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MASTER's Degree in ENGINEERING AND  
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MASTER's Degree Thesis

**ENTERPRISE RESOURCE PLANNING:  
A LITERATURE REVIEW**

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# Abstract

Enterprise Resource Planning systems (ERPs) are a tool implemented by organizations that work as resource planning systems and information management systems. It is an integrated software program that allows companies to easily evaluate, control, and manage their business more easily and is characterized by its great capacity for adaptation, modularity, and interfaces with other types of programs. The development of these systems did not come out of nowhere, it is the result of over 50 years of evolution in the areas of technological advances and management streams, which results in a much diverse environment for private companies and Public Sector Organizations (PSOs). This thesis submerges into the growth of ERP systems along with the challenges faced to reach a level where implementing an ERP-type system an undisputable competitive advantage for companies.

# Acknowledgments

The writing of this thesis has been an emotional ride. Some days I thought I would not see the end of it. Emotions collided inside me between the sense of failure for not accomplishing this milestone at the same time as my friends and letting my family down. It was the support of my partner, Sergio, who really pushed me to get through this process and complete this thesis. Without his compassion, encouragement, and love, I would not have been able to reach this spot.

This thesis is dedicated to my mom, Patricia, for all the sacrifices she has made for me to be in this place. To my dad, Jorge, for supporting me from the beginning when I was in the first years of my bachelor and came to him with this idea, even if he is not physically present to witness me accomplish this goal, I know he is happy and proud of the woman I have become. To my siblings, Jhonatan and Melissa, and my extended family for always believing in me.

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*“And lastly, I want to thank me for believing in me, I  
want to thank me for doing all this hard work”  
Snoop Dogg*



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# Chapter 1

## Enterprise Resource Planning: An Overview

For the past two decades, the socio-economic scenario has witnessed growing globalization of markets along with increasing competition among them, this situation has caused companies' CEOs to be faced with new and intricate demands. This highly volatile, dynamic, and complex environment makes it essential for the company to have some viable competitive advantage that grants maintaining and improving its position in the market. Taking these conditions into consideration, companies' needs had to evolve into strategic alternatives that went hand in hand with several options offered by the various developments that arose in the field of Information and Communications Technologies (ICT) as sources of competitive advantages for the organization

In this regard, the market offers a set of products to optimize business processes through mega information systems that capture, store, process and distribute the data and information generated by the different administrative, operational, and productive units of the company (Benvenuto, 2006). Companies

employed systems that oversaw managing functions for each department to which the system was installed. This arrangement resulted in problems that blocked the adequate timely knowledge of the and control of the operations and management of the company such as data duplication, access difficulty, lack of data integrity and low possibility of real time data sharing. The information is neither reliable, nor timely nor accurate.

In synthesis, managing a company in a world ruled by globalization, where competition is ruthless, efficient systems that relate to customers are required are a must. Is in this moment that Enterprise Resource Planning systems (ERP) come to light and play an important role since they supply the company with a flexible and integrated resource management.

Andonegi et. al (2005) established that to the extent that an information system is the platform from which a process is managed, the information system is also the one who defines how this process should be (what information should be entered, which people should be informed, what logical order should be followed, etc.). Thus, the basic philosophy of ERPs is to be the management support of the company as a whole and not simply the extension of the production management model to other departments. The best proof of this is that ERP applications are no longer only intended for companies where manufacturing is the strong point but have been implemented in all types of companies.

Enterprise Resource Planning systems can be seen as a resource planning and information management system that satisfies the demand for business management needs in a structured way. It is an integrated software program that allows companies to easily evaluate, control and manage their business across the board more easily (Muñiz, 2007).

Different definitions of an ERP system have been given throughout the years, even more so in its first stages from mid-nineties to mid-two thousand. One in its most basic form is "a system composed of several modules, such as, human

resources, sales, finance and production, which enable the integration of data through embedded business processes. These software packages can be configured to respond to the specific needs of each organization." (Esteves & Pastor, 1999, cited by Oltra et. al 2011) or "information systems that integrate key business processes so that information can flow freely between the different parts of the firm, thereby improving coordination, efficiency and the decision-making process" (Laudon & Laudon, 2004, cited by Oltra et. al 2011).

Da Conceição & Gonzalez (2010) define ERP as information systems that use IT associated with business process engineering for the redesign and integration of business processes, to support operations within the framework of business strategy. For example, ERP allows you to plan and control resources and activities related to purchasing, production, shipping and posting of an order. In addition, a typical ERP system is associated with a set of advantages: vertical extensions for various economic sectors, solid technical architecture, training, documentation, support during implementation, process design tools, etc.

ERP systems are cross-platform open systems that are able to adapt, modulate, and interface with other programs. It is a business management program that fulfills the functional requirements of the company, creating a workflow for the different users that allows to reduce repetitive tasks and increasing the communication between all areas of the company. The software is built on a relational database, intended for open architectures, which is based on client-server technology, uses state-of-the-art languages, and presents graphical user interface, as well as computer-aided design software. This makes ERP a World Class type software package that allow companies to evaluate, implement, automate, integrate, and efficiently manage the different operations that are presented in them. They can be used by all types of companies, but an adaptation is required according to the circumstances and type of organization that each of them has.

The Aberdeen Group Inc. (2004) gave a definition for that differs from some made previously. They defined ERP as "the software infrastructure that, on the one

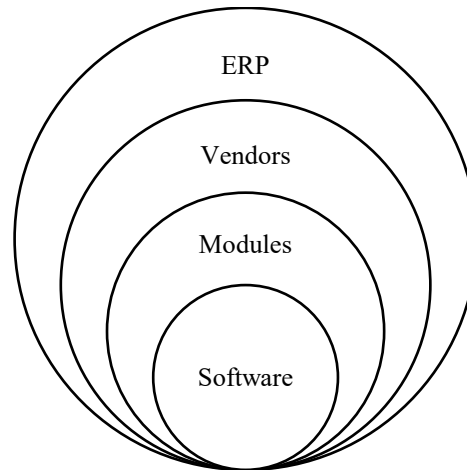
hand, supports all internal processes of the company, and on the other, supports the external business processes of the company", giving it a "support" functionality for connection with other systems. Parthasarthy (2007) also steps away from the general concept of ERP and establishes that it is necessary to forget about the planning and resource portion of its name and focus on the enterprise one, as it is ERP's true ambition as it "attempts to integrate all departments and functions across a company onto a single computer system that can serve all those different departments' particular needs". This way of interpreting an ERP, an integrated one, could generate a great payback if the software is installed correctly. Said payback is reflected in an improvement in the efficiency of the company through effective use of management resources.

In other words, the main feature of an ERP software is integration since it can unify all the departments of the same company, where each one of the operations can be managed under the same software, i.e., it is a unified set of programs that share the same software that covers all information systems from the reception of goods to the after-sales monitoring of a company. While there may be partial ERP systems that control a certain number of operations, a true ERP is present in all areas of the company (Pelaez, 2015). In fact, users can get general reports for several departments. In addition, reports can be generated with data from different departments, so the databases must be perfectly crossed between all the company's departments.

The ERP has as one of its main objectives to satisfy the different information needs of the company to ensure that the different managers can make decisions and control the fulfillment of objectives. However, as Muñiz (2007) signals, it must also be considered that the decision to implement an ERP is strategic for the company; therefore, it must have the ability to assume the changes and resources to be employed in the implementation.

The main components that distinguish any ERP system from others are the software that varies depending on its license, the modules integrated in it which are

different depending on the organization's requirements, and the vendor that provides the system where some are more established than others or (Figure 1). All these components are discussed below.



**Figure 1:** Main characteristics from an ERP

## **1.1. Software**

The component of an ERP that is the most recognizable to users is the software, hence it is the component associated and known as the product, the ERP (Marnewick and Labuschagne, 2005). Its procedure, where it is obtained before a company implements it, varies depending on its license and it represents the several modules that can be installed within the ERP. The next section focuses on the latter.

The software license is a contract that is established between the user and the owner of an application. Pelaez (2015) shares the different types of software licenses that apply to software:

- Software under GPL license allows the distribution and modification of the applications contained in the license. Free distribution ERPs are included in Open ERP solutions. For example, "Linux" operating systems offer good GPL licensed alternative to commercial Windows systems.

- Software under BSD license is developed by the North American University of Berkeley. It allows free redistribution and modification, but under certain conditions.
- Software under MPL license is developed by Netscape Communications Corporation. It allows limited distribution, copying, and even modification. They also support the release of source code, maintaining control over such modifications.
- Semi-free software is a non-free software, which allows the copying, use, distribution, and modification without profit.
- Free software. The advantages of free software are that you do not pay for a license, that updates are free, and that information is quickly accessed through a forum. The main disadvantage is that there is no trustworthy guarantee that updates will be error-free. Versions are not always reliable, and it should take a long time for the release to be considered stable. It is not always compatible with devices or peripherals. It is not always full of compatibility problems, especially if you consider very specific software (for example, the one provided by the tax agency, under a very specific format).
- Private software. One whose modification, redistribution and use without authorization is prohibited. They are the commercial licenses, the best known is the ERP version called SAP. It is the one elaborated by private companies, with commercial spirit, where it is paid for the license of use, the cost of implementation, the updates, and the adaptation of the software to the company. Its distribution without a license is strictly prohibited and constitutes a crime against intellectual property.

Of all these denominations we must focus on the last two that have encircled an ongoing debate about which is the best solution, the best ERP, to implement. This also alludes to a selection process that will be discussed later-on and now we will discuss its origin.



Richard Stallman can be considered as the pioneer of free software, not because he was the inventor of this, which dates back to the 1950s and 1960s, but because he created the Free Software Foundation, which contributed to the development of the concept laying its conceptual basis achieving that, at the beginning of the 2010s, its market is considered a mature industry (Oltra et al, 2011).

Stallman (2002) determined that the term "free software" refers to four levels of freedom that has beneficial consequences, both for the end user, as well as for the developer, the integrator, or the one who provides maintenance and services, which may vary depending on the recipient:

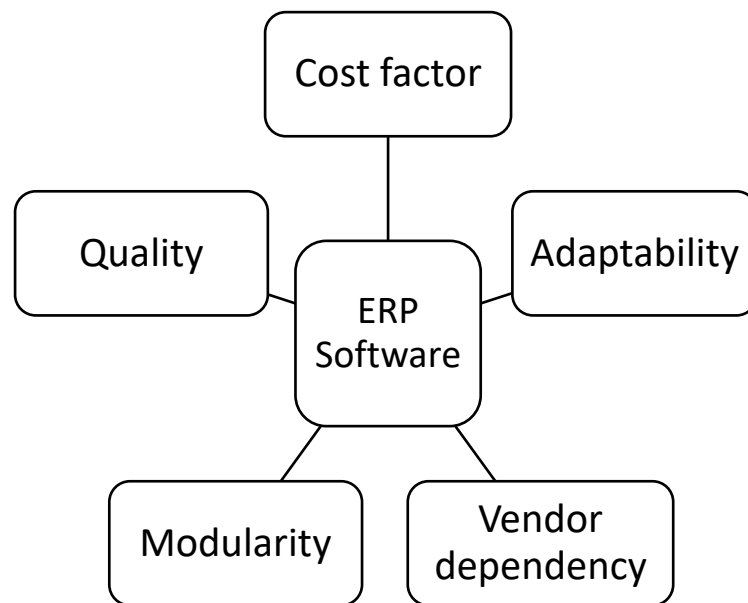
- Run the program anywhere, for any purpose and forever.
- Study it and adapt it to our needs. This requires access to the source code.
- Redistribution, so that we are allowed to collaborate with neighbors and friends.
- Improve the program and publish the improvements. It also requires the source code.

The free software ERP, which hereinafter we will call by the acronym FS<sub>w</sub> ERP (Free Software Enterprise Resources Planning), is an ERP that is conceived and developed under the principles of free software and fulfilling the four assumptions mentioned before.

Boulanger (2005) mentions that FS<sub>w</sub> ERP has evolved and improved since its inception and were being developed and designed for mass consumption by mid 2000s. This resulted in a shift on the market situation, and private ERP software vendors faced some challenges that had to be approached if they wanted to stay in business. However, this mass production and consumption did not completely shift the balance in favor of FS<sub>w</sub> ERP because of its reliability problem mentioned before. This results in a lack of confidence in the performance of the software by

most companies (Bonet 2007, as cited by Oltra et al, 2011). This is a reasonable point since companies are reluctant to entrust all the management of their sensitive information in a system, if it does not have a reputation that makes it a system of their absolute confidence.

Still, there are more factors that differentiate a private software ERP and an FSw ERP that should be considered by both the companies that must select an ERP, and by the companies that develop said ERP (Figure 2). The references to private software ERP are addressed from the point of view of solutions oriented to SMEs, since the factors that are going to be analyzed, and the considerations that are made regarding them, can be substantially different between the proprietary ERP solutions focused on large companies or multinationals (Oltra et al, 2011).



**Figure 2:** Differentiating factors between private and FSw ERP

### 1.1.1. Cost factor

Generally, the licenses to use proprietary ERP are expensive, which, above all, has restricted their access to SMEs. However, currently, the existing FSw ERPs change this situation, since their license is free and this places this group of ERP systems within the reach of any company (Oltra et al, 2011). On the other hand,

Economides and Katsamakas (2006) mention other important costs associated with free software related to its use, such as learning costs, installation costs and maintenance costs, although the software can be used for free.

In the case of ERP, it is important to take into account the associated costs of implementing and using ERP, which can be divided into three categories (Oltra et al, 2011).

- Program Licenses. It is the most differential cost since in the case of FSw ERP this cost does not exist, since the licenses are free, while in the case of private ERP, it is an important cost within the project.
- Hardware acquisitions. It can be said that this cost is the most similar in both cases, in the case of SMEs, both for the FSw ERP and for the private ERP (Johansson & Sudzina 2008, cited by Oltra et al, 2011)
- Services necessary for implementation. It is a necessary cost for both types of software. However, the difference lies in the ease of finding specialists for the implementation process of one ERP or another. In the 2010s it could be said that it is easier to find specialists and companies dedicated to the implementation of private ERP than FSw ERP. This can make the hourly price of services for the implementation of an FSw ERP higher than in the case of a private ERP.

### **1.1.2. Adaptability and development capacity**

A review of the existing literature on ERP shows that the main problem that arises in the implementation of an ERP is the mismatch between ERP functionality and business requirements (Shebab et al, 2004; Oltra et al, 2011). Soh et al (2000) say explicitly, the possible mismatch between the ERP and company processes is a very important factor to consider in the selection of the software package.

The problem of "mismatch" or "gap" means that there is a gap between the functionality offered by the ERP and the functionality required by the organization in which it is to be implemented (Johansson and Carvalho, 2009 cited by Oltra et

al, 2011). Due to this gap, the implementation of an ERP requires that modifications be made in the processes of the companies in which it is implemented, as well as adaptations of the ERP functionality to the needs of the company. This adaptation requires the participation of consulting companies. This is a fact regardless of whether the ERP is open source or private.

In the case of FSw ERP, the code is open, and this makes it possible for the companies that are going to use it, the end user, to actively participate in the developments and modifications of the software. This fact will make the developments more adjusted to the real needs of the user, that is, it will reduce in a more effective way the gap between the ERP and the company that will use it. Conversely, most private ERP cannot be substantially modified in the way they manage business processes. Sure, it is possible in many cases a basic customization, it is not possible to modify the complex processes, which are sometimes the key processes of the company.

### **1.1.3. Vendor dependency**

Companies that acquire a private ERP are highly dependent on the developers and distributors of these systems, that is, on the owners of the source code. If these agents disappear for any reason, ERP improvement and maintenance can have significant problems, as generally, only ERP developers have full knowledge of the system (Serrano & Sarriegi 2006 cited by Oltra et al, 2011).

