between 55 and 64 years old. Regarding qualifications, it appears that 10% have secondary education, 58% have bachelor´s degree, 21% have master's degree and 11% have a PhD. Finally, regarding the respondents' profession, 73% were accounting professionals[6], 15% were higher education professors in the management accounting area and 12% have other professions.

In terms of the interviews, 18 interviews were carried out, from these 18 interviewees 83% were male and 17% were female. Most of the respondents were from Portugal (15) and the remaining were from Brazil. In terms of age, 11% were between 25 and 34 years old, 5% were between 35 and 44 years old, 56% were between 45 and 54 years old, 22% were between 55 and 64 years old, and 6% were older than 65. Most of the respondents have a PhD (72%), 22% have master's degree and 6% have bachelor's degree. Regarding the profession 68% were higher education professors in the IT department, 17% were system analyst, 5% were engineer, 5% were IT project manager and the remaining 5% were CEO of a company.

[6] As accounting professionals, I considered accountants and management accountants, since in a small / medium-sized company it is the typical accountant who also perform the management accounting functions within their functions.

Chapter IV – Presentation and discussion of results

4.1 The impact of IoT on management accounting

With the objective of verifying how IoT impact management accounting, first was evaluated the answers from the 131 respondents in the questionnaire.

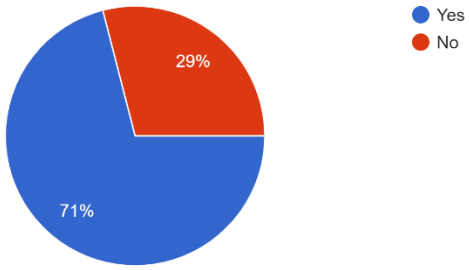


Figure 4.1: Number of professionals that are aware of the concept IoT

Source: Self-elaborated

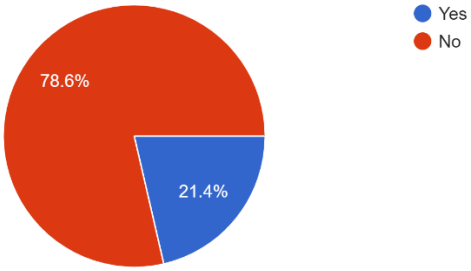


Figure 4.2: Number of professionals that are already using IoT in their work

Source: Self-elaborated

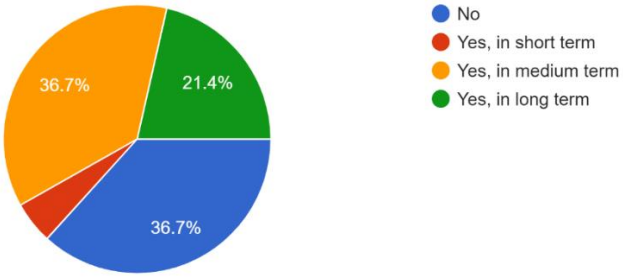


Figure 4.3: Number of professionals that don´t use IoT yet but are planning to implement IoT

Source: Self-elaborated

According to the reading of the figure 4.1 and 4.2, it can be seen that 71% of the inquiries are aware of the concept of IoT but only 21.4% are currently using this intelligent system in their daily tasks. According with the figure 4.3, from the participants that are not yet using IoT in any daily task, more than a half of them, more precisely 62,2%, planned to implement it in the future. However, the implementation of this intelligent system was more considered only in the medium term.

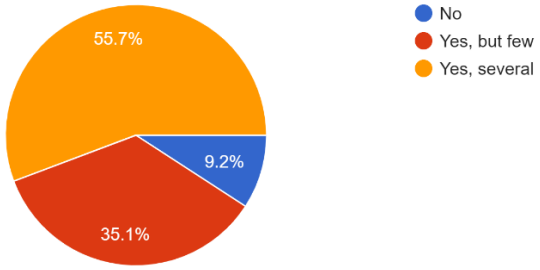


Figure 4.4: Number of professionals that consider that IoT could bring advantages for their work

Source: Self-elaborated

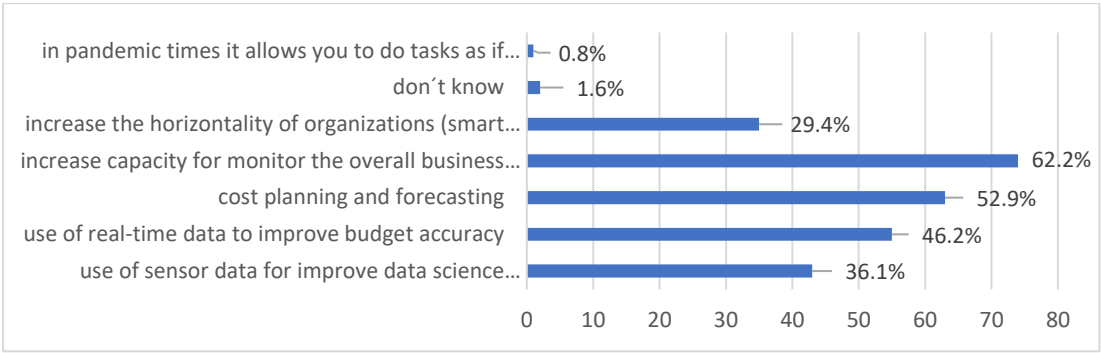


Figure 4.5: Benefits of IoT

Source: Self-elaborated

According to the figure 4.4, 55.7% of the participants consider that integrating IoT in their daily work could have several advantages, only 9.2% consider that IoT doesn´t bring any advantages to management accountant's profession. According to the figure 4.5, the three advantages of IoT that are considered as more substantial to management accounting for the inquiries are: use of real-time data to improve budget accuracy, use of real-time data for cost planning and forecasting and increase capacity for monitor the overall business processes.

To have more relevant information related to this research question, a set of interviews with intelligent systems professionals was also carried out to complement the answers given in the questionnaires. By doing this is possible to match the views and knowledge of both. Bellow was evaluated the answers given by the 18 interviewees to the following questions: Do you agree that IoT bring several benefits to management accounting? To what extent can IoT help management accounting professionals in their daily tasks?

Table 4.1: Content Analysis – Benefits of IoT to management accounting

Content Analysis - Interviews			
Interviewee	Text	Categories	Subcategories
IS professional 2	I would say that yes, the fact that we have the arrival of data and treatment of that data and incorporation of that data in the existing knowledge in real time, when it is possible,	**I.2**	**I.2.1**

	which is not yet at this moment, will help a lot in that planning, or re-planning, in the decisions that are increasingly not taken to have an impact in a month or a year and are increasingly taken to have an impact in the next moment.		
IS professional 3	I do not see directly that IoT will bring great advantages to management accounting. I think that IoT will bring concrete advantages to management, what I mean by this, I mean that the IoT in its various aspects allows to monitor in real time everything that is happening, essentially.	**I.2**	**I.2.1**
IS professional 4	It is a system that is automated, the data comes from the sensors and can be stored and quickly used and can be arriving all the time, it depends on the timeliness of the generation of this data by these sensors of what you want to collect and that can really impact because the data arrives faster and consequently being there can be processed faster.	**I.2**	**I.2.1**
IS professional 12	If we have a series of sensors that are communicating with a computer that makes certain decisions or provides information for decision making, I think this can be extremely useful, so I think so.	**I.2**	**I.2.1**

Source: Self-elaborated

Based on this assumption, does IoT bring benefits to management accounting, a global analysis of the responses of all interviewees was made - figure 4.6.

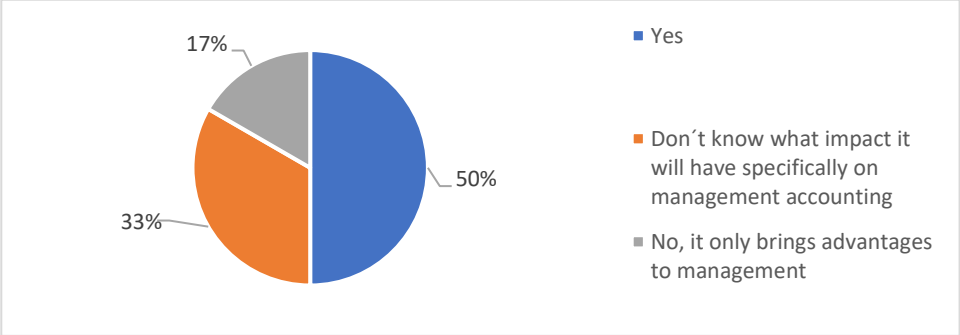


Figure 4.6: Answers of interviewees [Intelligent Systems professionals] about the benefits of IoT for management accounting

Source: Self-elaborated

According to the reading of figure 4.6 and the table 4.1 of the content analysis, 50% of the respondents agree that the IoT brings benefits to management accounting, the other 50% agree that IoT bring advantages but they are not sure if this technology has benefits specifically to management accounting, which is not in line with the answers given by the inquiries in the questionnaire, where 90.8% considered that IoT bring benefits to management accounting.

Based on the results from the questionnaire and the interview, it´s possible to answer to the research question – *How does IoT impact management accounting?* – The majority of the

questionnaire and interview answers are in line with what was stated by the authors Brous *et al.* (2020) and S. Li *et al.* (2015), as it allows us to conclude that IoT will have a positive impact resulting from the availability of information that is automatically collected and share immediately over a network. Consequently, most of the results are also according with what was stated by Wortmann & Flüchter (2015) as the majority of respondents agree that IoT technologies will create additional value. The results are also in line with what was advocated by the authors Pauget & Dammak (2019) due to the fact that the respondents focus the advantage of IoT increase the capacity for monitor the overall business processes. However, none of these authors spoke about the direct impact of IoT in management accounting.

The answers given by the 90.8% of respondents in the questionnaire go beyond what was stated by these authors by affirm that this technology has a direct and positive effect specifically in their work as they considered that the use of real-time data will allow them to improve budget accuracy, cost planning and forecasting and increase capacity for monitor the overall business processes.

In the interviews 50% of the IS professionals also affirm that IoT bring benefits to management accounting, focusing the use of real-time data as the main advantage for management accounting professionals, some considered that IoT can have a positive impact in monitor everything in real-time, planning and in the decision-making process as management accountants can count with more data arriving much faster and consequently being there can be processed and used immediately. However, the other 50% agree that IoT bring advantages but they are not sure if this technology will impact management accounting profession.

4.2 The impact of Big Data and AI in the improvement of management accountants' processes

With the objective of verifying how Big Data and AI impact management accounting, first was evaluated the answers from the 131 respondents in the questionnaire.

