NOVA IMS Information Management School

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Mestrado em Gestão de Informação
Master Program in Information Management

Towards the Implementation of an Intelligent ERP System

Guidelines for Building Intelligent ERP Systems

Filipe Inácio Ferreira da Silva de Sousa

Master Thesis presented as a partial requirement for obtaining the master's degree in Information Systems

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TOWARDS THE IMPLEMENTATION OF AN INTELLIGENT ERP SYSTEM

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Master Thesis presented as a partial requirement for obtaining the master's degree in Information Management, with a specialization in Information Systems and Technologies Management.

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October 2022

ACKNOWLEDGEMENT

Em primeiro lugar quero deixar o meu sincero agradecimento ao meu orientador, o Professor Doutor Vítor Santos, pela partilha de conhecimento na área, simpatia, disponibilidade e apoio incansável em todas as fases da tese.

Em segundo lugar a toda a minha família pela força e motivação constante. À minha mãe e ao meu pai, porque sem eles não seria possível realizar este marco no meu percurso académico. À minha irmã por ser uma fonte de inspiração.

Um agradecimento a todos os meus amigos pelo apoio durante o mestrado.

Por último, um obrigado a todas as pessoas que participaram nas entrevistas e que deram um feedback importante para a aceitação das recomendações propostas.

ABSTRACT

The digital age has forced companies to change the way they operate their businesses and adapt quickly to the digital transformation driven by increased global competitiveness in recent years. To remain competitive, organizations must implement management solutions that allow them to efficiently control all business areas through an Enterprise Resource Planning (ERP) system. Management systems have had to evolve to keep up with technological advancements by incorporating intelligent tools. As a result, ERP companies have created new systems known as intelligent ERP (i-ERP). Given the variety of improvement opportunities, it has become necessary to develop a series of guidelines for i-ERP manufacturing as well as for companies that want to implement intelligent solutions in their different business areas, in order to assist technical and non-technical people selecting the best existing option. A design science research (DSR) methodology was used to accomplish the study's goal. It was mandatory to start by defining what an i-ERP system is. Furthermore, their seven capabilities have been clarified, such as intelligent behaviour, learning management, advanced analytics, process automation, intelligent interfaces, dark analytics, and simplification of customization. These capabilities are based on technologies such as artificial intelligence, machine learning, big data, and cloud computing. The guidelines were based on these seven capabilities and were applied to the four major modules of an ERP, which are financial, purchasing, sales, and human resources. As a result, it was possible to create a table with recommendations in general by i-ERP capabilities, followed by guidelines focusing on the financial, purchasing, sales, and human resources areas, and an assessment tool that allowed creating measures to evaluate an ERP system, considering its level of intelligence based on the recommendations created. Finally, the evaluation system was used to rate the latest system developed by SAP SE, SAP S4/HANA, demonstrating its usefulness, followed by expert interviews to validate the recommendations for the four areas identified in terms of their use and acceptance. The relevant literature review and my personal work experience were used as the basis for this master's thesis. It is expected that this study will contribute to the scientific community's understanding of intelligent information systems as well as arouse curiosity in future studies.

KEYWORDS

Intelligent ERP; Artificial Intelligence; Machine Learning; Big Data; Cloud Computing; ERP Intelligent Capabilities

RESUMO

A era digital forçou as empresas a mudarem a forma como operam os seus negócios e a adaptarem-se rapidamente à transformação digital impulsionada pelo aumento da competitividade global nos últimos anos. Para se manterem competitivas, as organizações devem implementar soluções de gestão que lhes permitam controlar eficazmente todas as áreas de negócio através de um sistema de planeamento de recursos corporativos (ERP). Os sistemas de gestão tiveram de evoluir para acompanhar os avanços tecnológicos, incorporando ferramentas inteligentes. Como resultado, as empresas de sistemas ERP criaram produtos conhecidos como ERP inteligentes (i-ERP). Dada a variedade de oportunidades de melhoria, tornou-se necessário desenvolver uma série de orientações para fabricantes de i-ERP bem como para empresas que pretendam implementar soluções inteligentes nas diversas áreas de negócio, a fim de ajudar as pessoas técnicas e não técnicas na seleção da melhor opção existente. Uma metodologia de desenho de investigação científica (DSR) foi utilizada para atingir o objetivo do estudo. Foi obrigatório começar por definir o que é um sistema i-ERP bem como as suas sete capacidades identificadas, como ter um comportamento inteligente, gestão da aprendizagem, análise avançada, automatização de processos, interfaces inteligentes, análise escura, e simplificação da personalização, que têm como base tecnologias como inteligência artificial, aprendizagem de máquinas, grandes dados e armazenamento em nuvem. As orientações utilizaram como base estas sete capacidades e foram aplicadas aos quatro principais módulos de um ERP, que são o financeiro, compras, logística e recursos humanos. Como resultado foi possível criar uma tabela de recomendações gerais por capacidades de um i-ERP, seguida de recomendações com foco na área financeira, compras, logística e recursos humanos e por último uma ferramenta de avaliação que permitiu criar medidas para avaliar um sistema ERP, considerando o seu nível de inteligência com base nas recomendações criadas. Por último, o sistema de avaliação foi utilizado para classificar o mais recente sistema desenvolvido pela SAP SE, o SAP S4/HANA, demonstrando a sua utilidade, seguido de entrevistas a especialistas para validar as recomendações para as quatro áreas identificadas em termos de respetiva utilização e aceitação. Uma relevante revisão bibliográfica e a minha experiência profissional foram utilizadas como base para esta tese de mestrado. Espera-se que este estudo contribua para a compreensão dos sistemas de informação inteligentes pela comunidade científica, assim como despertar curiosidade em estudos futuros.

PALAVRAS-CHAVE

ERP Inteligente; Inteligência Artificial; Aprendizagem de Máquinas; Grandes Dados; Armazenamento em Nuvem; Capacidades ERP Inteligente

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial intelligence
BI	Business Intelligence
BPA	Business Process Automation
CRM	Customer Relationship Management
DSR	Design Science Research
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
FI	Financial Accounting
GUI	Graphical User Interface
HR	Human Resources
I-ERP	Intelligent ERP
IMS	Information Management System
IoT	Internet of Things
IPA	Intelligent Process Automation
ML	Machine learning
MM	Material Management
MRP	Material Requirement Planning
MRP II	Manufacturing Resources Planning
NLP	Natural Language Processing
RPA	Robotic Process Automation
SAP ECC	SAP ERP Central Component
SAP S/4HANA	SAP Business Suite 4 SAP HANA
SCM	Supply Chain Management
SD	Sales and Distribution
SME	Small and medium-sized company

1. INTRODUCTION

The first chapter of this master thesis contains the context, the motivation, and problem identification, which allows the elaboration of the research question and investigation objectives. The study's relevance and structure of the work are also presented.

1.1. CONTEXT

The Digital Age that followed the Industrial Age in the 1980s changed the way companies do business in society. Innovating the business model to achieve a competitive advantage has become key to surviving the competition, especially for small and medium-sized companies (SME) regardless of the market (Garzella et al., 2021). The companies that adapted more quickly and concisely to the market are the ones that survived.

Technological evolution, economic changes, and new markets have contributed to the increase in competitiveness among companies at a global level since the digitalization of processes enables companies to increase revenue, improve employee productivity, performance gain, customer satisfaction, and cost reduction (Abdullah et al., 2019). This new era has created new opportunities for billions of people around the world. Innovation, human capital, technology, flexibility, and agility were the most important factors to achieve economic success (Bal & Erkan, 2019).

Companies have invested in enterprise resource planning (ERP) systems to enable continued growing and adapting to constant changes. ERP systems are the backbone of any company in terms of information management system (IMS) integration. This system is defined as an enterprise management system that enables them to support their business (Holsapple et al., 2019). In this context, ERP systems have become indispensable in the day-to-day of a company due to the high capacity of data storage since they connect data from different processes of an organization into a single system. Moreover, it supports decision-making through fast data access, optimized workflows, and a global view of processes (Nwankpa, 2015).

Due to the attractiveness of the ERP market, several companies are competing, and according to Gartner analysts, the market grew 10% to a market size of 35 billion dollars in total software revenue in 2018 (Wilson, 2019). It is predicted to more than double to 117 billion dollars by 2030, indicating tremendous growth potential (K. Kumar et al., 2022). Currently, the top four companies in this area are SAP, Oracle, Sage, and Microsoft, but there are many other companies. In 2017, the top five ERP market shares were led by SAP SE with 23%, followed by Oracle with 12%, Sage with 6%, Workday also with 6%, and Infor with 5%. Other sellers represented 48% of the market, demonstrating the market's variety (Columbus, 2018).

As technology advances, systems also need to adapt, so the use of intelligent technology has become recurrent (Jenab et al., 2019). These technological advances also followed the IMS and ERP throughout history. The IMS comes from the minicomputer era in the 1960s, with very low access and few functionalities, to the mobile computing era in 2000s, with access everywhere and many functionalities (Laudon & Laudon, 2019). The ERP history also extends from the 1960s with inventory control systems to 2010s with cloud-based systems that support all departments and levels of management (Rashid et al., 2002). This evolution leads to the utilization of technologies such as digital, mobile, analytics, cloud,

and artificial intelligence (AI) in the ERP system, which has become a strategic requirement for an increasing number of companies in order to promote innovation and commercial growth (Ray & Solutions, 2019). Adding more creativity to information systems planning is becoming more important and could affect how well an organization does (Santos et al., 2016).

1.2. Motivation and Problem Identification

In an age affected by digital transformation, it is noted that companies have found ways to innovate through strategies that embrace the implications of digital transformation and lead to improved operational performance (Hess et al., 2016). This new reality offered great potential for improving performance in organizations, not only at the process level but also by improving the productivity of their employees (Vial, 2019). Companies that hesitated to move forward with intelligent technologies had an uncertain future in this competitive world.

ERP systems that use AI and other technologies are called "intelligent ERP systems" (i-ERP) and are seen as the new backbone of the digital transformation process (Morris et al., 2016). AI functionality has suddenly begun to appear more often in ERP software (Goundar et al., 2021). According to Basl and Novakova (2019), the new ERP contains technologies such as cloud computing, AI, and machine learning (ML).

Companies feel the need to move to i-ERP systems because it turns out that after the implementation of the ERP system, organizations face challenges daily. Whenever there are changes in business, needs, or even legal requirements, ERP systems must be changed to support the new reality, which leads companies to spend resources, whether internal or external, in a cyclical way. Panorama Consulting reports that in 2016, 37% of organizations with ERP systems already in place received less than half of the expected benefits (Costa et al., 2020). i-ERP can mitigate this problem considering that they can adapt to the market by creating results from the collected data. The system organizes them with the help of techniques such as ML and other advanced analytical techniques. The i-ERP system can provide important information via exceptions and business rules with the collected data (Ledford, 2017).

i-ERP is a relatively new concept, and as a result, there are few studies that can demonstrate its success in terms of implementations and its potential in the various business areas. The research gap found is that there are no studies focusing on the potential for ERP areas. They only talk about i-ERP as a general concept but do not go into detail about the various areas. If so, as a relatively new topic, it is important to get a wider array of perspectives regarding i-ERP (Hedenstrand, 2020). The identified research gap motivates this study by going into detail on specific business areas. Even so, it is clear that this evolution is required to ensure the success of organizations, and this topic has to be present in their future.

1.3. Research Questions and Investigation Objectives

Through the research gap that was found in the scientific community it was possible to identify and clarify the objectives for the presented study. The main goal of this thesis is to understand how i-ERP systems can be implemented and help the four main areas in a company, which are finance, purchase, sales, and human resources. However, it is not clear what can be done today in order to make the current ERP smarter in these areas. Then, the following research questions can be formulated:

RQ1: *What changes should the ERP manufacturers make to their products to make them more intelligent in the four main modules?*

RQ2: *What changes should the ERP implementers make in implementation services to make the ERP more intelligent in the four main modules?*

To achieve this goal, the research started with the explanation of the evolution of IMS, followed by the definition of an ERP system presented by the concept, advantages and disadvantages, history, and architecture. In the architecture part, the four main modules were identified. This early definition of an ERP system allowed the definition of an i-ERP system presented by the concept, advantages and disadvantages, and architecture. Then the technologies and capabilities behind an i-ERP system were identified, as well as a taxonomy to classify these systems. Through all the output taken from the previous topics, the guidelines for building intelligent solutions in the four major areas of an enterprise system, which are financial, purchasing, sales, and human resources, were created. Lastly, an assessment tool to evaluate the level of ERP intelligence based on the guidelines was constructed.

Furthermore, the following eight intermediate objectives were defined:

1. An explanation of the evolution of IMS.
2. Definition of an ERP system.
3. Identification of the four main modules of an ERP and their primary tasks.
4. Definition of an i-ERP system.
5. Identification of the technologies and capabilities behind an I-ERP.
6. Present a taxonomy to classify i-ERP.
7. Creation of a table with recommendations in general by i-ERP capabilities, followed by guidelines focusing on the financial, purchasing, sales, and human resources areas, and an assessment tool to evaluate the level of ERP intelligence.
8. Demonstration of the assessment tool by evaluating the new SAP product, and interviews to validate the proposed guidelines.

Subsequently, the last intermediate goal must be used to describe the artifact's validity through interviews, and the output allows the identification of recommendations for future research directions.

1.4. STUDY RELEVANCE

A recent study published by the Fraunhofer Institute for Manufacturing Engineering and Automation in Germany showed that the number of scientific publications on Google Scholar since 1990 containing the terms “artificial intelligence” and “sustainability” has been growing significantly, as can be observed in Figure 1 (Waltersmann et al., 2021).

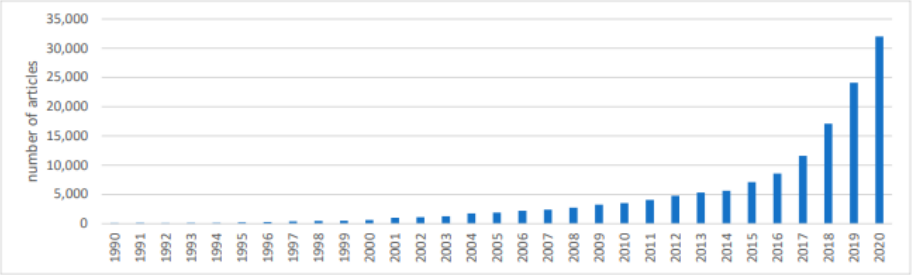

Figure 1: Number of articles containing terms "artificial intelligence" and "sustainability" on google scholar since 1990 (Waltersmann et al., 2021)

The so-called intelligent tools or techniques are altering the dynamics of the workflow by enabling humans to perform high-value work (Goundar et al., 2021). Although there are some scientific articles about i-ERP systems, it is still a very recent field and with little study. The benefits of these systems will undoubtedly be realized if businesses demonstrate openness and invest time in learning and implementing these techniques, which highlights the importance of this study to assist ERP manufacturers and companies that want to implement smarter ERPs.

In addition to the practical sense of guidance provided by the guidelines, the assessment tool created was used to evaluate the recent product from SAP SE, the SAP S/4 HANA. SAP SE is the market leader in enterprise application software, assisting businesses of all sizes and across all industries to operate at peak efficiency. SAP systems are used in 77% of all transactions worldwide (SAP SE, 2021b). This evaluation brought value to all companies that intend to acquire this product in the future and especially for those already using SAP ERP Central Component (SAP ECC) (SAP's legacy suite of enterprise applications) since according to their website, the SAP company will stop supporting this system in 2027 which will force companies to move to SAP S/4 HANA (SAP SE, 2021b).

Moreover, it is now even more relevant to understand how intelligent and disruptive components can be implemented in management systems to help companies in their business. Therefore, besides the practical sense that this set of guidelines offered for those who want to build or adopt an i-ERP, this study contributed not only to the scientific improvement of the fields of enterprise intelligent systems but also to other domains such as AI, ML, big data, and cloud computing, that are expected to grow and develop new products. Table 1 shows the relevance of the presented study to science, the scientific community, ERP providers, and users.

Table 1: Relevance of the study presented

Discipline	Relevance of the study presented
Science (Information and Management Systems)	• The ERP subject's evolution. • Technology and capabilities behind an i-ERP system. • Application of technology in specific areas, which are, finance, purchase, sales, and human resources. • ERP intelligence classification with the assessment tool. • Future research opportunities in the i-ERP field.

Scientific community (Students, teachers)	• Present the utilities of intelligent components and new technologies in ERP. • Evolution proposal for IMS and ERP fields. • Use case for AI, ML, big data, and cloud computing. • Arouse curiosity in future studies.
ERP Providers (Manufacturers and consultants)	• Understand the i-ERP main features and capabilities. • Understand which capabilities should be implemented in the i-ERP. • Assessment tool to evaluate the i-ERP intelligence level.
ERP Users (Companies)	• Understand the i-ERP main functions. • Help technical and non-technical people understand which capabilities should be implemented in the i-ERP system for the main four areas in their business. • Assessment tool to evaluate the i-ERP intelligence level.

1.5. THESIS ORGANIZATION

This thesis is divided into five main chapters:

Chapter 1 - Contains the context behind the presented work, the motivation and problem identification, the research question and investigation objectives, and its contributions to the research field.

Chapter 2– Aims to discuss the chosen methodology. Moreover, the six methodology steps were identified and explained in detail.

Chapter 3 – Comprise a rigorous literature review on the work performed by different authors that allows contextualization within the ERP and i-ERP concept, advantages and disadvantages, history and architecture, disruptive technology divided by i-ERP technology and capabilities as well as a taxonomy to classify ERP systems and the principals ERPs in the market.

Chapter 4 – Presents the artifacts created by the recommendation by i-ERP capabilities, the guidelines focusing on financial, material management, sales and human resources areas and the i-ERP assessment tool. Then it presents a use case with the i-ERP assessment tool demonstration and interviews with experts who evaluated the artifacts created.

Chapter 5 – Summarizes the dissertation's results, limitations and recommends future research directions.

2. METHODOLOGY

According to Järvinen (2000), the research question should serve as a guide for selecting the best methodology. Based on this idea, Järvinen developed the taxonomy presented in Figure 2, which presents the different methods that should be used, considering the research approach defined by the research question.

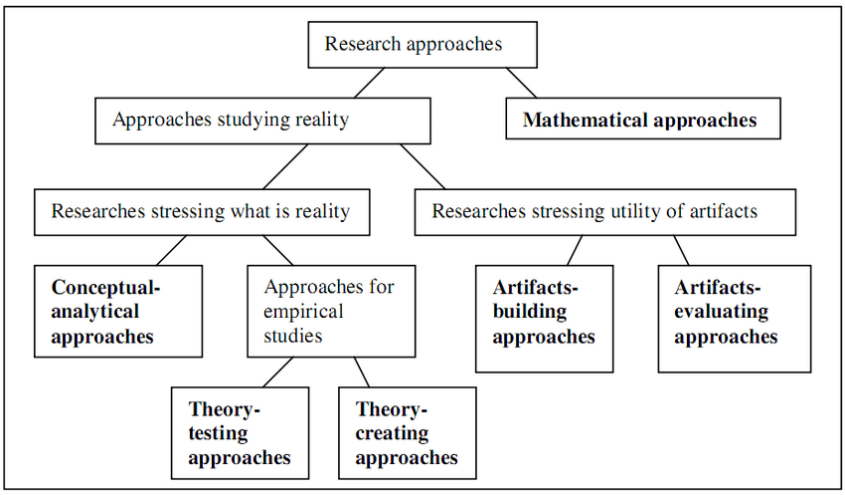

Figure 2: Järvinen's taxonomy of research method (Järvinen, 2000)

Given the objective of this master's thesis, the research approach chosen was the study of reality since most companies use ERP systems. Therefore the main idea was to create a set of guidelines for building i-ERP systems, it fits perfectly into the "research stressing utility of artifacts" through a set of guidelines that is an artifact.

2.1. DESIGN SCIENCE RESEARCH

Design science research (DSR) methodology highlights the importance of artifact construction for the effectiveness of information systems in a company (Peffers et al., 2018). An artifact is denoted by something that is constructed by humans since its manufacture is artificial and does not occur naturally (Baskerville et al., 2018).

This methodology contains a series of steps that must be followed according to Peffers to facilitate the presentation of new solutions to the problem initially encountered. The process includes six steps: problem identification and motivation, objectives definition, design and development, demonstration, evaluation, and communication (Peffers et al., 2006), as can be shown in Figure 3.

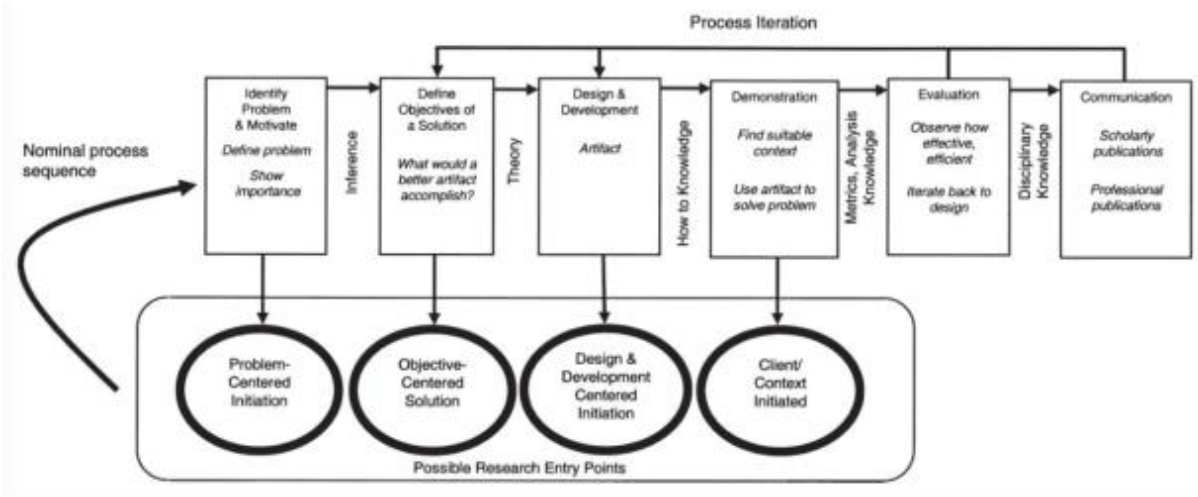

Figure 3: Design science research methodology (Peffers et al., 2006)

1st step: Problem identification and motivation - Define the unique research topic and demonstrate the usefulness of a proposed solution. This task requires knowledge of the current condition of the issue and the critical nature of its resolution (Peffers et al., 2006).

2nd step: Objective definition - The second step is the identification of objectives of a solution from the problem definition. The objectives can be quantitative or qualitative (Peffers et al., 2006).

3rd step: Design and development - With the help of the intermediate goals already defined, the artifact should be created to develop a set of guidelines to build an i-ERP system (Peffers et al., 2006).

4th step: Demonstration - Demonstrate the artifact's effectiveness in resolving the issue. This might include its use in an experiment, simulation, case study, or other relevant activity (Peffers et al., 2006).

5th step: Evaluation - Observe and measure how well the artifact helps you solve the problem. This activity compares the goals of a solution to how the artifact was used in the demonstration (Peffers et al., 2006).