The manufacturer is usually who develops the new versions of the ERP. Consultants and other specialized companies that are associated in some way with the manufacturer can carry out adaptations to the software to later be implemented since they have access to the source code. Therefore, it is clear that there is a very strong dependence on them.

Private ERP providers commonly give a slumber of several of the latest versions of their ERP. This is a much more complex task to do in the case of FSw ERP. Because of its definition, new developments to the system can be added and

modified by all users, and with it, multiple versions of an FSw ERP are created, which in turn difficults finding an expert that can provide the company with an accurate support of a certain "sub-version" of the FSw ERP.

Therefore, it can be said that in the case of the proprietary ERP there is a dependence on the provider (both the ERP, and the implementation services) much greater than in the case of the FSw ERP, although that dependence, which initially may seem an inconvenience, is associated with the provision of a series of services, which can be very advantageous for the company that implements an ERP.

#### **1.1.4. Modularity**

In MacCormack et al. (2006; cited by Oltra et al., 2011) it is stated that open source and proprietary code show a difference in modularity, with open source being more modular than proprietary software. The reason is that this type of development (free software), often involves many developers, and each one takes care of a small portion (module) of the system.

As one of the main advantages of modularity, it can be noted that when carrying out a development within a modular system, it is not necessary to take the complete code into consideration and it is possible to carry out a development for a specific purpose, without the need to know and involve other functions of the system (Johansson & Sudzina 2008). This significantly reduces the complexity of developing new functionalities or adapting an ERP to the specific needs of a company, so it is a very significant advantage.

#### **1.1.5. Software quality**

Once a critical mass of free software users has been formed, the momentum of the combined effort of all users will produce quality systems, which in many cases meet and exceed the security and reliability metric of their proprietary counterparts, and at a much lower cost (Boulanger 2005). Different ERP users may have the same problem, which needs adaptation or development, and can provide different points

of view and solution approaches, taking advantage of the synergy between them, and resulting in a better result than the solution that each of them could give individually.

However, in order for the software developed to reach a high level of quality, it is essential that this critical mass of users be formed, and act by sharing knowledge, cooperating with each other and helping each other by repairing and solving possible errors, providing new functionalities developed, etc. It is therefore important for organizations to change their point of view of the system, which must move from a user point of view to a developer point of view, to take advantage of the possible synergy of the rest of the developers.

## **1.2. Modules**

Companies need to have an automated system or program composed of different modules, which allows them to manage all their administrative and operational management activity.

With respect to said components that make up an ERP, we cannot draw up a closed list for two reasons. In the first place, the diversity of suppliers of this type of software means that the standard part of it is not homogeneous between the different offers although there are certain modules common to all of them. On the other hand, ERP offers the possibility of adding new components to the standard application that is supplied by the supplier, in such a way that each tool will be adapted according to the characteristics of the industrial sector in which the company operates. Nevertheless, there are modules that can commonly be found in such an application.

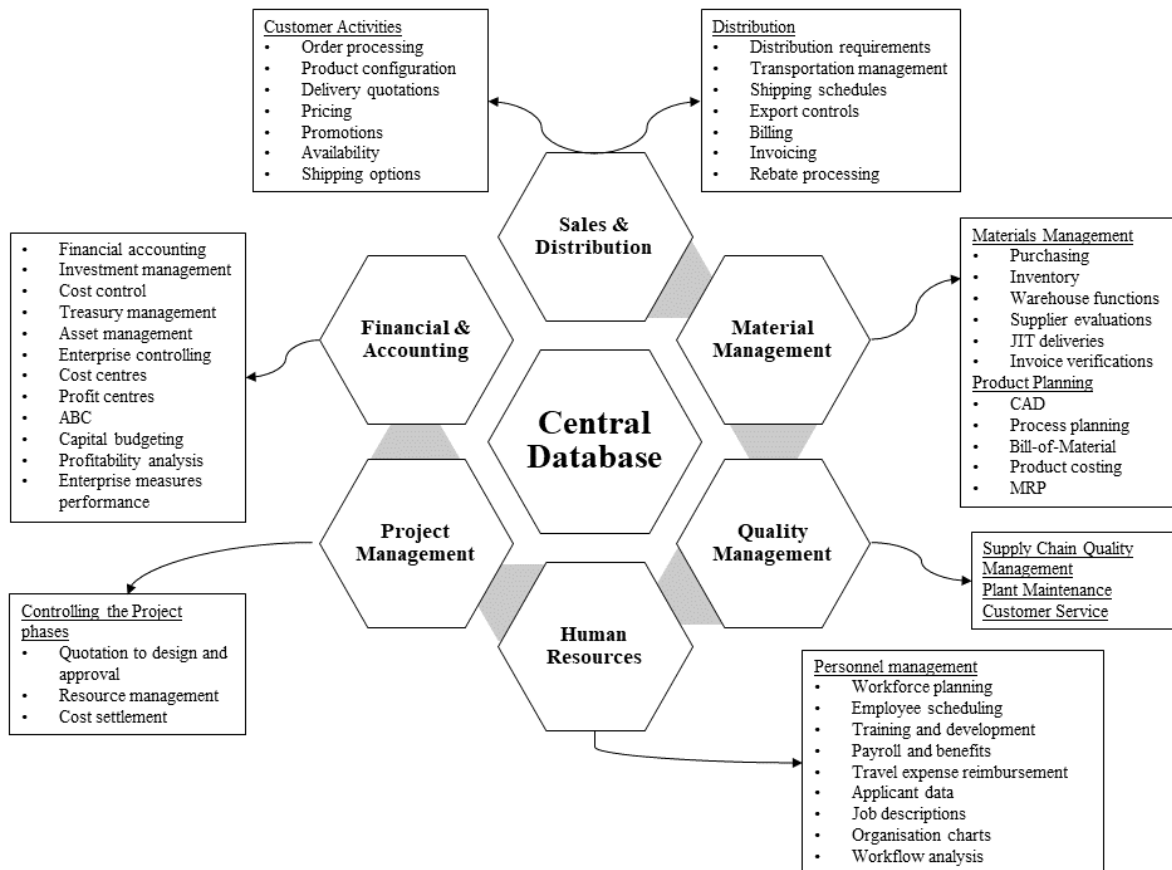
The modules allow companies to automate and integrate different operations that are carried out in different areas. This type of program is characterized by its ease of modularity, integration of processes, accuracy of information universality, ease of consultation, standardization, and interfaces with other applications (Muñiz, 2007).

An ERP can be composed of a certain number of modules that can be classified into three types:

- I.** Basic or elementary modules: they are usually those that must be purchased unavoidably because they are necessary for the ERP and the rest of the modules that can be added to work.
- II.** Additional or optional modules: these are the ones that are selected because there are specific needs in the company and are complemented by the basic modules.
- III.** Custom-made modules: these are those specifically designed to meet the needs of a specific company or for a specific sector.

Each module normally deals with a function. Therefore, there will be different modules, such as financial asset management, engineering data control, project management, works documentation, production management, procurement, quality management, sales, and distribution (logistics), maintenance management, human resource management, customer relationship management, etc. Said modules generally serve to a function or department of an organization, considering that “a typical system integrates all these functions by allowing its modules to share and transfer information by freely centralizing information in a single database accessible by all modules” (Chen 2001, cited by Shebab et al, 2004). Shebab et. al (2004) produced an overview of the most popular functions within each module displayed in Figure 3, without forgetting that each ERP vendor may assign a different name for a module or function or including more modules than the ones mentioned.

ERPs can also offer different packages for different industries. These packages are intended to provide solutions only for specific industries such as gas, process industry, automobile, steel, textile industry, finance, cement, banking, etc. (Ganesh et. al, 2014). In all these packages, the operational modules are responsible of a single function. However, they can be integrated later depending on the extent of implementation.



**Figure 3:** ERP general system modules

The specific functions of the Sales Department go beyond achieving the sale of a product or service, as it assumes roles of planning, execution and control of activities for the best performance of the area. The sales department is a specialized area within a company that is responsible for carrying out activities and processes for the fulfillment of commercial objectives. Its main function is to participate in a variety of activities with the aim of promoting the purchase of a product by the customer or the participation of the same in some service that the organization offers. The sales department must develop and implement a protocol to sell a product or service that is suitable for the industry or sector and connect it to people who might be interested and convert them into customers. It is also responsible for setting the pace of production, deciding the type of advertising together with the marketing team, as well as discounts and other types of promotions that motivate the target audience to obtain the product or service.



The Distribution module consists of controlling by means of a specific strategy the choice of the means of transport to be used and the programming of the movements to be used. This allows the implementation of tasks specific to the logistics sector that respond to different phases such as planification, provisioning, production, distribution and customer service. That is, transport management ensures the solidity and efficiency of flows, whether in distribution networks, warehouses or any other element or agent that influences transport processes. To carry out an optimal management of transport and logistics we must consider many factors within a company number of processes, people and departments that are involved, supply and demand predictions, what kind of supply chain we want to form, most suitable location for warehouses, predict unforeseen events that may arise and look for solutions in advance, among others. In short, what is sought is to integrate the different processes of all the departments of the company so that the product or service is in its correct form and in the optimal time.

The Human Resources department has been a department that has been erroneously linked to the payment of payroll and their management as the only task. However, it is a department that has undergone a transformation towards greater professionalization. The Human Resources module in a company is a key piece for the achievement of the strategic objectives of the organization This module is a support for those working in this area who focus on improving and helping the development and retention of the human talent that makes up the company and that can mean the success or failure of it. One of the functions found in this module is the personnel planning which is carried out according to the needs of the company preparing the staff templates, anticipating the possible needs in the medium and long term. The functions and responsibilities of the workers are also defined.

The Finance and Accounting department is that functional area of the company that deals with the management of finances. It is responsible for managing and controlling the capital of the company with the aim of achieving the most efficient use possible. It is, therefore, a fundamental module within the company because its growth and even its economic viability depend on its proper functioning.

Basically, the Finance and Accounting module deals with two main tasks: deciding the investments that the company needs for its activity and looking for the sources with which to finance them. But they are not the only ones; a financial department is also responsible for preparing the budget, recording accounting processes, investment management, control and planning, treasury, among others. All these functions are aimed at achieving a more efficient company, which minimizes its costs and risks, and maximizes its profits and the value of its shares.

An organization's Quality Policy does not work or implement on its own. In reality, it is the result of a set of coordinated efforts aimed at a specific purpose, which in this case is the continuous improvement of processes. The Quality Department is that area that is responsible for ensuring compliance with the policy of the companies in this field. That is, it verifies that the objectives that have been set in the previous stages are met within the planned deadlines and with the resources that have been allocated. The Quality module is fundamental to the supervision and operation of an organization's Quality Management. The correct application of the Quality Policy drawn up by the management and the alignment of resources implemented by the human capital involved in the process depends on it.

Project Management is a series of theoretical and practical perspectives that are applied to manage, design and guide efforts within a corporate, civil, technological and any other type of project from beginning to end. This methodical approach is oriented in the estimation, management and fulfillment of the specific, measurable, achievable and realistic objectives for the accomplishment of tasks within an organization. The objectives of this module are clear: to manage the start-up and evolution of projects; manage and resolve problems that may arise during the process; and facilitate the tasks of completion and approval of the project.

Since the use of ERP systems first appeared to improve the performance of manufacturing companies, one of the most wide-ranging modules is the one regarding to Material Management. Ganesh et. al (2014) make emphasis that the

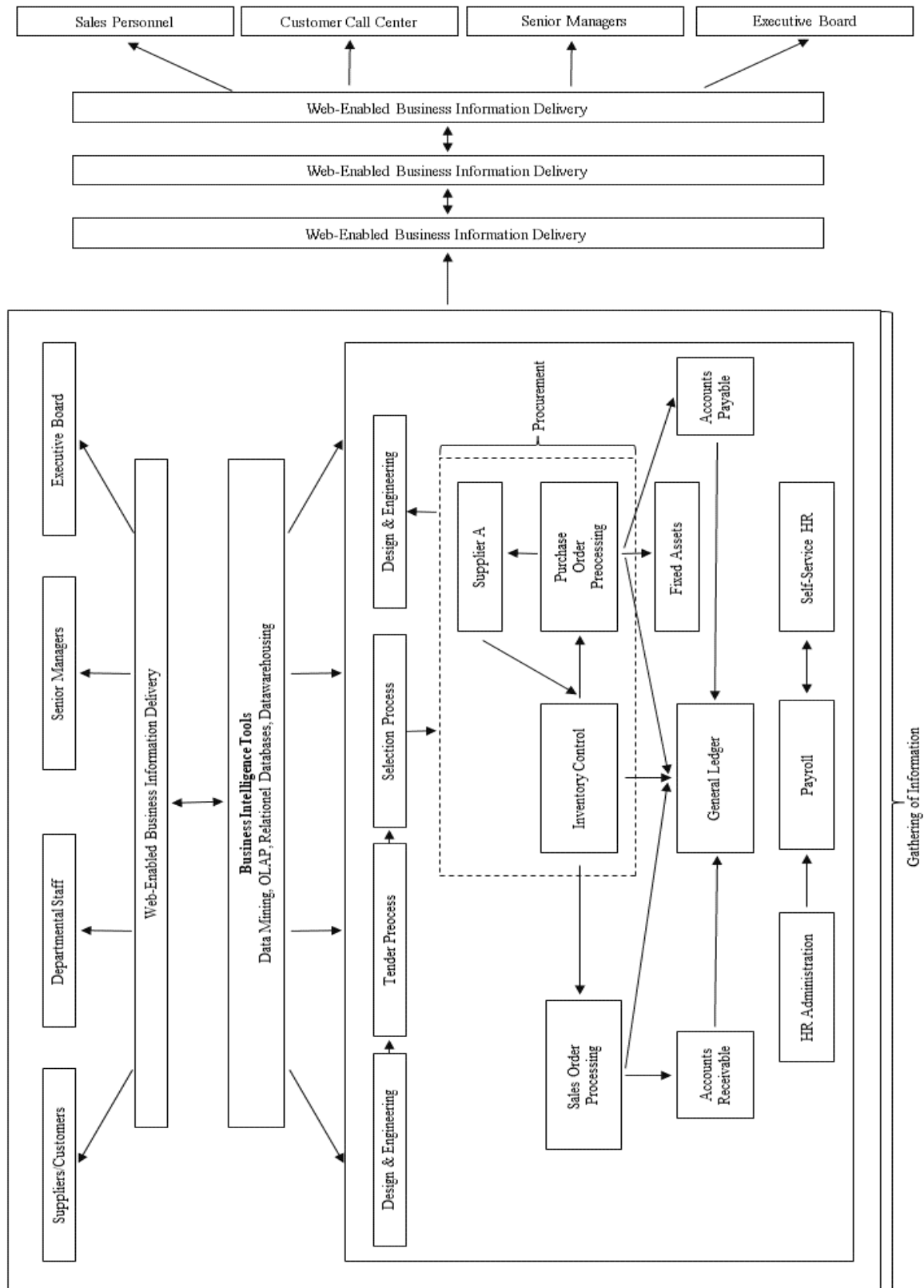


Figure 4: ERP Master Process Flow

automation on the business processes in the module ensures that inventory management and procurement (purchasing) have smooth and continuous information flow in each direction, roles and responsibilities assigned to processes, and that every business transaction receives a proper authorization before going forward.