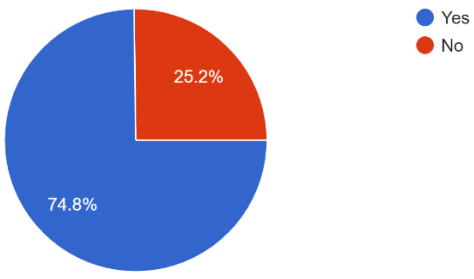


Figure 4.7: Number of professionals that are aware of the concepts Big Data and AI

Source: Self-elaborated

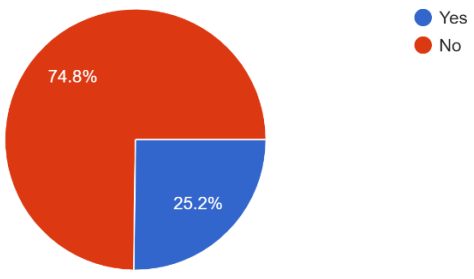


Figure 4.8: Number of professionals that are already using at least one of these intelligent systems in their work

Source: Self-elaborated

According to the reading of the figures 4.7 and 4.8, it can be seen that 74.8% of the inquiries are aware of the concepts of AI and Big Data but only 25.2% are currently using at least one of these intelligent systems in their daily tasks. When asked in what task(s) they were using an intelligent system the answers were diverse but there was one that was referred with higher frequency, which was "Product allocation expenses, employee costs and forecasting".

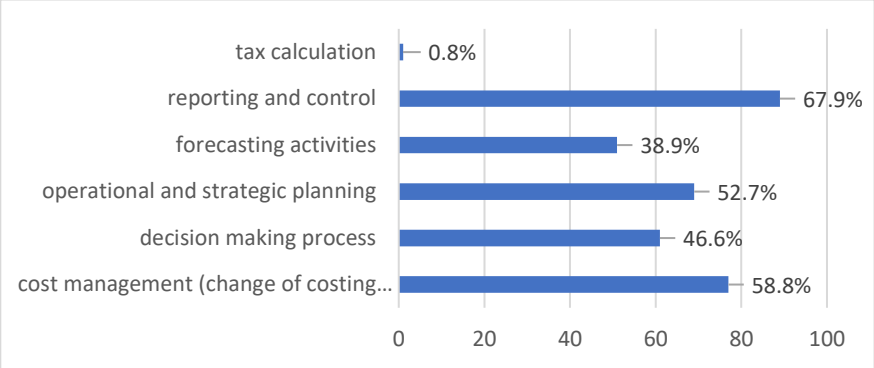


Figure 4.9: Areas where Big Data and AI have the greatest impact on management accounting

Source: Self-elaborated

According to the figure 4.9, multiple and different areas were focused, with most participants agreeing that AI and Big Data will have an impact in several areas of management accounting. The answer with higher percentage was reporting and control, followed by cost management (change of costing and measurement systems).

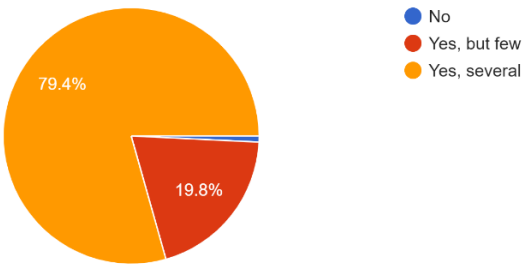


Figure 4.10: Number of professionals that consider that combining human and intelligent system-based decision making have advantages

Source: Self-elaborated

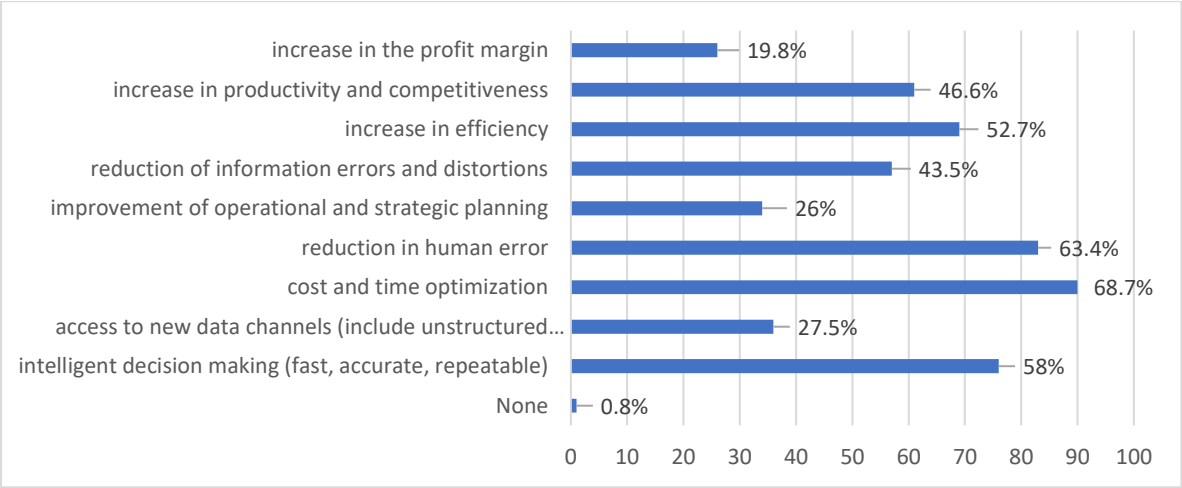


Figure 4.11: Benefits of Big Data and AI

Source: Self-elaborated

According to the figure 4.10, 99.2% of the participants agree that combine human and intelligent system-based decision making will bring advantages to management accounting processes. According to the figure 4.11, it is possible to mention that all participants except 1 saw benefits in the implementation of these intelligent systems. The benefits that more than a half of the 131 participants expect to have with the implementation of these technologies are cost and time optimization, reduction in human error, intelligent decision making (fast, accurate, repeatable) and increase in efficiency. This is not in completely agreement with what was mentioned by Warren *et al.* (2015), and Rybicka (2018) that considered that the access to new data channels through Big Data will bring huge benefits to these professionals, only 27,5% of the inquiries agree with this.

A high percentage of the inquiries agree with Rybicka (2018) that stated the following opportunities to management accountants: improvement of decision-making process, improvement of operational and strategic planning and cost and time optimization. Zhang *et al.* (2020) also mentioned the advantages of reducing information errors and distortions, better decisions and improving efficiency, which is in line with what was advocated by a large percentage of the respondents.

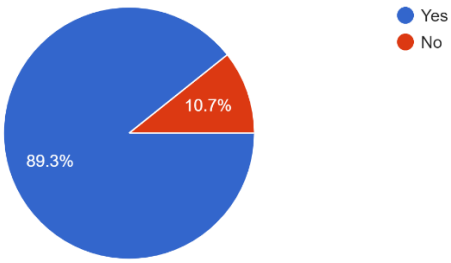


Figure 4.12: Number of professionals that consider that in certain situations not fully delegate decision making to an intelligent system is the best option

Source: Self-elaborated

On the other hand, according to the figure 4.12, 89.3% of the participants considered that in certain situations we can have advantages of not fully delegate the decision making to an intelligent system. The two main reasons appointed for this is the lack of interpretability of these systems and the fact that intelligent systems have difficulties at solving problems that are not very clearly delimited and well-structured.

In order to have more relevant information related to this research question, a set of interviews with professionals of intelligent systems was also carried out to complement the answers given in the questionnaires. By doing this is possible to match the views and knowledge of both. Bellow was evaluated the answers given by the 18 interviewees to the following questions: To what extent can AI and Big Data help management accounting professionals in their daily tasks? In what areas do you think that AI and Big Data systems will have the greatest impact on management accounting?

Table 4.2: Content Analysis – Impact of AI and Big Data on management accounting

Content Analysis - Interviews			
Interviewee	Text	Categories	Subcategories
IS professional 1	Automation in the identification and extraction of explicit or implicit data (data mining) about relevant information, optimization of the management of large databases, (…) automation in making decisions derived from large volumes of data. Therefore, AI and Big Data can help in actions or procedures which impose the need to equip machines with the knowledge and behavior of human specialists.	**I.1**	**I.1.1**
IS professional 2	Automated systems will greatly facilitate the daily task and will even free up part of the time of those who are working on these tasks and activities to a much more important dimension, which is the dimension of decision making.	**I.1**	**I.1.1**
IS professional 3	Very objectively, I think beside helping, human resources in these areas will be highly replaced.	**I.1**	**I.1.1**

IS professional 5	In a faster and more accurate decision-making process, I think it makes perfect sense and also in reducing human error. I believe that an intelligent system can adapt to the circumstances and try to diagnose a possible problem, and it may possibly minimize human error and perhaps facilitate the filling of things a little bit because it may have the capacity for suggestion, the capacity for validation.	**I.1**	**I.1.1**
IS professional 10	Time and costs optimization because there may be some automatic part for allocating expenses to certain items, there may be some automation. (…) The reduction of human error also by the same reason, by a kind of decision support in which some good candidates for these expenses were pre-selected by the automatic system.	**I.1**	**I.1.1**
IS professional 10	In forecasting it is more or less easy to understand that yes, because one of the things that these algorithms do, data science, data mining, machine learning is essentially forecasting, that is based on data from the past be able to predict what will be the future output for the standard, for the similar example that has never been seen before.	**I.1**	**I.1.2**
IS professional 14	All kinds of functions will be affected by AI without any doubt. So, the reporting part, the procurement part, all this will be affected. Reporting is increasingly interconnected with data mining for the presentation of data.	**I.1**	**I.1.2**
IS professional 16	The more data we have and the more detailed and deeper we can go to be able to determine what is the cause of what is happening to us, the more efficient our work will be, this is what Big Data brings.	**I.1**	**I.1.1**
IS professional 17	Through AI we have data to be able to make a better, more documented, and more informed decision.	**I.1**	**I.1.1**

Source: Self-elaborated

Based on this assumption, can AI and Big Data help management accounting professionals in their daily tasks, a global analysis of the responses of all interviewees was made - figure 4.13.