6th step: Communication - Communicate the problem and its significance, the artifact, its utility and originality, the rigor of its design, and its efficacy to researchers and other relevant audiences, such as practicing professionals, as appropriate (Peffers et al., 2006).

Although this method is constructed in a nominally sequential order, no expectation exists that the researcher(s) would always move sequentially from activity one to activity number six (Peffers et al., 2006).

2.2. RESEARCH STRATEGY

Below is a detailed description of what happened at each step considering the six objectives presented above, each one should be associated with the following stages:

1st step: Problem identification and motivation – A literature review happened to identify the research gap and research questions as well as to identify the main aspects of an ERP and i-ERP system. The

identification of existing scientific articles and observations of points for improvement in them was also done.

- ✓ Objective: Identification of the critical points to be considered an ERP and i-ERP system.

2nd step: Objective definition – At this stage, the definition of the objectives for the problem defined in section 1.3 – research question and investigation objectives happened.

- ✓ Objective: Clarification of the master thesis's primary objectives.

3rd step: Design and development – The artifacts were created based on the literature review presents in chapter 3 – literature review.

- ✓ Objective: Development of the recommendations by i-ERP capabilities, followed by the guidelines for financial, material management, sales and human resources area and the i-ERP assessment tool.

4th step: Demonstration – For the demonstration step, the i-ERP assessment tool was used to evaluate SAP Business Suite 4 SAP HANA (SAP S/4HANA), which is the optimized version for the in-memory database SAP HANA.

- ✓ Objectives: Presentation of the main points of SAP S/4HANA and classification of SAP S/4HANA taking into account the assessment tool created.

5th step: Evaluation - For this master's thesis, data collection methods were used to enrich the qualitative research. Structured interviews were the choice, as they are quick, easy to administer, and they provide relevant information on a variety of topics (Gill et al., 2008). A sequence of interviews was conducted with experts in the information systems area to collect relevant opinions.

- ✓ Objective: Empirical evaluation of the framework based on the literature review.

6th step: Communication: After the evaluation phase is over, the presentation of the artifact occurred, as well as its publication to the scientific community. It was important to collect feedback to enhance future work in the area.

- ✓ Objective: Encourage new research in the field.

3. LITERATURE REVIEW

The literature review is an essential part of any research process because it serves as the foundation for the execution of any investigation. The literature review is essential not only to define the research problem but also to gain an accurate understanding of the current state of knowledge on the topic of ERPs.

According to Cardoso et al. (2010), each researcher must first thoroughly analyze the work of the researchers before him. To enrich the empirical study of this thesis, this chapter was made using various sources such as articles, books, scientific papers, and other master's theses. The literature review is divided into four sections, as explained in Figure 4, to address the main concepts for the development of this study.

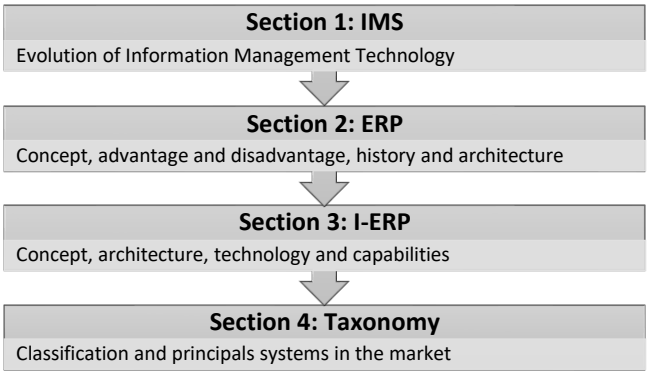

Figure 4: Structure of literature review

The history of IMS and their evolution over the years were discussed in section 3.1, followed by section 3.2, which is related to enterprise resource and planning systems. Section 3.3 was destined to investigate deeply the concept of i-ERP, and the last section, 3.4, is related to the identification of a taxonomy to classify intelligent systems.

3.1. INFORMATION MANAGEMENT SYSTEM

As previously stated, we live in a highly technological world. In today's society, our connection with technology has already become increasingly intense. Technologies touch every area of our lives, and with the quantity of data accessible and the velocity at which it is created, we must stay up with it and learn from it. According to Claude Shannon, considered the father of information theory, information is the resolution of uncertainty (Shannon, 1948). Despite the fact that this concept was said over fifteen years ago, it is still relevant today since these systems record useful information that enables support and planning from daily activities to management tasks.

The history of IMS undergoes a significant evolution with the development of disruptive technology and enterprise systems. Therefore, we can categorize them into five different eras, as can be seen in Figure 5.

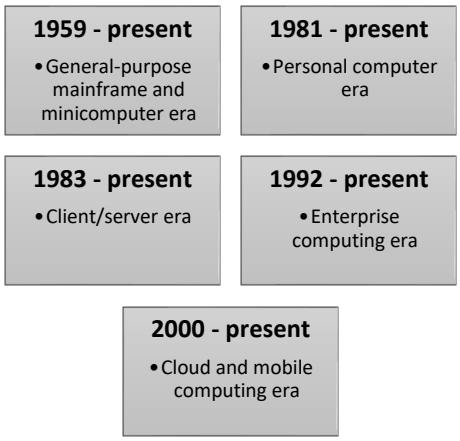

Figure 5: Evolution of information management technology infrastructure (Popovič, 2020)

General-purpose mainframe and minicomputer era (1959 - present) – Mainframes were the first powerful computers that were strong enough to accommodate thousands of remote terminals and could enable time sharing, multitasking, and virtual memory (Laudon & Laudon, 2019).

Personal computer era (1981 - present) – The IBM PC, which was introduced in 1981 and was the first computer and is often regarded as the beginning of the PC era (Laudon & Laudon, 2019).

Client/server era (1983-present) – In client/server era, people who use desktop or laptop computers called clients connect them to servers that provide services and capabilities for the clients (Laudon & Laudon, 2019).

Enterprise computing era (1992-present) - Companies switch to networking standards and software tools to integrate different networks and applications from different parts of the company into a single infrastructure for the whole company (Laudon & Laudon, 2019).

Cloud and mobile computing era (2000-present) - Cloud computing is a new model that gives people access to a common set of computing resources (computers, storage, applications, and services) over a network, like the Internet. This model is becoming more popular. These "clouds" of computing resources can be used by any device and in any place (Laudon & Laudon, 2019).

As we can observe, it has shifted from a very generic to a very specific perspective over the last few years. There are approximately more than two billion personal computers in the world today, as well as two thousand government data centers and an estimated eight thousand corporate data centers and cloud computing centers (Laudon & Laudon, 2019). The main question that businesses must answer is whether they are behind the technological curve or if they are properly prepared to implement disruptive technology. To capitalize on the business value associated with the internet, industries should significantly extend their internet connections, including wireless connectivity, as well as the power of their client/server networks, desktop clients, and mobile computing devices.

3.2. ENTERPRISE RESOURCE PLANNING SYSTEM

Section 3.2 is divided into four subsections to develop a major literature review on ERP systems. Sub-section 3.2.1 explains the concepts, while 3.2.2 explains the advantages and disadvantages associated with ERP systems, followed by the ERP history in 3.2.3 and architecture in 3.2.4.

3.2.1. ERP CONCEPT

To remain competitive in the current global and technological market, organizations must connect and converge data from multiple departments into a centralized and integrative solution (Laudon & Laudon, 2019), the so-called ERP systems. The ERP concept may be seen from a variety of perspectives (Klaus et al., 2000), since the ERP research community is varied, inclusive, multi-disciplinary, and interdisciplinary (Moon, 2007).

ERP systems are defined as comprehensive, packaged software solutions that seek to integrate the complete range of a business's processes and functions in order to present a holistic view of the business from a single information and IT architecture according to Klaus et al. (2000) but in short, ERP is a software used to integrate processes from different functional areas of a company (Al-Mashari et al., 2003) by a collection of software modules, with the objective of assisting businesses in automating and integrating corporate activities (Davenport, 1998).

When analyzing a company's management system, three points of view have to be considered. The first one is functional. What can the system do? The second is the technical, how does it work, and the last one is the business perspective impact for the business itself (Akkermans et al., 2003). Considering this perspective, ERP implementation is not merely a technological transformation, but it also affects how people and organization's function, as well as their strategy and culture (Davenport, 1998).

Adoption of ERP systems continues to be a means for organizations to gain a competitive advantage over their competitors. ERP systems provide an efficient and effective integrative tool by storing and sharing business processes and information in real-time across the entire organization. Because of this, it has been possible to confirm that the adoption of ERP systems in Europe is increasing. In 2012, the adoption rate was around 22%, rising to 26% in 2013, 31% in 2014, and 36% in 2015 (Amado & Belfo, 2021).

3.2.2. ERP ADVANTAGE AND DISADVANTAGE

Companies implement ERP systems in a broad sense to obtain benefits, but these benefits depend on external factors to the implementation of the system, such as organizational culture and strategy (Al-Mashari et al., 2003). Sometimes the predicted and actual effects of ERP are different from what was expected (Měsíček et al., 2021).

The benefits expected after the implementation of a management support system differ from organization to organization and can be tangible, intangible, or strategic benefits (Rashid et al., 2002). To achieve these benefits, businesses must adapt their business models to the technology at hand, which is undoubtedly the most difficult challenge for organizations. Table 2 contains the principal ERP advantages, followed by Table 3 with the disadvantages. It is worth noting that intelligent systems can mitigate some of the issues raised as ERP's disadvantages.

Table 2: Advantages of ERP system

Advantage	Description	Authors
Inventory control	Establishes effective material needs planning and uniform inventory management techniques across the organization.	(Meiryani et al., 2021; Ziff Davis, 2013)
Reduced time	Reduced time spent on routine administrative tasks.	(Rashid et al., 2002; Ziff Davis, 2013)
Better control	Better control of spending and more accurate information for analysis.	(Meiryani et al., 2021; Rashid et al., 2002; Ziff Davis, 2013)
Quality Improvement	Improve the quality of the processes and customer service.	(Meiryani et al., 2021; Ziff Davis, 2013)
More visibility	Better overall visibility from all departments.	(Meiryani et al., 2021; Ziff Davis, 2013)
Information centralization	Avoid data and operations redundancy with a central database that improves communication.	(Meiryani et al., 2021; Rashid et al., 2002; Ziff Davis, 2013)
Efficiency improvement	Processes are more efficient, which leads to less waste of resources.	(Meiryani et al., 2021; Ziff Davis, 2013)
Process improvement	It allows a redesign of the operational processes.	(Meiryani et al., 2021)
Easy adaptability	Business processes are easily adaptable and restructured.	(Rashid et al., 2002)

Table 3: Disadvantages of ERP system

Disadvantages	Description	Authors
Software costs	This includes implementation and maintenance costs.	(Brahmadeep & Thomassey, 2016; Nwankpa, 2015; O'Shaughnessy, 2022; Rashid et al., 2002)
Ongoing training	IT users must be educated on the technical aspects of the ERP system.	(Brahmadeep & Thomassey, 2016; Nwankpa, 2015; O'Shaughnessy, 2022)
Complexity	The complexity of the modules and the customization process leads to greater complexity.	(Brahmadeep & Thomassey, 2016; Nwankpa, 2015; O'Shaughnessy, 2022; Rashid et al., 2002)
Data conversion	Data migration errors.	(Brahmadeep & Thomassey, 2016; O'Shaughnessy, 2022)

Missing Flexibility	Sometimes processes have to be redesigned because the system cannot do what the customer wants.	(Brahmadeep & Thomassey, 2016)
Implementation Issues	Problems resulting from the system implementation process.	(Brahmadeep & Thomassey, 2016)
Supplier dependence	The cost of switching to another supplier is high.	(Rashid et al., 2002)

3.2.3. ERP HISTORY

In Figure 6, the evolution of these systems from the 1960 to 2010 century is illustrated. Just by curiosity in Portugal, the ERP started to become used not for inventory purposes but for financial and accountability.

Figure 6: Enterprise resources planning history (adapted from (Rashid et al., 2002))

As we can see in the 1960s, the majority of organizations designed, developed, and implemented centralized computing systems, simplifying their inventory control systems primarily through the use of inventory management and control packages (Rashid et al., 2002).

In the 1970s, material requirement planning (MRP) systems were developed, which focused on planning product or component requirements in accordance with the master production schedule (Klaus et al., 2000). Following this journey, in the 1980s, new software systems called manufacturing resources planning (MRP II) were introduced, focusing on optimizing manufacturing processes by synchronizing materials with production requirements (Rashid et al., 2002).

The term ERP systems appeared in the 1990s, and they integrate business processes from different areas such as manufacturing, distribution, accounting, financial, human resource management, project management, inventory management, and transportation, and provide consistency, accessibility, and better visibility across the enterprise, based on the technological foundations of MRP and MRP II (Rashid et al., 2002).

In 2000 century, the term ERP II was used to refer to internet-enabled systems that could retrieve data from external sources, such as front-office applications like customer relationship management (CRM), e-commerce, and marketing automation, as well as back-office applications like supply chain management (SCM) and human capital management (HCM) (Rashid et al., 2002). This was a big advancement since the more data sent into the ERP system, the simpler it is to detect and handle difficulties as well as capitalize on chances for development.

Cloud ERP is an ERP system that is hosted on a vendor's cloud platform rather than on-premises, enabling enterprises to access it over the internet. It started to appear in the year 2010. Since technological advancements have always followed the history of ERP, they will undoubtedly intensify the creation of new ideas in the next few years.

3.2.4. ERP Architecture

Each ERP is made up of several modules which are designed for specific business functions, such as providing data and supporting processes that help employees do their jobs. Every module integrates with the ERP system, ensuring the system offers a single source of accurate data by a central database (Klaus et al., 2000). The concept of the ERP system is illustrated in Figure 7.

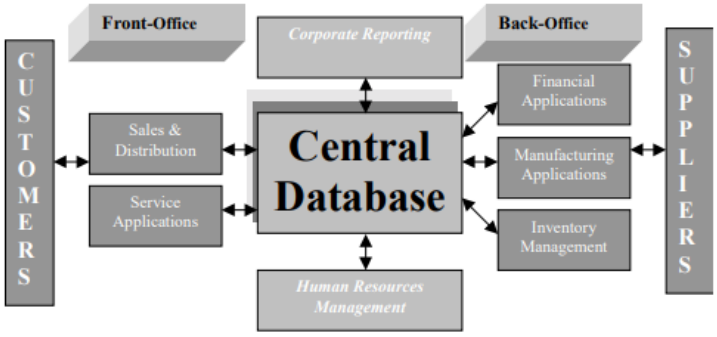

Figure 7: ERP systems concept (Rashid et al., 2002, p. 3)

These ERP modules are connected to the central database, and data is shared across modules (Davenport, 1998). Normally, a company can buy just the modules that are relevant to their business and then add more modules to address new business needs or challenges without the need to implement a new ERP system. It is important to note that there are many more modules than those mentioned, but the following modules are the most commonly used by businesses to support their business needs (Hayes, 2022; Laudon & Laudon, 2019; Rashid et al., 2002).

Financial Accounting (FI) – This module is one of the most used in ERP systems because finances are the backbone of any organization, and an effective finance tool works with every department. In depth, the FI module usually involves functionalities such as general ledger accounts, accounts payable and receivable, reports, and financial statements.

Material Management (MM) – Also known as SCM, provides information about inventory stock and provides an overview of the sales order process from acquisition to final shipping notification. Having an efficient SCM increases profit margins and strengthens the company's supplier relationship.

Sales and Distribution (SD) – A positive customer relationship is critical for the growth of a business, and a good SD or CRM system is required to build customer loyalty and avoid losing them to

competitors. Dashboards and reports are used to record and track customer purchase histories in order to maximize sales.

Human Resources (HR) – Control of all employee information, from the most basic, such as names, birthdays, and holidays, to the more complex, such as payroll processing. The best advantage of using an ERP system with an HR module is that it eliminates duplicate or inaccurate data by either compiling all data in the same system or using internal workflows to integrate different sources of data.

Table 4 presents the main macro activities of the FI, MM, SD, and HR modules.

Table 4: Main macro activities for FI, MM, SD, and HR modules

Module	Macro Activities	Authors
Financial Accounting (FI)	1) Process financial invoice. 2) Classify and reconcile accounting documents. 3) Analyze financial reports. 4) Optimize reports and transactions. 5) Asset depreciation.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Material Management (MM)	1) Verify and update stocks. 2) Supplier relationship management. 3) Warehouse management. 4) Optimize production. 5) Procurement.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Sales and Distribution (SD)	1) Price and conditions. 2) CRM. 3) Quote request. 4) Sales order creation. 5) Sales order shipping. 6) Sales delivery. 7) Marketing analysis.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Human Resources (HR)	1) Compensations, benefits and payroll. 2) Performance management. 3) Recruitment and selection. 4) Employee registration. 5) Training and development.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)

Since there are several modules, these systems are so varied that they can be used for various industries, as can be observed in Figure 8, and explained below, according to Shukla (2021).

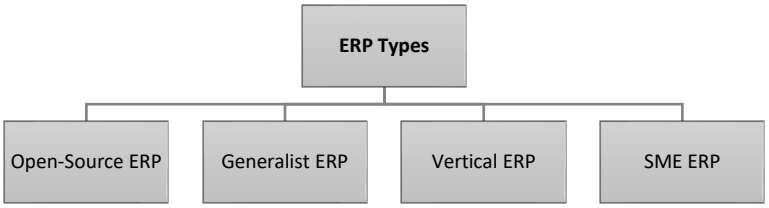

Figure 8: Types of ERP systems (adapted from (Shukla, 2021))

Open-Source ERP - Open-source ERP is a type of system in which the source code is freely available to the public (Shukla, 2021). According to Cereola et al. (2012), SMEs are suitable candidates for open-source ERP due to their agility and flexibility.

Generalist ERP - This type of ERP is relevant to many sectors because it is adaptable to the business processes and has high customization capability (Shukla, 2021). It can also be called ERP for corporations.

Vertical ERP - It has been used for a single niche of business (Shukla, 2021), for example, industries such as the public sector, healthcare, and education.

SME ERP - It is modest software since some of the ERP solution's extra functions have been eliminated (Shukla, 2021).

3.3. INTELLIGENT ERP

Section 3.3 contains five subsections to introduce and explain the i-ERP topic. Sub-section 3.3.1 explains the concepts, 3.3.2 the advantages and disadvantages associated with I-ERP systems, followed by the architecture in 3.3.3, technologies in 3.3.4, and capabilities in 3.3.5.

3.3.1. INTELLIGENT ERP CONCEPT

We are, without a doubt, in the early stages of this revolution in application architecture. As a result, new disruptive entrants with competence in the application of intelligent solutions to business processes are expected to join the industry in the near future. Technology is certainly fundamental to the problem of efficiency and agility, and its role has historically been recognized in enabling ERPs to be competitive (Srinivasan, 2016).

Since it is a recent topic, there are few academic studies on this topic. One of the first was from Morris et al. (2016), who describes an i-ERP as a cloud-based ERP system that enables creative goods and services, increases employee productivity, and maximizes the return on information assets, all while enabling digital transformation. According to Ledford (2017), an i-ERP system creates outcomes from the data it gathers and augments them using ML and advanced analytics technology. For Jenab et al. (2019), this upgraded ERP system is referred to as "intelligent ERP", because it enables businesses to make more informed business decisions and innovate.

These new systems use learning capabilities, prediction, and natural language processing (NLP) to comprehend user intents, improve data quality, and offer information in context to a user (Morris et al., 2016). An intelligent enterprise should be defined as a system sufficiently "smart" to require the

ability to monitor and analyze internal and external threats and opportunities continuously and to adjust operational processes to counter such threats or leverage opportunities using intelligent capabilities (Srinivasan, 2016).

3.3.2. INTELLIGENT ERP ADVANTAGES AND DISADVANTAGES

Due to the fact that this is a new topic, there are only a few publications that discuss the true benefits of these new systems. However, Table 5 and Table 6 contain the advantages and disadvantages of i-ERP systems. Furthermore, for these benefits to be realized, the organization must use an appropriate implementation process for the intelligent components.

Table 5: Advantages of intelligent ERP

Advantage	Description	Authors
Accurate decisions	The system can self-learn and assist managers making accurate decisions.	(Jenab et al., 2019; Morris et al., 2016)
Improve Quality	Improve the quality of the operations.	(Jenab et al., 2019)
Accelerates operations	Faster processing is ensured by data processing capabilities.	(Jenab et al., 2019)
Increases flexibility	Enables continuous reconfiguration.	(Jenab et al., 2019; Morris et al., 2016)
Reduces costs	Since they are more efficient, the costs of running the business go down.	(Jenab et al., 2019)
Improve processes	It keeps getting better over time because of the way it works.	(Jenab et al., 2019; Morris et al., 2016)
More efficiency.	Automation capability makes the process more efficient.	(Jenab et al., 2019)

As there are no studies on the disadvantages of i-ERP, the table below was constructed considering the disadvantages of technologies such as AI and business intelligence (BI).

Table 6: Disadvantages of intelligent ERP

Disadvantages	Description	Authors
Implementation Costs	Intelligent technology has a high cost of implementation and maintenance.	(Salur & Kattar, 2021)
Additional training	It requires the company to give more training or even hire an outside consultant, which increases the cost of putting it in place.	(Salur & Kattar, 2021)
Make humans lazy	Less human intervention, which leads to less human thinking in tasks.	(Verma et al., 2021)

Takes time	After implementation, the algorithms take time to collect the data.	(Verma et al., 2021)
Ethical dilemmas	There is a great dominance of ethics in the new technologies that must be respected.	(Verma et al., 2021)

3.3.3. INTELLIGENT ERP ARCHITECTURE

According to SAP SE (2021a), there are several new technological options, both in terms of goods and services for ERP systems, such as: self-service configuration (user experience), better analytic and reporting tools, a complete integrated software solution, company-wide customer data, embedded ML for learning and knowledge management, and AI for intelligent behaviour, extended functionality to integrate with other technologies, and cloud service to provide wide-reaching access.

The i-ERP systems must use a cloud deployment due to the demanding infrastructure requirements, ML technology to allow for new products and services and more productive employees, focus on process perspective and user experience, letting users find insights, better predict and plan for outcomes, get suggestions for the next best steps, and automate processes (Morris et al., 2016). According to Ledford (2017), i-ERP should have AI, ML, NLP, and advanced analytics combined with big data and cloud computing. The outcomes are better forecasting, analyzing, predicting, and reporting.

Basl and Novakova (2019), argue that new ERP systems must have cloud computing because it improves data storage and allows internet of things (IoT) devices to have real-time data availability for AI and ML. According to Jenab et al. (2019), an i-ERP system needs to connect to BI to better support making effective decisions, ML to identify unexpected customer behaviours, and advanced analytics. The requirements to differentiate from competitors are real-time analytics, IoT devices, big data combined with AI algorithms with real-time data, use of cloud computing, predictive analytics, and user-friendly interface, according to Ray and Solutions (2019).

Finally, and most recently, Hedenstrand (2020), argues that i-ERP should have BI, ML, predictive analytics, and IoT devices for automation, while Goundar et al. (2021), say that new systems should have AI, sensors to track real-time data, cloud solutions to handle huge amounts of data, and personal assistants (chatbots) to simplify and accelerate information retrieval.