It is known that for the proper functioning of the ERP modules must be interconnected. Therefore, the integration of Material Management module with the Finance and Accounting module is necessary since it allows data transferring for cost accounting that takes place after a purchase order is allocated. “For a purchase order, a cost center would require materials and services for procuring and so the cost of procurement needs to be assigned to the cost center” (Ganesh et. al, 2014). The link with the Finance and Accounting module also allows the procurement to retrieve a vendor master list that contains information about previously selected vendors and its associated creditor account in accounting modules, to which the costs will be charged during a purchasing operation (Ganesh et. al, 2014). As it is possible to see, the linkage between and inside modules contributes to the information flow, facilitating the visibility and maintenance of each business transaction.

The first thought that comes to mind by hearing Process flow is a process flow diagram that consists of a series of steps that a company goes through to achieve a goal, that helps the company to uncover redundancies, repetitive tasks, or bottlenecks, and can be observed in schedules or workflow diagrams. On the contrary, it refers to the flow of information between the different modules that make up an ERP (Marnewick and Labuschagne, 2005). Figure 4 represents how the information flows across the ERP system “jumping” from one module to the other, i.e., the master process flow.

### **1.3. Vendors**

The term ERP vendor is a generic term to refer to those partners who can implement an ERP system in a company. There are more vendors than ERP systems. Some are more specialized in one business size or another, others in a type of sector or even only act in certain territories. Despite having so many, there are some suppliers that have managed to expand and have taken a good share of the market.

The word vendor is used to refer to any company that can implement a system. However, suppliers are divided into manufacturers and implementers. An ERP software manufacturer is an organization that has created a system from 0. Manufacturers implement their own ERP solutions and/or have a network of distributors. That network of distributors are the implementers. Implementers perform ERP installation and configuration, although the software is not theirs. A manufacturer can use this strategy to reach territories or companies where it does not normally reach. Something distinctive about implementers is that they can be a partner of one or more manufacturers. Thus, it can offer different solutions and has the advantage of being able to choose one or the other according to the needs and budget of the client. However, there are exceptions where software vendors implement third-party software (which they lack).

The developments that implementers make on a software are usually small add-ons, customizations and modules. These developments do not make them manufacturers, since they take advantage of the code of an existing one to expand their functionalities. These developments provide a great competitive advantage to the supplier over others. This advantage is due to the fact that they are specialized developments in certain sectors, such as food or fashion. These suppliers are therefore more attractive to companies in these sectors. However, it is important to know if the supplier's development is certified by the manufacturer or not. If you do not run the risk that it will stop working after an update.

Some implementers become partners of the ERP labels that serve as a quality certificate in front of potential client companies. Not all implementers manage to be Silver, Gold or Platinum partners, but they have to meet a series of requirements for the manufacturer to grant them the title. Once achieved, implementers can put that certification on their website and documents. However, there are suppliers who may have the same level of quality but have not asked for certification.

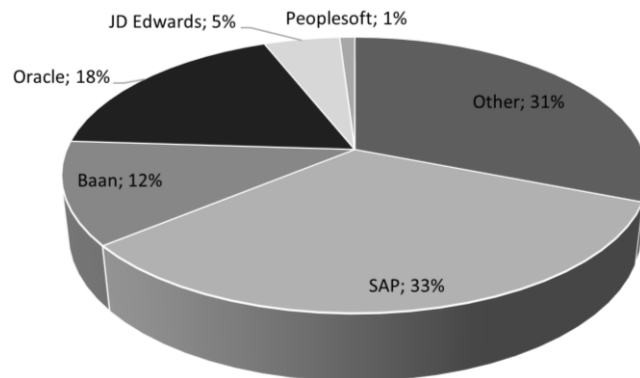
By the year 2000 there were already more than 100 ERP vendors worldwide. Out of those, there are five that were considered the “Big Five” of ERP vendors, SAP-AG, JD Edwards, Oracle, Baan, and PeopleSoft, with a combined market share of approximately 70% (Figure 5 a) (Shebab et al., 2004). Said dominance by the Big Five has decreased with the years because some companies merged with other vendors and the creation of new ERP systems did not have to start from scratch, to which the technological evolution contributed to its fast growth (compared to those ERP developed in the early nineties), and some new companies had previous knowledge related to data science, and that resulted in a change in market share (Figure 5 b) (Davidson, 2022).

### **1.3.1. SAP**

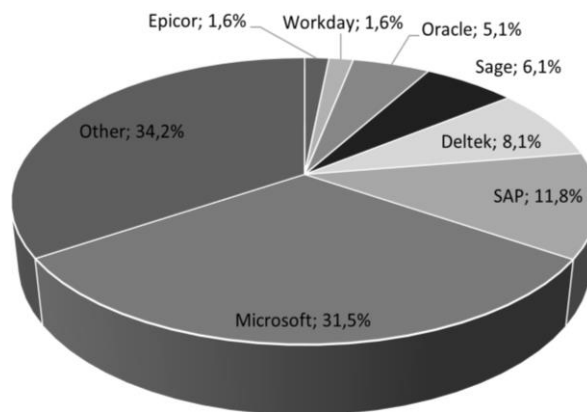
SAP SE is a European multinational for the production of management software, one of the leading companies in the world in the field of ERP and in general in IT solutions for companies. The acronym SAP means "Systeme, Anwendungen, Produkte in der Datenverarbeitung" (Systems, Applications and Products in Data Processing). SAP in fact is much more than a common management system, it is part of the ERP software, an acronym that stands for "Enterprise Resource Planning". We are talking about a program that can manage virtually all company resources and plan activities. SAP is mainly used by multinationals and large companies.

The first concept that must pass is that SAP allows an organization to carry out practically everything in the company: from purchases to orders, from accounting to budgeting, from production planning to strategic data analysis (we

will talk in this case about Business Intelligence). So, it is impossible for anyone to know perfectly the complete "operation" of SAP.



a. 2000s ERP market share



b. 2020s ERP market share

**Figure 5:** ERP market share comparison

SAP is a modular software: it means that it is built on modules, i.e., macro-areas that are completely disjointed but at the same time 100% integrated with each other. This means that each "user" of SAP (called user) works only on certain modules and is specialized only in certain areas. There is no such thing as the "all-rounder". There are about 15 SAP modules, among which the main ones are FI (Finance module or Finance / Accounting), CO (Controlling module or Management Control), MM (Material Management module or management of materials / purchases), SD module (Sales Distribution or sales management); PP module (Production Planning); QM module (Quality Management) etc.

SAP is the world's largest software business company in the areas of CRM, ERP and SCM, and the third largest as an independent software vendor (as of 2007). It operates in: Europe, the Middle East, Africa, the United States, Canada, Latin America, the Caribbean, Asia and Japan. In addition, SAP operates a network of 115 subsidiaries, and in R&D (Research and Development) with facilities worldwide: Germany, India, United States, Canada, France, Brazil, Turkey, China, Hungary, Israel, Ireland, and Bulgaria.

SAP focuses on six industry sectors: Process Industries, Discrete Industries, Consumer Industries, Service Companies, Financial Services, and Utilities offers more than 25 portfolios of industry solutions for large enterprises and more than 550 vertical solutions for small and medium-sized businesses.

### **1.3.2. Oracle**

Oracle Corporation is a multinational computer company, headquartered in Austin, Texas. The company sells software and technology for databases, cloud engineering systems, and enterprise software products, especially its own brands of database management systems. In 2019, Oracle was the second largest software company by revenue and market capitalization. The company develops and builds tools for database development, hardware, enterprise resource management software (ERP), customer relationship management (CRM) and supply chain management (SCM) and human capital management software (HCM).

It was founded in 1977 under the name "Software Development Laboratories" and later changed to "Relational Software, Inc" in 1979. A new name change took place in 1982 with the adoption of "Oracle Systems Corporation" replaced, in 1995, by the current company name. Part of Oracle Corporation's first success came from using the C programming language to implement its products. This has facilitated porting to several operating systems, most of which support C.

The company, initially active in the database sector, has over time expanded its range of action through a prolonged policy of acquisitions that has led it over



time to become the second largest software manufacturer in the world (software house) by turnover.

Oracle designs, manufactures, and sells software and hardware products, as well as offering services that complement them (such as financing, training, consulting, and hosting services). Oracle heavily relied on acquiring many of the products that could be found on its portfolio. Oracle's Electronic Delivery Service (Oracle Software Delivery Cloud) provides generic downloadable Oracle software and documentation.

Oracle also sells a suite of business applications. The Oracle E-Business Suite includes software to perform various business functions related to (for example) financial data, manufacturing, customer relationship management (CRM), enterprise resource planning (ERP), and human resource management. Oracle Retail Suite covers the vertical sector of the retail industry, providing merchandise management, pricing, invoice matching, allocations, store operations management, warehouse management, demand forecasting, merchandise financial planning, assortment planning, and category management. Users can access these facilities through a browser interface on the Internet or through a corporate intranet.

### **1.3.3. JD Edwards**

JD Edwards World Solution Company or simply JD Edwards, also called JDE, was a software company founded in March 1977 in Denver (Colorado) by Jack Thompson, Dan Gregory and Ed McVaney. The company began its activity by producing accounting software for IBM minicomputers, working with the System/34 and /36, focusing from the mid-80s on system/38 minicomputers and then moving on to THE AS/400 after their introduction on the market.

The company's first customers dealt with the wholesale distribution of machine tools, so they needed to integrate the accounting system with a software that also took care of logistics and deliveries (Distribution). With the entry of the Colorado Highway Department in the customer portfolio, costing was developed

and thanks to the Shell Oil Company, a multinational company, the multi-currency system.

The size of the client companies, consisting almost entirely of medium-sized companies, has led to the implementation of new IT management modules integrated with the previous ones: from general accounting (integrated with all additional modules) to personnel costs, from inventory management to production management and MRP systems.

The main product offered on the AS/400 platform was the JD Edwards World Software which quickly reached a worldwide diffusion. In 1996, the company launched the first client-server system, called OneWorld, with its own interface and a new operating model. Starting in 2001, again for the first time, a web-based version was introduced, in which the user accesses the JDE software through a browser.

On September 24, 1997, the company listed NASDAQ under the symbol JDEC. In 1998 McVaney decided to retire, but then returned to the head of the company to personally follow the solution of the youth problems encountered by the client-server version, and finally retire permanently in January 2002. In June 2003, the board of directors accepted the purchase offer made by PeopleSoft, also active in the ERP market, which took shape in July of the same year. Subsequently, PeopleSoft, after a first offer at the end of 2003 considered hostile, was purchased by Oracle in 2005.

#### **1.3.4. Peoplesoft**

Peoplesoft Inc. was a software company active in the field of business management. Among its products were: Human resource management system (HRMS), Financial Management Solutions (FMS), Supply Chain Management (SCM) and Customer relationship management (CRM), Enterprise Performance Management (EPM), but also IT solutions for the management of production and business performance.

The software produced by People Soft Inc. is still used by Wind Tre for the management of ex-H3G customers. In 2003, he completed a merger by incorporation of JD Edwards, also active in the Enterprise Resource Planning (ERP) market.

Beginning in 2003, the company was the subject of an attempted acquisition of Oracle Corporation, considered hostile by the company's board, which offered \$13 billion. A new offer, down to \$9.4 billion, was rejected by the company's board in February 2004. During the same, the American Court and the European Commission ruled on the acquisition as lawful and not in violation of their respective antitrust laws. 2004 saw Oracle's offer rise to \$7.7 billion and then rise back to the previous one of \$9.4 billion. In December of the same year, Oracle announced the signing of a definitive agreement to acquire the company at a price of approximately \$10.3 billion.

The period following the acquisition saw the company's workforce shrink by half, repositioning products under the JD Edwards brand. Under Oracle, Peoplesoft offers different cloud-based software products, including Human Capital Management (HCM), Campus Solutions, Procurement and Supplier Management, Financial Management, and PeopleTools and Technology.

In 2010, In-Memory Project Discovery was marketed by Peoplesoft to be a software that allowed users to filter keywords and data, that was previously unstructured, on the Services Automation suite. The program could run thanks to Oracle's Exalytics in-memory machine and Oracle Endeca Information Discovery enterprise data platform.

All these developments led to Oracle Peoplesoft ERP to be able to run on most operating systems such as Linux, Windows, IBM and UNIX environments by 2015. As mentioned before, Peoplesoft could be used only for the Human Resources modules, this was the case for the Department of Foreign Affairs and Trade (DFAT) when it contracted Peoplesoft for its Enterprise Human Resource

platform in 2019 with the goal of improving several activities such as security, manager and employee self-service tools, and tracking employees' labor-hours.

### **1.3.5. Baan**

Baan was a manufacturer of enterprise resource planning (ERP) software that is now owned by Infor Global Solutions, also known as Baan ERP on its beginning phases. The company was created by Jan Baan in 1978 in Barneveld, the Netherlands, to provide administrative and financial advisory services.

When Gartner drew attention to the ERP phenomenon in the second half of the nineties, interest in the German SAP and the American companies Oracle and Peoplesoft steadily increased. After contracting customer Boeing, the interest in the Dutch Baan took such forms that the IT sector introduced the abbreviation BOPS to indicate the most important ERP suppliers where the B stood for Baan, O for Oracle, P for Peoplesoft and the S for SAP.

Baan's listing developed in an incredible way towards the year 2000: Baan's market value became larger than KLM's. However, the sales figures turned out to have been artificially increased by accounting tricks and this ultimately became fatal for the image of the company. On October 17, 2007, however, a lawsuit ruled that no accounting rules had been violated. Baan did not recover from the dramatic price drop and was sold in 2000 to the British Invensys and three years later to the American ERP supplier SSA, which later merged into Infor (a collection of ERP suppliers from all over the world).

In 2005 Jan Baan published the book *De weg naar marktleiderschap* (My life as an entrepreneur), in which he sketches the history of the company up to and including the creation of Cordys. At the beginning of 2001, two editors of *Het Financieele Dagblad*, Mark Houben and Jeroen Wester, also wrote a book about the history of Baan under the title *Baan, rise and fall of a software company*. The two books deal with the same history but show remarkable differences.

### **1.3.6. Microsoft Dynamics 365**

Microsoft Dynamics 365 is a set of business applications, which integrates numerous ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) functionalities, allowing to transform the automation of business processes and employee productivity. Thanks to Dynamics 365, there is a very wide range of services to manage customer relationships optimally and at all levels. In addition, you can plan and manage the resources available in any area of activity, from finance to customer service or commercial service.

## Chapter 2

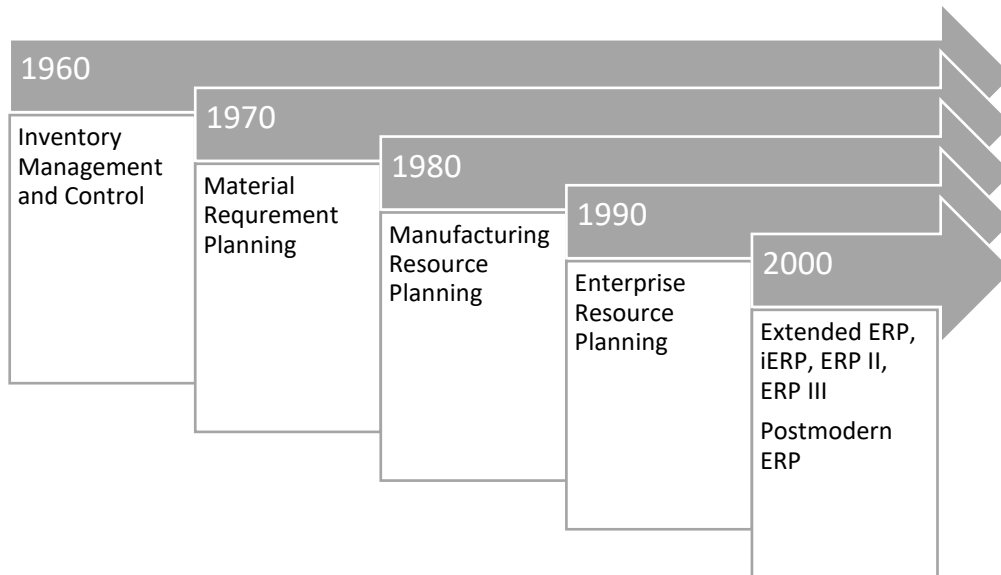
# Development of ERP systems

In order to completely understand the current condition of ERP systems, it is important to transport us to the early 20<sup>th</sup> century when Fordism was expanding throughout the manufacturing industry in the United States. The evolution of ERP systems it is tightly connected to the development of new technologies. It is also impossible to talk about an ERP software without mentioning the computer hardware that was the protagonist in the late 20<sup>th</sup> century (Thompson, 2020).