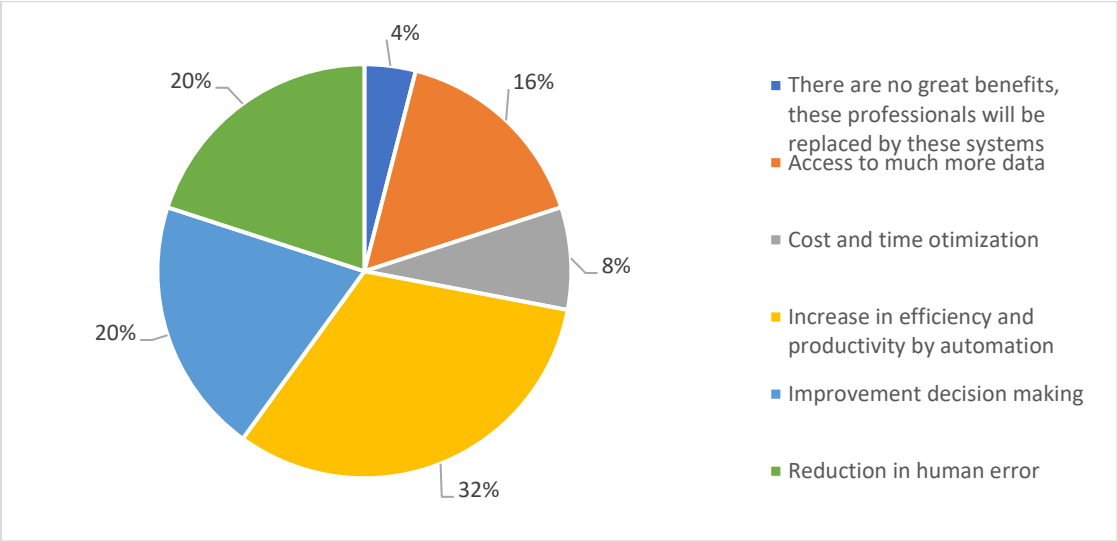


Figure 4.13: Answers of respondents [Intelligent Systems professionals] about the benefits of AI and Big Data for management accounting

Source: Self-elaborated

According to the reading of figure 4.13 and the table 4.2 of the content analysis, most interviewees agree that AI and Big Data help management accounting professionals in their daily tasks, which is in line with the answers given by the respondents in the questionnaire. Regarding the concrete advantages of AI and Big Data, the benefits that were appointed by more IS professionals are the increase efficiency and productivity derived from automation (32%), followed by the reduction in human error (20%) and the improvements that these IS can bring to decision making (20%) all these advantages are in agreement with Zhang *et al.* (2020) and the last one is also in agreement with Rybicka (2018). Comparing to the answers given in the questionnaire they are similar, they simply do not consider the advantages in the same order of importance, as in the questionnaire was considered as the more important advantage cost and time optimization and in the interviews only two IS professionals appointed this advantage.

Regarding the areas where AI and Big Data systems will have the greatest impact on management accounting, the IS professionals didn´t have a lot of knowledge about it, a few of them mentioned forecasting, reporting, and strategic and operational management. Although this question was not answered by all IS professionals, the answers that I got are in line with the answers given in the questionnaire, as they considered that the area that will be more affected is reporting and control.

Based on the results from the questionnaire and the interview, it´s possible to answer to the research question – *Can Big Data and AI improve management accountants' processes?* – The results are in agreement with what was stated by the authors Bhimani (2020), Rybicka (2018) and Richins *et al.* (2017), it allows us to conclude that the huge volumes of data combined with AI technologies will

create value for these professional's work, as 99.2% of the inquiries in the questionnaire and 96% of the interviewees stated that AI and Big Data improve and bring benefits to management accounting.

Part of the results are also in line with what was advocated by the authors Bhimani (2020), Rikhardsson & Yigitbasioglu (2018), Rybicka (2018), Elliot *et al.* (2020) and Richins *et al.* (2017) due to the fact that 20% of IS professionals and 58% of the professionals that answer to the questionnaire mentioned that these systems will have a positive impact in the decision-making process. Although Cubric (2020) and Shrestha *et al.* (2019) didn´t mentioned specifically management accounting in their studies, it is possible to said that the results are also in agreement with these authors as they stated that by using AI is possible to reduce human error and have faster and high-quality decisions.

To explore deeply the impact of intelligent systems on management accounting bellow was evaluated the answers given by the interviewees to the subsequent question: Do you think that we can have advantages in certain cases of not fully delegating decision-making to an intelligent system? Why?

Table 4.3: Content Analysis – Advantages of not fully delegate decision-making to an intelligent system

Content Analysis - Interviews			
Interviewee	Text	Categories	Subcategories
IS professional 1	Eventually, yes. When there is no prior knowledge of what the behavior is, a human specialist must proceed, or when there are subjective factors that are not formalized or even in situations that require emotions. (…) Neural networks have difficulty in presenting the explanations for the inference that were performed (…) it is extremely important to justify the decision making.	**I.1**	**I.1.3**
IS professional 2	I totally agree. (…) There will always be some need for now, at least, and in the medium term, before being able to fully automate this decision making. (…) It also does not progress more quickly, precisely because of the lack of explainability that exists in the most complex systems, not all, some are dominable, but those that are really showing better performance, in forecasting, planning are still a bit obscure.	**I.1**	**I.1.3**
IS professional 3	In the case of accounting, I think it will be much more perfect than the human in 99% of situations.	**I.1**	**I.1.3**
IS professional 10	Only when the error rate is very low in the tests that were made to that model and simultaneously the error is quite easy to correct and go back without having a very significant impact, only then we can let the system do a few things alone without a direct and immediate supervision, I think that beside this we should not let the system make too many decisions alone.	**I.1**	**I.1.3**

IS professional 14	The path that seems to me to be more mature is in decision support systems (…). I am not saying that in the future will not be almost everything through expert system, that is, automatic decisions, but the path that seems to me that makes the most sense is decision support system, that is, there is support and then the end user decides.	**I.1**	**I.1.3**

Source: Self-elaborated

Based on this assumption, can we have advantages in certain cases of not fully delegating decision-making to an intelligent system, a global analysis of the responses of all respondents was made - figure 4.14.

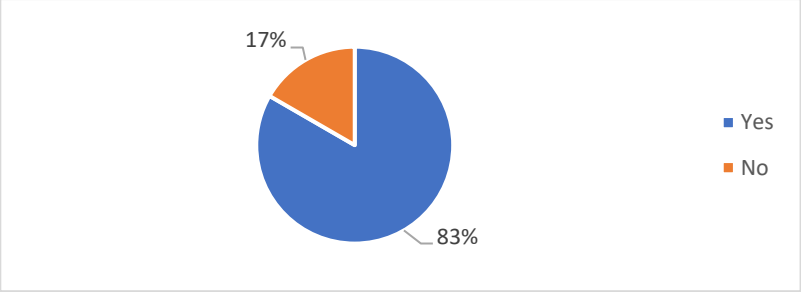


Figure 4.14: Answers of respondents [Intelligent Systems professionals] about not fully delegate decision-making to an intelligent system

Source: Self-elaborated

According to the reading of figure 4.14 and the table 4.3 of the content analysis, despite agreeing on the question before that AI and Big Data help and improve management accountants' processes, 83% of the IS professionals agree that we have advantages in certain cases of not fully delegating decision-making to an intelligent system, which was in line with 89.3% of the questionnaire´s answers.

These results complement the answer to the research question above that even though it has been stated that AI and Big Data contribute to the improvement of management accounting processes, it is important to not fully delegate all the tasks to an intelligent system, is still very important the management accountant professional. These results are in agreement with what was referred by Bolander (2019) and Shrestha *et al.* (2019), as the majority of IS professionals considered that we potentially lose something by fully automation through AI because human intelligence and machine intelligence have different strengths and weaknesses, so they think that the best path to follow is combine human and AI intelligences in order to explore the advantages of each. The majority of IS professionals appointed that the lack of explainability and transparency by these intelligent systems is a big problem that still don´t have a solution, which is also in agreement with the authors Bolander (2019), Burrell (2016) and Shrestha *et al.* (2019).

4.3 Probability of implementing AI, for decision making, in management accounting

To test the conceptual model and assess the probability of implementing AI in management accounting was used the SmartPLS 3 software (Ringle et al., 2015). To answer to this research question was evaluated the answers of 98 respondents in the questionnaire to four questions (2.2; 3; 6; 8). This analysis was carried out with 98 respondents and not with the total sample because it aims to assess the probability of adopting AI, so only respondents who currently do not use AI in their daily tasks were considered. Of the 131 inquiries who answer to the questionnaire, 33 who are already using AI were excluded, so the sample that will be considered to answer to this research question is composed by 98 respondents.

In first place was applied descriptive statistic (table 4.4) where was evaluated the mean, median, maximum, minimum and standard deviation. As can be seen all variables have high mean values and all of them have a median of 4, which is a high value. The variable with the highest mean was the "Value of AI for management accounting", the average of responses was slightly above 4, which means that these professionals see great value in AI.

Then was assessed and evaluated the model reliability and validity. To evaluate the quality of the measurement model, was examined the individual indicators of reliability, convergent validity, internal consistency reliability, and discriminant validity (Hair et al., 2017). In this particular case, there was only one question in the questionnaire for each item, thus this automatically provides evidence for the individual indicator reliability and internal consistency reliability (Hair et al., 2017). For the same reason the average variance extracted (AVE) for all constructs are equal to 1 and so exceeded the threshold of 0.50 (Bagozzi & Yi, 1988).

The discriminant validity was assessed using two approaches. First, was used the Fornell and Larcker criterion. This criterion implies that the square root of AVE, exposed on the diagonal with bold values in (table 4.5) is larger than its biggest correlation with any construct (Fornell & Larcker, 1981). Table 4.5 shows that this criterion is verified for all constructs. Second, was used the heterotrait-monotrait ratio (HTMT) criterion, this provides additional evidence of discriminant validity (Hair et al., 2017; Henseler et al., 2015). As table 4.5 shows, in this particular case, as there was only one question in the questionnaire for each item, HTMT ratios are equal to the correlation between construct below. More important to this is verified that all HTMT ratios are below the more conservative threshold value of 0.85 (Hair et al., 2017; Henseler et al., 2015).