In summary, four technologies have been identified by the various authors, namely AI, ML, big data, and cloud computing, that have been addressed in this thesis. IoT devices were also mentioned by some authors, but in order to simplify this study, the real-time data part has been incorporated into advanced analytics.

In Table 7, we can observe what distinguishes the new i-ERP from the previous ERP generation, according to Morris et al. (2016), and the new capabilities that have been considered in this thesis.

Table 7: Differences between the new i-ERP and previous ERP

ERP Application	New i-ERP Applications	New Capabilities
Automate and optimize business processes.	Forecast, monitor, learn, route, analyze, predict, report, and manage these resources and	Intelligent behaviour, learning management and advanced analytics.

	business processes using ML and sophisticated analytics.	
Collecting data on many parts of the firm, such as administrative details, transactional information, and operations.	They provide a better user experience by automating repetitive processes and enhancing (through human-machine interaction) less frequent ones.	Process automation.
Integration between different departments.	Capable of processing, analyzing, and responding in real time on huge amounts of data using in-memory computing technology.	Advanced analytics.
The software might be industry-specific or intended to be generally applicable to a set of industries.	It must allow for continual reconfiguration to improve processes and user experience.	Simplification of customization and intelligence interface.

Source: Adapted from (Morris et al., 2016)

To the six capabilities mentioned above, a seventh one has been added, which is related to the analytical part. The ability to integrate such analytical processes into its daily processes and analyze a huge amount of structured and unstructured data will follow this evolution in companies (Srinivasan, 2016), so the topic of dark analytics had to be added to deal with unstructured data. Figure 9 shows the four technologies that are the basis and foundations for the seven capabilities identified.

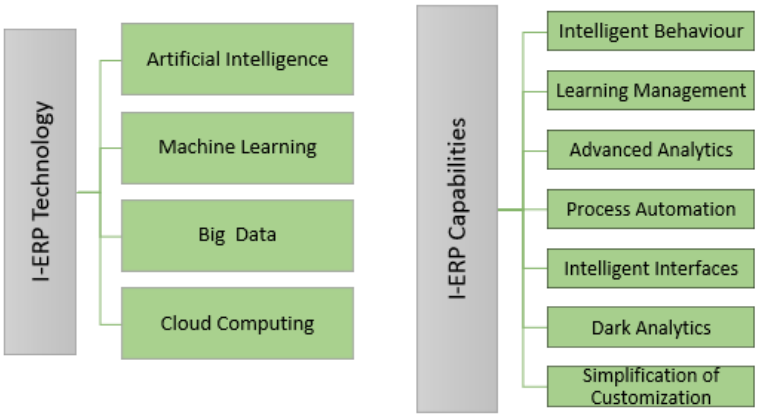

Figure 9: i-ERP technologies and capabilities.

The i-ERP approach started by defining the principal technologies that enable ERP to have intelligent and disruptive capabilities. It is important to note that the capabilities are the capacity to turn the technology into an ability to maintain and achieve a competitive advantage, and that is why it is necessary to divide them.

3.3.4. INTELLIGENT ERP TECHNOLOGY

Everything in life evolves just as ERP systems do, and the main technologies that are the basis for this evolution are the four domains according to Basl and Novakova (2019), namely AI, ML as a sub domain of AI but considering their importance must be treated separately, big data, and cloud computing. The following four subsections were devoted to exploring and explaining these domains.

3.3.4.1. ARTIFICIAL INTELLIGENCE

In a simple way, artificial intelligence, or AI, can be defined as the theory and development of computer systems able to perform tasks normally requiring human intelligence (Burgess, 2018). Recently, there has been a lot of discussion regarding this subject due to the rise of big data and improvements in computing power, but AI comes from a few decades ago. According to MIT (Massachusetts Institute of Technology) Technology Review, the magazine from the institute, AI is the concept to building machines that can reason, learn, and act intelligently, and it has barely begun (MIT, 2022).

The foundations of AI are disciplines such as philosophy, mathematics, economics, neuroscience, psychology, computer engineering, cybernetics, and linguistics (Russell et al., 2010), which shows the complexity of this area. Although it is difficult to identify, the origins of AI are most likely in the 1940s, more precisely in 1942, when American science fiction author Isaac Asimov published Runaround, often shortened to the three laws (a set of rules devised by science fiction) (Asimov, 1981). This work served as an inspiration for generations of scientists working in the fields of robotics, AI, and computer science.

Alan Turing, an English mathematician, worked on developing a code-breaking computer known as *The Bombe* for the British government with the goal of cracking the enigma code used by the German army during World War II (Haenlein & Kaplan, 2019) and this was the first time the relevance of AI was recognized, in order to enable a machine to execute tasks previously unattainable for even the finest human mathematicians.

Just note that this study did not cover the wide variety of dates in the history of AI. The historical analysis previously done only serves to show that it is not a recent topic and that its potential has been quickly realized. Therefore, Figure 10 presents a timeline in which we can examine the most significant events that have shaped the way we view AI between 1950 and 2018.

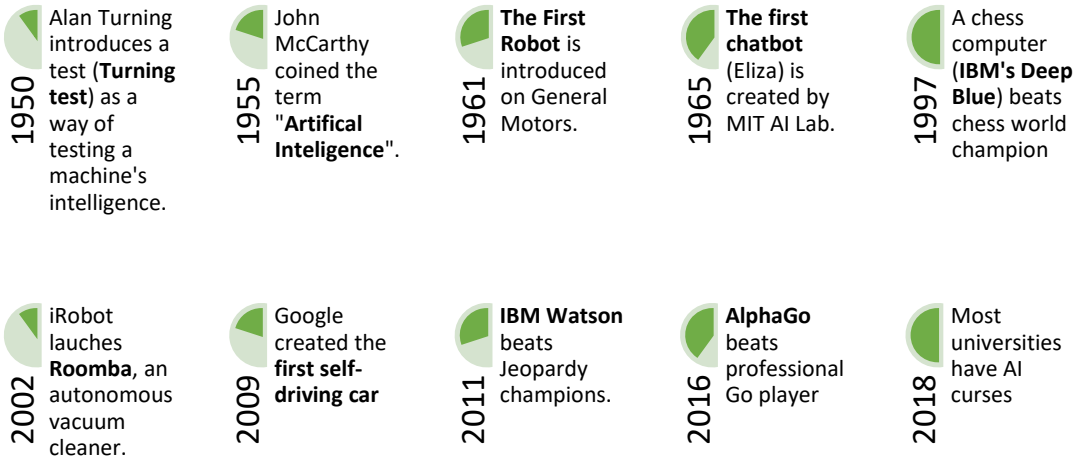

Figure 10: AI history between 1950 – 2018 (adapted from (Haenlein & Kaplan, 2019))

Due to its complexity, artificial intelligence should be separated into several AI subfields, and the most important are the following eight present in Figure 11 according to (Jeyamani et al., 2016) and most of them include both engineering and scientific aspects.

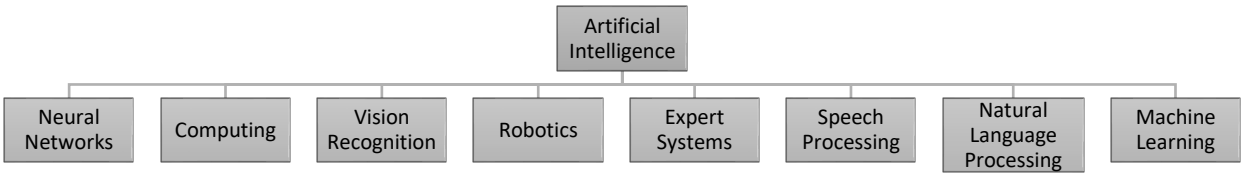

Figure 11: Sub-fields of artificial intelligence (adapted from (Jeyamani et al., 2016))

Neural Networks = is a collection of algorithms that attempt to detect underlying links in a piece of data by simulating how the human brain works (Jeyamani et al., 2016).

Computing = Evolution of genetic computing is a technique of evolving programs (Jeyamani et al., 2016).

Vision Recognition = is a computer program's capacity to recognize things, locations, people, text, and activities in photographs (Jeyamani et al., 2016).

Robotics = is the field that deals with the design, production, and employment of machines (robots) to do jobs formerly performed by humans (Jeyamani et al., 2016).

Expert Systems = is a computer program that simulates the capacity of a human expert to make decisions (Jeyamani et al., 2016).

Speech Processing = is a field of computer science concerned with the construction of computer systems capable of recognizing spoken language (Jeyamani et al., 2016).

Language Processing = NLP is concerned with providing computers with the capacity to comprehend text and spoken language in a similar way to how humans do (Jeyamani et al., 2016).

Machine learning = Identifies patterns in previous data and adjusts program actions consequently (Jeyamani et al., 2016).

In 2021 was posted an article in Portugal's economic journal that highlights the need for Portugal to increase its investment in AI training and specialization since Portugal doesn't have the resources to compete in all AI areas (Ferreira, 2021). One of the biggest questions around the meaning of AI is how we can ethically develop and apply it, and how we can keep it safe (Russell et al., 2010). Considering AI as an emergent technology, we have a moral duty to maximize its beneficial elements while avoiding or mitigating its negative ones.

3.3.4.2. MACHINE LEARNING

Currently, we assist an ascension of data to the status of a crucial commercial asset. From the fundamental skills required to handle the data's increasing volume and complexity towards more sophisticated analytics tools available to extract business insights from data collectors. Intelligence machines are being driven by a convergence of three major factors, namely, exponential data growth (it is expected to reach 44 zettabytes in size by 2020), faster distributed systems, and smarter algorithms (Deloitte, 2017).

As explained previously, ML is a subset of the broad area of AI, as can be observed in Figure 12. The central aspect of ML is the development of algorithms that learn from and make predictions about data (Gulli & Pal, 2017), which can be seen as the science and art of programming computers so they can learn from data (Géron, 2017).

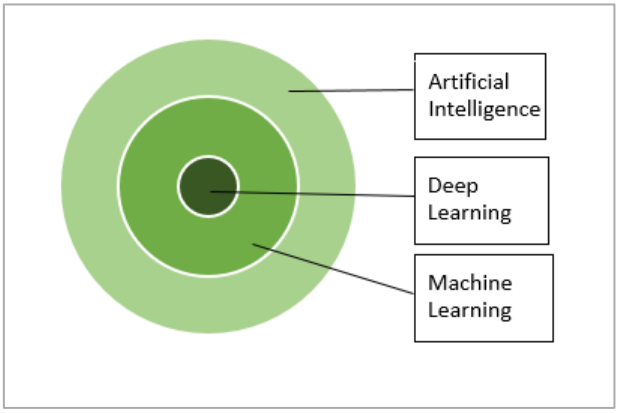

Figure 12: Artificial intelligence subsets (adapted from (Ongsulee, 2017))

Artificial intelligence - The field of AI research defines itself as the study of intelligent agents (any device that perceives its environment and takes actions that maximize its chance of success at some goal) (Ongsulee, 2017).

Machine learning - In AI, ML explores the study and construction of algorithms that can learn from and make predictions on data (Ongsulee, 2017).

Deep Learning - Alternatively referred to as deep structured learning, hierarchical learning, or deep ML, is the study of artificial neural networks and associated ML algorithms with several hidden layers (Ongsulee, 2017).

In a summary, ML is a collection of strategies that computers use to anticipate something based on their past behaviour. For example, when a computer is trying to anticipate the worth of a home, it needs to learn it from past house sales. The flow of the learning process started with building a database, whereby the quality of the data greatly influences the response of the system. By analyzing the input data, the system looked for patterns in the relationships between variables and learned from them and that is called the ML model (Molnar, 2020).

Taking into consideration the example above, the model for forecasting housing prices might be considered a simpler one, and they are designed as “white box” models. The opposite is the “black

box" and describes the models that cannot be understood by looking at their parameters, for example, the neural network (Molnar, 2020).

Figure 13 represents in detail how a neural network works using a deep neural network (Wolchover, 2017) or, in other words, how a computer achieves the desired output. In simple terms, the picture represents a ML model, and each layer (balls with a value of 0 or 1) represents deep learning by associating ML technology algorithms with several hidden layers.

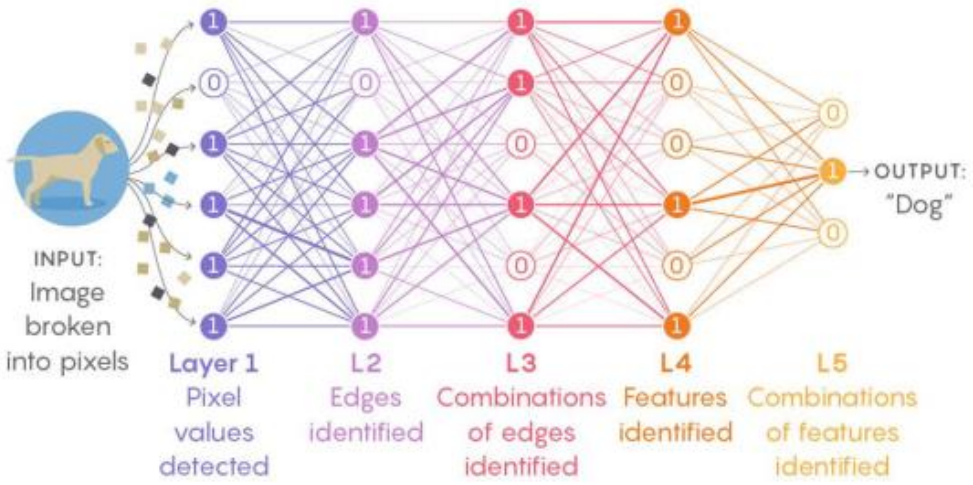

Figure 13: Deep neural network (Wolchover, 2017)

3.3.4.3. BIG DATA

Big data is the field of knowledge that studies how to treat, analyze, and derive information from large data sets and big data tools can help companies understand the data by applying various tools and methods (Chawda & Thakur, 2016). It is essential because it allows organizations to collect, store, manage, and manipulate massive volumes of data at the proper rate and timing in order to get the relevant insights (Hadi et al., 2015). As illustrated in Figure 14, big data is often characterized by its five components: volume, velocity, veracity, variety, and value (Naeem et al., 2022).

Figure 14: Big data v's model (adapted from (Naeem et al., 2022))

Big data must create scalable data (volume) of diverse types (variety) at predictable rates (velocity), while preserving the critical characteristics of the raw data (veracity), which the collected data can

contribute to the intended process (value) (Hadi et al., 2015). Since big data is a large database that collects data from numerous sources and analyzes it, it is necessary to first group this huge amount of data, then filter and process the data, and finally analyze it (Ivanović & Marić, 2021).

Their use in ERP systems leads to advantages such as making quick decisions, more efficient and in-depth analyses, and transparency of all data. The big disadvantages are the high costs, but the technology that can help big data lower its costs is cloud technology by providing only the data that the company needs, the costs are proportional to the services provided (Ivanović & Marić, 2021).

3.3.4.4. CLOUD COMPUTING

Cloud computing is characterized as one of the most desired domains for most IT professionals, as it helps to manage and store data for personal and business use by allowing the remote use of these resources over the Internet (Mircea et al., 2011). In 1999, Salesforce became an example of the successful use of cloud computing. They used it to pioneer the idea of using the Internet to deliver programs to end users, since it could be accessed and downloaded by anyone with Internet access (Rittinghouse & Ransome, 2017).

To better comprehend the idea of cloud computing according to Mircea et al. (2011), the main features are the abstract computing and IT service-oriented approach, scalable infrastructure, shared, configurable, flexible, dynamic resources, accessible from any device over the internet and a platform that requires little or no management. There are essentially two types of clouds, one serves individuals for personal use, and the other serves businesses. Cloud computing storage for personal use allows for easy access and file sharing. The services offered by the enterprise cloud are quite different and fall into three basic service categories (Mircea et al., 2011; Rittinghouse & Ransome, 2017):

Infrastructure as a Service (IaaS) - Deals with raw computing capacity by providing a server in the cloud along with storage. The goal is to have access to the computing capacity, without the responsibilities of installation or maintenance.

Platform as a Service (PaaS) - Supports writing software for computer systems that require it. This cloud-based service allows companies to write software to integrate existing applications or develop custom applications.

Software as a Service (SaaS) - This part of the cloud is the largest and most developed. It is a program, or a set of applications, available within the cloud, rather than on a computer's hard drive.

Most clouds can be deployed in public, private, or hybrid options. In a very general way, according to Coyne et al. (2018), public clouds are provided over the internet, presenting high elasticity and scalability and a low-cost subscription-based pricing level. Private clouds are characterized by the use of a single organization. In a private cloud, one is not sharing cloud computing resources with any other organization. Computing resources are isolated and delivered over a private and secure network. There is also the possibility of a hybrid cloud, which combines public and private cloud solutions, allowing better control of topics such as security, performance, scalability, and efficiency despite the difficulty of controlling wasteful spending, management, and high complexity.

3.3.5. INTELLIGENT ERP CAPABILITIES

As mentioned before, capabilities are the capacity to turn technology into an ability to maintain and achieve a competitive advantage. The seven capabilities of an i-ERP, which are intelligent behaviour, learning management, advanced analytics, process automation, intelligent interface, dark analytics, and simplification of customization, were identified considering the four technologies previously presented.

3.3.5.1. INTELLIGENT BEHAVIOUR

The intelligent behaviour of an ERP system is based on AI algorithms, and currently, the challenge is that AI is fiendishly hard and replete with intricate mathematics, much above the capabilities of an average businessperson (Burgess, 2018). To integrate this concept into ERP systems, it is crucial to first grasp how it works. Andrew Burgess (strategic adviser, author, and speaker on AI) has developed a framework for comprehending the complete complexity of applying AI to business, based on eight characteristics seen in Figure 15.

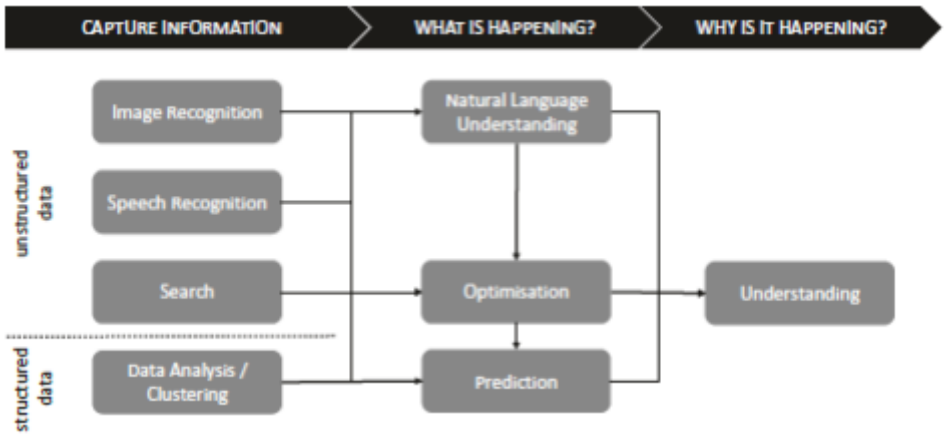

Figure 15: Artificial intelligence framework (Burgess, 2018)

AI is a complicated topic that involves a wide range of ideas and opinions and is continually evolving, and the framework is intended to serve as a guide, not as a technical handbook (Burgess, 2018). The characteristics used by the author are image recognition, speech recognition, search, and data analysis/clustering in the information capture of unstructured and structured data. This first step should be followed by natural language, optimization, and prediction to understand what is happening with data capture, and the last part is to understand what is happening. According to Basl and Novakova (2019), and Basl (2016), AI algorithms are dominant for the development of intelligent systems since 73% of the ERP manufacturers intend to use AI in their systems. Table 8 presents the advantages of using AI in ERP systems.

Table 8: Advantages of intelligent behaviour in ERP system

Advantage	Description	Authors
Complete complex tasks	Robots understand complex tasks simply by observing humans perform.	(Paschek et al., 2017; Ribeiro et al., 2021)
Reduce cost	AI improves efficiency, which leads to lower operating costs.	(Goundar et al., 2021; Paschek et al., 2017; Ribeiro et al., 2021)
Improve the quality of goods and services	Using a combination of AI and computer vision technologies.	(Paschek et al., 2017; Ribeiro et al., 2021)
Process self-optimization	Using AI machines based on material input and process parameters, they can self-optimize their parameters.	(Goundar et al., 2021)
Optimizing resources efficiency	Optimize resource efficiency with AI, which improves process efficiency.	(Hoffman, 2022; Ledford, 2017)

3.3.5.2. LEARNING MANAGEMENT

In this context, the learning management system is not the software that allows companies to create, store, manage, and deliver educational content to employees but the ability of ERP to use algorithms and ML techniques that provide them learning management capability. Nowadays, companies have to deal with massive volumes of data, which is called big data. It means that ERP systems must extract and gain insight from vast databases to add value for business purposes. Although much work has to be done in this area, it is evident that there is considerable potential for its application since it enhances both the results and the efficiency of all ERP system activities. According to Basl (2016), ML is used by a minority of ERP suppliers, although 60% of companies expect to employ it in the future. These strategies can be applied to data in the enterprise application to improve its decision-making skills (Kohli, 2018). Table 9 contains the main advantages of having learning management skills in the ERP system.

Table 9: Advantages of learning management in ERP system

Advantage	Description	Authors
Self-learning systems	By using a variety of methods such as data mining, pattern recognition, and NLP.	(Goundar et al., 2021)
Eliminating root issues	Direct continuing efforts to identify and remove error' causes with ML.	(Hoffman, 2022)

Fraud Detection	ML models can learn from patterns of normal behaviour and subsequently identify suspicious activities.	(Fuchs et al., 2021)
Prediction of equipment failures	ML can predict equipment failure by considering previous data.	(Kohli, 2018; Ledford, 2017)
Improvement in HR and Inventory	Improvement in the recruitment and selection activities as well as inventory management.	(Rupa et al., 2019)
Digital assistants	Through the utilization of chatbots, to simplify and accelerate information retrieval.	(Goundar et al., 2021; Ivanović & Marić, 2021)

3.3.5.3. ADVANCED ANALYTICS

According to Gartner, advanced analytics is the autonomous or semi-autonomous study of data or content using complex methods and tools, often beyond those used in standard BI, in order to gain deeper insights, make predictions, or produce suggestions (Gartner, 2021a). While BI used the data to answer what happened in the past and let the users know if what they believed was true, advanced analytics used the data from the past to predict the future trying to find hidden patterns that allowed the optimization of the entire process (Rapidminer, 2022).

If a company already has a powerful data warehouse, they are ready to improve their data and analytics practices with advanced analytics tools. Modern advanced analytics systems include ML and BI as core techniques (Basl & Novakova, 2019). IoT devices should be used to utilize real-time data because they are devices that provide real-time data that enables real-time analysis (Ray & Solutions, 2019). Figure 16 shows the most important fields where advanced analytics concepts can be applied according to Rapidminer (2022).