Said evolution can be broken down into six key stages: inventory management and control, material requirement planning, manufacturing resource planning, enterprise resource planning, extended ERP, and postmodern ERP (Figure 6). Each phase almost elapses with every decade, starting from the 1960s. However, to reach that point some events had to occur.

The first step dates back to 1915 when the Ford Motor Company was at its peak, the introduction of the Model T had been a success, and Ford, considered the

father of mass production, introduced mobile assembly lines in its plants. The production model by default was by batches and is in this moment when Ford W. Harris along with K. Andler introduced the Economic Order Quantity model (EOQ) where the bases are established to integrate inventory along with other costs when determining the size of the batches to be produced or purchased (Delgado & Marín, 2000).



**Figure 6:** Concise ERP timeline

By 1934, R.H. Wilson took Harris’ approach to design an inventory replenishment system through order point (ROP), where the concept of replenishment period is used to incorporate the variable "time" to materials management (Delgado & Marín, 2000). Said “point” refers to the moment when the company must order a new purchase of stock from its suppliers to avoid falling into a stock break. When organizing the supply of stock of the warehouse, it is necessary to answer two fundamental questions: when to place a new order? How much to order from each product? The answers vary depending on the stock management model the company applies.

World wars are events that propel innovation to make the job easier for those that fight on the trenches and risk their lives non-stop on the battlefield. That is why by 1940, mathematical programming techniques were developed amidst WWII to

facilitate the resolution of larger problems around production planning with the aim of supporting the management of material resources demanded by the army (the first steps to what later would become Operations Research) (Delgado & Marín, 2000; Benvenuto, 2006)

Following that path, The U.S. War Production Board issued on 1943 instructions on Bill of Materials for the Controlled Materials Plan designed to oversee the BOM on major repetitive products like airplanes, tanks and guns (U.S. War Production Board, 1943). A BOM is the list of all components, subassemblies, semi-finished products and raw materials necessary to make a product along with its required quantity. It is organized hierarchically, and is represented as a tree, with the shape similar to a family tree, with the finished product in the head, and to descend in the various levels are the subassemblies, semi-finished products and raw materials. By convention, the top of the tree, i.e., the finished product, is at zero level. Its direct components are at level one, and so on.

The development of ERP has as protagonist of its next step a teashop on the UK. Lyons Teashop implemented a system, on the early computers, to keep track of materials (ingredients) required, the daily orders made by customers and plan the distribution of goods (Katu, 2020).

The 1950s saw the introduction of computers to universities. It is almost a transition period that witnessed the creation of the Society for Help to Avoid Redundant Effort (SHARE) in 1955 with the objective to share knowledge to avoid redundant work as much as possible, and the most important event, the development of an application that can be considered the first approximation to what later became known as Material requirement Planning (MRP) by Bosh (Andonegi et al, 2005).

## **2.1. Inventory Management and Control**

The 1960s are the turning point to what concerns not only technology development, but also for management and industrial engineering. During this decade numerous companies were founded dedicated to software development which also



incentivized the creation of the first utility libraries, in which companies could get certain applications for free. This innovation evolved to a place where the concept of software as a product begun to be considered commercially viable and led to the creation of the first software catalogue with 49 applications on 1967 (Andonegi et al, 2005).

From the management perspective, the practices used through the 1960s were based on the traditional models of order point (ROP previously described) and economic purchase lot. In consequence, the first computer applications were oriented to inventory management (Andonegi et al, 2005). Concurrently, manufacturing companies sought to manage and rationalize their inventories and plan the use of resources according to the real demand for their products with what would be known as Inventory Control systems (Benvenuto, 2006). All these systems were based on programming languages like ALGOL, FORTRAN and COBOL (Katuu, 2020).

On 1964 the Toyota Manufacturing Program (TPS) was revolutionizing the way manufacturing companies behaved and it became the pioneer of lean manufacturing. Its methodology born from the need to long-run material planning. As a response to the TPS, Jhoseph A. Orlicky developed the basis of a Material Requirement Planning (Kemp, 2018) and Dick Alban took this approach to manufacturing and led Black & Decker to be the first company to implement a MRP like system (Foreplanner, 2017; MRPeasy, 2019).

By late 1960s there where two investigative branches about how companies managed its materials management. The first one arose from the need to change the case of demand or constant consumption to discontinuous demand, i.e., a switch from the EOQ method to batch calculation methods. The second one is the Gozinto method that collects techniques for determining requirements for components that are used at different stages of the manufacturing process of a product or that are common to different finished products (Delgado & Marín, 2000).

Is in this period that manufacturing companies transition into the implementation of MRP systems. One of its first appearances occur between 1968 and 1969 with International Business Machines Corporation (IBM) and J.I. Case as protagonists, and the system expanded to very few and selected manufacturing companies. J.I. Case functioned as a company on the construction machinery industry with tractors as its main product. One of the benefits the companies realized was their new ability to reach and exceed the market needs as a result of computerizing daily business operations achieved by systematizing the schedule containing the procurement and operational processes (Thomson, 2020). As the companies could expect, this environment contributed to the development of MRPs due to its focus on the procurement operations that controlled the acquisition of raw materials, the manufacturing processes, and the transport of products to its final sellers (Belet & Purcârea, 2017).

## **2.2. Material Requirement Planning**

The 1970s start with the next step on the software market previously mentioned, when IBM began to sell software packages separately from hardware (Andonegi et al, 2005) along with the promotion of «MRP crusades» with the aim of promoting the change of materials management models in companies. One of its precursors was the American Production and Inventory Control Society (APICS) who identified the implementation of MRP systems as the main challenge for business modernization in the US (Delgado & Marin, 2000).

During this decade the MRPs witnessed its greatest contributions where its benefits, weaknesses and implementation was largely researched and applied in many companies which will be discussed in further sections. Also, 1970s overlooked the development of the first principally marketed MRP products, created by now worldwide renown companies, that evolved hand-in-hand with the growth of business practices.

On 1972 IBM introduces COPICS (Communications Oriented Production Information and Control System) as a support system for the application of MRP techniques. The module consists of an eight-volume series that outlined a methodology to achieve an integrated computer-based manufacturing control system (Delgado & Marin, 2000; Belet & Purcărea, 2017).

By 1975 Orlicky expands its previous work and publishes "MRP, The New Way of Life in Production and Inventory Management" which includes conceptual bases, trends and problems of implementation and operation of MRP systems. The author himself informally denominated the book as "MRP from A to Z" and it is what truly encouraged manufacturing companies to change its management lineaments. This publication made a revolution in the industry at such a big scale that from this moment Orlicky was considered the precursor of MRP (Andonegi et al, 2005; Delgado & Marin, 2000).

### **2.3. Manufacturing Resource Planning**

From the technology perspective, the 1980s worked around the dispute regarding the type of software to be used in MRP systems: "homemade" software, tailored to the needs of the company, as opposed to standard or "commercial" software made by specialized companies (Delgado & Marin, 2000). From the managerial side, the next step came with Oliver wight in 1983 when he introduced the concept of an information system that integrates production, stock and finances baptized as Manufacturing Resource Planning (MRP II) (Andonegi et al, 2005).

These systems did not go far from previous MRP software, i.e., it included the same modules from MRP but brought into light the integration form different departments of the company involved in the production of goods to achieve a higher level of coordination (Thomson, 2020). Said integration between departments focused on reaching a synergy between material and production requirements (Katu, 2020; Belet & Purcărea, 2017).

JD Edwards was established on 1977, one of the most recognized ERP vendors today. It was founded by Jack Thompson, Dan Gregory and Edward McVaney in Denver (Colorado) and it succeeded in creating an accounting program for IBM's System/34 and System/36 minicomputers (Ganesh et al, 2014). One of the first projects of the company was to develop a MRP II software for the IBM System/38 on the early 1980s with the goal of it being an excellent and cost-effective alternative for mainframe.

The lower cost of the software was a success thanks to IBM updating the COPICS software to a newer Cost Integrated Manufacturing (CIM) framework that offered a “comprehensive strategy to help integrate information in a consistent, effective manner across the enterprise” (Belet & Purcărea,2017). Another significant step forward in technology was when attempts around 1987 were made to have the supporting software suggest performing certain actions so that the resulting production plan would be compatible with capacity availability (Delgado & Marin, 2000).

## **2.4. Enterprise Resource Planning**

Thanks to globalization, companies began to require systems that supported business management, integrated parts of the business, promoted operational efficiency and served as support for critical aspects of administration on the early 1990s (Benvenuto, 2006). This is when the term Enterprise Resource Planning (ERP) first appeared when the Gartner Group Inc. coined the term to refer to software systems that collected the last improvements from MRP II systems (Harreld, 2001; Shebab et al, 2004; Belet & Purcărea, 2017).

The need for ERP systems was powered by the rise of relational databases and client/server architecture which propelled vendors to generate analytics and corporate intelligence features and by late nineties vendors realized the need to add more modules and functions as to the main modules moving to a phase called extended ERPs (Katuu, 2020). However, this evolution started much earlier along

with the development of new technologies and new approaches to business management practices.

On 1972 Dietmar Hopp, Hans-Werner Hector, Hasso Plattner, Klaus Tschira and Claus Wellenreuther, ex-IBM employees, founded the Applications and Products in Data Processing Company (Systemanalyse Programmentwicklung in German) to provide integrated business solutions software for the manufacturing industry (Katu, 2020; Thomson, 2020; Rashid et al, 2002).

The first steps towards a true ERP counted with IBM as protagonist when the company created the Manufacturing Management and Account System (MMAS) in 1975. The software worked because it highlighted the integration from different departments by producing entries that kept track of the business' daily operations along with forecasting informs as a result "from both inventory and production transactions and could generate manufacturing orders from customer orders using either a standard bill of material or a bill of material attached to the customer order" (Belet & Purcârea, 2017).

Between 1977 and 1978 three of the prominent ERP vendors were founded and the first ERP systems were marketed. Oracle was founded in 1977 as Software Development Laboratories, rebranded as Oracle in 1983, along with JD Edwards as previously discussed (Ganesh et al, 2014). That same year SAP introduced R/1 to the market, their first ERP system (Hasan et al, 2019). Baan is founded in The Netherlands in 1978 and it began as a direct competition to SAP since some manufacturing companies were cautious of implementing SAP's system, and because of the Baan software exceeded in their cross-functionality system involving many businesses processes (Shebab et al, 2004; Thomson, 2020). Later that year, SAP released an update for their R/1 system with R/2 with a main difference from its previous version: the interactivity between department modules, a centralized database and additional functions like order tracking (Rashid et al, 2014; Belet & Purcârea, 2017).

The next prominent ERP vendor, PeopleSoft, was founded in 1987 in Pleasanton, California. The main feature that distinguished this vendor from other was its specialization in financial services and human resource modules, being the latter a differentiating factor that made companies choose PeopleSoft over other ERP vendors for its HR module while implementing the rest of the modules from other providers (Ganesh et al, 2014; Shebab et al, 2004; Rahid et al, 2002). Later that year, Oracle's database was intertwined with the ERP applications of its software (Rashid et al, 2014).

SAP reached the peak of the ERP systems market share around 1992 with the introduction of its latest upgrade to its ERP software with R/3, a client/server architecture, being its main differentiating factor with previous versions of the ERP system, that already integrated all modules applications a company could require (human resources, financial, quality control, manufacturing, logistics and distribution) (Shebab et al, 2004; Belet & Purcărea, 2017; Abdullah, 2017; Thomson, 2020). Realizing the success of SAP for its interdisciplinary, that same year PeopleSoft started to market other software functions besides its successful human resources system and so, it could realize a revenue of \$32 million dollars (Shebab et al, 2004).

By mid-nineties, the biggest car manufacturing multinationals like BMW, Boeing, Ford and Mercedes-Benz, which count with a large experience in industrial engineering and operations, led the transformation of business practices by adopting ERP systems, and so incentivized the worldwide adoption of SAP or Baan software (Kumar & van Hillegersberg, 2000). Said adoption led to SAP to obtain a workforce of over 20,000 employees worldwide attaining a revenue of \$3,1 billion dollars (Shebab et al, 2004). JD Edwards did not want to be left out of the picture, so it dedicated its efforts to improve its accountability software, which was called OneWorld, that included major changes like moving from its previous server-centric model towards a user-friendly interface emphasizing in a distributed computed model (Ganesh et al, 2014; Wu et al, 2009).

It was in 1998 that Baan truly managed to market the BaanERP system with the idea that the internet would help them to reach new levels after improving from their previous products Triton and Baan IV (Rashid et al, 2002; Thomson, 2020). By that year, the annual growth of the ERP systems market was high reaching peaks of 50% and minimums of 30% with an approximately spending of \$17 billion dollars, which included in its majority implementation and maintenance costs (Rashid et al, 2002).

The new millennia brought uncertainty towards the ERP market, even if such opinions were mostly unfounded. Several publications on reliable journals anticipated the demise ERP systems sales as a cause of some problems related to its functioning (implementation complexity) and it caused such a ruckus that some companies were considering whether to implement or not ERP systems for their business (Kumar & van Hillegersberg, 2000). However, this situation did not stop the expansion of the ERP market, which by 1999 held a value of \$19 billion dollars, an increase of \$2 billion respect to the previous year, with the main companies thriving: SAP was the largest ERP vendor with presence on over 100 countries, more than 17,000 customers and controlling 36% of the market; Oracle managed 27% of the market with accounts in 140 countries and valued at \$9,3 billion dollars; and JD Edwards' revenue was of \$944 million dollars, an increase of \$824 million respect to 1992 (Rashid et al, 2002).

## **2.5. Extended ERP: iERP, ERP II, ERP III**

The previous doubts about the future of ERPs systems with the change of century proved to be baseless. SAP-AG, Oracle, JD Edwards, PeopleSoft and Baan, known as the Big Five of ERP vendors, controlled approximately 70% of the ERP market share by 2000, with its newest addition, Baan, already working in 5,000 sites worldwide with 3,000 plus clients (Shebab et al, 2004). The uncertainty about the future was nothing but far from reality, the ERP systems market value increased a 13,1% respect to the previous year reaching a value of \$21,5 billion dollars (Rashid et al, 2002).

The 2000s' ERP technology improvement circled around two main changes. The first one involves the architecture of the systems, moving from a monolithic architecture to a software with a three-tier architecture: the presentation tier that works as the user interface, the middle application tier where data is processed, and a back database tier where data is collected and stored. The second change came with the introduction of cloud-based storage by mid 2000s with the belief that it would be beneficial to step away from on-ground ERPs (Katu, 2020).