Table 4.4: Mean, median, maximum, minimum and standard deviation of the five variables in study

	Variable	*Mean*	*Median*	*Min*	*Max*	*Standard Deviation*

(1) Probability of adopting AI	Dependent	3.63	4	1	5	0.95
(2) Value of AI	Independent	4.16	4	2	5	0.80
(3) Challenges to implement AI	Independent	3.76	4	2	5	0.73
(4) Trust in information provided by an intelligent system	Independent	3.81	4	1	5	0.74

Source: Self-elaborated

Table 4.5: Composite reliability, average variance extracted, correlations, and discriminant validity checks

Latent Variables	α	CR	AVE	1	2	3	4
(1) Probability of adopting AI	1.000	1.000	1.000	**1.000**	0.638	0.297	0.465
(2) Value of AI	1.000	1.000	1.000	0.638	**1.000**	0.294	0.535
(3) Challenges to implement AI	1.000	1.000	1.000	0.297	0.294	**1.000**	0.272
(4) Trust in information provided by an intelligent system	1.000	1.000	1.000	0.465	0.535	0.272	**1.000**

Note: α -Cronbach Alpha; CR -Composite reliability; AVE -Average variance extracted. Bolded numbers are the square roots of AVE. Below the diagonal elements are the correlations between the constructs. Above the diagonal elements are the HTMT ratios. (Source: Self-elaborated)

The structural model was calculated with the sign, magnitude, and significance of the structural path coefficients, the magnitude of R2 value for the dependent value as a measure of the model's predictive accuracy (Hair et al., 2017). Before analyzing the structural model was assessed the collinearity (Hair et al., 2017). For the same reason that was mentioned above, the VIF values were all 1.00, which was below the indicative critical value of 5 providing evidence for no collinearity (Hair et al., 2017). The coefficient of the determination R2 for the dependent variable "probability of adopting AI" was 42.9% (figure 4.15), this value far exceeds the threshold value of 10% (Falk & Miller, 1992). In the figure 4.15 it is also possible to observe the SmartPLS model with all the direct and indirect relations between the four constructs.

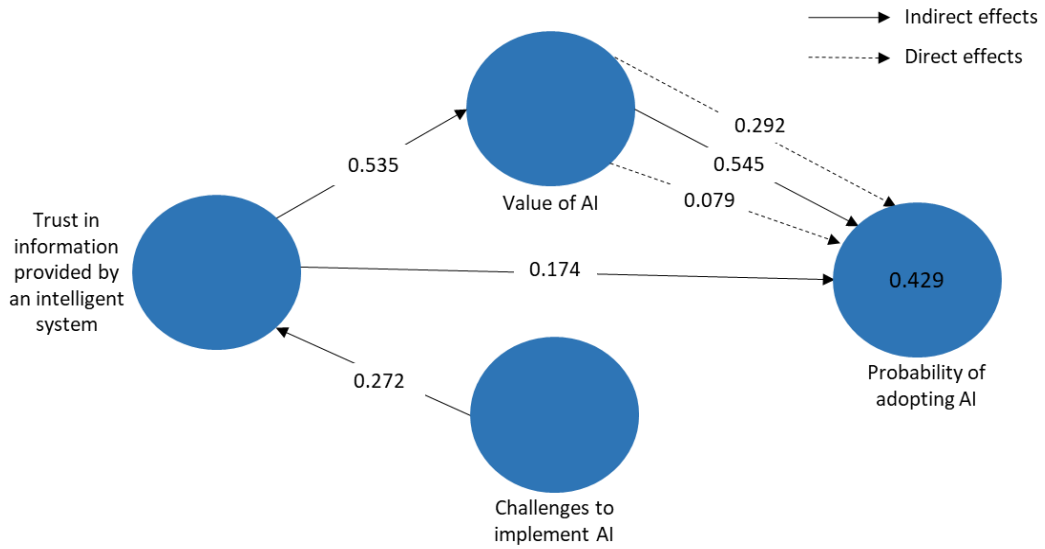


Figure 4.15: SmartPLS Model

Source: Self-elaborated

Table 4.6: Structural model assessment

Path	*Path coefficient*	*Standard errors*	*t statistics*	*p values*
Value of AI -> Probability of adopting AI	0.545	0.085	6.444	0.000
Trust in information provided by an intelligent system -> Value of AI	0.535	0.074	7.199	0.000
Trust in information provided by an intelligent system -> Probability of adopting AI	0.174	0.084	2.079	0.038
Challenges to implement AI -> Trust in information provided by an intelligent system	0.272	0.112	2.439	0.015

Source: Self-elaborated

Table 4.7: Bootstrap results for indirect effects

Indirect effect	*Estimate*	*Standard errors*	*t statistics*	*p values*
Trust in information provided by an intelligent system -> Value of AI -> Probability of adopting AI	0.292	0.061	4.791	0.000
Challenges to implement AI -> Trust in information provided by an intelligent system -> Value of AI -> Probability of adopting AI	0.079	0.040	2.000	0.046

Source: Self-elaborated

The results in the table 4.6 demonstrate that the value that inquiries see in AI has a significantly positive effect on the probability of adopting AI for decision making ($\beta=0.545$, $p<0.05$), which provides support for H1. The level of trust that the inquiries have on information provided by an intelligent system has a significantly positive relation with the value perceived of AI ($\beta=0.535$, $p<0.05$) and the probability of adopting AI ($\beta=0.174$, $p<0.05$), which supports H2 and H3, respectively. The level of challenges to implement AI has a significantly positive effect on trust that the inquiries have in information provided by an intelligent system ($\beta=0.272$, $p<0.05$), which proves that the relation between these two variables is positive and not negative, as speculated in H4. Thus, although there is a significantly relation, hypothesis H4 is not supported.

To test the mediation hypotheses was used a bootstrapping procedure to test the significance of the specific indirect effects via the mediator (Preacher & Hayes, 2008). Table 4.7 presents the results of the mediation effects. The indirect effects of trust in information provided by an intelligent system on the probability of adopting AI for decision making via the mediator of value perceived of AI is significant with ($\beta=0.000$; $p>0.05$). This result supports the mediation hypothesis H5a. The indirect effects of challenges to implement AI on the probability of adopting AI via the mediator of trust in

information provided by an intelligent system and value perceived of AI is significant with (β=0.046; p>0.05). This result supports the mediation hypothesis H5b.

Based on these results, it´s possible to answer to the research question – *What is the possibility of implementing AI, for decision making, in management accounting?* – According to these results in order to successfully apply the framework developed by Shrestha *et al.* (2019) in the management accounting area, to be able to combine human and algorithmic decision making and exploit the advantages of each, is very important that these professionals could see the value and advantages of the AI system and trust in the information provided by it. According to Güngör (2020) the perceived value creation with AI is seen predominantly for shareholders and customers not by employees and society, the results of this study go against this author by affirm that all the respondents that answer to this questionnaire, including employees, saw value on AI. Although there are no studies about the perceived value of AI on management accounting the results are in line with Petkov (2020) and Shrestha et al. (2019) as AI brings value to human capabilities, however these studies does not make a correlation between the increase in value perceived and the probability of adopting AI.

Additional to this is possible to affirm that the higher the trust in the information provided by an intelligent system the higher is the value perceived by these professionals and consequently the higher is the likelihood of companies implementing AI in the decision-making process. Although there are no studies about this in the management accounting area, this is in line with what Siau, K. and Wang (2018) stated in their study by affirm that trust is crucial in the development and acceptance of AI. Bitkina *et al.* (2020) study also support this view by proving that the perceived performance of AI grows along with the perceived trust.

Based on the results it is also possible to state that the challenges in AI implementation are not an obstacle to its implementation, as was expected, they are, on the contrary, a driver for the trust in AI systems to be higher, consequently, the perceived value of AI will be higher, and therefore the probability of adopting AI will be higher. These results are not according with Bitkina *et al.* (2020) study, that demonstrates that the growth on the task complexity, which can be considered as challenges, undermines the perceived trust and perceived performance of AI.

4.4 The shifts in management accounting profession with the massive introduction of intelligent systems into day-to-day tasks

With the purpose of verifying what shifts can occur in management accounting with the introduction of intelligent systems, first was evaluated the answers from the 131 respondents in the questionnaire.

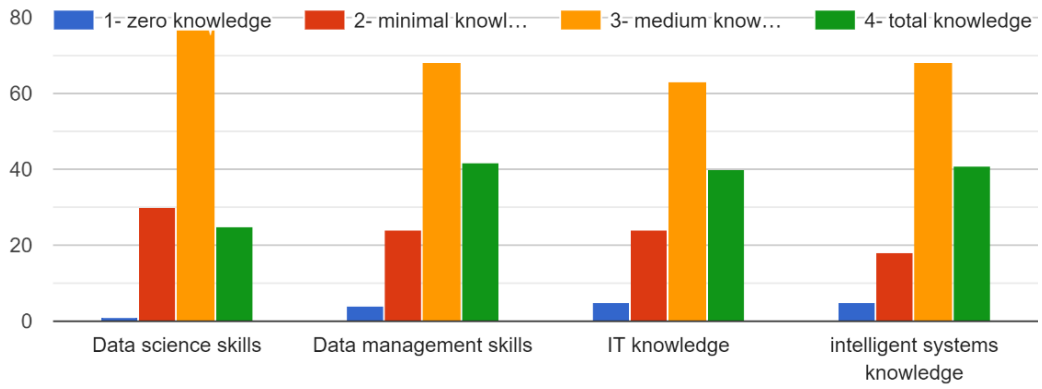


Figure 4.16: Skills that needed to be developed with the introduction of intelligent systems rate from 1 to 4
Source: Self-elaborated

According with the figure 4.16, most of the inquiries considered that management accountants will need to develop medium knowledge in data science, data management, IT and intelligent systems. An improvement and update in management accountants' skills is considered necessary by the majority of the participants.

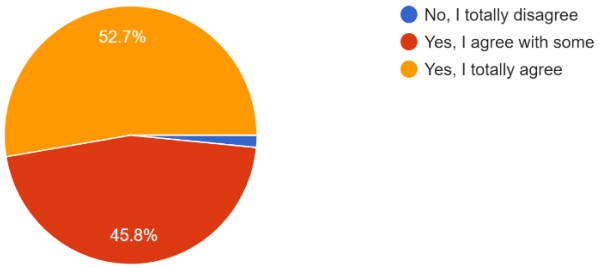


Figure 4.17: Number of professionals that agree with the six domains of competencies needed by management accountants to protect their careers in the future suggested by the updated Management Accounting Competency Framework 2019
Source: Self-elaborated

According with the figure 4.17, most of the inquiries agree with the six domains but some of them only agree with some. From the ones that only agree with some only 20 inquiries (15,3%) answer that the domain of Technology and Analytics is not needed to protect management accountants' careers in the future.

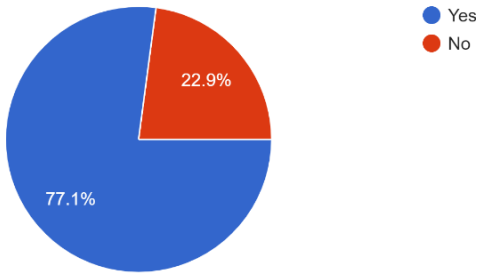


Figure 4.18: Number of professionals that consider that the certification process in the accounting area should now include intelligent systems

Source: Self-elaborated

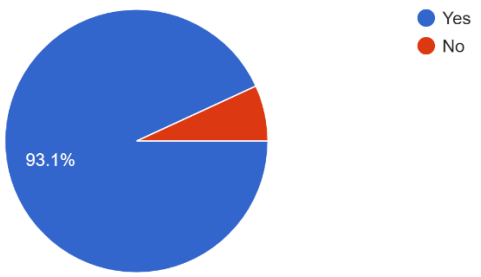


Figure 4.19: Number of professionals that consider that will be pressure in the future for the integration of intelligent systems in management accounting profession

Source: Self-elaborated

According to the reading of the figures 4.18 and 4.19, it can be seen that 77.1% of the inquiries considered that the certification process in the accounting area should now include intelligent systems. Additionally, 93.1% of the participants think that there will be pressure in the future for the integration of intelligent systems in management accounting profession.