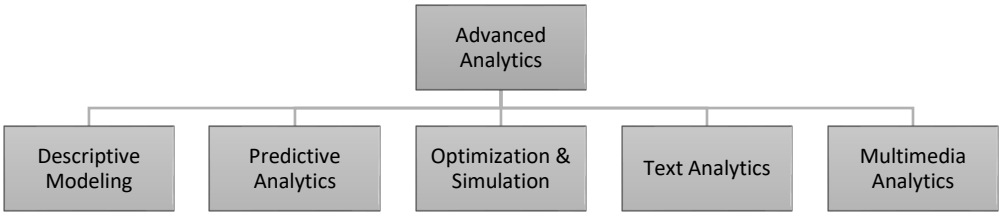

Figure 16: Advanced analytics fields (adapted from (Rapidminer, 2022))

Descriptive Modeling - A mathematical model which explains actual occurrences and links the elements between them. It is mostly used by consumer-driven companies since it allows them to optimize advertising by targeting their marketing (Rapidminer, 2022).

Predictive Analytics - Uses the data to model future learning identified patterns based on past events (Rapidminer, 2022).

Optimization & Simulation - Use of analytical tools and models performing different tests and examining alternative outcomes before, during, and after process execution (Rapidminer, 2022).

Text Analytics - Is used to examine the text for deeper analysis, for example, to identify a trend for unstructured texts (Rapidminer, 2022).

Multimedia Analytics - A new trend that combines techniques to examine multimedia data, for example, for processing video and images (Rapidminer, 2022).

To summarize, advanced analytics advises companies to clarify and solve challenges by giving them future-oriented insights to make better business decisions, which can give them a competitive advantage. Table 10 contains the advantages of advanced analytics in ERP systems.

Table 10: Advantages of advanced analytics in ERP system

Advantage	Description	Authors
Increases operational efficiency	Enables the analysis of a variety of data types in order to generate information that improves operational efficiency.	(de Moura et al., 2017; Soofastaei, 2020)
Discovery of deeper insight	Deeper research inside the data warehouse.	(Buytendijk et al., 2020; de Moura et al., 2017; Morris et al., 2016; Soofastaei, 2020)
Generation of predictions	Predictive modeling utilizes historical data to predict what will happen in the future.	(Buytendijk et al., 2020; de Moura et al., 2017; Morris et al., 2016; Soofastaei, 2020)
Market analysis	Identifying opportunities through the previous records.	(Hoffman, 2022)
Help decision support	Considering its data analysis and intelligent data processing.	(Buytendijk et al., 2020; de Moura et al., 2017; Morris et al., 2016; Soofastaei, 2020)
Reveal Patterns	Using the capability of predictions from patterns in demand and environmental data to forecast future demand.	(Goundar et al., 2021; Hoffman, 2022)
Real-time data	Connecting to people, devices, and business networks in real-time.	(Ray & Solutions, 2019)

3.3.5.4. PROCESS AUTOMATION

In recent years, the nature of work has suffered various changes driven by disruptive technology. These changes were pretty much associated with the automation mechanism. Allowing organizations to

perform better activities in a shorter time has been a constant demand for companies since it can save them time and money. Taking into consideration the industry's case, the manufacturing processes are already more efficient due to the systematic introduction of technology and methods like Lean (a method used to eliminate waste activities during the process). Services have been led by this automation trend and software that has now reached a degree of maturity that allows them to change or complement the human operators in task execution (Mamede, 2021). Figure 17 shows the different types of process automation.

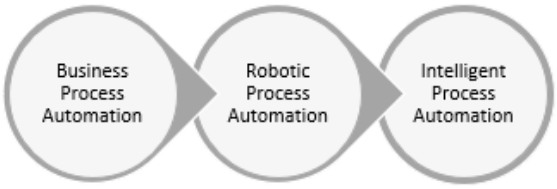

Figure 17: Types of process automation (adapted from (Mamede, 2021))

Business Process Automation (BPA) - Is the use of technology to automate business operations throughout a company. A perfect example of a BPA is purchase order fulfillment automation.

Robotic Process Automation (RPA) - Is a concept for tools that interact with other computer systems' interfaces in the same manner that a person would (Van der Aalst et al., 2018). The tools used are lightweight executables, requiring low or no codification and a few implementation efforts (Mamede, 2021).

Intelligent Process Automation (IPA) - Besides automating basic repetitive jobs, IPA enables more complicated automation by minimizing human-dependent training and automating more complex tasks that need decision-making (Chakraborti et al., 2020). Unlike RPAs, an IPA is associated with higher costs and complexity.

This technology can be used in many areas and can benefit mainly from solutions that replicate manually operated processes (Srinivasan, 2016). Companies that want to automate a process should take into consideration that the initial workflow design costs are significant, and that potential savings are always conditioned by the implementation of automation. Table 11 provides the advantages of process automation.

Table 11: Advantages of process automation in ERP system

Advantage	Description	Authors
Quality improvement	Efficiency improvements and continual service improvements increase the quality.	(Antonoaie et al., 2017; Mamede, 2021)
IT staff production	Frees the staff from routine tasks.	(Antonoaie et al., 2017; Mamede, 2021)

Prevent errors and waste activities	It mitigates human error and improves worker efficiency.	(Antonoaie et al., 2017; Mamede, 2021; Ribeiro et al., 2021)
Reduce operational costs	It avoids outsourcing and reduces operational costs because bots are cheaper.	(Mamede, 2021; Ribeiro et al., 2021)
Solve integration problems	It removes data gaps from different sources	(Mamede, 2021)
Availability and compliance	Bots are available 24 hours per day, and 365 days per year.	(Mamede, 2021)

3.3.5.5. INTELLIGENT INTERFACES

The user interface (UI) or graphical user interface (GUI) is the point of interaction and communication between humans and computers in a device. This may contain monitors, keyboards, a mouse, and a desktop computer. The UI allows a user to interact with a program or a website, and the ways of interacting are different for each system. An efficient and good UI is mandatory to reduce the user effort to learn how to use a new system. In other words, a good interface allows easy and natural interaction between the user, and the system. A bad UI results in frustration and dissatisfaction by the user which leads to weak results for a task (Stone et al., 2005). UI adaptation is the process of customizing the interface of a software system to meet user-specific criteria, such as the needs, desires, and preferences of a single user or a group of users (Abrahão et al., 2021).

Intelligent UIs are human machine interfaces whose objective is to increase the performance, affectivity, naturalness, and, in general, usefulness of interactions between people and computers. The concept of Intelligent UI is a combination of different disciplines, as can be observed in Figure 18.

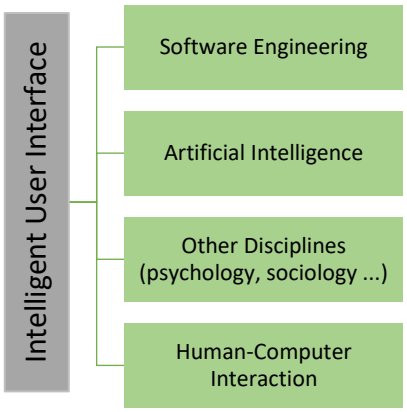

Figure 18: Disciplines in the design of intelligence user interface (adapted from (Stone et al., 2005))

One of the problems of current ERP systems is the user interface, and they suggest future developments in special focus groups, such as new users and advanced users (Bender et al., 2021). The primary difficulty of intelligent UI is recommending the best modification at the right time and in the

right location in order to provide value to the end user (Abrahão et al., 2021). To fulfill the primary purpose of intelligent user interfaces and to assist them in a variety of situations, they must be able to reflect the information they have about users, like the activities and interactions between users and the system. Table 12 lists the advantages of the intelligent interface in ERP systems.

Table 12: Advantages of intelligent interface in ERP system

Advantage	Description	Authors
Increase user motivation	A good interface increases a user's motivation when using the program.	(Abrahão et al., 2021; Ray & Solutions, 2019)
Reduce task completion time	Increase the process efficiency.	(Abrahão et al., 2021)
Ensuring effectiveness	Facilitation of use of the program leads to greater user efficiency.	(Abrahão et al., 2021)
Personalized experience	Improving user satisfaction.	(Abrahão et al., 2021; Ray & Solutions, 2019)
Improves learning	Improving the learning user experience	(Abrahão et al., 2021)

3.3.5.6. DARK ANALYTICS

Today, organizations that have not implemented digital technology are going to lose their relevance in the competitive economy. Moreover, firms started their digital transformation path and data analytics, where dark analytics is included. Advanced analytics and big data are primarily interested in "tangible data," or data that is available to the knowledgeable user. On the other hand, there is "dark data", understood as data that is stored on servers and available for use, but users do not know it is there (Schembera & Durán, 2020).

Companies often apply analytical capabilities to structured data, but there are nontraditional data sources that should be analyzed as they might be useful. In the business world, dark analytics refers to anything that is hidden, and this concept focuses on unanalyzed raw text-based data. Despite recent advances in cognitive analytics, pattern recognition, and computer vision, only a few organizations have been able to analyze unstructured data such as text messages, images, video, emails, and audio files (Deloitte, 2017).

According to the Gartner dictionary, dark data is described as information that businesses acquire, process, and retain as part of routine business operations but normally do not really use for other purposes (Gartner, 2021b). As claimed by some studies, 90% of large data sets are unstructured (A. Kumar et al., 2020), which reinforces the future potential of this trend. Figure 19 represents the three dimensions of dark analytics, and below, each one will be detailed.

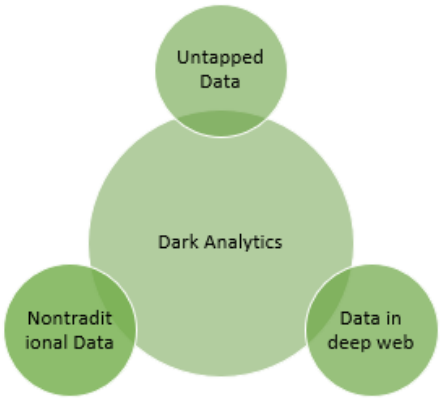

Figure 19: Dark analytics dimensions (adapted from (Deloitte, 2017))

Untapped Data - can be defined as a vast amount of structured (quantitative data easily countable) and unstructured data (for example, emails, notes, messages, documents) that is not being utilized by businesses but is already in their possession (Deloitte, 2017). According to some studies, at least 80% of the information contained in organizations is unstructured (Eberendu, 2016).

Nontraditional Data - the second dimension is related to unstructured data produced by media like audio, images, and video that cannot be extracted using traditional reporting techniques. Currently, with recent advances in areas like computer vision, sound analytics, and pattern recognition, organizations can extract data contained in unstructured formats and create value with them (Deloitte, 2017).

Data in deep web - the last dimension of dark analytics is related to data in the deep web, for example data created by government agencies, academics, consortia and other third-party. An example of this is the licensable data owned by a private company (Deloitte, 2017).

In the case of the ERP system, the difference between advanced and dark analytics is in the source of the data. While the first one comes from tables and dashboards visible to users, the dark analytics comes from ERP logs, dumps, and, for example, XML and TXT files. The use of dark data becomes strategic for organizations of all sizes and industries, as it can provide illuminating opportunities for new business insights and market share opportunities within unstructured data as observed in Table 13.

Table 13: Advantages of dark analytics in ERP system

Advantage	Description	Authors
Help in decision-making	Through the treatment of unanalyzed data.	(Deloitte, 2017)
Make new target paths for the future	It can provide illuminating opportunities for new business.	(Deloitte, 2017)

Give new opportunities	By exploring dark data various insights can be found on businesses and shape future business models and processes.	(Ahmed & Pathan, 2018; Deloitte, 2017)
Reduce risk	Because companies realize that there is "dark data".	(Deloitte, 2017)

3.3.5.7. SIMPLIFICATION OF CUSTOMIZATION

The last capability is the simplification of customization, and this represents an important role in any company that has an ERP system. When an organization purchases an ERP system, it comes in the standard version and, generally, it cannot address all business needs. Moreover, ERP customization has become common in ERP implementation (Wang et al., 2022). According to a recent research, organizations use ERP customization to bridge the gap between intrinsic ERP functionality and their existing business processes (Etame & Atsa, 2018).

But one of the critical factors in implementing an ERP system consists of how to minimize the gap between the enterprise system and an organization' processes since customization is the major constraint in most implementation projects (Parthasarathy & Sharma, 2014). ERP customization is a difficult task, expensive, but necessary for enterprises since an ERP system acts as an organization' system that addresses all departments. When used effectively, it can easily coordinate all the activities of all divisions (Wang et al., 2022).

Furthermore, if business or even legal requirements change, ERP systems must adapt to the new reality, which reinforces the constant need to customize ERP systems. Normally, this implementation and changes are made by a consultant company that has a partnership with the ERP. According to studies of ERP customization projects, the efficacy of information flows between consultants of ERP vendors and clients' employees is essential to succeed (Wang et al., 2022).

Until a few years ago, organizations only had the choice to host their software parts on their own server (on-premises deployment). This option allows companies to customize each component in the systems, but when a software solution is customized, it becomes more difficult to upgrade each component of the system, which increases the complexity of it. Today's ERP Cloud software has reduced many of the complexities associated with on-premises deployment because every company that uses the cloud solution is using the same code. Table 14 represents the main differences between these two systems.

Table 14: Main differences between on-premise ERP and cloud ERP

Categories	Traditional ERP (On-premise)	Cloud ERP	Authors
Total cost	Cost of the license and maintenance is often annual.	Monthly Subscription Fee and no maintenance cost.	(Al Hayek & Abu Odeh, 2020; Hadidi et al., 2020)
Implementation	Complex implementation.	Short time.	(Al Hayek & Abu Odeh, 2020; Hadidi et al., 2020)

Mobility	From the location of ERP or web (but special packages must be purchased).	From anywhere.	(Al Hayek & Abu Odeh, 2020; Hadidi et al., 2020)
Updates and upgrades	Easily customized.	Faster updates but limited customization.	(Al Hayek & Abu Odeh, 2020; Hadidi et al., 2020)
Customization	Is open for all types of customizations.	Simplified Customization	(Al Hayek & Abu Odeh, 2020)

Intelligent ERP systems should have the capability of simplifying the customization process using the rule that it should be the business to adapt their processes to the ERP rather than the ERP adapting their processes to the business.

3.4. TAXONOMY TO CLASSIFY INTELLIGENT ERP SYSTEM

The last section of the literature review is divided into two sub-sections. In 3.4.1, the taxonomy was identified and presented, and the principal ERP companies and systems were presented in sub-section 3.4.2.

3.4.1. IDENTIFICATION OF TAXONOMY

Considering that i-ERP is a new subject that requires extensive research, it was critical to identify a taxonomy for classifying the various degrees of intelligence. A taxonomy is a system of classification and categorization, especially used as a hierarchical classification in which the objects are classified according to their groups. Silva (2020) presented a taxonomy in 2020 to classify ERP systems with six levels summarized in Figure 20. The first level is the basic one, and as it goes up, the scale of intelligence increases. To develop this taxonomy, the author has considered that the i-ERP should contain six dimensions: RPA, advanced analytics, dark analytics, ML, user experience, and AI foundation (Silva, 2020).

Figure 20: Taxonomy to classify ERP system (Silva, 2020)

Level 1: Basic ERP – Is the first level where humans control the system, and it is static with a few options for customization and usually limited functionalities (Silva, 2020).

Level 2: Generic ERP - Similar to the first level but with the ability to have batch jobs automatically to automate tasks that need to be executed regularly (Silva, 2020).

Level 3: Automated ERP - The third level, the system should start implementing functionalities to avoid repetitive tasks to improve those processes. The concept of process automation appeared at this stage through basic RPA implementations (Silva, 2020).

Level 4: Semi-Autonomous ERP - Here companies should start training the users to improve the connections between humans and the system. RPA continues to have an important role in the company, and the quality of data has become a priority to support real decision making. Concepts like advanced analytics and dark analytics are vital to increase data quality (Silva, 2020).

Level 5: Autonomous ERP - Autonomous ERP must have the six capabilities, AI, ML, process automation, advanced analytics, dark analytics, and user experience working at least in specific domains (Silva, 2020).

Level 6: Intelligent ERP - The six concepts presented at the previous level are now used in every company, and the ERP system must be equal to a human decision-maker and adapt to different business scenarios (Silva, 2020). The ERP must be implemented in a cloud platform to become faster and more flexible. Cloud ERP is frequently referred to as a "*gateway to modernization, because of the lack of innovations available in older traditional solutions*" (Basl & Novakova, 2019, p.3).

Bertram (2022) presented a similar taxonomy in 2022 but only with five levels. The first level is the elementary ERP, with no intelligent functions, followed by advanced ERP, with initial and prerequisite intelligent functions. Then elementary i-ERP, with the first intelligent capabilities. The fourth level is partially i-ERP which has advanced intelligent features, and in the fifth place the i-ERP, with all smart features of an i-ERP. The author has considered that the i-ERP should contain five dimensions: system role, general prerequisite dimension, data dimension, process dimension, and user experience dimension (Bertram, 2022).

3.4.2. PRINCIPALS ERP SYSTEMS IN THE MARKET

In Figure 21, according to Forbes and Gartner, in 2017, SAP maintained its market leadership with 23%, followed by Oracle with 12%. In third place, Sage with 6%, Workday ranks fourth with 6%, and Infor ranks fifth with 5%. It is possible to observe that the top five companies-controlled 52 percent of the market in 2017 (Columbus, 2018).

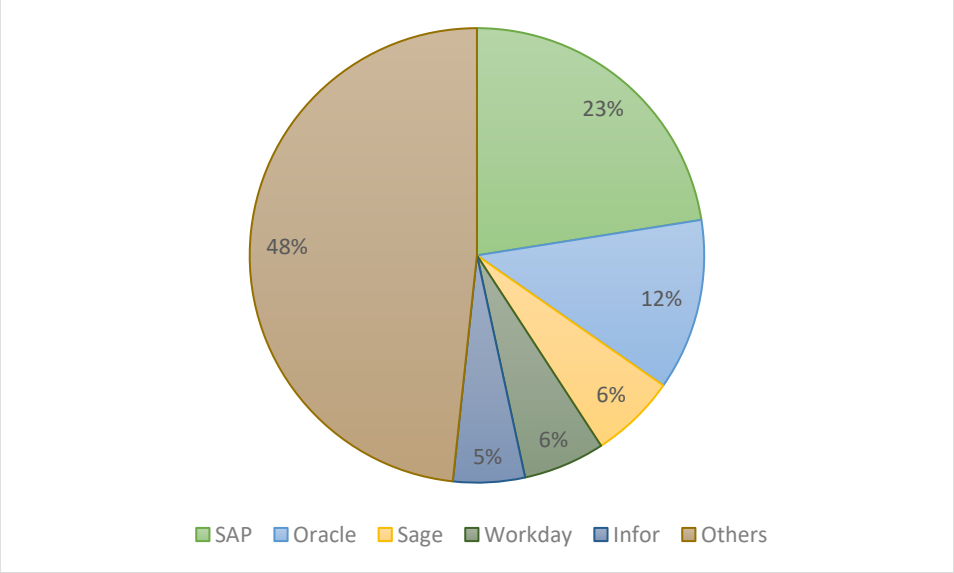

Figure 21: Worldwide ERP software market share 2017 (adapted from (Columbus, 2018))

Gartner published a new report in 2018 stating that SAP remains the ERP market leader with 7.7 billion dollars, which represent 23 percent of the market (Wilson, 2019), which continues to demonstrate its supremacy in the market. SAP's versatile products help companies of all sizes and in all industries to operate at maximum efficiency. Moreover, SAP systems are used in 77% of all transactions worldwide (SAP SE, 2021b).

4. GUIDELINES FOR BUILDING INTELLIGENT ERP SYSTEMS

It is inevitable that organizations must implement intelligent solutions in their systems, and this process is unavoidable as part of evolution. According to section 3.2.3-ERP History in Figure 6, every ten years since the 1960s, a new label has appeared with disruptive ideas that change the ERP architecture and purpose, preventing stagnation. Using the same method as ML, by observing the past, we conclude that in the 2020s, we have to create a new tab, as can be observed in Figure 22.

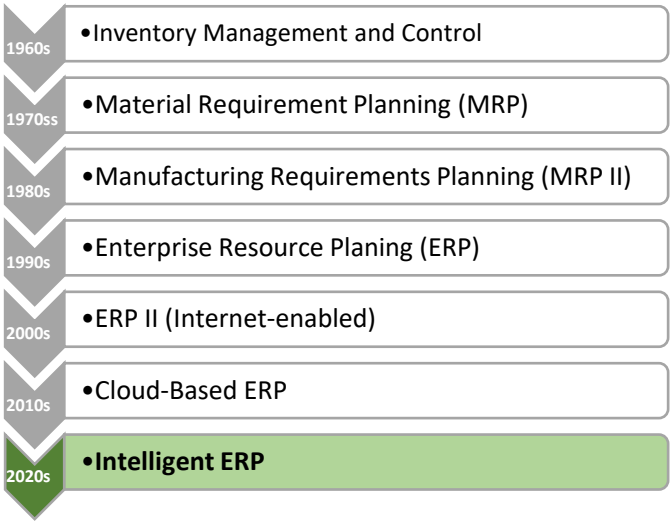

Figure 22: Proposed enterprise resource planning history

We have seen an increase in cloud-based ERP solution solutions that integrate with IoT capabilities as well as AI and ML. With this new software, the experience of using ERP becomes much more consumer-focused and allows companies to add much more value to their business. In this chapter, the following artifacts are presented to give a vision of how intelligent capabilities can help the ERP modules:

- **Recommendations by i-ERP capabilities:** The division by i-ERP capabilities allows for a general overview of the recommendations as it addresses each capability in all four modules.
- **Artifact 1 - Guidelines for Finance:** It presents the capabilities, focusing on the FI module.
- **Artifact 2 - Guidelines for Material Management:** It presents the capabilities, focusing on the MM module.
- **Artifact 3 - Guidelines for Sales and Distribution:** It presents the capabilities, focusing on the SD module.
- **Artifact 4 - Guidelines for Human Resources:** It presents the capabilities, focusing on the HR module.
- **i-ERP Assessment tool:** The assessment tool enables the creation of measures to assess an ERP system considering its level of intelligence based on the recommendations created.

The processes used for the creation of the artifacts and assessment tool started with the literature review that allowed the basis of the artifacts to be created. Then, the recommendations by i-ERP capabilities allowed the creation of general recommendations, going into the details of the capabilities and their respective domains. The general recommendations led to specific recommendations by area as well as to creating a system for evaluating the intelligence of an ERP system.

4.1. ASSUMPTIONS

The objective of this section is to outline briefly how the results from the literature study were utilized to contextualize the development of the artifacts and to explain why the artifacts are presented in the manner they are. The artifacts have been created considering the literature review on IMS, ERP, and i-ERP, especially the i-ERP technologies and capabilities. Below is detailed what was taken from each literature review topic to create the artifacts, and Table 15 shows the resume of artifacts assumptions taken from literature review.

Information and Management Systems

- According to Laudon and Laudon (2019), the new era in place for information and management systems is the cloud and mobile computing era that uses cloud computing.

Enterprise Resource and Planning System

- Disadvantages of ERPs identified by Rashid et al. (2002), Brahmadeep and Thomassey (2016), and O'Shaughnessy (2019) were important as a basis for the artifacts to mitigate these problems.
- ERP history is explained by Rashid et al. (2002) in order to understand which way the ERPs should go.
- ERP Architecture to understand the main activities of the four main modules identified by SAP SE (2021c), Laudon and Laudon (2019), and Rashid et al. (2002).