The introduction of the term ERP II was proposed by The Gartner Group in 2000 highlighting two new ways of managing the ERP systems: business coordination and industry orientation, without putting aside the need for systems to expand in order to serve the market needs required by each industry or sector (Wu et al, 2009). This is what will be known as iERP, a modification to the general-purpose ERP with the aim of designing a software for a particular industry sector that can target specific requirements that otherwise would be look over with generic ERP systems (Wu et al, 2009).

All these improvements led ERP to be the price of entry for new companies in 2001 and, in particular, in the creation of business-to-business e-commerce (Marnewick & Labuschagne, 2005). That same year, T.F. Wallace & M.H. Kremzar designed guidelines focused on one of the phases that gives the most problems of ERP, implementation. These guidelines' goal was to implement different functions like planning, scheduling, and forecasting, to estimate and equilibrate demand and supply, with the connection with suppliers and customers in mind, by following a decision-making process to manage business processes (Chofreh et al, 2019). All these factors propelled the implementation of ERP systems worldwide to a level where over 60% of the Fortune 1000 companies had just implemented or were in the process of implementing an ERP system (Rashid et al, 2002).

The first half of the decade also witnessed progress among ERP vendors. In 2001 Oracle's web store, FastForward, worked as a catalogue of applications that could be linked to the company's ERP system and involved the transaction



processes (Rashid et al, 2002). SAP acquired an Israeli portal in 2003 called NetWeaver that worked as an independent user-oriented architecture platform that could connect with other applications. That same year JD Edwards accepts the merge offer made by PeopleSoft, that was later purchased by Oracle in 2005 (Ganesh et al, 2014).

The ERP environment in late 2000s orbited around the latest features or approaches that could be intertwined with the management side of ERP, not so much from a technological point of view. Lida Xu, Chengen Wang, Xiaochuan Luo and Zhongzhi Shi realized that Knowledge Management (KM) could very well function concurrently with ERP systems, giving way to the concept of ERP III in 2006 (Wu et al, 2009). This method focused on the need to embed the organization with the know-how of employees and translate it into the ERP applications to develop a learning culture with a service-oriented architecture.

By 2009 most ERP systems counted with many functionalities, all of them added progressively as in the likes of Product Lifecycle Management, Supplier Relationship Management, Supply Chain Management, Data Warehouse, Customer Relationship Management, Business Intelligence, Knowledge Management System, Balanced Scorecard, Point of Sale Terminal, among others (Oltra et al, 2011). Lida Xu went a step ahead and introduced Entire Resource Planning or Complete Resource Planning, the subsequent generation information system for companies, where its methodology recollects the functions of ERP, ERP II and ERP III, integrating them in various industrial areas in a cohesive way to incorporate the resource management (resources used and produced) without letting aside the socioeconomic development (Wu et al, 2009).

## **2.6. Postmodern ERP**

iERP systems were mentioned before to show the relevance of adapting an ERP system to the demands of a specific industry. This is evident in the early 2010s where generic ERP systems were progressively advertised to certain market

segments like hospitals, law offices, refineries and automotive assembly, markets with niche products and suppliers (Belet & Purcârea, 2017).

By mid 2010s The Gartner Group was once again a protagonist when it came to providing definitions. A new concept emerged to describe systems that referred to more outward facing and agile ERP systems known as Postmodern ERP, where technology played a big role with cloud storage services supporting some of its functionalities or outsourcing business processes “with levels of integration that balance the benefits of vendor-delivered integration against business flexibility and agility” (Katu, 2020). However, Gartner also foresaw that the possibility of postmodern ERP failing, and with it the cloud initiative, because of an absence of capabilities to fulfill postmodern strategies (Zerbino et al, 2021).

Then again, this never happened just like with the 2000s uncertainty. SAP can be taken as an example after reporting a turnover growth higher than expected because of its cloud applications due to Covid-19, which led to the ERP market to encounter a successful trend in 2021 (Zerbino et al, 2021).

## Chapter 3

# ERP Methodology: Implementation

When we discuss about methodology in the ERP context, we refer to a meticulous and concise approach towards the implementation of an ERP system to guarantee its correct integration through the combination of software, change management, process flow and customer mindset (Marnewick & Labuschagne, 2005). The implementation of an ERP software must ensure that it meets all the basic management requirements from the company, and, in addition, it must serve to support the current situation and the preparation of the evolution of the business.

Companies can have different dimensions, but they must all develop the same activities. At first, the implementation of ERP systems had been carried out mostly in large companies, but later it has been extended more and more to small and medium enterprises (SMEs), thanks to the launch of ERP-type programs that need fewer resources, with less astronomic prices and with shorter implementation times, technologies that support the objectives to be achieved and that allow them to react quickly and flexibly, to external constraints that affect the commercial

organization, logistics or production and in financial decision-making (Andonegi et al., 2005).

Large companies, such as multinationals, implement ERP systems as part of their strategic plan and upgrade their systems to new software and processes, using a phased approach to implementation that supports greater financial benefits. On the contrary, SMEs tactical factors influence the decision-making process that leads to a big reengineering process, a more radical implementation methodology, and produce greater benefits in the manufacturing and logistics departments (Maber et al., 2003; cited by Serrano & Hernando, 2006).

Organizations, regardless of their size and sector of activity, require the previously mentioned elements and solutions that allow them to adapt their costs, face growing competition, optimize relationships with their customers, improve their supply chain and act in a competitive way in the market, all this is characterized by a strong internationalization. In addition, since organizational needs are not constant, they change through the years, the implementation of ERP systems arrive as a solution to continue the planning areas of an organization matching de capabilities of the organization with its operational demands through a process reengineering (Hasan et al., 2019).

An important characteristic of the implementation process is the documentation. This includes the preparation of manuals specific to each company because, although the process is usually sufficiently documented, the modifications and particularities done must be written and shared conveniently among all employees. The most common distribution channel for said manuals is through the company's intranet, or through the employees' corporate emails (Delgado & Marin, 2000).

An aspect that has not been challenged through the years is the knowledge that the implementation process requires great effort to adapt the organization's business processes. This resistance is complemented with best business practices

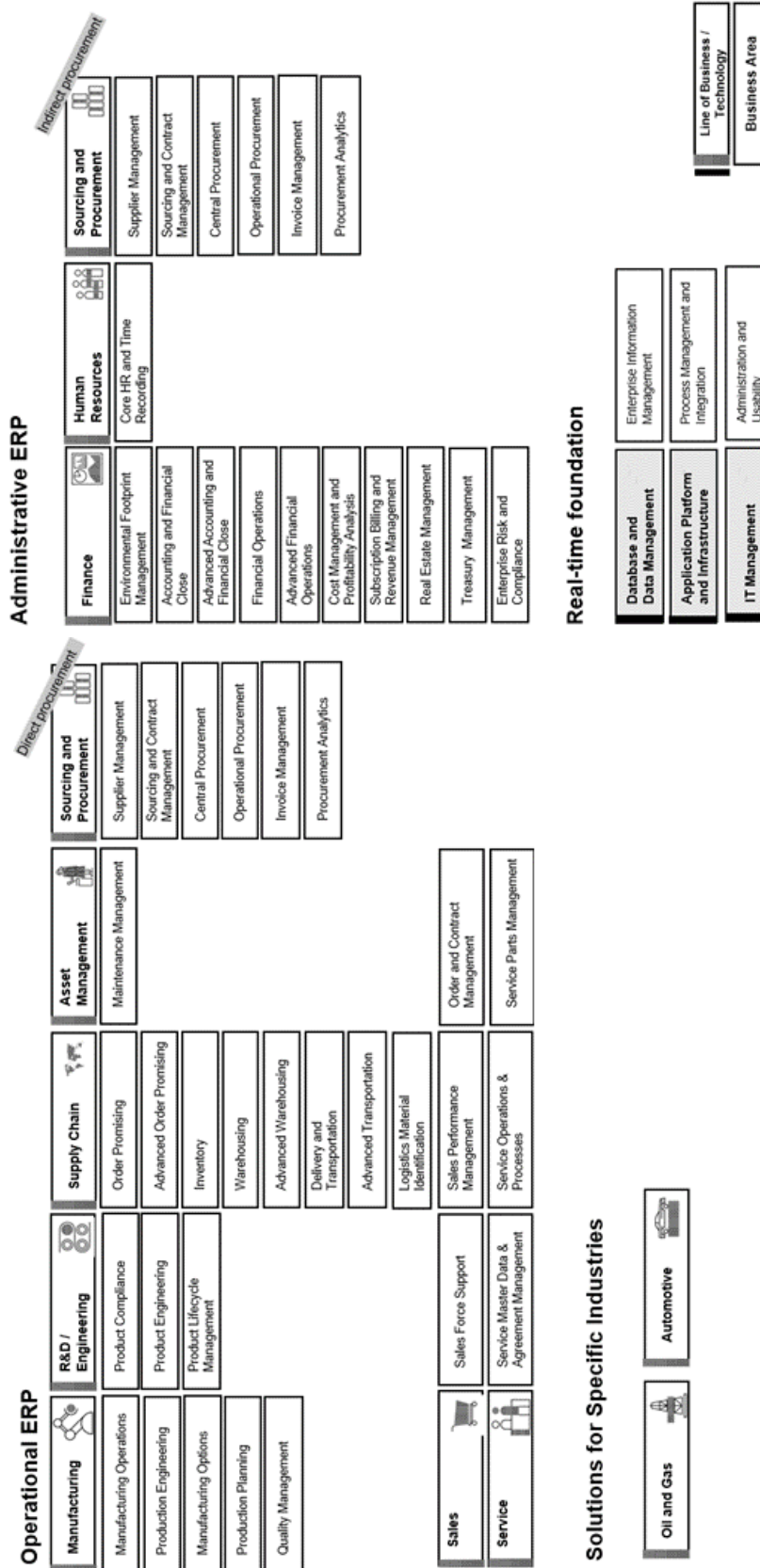
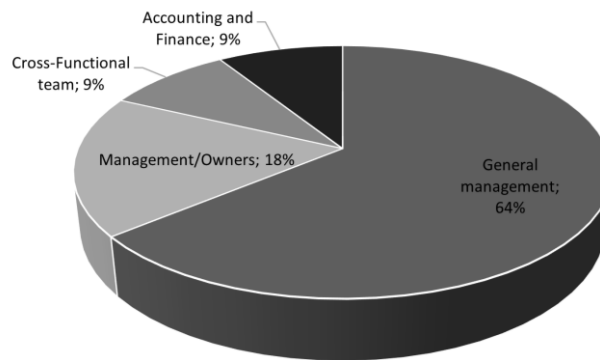


Figure 7: Best practices for SAP S/4HANA

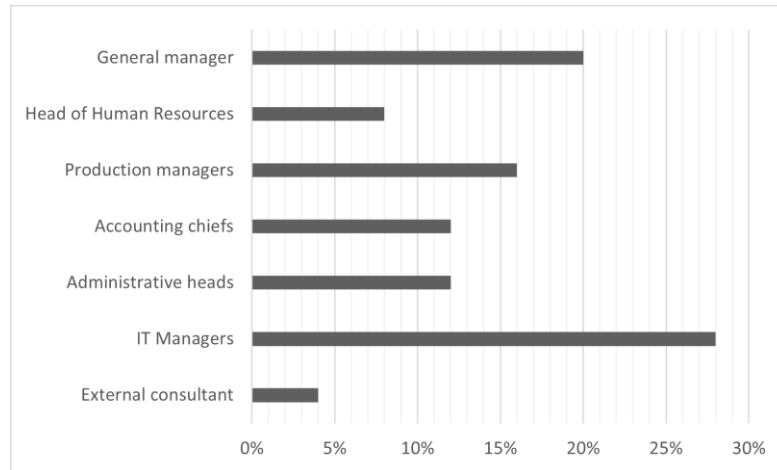
that come with the ERP “generic”, which in turn the company adapts to improve their performance (Shebab et al., 2004). One of the most prominent examples are those of SAP, a company that has had the opportunity to perfect their business practices thanks to their 50-year experience in over 150 industries, so it is very likely that SAP has already developed the best practices for almost every business model and offers them with their SAP package. Figure 7 shows the explanatory diagram for SAP S/4HANA (on premise) areas of each ERP module that the vendor includes a guide for best practices.

Benvenuto (2006) reviews a sample of eleven companies that have implemented ERP systems (out of almost ninety), where they ask who is responsible for the decision to implement an ERP system (Figure 8). The decision to implement an ERP system, in 9% of cases on the work team formed by a member of each department of the organization; 9% on the accounting or financial area of the company; 18% over the management and/or owners of the organization; and the remaining 64% falls to general management.



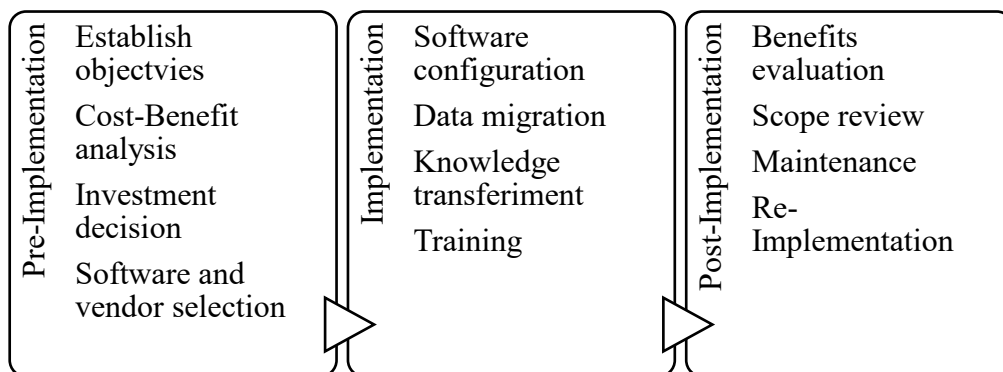
**Figure 8:** Roles affecting implementation decision-making

Once it is established who makes the decision to implement the ERP system, Benvenuto ventures to see who leads the process itself. In the results it can be seen that there are different styles in the implementation process (Figure 9). In the set of companies studied, 25 senior executives participated as leaders: 7 IT managers, 5 general managers, 4 production managers, 3 accounting chiefs, 3 administrative heads, 2 heads of human resources and 1 external consultant.



**Figure 9:** Implementation project leaders

The process of implementing an ERP is composed of three main stages: pre-implementation, implementation, and post-implementation (Figure 10). Said stages can be found on the literature with different labels, or include one or two more stages, but in general all necessary steps to carry out the implementation process can be summarized on these three stages. For example, Swanson & Ramiller (2004) observe the ERP life cycle consists of adoption, implementation and post-implementation (Hasan et al., 2019); Rajagopal (2002) and Zmud (1987) propose a six-phase model with initiation, adoption, adaptation, acceptance, routinization, and infusion stages (Serrano & Hernando, 2006); Mahendrawathi et al. (2017) define stages as scope and commitment, analysis and design, acquisition and development, implementation and operation; and Chofreh et al. (2019) propose a five-phase approach to implementing sustainable ERPs across strategic, tactical, and operational levels (Table 1).