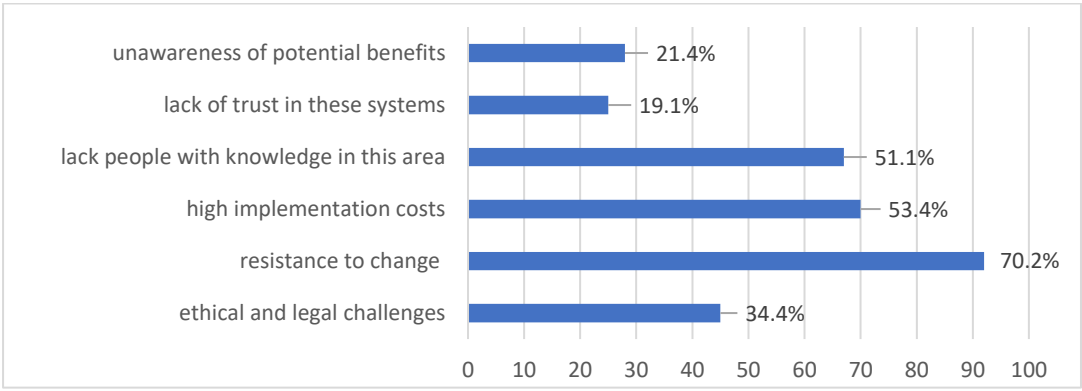


Figure 4.20: The biggest challenges for the implementation of these intelligent systems

Source: Self-elaborated

According to the answers that were given to the present questionnaire most of the management accountants that answer to it considered that a change must occur in order to remain competitive in the future and protect their careers. The implementation of intelligent systems will help a lot in this by having a very positive impact in many aspects. According to the figure 4.20, the biggest challenge for the implementation of these intelligent systems is the resistance to change.

To have more relevant information related to this research question, a set of interviews with professionals of intelligent systems was also carried out to complement the answers given in the questionnaires. By doing this is possible to match the views and knowledge of both. Bellow was evaluated the answers given by the 18 interviewees to the subsequent questions: Do you think that

there will be a major transformation in the functions of management accounting professionals with the introduction of intelligent systems? What are the main transformations that will occur? What new skills need to be developed by these professionals?

Table 4.8: Content Analysis – Transformations in the functions and competencies of management accountants with the introduction of intelligent systems

Content Analysis - Interviews			
Interviewee	Text	Categories	Subcategories
IS professional 1	Probably yes. Automation of tasks that can be performed by machines equipped with AI and Big Data techniques. They needed to have knowledge of techniques for using computer systems with Big Data and AI.	**I.3**	**I.3.2**
IS professional 3	What I see in general terms and this applies in particular to accounting is the rapid elimination or replacement of human intelligence or human work by machine work in everything that is routine. What is beginning to be realized is that perhaps the work of an accountant has to evolve into work that, in the end, in collaboration with the machine, can work on other aspects. What I think and see is that these professionals have to take advantage of IS to migrate to a higher level in the value chain, that is, intelligence at the service of added value. I think that these professionals will have to do the upskilling of more static tools and will have to evolve to more analytical and eventually more emotional functions, the relationship part, the internal negotiation part within organizations, the ability to deal with all elements of different cultures and different positions within the organization is basically what will make people stand out in the future because the routine things the machine and the computer will do much better and faster than the human. And it is in this aspect in the components of soft skills that people have to evolve in order to be able to keep themselves in organizations and where the machine will hardly enter.	**I.3**	**I.3.2**
IS professional 6	I think there is no need for specific knowledge, it has to be a tool implemented for day-to-day life, so the tool has to adapt to the processes and not the other way around.	**I.3**	**I.3.2**
IS professional 8	I would say no. Being something that helps, in spite of being an IS the part that is missing is another type of intelligence that has to be in people, and that they already have, if they are management accounting specialists, they already have all the capacities for that, they will only be provided with tools that give them much more information in decision making. So, I think that you don't have to change anything, in practice they will have better tools to do what they already do.	**I.3**	**I.3.2**
IS professional 12	I think it can have a really big impact, in fact. Accountants as specialists in their field can in fact make an important contribution to the development of these IS, instead of	**I.3**	**I.3.2**

	them feeling that they are being overtaken by machines they can help in the construction of these machines and have a relevant role in the construction of these machines, which makes them focus on more intellectually stimulating jobs and less on routine tasks.		
IS professional 17	The very big impact will be, above all, that people have to be aware of what data science is, how to get from a set of statistics and data, how to extract information from here that has added value to their work.	**I.3**	**I.3.2**

Based on this assumption, about the transformation in the functions of management accounting professionals with the introduction of intelligent systems, a global analysis of the responses of all respondents was made - figure 4.21

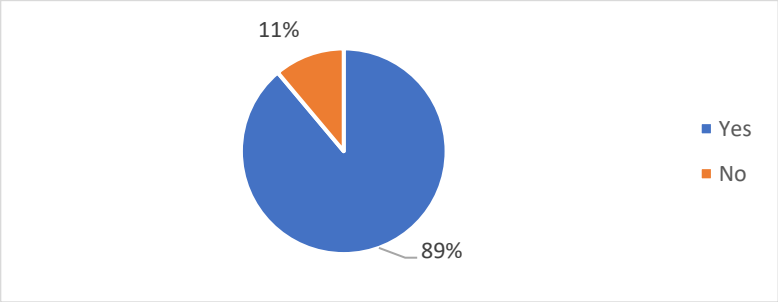


Figure 4.21: Answers of interviewees [Intelligent Systems professionals] about if there will be a major transformation in the functions of management accountants with the introduction of intelligent systems

Source: Self-elaborated

According to the reading of figure 4.21 and the table 4.8 of the content analysis, 89% of the respondents agree that intelligent systems will introduce big changes in the management accounting profession. The respondents focused "…the rapid elimination or replacement of human intelligence or human work by machine work in everything that is routine...", the importance of the soft skills and the importance of upskilling and focus on more intellectually stimulating jobs.

Based on the results from the questionnaire and the interview, it´s possible to answer to the research question – *What will be the shifts in management accounting profession with the massive introduction of intelligent systems into day-to-day tasks?* **–** The results are in accordance with what was mentioned by Lawson (2019), Richins *et al.* (2017), Sulaiman *et al.* (2015), Bhimani (2020) and Rybicka (2018) that referred that these emerging technologies have the potential to replace many of the more repetitive and manual tasks, allowing accountants to focus on opportunities that delivered higher value. The results are also according to Richins *et al.* (2017) and Nicoleta (2019), this can be

seen by what was stated by an IS professional in the interview "…they can help in the construction of these machines and have a relevant role in the construction of these machines...".

Most of the professionals that answer to the questionnaire and some IS professionals considered also the importance of include now data science, intelligent systems and IT skills in their knowledge, this is in line with what was stated by Pilipczuk (2020), that mentioned that the future management accountants will need to develop high cognitive, like IT and management skills.

In order to explore deeply the transformations and challenges of the introduction of intelligent systems on management accounting bellow was evaluated the answers given by the interviewees to the next question: What are the biggest challenges for the implementation of these intelligent systems in management accounting?

Table 4.9: Content Analysis – Biggest challenges for the implementation of intelligent systems in management accounting

Content Analysis - Interviews			
Interviewee	Text	Categories	Subcategories
IS professional 2	Resistance to change (…). The other part is that we are creating mechanisms that often use samples to do planning or decision making, the data that we are providing to those mechanisms, are the algorithms to form the automatic mechanisms may not be completely exempt and, so it is true that we still need to have some way to validate the equity and fairness of the results that are being provided to us and finally the legal norms.	**I.3**	**I.3.1**
IS professional 3	I think that this will be overcome by the conjuncture of the market's needs, that is, by nature it wants to be as efficient as possible, it will force these systems to emerge almost by force of law. And, therefore, this will delegate to the background if they want or not want if they are adverse to the change or not, in the end they will be overcome.	**I.3**	**I.3.1**
IS professional 4	The professionals who are going to implement this have to understand what are the needs and then have to adapt the algorithms to those needs, that is one of the reasons. Resistance to change also exists everywhere when changes are needed. Intelligent systems are in the IT area to be applied to management accounting, so it´s necessary time to communicate for them to realize what they can do with this type of tools.	**I.3**	**I.3.1**
IS professional 5	The biggest difficulty is to make a system that takes advantage of current AI technologies apply it to the area of management or accounting.	**I.3**	**I.3.1**
IS professional 7	I think that the ethical part is going to be a challenge and the resistance to change will always exist, what you have to realize is that there are advantages to changing to a system	**I.3**	**I.3.1**

	that helps us, this is very important, technology exists to help humans, it is not the technology by itself.		
IS professional 9	There is a big problem that is the following, often the data that is used by this system learn and is distorted in a certain sense, there is a set of news about the use of AI algorithms that have learned for example to discriminate racially or based on other criteria. Another problem is that the access to these data often raises ethical problems.	**I.3**	**I.3.1**
IS professional 15	It is the lack of knowledge versus the lack of data quality.	**I.3**	**I.3.1**

Based on this assumption, about the biggest challenges for the implementation of these intelligent systems in this profession, a global analysis of the responses of all interviewees was made - figure 4.22

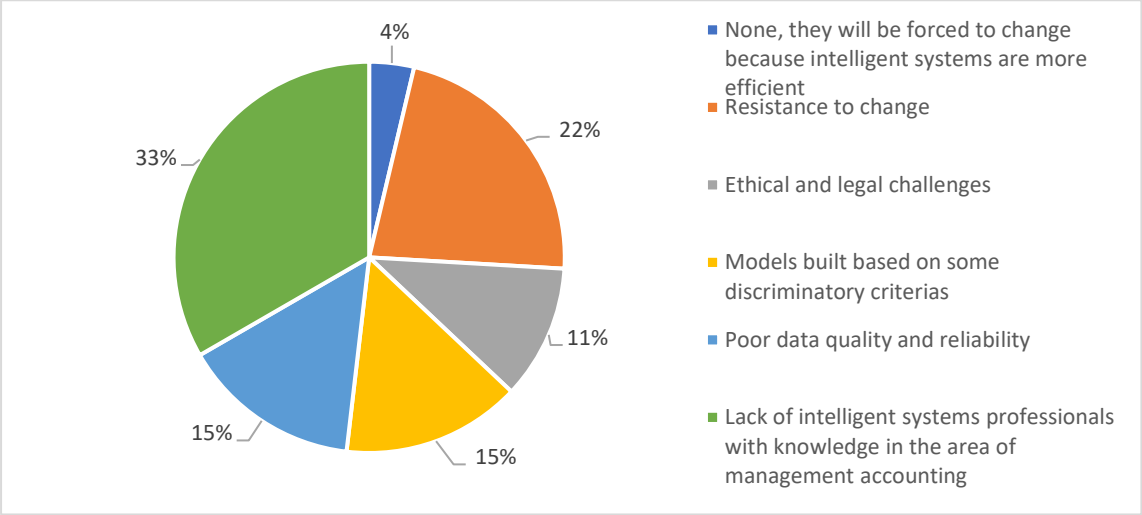


Figure 4.22: Answers of respondents [Intelligent Systems professionals] about the biggest challenges for the implementation of these intelligent systems in this profession

Source: Self-elaborated

According to the reading of figure 4.22 and the table 4.9 of the content analysis, the respondents mentioned several challenges for the implementation of these intelligent systems in management accounting, the challenge that was appointed for more interviewees was the lack of intelligent systems professionals with knowledge in the area of management accounting (33%), in the questionnaires 51,1% of the inquiries also mentioned this.