Intelligent Enterprise Resource and Planning System

- As it is a recent topic, it was important to first understand what the concept of i-ERPs is according to Srinivasan (2016), Morris et al. (2016) and Jenab et al. (2019).
- The advantages of the i-ERPs identified so far by Morris et al. (2016) and Jenab et al. (2019) helped guide the purpose of the artifacts and quantify the requirements.
- Through the technologies that underlie the i-ERP, according to Basl and Novakova (2019) and Srinivasan (2016) it was possible to identify the seven capabilities.

Taxonomy

- The taxonomy is important to show all the possible development phases, starting from a basic ERP to an i-ERP according to Silva (2020) and Bertram (2022).

Table 15: Resume of literature review artifacts assumptions

Literature review topic	Main orientation	Authors
IMS	A new era with cloud computing and IoT.	(Laudon & Laudon, 2019)
ERP	Mitigate the disadvantages of ERPs.	(Brahmadeep & Thomassey, 2016; Nwankpa, 2015; O'Shaughnessy, 2022; Rashid et al., 2002)

	ERP History.	(Rashid et al., 2002)
	Four most used ERP modules.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
I-ERP	i-ERP concept.	(Jenab et al., 2019; Morris et al., 2016; Srinivasan, 2016)
	i-ERP advantages.	(Jenab et al., 2019; Morris et al., 2016)
	Technologies and capabilities that underlie the I-ERP.	(Basl & Novakova, 2019; Srinivasan, 2016)
Taxonomy	Development phases.	(Bertram, 2022; Silva, 2020)

4.2. ARTIFACT BASE

The artifacts created by the guidelines for building i-ERPs have the following objectives:

- Understand at a general level how intelligent components change the routine tasks of a company.
- Understand at a general level how intelligent components change the way modules are implemented in an ERP.
- Understand at a general level how intelligent components change the way an ERP module is built.

In a simple way, the artifacts consist of a table highlighted in 3 aspects:

1. The four main modules of an ERP - finance, material management, sales, and human resources.
2. The main activities of these four modules are summarized in Table 16.
3. Seven identified capabilities of an i-ERP are summarized in Table 17 with their main advantages.

Table 16: ERP main modules and characteristics

Modules	Main characteristics	Authors
Finance	Accounting reconciliation, financial management, reporting, and analytics.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Material Management	Inventory, purchasing and material resource planning.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Sales and Distribution	Sales support, billing, shipping, and transportation.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)
Human Resources	Employee management, payroll, training, and recruitment.	(Laudon & Laudon, 2019; Rashid et al., 2002; SAP SE, 2021c)

Table 17: Main advantages of i-ERP capabilities

Capabilities	Main Advantages	Authors
Intelligent Behaviour	Complete complex tasks, reduce costs, improve the quality of goods and services, resource optimization.	(Goundar et al., 2021; Hoffman, 2022; Ledford, 2017; Paschek et al., 2017; Ribeiro et al., 2021)
Learning Management	Self-learning systems, eliminate root issues, fraud detection, predict equipment failure, improvement in HR and inventory management, chatbots.	(Fuchs et al., 2021; Goundar et al., 2021; Hoffman, 2022; Ivanović & Marić, 2021; Kohli, 2018; Ledford, 2017; Rupa et al., 2019)
Advanced Analytics	Increase operational efficiency, discovery of deeper insight, generation of predictions, market analysis, help decision support and reveal patterns, real-time data.	(Buytendijk et al., 2020; de Moura et al., 2017; Hoffman, 2022; Morris et al., 2016; Ray & Solutions, 2019; Soofastaei, 2020)
Process Automation	Quality improvement, IT staff production, preventing errors and waste activities, reducing operational costs, solving integration costs, and availability and compliance.	(Antonoaie et al., 2017; Mamede, 2021; Ribeiro et al., 2021)
Intelligent Interface	Increase user motivation and experience, reduce task completion time, ensure effectiveness, personalized experience and improves learning.	(Abrahão et al., 2021; Ray & Solutions, 2019)
Dark Analytics	Help in decision-making, make new target paths for the future, give new opportunities, and reduce risk.	(Ahmed & Pathan, 2018; Deloitte, 2017)
Simplification of Customization	Decrease costs, faster updates, better implementation, increase flexibility.	(Al Hayek & Abu Odeh, 2020; Hadidi et al., 2020)

It is important to note that in addition to all the previous points identified in the literature review, my personal experience has also been used to create the artifacts. Although the focus was always presenting a general artifact that can be used for any kind of company or industry, some choices were made. The financial module was focused on a financial perspective and not so much on cost control (controlling part). The purchase is to be used in a company that has to create products through its production process. The sales very much in a sales logic and sales process. And lastly, HR is very much in terms of recruitment.

4.3. ARTIFACT PRESENTATION

The artifacts, the tables of recommendations by i-ERP capabilities and the guidelines for the four primary areas of an ERP system, enabled us to answer the identified research question because they can assist technical and non-technical people in selecting the best existing option for an ERP system. The guidelines for the four modules are created on the basis of the recommendations by i-ERP capabilities. They have been divided in this way in order to facilitate the interpretation.

4.3.1. RECOMMENDATIONS BY I-ERPS CAPABILITIES

Each capability was subdivided into two domains to understand in detail the advantages of its implementation in an ERP system. Intelligent behaviour was divided into document classification and reconciliation and resource optimization. Learning management into chatbots and proactive troubleshoot. Advanced analytics into forecasting and reveal patterns. Process automation into load information and automatize reports. Intelligent interface into user auto adaptation and country specification. Dark analytics into TXT files and untapped general data. Simplification of customization into smart error message and system updates. Table 18 until 24 contains the recommendation by the seven i-ERP capabilities.

Capability 1 - Intelligent Behaviour

Table 18: Recommendation for intelligent behaviour capability

		Intelligent Behaviour	
General	**Macro Activities**	**Classify and Reconcile Docs**	**Resource Optimization**
Finance	Accounting, Financial Management, Reporting and Analytics.	A1) Classify and Reconcile FI Documents	A2) Optimize Cash Flow
Material Management	Inventory, Purchasing and Material Resource Planning.	B1) Classify and Reconcile MM Documents	B2) Verify and Update Stocks
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C1) Classify and Reconcile SD Documents	C2) Sales Management
Human Resources	Employee Management, Payroll, Training and Recruitment.	D1) Classify and Group CVs	D2) Proactive Talent Management

Intelligent Behaviour - Classify and Reconcile Documents

With AI algorithms, such as optical character recognition to convert images of text into data that has been coded by a machine, ML to create the learning mechanism, and NLP to provide a computer program with the capacity to comprehend human language, the ERP systems must be able to identify and group the documents into categories or classes. In addition, the system must have the ability to assist companies in the process of reconciling documents. In the case of HR, the documents identified with greater value are the CVs so the system must be able to group CVs, for example, by departments or academic background.

- A1) Group in categories or classes such as client, supplier, bank, general ledger, and asset document. The system should also help a company with bank reconciliation and checking bank accounts against company accounts.
- B1) Group in categories or classes such as purchase requisition, request to quotation, purchase order, goods receipt, service entry, invoice handling, and payment document. The system should also help a company with accounts payable reconciliation.

- C1) Group in categories or classes such as sales quotation, sales order, delivery note, goods issue, and billing document. The system should also help a company with accounts receivable reconciliation.
- D1) Group CVs by categories or classes such as department or academic background.

Intelligent Behaviour - Resource Optimization

In general, the optimization of resources for the different areas can be done by AI and ML algorithms like neural networks because they can perform almost real-time resource allocation. Optimizers, on the other hand, are algorithms or strategies for altering the parameters of neural networks, such as their weights and learning rates, in order to minimize losses. The management of resources in FI is done by optimizing cash flow, MM is done through the management and updating of inventories, SD with improving sales management, and in HR by human resource management.

- A2) Optimize cash flow is any source of money, credit, and other forms of funding for a company, and an optimization of these resources leads to stability and financial growth.
- B2) By verifying and updating stocks, companies can minimize the possibility of overproduction or lack, and this means less inventory issues and production optimization.
- C2) Sales management in this context is related to sales techniques like optimized sales territory plans and even forecast the ideal number of sales representatives necessary to cover areas during a new product launch.
- D2) A proactive talent management can determine which workers need a raise based on their performance.

Capability 2 - Learning Management

Table 19: Recommendation for learning management capability

		Learning Management	
General	**Macro Activities**	**Chatbots**	**Proactive Troubleshoot**
Finance	Accounting, Financial Management, Reporting and Analytics.	A3) Financial Internal Chatbot	A4) Fraud Detection
Material Management	Inventory, Purchasing and Material Resource Planning.	B3) Inventory Internal Chatbot	B4) Solve Manufacturing Problems
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C3) Sales External Chatbot	C4) Solve Sales Order Fulfillment Issues
Human Resources	Employee Management, Payroll, Training and Recruitment.	D3) Recruitment Chatbot	D4) Recruitment and Selection

Learning Management – Chatbots

A chatbot is a computer software that simulates human-to-human communication, particularly via the internet. Through the use of ML algorithms and NLP, which allows interaction between computers and human language, this feature can be integrated with an ERP system. They are capable of comprehending the user's requirements, locating the information in the database, and delivering it to the user. They can be used in different departments, such as finance and material management internally and purchasing and human resources externally.

- A3) Finance chatbots for tracking financial invoices, for example, the user might inquire, "Are any bills pending?", and the chatbot will do a brief search of the database and inform the user of its results.
- B3) For inventory and order management, a chatbot can be made to send real-time information about stock status, inventory movements, and open orders to MM managers to help them make better decisions about how much inventory they have, which in turn helps them make money.
- C3) A sales chatbot can automate the sales process and make the sales process easier for the customer. This chatbot must be connected to the ERP system to create sales documents automatically.
- D3) A recruitment chatbot facilitates the recruitment process of an employee, making it faster and more efficient.

Learning Management – Proactive Troubleshoot

Through ML and AI mechanisms and based on previously available data, the ERP can take this data and learn to solve problems in different areas. At an early stage, the system is programmed to react to problems, at a later stage to be proactive. Since the first stage is not enough for the business to invest in this technology, being proactive keeps things running smoothly by watching for, predicting, and fixing problems before they happen, and then fixing them before they happen. Effective proactive maintenance can reduce the number of times things go wrong, making them less likely.

- A4) Fraud detection uses logistic regression, a ML algorithm. This algorithm is used when a choice is categorical. For this reason, the system can determine whether a transaction is legal or illegal in real-time.
- B4) Manufacturing troubleshooting helps identify failing manufacturing units and solve their problems considering solutions used in the past.
- C4) In a company, the majority of the bottlenecks in the sales process are related to sales order fulfillment issues that slow down the process. To avoid losing time, the system should detect and actively try to solve these issues, mainly with ML algorithms.
- D4) Recruitment and selection by evaluating individuals' eligibility for positions, retrieving information from their resumes, and analyzing their profiles.

Capability 3 – Advanced Analytics

Table 20: Recommendation for advanced analytics capability

		Advanced Analytics	
General	**Macro Activities**	**Forecasting**	**Reveal Patterns**
Finance	Accounting, Financial Management, Reporting and Analytics.	A5) Financial Forecasting	A6) Financial Patterns
Material Management	Inventory, Purchasing and Material Resource Planning.	B5) Predict Purchase Delivery	B6) Manufacturing Optimal Point
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C5)Predict Customer Needs	C6) Sales Patterns or Bottlenecks
Human Resources	Employee Management, Payroll, Training and Recruitment.	D5) Predict Turnover and HR Needs	D6) Recruitment Patterns

Advanced Analytics – Forecasting

With ML algorithms for forecasting, prediction neural networks to predict numbers and big data to handle large amounts of data, i-ERPs have the ability to predict future situations for various business areas. The ability of i-ERP to work with massive amounts of data enables accurate and real-time insights.

- A5) Considering financial historical data and macroeconomics data, the creation of datasets with automatic updating for information such as growth rates, interest rate, or inflation to better analyze the macro-economic environment which enables companies to have financial forecasting.
- B5) Based on the previously available data, ERP should predict the days on which purchases will arrive.
- C5) Predicting customer needs with ML improves the response capacity and proactivity of companies to anticipate the needs of their customers since the machines are programmed to carry out this analysis constantly.
- D5) Losing an employee is always a problem for a company. Moreover, predicting turnover trends considering historical data improves employee retention as well as the company's finances. An intelligent system should also have the capability to predict the HR needs for the next years.

Advanced Analytics – Reveal Patterns

The processing of data through advanced big data technologies like AI, ML, and other cognitive approaches like data mining and pattern recognition is used to find out what kinds of patterns there are in the data and how they are related to each other. The aim is to determine if there is any pattern in the data found or an anomaly in the process in order to make the process as efficient as possible.

- A6) The processing of big financial data leads to the identification of patterns that help managers redesign and improve processes in the company.
- B6) ML enables the capability of improving all yield rates across the business from the system to the manufacturing part finding what is the optimal point. This optimization algorithm can work in real-time and connect data from manufacturing and delivery to the operational department, suggesting improvement opportunities.
- C6) This technique can be used to identify seasonal sales patterns and offer suggestions to tailor the production, as well as check if there are any sales bottlenecks in the process through data mining techniques.
- D6) The compilation of data from the selected CV’s and employee evaluation can detect patterns and identify characteristics of the employees with the highest scores.

Capability 4 – Process Automation

Table 21: Recommendation for process automation capability

		Process Automation	
General	**Macro Activities**	**Load Information**	**Automatize Reports**
Finance	Accounting, Financial Management, Reporting and Analytics.	A7) Process Financial Invoice	A8) Financial Reports
Material Management	Inventory, Purchasing and Material Resource Planning.	B7) Process Inventory	B8) Inventory Reports
Sales and Distribution	Sales Support, Billing, Shipping and Transportation	C7) Process Sales Invoices	C8) Sales Reports
Human Resources	Employee Management, Payroll, Training and Recruitment.	D7) Process Employee Information	D8) Employee Reports

Process Automation – Load Information

The best way to automate a process is through an RPA, as they easily integrate with existing applications. RPA enables replicating the actions that human operators perform on systems, which means they interact with the data in the presentation layer.

- A7) Through an RPA the process of invoice processing and payment or the loading of bank statements can be done automatically, minimizing errors.
- B7) Enables stocks to be consulted and updated automatically as well as document processing of the entire procurement process.
- C7) Automatic document processing of the entire sales process, like setting quotation, preparing contracts, and order management invoicing, and sales orders processing.
- D7) In the area of human resources, RPA can automate many tasks, including employee onboarding and offboarding, employee information updating, and timesheet submission processes and payroll.

Process Automation – Automatize Reports

Using ML and RPA algorithms, the reports for month-ending closing activities or operational reports can be automatized, which leads to time and effort savings, as well as the elimination of mistakes for a more accurate report.

- A8) Financial reports include things like external financial statements, quarterly and annual reports to stockholders, financial information on a company's website, and financial reports to government agencies, like the SAF-T file for Portuguese companies.
- B8) Inventory reports such as procurement KPIs (key performance indicator), supplier delivery, procurement costs and quality.
- C8) Reports with the sales analysis, such as sales cycle report, customer hierarchy, completed and incomplete sales orders, sales volume, revenue, and costs for a given period and competitors' prices.
- D8) Human resources reports include reports like attendance and absence per employee or department, turnover and retention, performance management and training and development reports.

Capability 5 – Intelligent Interface

Table 22: Recommendation for intelligent interface capability

		Intelligent Interface	
General	**Macro Activities**	**User Auto Adaptation**	**Country Specification**
Finance	Accounting, Financial Management, Reporting and Analytics.	A9) Financial Roles	A10) FI Country Specification
Material Management	Inventory, Purchasing and Material Resource Planning.	B9) Purchasing Roles	B10) MM Country Specification
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C9) Sales Roles	C10) SD Country Specification
Human Resources	Employee Management, Payroll, Training and Recruitment.	D9) Human Resources Roles	D10) HR Country Specification

Intelligent Interface - User Auto Adaptation

An intelligent user interface should distinguish senior users from junior users and display a different interface. For example, juniors should have fewer options available in order to facilitate the learning process. The system differentiated them according to the following roles presented below.

- A9) Financial roles such as, accounting payable clerk and supervisor, accounting receivable clerk and supervisor, asset accounting clerk and supervisor, and CFO (Chief Financial Officer).
- B9) Purchasing roles such as, purchase requester, good receive maker, and purchasing clerk and supervisor.
- C9) Sales roles such as, collection clerk and supervisor, and order to cash clerk and supervisor.
- D9) Human Resources roles such as payroll clerk and supervisor, administration clerk and supervisor, and HR manager.

Intelligent Interface – Country Specification

There are different specifications and rules in every country, and an intelligent interface must be able to understand the geography of the user and adapt to the rules of his country. For example, in Malaysia, the Malaysian government banned yellow clothing, so the ERP must exclude yellow. In Portugal and Spain, it isn't usual to write in red except in specific cases, such as in the case of an alert. Another example is the green color in China that is associated with bad luck and infidelity. Therefore, the ERP must have the ability to understand what the color symbols mean for the different regions.

Another type of specification is the legal one, where the systems have to differentiate the legal and financial needs of each country, for example, in Portugal, companies have to report monthly and annually the SAF-T file that contains all the fiscal and accounting information of the company. The same logic must be applied to purchase, sales, and human resources country specifications.

- A10) The system needs to understand the financial legislation of the user's country.
- B10 The system needs to understand the purchase legislation of the user's country.
- C10) The system needs to understand the sales legislation of the user's country.
- D10) The system needs to understand the human resources legislation of the user's country.

Capability 6 – Dark Analytics

Table 23: Recommendation for dark analytics capability

		Dark Analytics	
General	**Macro Activities**	**Txt Files**	**Untapped General Data**
Finance	Accounting, Financial Management, Reporting and Analytics.	A11) Bank Statements	ERP Logs and Dumps (equal for all)
Material Management	Inventory, Purchasing and Material Resource Planning.	B11) EDI Material Files	
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C11) EDI Sales Files	
Human Resources	Employee Management, Payroll, Training and Recruitment.	D11) Payroll Files	

Dark Analytics – Txt Files

As earlier defined, the aim of dark analytics is to take information that is already held by the company and add value from that data. One example is through the TXT files used in the departments and loaded into the ERPs.

- A11) Bank statements support companies in the processing of incoming payments or MT940 files, which is the SWIFT standard for the electronic transmission of account statement data.
- B11) EDI (electronic data interchange) is the exchange of business information over the Internet using a standard format of an electronic version of a paper invoice. For MM modules, an example is purchase order and inventory documents.
- C11) The logic is the same as in the previous paragraph but for the sales part. An example is the shipping status and payment confirmations.
- D11) The payroll files contain everything that the company pays to the employee on a monthly basis, for example, salary, bonus, and meal card.

Dark Analytics – Untapped General Data

Cognitive data steward technologies that use ML can help speed up the process of finding data and revealing its insights and connections. The difference between dark analytics and advanced analytics is the source of the data. Instead of being in tables that feed the dashboards of an ERP, it will be all kinds of data, such as ERP logs and dumps. This domain is equal for all since they are used for all four modules.

Capability 7 – Simplification of Customization

Table 24: Recommendation for simplification of customization capability

		Simplification of Customization	
General	**Macro Activities**	**Smart Error Message**	**System Updates**
Finance	Accounting, Financial Management, Reporting and Analytics.	A12) Related with FI Processes	System corrective updates (equal for all)
Material Management	Inventory, Purchasing and Material Resource Planning.	B12) Related with MM Processes.	
Sales and Distribution	Sales Support, Billing, Shipping and Transportation.	C12) Related with SD Processes	
Human Resources	Employee Management, Payroll, Training and Recruitment.	D12)Related with HR Processes	

Simplification of Customization – Smart Error Message

In order to simplify the customization of an ERP, the error messages should contain an explanation of the error as well as a suggestion and identify what remains to be customized to overcome the error, where possible. The system differentiated them according to process modules, for example, the following smart error message:

- A12) For the financial module, the message related to accounting period x being closed immediately has the transaction that opens the period.
- B12) For the purchasing module, the message related to account assignment mandatory for material has the transaction where this configuration is made.
- C12) For the sales module, the message related to maintaining the sale organization/division/distribution channel in the supplying plant has the transaction where this configuration is made.
- D12) For the human resources module, the message related to no data stored for an employee in the selected period has the transaction and field where the employee data can be changed.

Simplification of Customization – System Updates

Given the fact that an ERP is constantly evolving, the respective manufacturers develop and release new system versions to rectify identified problems. An example of these updates is at the interface level and corrective updates. Taking the example of the SAP SE company, at the interface level, the various versions of the SAP GUI in order to make the UI better and better. At the corrective updates level, the SAP Notes are related to the SAP Knowledge Base that addresses recognized problems with the SAP system. It is continuously updated when SAP customers identify problems with the SAP standard system, and SAP provides a note with specific instructions on how to resolve or manage the problem. An intelligent system must have the ability to perform these two activities automatically. Every ERP system should update automatically whenever a new UI version comes out and every time there is a new update related to standard tasks.

Table 25 presents the summary of seven capabilities and the domains and main goals.

Table 25: Summary of capabilities, domains, and objectives

Capabilities	Domains	Main Goals
Intelligent Behaviour	Classify and Reconcile Documents	Identify, group, and reconcile the documents.
	Resource Management	Optimize resources to maximize efficiency.
Learning Management	Chatbots	Chatbots to simulate a human conversation.
	Proactive Troubleshoot	Solving problems before impacts the business.
Advanced Analytics	Forecasting	Uses historical data to make future estimations.
	Reveal Patterns	Identify a set of data that follows a recognizable pattern.
Process Automation	Load Information	Automatize the load information process.
	Automatize Reports	Automatize the ERP reports and dashboards.
Inteligente Interface	User Auto Adaptation	Distinguish senior users from junior users.
	Country Specification	Adapt to each country specification.
Dark Analytics	TXT Files	Adding value through TXT files.
	Untapped General Data	Adding value with ERP dumps and logs.
Simplification of Customization	Smart Error Message	An error message indicates the solution o the problem.
	System Updates	Automatic system updates.

With the tables created for the seven i-ERP capabilities, it was possible to divide them into the four areas as shown in Figures 23 to 26. Keeping the logic used before, on the left side the seven capabilities, in the center the respective domains, and on the right side the objectives of each domain.

4.3.2. ARTIFACT 1 - GUIDELINES FOR FINANCE

Figure 23 shows artifact 1, the guidelines for the FI module. The domains are financially oriented, intelligent behaviour is divided into classify and reconcile FI documents and optimize cash flow. Learning management into financial internal chatbot and financial fraud detection. Advanced analytics into financial forecasting and reveal financial patterns. Process automation to process financial invoices and automatize financial reports. Intelligent interfaces into user adaptations taking into account the financial roles and financial country specification. Dark analytics into bank statement files and untapped general data with ERP dumps and logs. And finally, simplifications of customization into smart financial error messages and system updates.