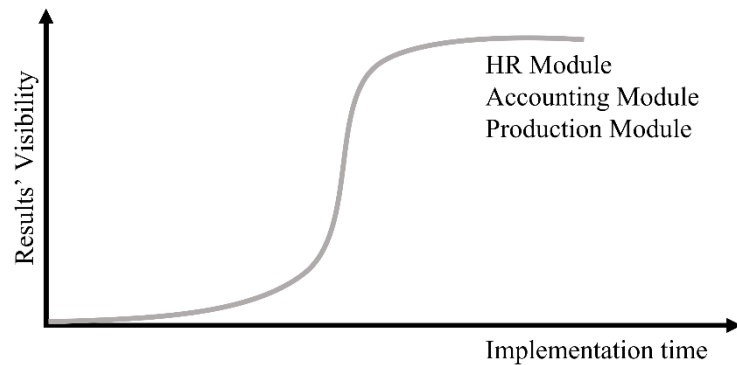
**Figure 10:** Brief ERP implementation process

<b>LEVELS</b>	<b>OPERATIONAL</b>	<b>TACTICAL</b>	<b>STRATEGIC</b>
<b>INITIATION</b>	Design project charter	Identify business requirements Identify stakeholders Analyze required resources Software and hardware selection Vendors selection System integration preparation Analyze requirements of project documentation	Strategic inputs
<b>PLAN</b>	Design system implementation activities	Design requirements change management process plan Plan stakeholders' involvement Resources acquisition plan Design a plan to get the required software and hardware Design system integration plan	Formulate strategies Select appropriate strategies
<b>EXECUTION</b>	Implement the system	Implement change management Manage stakeholder involvement Acquire resources Vendors selection Select required software and hardware Execute system integration process Provide documentation	Involve in the strategic alignment process
<b>MONITORING AND CONTROLLING</b>	Monitor and control system implementation	Review and evaluate system implementation	Review and evaluate performance
<b>CLOSURE</b>	Close the system implementation	Close the tactical management phase	Close the strategic management phase

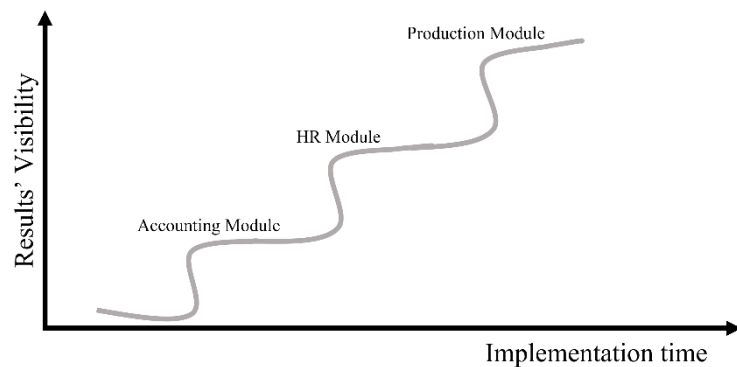
**Table 1:** Concise S-ERP implementation guidelines



The three-stages model could be considered simple, yet concise. This approach is frequently recommended since it allows the members of the implementation team to focus on all aspects of an ERP system, instead of just aiming towards the software implementation, that is usually associated as the whole ERP system (Marnewick & Labuschagne, 2005).



a. "Big Bang" implementation strategy



b. Gradual implementation strategy

**Figure 11:** Implementation process strategies

This process is not linear, it has a learning curve. The implementation process strategy could focus on two approaches, a "Big Bang" and a Gradual Strategy (Benvenuto, 2006). The former establishes that all modules should be installed on the organization at once (Figure 11 a) in order to shorten the implementation time of the set of modules of the system, reducing the transition time of the previous system with respect to the ERP system. On the contrary, the Gradual strategy, as its name states, modules are implemented gradually one by one

until the implementation of the previous one has been finalized (Figure 11 b). In addition, it is convenient to start with those modules that do not require a high degree of customization. In terms of which strategy is better, there is no doubt that the Big Bang one should be avoided, and the Gradual strategy offers organizations to better control the visibility of results.

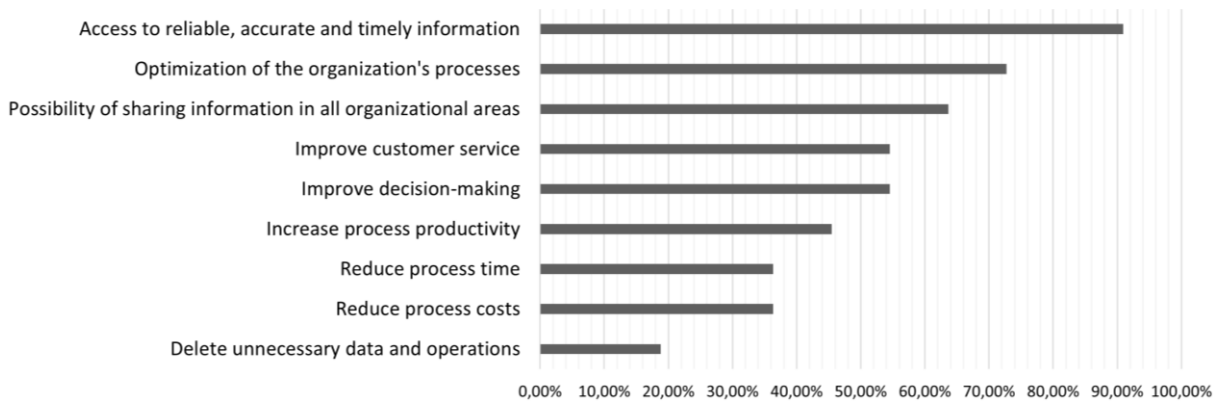
### **3.1. Pre-Implementation**

The pre-implementation phase is an “adoption” phase where activities such as the cost-benefit analysis, investment decision and software and vendor selection are carried out. Before starting with the installation of the software, it is necessary to prepare a study about the needs of the organization. It is what is colloquially called "fieldwork", where the forms that are needed are established, and tables and reports are elaborated of what is needed, how, when, and where (Delgado & Marin, 2000).

Besides the needs of the organization, it is also important to review the commitment top managers would invest, statistical objectives, business drivers, human resource planning, strategic plans, willingness to change structure and culture, training facilities, and other considerations that will contribute to the decision-making process of implement an ERP, along with the definition of the project scope and goals of implementing the ERP system (Marnewick & Labuschagne, 2005; Shebab et al., 2004; da Conceição & Gonzalez, 2010).

Commonly, it is difficult to carry out an analysis of the company's needs, and to confirm or redefine the characteristics of the software the company chooses to implement. The analysis serves as a way to set a baseline of the current state of the organization, its business processes, the chance of re-engineering processes, and technical requirements, in order to build and implement the new ERP system (Marnewick & Labuschagne, 2005; Shebab et al., 2004). To do said analysis, those responsible for installing the program must analyze all the available information and how the integration of new needs between the different areas or departments of a company is carried out (Andonegi et al., 2005).

Benvenuto (2006) investigates the objectives proposed by organizations during pre-implementation. The objectives were grouped according to a thematic criterion as shown in Figure 12, where it can be seen that companies give greater priority to the management of information regarding its access and possibility of sharing; process improvement, customer service and decision-making is relegated to second place; and reduction of costs, time, and unnecessary data are the objectives least taken into account.



**Figure 12:** Pre-Implementation proposed objectives

From an organizational standpoint, it is important to recognize unbalanced structures that are likely to impose a large tailor-made adaptation, expanding the modification costs and the project risk. Deliberate disparities can be prevented through proactive change management, instructing users on the different methods of working that make the new system possible (da Conceição & Gonzalez, 2010).

During the pre-implementation process it is also possible, and needed, the identification of the magnitude of change the implementation could have; what, if any, change occurs in the company's ownership; and the expectation for future benefits because of implementing an ERP system (Marnewick & Labuschagne, 2005). Chen (cited by Shebab et al., 2004) introduces the economic justification of the project as a factor to consider before implementing an ERP because it contributes towards the identification of probable benefits, which later could become measurements to evaluate the performance of the organization.

Once the implementation team has decided on the course of action to take regarding the goals set, it is necessary to design the ERP system with the constraints identified and build the information system and operational processes and incorporate them into the ERP model (Marnewick & Labuschagne, 2005).

Regarding how to design the ERP system, there is not a single accurate solution because each company has its requirements and constraints and the systems on the market have a high degree of modularity. A company can install the complete ERP software from a single vendor, bring together modules from several vendors depending on its requirements, or customize a “generic” ERP package. All these approaches bring their pros and cons. By contracting a single vendor, the integration will be easier, but it may not give a thorough functionality. Integrating modules from different vendors may give the best efficient result from that single module point of view, as it has been the case with PeopleSoft and its renown human resources management modules, but achieving a successful implementation becomes complex since each vendor has its own interfaces. Customized ERP packages can have a smooth implementation process but require higher maintenance in the long run that relies on the company (Shebab et al., 2004).

### **3.1.1. Selection process of an ERP**

There are two main phases that could generate challenges when talking about ERP systems, those are the selection and implementation processes. Regarding the selection, it is a sensible matter because ERP packages from different vendors have some critical design differences while maintaining resemblances (Shebab et al., 2004).

Selecting the right, most fitting ERP for a company requires taking into account the needs derived from the strategy in terms of information obtained from customers, suppliers (vendors) and competitors (da Conceição & Gonzalez, 2010). Even more so, organizations must address how to support the information technology, accounting, and finance personnel to select the appropriate ERP system according to their businesses (Huang et al., 2019).

<b>Author(s)</b>	<b>Type and field of study</b>	<b>Selection factors considered</b>
Siriginidi (2000)	Theoretical	Stability and history of the ERP supplier Last 12-month track record of ERP sales Implementation support from suppliers Improvement in ERP packages including stability of the product and functionality
Bernroide & Koch (2001)	Empirical Austrian	Implementation time Costs Vendor support Team size and structure Market position of vendor Customer and supplier needs
Everdingen et al. (2000)	Empirical European	Fit with business process Flexibility User-friendliness Costs Scalability Supplier support and training Product functionality and quality Implementation speed Interface with other systems Price Market leadership Corporate image and international orientation
Sprott (2000)	Theoretical	Applicability Integration Adaptability Upgradability
Chen (2001)	Theoretical	Competitive strategy Targeted market segments Customer requirements Manufacturing environment Characteristics of the manufacturing process Supply chain strategy and available resources
Rao (2000)	Theoretical	Affordability Domain knowledge of suppliers Local support Technical upgradable Incorporation of latest technologies
Verville & Halington (2002)	Empirical USA	Vendor evaluation Functional and technical aspects of the software

**Table 2:** Comparison of ERP selection criteria

Shebab et al. (2004) carries out a review of selection criteria from different authors that have been documented through the years until that point, pointing out seven works that contributed the most towards their research with its respective selection factors (Table 2) that include Sririginidi (2000), Bernoide & Koch (2001), Everdingen et al. (2000), Sprott (2000), Chen (2001), Rao (2000), and Verville & Halington (2002).

Benvenuto (2006) investigated the determining variables in the acquisition of ERP among eleven companies that have implemented ERP systems (Figure 13). In their work it is observed that 9 companies consider quality and services, both support and maintenance, as the defining variables when choosing an ERP system. On the contrary, the price and the existing suppliers in the market are little relevant aspects for the purposes of choosing where to invest, companies consider that high investment is necessary, no matter how much they must pay for the system.



**Figure 13:** Determining variables in the acquisition of ERP

### 3.2. Implementation

This stage of the process is about implementing the ERP itself on the company lead by the implementation team that knows the needs of the organization from the perspective of its business processes, to develop a project that considers the end users of the system (da Conceição & Gonzalez, 2010). Here, the servers and client computers are installed, the ERP software is incorporated to the company, and the software is adapted to follow the configurations and requirements of the company

from their “standard/generic” form, along with specific modules the company might need (Delgado & Marin, 2000).

The implementation stage is what actually deploys the ERP system. Here is where the previously designed plan of action begins, and changes are made as the implementation progresses regarding the structure, practices, procedures, and guidelines of the ERP before going live and managed by customers (Marnewick & Labuschagne, 2005).

The implementation process is divided into the overall strategy of the implementation, the associated project management, the design of the business process and the configuration of the software. The implementation strategy involves sizing its duration, seeking reduction and balance with respect to the possible combinations of the system modules that can be implemented and integrated (da Conceição & Gonzalez, 2010).

According to Delgado & Marin (2000) there are three main requirements for the installment of an ERP system:

- a. The hardware: it must be at least one server.
- b. The software: the majority operating systems are Windows, Unix AS/400 and Linux.
- c. User interface: It allows the user to work with different compatible applications. Nowadays, it is increasingly productive that it can handle the own format provided by the web browser itself.

da Conceição & Gonzalez (2010) expand this approach to consider the transition process from the old management system to the new ERP:

- a. Hardware, software, and database test.
- b. Functional test with the business processes applied.
- c. Commissioning in the real environment with specified technical and business performance criteria.

Shebab et al. (2004) explain two strategic approaches to successfully implement the ERP software that deal with a gap between the ERP business processes and the legacy system of organizations, with the ERP vendor being who suggests which approach to adapt.

1. The organization entails deep changes to their business processes, re-engineering them, in order to fully accommodate the ERP system's functionality, a proven logical and effective method. This approach would have as a challenge that responsibilities of employees will shift, creating a natural resistance. On the other hand, this approach will benefit the organization with each future ERP release as processes are mostly optimized, which in turn saves money for the organization.
2. Take the existing business processes and customize the ERP software around them. This approach can introduce bugs to the system and difficult the updating process with new releases since the software would have to be modify once again, which in turns delays the overall project, not just the software implementation stage.

One vital and delicate process that most take off during this period of the implementation process is the data migration. It is the process of moving data from the previous management system to the newer ERP software, including data of customers, accounting, suppliers, payroll, billing, among others. This process most follow data protection law since some of the information is confidential. The data migration also has a volume complexity since it involves a large amount of data, and there is the possibility for the process to be done manually because of old files with outdated, non-existent, formats (Delgado & Marin, 2000).

During the implementation process, while the organization installs and adopts the ERP software, a transfer of knowledge occurs from the software architecture into the organization. The processes imbedded in the software along with the ERP best practices previously mentioned, which contributes to the flexibility of the system. However, the adoption and appropriation of these business



practices that are mostly standardized do not come out of the blue, they are influenced by the creation of the new knowledge structure and the ability to reshape roles and responsibilities within the organization (Shebab et al., 2004).

Once the ERP system is ready to run, that's it, when all modules and functionalities have been installed and are prepared to perform correctly according to the desired processes, a post-implementation audit needs to be carried out to evaluate the effectiveness of the system, associating it with its goals and objectives set (Marnewick & Labuschagne, 2005).

### **3.3. Post-Implementation**

Delgado & Marin (2000) reiterate that some control must be done for a period after installing the ERP software, a transition phase. It consists of carrying out some tests while the previous management system coexists with the new ERP. Said tests must not be done randomly, they must be performed formally, often by an outside company, and their results recorded thoroughly. This approach falls under what is considered the support maintenance of the system, which absence could compromise the operation and stability of the system, because there are greater interactions between the implementation phases, for example, after the initial implementation there are additional revisions, re-implementations, and updates (da Conceição & Gonzalez, 2010).