To complement the answer to the research question above is also important to look at the challenges that exist and will need to be addressed in order to implement intelligent systems in the management accounting area. The answers given in the questionnaires and in the interviews are in line with Gärtner & Hiebl (2018) and Quattrone (2016) as they referred that the lack of people with

knowledge in this area will be a huge challenge. However, the majority of the inquiries in the questionnaire mentioned the resistance to change as the main challenge which is not mentioned directly by none of the authors in the literature review.

Some IS professionals also mentioned the data quality and reliability which was also referred by Gärtner & Hiebl (2018) and Quattrone (2016). These two authors also mentioned in their studies the overload of information, changing cost structure and the possibility of faster false decisions as main challenges, these challenges were not referred in the interviews and in the questionnaires.

15% of IS professionals are also in agreement with the authors Richins *et al.* (2017), Elliot *et al.* (2020) Bolander (2019) and Shrestha *et al.* (2019) that stated that inaccuracies or biases that can be present in the huge amount of data can be a challenge in the management accounting area. Although Cubric (2020) focused their study on the management and business area it is possible to said that the results are also in agreement with this author that stated that the main barriers for AI implementation are: dependence on non-humans, job security fears, lack of knowledge and understanding of potential benefits and lack of trust. All these challenges were appointed in the questionnaires, in the interviews were only mentioned the resistance to change and the lack of people with knowledge in this area.

The answers from 34,4% of the inquiries in the survey and 11% of IS professionals in the interview are also in line with what was advocated by Cubric (2020), Dwivedi *et al.* (2019), Haenlein & Kaplan (2019) and Robles Carrillo (2020), as they appointed the ethical and legal challenges in the implementation of AI in an organization. Cubric (2020), Dwivedi *et al.* (2019) and Robles Carrillo (2020) also focused the economic barriers that were appointed by 53,4% of the participants in the questionnaire but were not mentioned in the interviews.

Conclusion

In the digital era where we are now more and more intelligent systems are implemented to help and improve several tasks. The present dissertation had as main objective to understand how intelligent systems and management accounting are related and how the first can be used for the benefit of the second. As management accounting is a profession that involves very repetitive tasks and structured procedures that could be easily optimize by an intelligent system. After the analysis of the literature review, as well as the answers to the research questions, it was possible to take some final considerations that, in a way, allow to deepen the study of the proposed theme. Through the questionnaires and interviews that were applied, it is possible to observe that intelligent systems will have a huge impact in the management accounting area. Intelligent systems can offer added value to these professionals in many tasks and procedures that are part of their daily work.

As it was possible to observe throughout the analysis of data and discussion of the results of the first research question, although accountants and the IS professionals agree that IoT could bring benefits mainly through the possibility of use real-time data, which are in line with what was stated by Brous et al. (2020) and S. Li et al. (2015), 50% of the IS professionals are not sure that these benefits will affect directly this profession, 17% even claim that the advantages are in the management area only not in management accounting. On the opposite 90.8% of the accountants stated that IoT will brings benefits directly to their daily tasks. Therefore, based on these results, was not clear that IoT will impact management accounting.

Through the analysis of the results of the second research question most accountants and experts in IS agree that Big Data and AI have the capability to create additional value in management accountants' processes, which is according to Bhimani (2020), Rybicka (2018) and Richins et al. (2017). When asked about the more important benefits IS professionals appointed the increase efficiency and productivity derived from automation as main advantage, accountants appointed the cost and time optimization. These two advantages end up being complementary to each other because higher efficiency and productivity at work, will lead to a better use of time and in the long run to an optimization of costs.

Despite all the benefits the majority of the questionnaire and interview inquiries affirm that they won´t fully delegate all the tasks to an intelligent system due to the lack of explainability that exists in the systems that show better performances, as was stated in the interviews these systems are still a bit obscure and is extremely important to be able to justify the decision that is taken. The path that was more appointed was a complementary work between the human and the machine.

In the third research question was only collected data through the questionnaires applied to accountants. By analyze the model that was built it is possible to state that the trust that management

accountants have in the information provided by an intelligent system positively influences the value that these professionals see in AI and has also a direct impact in the probability of adopting AI. The value that accountants see in AI has also a direct influence in the probability of implementing AI. Moreover, the indirect link that exists between trust and the probability of adopting AI reinforces the importance of the value perceived of AI.

Furthermore, the indirect link between challenges to implement AI and the probability of adopting AI reinforces the importance of the trust in information provided by an intelligent system and the value that management accountants see in AI. Thus, on the opposite of what was expected challenges in AI implementation are not an obstacle, but a driver for the trust in the AI systems to be better. Based on these results is possible to affirm that value and trust are direct drivers for AI implementation, so it´s necessary to create trust by demonstrating the value of this systems to management accountants. By doing this successfully management accountants will be open to this technology and will embrace it easily in their daily tasks.

By evaluating the results from the fourth research question it is possible to state that these technologies will transform the management accounting profession, these results are in line with was referred by Lawson (2019), Richins et al. (2017), Sulaiman et al. (2015), Bhimani (2020) and Rybicka (2018). Most of the accountants and some IS professionals considered important to start to include now data science, intelligent systems and IT knowledge as new necessary skills for this profession. By updating their existing skills, these professionals will be able to adapt and become more valuable for the company because they will have all the necessary skills to work together with these emerging technologies that are the future.

However, to implement these technologies it is necessary to face many challenges, the main one that is mentioned by IS professionals was the lack of intelligent systems professionals with knowledge in the area of management accounting, accountants referred as the biggest challenge the resistance to change. However, as was observe in the results of the third research question, where the sample taken into account were only the accountants that currently do not use AI in their daily tasks, the resistance to change was not considered a real barrier if it could be successfully prove to accountants that they can trust in the information provided by an intelligent system, on the other hand this can be difficult to demonstrate due to the lack of transparency of these systems.

As this research has shown, despite the benefits and the growing implementation of these emerging technologies in multiple areas and professions, in the management accounting area is still in the very beginning. There is still a long way to go for most management accountants start working together with these technologies and carry out tasks of greater value and relevance for the companies in which they operate. But this is certainly the future because these technologies, mainly AI and Big

Data, as was proved by the results of this investigation, have the power to greatly improve productivity and efficient, which is a necessary requirement for companies to remain competitive in the market.

Limitations

Throughout the study, naturally, some limitations have emerged. Firstly, concerning the literary review, it was not possible to access information regarding the impact of IoT in management accounting. Moreover, and still related to the literature, it was not possible to access relevant information about what conditions/ variables that lead to a higher likelihood of successfully implementation of AI systems in management accounting.

Another limitation in this study was the pandemic issue, it was not possible to conduct face-to-face interviews, which may have affected the quality of respondents' responses. Moreover, this study contains some limitations due to the exclusive focus on the Portuguese and Brazilian market. Given the referred limitation, it is not recommended to extrapolate the data to a global analysis and conclusions.

Other limitation of the present study is the fact that the selected sample for the interviews was a bit small. This is due to the fact that the respondents were selected according to some previously defined requirements. In this way, it was possible to avoid responses that did not allow drawing relevant conclusions for this investigation, the participants are professionals who understand, work and are interested in the selected topic. Other limitation regarding the interviews is the fact that was only conducted interviews with IS professionals, the data collected from management accountants was throw questionnaires which leads to slightly different results.

On the other hand, it is necessary to continue this study, mainly because the themes that were addressed throughout this dissertation are constantly changing, as we are facing an era of digital transformation. Therefore, the conclusions that were drawn in this investigation may be changed in a medium period of time.

Suggestions for future research

To share a suggestion for future research, it would be interesting to extend the study to other countries. In this way, it would be possible to understand whether people's opinions regarding the topics covered follow the same line of thought across different countries and cultures.

In order to explore more deeply this theme, it would be interesting to conduct a study with interviews to both professionals, IS professionals and management accounting professionals and analyze the different perspectives about intelligent systems.

It may also be interesting to study the possibility of implementing AI, for decision making, in management accounting using different independent variables from the ones that are used in this investigation, to understand which variables, have the most influence on the probability of successfully implementing AI in management accounting.

Moreover, based on results of the present study it´s clear that Big Data and AI will impact several management accounting processes so it´s interesting to see in practice in the medium run the real impact, by applying these technologies in the management accounting area in a company or study a company where they are already implemented. It can be also relevant to study the impact of the IoT technology in this profession and see if it real has an impact directly on management accounting daily tasks or not.

References

Akter, S., Wamba, S. F., Gunasekaran, A., Dubey, R., & Childe, S. J. (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics*, *182*(October 2017), 113–131. https://doi.org/10.1016/j.ijpe.2016.08.018

Alina, M. (2018). Impact of Digitalization in Business World. *Revista de Management Comparat Internațional*, *19*(4), 350–358.