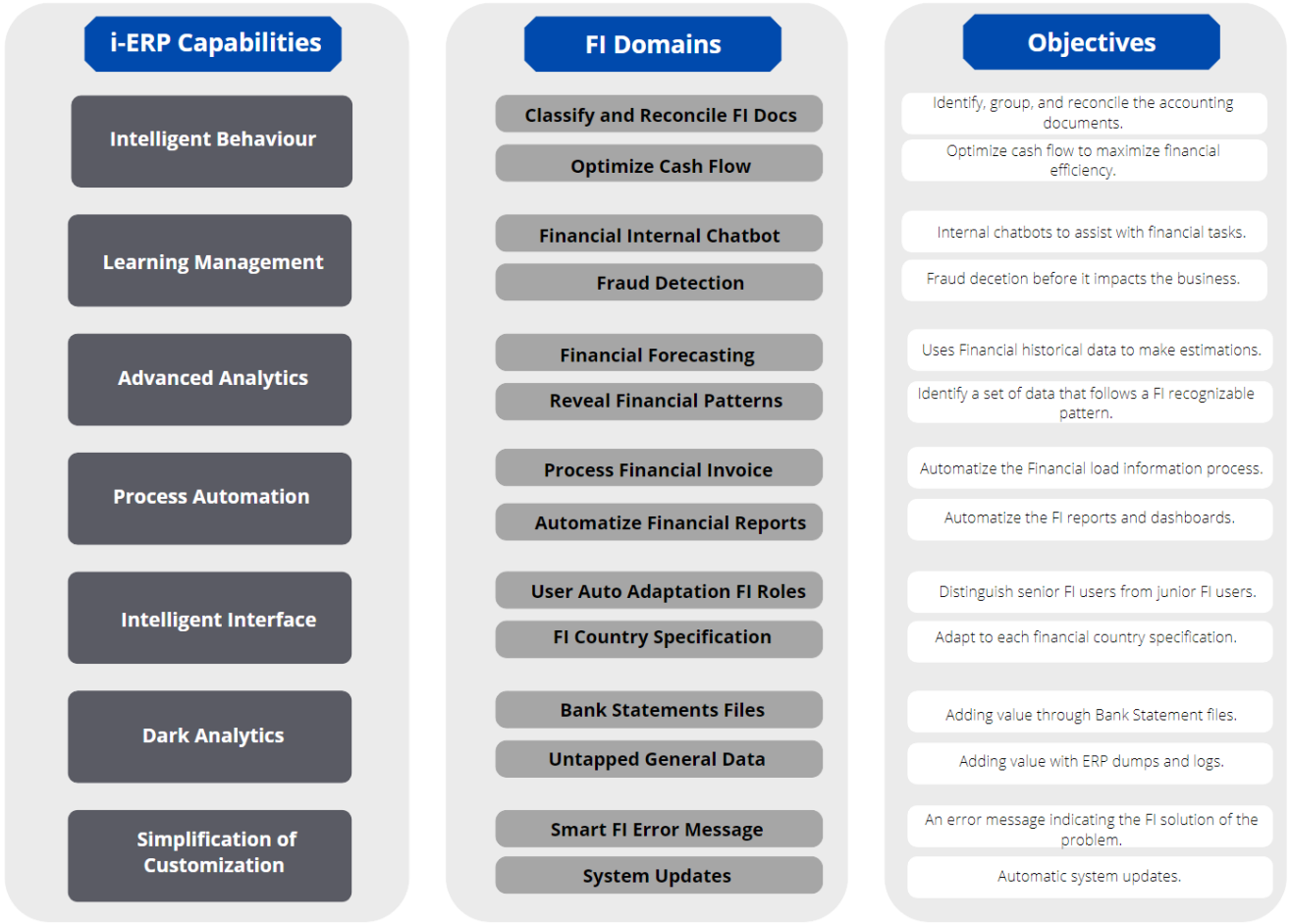

Figure 23: Artifact 1 - guidelines for finance

4.3.3. ARTIFACT 2 - GUIDELINES FOR MATERIAL MANAGEMENT

Figure 24 shows artifact 2, the guidelines for the MM module. The domains are material and purchase oriented, intelligent behaviour is divided into classify and reconcile MM documents and verify and update stocks. Learning management into inventory internal chatbot and solve manufacturing problems. Advanced analytics to predict purchase delivery and manufacturing optimal points. Process automation into process inventory and automatize material reports. Intelligent interfaces into user adaptations considering the MM roles and purchase country specification. Dark analytics into EDI material files and untapped general data with ERP dumps and logs. And finally, simplifications of customization into smart MM error messages and system updates.

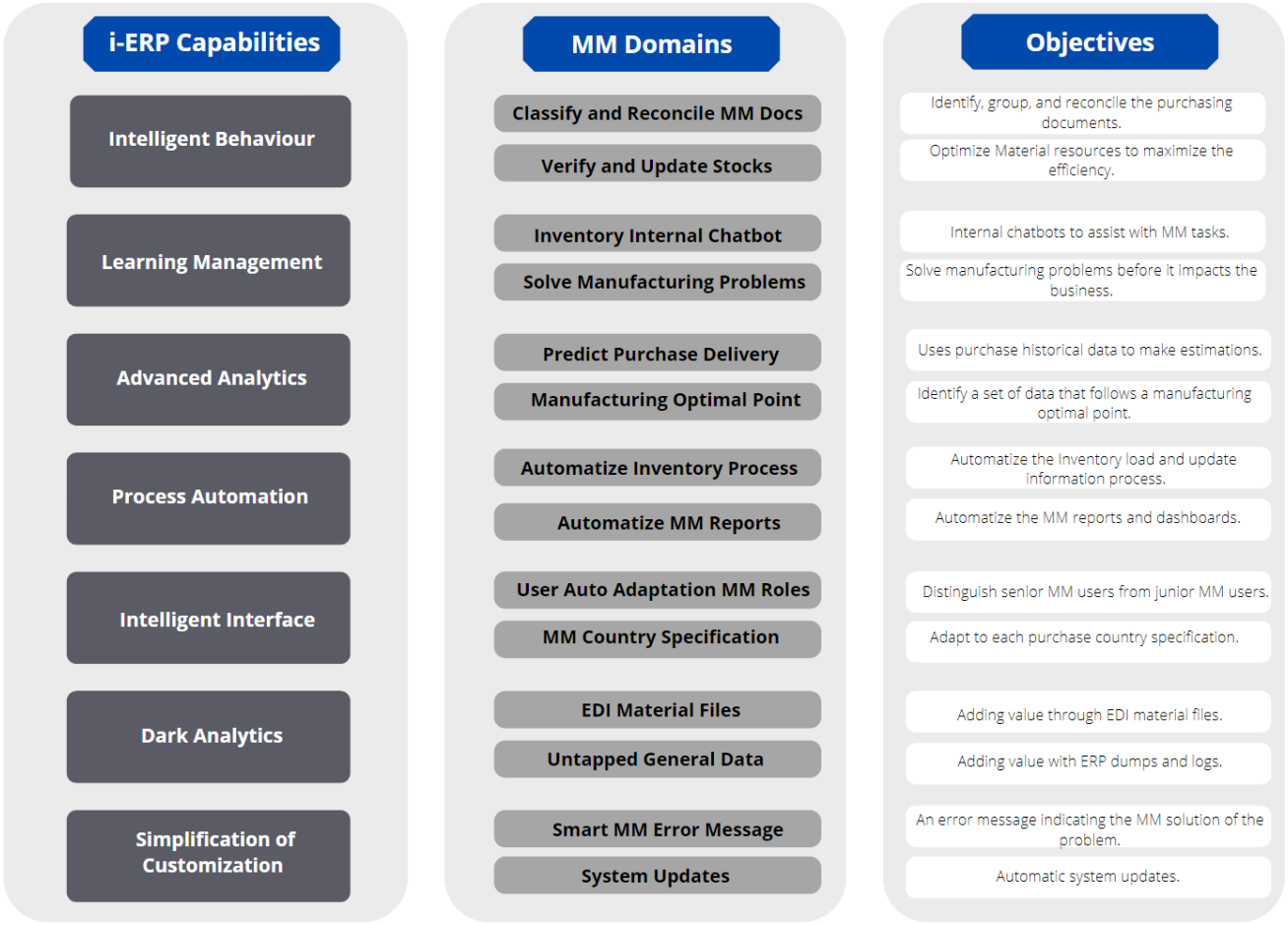

Figure 24: Artifact 2 - guidelines for material management

4.3.4. ARTIFACT 3 - GUIDELINES FOR SALES AND DISTRIBUTION

Figure 25 shows artifact 3, the guidelines for the SD module. The domains are sales oriented, intelligent behaviour is divided into classify and reconcile SD documents and sales management optimization. Learning management into sales external chatbot and solve sales order fulfillment issues. Advanced analytics into predict customer needs and find sales patterns or bottlenecks. Process automation into the sales process and automatize sales reports. Intelligent interfaces into user adaptations considering the sales roles and sales country specification. Dark analytics into EDI sales files and untapped general data with ERP dumps and logs. And finally, simplifications of customization into smart sales error message and system updates

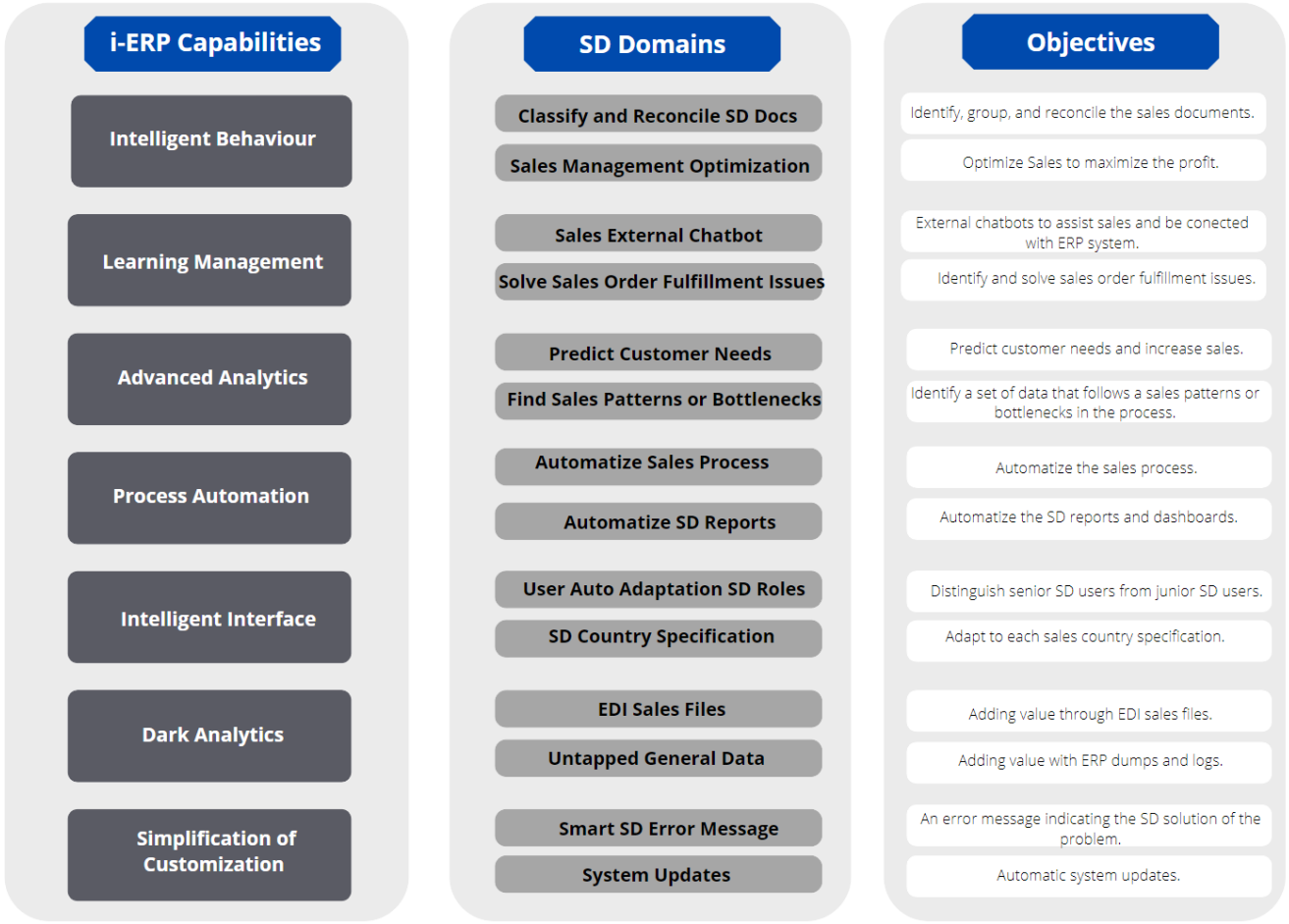

Figure 25: Artifact 3 - guidelines for sales and distribution

4.3.5. ARTIFACT 4 - GUIDELINES FOR HUMAN RESOURCE

Figure 26 shows artifact 4, the guidelines for the HR module. The domains are sales oriented, intelligent behaviour is divided into classify and group CVs and proactive talent management. Learning management in recruitment chatbots and proactive recruitment and selection. Advanced analytics to predict turnover and HR needs and identify recruitment patterns. Process automation into automatize employee information and automatize HR reports. Intelligent interfaces into user adaptations considering the HR roles and HR country specification. Dark analytics into payroll files and untapped general data with ERP dumps and logs. And finally, simplifications of customization into smart HR error messages and system updates.

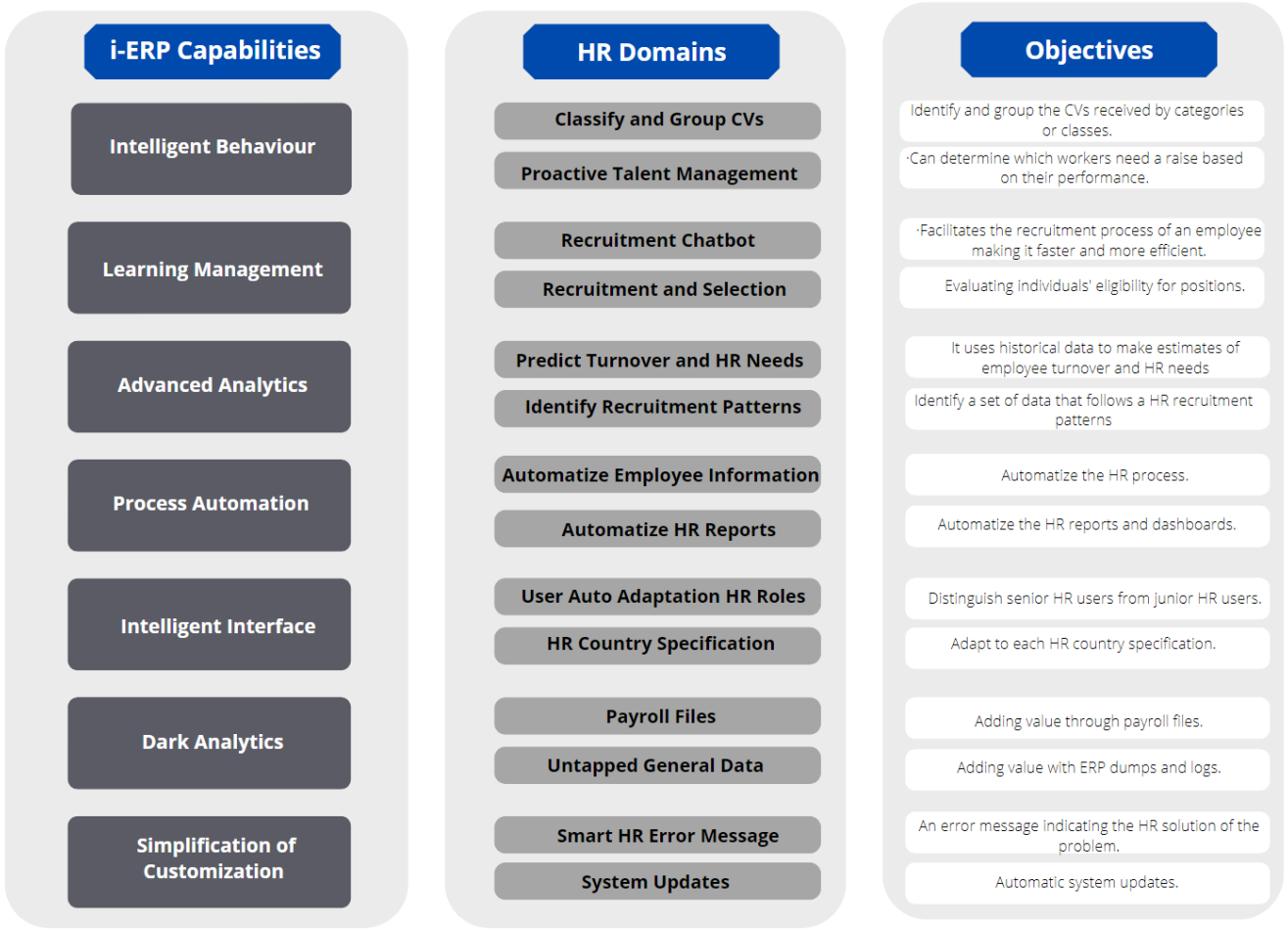

Figure 26: Artifact 4 - guidelines for human resource

4.3.6. I-ERP ASSESSMENT TOOL

The i-ERP assessment tool allows the evaluation of a system considering the capabilities and domains identified in the previous chapters. The assessment tool has two objectives: to evaluate the ERP intelligence capabilities activities and to evaluate the i-ERP system. To achieve the objectives, the following two evaluation tools were created:

- **i-ERP Activity Evaluation:** Measure the intelligence level of each activity considering the seven capabilities and respective domains previously identified.
- **i-ERP System Evaluation:** Measure the intelligence level of an ERP system considering the i-ERP capabilities evaluation.

These tools can be used by any type of company whenever they need to evaluate an ERP system, considering the level of intelligence. Below are the details of each evaluation system.

1. **i-ERP Activity Evaluation**

The ERP activity evaluation tool has been created based on the i-ERP literature review and the intelligent capabilities activities identified. Table 26 shows the structure of the i-ERP evaluation tool.

Table 26: i-ERP activity evaluation structure

Capability A						
Domain X	**Scoring Level**					**Activity Score**
Activity 1	Level 0 - Act. 1	Level 1 - Act. 1	Level 2 - Act. 1	Level 3 - Act. 1	Level 4 - Act. 1	Act.1 Score
Activity 2	Level 0 - Act. 2	Level 1 - Act. 2	Level 2 - Act. 2	Level 3 - Act. 2	Level 4 - Act. 2	Act.2 Score

(+ add if needed)

Each table represents a capability to facilitate its evaluation. For the example of the structure, capability A was used. Then the activities should be identified, taking into account the capabilities' domains. For example, domain X and activities 1 and 2 were used. Then each activity has a scoring level from 0 to 4, where 0 represents the lower lever and 4 the higher. A color system has been used to facilitate the identification of the levels. The parameters and descriptions are shown in Table 27.

Table 27: Scoring parameters and description for evaluation

Scoring	Description
Absent - 0	Practices are required for the business, but they do not exist.
Poor - 1	Practices exist but often fail to support the business.
Good - 2	Practices exist and are functioning but could be improved.
Very Good - 3	Practices exist and have undergone improvement over time, regularly contributing to meeting targets.
Excellent - 4	Practices are in place, fully effective, and contribute to improve performance or industry best practice.

Considering the seven capabilities identified in the literature review, the artifacts created by capabilities and for the four principal ERP models, the i-ERP capability evaluation structure and scoring parameters, it was possible to develop an i-ERP capabilities evaluation proposal for this master thesis, presented below in Table 28. Each "x" represents the score number when used in a real evaluation, ranging from 0 to 4.

Table 28: Proposed i-ERP activity evaluation

Intelligent Behaviour						
Classify and Reconcile Documents	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Classify and Reconcile FI, MM, and SD Documents	The system can´t classify and reconcile FI, MM, and SD documents.	The system can only classify by ERP area.	The system can classify by department and do basic reconciliations.	The majority of the documents can be classified and reconciled.	All documents can be classified and reconciled.	x
Classify and Group CVs	The system can´t classify and group CVs.	The system can do only basic CV' classifications.	The system can do semi-complex CV' classifications.	The system can do complex CV' classifications.	All CVs can be classified and grouped.	x
Resource Optimization	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Optimize Cash Flow	The system can´t optimize cash flow.	Only basic cash flow can be optimized.	Some of the cash flow can be optimized.	Most of the cash flow can be optimized.	All cash flow can be optimized.	x
Verify and Update Stocks	Stocks are updated manually.	Basis stocks can be optimized.	Some stocks can be optimized.	Most stocks can be optimized.	Stocks are fully and intelligently updated.	x
Sales Management	The system can´t optimize sales.	Basic sales criteria can be optimized.	Some sales criteria can be optimized.	Most sales criteria can be optimised.	Sales are fully up to date in an intelligent way.	x
Proactive Talent Management	The system can't identify employees' needs.	The system enables basic talent management capabilities.	The system can identify basic employees' needs according to their evaluation.	The system can identify and propose employees' needs according to their evaluation.	Proactive talent management is fully up to date in an intelligent way.	x

Learning Management						
Chatbots	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Internal Chatbots for FI and MM	The system doesn't provide capacity for an internal chatbot.	The system provides the capacity for a basic internal chatbot.	The system provides the capacity for a basic internal chatbot to help users in basic activities.	The system provides the capacity for an internal chatbot to help users in semi-complex activities.	The system can have an internal chatbot to help the users in all activities.	x
External Chatbots for SD and HR	The system doesn't provide the capacity for an external chatbot.	The system provides capacity for a basic external chatbot.	The system can have a basic external chatbot with some synchronized with the ERP system.	The system can have an external chatbot partially synchronized with the ERP system.	The system can have an external chatbot fully synchronized with the ERP system.	x
Proactive Troubleshoot	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Fraud Detection	The system can´t detect financial fraud.	Only basic financial fraud can be detected.	Some financial fraud can be detected.	Most financial fraud can be detected.	All financial fraud can be detected	x
Solve Manufacturing Problems	The system can´t solve manufacturig problems.	Only basic manufacturing problems can be solved.	Some basic manufacturing problems can be solved.	Most basic manufacturing problems can be solved.	All manufacturing problems can be solved.	x
Solve Sales Order Fulfillment Issues	The system can´t solve sales order fulfillment issues.	Only basic sales order fulfillment issues can be solved.	Some sales order fulfillment issues can be solved.	Most sales order fulfillment issues can be solved.	All sales order fulfillment issues can be solved.	x
Recruitment and Selection	The system can't analyze CVs or candidate profiles.	The system enables basic candidate analysis.	The system can identify some candidate analysis and basic filtering of CVs.	The system can identify some candidate analysis and semi-complex filtering of CVs.	Recruitment and Selection is fully up to date in an intelligent way.	x