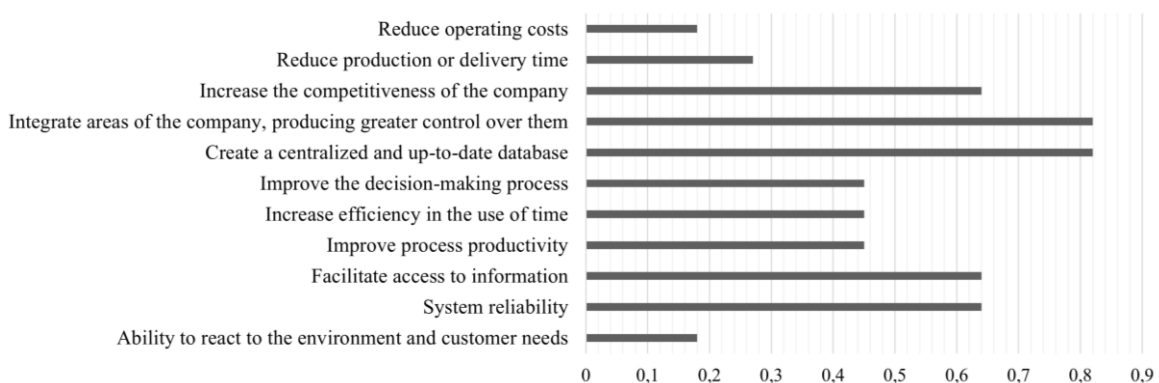
This point of view correlates with what Marnewick & Labuschagne (2005) propose on their work. After implementation is completed, the company must set measuring mechanisms to compare and balance the obtained results regarding the objectives established on the pre-implementation stage, e.g., is a bridge between stages that completes the feedback in terms of performance and development of the system. Other aspects that can bring light to these measurements are the support of the supplier, the organizational connection, knowledge management, data conversion, the reluctance in the acceptance of discordant visions, the lack of

support from the consultancy, cost-benefit, etc. (da Conceição & Gonzalez, 2010). All these aspects are identifiable after performing various evaluations such as:

- Review of the scope and planning of the project.
- Assessment of the principles that drive the project.
- Evaluation of unsupportiveness resolution strategies
- Estimation of the benefits achieved and of individual and organizational learning.

As it can be observed, it is a thorough analysis with support and maintenance activities that can cost millions of dollars for organizations, a considerable monetary investment. It is an unavoidable step because of the critical outcome required from the ERP system implementation, or any information system, in organizations (Hasan et al., 2019; Huang et al., 2019).

Some of the benefits detected post-implementation, after performing analyses such as those mentioned above, are described by Benvenuto (2006) in Figure 14. From the analysis arise benefits regarding improving productivity, decision making, use of time, competitiveness of the company, access to information, integration of processes and areas of the company, and reduction of operational costs and production time.



**Figure 14:** Benefits detected Post-Implementation

Zerbino et al. (2021) study the success of ERP implementation in the long run among four selected firms working on the fields of electrical equipment, iron

and steel, civil and defense applications for system engineering, and cryogenic liquid storage tanks. The findings were that indirect performance expectations from stakeholders could clash with the flow of ERP benefits, post-implementation benefits may be achieved through reaching a complete level of system information and knowledge awareness of system by users, the flow of ERP benefits may be affected by the constant change of information and system requirements during the pre-implementation and implementation stages, and direct performance expectations from stakeholders could tacitly cause ERP benefits, if stakeholders are involved increasing the interaction between a competently operational ERP and its users.

Integration efforts must manage the resistance to change based on the lack of influence capacity of the implementation team, cultural issues, and low acceptance of the project, avoiding the realization of unnecessary adaptations.

It is not enough to just install the ERP software on an organization, it is a must to accompany employees during the transition period and train them on the functioning of the system with workshops, talks, courses, conferences, or any other means. The training must not be spared, assumed, or left on amateurish personnel no matter how intuitive the ERP interfaces are, even if the management of the ERP is becoming easier (Delgado & Marin, 2000).

In this sense, training becomes a critical factor that will ensure a successful implementation of ERP systems. For example, Altamony et al. (2016, cited by Hasan et al., 2019) found on their research that 70% of respondents, consisting of ten ERP and information technologies (IT) experts on Bangladesh, signaled that “End-User training” impacts on the successful ERP implementation in regard to the change management strategy, even more so with the thought in mind that the personnel of an organization are not constant, so the organization has to invest on training new employees.

### **3.4. CSFs for implementing private ERPs**

As Shebab et al. (2004) dictate on their work, successfully implementing an ERP gives a company a competitive advantage with respect to its competitors by, first and foremost, expanding customer satisfaction and quality, speeding up business processes thanks to decreasing lead times and stock levels, and one of the cores of ERP systems, eliminating redundancy. Critical success factors (CSFs) were first introduced to the environment of information systems research in 1979 by Rockart, and it has been since a challenge for organizations (Hasan et al., 2019).

Serrano & Hernando (2006) give insight to some key factors for success in the implementation of an ERP by three authors that impacted the ERP research field.

- Davenport (1998) identifies the adaptation or adjustment, as far as possible, of the ERP to the existing processes in the organization, and the participation of the senior managers in the implementation process of the system, bearing in mind the technical, strategic, cultural, and organizational consequences that derive from it.
- Hong & Kim (2002) follows the first approach of Davenport introducing variables such as the degree of adaptation of the ERP, the degree of adaptation of the processes of the organization and the degree of resistance to change present in it, to evaluate the adjustment between the existing processes of the organization and the ERP.
- Stratman & Roth (2002) bring into light the strategic technology planning, project management, ERP training, management commitment, learning and change management, development of information technology skills, as well as business practices, to be considered the eight dimensions related to success in ERP implementation

Shebab et al. (2004) review the literature and found the most common CSFs mentioned for private organizations implementing an ERP system (Table 3), not to be confused to those that could be applied to Public Sector Organizations (PSOs) which are discussed later on.

Hasan et al. (2019) focused their study on factors influencing the success of post-implementation ERP systems. They found five areas with specific factors that are directly correlated to Bangladesh's ERP successful ecosystem in the context of post-implementation.

- There is a positive relationship between extensive competent team and top management support and between post-implementation training and top management support, where said management team directly influences the inter-department information sharing in a positive way.
- Efficient decision-making processes have a positive relationship with an extensive competent team.
- A positive continuous system development is possible because of a post-implementation training of employees.
- Business process performance and decision support have both a positive relationship and effect, respectively, with a continuous development system.
- A capable and active decision support team positively impact the business process performance.

Uddin et al., (2020) verifies factors affecting ERP adoption and implementation with 225 respondents from Human Resources departments that dealt with ERP on South Asia based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Their work found that facilitating conditions do not impact the actual use of ERP since this is predicted by the intention to use the system, the size of an organization has a direct and positive effect on whether adopt and implement an ERP system or not, and the intention to use an ERP is predicted

<b>Author(s)</b>	<b>Validation</b>	<b>Critical factors of ERP implementation</b>
Bancroft et al. (1998)	Yes. Three multinational companies	Top management support Presence of a champion Good communication with stakeholders Effective project management
Holland and Light (1999)	Yes. Two case studies	Strategic factors, such as the overall implementation strategy Tactical factors such as technical software configuration Project management variables Critical impact of legacy systems upon the implementation process Importance of selecting an appropriate ERP strategy
Nah et al. (2002)	No	ERP teamwork and composition Change management program and culture Top management support Business plan and vision BPR with minimum customization; project management Monitoring and evaluation of performance Software development, testing and troubleshooting Project champion Appropriate business and IT legacy systems
Markus et al. (2000a)	No	Simple structure of organizations Operate in one or a few locations
Marsh (2000)	Yes. Nine case studies	Success factors include: Cross-functional team approaches Organizational experience of similar scale IT or organizational change projects Deep understanding of the key issues relating to ERP implementations Failure factors including: Top-down or consultant driven implementations IT department driven implementations Implementations where the ERP is seen as a quick technological fix to problems within the operation of the firm, rather than as a strategic investment
Francalanci (2001)	No	Technical size and organizational complexity
Sarker and Lee (2000)	Yes. One case study	Strong and committed leadership Open and honest communication Balanced and empowered implementation team
Umble et al. (2003)	Yes. One case study	Clear understanding of strategic goals Commitment by top management Excellent project management A great implementation team Data accuracy Extensive education and training Focused performance measures

**Table 3:** Comparison of critical factors of ERP implementation

by the expected performance of the system and is influenced by effort expectancy, facilitating conditions and social influence.

Huang et al. (2019) work on critical success factors for implementing ERP system on organizations certified as “B-Corporation”. This certification is awarded by ‘The B-Lab’, a Philadelphian non-profit organization, that authenticates companies follow certain guidelines for environmental and social performance, transparency and accountability. Their study found CSFs distributed among dimensions as business organizations strategies, system users, counseling team, software vendor, and enterprise performance (Table 4).

### **3.5. Implementation challenges for private companies**

As it has been shown on this work, implementing an ERP system is not an easy nor simple task that consist of merely installing systems, it requires the work of many people through following a meticulous process which makes it intricated and risky.

Some of the implementation failures occur because end-users of the ERP systems did not obtain the appropriate training required by the complexity of the implementation, which leads to said end-users to not fully comprehend the functions of the system. Some mistakes during implementation may cause for functions not to be able to run when activated by users, that is, intentional system operations could not be prevented by the built-in controls of the ERP. In addition, profits and earning losses could be manipulated by top management if certain controls are deactivated (Huang et al., 2019).

It is crucial to select the correct software or carry out the best modifications to it, to assure a successful implementation. If adaptations are not the most fitted towards the strategic objectives, it could compromise the advantages of integration. That is why most successful companies have improved their business processes to adjust to the new system, considering both organizational change and adaptation (da Conceição & Gonzalez, 2010). It is the same case with generic ERP packages

<b>Dimension</b>	<b>CSFs</b>	<b>Rank</b>	
<b>Business Organization Strategies</b>	Top management support	1	
	Business process reengineering	2	
	Change in management/Management of effective organizational changes	7	
	Cultural and structural changes/Readiness/Organizational culture	9	
	Standardization of business processes to the extent possible to fit the ERP system	9	
	Optimal Project Team	4	
	Project champion/sponsor	8	
	Project management and evaluation/Project management capabilities	2	
	Time frame/Schedule	7	
	Implementation strategy	3	
	Software migration	9	
	Integration of other management information/legacy systems within the organization	5	
	Defining architecture choices	9	
	Business plan and vision/Management of expectations	6	
<b>System Users</b>	Interdepartmental communication	2	
	Enterprise-wide communication/Strong communication inward and outward/Communication plan	4	
	Training and education/Training employees/User training and education/Job redesign	1	
	Familiarity with professional competence and processes in the field of work	5	
	User involvement	3	
	The role of seed personnel/The role of the project sponsor	5	
	Entering accurate information/Data accuracy	4	
	Data analysis and conversion/System analysis	4	
	<b>Counseling Team</b>	Appropriate use of consultants	2
		Professional competence of the consultant team	1
The consultant team must possess strong coordination and communication skills		3	
Consultant team understands business needs and goals		3	
Advisory team personnel's stability		3	
Consultant team's project time control ability		3	
Service quality provided by the consultant		3	
Dedication of the consultants		3	
The consultant team having had a successful introduction experience in similar industries		3	
<b>Software Vendor</b>		Vendor system quality	4
	Support of vendor	3	
	System software vendor's professional competence	5	
	Differences in ERP versions/Appropriate system version	5	
	Appropriate configuration of the software/Careful selection of appropriate package	1	
	Degree of customization/Minimum customization/Avoiding customizations	2	

**Table 4:** Key factors for sustainable ERP implementation



that are implemented in organizations with distinct national and corporate cultures, projects could be over cost and overdue if the organization fails to adapt the software to fit said cultures (Shebab et al., 2004).

There are barriers that difficult the learning and assimilation of the system knowledge associated with the assimilation of new processes and work methods, and with the configuration of the software. An adequate relationship with consultants and the creation of teams are mechanisms identified to overcome the existing barrier, along with addressing technical and organizational changes simultaneously (Robey et al., 2002; cited by Serrano & Hernando, 2006).

Technological complexity becomes a challenge for organizations if organizational complexity is not handled appropriately (Rodriguez et al., 2019). The former is possible only if the ERP users comprehend the incredible potential of the system, otherwise, it affects the knowledge and comprehension users could obtain by studying the system prior to implementation since it would require the allocation of more time to perform fast and simple tasks, with the possibility of hampering any performance at all.

## Chapter 4

# ERP for Public Sector Organizations

The government plays a driving and promoting role in Information and Communication Technologies and in the incursion of the Internet in government as another way to provide better services to citizens through what is currently known as e-government. There is a stream that summarizes this transformation known as New Public Management (NPM), which looks for a reform in the public sector to imitate business processes of private companies to a certain level (Fernandez et al, 2016). The citizenry, which could be seen as the competition of companies for the private sector, is increasingly demanding greater transparency from the government and accountability to demonstrate a more efficient administration, which is why governments have been forced to modernize the entire government platform, making incursions into the use of systems that have already borne fruit in the business sector (SIEP Enterprise, s.f.).

Private companies that want to stay in the market implement initiatives such as ERP, CRM, and SCM to be competitive and profitable (it refers to the internal

administration of the company, customer service, and production respectively). In the same way, the government also constitutes an institution, and its functioning can be comparable to that of the company, under a focus on service to citizens from which it is sustained by the collection of taxes that allow it to pay for its activities (SIEP Enterprise, s.f.). However, it is appropriate to note that although most Public Sector Organizations (PSOs) share common requirements and procedures, each country has its unique administration which difficult the creation of a universal “model” or the propagation of best practices for the public sector (Wagner & Lederer, 2004).

As it has been previously established, the implementation of ERP systems began in the private sector, public organizations were not considered when creating ERP models nor by ERP vendors which targeted manufacturing companies (Gaspar & Amaral, 2011; SIEP Enterprise, s.f.). An increasing amount of PSOs have been looking to substitute the existing control and operational systems by embracing ERP because of a concern for efficiency (Chang et al, 2000). Other authors put aside the implementation of ERP systems as a core process of the organization and see them as a way to support existing processes like fixed assets, human resource, inventory and payroll management, and accounting (Ziemia & Obłąk, 2013).

It is necessary to mention that the government is one of the biggest contributors to the economic development of a country. PSOs have an inimitable culture where they are faced with a diverse number of challenges attributable to their high public expectations, social duties, and their complex legislative work. Also, the implementation of new and better information technology systems is conditioned by political, legal, and governmental issues (Gaspar & Amaral, 2011). That is the reason why PSOs implement procedures to develop the quality and responsibility of government agencies in order to deliver good quality services without letting aside the importance that citizens give to transparency in financial management (Fernandez et al, 2016). Davenport also introduces the idea that governments adopting ERP systems contribute to remodel governmental agencies

as they search for solving challenges posed by the currently used applications that are disengaged and uncoordinated (cited by Fernandez et al, 2016).

Wagner & Lederer (2004) and Gaspar & Amaral (2011) raise the issue of organizational culture being a major difference between private and public sector companies. The processes PSOs face are more complex than those of a private company, with the former located in a thoroughly set organizational structure with slow and extremely formalized decision-making processes (Ziemba & Obłąk, 2013). Another core difference is the nature of a public administration, it has a limit, a deadline, that comes with every change of administration making the short-term planning very common among its policies which limits the technology investment (Gaspar & Amaral, 2011).

The previously mentioned organizational structure consists of many departments with many divisions and sub-divisions, which make integration difficult and complex because each of them has its processes, manager, and business rules (Wagner & Lederer, 2004). Said departments also have a tight independent decision-making process to fulfil their own established goals that go separate from the government agency in its entirety, and the communication between departments becomes complex as it relies in tasks performed by individual employees (Ziemba & Obłąk, 2013). As a consequence, it is complicated to identify roles and responsibilities among employees because the project team adapts from the private-sector one, and its composition adjusts to include delegates from each department and division (Wagner & Lederer, 2004).

It is possible to point at more differences between the implementation of ERP systems in public versus private organizations. The first point is one of the reasons for implementing ERP, where PSOs would end up with software and applications shared with other agencies while private companies see the incorporation of such software as a competitive advantage (Gaspar & Amaral, 2011). On the other hand, the managers make another difference between these organizations. Top-managers from PSOs are politically appointed by the current

administration to work for their interests, which means it changes periodically impacting the leadership and goals of the organization (Wagner & Lederer, 2004). In contrary to managers from private-sector companies, they are not leaning towards building a culture that concerns about the development of new technologies (Gaspar & Amaral, 2011).