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16(1)*, 74–94. https://doi.org/10.1007/BF02723327

Bhimani, A. (2020). Digital data and management accounting: why we need to rethink research methods. *Journal of Management Control*, *31*(1–2), 9–23. https://doi.org/10.1007/s00187-020-00295-z

Bitkina, O. V., Jeong, H., Lee, B. C., Park, J., Park, J., & Kim, H. K. (2020). Perceived trust in artificial intelligence technologies: A preliminary study. *Human Factors and Ergonomics In Manufacturing*, *30*(4), 282–290. https://doi.org/10.1002/hfm.20839

Bolander, T. (2019). What do we loose when machines take the decisions? *Journal of Management and Governance*, *23*(4), 849–867. https://doi.org/10.1007/s10997-019-09493-x

Brous, P., Janssen, M., & Herder, P. (2020). The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations. *International Journal of Information Management*, *51*(September 2018), 101952. https://doi.org/10.1016/j.ijinfomgt.2019.05.008

Burrell, J. (2016). How the machine 'thinks': Understanding opacity in machine learning algorithms. *Big Data and Society*, *3*(1), 1–12. https://doi.org/10.1177/2053951715622512

Chen, M., Mao, S., & Liu, Y. (2014). Big data: A survey. *Mobile Networks and Applications*, *19*(2), 171–209.

Choi, T. M., Wallace, S. W., & Wang, Y. (2018). Big Data Analytics in Operations Management. *Production and Operations Management*, *27*(10), 1868–1883. https://doi.org/10.1111/poms.12838

Cognitive Computing and the Future of the Accounting Profession | CPA Practice Advisor. (2017). https://www.cpapracticeadvisor.com/firm-management/article/12318632/cognitive-computing-and-the-future-of-the-accounting-profession

Comaniciu, D. (2020). Artificial Intelligence for Healthcare. *Journal of Emerging Technologies in Accounting*, *17*(1), 3603–3603. https://doi.org/10.1145/3394486.3409551

Cubric, M. (2020). Drivers, barriers and social considerations for AI adoption in business and management: A tertiary study. *Technology in Society*, *62*(March), 101257. https://doi.org/10.1016/j.techsoc.2020.101257

Darwiche, A. (2018, September 26). Human-level intelligence or animal-like abilities? *Communications of the ACM*, *61*(10), 56–67.

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., … Williams, M. D. (2019). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *July*, 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Elliot, V. H., Paananen, M., & Staron, M. (2020). Artificial intelligence for decision-makers. *Journal of Emerging Technologies in Accounting*, *17*(1), 51–55. https://doi.org/10.2308/jeta-52666

Falk, R. F., & Miller, N. B. (1992). A primer for soft modelling. *University of Akron Press*.

Félix, G., & Thomas, N. (2004). Evidence of two effects in the size segregation process in dry granular media. *Physical Review E - Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics*, *70*(5), 16. https://doi.org/10.1103/PhysRevE.70.051307

Floridi, L. (2019). What the Near Future of Artificial Intelligence Could Be. *Philosophy and Technology*, *32*(1), 1–15. https://doi.org/10.1007/s13347-019-00345-y

Forbes Insights: The Next-Generation Accountant. (2019). https://www.forbes.com/sites/insights-kpmg/2019/04/29/the-next-generation-accountant/#627c8772ae67

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18(3)*, 382–350. https://doi.org/10.2307/3151312

Fortin, M. F. (2009). *Fundamentos e etapas do processo de investigação* (Loures: Lu).

Gärtner, B., & Hiebl, M. R. W. (2018). Issues with Big Data. In Q. M. Strauss (Ed.), *The Routledge Companion to Accounting Information Systems* (Abingdon, pp. 5–10). https://doi.org/10.4324/9781315647210

Ge, M., Bangui, H., & Buhnova, B. (2018). Big Data for Internet of Things: A Survey. *Future Generation*

Computer Systems, *87*, 601–614. https://doi.org/10.1016/j.future.2018.04.053

George, G., Haas, M. R., & Pentland, A. (2014). From the editors: Big data and management. *Academy of Management Journal*, *57*(2), 321–326. https://doi.org/10.5465/amj.2014.4002

Ghasemaghaei, M., & Calic, G. (2020). Assessing the impact of big data on firm innovation performance: Big data is not always better data. *Journal of Business Research*, *108*(April 2019), 147–162. https://doi.org/10.1016/j.jbusres.2019.09.062

Goundar, S. (2012). Research methodology and research questions. In *Research Methodology and Research Method* (pp. 84–193).

Goyal, P., Sahoo, A. K., & Sharma, T. K. (2020). Internet of things: Architecture and enabling technologies. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.04.678

Grable, J. E., & Lyons, A. C. (2018). Economcis & investment management; An introduction to big bata. *This Issue of the Journal*, *72*(5), 17–20.

Grabowska, S. (2020). Changes in the social architecture of business model in the perspective of the Industry 4.0 concept. *Management*, *24*(1), 130–142. https://doi.org/10.2478/manment-2019-0039

Güngör, H. (2020). Creating Value with Artificial Intelligence: A Multi-stakeholder Perspective. *Journal of Creating Value*, *6*(1), 72–85. https://doi.org/10.1177/2394964320921071

Haenlein, M., & Kaplan, A. (2019). A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review*, *61*(4), 5–14. https://doi.org/10.1177/0008125619864925

Hair, J. F., Hult, G. M., Ringle, C., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling*. Sage Publications.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43(1)*, 115–135. https://doi.org/10. 1007/s11747-014-0403-8

Hermann, M., Pentek, T., & Otto, B. (2016). Design principles for industrie 4.0 scenarios. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2016-March*(1), 3928–3937. https://doi.org/10.1109/HICSS.2016.488

Huang, M. H., Rust, R., & Maksimovic, V. (2019). The Feeling Economy: Managing in the Next Generation of Artificial Intelligence (AI). *California Management Review*, 43–66. https://doi.org/10.1177/0008125619863436

IMA. (2019). *IMA Management Accounting Competency Framework: Statement on Management Accounting [SMA]*. https://www.imanet.org/insights-and-trends/the-future-of-management-accounting/ima-management-accounting-competency-framework?ssopc=1

IoT Agenda 2019. (n.d.). Retrieved September 29, 2020, from https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

John Walker, S. (2014). Big Data: A Revolution That Will Transform How We Live, Work, and Think. In Houghton Mifflin Harcourt (Ed.), *International Journal of Advertising* (Vol. 33, Issue 1). https://doi.org/10.2501/ija-33-1-181-183

Khan, A. I., & Al-Habsi, S. (2020). Machine Learning in Computer Vision. *Procedia Computer Science*, *167*(2019), 1444–1451. https://doi.org/10.1016/j.procs.2020.03.355

Lawson, R. (2019). New Competencies for Management Accountants. *CPA Journal*, *89*(9 (Sept)), 18–21. https://www.cpajournal.com/2019/10/23/new-competencies-for-management-accountants/

Lewis, T. G., & Denning, P. J. (2018). The profession of IT learning machine learning. In *Communications of the ACM* (Vol. 61, Issue 12, pp. 24–27). Association for Computing Machinery. https://doi.org/10.1145/3286868

Li, F., Lam, K. Y., Li, X., Sheng, Z., Hua, J., & Wang, L. (2020). Advances and Emerging Challenges in Cognitive Internet-of-Things. *IEEE Transactions on Industrial Informatics*, *16*(8), 5489–5496. https://doi.org/10.1109/TII.2019.2953246

Li, S., Xu, L. Da, & Zhao, S. (2015). The internet of things: a survey. *Information Systems Frontiers*, *17*(2), 243–259. https://doi.org/10.1007/s10796-014-9492-7

McAfee, A., & Brynjolfsson, E. (2012). Big data: The management revolution. *Harvard Business Review*, *90*(10), 4.

Mohanta, B. K., Jena, D., Satapathy, U., & Patnaik, S. (2020). Survey on IoT security: Challenges and solution using machine learning, artificial intelligence and blockchain technology. *Internet of Things*, *11*, 100227. https://doi.org/10.1016/j.iot.2020.100227

Müller, O., Fay, M., & vom Brocke, J. (2018). The Effect of Big Data and Analytics on Firm Performance: An Econometric Analysis Considering Industry Characteristics. *Journal of Management Information Systems*, *35*(2), 488–509. https://doi.org/10.1080/07421222.2018.1451955

Nicoleta, G. C. (2019). *Journal of Academic Research in Economics Management Accounting : the Boundary Between Traditional and Modern*. *11*(2), 453–462.

Nielsen, S. (2018). Reflections on the applicability of business analytics for management accounting – and future perspectives for the accountant. *Journal of Accounting and Organizational Change*, *14*(2), 167–187. https://doi.org/10.1108/JAOC-11-2014-0056

O'Leary, D. E. (2015). Big data and privacy: Emerging issues. *IEEE Intelligent Systems*, *30*(6), 92–96. https://doi.org/10.1109/MIS.2015.110

Pauget, B., & Dammak, A. (2019). The implementation of the Internet of Things: What impact on organizations? *Technological Forecasting and Social Change*, *140*(May 2017), 140–146. https://doi.org/10.1016/j.techfore.2018.03.012

Petkov, R. (2020). Artificial intelligence (Ai) and the accounting function—a revisit and a new perspective for developing framework. *Journal of Emerging Technologies in Accounting*, *17*(1), 99–105. https://doi.org/10.2308/jeta-52648

Pilipczuk, O. (2020). Toward cognitive management accounting. *Sustainability (Switzerland)*, *12*(12). https://doi.org/10.3390/su12125108

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40(3)*, 879–891. https://doi.org/10.3758/BRM.40.%0A3.879

Quattrone, P. (2016). Management accounting goes digital: Will the move make it wiser? *Management Accounting Research*, *31*, 118–122.

Rajasekar, S., Philominathan, P., & Chinnathambi, V. (2006). *Research Methodology*. *January*, 1–53.

Ratnatunga, J. (2015). The Impact of New Technologies on the Management Accountant. *Developmental Review*, *35*(1), 98–112.

Ratnatunga, J. (2016). Applying Disruptive Technologies to Audited Financial Statements. *Journal of Applied Management Accounting Research*, *14*(2), 1–8.