Advanced Analytics						
Forecasting	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Financial Forecasting	The system can´t reveal financial patterns.	The system provides a basic capacity to reveal financial patterns.	The system provides a basic capacity to reveal financial patterns with real-time data.	The system provides a semi-complex capacity to reveal financial patterns with real-time data.	The system provides a full capacity to reveal financial patterns with real-time data.	x
Predict Purchase Delivery	The system doesn't provide the capacity to predict purchase delivery.	The system provides basic capacity to predict purchase delivery.	The system provides some capacity to predict purchase delivery with real-time data.	The system provides a semi-complex capacity to predict purchase delivery with real-time data.	The system provides a full capacity to predict purchase delivery with real-time data.	x
Predict Customer Needs	The system doesn't provide the capacity to predict customer needs.	The system provides basic capacity to predict customer needs.	The system provides some capacity to customer needs with real-time data.	The system provides a semi-complex capacity to predict customer needs with real-time data.	The system provides a full capacity to predict customer needs with real-time data.	x
Predict Turnover and HR Needs	The system doesn't provide the capacity to predict turnover trends and HR future needs.	The system provides a basic capacity to predict employee turnover trends and HR future needs.	The system provides some capacity to predict employee turnover trends and HR future needs with real-time data.	The system provides a semi-complex capacity to predict employee turnover trends and HR future needs with real-time data.	The system provides a full capacity to predict employee turnover trends and HR future needs with real-time data.	x
Reveal Patterns	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Financial Patterns	The system can´t reveal financial patterns.	The system provides a basic capacity to reveal financial patterns.	The system provides a basic capacity to reveal financial patterns with real-time data.	The system provides a semi-complex capacity to reveal financial patterns with real-time data.	The system provides a full capacity to reveal financial patterns with real-time data.	x
Manufacturing Optimal Point	The system can´t determine the manufacturing optimal point.	The system provides a basic capacity to determine the manufacturing optimal point.	The system provides a basic capacity to determine the manufacturing optimal point with real-time data.	The system provides a semi-complex capacity to determine the manufacturing optimal point with real-time data.	The system provides a full capacity to determine the manufacturing optimal point with real-time data.	x
Sales Pattern or Bottlenecks	The system can´t reveal sales patterns or bottlenecks.	The system provides a basic capacity to determine sales patterns or bottlenecks.	The system provides a basic capacity to determine sales patterns or bottlenecks with real-time data.	The system provides a semi-complex capacity to determine sales patterns or bottlenecks with real-time data.	The system provides a full capacity to determine sales patterns or bottlenecks with real-time data.	x
Recruitment Patterns	The system can't analyze CVs or candidate profiles.	The system provides a basic capacity to determine recruitment patterns.	The system provides a basic capacity to determine recruitment patterns with real-time data.	The system provides a semi-complex capacity to determine recruitment patterns with real-time data.	The system provides a full capacity to determine recruitment patterns with real-time data.	x

Process Automation						
Load Information	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Load automatically information for FI, MM, SD, and HR	The system doesn't provide load information automation capability.	Simple process information can be automated.	Most repetitive process information can be automated.	All repetitive process information and most less repetitive process information can be automated.	All information can be imported automatically.	x
Automatize Reports	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Automatize ERP reports for FI, MM, SD, and HR	The system doesn't provide reports automation capability.	Simple reports can be automated.	Most repetitive reports can be automated.	All repetitive reports and most less repetitive reports can be automated.	All reports can be created automatically.	x

Intelligent Interface						
User Auto Adaptation	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Automatic user adaptation according to the functional roles for FI, MM, SD, and HR	The system doesn't provide user auto adaptation capability.	Manual user adaptation is possible according to the functional roles.	The system can understand and learn basic adaptations according to functional roles.	The system can understand and learn basic and semi-complex adaptations according to functional roles.	The system can fully adapt according to user function roles and distinguish a junior from a senior user.	x
Country Specification	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Able to understand the FI, MM, SD, and HR country specifications and legislation	The system can't adapt to the user country's specifications and legislation.	Manual user adaptation is possible.	The system can understand and learn basic adaptations according to the country's specifications and legislation.	The system can understand and learn basic and semi-complex adaptations according to the country's specifications and legislation.	The system can fully adapt according to the country's specifications and legislation.	x

Dark Analytics						
Txt Files	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Create additional value with Txt files (ex: bank statements, EDI files, and payroll files)	The system can't create any additional value from txt files.	The system can only create basic additional value from txt files.	The system can create basic additional value from txt files with real-time data.	The system provides a semi-complex capacity to create basic additional value from txt files with real-time data.	The system provides a full capacity to create basic additional value from txt files with real-time data.	x
Untapped General Data	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
ERP dumps and logs	The system can't create any additional value from ERP dumps and logs.	The system can only create basic additional value from ERP dumps and logs.	The system can create basic additional value from ERP dumps and logs with real-time data.	The system provides a semi-complex capacity to create basic additional value from ERP dumps and logs with real-time data.	The system provides a full capacity to create basic additional value from ERP dumps and logs with real-time data.	x

Simplification of Customization						
Smart Error Message	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Error messages should contain an explanation of the error as well as a suggestion	The system doesn't provide any information in the error message.	Only basic insights to assist the user.	In a clearly defined situation, the system provides advice/recommendation.	In a semi-complex defined situation, the system provides advice/recommendation.	In any situation, the system provides advice/recommendation.	x
System Updates	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Interface and corrective updates.	The system doesn't provide any type of updates	The system provides only basic updates.	The system provides somes interface improvements and corrective updates.	The system systematically provides interface improvements and corrective updates.	The system provides automatically any updates.	x

2. i-ERP System Evaluation

After evaluating each activity, it is possible to assign a final value to the domain. Then, after evaluating each domain, it is possible to evaluate the capability. Finally, after evaluating the various capabilities, it is possible to obtain a clear overview to evaluate the i-ERP system, as can be shown in Table 29.

Table 29: i-ERP system evaluation structure

Capability	Domain	Activity	Activity Score	Domain Score	Capability Score	i-ERP Score
Capability A	Domain X	Activity 1	Score Act. 1	Domain X Score	Capability A Score	i-ERP Score
		Activity 2	Score Act. 2			
	Domain Y	Activity 3	Score Act. 3	Domain y Score		
		Activity 4	Score Act. 4			
Capability B	Domain Z	Activity 5	Score Act. 5	Domain Z Score	Capability B Score	
		Activity 6	Score Act. 6			

(+ add if needed)

The following activities were used for the i-ERP assessment system:

1. Evaluate each activity individually.
2. Evaluate each domain by calculating the average classification for the domain's activity.
3. Evaluate each capability by doing the average classification for the capability's domains.
4. Evaluate the ERP system by doing the average classification for all capabilities.

Note: In case the average does not give a whole number, rounding must be done.

Example: (4+3)/2 = 7/2 = 3,5 → 4

(4+3+3)/3 = 3,3(3) → 3

Table 30 was based on the seven capabilities identified in the research, the fourteen domains and their respective activities. All this has made it possible to create the proposed i-ERP System Evaluation. This is the blank version, and all the "x" represents the values to be assigned by users from 0-4.

Table 30: Proposed i-ERP system evaluation

Capability	Domain	Activity	Activity Score	Domain Score	Capability Score	i-ERP Score
Intelligent Behaviour	Classify and Reconcile Documents	Classify and Reconcile FI, MM, and SD Documents.	x	x	x	x
		Classify and Group CVs	x			
	Resource Optimization	Optimize Cash Flow	x	x		
		Verify and Update Stocks	x			
		Sales Management	x			
		Proactive Talent Management	x			
Learning Management	Chatbots	Internal Chatbots for FI and MM	x	x	x	
		External Chatbots for SD and HR	x			
	Proactive Troubleshoot	Fraud Detection	x	x		
		Solve Manufacturing Problems	x			
		Solve Sales Order Fulfillment Issues	x			
		Recruitment and Selection	x			
Advanced Analytics	Forecasting	Financial Forecasting	x	x	x	
		Predict Purchase Delivery	x			
		Predict Customer Needs	x			
		Predict Turnover and HR Needs	x			
	Reveal Patterns	Financial Patterns	x	x		
		Manufacturing Optimal Point	x			
		Sales Pattern or Bottlenecks	x			
		Recruitment Patterns	x			
Process Automation	Load Information	Load automatically information for FI, MM, SD, and HR	x	x	x	
	Automatize Reports	Automatize ERP reports for FI, MM, SD, and HR	x	x		
Intelligent Interface	User Auto Adaptation	Automatic user adaptation according to the functional roles for FI, MM, SD, and HR	x	x	x	
	Country Specification	Able to understand the FI, MM, SD, and HR country's specification	x	x		
Dark Analytics	Txt Files	Create additional value with Txt files (ex: bank statements, EDI files, and payroll files)	x	x	x	
	Untapped General Data	ERP dumps and logs	x	x		
Simplification of Customization	Smart Error Message	Error messages should contain an explanation of the error as well as a suggestion	x	x	x	
	System Updates	Interface and corrective updates.	x	x		

4.4. USE CASE – SAP S/4 HANA

According to the methodology used in design science research, the next step is the demonstration phase. The demonstration of the artifacts created was only used for the i-ERP assessment model because for the recommendations, an i-ERP system would have to be built, which is beyond the limits of this thesis. For the i-ERP assessment model, tables 28 and 30 were used to consider the proposed i-ERP capabilities evolution and i-ERP system evaluation, respectively, and the system chosen for evaluation was SAP S/4 HANA, the latest product developed by SAP SE.

SAP SE is a German company founded in 1972 that develops ERP software to manage business operations and customer relations and is the largest non-American software company by revenue. As observed in Figure 27, SAP/S4 HANA is the predecessor of SAP ECC. To help companies go to S/4 HANA, SAP has developed a methodology through automation conversion from ECC to the new system, which helped companies in the transition and migration process.

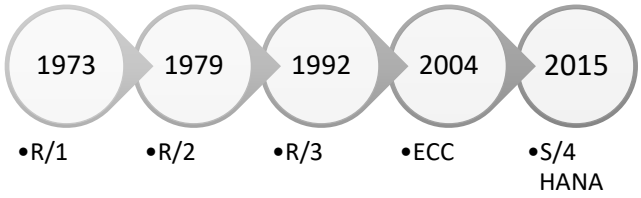

Figure 27 - SAP products roadmap (Roan, 2020)

For this evaluation, the deployment in the cloud has been considered instead of on-premises because it can leverage their capabilities and the deployment is faster. According to the SAP website, "*SAP S/4HANA Cloud is a complete enterprise resource planning (ERP) system with built-in intelligent technologies, including AI, ML, and advanced analytics*" (SAP SE, 2021c). SAP S/4 HANA Cloud uses domains such as ML to optimize, situation handling to anticipate, RPA to act, chatbots to interact, and IoT to connect. The four key pillars are: digital assistance and natural language conversation for increased productivity and user satisfaction, AI, and RPA to eliminate manual tasks, the ability to rapidly design and execute new business models and services on advanced end-to-end processes, and the last one is real-time predictive insight to improve decision-making (SAP SE, 2021c).

Considering my personal work experience and my knowledge of SAP, it was possible to evaluate SAP S/4 HANA, taking into account the proposed i-ERP activity evaluation. Tables 31 through 43 describe all activity evaluations.

Capability 1 - Intelligent Behaviour | Domain: Classify and Reconcile Documents

Table 31: SAP S/4 HANA activity evaluation for classify documents domain

Intelligent Behaviour						
Classify and Reconcile Documents	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Classify and Reconcile FI, MM, and SD Documents	The system can´t classify and reconcile FI, MM, and SD documents.	The system can only classify by ERP area.	The system can classify by department and do basic reconciliations.	The majority of the documents can be classified and reconciled.	All documents can be classified and reconciled.	4
Classify and Group CVs	The system can´t classify and group CVs.	The system can do only basic CV' classifications.	The system can do semi-complex CV' classifications.	The system can do complex CV' classifications.	All CVs can be classified and grouped.	3

One of the functionalities available in SAP HANA is text mining capabilities. One of the functions is the analysis function, which involves categorizing or classifying documents, for example, organizing documents by related terms. Reconciliation can also be done in SAP HANA with a single bank account for simplified reconciliation accounts. With text search and text analytics SAP HANA can do complex CV' classifications.

Capability 1 - Intelligent Behaviour | Domain: Resource Optimization

Table 32: SAP S/4 HANA activity evaluation for resource optimization domain

Intelligent Behaviour						
Resource Optimization	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Optimize Cash Flow	The system can´t optimize cash flow.	Only basic cash flow can be optimized.	Some of the cash flow can be optimized.	Most of the cash flow can be optimized.	All cash flow can be optimized.	3
Verify and Update Stocks	Stocks are updated manually.	Basis stocks can be optimized.	Some stocks can be optimized.	Most stocks can be optimized.	Stocks are fully and intelligently updated.	3
Sales Management	The system can´t optimize sales.	Basic sales criteria can be optimized.	Some sales criteria can be optimized.	Most sales criteria can be optimised.	Sales are fully up to date in an intelligent way.	3
Proactive Talent Management	The system can't identify employees' needs.	The system enables basic talent management capabilities.	The system can identify basic employees' needs according to their evaluation.	The system can identify and propose employees' needs according to their evaluation.	Proactive talent management is fully up to date in an intelligent way.	3

SAP S/4 HANA's high-performance technology enables the examination of graphical data in real-time, therefore optimizing a significant number of financial resources. Smarter inventory management can be created with SAP services. The visualization of data in real-time also makes it possible to optimize the sales side. The SAP SuccessFactors software suite provides a cloud-based solution for managing HR operations such as talent management.

Capability 2 - Learning Management | Domain: Chatbots

Table 33: SAP S/4 HANA activity evaluation for chatbots domain

Learning Management						
Chatbots	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Internal Chatbots for FI and MM	The system doesn't provide capacity for an internal chatbot.	The system provides the capacity for a basic internal chatbot.	The system provides the capacity for a basic internal chatbot to help users in basic activities.	The system provides the capacity for an internal chatbot to help users in semi-complex activities.	The system can have an internal chatbot to help the users in all activities.	3
External Chatbots for SD and HR	The system doesn't provide the capacity for an external chatbot.	The system provides capacity for a basic external chatbot.	The system can have a basic external chatbot with some synchronized with the ERP system.	The system can have an external chatbot partially synchronized with the ERP system.	The system can have an external chatbot fully synchronized with the ERP system.	3

The SAP system allows connections between any chatbot to an SAP HANA database as well as the building of an internal chatbot on SAP Conversational AI, a low code chatbot building platform connected with the SAP S/4HANA backend.

Capability 2 - Learning Management | Domain: Proactive Troubleshoot

Table 34: SAP S/4 HANA activity evaluation for proactive troubleshoot domain

Learning Management						
Proactive Troubleshoot	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Fraud Detection	The system can´t detect financial fraud.	Only basic financial fraud can be detected.	Some financial fraud can be detected.	Most financial fraud can be detected.	All financial fraud can be detected	1
Solve Manufacturing Problems	The system can´t solve manufacturig problems.	Only basic manufacturing problems can be solved.	Some basic manufacturing problems can be solved.	Most basic manufacturing problems can be solved.	All manufacturing problems can be solved.	2
Solve Sales Order Fulfillment Issues	The system can´t solve sales order fulfillment issues.	Only basic sales order fulfillment issues can be solved.	Some sales order fulfillment issues can be solved.	Most sales order fulfillment issues can be solved.	All sales order fulfillment issues can be solved.	2
Recruitment and Selection	The system can't analyze CVs or candidate profiles.	The system enables basic candidate analysis.	The system can identify some candidate analysis and basic filtering of CVs.	The system can identify some candidate analysis and semi-complex filtering of CVs.	Recruitment and Selection is fully up to date in an intelligent way.	2

SAP Business Integrity Screening is a technology that helps businesses across sectors to identify, mitigate, and discourage fraud in situations containing large amounts of data, but still needs to be improved. SAP HANA can solve internal problems by using the 8D methodology. This methodology is associated with an app that has to be customized using a problem-solving approach. With this,

companies can identify the sources of faults and establish tasks for eradicating them. SAP Predictive analytics can identify and solve some same sales order fulfillment issues in the SD module. The Recruitment and Selection part is also available in SAP SuccessFactors but can only identify some candidate analysis and basic filtering of CVs.

Capability 3 - Advanced Analytics| Domain: Forecasting

Table 35: SAP S/4 HANA activity evaluation for forecasting domain

Advanced Analytics						
Forecasting	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Financial Forecasting	The system doesn't provide capacity for financial forecasting.	The system provides basic capacity for financial forecasting.	The system provides some capacity for financial forecasting with real-time data.	The system provides semi-complex capacity for financial forecasting with real-time data	The system provides a full capacity for financial forecasting with real-time data.	3
Predict Purchase Delivery	The system doesn't provide the capacity to predict purchase delivery.	The system provides basic capacity to predict purchase delivery.	The system provides some capacity to predict purchase delivery with real-time data.	The system provides a semi-complex capacity to predict purchase delivery with real-time data.	The system provides a full capacity to predict purchase delivery with real-time data.	3
Predict Customer Needs	The system doesn't provide the capacity to predict customer needs.	The system provides basic capacity to predict customer needs.	The system provides some capacity to predict customer needs with real-time data.	The system providess a semi-complex capacity to predict customer needs with real-time data.	The system providess a full capacity to predict customer needs with real-time data.	3
Predict Turnover and HR Needs	The system doesn't provide the capacity to predict turnover trends and HR future needs.	The system provides a basic capacity to predict employee turnover trends and HR future needs.	The system provides some capacity to predict employee turnover trends and HR future needs with real-time data.	The system provides a semi-complex capacity to predict employee turnover trends and HR future needs with real-time data.	The system provides a full capacity to predict employee turnover trends and HR future needs with real-time data.	3

SAP HANA has semi-complex forecasting capabilities with real-time data with financial planning and analysis tools, a set of activities like planning, forecasting, budgeting, and analysis that help a company make important business decisions and stay financially healthy as a whole. SAP Predictive Maintenance and Service have a semi-complex capacity to predict purchase delivery with real-time data. The sales module has forecasting features since it uses a material's historical consumption data to predict its future demand. Is it possible with SAP Infinite Insight to create a classification model to predict whether employees will quit within 12 months or stay with the company and future HR needs.

Capability 3 - Advanced Analytics| Domain: Reveal Patterns

Table 36: SAP S/4 HANA activity evaluation for reveal patterns domain

Advanced Analytics						
Reveal Patterns	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Financial Patterns	The system can´t reveal financial patterns.	The system provides a basic capacity to reveal financial patterns.	The system provides a basic capacity to reveal financial patterns with real-time data.	The system provides a semi-complex capacity to reveal financial patterns with real-time data.	The system provides a full capacity to reveal financial patterns with real-time data.	2
Manufacturing Optimal Point	The system can´t determine the manufacturing optimal point.	The system provides a basic capacity to determine the manufacturing optimal point.	The system provides a basic capacity to determine the manufacturing optimal point with real-time data.	The system provides a semi-complex capacity to determine the manufacturing optimal point with real-time data.	The system provides a full capacity to determine the manufacturing optimal point with real-time data.	3
Sales Pattern or Bottlenecks	The system can´t reveal sales patterns or bottlenecks.	The system provides a basic capacity to determine sales patterns or bottlenecks.	The system provides a basic capacity to determine sales patterns or bottlenecks with real-time data.	The system provides a semi-complex capacity to determine sales patterns or bottlenecks with real-time data.	The system provides a full capacity to determine sales patterns or bottlenecks with real-time data.	1
Recruitment Patterns	The system can't analyze CVs or candidate profiles.	The system provides a basic capacity to determine recruitment patterns.	The system provides a basic capacity to determine recruitment patterns with real-time data.	The system provides a semi-complex capacity to determine recruitment patterns with real-time data.	The system provides a full capacity to determine recruitment patterns with real-time data.	2

SAP HANA Smart Data Streaming is an option that enables real-time collection, processing, and analysis of streaming events that can be used to find basic financial patterns. SAP S/4HANA project

manufacturing management is a standard function that provides a semi-complex capacity to determine the manufacturing optimal point with real-time data. Regarding finding bottlenecks, SAP HANA does not have great datamining capabilities, but it can connect with data mining specific systems. Regarding the HR module, SAP SuccessFactors can identify basic recruitment patterns with real-time data.

Capability 4 - Process Automation | Domain: Load Information

Table 37: SAP S/4 HANA activity evaluation for load information domain

Process Automation						
Load Information	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Load automatically information for FI, MM, SD, and HR	The system doesn't provide load information automation capability.	Simple process information can be automated.	Most repetitive process information can be automated.	All repetitive process information and most less repetitive process information can be automated.	All information can be imported automatically.	3

The functionality is called LTMC and stands for Legacy Transfer Migration Cockpit, which allows data to be automatically loaded into the system. It is widely used to migrate massive amounts of data into the system, for example, master data.

Capability 4 - Process Automation | Domain: Automatize Reports

Table 38: SAP S/4 HANA activity evaluation for process automation domain

Process Automation						
Automatize Reports	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Automatize ERP reports for FI, MM, SD, and HR	The system doesn't provide reports automation capability.	Simple reports can be automated.	Most repetitive reports can be automated.	All repetitive reports and most less repetitive reports can be automated.	All reports can be created automatically.	4

All reports in SAP can be automated. The user only has to schedule a background job to be run when they want.

Capability 5 - Intelligent Interface | Domain: User Auto Adaptation

Table 39: SAP S/4 HANA activity evaluation for user auto adaptation domain

Intelligent Interface						
User Auto Adaptation	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Automatic user adaptation according to the functional roles for FI, MM, SD, and HR	The system doesn't provide user auto adaptation capability.	Manual user adaptation is possible according to the functional roles.	The system can understand and learn basic adaptations according to functional roles.	The system can understand and learn basic and semi-complex adaptations according to functional roles.	The system can fully adapt according to user function roles and distinguish a junior from a senior user.	1

Adaptations have to be done manually, taking into account the functions of user roles. Normally, each role contains several authorization objects that give access to only a few transactions, but this process has to be manual.

Capability 5 - Intelligent Interface | Domain: Country Specification

Table 40: SAP S/4 HANA activity evaluation for country specification domain

Intelligent Interface						
Country Specification	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Able to understand the FI, MM, SD, and HR country specifications and legislation	The system can't adapt to the user country's specifications and legislation.	Manual user adaptation is possible.	The system can understand and learn basic adaptations according to the country's specifications and legislation.	The system can understand and learn basic and semi-complex adaptations according to the country's specifications and legislation.	The system can fully adapt according to the country's specifications and legislation.	3

The SAP system consists of and is available in more than 50 countries. When selecting the country, the system can understand the basic and some more complex legal requirements. In the event of a change in requirements, SAP provides updates that must be made manually in the system. SAP also has the Localization Toolkit, a set of tools that allows the extension of standard capabilities, for example in the areas of general ledger and tax reporting.

Capability 6 - Dark Analytics| Domains: Txt Files and Untapped General Data

Table 41: SAP S/4 HANA activity evaluation for txt and untapped general data domain

Dark Analytics						
Txt Files	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Create additional value with Txt files (ex: bank statements, EDI files, and payroll files)	The system can't create any additional value from txt files.	The system can only create basic additional value from txt files.	The system can create basic additional value from txt files with real-time data.	The system provides a semi-complex capacity to create basic additional value from txt files with real-time data.	The system provides a full capacity to create basic additional value from txt files with real-time data.	1
Untapped General Data	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
ERP dumps and logs	The system can't create any additional value from ERP dumps and logs.	The system can only create basic additional value from ERP dumps and logs.	The system can create basic additional value from ERP dumps and logs with real-time data.	The system provides a semi-complex capacity to create basic additional value from ERP dumps and logs with real-time data.	The system provides a full capacity to create basic additional value from ERP dumps and logs with real-time data.	1

Despite the good capabilities of the SAP analytical solutions like SAP Analytics Cloud, SAP Data Warehouse Cloud, and SAP Data Intelligence and the advances that SAP and Intel (a company operating in the cloud computing, data center, and IoT), have made in this field, there is still much to explore. Nevertheless, however strong SAP and Intel technology may be, only humans can make sense of dark data and comprehend the context of how data is kept.