Another difference arises when it comes to budgeting. Most public organizations are requested for their budget from a central PSO and then be awarded some of it, and even requested to provide proposals from suppliers before granting a deal to a specific contractor. The funding for said contracts come from an allocation by the central and local government, and collections from members of associations and independent donors (Wagner & Lederer, 2004).

#### **4.1. ERP Implementation on PSOs**

Some authors name ERP adapted to the public sector as a Government Resource Planning system (GRP). In the context of Latin America, the use of a single ERP system in the public sector is more common at the subnational level, or in individual entities at the central level, generally entities with entrepreneurial or financial characteristics, being less common to observe the implementation of a single ERP type system for an entire country (Pessoa et al, 2015).

Wagner & Lederer (2004) establish that in order to implement an ERP in the public sector more time is required for the first phases of the process, with it being in general similar to the process taken on private-sector companies. When it comes to upgrading the ERP software installed, PSOs need to see this process as an essential part of their organization, that the time required to complete this process is an investment, and that this project must start before completing a diagnosis of the current ERP software (Scheckenbach et al, 2014).

The ERP for the public sector ceases to be an application to solve a large number of inconveniences, making some processes within the entities easier and more effective. However, the advantages offered by an ERP for the public sector

are much broader than is believed, even its importance is greater within this sector in which the processes are in accordance with changing government regulations (Gaspar & Amaral, 2011; Ziemia & Obłak, 2013).

The implementation of ERP systems in PSOs create many benefits for them. These systems help to manage management efficiently, transparently, and more completely, which leads to efficient processes; ERP systems comply with responsible and effective management of public spending; they improve the service delivery of many public entities, simplify the performance of processes, and reduce duplication of these; and one of the main benefits is that it helps to improve citizen satisfaction by having controlled and efficient processes.

Gaspar & Amaral (2011) worked with 8 Portuguese PSOs that implemented SAP systems to identify the reasons as to why did the organizations implemented ERP systems and are presented on Table 5. The research also requested for information regarding which modules were implemented within the organizations. The modules implemented the most where the Controlling, Accounting, and Materials Management module implemented in six, eight, and six organizations respectively. According to this and the reasons to implement an ERP, it is fair to assume that Portuguese public organizations searched for and integration on their accounting processes.

<b>Reasons</b>	<b>Frequency</b>	<b>%</b>
Integration of applications	8	100%
Increased demand for real-time information	6	75%
Integration of information	6	75%
Information generation for decision-making	6	75%
Business process re-engineering (BPR)	3	38%
Introduction of EURO	3	38%
Competition	2	25%
Other situations	2	25%
Costs reduction	1	13%
Y2K problems (new millennium data format)	1	13%

**Table 5:** Motives to implement ERP systems on Portuguese PSOs

It is to be noted that it is not recommended to choose an ERP system lightly, a study must be carried in order to pond on the benefits of choosing one vendor or other. For small governments, the decision to choose an ERP is a huge and difficult decision to make given budget and resource constraints, they have to research as much as possible the perceived processes, functionalities and complexities of implementing an ERP, thus staying above the purpose of replacing old legacy systems with new products built with the promise of helping government agencies to achieve efficiency (SIEP Enterprise, s.f.).

DigitalWare (2020), a company focused on technological solutions including ERP, suggest some key points to focus while performing this process, which are:

- An ERP for the public sector must be a highly configurable solution in its administrative, financial, and commercial processes. In addition, for the management it has throughout the budget chain in public entities, generating alerts and controlling each part of the budget.
- An ERP software for this sector must contain a zero-paper philosophy, this not only saves costs, but also allows you to keep track of your documents more effectively.
- The ERP for the public sector must work with a philosophy of processes, that allows to cover needs that others do not cover and must have the facility to adapt to any business or entity, allowing to model and take control of the operation.
- An ERP for the public sector must ensure that information is secure and available. It has to show that the stability of the system and the security that characterizes it to generate a lot of credibility to the entities that use it.
- Remember that the ERP for the public sector that an organization implements must have trajectory and experience in the market, that way the government will ensure that the entity has an ally.

Chang et al (2000) carried out a study in Queensland, Australia, years after the government made de decision to implement an ERP system. Said implementation began in 1983 with the introduction of the Queensland Government Financial Management System (QGFMS) which assisted government organizations with a general financial management system. SAP R/3 Financials was implemented in 1995, replacing the previous QGFMS, and it was the turnover for state government agencies to implement an ERP system, adding up Payroll and Human Resources Management modules later. However, this procedure is not smooth, it has its challenges. The research carried out categorized implementation issues that the state organizations faced with this change in software on Table 6.

Issue Categories	Respondents Who Nominated the Issue	
	Frequency	%
Knowledge management	34	56%
System development	32	52%
Operational deficiencies	30	49%
Organizational context	16	26%
System performance	15	25%
Cost/benefit	12	20%
Support	12	20%
Data Conversion	8	13%
Lack of consultation	6	10%
Indeterminate	4	7%
Reluctance to accept dissenting view	3	5%

**Table 6:** ERP implementation issues for Queensland's PSOs

The research produced a collection of 10 major issue categories. 20% of respondents considered the support system to be insufficient while dealing with the implementation, another 20% considered that the relation cost-benefit was imbalanced because of SAP's complexity in contrast to the requirements of organizations, 25% of respondents gave a low score to the system performance rating it as inadequate to meet goals settled, 26% of respondents considered that diversity in the organizational culture makes integration difficult as it has been previously mentioned in this thesis, 49% realized that operational deficiencies affected the proper use of the system resulting in a lack of accuracy, 52% pointed out that updating the system puts a burden on the maintenance team affecting the

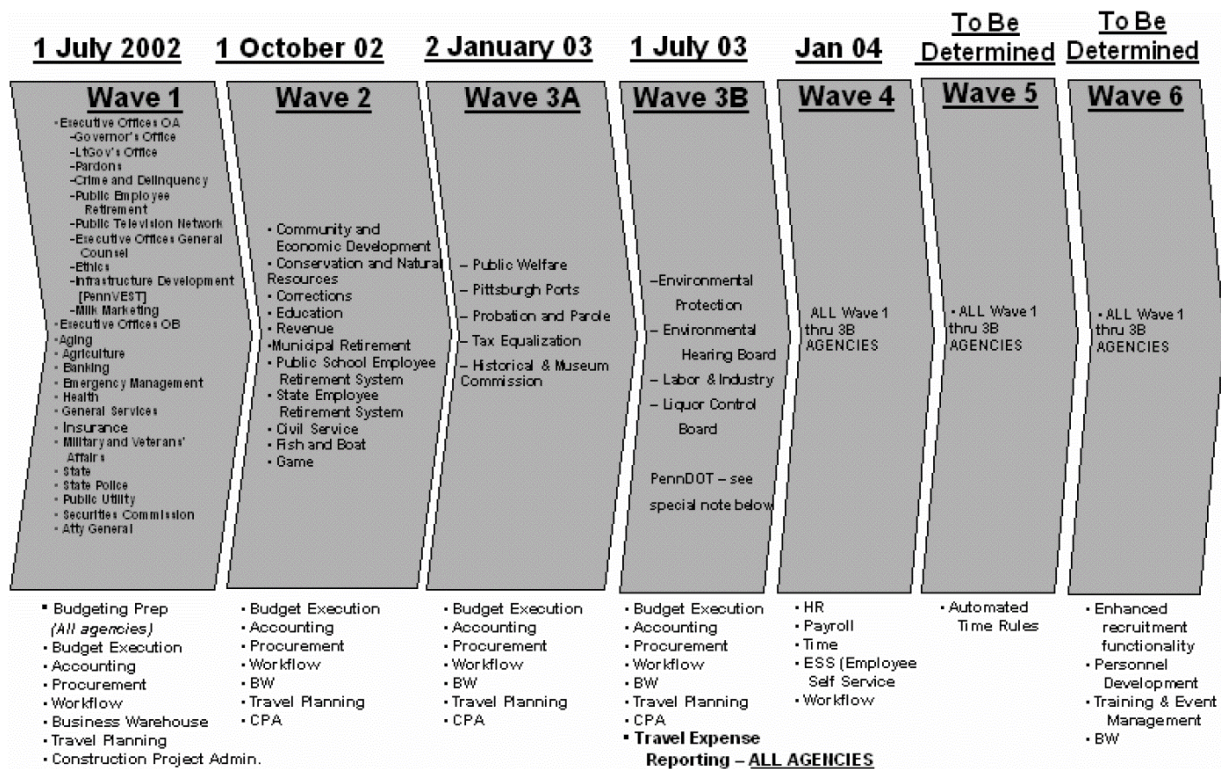


system development, and 56% identified that it could be difficult to retain expert human capital due to the competitiveness of the market.

Fernandez et al (2016) focused their study on the benefits of implementing ERP on Malaysia at city, municipal and district council level instead of the challenges faced to employ it. The system consisted of accounting, revenue management, and complaint report modules to assist local authorities processing and tracking financial and accounting transactions in order to offer better services to customers depending on their requirements, to improve efficiency and effectiveness of the local government according to the country's development, and to improve the delivery system used by government employees implementing the newest Information and Communication Technologies (ICT).

After completing the research, the improvement on the public organizations' performance was notorious. The high-tech system contributed to a reduction of procurement, administrative, search, and documentation costs because of the user-friendly interface and the restructuring of business processes that eliminated automated secretarial tasks. The government staff was also able to reduce the number of errors incurred in when customers filed documents, improving the service quality, facilitating feedback with this new interactive platform, and consequently reducing complaints.

Wagner & Lederer (2004) report one of the most ambitious large-scale ERP implementation projects on the public sector attributed to the commonwealth of Pennsylvania in the United States, which looked toward the integration of 59 governmental agencies across the state in a single ERP software known as Imagine PA. This initiative was proposed by the commonwealth leaders to improve their business strategy and it was planned to take 33 months divided in 6 waves starting July 2002 (Figure 15), while implementing SAP R/3 to support nearly 80% of the commonwealth's requirements (of which 90% involves procurement of goods and services).



**Figure 15:** Imagine PA project timeline

As of July 2003, the Imagine PA had completed its third wave and it was already delivering benefits. By threading change management into the implementation life cycle, the PSOs were able to incentive employees to adapt changes made to successfully implement the ERP software. Another of the main benefits the study recognizes relates to the end of the fiscal year when agencies needed to close the books, reducing it from a previous two-week “black out” to 10 days when only have of the project completed. Additional to this, decision-making and analysis improved with the introduction of personnel data, and the payroll processing costs reduced.

## 4.2. CSFs for implementing ERPs on PSOs

The success evidenced from the implementation of the ERP system in the Pennsylvania case did not occur just because, was a coincidence, not was luck. The most accurate process to determine the success of the ERP implementation is with the use of specific areas and operations known as Critical Success Factors (CSFs). In order to achieve the most successful outcome from the ERP implementation, said

CSFs must be followed. Ziemba & Obłąk (2013) introduce these factors for the successful implementation of ERP on Polish government agencies, which became relatively popular by Rockart (1979) in the context of implementing information systems.

The Polish case study identifies the most common CSFs described on the literature, and then filtered them to obtain the most relevant ones relative to implementing an ERP in the public sector (Table 7). Those methods were divided into four categories: public procurement procedure, government processes management, project team competences, and project management. Of these categories, only the first two apply only to the public sector procedures, while the last two apply for both private and public organizations. These former factors could be found in private organizations but are relatively different because of the nature of government processes.

<b>Factors related to public procurement procedure</b>	<b>Factors related to government processes management</b>	<b>Factors related to project team competences</b>	<b>Factors related to project management</b>
<ul style="list-style-type: none"> <li>• Clear and precisely defined tender specification (information and government processes requirements, technological requirements, organizational requirements)</li> <li>• Realistic and chronologically arranged schedule</li> <li>• Clear goals and objectives of the ERP system implementation</li> </ul>	<ul style="list-style-type: none"> <li>• Frozen information requirements</li> <li>• Identified government processes</li> <li>• Government process reengineering</li> </ul>	<ul style="list-style-type: none"> <li>• Project team competence on ERP systems</li> <li>• Project team competence on public administration</li> <li>• Use of consultants</li> <li>• Cooperation with research centers</li> <li>• Expertise in IT</li> </ul>	<ul style="list-style-type: none"> <li>• Top management support</li> <li>• Clear assignment of roles and responsibilities</li> <li>• Change management</li> <li>• Risk management</li> <li>• Involvement ERP system end-users</li> <li>• Interdepartmental communication</li> <li>• Use of proven project management methodology</li> <li>• Effective monitoring and control</li> </ul>

**Table 7:** CSFs for ERP implementation in Polish PSOs

As processes are uniform, the ERP facilitates the transformation of government to the best it can be. The role of government becomes that of a role

model, a government that is progressive in its use of technology to achieve efficiencies and that will make businesses look favorably on reallocation or expansion in that state. The government through an adequate process of modernization and government innovation already greatly promoted in countries at the forefront in the use of technologies, will obtain considerable improvements in the use of public resources in all areas and levels of government (federal, state, and municipal).

It is unavoidable to recognize the gains in administrative efficiency and cost reduction through the proper use and correct implementation of technology in any organization, the importance of combating resistance to change in human resources is fundamental and key to the success of changes in governmental processes. It is no less important the establishment of a sustained policy of modernization and adoption of the most modern technologies, traced to a long-term plan within the governmental entities, as well as the elaboration of a process reengineering (SIEP Enterprise, s.f.).

# Conclusions

Current and future business interests force companies to become increasingly competitive; For this, it is necessary that they have optimized and integrated all their internal information flows and their external commercial relations. In addition, strategic objectives such as improvements in productivity, quality, customer service and cost reduction must be achieved.

Information technologies have largely made it possible to achieve these objectives. Any company that wants to compete in the market must consider information as a very important asset. For this reason, it is necessary that the company has its adequate information systems to quickly and effectively provide information. The company has the option of developing its own information systems or acquiring them from external companies dedicated to their development. A viable and appropriate option is the acquisition of an ERP system, as long as the company that acquires it is aware that for it to work it must not only buy the necessary software and hardware but must also apply the appropriate changes so that users can work in the new conditions. The implementation of an ERP is not easy and requires the involvement and participation of all the people affected by the project. The deficient installation and commissioning of an ERP can bring very serious consequences for the daily operation of the company.

Nor should it be forgotten that ERP programs are expensive, complex and difficult to implement. To install and parameterize the system correctly, the help of external consulting companies is usually required. Therefore, the total cost of installation, which includes the software and in most cases also the renewal of all

or part of the hardware, consulting and the cost of internal personnel, can represent 2 or 3% of the annual turnover of a large company.

The implementation of an integrated ERP program must ensure that it contemplates all your basic management needs and, in addition, must serve to support the current situation and the forecast of the future evolution of the business. It is crucial to carry out an analysis of the needs of the company to carry out the search for a new program and to confirm or redefine the characteristics of the one you want to implement. To do this, those responsible for installing the program must analyze all the available information and also how the integration of new needs is carried out between the different areas or departments of a company.

Companies may have different sizes, but they must all carry out the same activities (buying, venerating, maintaining relationships with customers, keeping accounts, managing personnel and adapting to changes in legal and financial regulations). Therefore, small and medium-sized enterprises must also adopt technologies that fully support the objectives to be achieved and that allow them to react, quickly and flexibly, to external events affecting commercial organization, logistics or planning and financial decision-making. Companies, regardless of their size and sector of activity, require those tools and solutions that allow them to adapt their costs, face the growing competition, optimize relationships with their customers, improve their supply chain and act in a competitive way in the market, all characterized by a strong internationalization.



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