Richins, G., Stapleton, A., Stratopoulos, T. C., & Wong, C. (2017). Big data analytics: Opportunity or threat for the accounting profession? *Journal of Information Systems*, *31*(3), 63–79. https://doi.org/10.2308/isys-51805

Rikhardsson, P., & Yigitbasioglu, O. (2018). Business intelligence & analytics in management accounting research: Status and future focus. *International Journal of Accounting Information Systems*, *29*(June 2016), 37–58. https://doi.org/10.1016/j.accinf.2018.03.001

Ringle, C. M., Wende, S., & Will, A. (2015). *SmartPLS3.0.* hamburg: www.smartpls.com

Robles Carrillo, M. (2020). Artificial intelligence: From ethics to law. *Telecommunications Policy*, *44*(6),

101937. https://doi.org/10.1016/j.telpol.2020.101937

Rowe, S. Del. (2016). There are as many as five V's, but one trumps all of them. *CRM Magazine*, *20*(6), 29–31. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=115880411&lang=es&site=ehost-live

Rybicka, K. (2018). New Technologies – the Impact on Contemporary Management Accounting. *Prace Naukowe Uniwersytetu Ekonomicznego We Wrocławiu*, *515*, 26–36. https://doi.org/10.15611/pn.2018.515.02

Schoenick, C., Clark, P., Tafjord, O., Turney, P., & Etzioni, O. (2017). Moving beyond the turing test with the allen AI science challenge. *Communications of the ACM*, *60*(9), 60–64. https://doi.org/10.1145/3122814

Shrestha, Y. R., Ben-Menahem, S. M., & von Krogh, G. (2019). Organizational Decision-Making Structures in the Age of Artificial Intelligence. *California Management Review*, 66–84. https://doi.org/10.1177/0008125619862257

Siau, K., and Wang, W. (2018). Building Trust in Artificial Intelligence, Machine Learning, and Robotics. *Cutter Business Technology*, *31*(2).

Software, V. (2019). MAXQDA 2020 [computer software]. *Berlin, Germany: VERBI Software*. Available from maxqda.com

Sulaiman, S., Ramli, A., & Mitchell, F. (2008). What Factors drive Change in Management Accounting in Malaysian Organisations? *Malaysian Accounting Review*, *7*(1), 61–76. http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=34904978&site=ehost-live

Vilelas, J. (2009). *Investigação : O processo de Construção do Conhecimento* (E. Sílabo (Ed.); 1ª).

Warren, J. D., Moffitt, K. C., & Byrnes, P. (2015). How big data will change accounting. *Accounting Horizons*, *29*(2), 397–407. https://doi.org/10.2308/acch-51069

Wortmann, F., & Flüchter, K. (2015). Internet of Things: Technology and Value Added. *Business and Information Systems Engineering*, *57*(3), 221–224. https://doi.org/10.1007/s12599-015-0383-3

Wu, J., Xiong, F., & Li, C. (2019). Application of Internet of Things and Blockchain Technologies to Improve Accounting Information Quality. *IEEE Access*, *7*, 100090–100098. https://doi.org/10.1109/access.2019.2930637

Younas, M. (2019). Research challenges of big data. *Service Oriented Computing and Applications*, *13*(2), 105–107. https://doi.org/10.1007/s11761-019-00265-x

Zahid, N., & Vagif, L. (2020). The Role of Management Accounting in the Organization. *International Research Journal of Applied and Basic Sciences*, *9*(11), 1912–1915.

Zhang, Y., Xiong, F., Xie, Y., Fan, X., & Gu, H. (2020). The Impact of Artificial Intelligence and Blockchain on the Accounting Profession. *IEEE Access*, *8*, 110461–110477. https://doi.org/10.1109/ACCESS.2020.3000505

Annexes

Annex A- Questionnaire Script

Sample Characterization

1.) What is your gender?

- ☐ Female
- ☐ Male

2.) What age group do you belong to?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65-older

3.) What is your level of education?

- ☐ Secondary Education
- ☐ Bachelor´s degree
- ☐ Master's degree
- ☐ PHD

4.) What is your profession or study area?

Questionnaire

1. Are you aware of the concepts of Artificial Intelligence and Big Data?

- ☐ Yes
- ☐ No

2. Are you already using at least one of these intelligent systems in any daily-task of your work?

- ☐ Yes
- ☐ No

2.1 If yes, in what task?

2.2 If not, what is the probability of adopting AI in your professional activity in the near future?

Scale: 1 (none) to 5 (very high)

3. Does AI bring value to management accounting?

Scale: 1 (none) to 5 (very high)

4. In what area(s) do you think these intelligent systems will have the greatest impact on management accounting?

- ☐ Cost management (change of costing and measurement systems)
- ☐ Decision making process
- ☐ Operational and strategic planning
- ☐ Forecasting activities
- ☐ Reporting and control
- ☐ Others

5. What benefit(s) do you have or expect to have with the implementation of these technologies?

- ☐ None
- ☐ Intelligent decision making (fast, accurate, repeatable)
- ☐ Access to new data channels (include unstructured data)
- ☐ Cost and time optimization
- ☐ Improvement of operational and strategic planning
- ☐ Reduction in human error
- ☐ Reduction of information errors and distortions
- ☐ Increase in efficiency
- ☐ Increase in productivity and competitiveness
- ☐ Increase in the profit margin

6. How do you assess the challenges to implement AI in management accounting?

Scale: 1 (very low) to 5 (very high)

7. What are the biggest challenges for the implementation of these intelligent systems?

- ☐ Ethical and legal challenges (ethical concerns whenever a business can collect microlevel data about consumers / privacy concerns)
- ☐ Resistance to change (big transformation in the role of management accountants)
- ☐ High implementation costs
- ☐ Lack of knowledge (lack of people with knowledge in this area)
- ☐ Lack of trust in these systems
- ☐ Unawareness of potential benefits
- ☐ Others

8. Would you trust information provided by an intelligent system?

Scale: 1 (don´t trust anything) to 5 (fully trust)

9. Do you think that combine human and intelligent system-based decision making would bring several advantages?

- ☐ No
- ☐ Yes, but few

☐ Yes, several

10. Do you think that we can have advantages in certain cases of not fully delegating decision-making to an intelligent system?

☐ Yes

☐ No

10.1 If yes, why?

☐ Lack of interpretability (AI systems cannot explain their own reasoning and behavior the way humans can, they make a binary classification)

☐ Intelligent systems have difficulties at solving problems that are not very clearly delimited and well-structured

☐ Others

11. Do you consider that there are situations in which the total delegation of decision-making to an intelligent system is the best option?

☐ Yes
☐ No

12. Are you aware of the concept of Internet of things?

☐ Yes
☐ No

13. Are you already using this intelligent system in any daily task of your work?

☐ Yes
☐ No

13.1If so, in what task?

13.2 If not, are you planning to implement this technology?

☐ No
☐ Yes, in short term
☐ Yes, in medium term
☐ Yes, in long term

14. Do you consider that integrating this technology in your daily work could have advantages?

☐ No
☐ Yes, but few
☐ Yes, several

14.1 If you agree, what are the advantages that are more substantial for you?

☐ Use of sensor data for improve data science processes and decision making
☐ Use of real-time data to improve budget accuracy

- ☐ Use of real-time data for cost planning and forecasting
- ☐ Increase capacity for monitor the overall business processes
- ☐ Increase the horizontality of organizations (smart organizations)
- ☐ Others

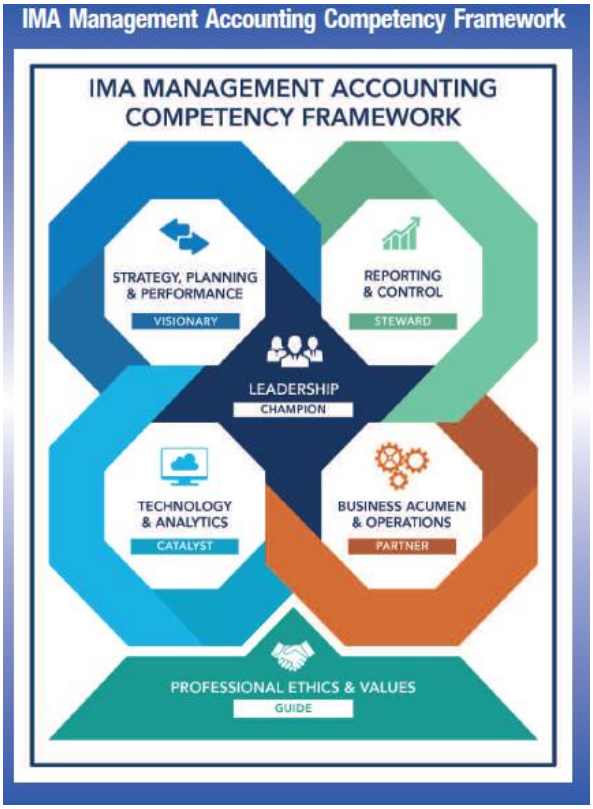
15. What knowledge level about intelligent systems do management accountants need to have to be able to implement AI successfully?

Scale: 1 (zero knowledge) to 5 (very high knowledge)

16. What new skills need to be developed with the introduction of intelligent systems? Rate from 1 to 4, the level of knowledge that you consider that these professionals must have in each one.

Options: Data science skills; Data management skills; IT knowledge; Intelligent systems knowledge; Others. (Scale 1 to 4 in each one; 1- zero knowledge; 4- total knowledge).

17. Do you agree with the six domains of competencies needed by management accountants to protect their careers in the future suggested by the updated Management Accounting Competency Framework 2019, represented in the picture bellow?



(Lawson, 2019)

- ☐ No, I totally disagree
- ☐ Yes, I agree with some
- ☐ Yes, I totally agree

17.1 If you only agree with some, which domain(s) of competence do you think should not be considered as necessary skills for these professionals?

- ☐ Strategy, Planning & Performance

- ☐ Reporting & Control
- ☐ Technology & Analytics
- ☐ Business Acumen & Operations
- ☐ Leadership
- ☐ Professional Ethics & Values

18. Do you consider that the certification process in the accounting area (CC) should now include intelligent systems?

- ☐ Yes
- ☐ No

19. Do you think that there will be pressure in the future for the integration of intelligent systems in management accounting profession?

- ☐ Yes
- ☐ No

Annex B- Interview Script

Sample Characterization

1.) What is your gender?

- ☐ Female
- ☐ Male

2.) Which country do you live?

3.) What age group do you belong to?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65-older

4.) What is your level of education?

- ☐ Secondary Education
- ☐ Bachelor´s degree
- ☐ Master´s degree
- ☐ PHD

5.) What is your profession or study area?

Interview Questions

1. To what extent can AI and Big Data help management accounting professionals in their daily tasks?

2. In what areas do you think that AI and Big Data systems will have the greatest impact on management accounting?

3. Do you think that we can have advantages in certain cases of not fully delegating decision-making to an intelligent system? Why?

4. What are the biggest challenges for the implementation of these intelligent systems in this profession?

5. Do you agree that IoT bring several benefits to management accounting? To what extent can IoT help management accounting professionals in their daily tasks?

6. Do you think that there will be a major transformation in the functions of management accounting professionals with the introduction of intelligent systems? What are the main transformations that will occur?

6.1 What new skills need to be developed by these professionals?

7. Do you think that the professionals who do not adapt to these new technologies will face difficulties competing in this profession?