Capability 7 - Simplification of Customization | Domain: Smart Error Message

Table 42: SAP S/4 HANA activity evaluation for smart error message domain

Simplification of Customization						
Smart Error Message	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Error messages should contain an explanation of the error as well as a suggestion	The system doesn't provide any information in the error message.	Only basic insights to assist the user.	In a clearly defined situation, the system provides advice/recommendation.	In a semi-complex defined situation, the system provides advice/recommendation.	In any situation, the system provides advice/recommendation.	2

Normally, SAP HANA always contains a text explaining the error message, but only in clearly defined situations does the system provide indications on how to parameterize in order to overcome the error message.

Capability 7 - Simplification of Customization | Domain: System Updates

Table 43: SAP S/4 HANA activity evaluation for system updates domain

Simplification of Customization						
System Updates	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Activity Score**
Interface and corrective updates.	The system doesn't provide any type of updates	The system provides only basic updates.	The system provides somes interface improvements and corrective updates.	The system systematically provides interface improvements and corrective updates.	The system provides automatically any updates.	3

SAP provides several interface versions and notes for updating the system, but both of them have to be implemented manually. Both are available on the SAP launchpad service, a service that enables companies to establish a central point of access to SAP.

After each activity was evaluated, it was possible to evaluate the whole system using the proposed i-ERP system evaluation assessment described in Table 44. The final SAP S/4 HANA classification was 3, considering that practices exist and have undergone improvement over time, regularly contributing to meeting targets. This use case shows how the proposed recommendations and respective assessments are used, and its relevance shows the best way towards the implementation of an i-ERP system.

Table 44: SAP S/4 HANA system evaluation

Capability	Domain	Activity	Activity Score	Domain Score	Capability Score	i-ERP Score
Intelligent Behaviour	Classify and Reconcile Documents	Classify and Reconcile FI, MM, and SD Documents.	4	4	4	3
		Classify and Group CVs	3			
	Resource Optimization	Optimize Cash Flow	3	3		
		Verify and Update Stocks	3			
		Sales Management	3			
		Proactive Talent Management	3			
Learning Management	Chatbots	Internal Chatbots for FI and MM	3	3	3	
		External Chatbots for SD and HR	3			
	Proactive Troubleshoot	Fraud Detection	1	2		
		Solve Manufacturing Problems	2			
		Solve Sales Order Fulfillment Issues	2			
		Recruitment and Selection	2			
Advanced Analytics	Forecasting	Financial Forecasting	3	3	3	
		Predict Purchase Delivery	3			
		Predict Customer Needs	3			
		Predict Turnover and HR Needs	3			
	Reveal Patterns	Financial Patterns	2	2		
		Manufacturing Optimal Point	3			
		Sales Pattern or Bottlenecks	1			
		Recruitment Patterns	2			
Process Automation	Load Information	Load automatically information for FI, MM, SD, and HR	3	3	4	
	Automatize Reports	Automatize ERP reports for FI, MM, SD, and HR	4	4		
Intelligent Interface	User Auto Adaptation	Automatic user adaptation according to the functional roles for FI, MM, SD, and HR	1	1	2	
	Country Specification	Able to understand the FI, MM, SD, and HR country's specification	3	3		
Dark Analytics	Txt Files	Create additional value with Txt files (ex: bank statements, EDI files, and payroll files)	1	1	1	
	Untapped General Data	ERP dumps and logs	1	1		
Simplification of Customization	Smart Error Message	Error messages should contain an explanation of the error as well as a suggestion	2	2	3	
	System Updates	Interface and corrective updates.	3	3		

4.5. ARTIFACT VALIDATION

The fifth step, according to the DSR methodology, is the evaluation of the artifact through structured interviews because they provide relevant information and gather opinions on the evaluation and respective acceptance of the artifacts created.

Five interviewees were selected to validate the respective artifacts. The interviewees were all from Portugal, and they had all been interviewed by me. In the process of choosing the experts, there were some selection criteria. At least one would have to be a junior to have a different perspective from the seniors. Male and female individuals were also selected. It has also been selected by some experts with SAP experience and without this experience. All these criteria were chosen to enrich and diversify the experts' knowledge. For anonymity purposes, the names, companies, and universities of the interviewees were kept private. So below are the details of each one:

Interviewee 1 (I1): The interviewee is a junior SAP consultant with more than two years of experience. He has a degree and a master's degree in management from Lisbon Business School. His consultancy focuses on the FI-CO module.

Interviewee 2 (I2): The interviewee is a senior consultant and business analyst with more than eight years of experience in SAP in all modules. She has a master's degree in accounting and the initial part of a PhD completed in accounting from Porto Business School. She already has experience working with SAP S/4 HANA.

Interviewee 3 (I3): The interviewee is a senior IT business analyst with more than eight years of experience. His main functions are as the first support line in the IT troubleshooting department in a Lisbon company.

Interviewee 4 (I4): The interviewee works as a solution advisor in SAP, and he has more than ten years of experience in the ERP area. He has a master's degree in finance from Lisbon Business School. He already has experience working with SAP S/4 HANA.

Interviewee 5 (I5): The interviewee is a digital enterprise professor from Lisbon Business School with a PhD in how software as a service adoption impacts firm performance. He has great experience in the area of information systems, especially in cloud solutions. In addition to his vast professional experience, it should be noted that he worked for about ten years at Microsoft as a business solution advisor.

Firstly, the interviews were previously prepared in four parts. The first part begins with a brief introduction from both the parties, the interviewer, and the interview. The second part started with the presentation of the master's thesis motivation and objectives. In the third part, the artifacts were presented, and in the final part, the following questions were made.

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

Q2: Do you have any criticism towards the proposed framework? Please explain

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

The interviews were conducted between June 20th, 2022, and July 13th, 2022. All of them were done by Zoom and Microsoft Teams, with an average duration of 30 minutes. The interviews were conducted in Portuguese, which is the native language of all the participants. But since this master's thesis is written in English, the answers were translated into English, and they can be seen in full at the appendix section.

4.6. DISCUSSION OF THE RESULTS

In this part of the study some specific points from the literature review and the output from experts are presented to discuss the final evaluation of the artifacts and its acceptance. The aim of this section is to understand the level of acceptance, criticism, and recommendations for improvement of the proposed artifacts.

The literature review proved some important topics. The first one was the fact that i-ERP is a recent concept and there is an identified research gap. Then the fact that i-ERP will be a part of the future and that companies that implement technology in their systems can achieve huge competitive advantage. So far, AI seems to fit in with disruptive technologies and has made great progress (Russell et al., 2010). Finally, the guidelines enrich the ERP manufacturers and companies that want to make ERPs smarter, and the assessment tool helps classify the intelligence level of an ERP.

A company's relationship with its ERP system is frequently compared to that of a marriage, as it necessitates long-term commitment and compromise from both parties. Given the cost, time, and resources required for implementation and maintenance, most companies that choose an ERP do not switch to another player in the market (Osnes et al., 2018). ERP projects are large-scale software projects, most of them involving customization of the system (Sudhaman & Thangavel, 2015). Therefore, the good implementation and choice of the system for a company is crucial for its success since only efficient projects are found to provide the expected benefits to the organization (Chen et al., 2009) which reinforces the importance of this study.

Regarding the feedback from experts, this part was divided into three taking into account the three questions made. The first part with the acceptance level, then criticism made to the artifacts ending with recommendations. Only the important aspects mentioned by each expert were considered for this part.

Acceptance of the guidelines

In general, the experts accepted the proposed guidelines and found them important. Interviewees 1, 2, 3, 4 and 5 accepted the artifacts mainly because it correctly covers the principal departments in a company. I1 liked the fact that the guidelines have concrete examples which facilitate their interpretation. I1 also said that his company is currently switching for a new ERP system with more AI capability, and they expect to achieve some of the advantages mentioned in the guidelines. I2 mentioned that she can identify some of the domains presented in the guidelines in S/4 HANA systems, mainly the reports and process automation. I3 agreed that if well implemented the guidelines can save costs and ensure data security for companies. He also mentioned that the guidelines are easy to incorporate for non-technical people which is a great advantage. I4 accepted the ERP macro processes and agreed with the capabilities and technology chosen. Regarding the proposed frameworks, he said that they made some sense. I5 considers the framework useful mainly for PMEs, both ERP manufacturers and companies, because large companies already use ERPs with some intelligent capabilities. It is really important when a company chooses an ERP to understand the functionalities available in the market to assist the decision-making.

Criticism of the guidelines

Although all the experts accept the artifact, they left some critics. I1 said the guidelines are too generic and do not adapt for every company. The usability and acceptance depend on the reality of each company. Taking into account the financial background of I2, she considered the guidelines for the financial department only focused on the stakeholder's needs and not on the internal costs controlling. She also makes a critique for the proactive talent part in the guideline for HR. In her opinion, this domain should first search if internally there is a person to fulfill the open position and only after that search externally. I3 also said that the guidelines are very generic and should have a fifth guideline for

general information, because in his opinion, there are domains that are equal for all departments and if a fight guideline was created would avoid duplication of data. I4 referred that he does not agree with some choices made because they should be more focused on the real problems of the four areas, but he understands the choices that were made. I5 left no criticism of the framework.

Recommendations of the guidelines

Like the previous point, all the experts gave a set of recommendations for the guidelines. I1 said they should contain IoT devices, for example, in the MM modules in the inventory, and the i-ERP technologies should also contain IoT. He also said that the guidelines should consider more information out of the scope, for example, weather conditions in the warehouse zones to avoid lost inventory caused by a storm. I2 recommends that the guidelines should be more connected between them because she had the impression that they are treated separately, and these four modules are very connected among them. I3 recommends that a set of best practices should be added to the guidelines because in his opinion the guidelines are focusing only on technology and not on people but technology without best practices does not bring the expected value. I4 considered that a different methodology should be used. First, identify the process failures for each area and then associate the correct capabilities to solve them. I5 recommends complementing the framework with tangible objectives and KPIs because with this it will help PME companies calculate the costs vs benefits of moving forward to an intelligent solution.

5. CONCLUSION

The final chapter contains three sections to conclude this work. Section 5.1 contains the summary of the research, section 5.2 the limitation of the study and finally section 5.3 with the future research.

5.1. SUMMARY OF THE RESEARCH

The purpose of this research was to fill a gap that was found in the scientific community in the i-ERP field. The problem identified was the lack of studies about the potential of an i-ERP in various business areas. The concept of intelligent technologies such as AI, ML, big data, and cloud computing is increasingly present in companies. The interdependence of ERP systems and organizations, the high switching costs and the growth of disruptive technology leads to an increase in the number of companies adopting these systems.

Given the high diversity of these systems on the market, when a company chooses an ERP system, they undergo several business adaptations because they provide a standard tool that has to be parameterized according to each organization's processes. On the other side, given the diversity of technology the ERP fabricants have difficulty understanding which path they should follow. To facilitate both sides, some artifacts were created through a DRS methodology. The recommendations by i-ERP capabilities, the guidelines for finance, purchase, sales and human resources and an i-ERP assessment tool.

In the introduction, in the problem identification part, two research questions were identified. The recommendation by i-ERP capability served to assist ERP builders in selecting the best improvement option for their systems, because it contains more technical details, which answered RQ1. Moreover, for RQ2, the guidelines for the four primary areas of an ERP system served to help technical and non-technical people choose the best option on the market for their company. Relatively the i-ERP assessment tool, it can be addressed for both questions since it can be used by ERP manufacturers and companies that already have or want to implement a new system to evaluate the level of intelligence.

Also, in this section eight intermediate objectives were identified. The first six were accomplished during the literature review, which was divided into four parts. First, the IMS history was presented. Then the ERP concept, advantages, disadvantages, history, and architecture. In this part it was important to identify the four main ERP modules and their activities. In the third part, the concept of i-ERP was introduced as well as the technologies and capabilities presented in these systems. Lastly, a taxonomy was identified to classify these i-ERP systems and the evolution stages from a basic ERP to an intelligent system. The seventh objective was accomplished with the creation of the artifacts mentioned previously. The last objective was accomplished with the demonstration of the i-ERP assessment tool with the evaluation of the S/4 HANA system and the artifacts validation through the expert's interview.

It is possible to conclude that the purpose of the research was achieved. The research questions have been successfully answered and the intermediate objectives reached. With the literature review and the feedback collected from the experts, it was possible to ensure that the i-ERP capabilities, if well implemented, can mitigate some disadvantages identified for ERP because these new systems contain intelligent features that can better adapt to market changes.

5.2. LIMITATIONS OF THE STUDY

During this study, some limitations were constantly presented in addition to those identified by the experts in the discussion of the results, in section 4.6. The first one begins with the i-ERP concept presented in the literature review because the technologies and capabilities identified consider only some authors. Other authors consider other technologies, such as IoT, which were only partly considered in this research. It was only considered IoT for the real-time data in the analytics part and not in other domains.

The artifacts created are only for four areas and are very generic. This work excluded the other ERP models, which makes the guidelines very generic. Also, the guidelines were created to be used for any company, which means that it may not adapt to all realities. The logic used for the creation of the artifacts was the keep it simple methodology which does not cover all the domains for the identified capabilities.

According to the DSR, artifacts have to be demonstrated, and to be accurate the guidelines should be demonstrated in practice, building an i-ERP system. Since this was not in the scope of this research an assessment tool was created based on the guidelines to demonstrate its usability.

In the validation part, the target audience was small. Although the experts cover a wide range of male and female persons, junior and seniors, and with ERP experience and without, a large audience has to be used to obtain better feedback, preferably from companies from different areas. Because another limitation of this research is the fact that it does not consider the level of acceptance in practice, and only after putting it into practice it is possible to understand the real value of the guidelines.

Finally, this work did not consider any ethical or legal field. And when it comes to disruptive technology, the ethical part is very important to consider because it limits the action of the technology. And it requires setting up a mechanism to ensure that the data is used ethically and legally.

5.3. FUTURE RESEARCH

In this context, future research contains some suggestions identified during the interview and the research writing in order to stimulate this topic research since it is recent and has the need to be even more detailed and it is expected that the number of scientific research in this field will increase in the future.

In a summary, the experts consider that future research should be done on the guidelines to increase their complexity. They should be divided into more modules to cover more business areas and more domains should be added as well. A possible future will be the implementation of the guidelines in different companies. Ideally, from different areas and sizes to get a more detailed opinion to understand the real gains.

Since the number of interviews conducted was small, one option is to increase the number of experts and collect even more opinions through interviews, always considering the fact that the target audience should be diverse, with people from different areas.

Another example is the creation of best practices for business process changes in the context of the implementation of intelligent tools, for example, presented in the proposed guidelines. Another

possibility is to incorporate different technologies in the i-ERP concepts, for example, IoT devices and information out of scope for an ERP system. It is very important that in the future, more studies appear related to i-ERP acceptance, preferably with examples of practical and quantifiable gains that companies have made by adopting smarter solutions.

As a conclusion of all the research, we can see that intelligent systems have made huge progress in their short history, and undoubtedly the final sentence of Alan Turin's essay on *Computing Machinery and Intelligence*, is still valid today (Turing & Haugeland, 1950, p.95):

"We can see only a short distance ahead,
but we can see that much remains to be done."

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APPENDIX - INTERVIEWS

Interviewee 1 on date: 20.06.2022

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

In general, I really like the artifacts and the way they have been presented, mainly because they are divided into the four main areas, which are finance, purchase, sales, and human resources. It is interesting that each domain has a future and past perspective, for example, in the advanced analytics part you have put the past perspective with the activity of revealing patterns and the future with forecasting.

I liked the fact that it has practical examples that enrich the artifacts and facilitate their reading. I also liked the fact that all objectives are real and credible in the market, and the majority of them I can see implemented in my company. It is interesting because my company is switching to an ERP with more AI capability to achieve some of the presented objectives.

Q2: Do you have any criticism towards the proposed framework? Please explain

Although I liked the artifacts, they are fairly generic, which can be a positive aspect but also a negative one because they cannot be adapted to some realities. For example, its usability and implementation depend on the company size and business sector. A simple example: the country specification in the intelligent interface is important for an international company, but for a national company it no longer has relevance.

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

I think the artifacts should contain mode IoT device technology to help with some capabilities, mainly in the MM sector, because ERP systems should be more directly connected with the warehouse with these sensors. Also, it's important to add new domains in order to make the framework more applicable to other market businesses.

It will also be important to be able to input more information outside of the scope of the ERP system, for example, the weather conditions in the warehouse zones, to be able to predict possible inventory damage. Another example will be the internet capacity in the users' zone to predict possible system failure.

Interviewee 2 on date: 21.06.2022

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

I consider the framework useful mainly because of the desegregation it allows to cover the main four areas of a company. The manufacturing process, the purchasing part, the sales, the human resources for human capital management, and last but not least, the financial part that has to cover and connect all of the other areas, because all of them are connected with the financial part of a company.

I have already worked with SAP S/4 HANA, and I can identify some of the domains presented in the frameworks with the system. Especially the reports and process automation parts. S/4 HANA allows searching for information by area and by function, which allows a better detailed view of each item.

It is important when a system allows the user to search not only for the macro-overview but also for the micro-overview. But of course, you can only have access to see information which concerns you, according to your functional role.

Q2: Do you have any criticism towards the proposed framework? Please explain.

I think the financial proposed framework is too much focusing just for the financial information. To meet the stakeholders' needs, the owners of the capital. For example, the investors, audit, and regulatory companies. But then I have a sensation that it doesn't have much detail for internal information, the controlling part, which is very important in a company.

In the HR part, I am not sure if the proactive talent management is also doing a reallocation of the resources. For example, imagine that a company needs to increase the financial team and I work in the purchase department, but I already have some experience in the financial part. Instead of the company searching externally to fill the open position, the system should be able to identify first if we have someone internally to fill the position.

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

Although there is some similarity in the domains and objectives chosen for the four frameworks, it gives me the sensation that they are all very far away from each other and that there isn’t any connection between them. I recommend that in the future the framework becomes more connected between themself. If companies want to move to an intelligent system, it makes more sense if there is a perfect connection between all the modules to facilitate the management of all the data inside the ERP system.

Interviewee 3 on date: 30.06.2022

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

Yes, I think the proposed framework is useful. Basically, it covers the most important areas and departments in every company where the most useful information is stored.

I agreed with the recommendations because, if well implemented, they can help companies save money and secure data administration. For example, the automation part will reduce not only cost but also the failure risk, which is a great advantage for all companies.

I also appreciate the fact that it is easy to interpret the artifacts for non-technical people, which is a major point because, in a company, a huge part of the employees does not have technical skills, and sometimes it is difficult to convince that part that changing to something smarter or different brings advantages.

Q2: Do you have any criticism towards the proposed framework? Please explain

I just think that the proposed framework is too generic and should be divided. For example, there are some domains that are repeated for the four modules, for example, the untapped general data for dark analytics. In this case, you should create a fifth guideline table with general information for such cases.

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

I'm not sure if this can be considered a recommendation, but although there is some cost reduction with the intelligent tools, the proposed framework only focuses on technology. I think that a company can implement technology in their ERP system, but if the company does not consider changing the processes according to best practices, the gain will be lower. The same can be applied to people. If a company invests in intelligent technology but does not invest in training people, the possible gain will be lower.

In my opinion, the recommendations should also contain other components, like best practices to achieve the goals proposed by the four recommendations that you created. And all of them must be aligned between them. With this improvement, you will achieve two important groups: the managers with the technology recommendations and the workers with the best practices.

Interviewee 4 on date: 05.07.2022

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

In general, I think the artifacts are useful. They cover inside the ERPs areas the macro processes and the principals' modules. For the constructions of all of them the following methodology has been used. First a technology base as the pillars of all research, then the capabilities provided by the technology and finally the processes that this technology can be applied. You did not go as deep as possible but yes, it makes some sense what is proposed. I identify some points with SAP HANA, namely the process automation in the reporting part and the simplification of customization because of the cloud solution.

Q2: Do you have any criticism towards the proposed framework? Please explain

I think that the financial framework should contain different domains more related to the major problems that companies have in this area, and I do not think that the bank statement should be used in the dark analytics field. I understand the logic, but the bank statement already has value for the company.

The purchase framework is too much focused on industrial companies with the stocks, manufacturing problems, and manufacturing optimal point and less focus on companies that provide services. It is correct, but you should have contextualized them.

In the sales framework, you should have focused more on the sales part, the logistics of sales, and not on the client part, because the ERP in this part has less priority. Sales are more related to CRM.

Lastly, in the HR framework, I do not agree with the payroll file because it already brings value to the company. Another point, I think the format for the presentation of the artifacts should have more processes.

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

In my personal opinion, you should have used a different methodology. Instead of technology, then capabilities, then process, you should have used the opposite way. First, identify together with companies the major problems of each module, then understand which capability and respective technology can be used to solve the issue.

For the sales framework, I suggest focusing more on the logistic process and solving the main problems with this process. In the HR framework, I suggest using the CVs for dark analytics instead of the payroll file.

Interviewee 5 on date: 13.07.2022

Q1: Do you consider the proposed framework as useful and why? If not, why do you believe it is not?

The proposed frameworks are useful from the ERP manufacturers' point of view since they help them develop new services. Mainly the smallest ERP manufacturers, not for SAP or Microsoft because they already know these new technologies and how to implement them. The ERP market has a lot of local suppliers because of the specifications by country, mainly financial. For example, Primavera ERP in Portugal.

When we analyze the companies, we have to understand two characteristics, the vertical market with the type of industry and the type of company and the dimension of the company. Micro companies, mainly, buy a smaller ERP on an annual subscription. But if the ERP has this level in the proposal, it is very good for them.

So, I would say that it is particularly interesting for the manufacturer, not for the bigger ones, and for the clients to understand the existing possible functionalities, and after that, they can discuss with the suppliers what they want for the system. It is useful for both of parties.

Q2: Do you have any criticism towards the proposed framework? Please explain

I do not have any criticism because this work is presented in a good way. It is noticeable that you did a good research job and I agree with the technologies chosen as well as the functionalities/domains.

Q3: Do you have any recommendations or suggestions for further improvements to the proposed framework?

You only focused on the four general modules, and for a starting point in this i-ERP area, you have chosen well. Typically, they are the four bigger modules, mainly for the PME companies. The larger companies have many more modules and areas. For example, in SAP, the financial part is divided into three parts: the accounting part, the control, and the asset management. In this example, we can see the complexity of these areas. In the future, more areas should be addressed within the proposed framework to enrich the work.

The only recommendation that I have is to complement the framework with tangible objectives and KPIs. For example, if a company decides to automatize the invoice process, how much will they expect to gain with this automation. Because in the future, smaller companies will have to choose between ERP and I-ERP and they will have to understand the potential gains with an i-ERP to evaluate the investment, because this solution will be more expensive than a normal ERP. With this, it is easier for them to calculate the costs vs benefits of more forward to an intelligent solution.